Modern Carriages for Heavy Naval Ordnance

Commander R. A. E. Scott R.N.

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LECTURE.

Friday, 15th, June, 1866.

CAPTAIN E. GARDINER FISHBOURNE, R.N., C.B., Vice-President,
in the Chair.

MODERN CARRIAGES FOR HEAVY NAVAL ORDNANCE.

By Commander R. A. E. SCOTT, R.N.*

I APPROACH the subject of the afternoon's lecture with some diffidence. I am not now about to advocate a proposal which has yet to be tried, but I have principally to describe a success which has been already achieved. The necessary consequence of this is, that I shall appear to some to be sounding my own trumpet somewhat loudly; and I must therefore endeavour, as far as possible, to let the facts which I shall lay before you speak for themselves. Still, I cannot forego the satisfaction of pointing out the opportunities which this Institution has afforded me of developing ideas which have since borne good fruit.

The importance of having such an arena for discussion as the theatre of the Royal United Service Institution, cannot be overrated, and I shall not be blamed by the lovers of this Institution if I demonstrate clearly that some of the first steps towards the realisation of my projects for working heavy guns on a broadside, were taken in this room, and that in this room also both sides of the question were fairly and freely discussed.

In May, 1862, in the discussion which ensued on Captain Fishbourne's lecture on the best gun for naval warfare, Sir W. Armstrong stated—"As regards present ships, naval men seem to be agreed that "it is not possible to carry broadside guns much heavier than the "present 68-pr., or, at the very most, that six tons must be the "limit."

In January, 1863, Mr. Barras gave here a lecture on the stability of ships in a seaway, and at that lecture I exhibited on the walls designs for a frigate and corvette, which were to be armed with 20-ton guns on the broadside, and the designs were accompanied by a table shewing the immense superiority of a few heavy guns over a number of small ones.

These diagrams and this table were again brought to your notice in March, 1863, on the occasion of Captain Arbuckle's lecture on iron forts and ships, at that officer's request, and the meeting wished me to explain them.

They are now again placed before you, that you may the more

* Now Captain Scott, R.N.—Ed.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1a.

Fig. 2a.

Fig. 3a.

Fig. 1b.

Fig. 1c.

Fig. 2b.

Fig. 2c.

Fig. 1d.

Fig. 1f.

BELLEROPHON.

Armstrong's Carriage and Slide.

Fig. 1.

BELLEROPHON.

Scott's 300 PF Carriage and Slide.

BELLEROPHON.

Arsenal 300 PF Carriage and Slide.

Fig. 2.

COMPRESSORS.

Fig. 1.
OLD PATTERN Fig. 4.
HOLDING DOWN
MINOTAUR. Fig. 7.
SCOTT'S
MINOTAUR AND
BELLEROPHON.

Fig. 10.

ERICSSON
BROADSIDE. Fig. 2.
FERGUSON.

Fig. 5.

SELF ACTING
ECCENTRIC
MINOTAUR. R.C.D.

Fig. 8.

ARMSTRONG
BELLEROPHON.

Fig. 11.

ERICSSON
TURRET.

Fig. 12.

SELF ACTING

Self acting
Lever

ARMSTRONG'S

Self acting
LeverAdjusting
Lever

SCOTT'S

Adjusting
LeverAdjusting
LeverAdjusting
Lever

Fig. 3.

Fig. 3.
PLATE. R.C.D.

Fig. 6.

INSIDE
WOOD.

Fig. 9.

R.C.D.
BELLEROPHON.

"RESEARCH" Fig 1.
Arsenal Wooden Gun Carriage and Slide

"RESEARCH" Fig 2.
Iron Gun Carriage and Slide 100 P^r Mounted.

Section through Iron Gun Carriage and Slide
Showing 2^d Compressor.

readily follow the course which events have taken as respects these proposals.

Comparative Power and Cost of Ordnance of different Calibres.

No.	Guns.	WEIGHT.			Cost.	No. of Men.		No.	Gun.	WEIGHT.			Cost.	No. of Men.
		Guns.	Powder.	Shot.						Guns.	Powder.	Shot.		
		Tons.	lbs.	lbs.	£ s.					Tons.	lbs.	lbs.	Powder and Shot.	
5	32-prs.	14½	50	100	2 1	65	=	1	68-pr.	4¾	16	681	40 14	17
10	68-prs.	47½	160	680	7 0	170	=	1	150-pr.	12	40	150	1 13	*16
7	150-prs.	84	280†	1050	11 10	112	=	1	330-pr.	26	80	330	3 8	*16
350	68-prs.	1662½	5600	23800	245 0	5350	=	5	330-pr.	130	400	1650	17 0	*80
20	68-prs.	95	320	1360	14 0	340	=	"Warrior's" Broadside.						
17½ "Warrior's" Broadside														
= Broadside of 5 Horsfall Guns.														

* Number of men to work these guns in the manner proposed by Commander Scott in 1862.
 † A thousand balls of 1 lb. weight each would produce no effect upon an iron-clad.

In February of the following year, viz., 1864, Mr. Cunningham commenced his lecture before you with this question—"Can we continue to

work our heavy guns by manual power?" and he decides the question in the negative. He thinks that "arms of flesh and bone must give way to the iron arms and sinews of the mighty steam-engine," and that though 12-ton guns may be worked by 21 men on a level battery deck, he doubts whether half as many again would be able to control such ponderous guns *at sea*. "One word," he adds, "more on this point:" "It has often been remarked to me by officers, that they always "dreaded casting loose their 68-prs. at sea, and were always delighted "when the guns were again secured. If, then, this anxiety existed "in regard to guns of between four or five tons in weight, how great "must it be, or rather will be, when dealing with guns three times "heavier, with probably all the embarrassing accompaniments of wet, "slippery decks." (See Journal Royal United Service Institution, vol. viii, page 70.)

In May, 1865, the Turret Committee sat, and Captain. Preedy, in answer to Captain Kennedy's question—Can you imagine any possible way of fighting a 12-ton gun except in a turret? replied "No."

Captain Hornby stated before the same Committee that Captain Willes, having cast a 6½-ton gun adrift in a seaway (that is to say, having removed the lashings, ready for working), the gun was unmanageable, and the men were afraid to go near it. The slide also was damaged in firing the gun.

Still, at this time, the views of men were undergoing some change, for, through the assistance of the Admiralty, I had made a slide and carriage for a 6½-ton gun, to which I shall have again to refer. It is represented in diagram, Fig. 2, plate xxv, and my confidence in its success was beginning to have weight.

Captain Heath, for instance, thinks, in the same month, when questioned by the Turret Committee, that a 12-ton gun ought long ago to have been tried in the Channel squadron, and considers that the danger most to be apprehended will be the running-out of the gun.

Captain Key also hopes, at this time, that we shall be able to work the 12-ton gun with 16 men, but expresses similar fears concerning the running in and out; and Captain Preedy, who had commanded the Hector, one of the iron-clads of the channel squadron, informed the Committee that "the other day we had great difficulty in running the "gun in with 22 men on the train whips and tackles attached to the "carriage, the ship only heeling over six degrees; but the fact of "firing the gun I have no doubt would have brought it in. Why I "alluded to running-in was this, the ports of these iron ships are low, "and if you get a gun out and cannot get it in again, it would be a "very serious matter in a seaway, for you would ship such heavy seas "that it would become a very serious matter."

And Captain Hornby, in concluding his evidence, gave a very similar opinion.

It will be seen from all this that; though we now talk familiarly of working 12-ton guns in a seaway, it is only very recently that the most sanguine, timidly hoped to accomplish the task, and the less hopeful, who had seen the 68-prs. in a seaway, looked at by the sailors from a distance like some savage animal dangerous to approach, pronounced it an impossibility.

The month after this evidence was given my carriage and slide for a 6½-ton gun were placed in the "Research." I desired that they should be prepared for a 12-ton gun at once. I said in my official letter of February 4th, 1864—"I feel sure that the 12-ton guns could "by this method be worked in a seaway with greater ease and safety than 68-prs. mounted upon the old principle." The Admiralty, however, cautiously, and perhaps more wisely, in the face of such doubts and fears on the part of many experienced and able Officers, cognizant alone of the old system of working guns, restricted my first experiment to a carriage of the smaller size.

Now here I wish to call your attention especially to Captain Freedy's evidence, just quoted. He speaks of the danger and difficulty which had been experienced in working a 6½-ton gun in a seaway, and in a *heel of only six degrees, with 22 men.* He is so impressed with this danger and difficulty, that he would not go an ounce over a 6-ton gun for the broadside, and yet in the very next month, my carriage and slide for a 6½-ton gun were worked in *a roll of seven degrees with 9 men—quick firing,* with the greatest ease and safety.

Previous to this, the Admiralty had given authority for the commencement of the 12-ton gun-carriage and slide. They had seen the 6½-ton gun-carriage and slide in Woolwich Dockyard early in 1865, and felt justified in authorizing the further expenditure. The arrangements for experimenting with the larger carriage and slide were not, however, completed until the latter part of last year, when they were put on board the "Minotaur."

It is necessary, however, that I should here retrace my steps. My course was not so easy and pleasant as may have appeared from my correspondence with my Lords of the Admiralty.

By existing regulations and arrangements, the Navy does not make its own carriages and slides, any more than design its own guns.

My proposals were, in regular course, submitted to the War Department, and the officers of that department having had the advantage of my plans and seeing that I had introduced the word "American," in reference to the use of compressors in *turrets*, thought that it would be better to improve on what they chose to consider this "American" notion to giving a trial to my system in its integrity. I trust you will pardon my being a little bitter here. I don't like the system of improvement on other people's ideas by Committees appointed to test the value of inventions, and I believe it will generally be found to lead to what happened in this case.

My carriage and slide when thus improved upon, but with some of its most important features omitted, was sent to the "Excellent" for trial, and the report on them was—"that the compressor did not act, though, to all outward appearance, in working order; and on January 29th, during practice, without the least warning, ceased to act,"—"that no safe conclusion can be drawn from experience in the United States, as their guns are heavy and fired with low charges"—and that "this form of compressor had been abandoned in the American navy."

On the communication to me of this report, I called attention to the fact, that it was not *my* notion which had been tried, but the American notion, improved upon by a Committee; and thereupon orders were given

that I should carry out my own notion in my own way, in Her Majesty's Dockyard; and when I have concluded my history of the broadside 12-tonners, I think you will agree with me, that it was at least a step towards the solution of the problem.

My carriage and slide for a 6½-ton gun were made, and proved successful, beating the improved Arsenal carriage with its new plate-compressor and eccentrics as well as the *then* service-pattern carriage (Plate xxv, fig. 1) on every point, as seen by the following records of the firing:—

No. 1.

REPORT OF FIRING WITH CAPTAIN SCOTT'S AND OLD PATTERN WOODEN CARRIAGE, JUNE 2ND, 1865.

Guns pointed at a ship at a distance.

No. of crew (Scott)..... 9
Do. wooden carriage..... 19

Rounds.	Times.		Remarks.
	Captain Scott's.	Old wooden carriage.	
	m. s.	m. s.	
1	" "	" "	Both guns single shot. 20 lb. charge. 2° elevation.
2	1 00	1 33	
3	0 48	1 25	Captain Scott's carriage. 14 rounds in 11m. 32s. Old wooden carriage. 10 rounds in 11m. 07s. } Interrupted.
4	0 56	1 22	
1	" "	" "	Captain Scott's carriage. Rear compressor just touching; fore compressor not used. Recoil to a moderately taut breeching each time.
2	0 40	1 01	Old wooden carriage. Right rear compressor carried away. Slide very much injured. Left rectangular pivot bar cracked across the hinge.
3	0 59	1 03	
4	0 53	1 38	
5	1 10*	1 18	
6	1 00*	1 11	
7	0 45	1 03	
8	0 53	1 03	
9	0 50	1 28	
10	0 51	1 22	
11	0 50		
12	0 49		
13	1 02*		
14	0 49		
	11 32	11 07	

* In these rounds trigger line came unhooked, causing mis-fire.

No. 2.

REPORT OF FIRING WITH CAPTAIN SCOTT'S IRON, AND NEW PATTERN WOODEN CARRIAGE, 3RD JUNE, 1865.

Rounds.	Times.		Remarks.
	Captain Scott's iron carriage.	New pattern wooden carriage.	
	m. s.	m. s.	
1	" "	" "	Captain Scott's iron carriage. Fired 10 rounds in 6m. 32s.
2	0 41	0 39	New pattern wooden carriage. Fired 10 rounds in 6m. 53s.
3	0 42	0 48	Distant charges 25lbs., and single shot. Elevation 5°.
4	0 43	0 42	Captain Scott's. Fore compressor not used; rear one touching. Recoil to a moderately taut breech each round.
5	0 48	0 42	
6	0 50	0 51	New pattern wood. Recoil to a taut breech each round.
7	0 40	0 42	
8	0 42	0 51	Captain Scott's worked with 9 men. New pattern wood, worked with 19 men.
9	0 46	0 41	
10	0 39	0 57	

Besides the successful issue of this competition with the improved carriage, specially prepared to compete with mine, I had the further satisfaction to find that both the Officers of the ship, and the men who worked the guns were equally in favour of the wrought-iron carriage. The crews of the guns mounted upon the improved and upon the service-pattern carriages, ascribed their defeat to the superiority of the iron carriage, and wished to be allowed to work it in turn with its proper crew.

Subsequent to these trials, some of which are recorded in tables 1 and 2, further experimental firing, from the same carriages, took place at Portland and was thus reported upon:—"Judging, however, from the performance of Commander Scott's carriage, at anchor and in smooth water, I think its superiority over the other carriages in its indestructibility, power of control, training, elevating, and the smallness of its crew (9 instead of 19), is very manifest.

"All the wooden carriages exhibit, in a greater or less degree, symptoms of weakness, whereas Commander Scott's seems to improve by use."

The final report of October, 1865, stated that the simplicity of the moving parts of Scott's carriage has caused the carriage and slide to be worked with perfect confidence by the men, and that the carriage

and slide possessed the special advantage of doing away with the necessity for the usual long and harassing drill.

In the meanwhile the plate-compressor and eccentrics were adopted, and, at the same time, the rear racer, which formed part of my plan. The front rollers on the slide, which had been shown in my drawing of February, 1864, and which were described in this theatre on March 2nd, 1863 (see Royal United Service Journal, vol. vii, page 92), were adopted for broadside slides on September 3rd, 1864, and the slide was of a somewhat similar pattern to that shown in Fig. 1, plate xxv, except that eccentrics were applied to its rear rollers for training. The plate-compressor is shown in Fig. 3, plate xxvi, under the head of compressors.

The improved carriage which competed with mine, and to which this compressor was affixed, is somewhat similar to the service carriage shown in Fig. 1, plate xxv.

The state of the gun-carriage question and the improvement made during late years in the mode of working guns, will be more clearly shown by a slight sketch of the past, up to the date of my first competition in the "Research."

A compressor (Fig. 2, plate xxvi), called Ferguson's, had been in use since 1858, but does not seem to have latterly given very satisfactory results, for we find that in August, 1863, the Ordnance Select Committee state, that the charge of the 9-inch smooth-bored gun "had to be reduced" from the 33 lbs., proposed by Sir W. Armstrong, "to 25 lbs., on account of the recoil," and they add, "that wrought-iron guns might be made lighter than they are, or be used with heavier charges, if the recoil could be more effectually checked."

And in the same Committee's report of the previous month, it is stated in respect to this 100-pr. smooth-bore, that "Sir W. Armstrong originally contemplated a charge of 33 lbs., with which 80 rounds were fired without apparent injury to the gun, but this charge proved too great for the carriage, which broke three times under it. On one occasion, when fired on a naval slide and carriage with this charge, Ferguson's compressor and an inside compressor (Fig. 6, plate xxvi), being used, it recoiled 6 feet off the slide."

That the need of a good compressor was urgently felt and could, *not* be obtained, is clear, for at the end of July, 1863, Sir W. Armstrong, in answer to the Committee's enquiry, states, that "he is not prepared with any plan of compressors for more effectually controlling recoil."

I think I have now shown that not only was there no good naval carriage, but that its want had occasioned the charge of the 100-pr. to be reduced below efficiency, viz., from 33 lbs. to 25 lbs. This charge lessened the initial velocity of its shot more than 200 feet per second; and as a reduction to a 20 lb. charge was in prospect, with a proportionate diminution in the charge of the 12-ton guns, I thought that at last there was surely a "rowlock" for a *seaman's* oar; and hence, at the end of 1863, my propositions of 1862, with respect to the mounting of very heavy guns, were again brought forward and submitted to the naval authorities. With the results of that submission you have already been made acquainted. Shortly before my drawings had been sent

forward, an attempt was made to supply the want of a good broadside carriage. The result was the spider or Jim Crow carriage, which proved, however, far too nimble for poor Jack's safety, and has since been converted into a land service mounting.

It is now, however, necessary to describe the compressor which followed the Ferguson's, and also the plate compressor which was recommended to be adopted for all slides in July, 1865, only one month after its first trial against my compressor in the "Research."

In the old system of slide carriages for revolving guns, two compressors were applied for the 68-prs.; but when the 100-pr. smooth bore, firing a larger charge, was introduced into the service as a broadside gun, another compressor was added on each side of the carriage, making four compressors, as shewn in Fig. 1, plate xxv. These could not possibly be tightened alike, and hence there was great chance of that which bore the most strain being carried away.

This frequently happened, and at best these compressors are very difficult to manage, and uncertain in action. An inside compressor (Fig. 6, plate xxvi) was then introduced as an auxiliary, making five separate compressors, requiring five men to work them. These compressors were used in 1864 on both the 100-pr. and 12-ton gun-carriages (see Figs. 1 and 6, plate xxvi), but were being gradually displaced by the plate compressor towards the end of 1865; but the charge of the 100-pr. has not been increased.

The competition in the "Research," and the labours of the Turret Committee, seemed to have turned public attention to the improvement of gun mounting; for now I had competitors for the 12-ton gun-carriage and slide. I worked at my single carriage and slide in Woolwich dockyard, and the committee worked at their various ones in the Royal Arsenal at the same time.

I will now describe how these systems turned out when tried in the "Minotaur." But first let me give you some of the particulars of my competitors' plans, which will hereafter be more particularly described:—

1. The Arsenal wrought-iron carriage and slide.
2. The improved pattern, wooden carriage and slide.
3. Another improved pattern, wooden carriage and slide.

1. *The Wrought Iron Carriage and Slide.*—To this was affixed, 1st, the plate compressor, which was removed before trial; then a holding-down compressor (Fig. 4, plate xxvi), which broke down after a few discharges, allowing the gun to recoil nearly clear of the slide. 3rdly, a self-acting compressor (Fig. 5), which entirely failed. This mounting was trained by tackles.

2. *The Improved Pattern.*—This was fitted with the plate compressor, which failed to arrest the gun, and left great part of the recoil to be checked by the breeching. The training was done by Mr. Cunningham's chain-gearing (in lieu of the winches previously used on board the "Minotaur"), and single chains were, immediately preceding the trial, put on by Mr. Cunningham to run the gun in and out.

3. This carriage was provided with a new arrangement of elevating gear, and had a rifled gun mounted upon it. The self-acting com-

pressor of new pattern fitted to it, proved a failure; and hence tapering the sides of the slides, in imitation of my wooden baulks, was resorted to, but without success.

The competition was thus ended by the failure of the compressors, and of the other gear which competed with mine. The iron slide of the Arsenal gun was found to have become bent. During the trials which took place a short time previously in the "Minotaur" with a 12-ton gun, mounted upon an improved wooden carriage and slide, the quickest firing obtained was ten rounds in 11' 7", and this was considered remarkably quick, being much faster than the firing from a similar gun in a turret.

With Scott's carriage and slide, and a crew that had never worked together before being sent to the "Minotaur," or had ever seen a 12-ton gun fired, the first ten rounds that were fired were completed on January 17th, 1866, in 8' 54"
 2nd. Four rounds, slow time, rolling from 4° to 5° each way 4' 20"
 3rd. Three rounds independent, slow 1' 37"
 4th. Four rounds, slow time, rolling 8° to port and 6° to star-board 3' 3"
 5th. Five rounds, quick, rolling 4° to 5° each way 3' 10"
 6th. Ten rounds, quick 6' 18"
 7th. Ten rounds, slow 8' 28"
 8th. Ten rounds, slow 8' 13"

On January 18th (the next day) some rounds were fired with the gun double-shotted, with the full 40 lbs. charge, but although only one compressor was used, the gun did not recoil to a taut breeching. The quickest firing on this day was—

Ten rounds, quick, in	..	..	5'	58"
Twelve rounds, quick, in	..	..	6'	32"

On February 2nd; the third day's trial, full 40 lb. charges being still used, the firing was as follows:—

1st. Ten rounds, quick, in	..	..	5'	45"
2nd. do. do.	..	..	5'	38"
3rd. do. do.	..	..	4'	48"

Men changed rounds twice, same captain of gun retained.

4th. Ten rounds, quick, in	..	..	5'	58"
5th. do. do.	..	..	5'	25"
6th. do. do.	..	..	5'	13"
7th. do. do.	..	..	5'	1"

The final trial—the other gun-carriages being *hors de combat*—was to test the strength of Scott's racers, and the power of his compressors, by firing the gun at the top or sharpest part of the roll. The front pivot-block was let go, and the hook under the front racer slack, so that the whole shock, &c., was taken by the racers only. The firing of 19 rounds was as follows, with only one compressor, and breeching never taut:—

1st.	Ship rolled up and gun fired at	..	$2\frac{1}{2}^{\circ}$
2nd.	do. do.	..	4°
3rd.	do. do.	..	2°
4th.	do. do.	..	4°
5th.	do. do.	..	1°
6th.	do. do.	..	5°
7th.	do. do.	..	$7\frac{1}{2}^{\circ}$
8th.	do. do.	..	$3\frac{1}{2}^{\circ}$
9th.	do. do.	..	2°
10th.	do. do.	..	(?)
11th.	do. do.	..	5°
12th.	do. do.	..	$5^{\circ}\frac{1}{2}$
13th.	do. do.	..	6°
14th.	do. do.	..	$6\frac{1}{2}^{\circ}$
15th.	do. do.	..	$10\frac{1}{2}^{\circ}$
16th.	do. do.	..	7°
17th.	do. do.	..	$6\frac{1}{2}^{\circ}$
18th.	do. do.	..	10°
19th.	do. do.	..	5°

The result astonished every one, and it was publicly stated by the Officer who conducted the experiments, that Commander Scott's carriage had come out "most triumphantly." And it was then recommended that some form of the American compressor should be adopted, which, judging from the carriages subsequently made, seems to have meant that the features of Scott's compressor, with its double action and lever arms, and its frictional surfaces which had been so carefully worked out and so successfully applied to *slides*, should be imitated.

The question was now settled; there seemed no room for another invention; but still the opportunity was tempting. People may ask the question, "What's in a name"—but there is a good deal in a name. Commander Scott's name, for instance, does not command the same attention as Sir W. Armstrong's. Think of the figure I should have cut if Sir William Armstrong had been the first to devise the method of working heavy guns in a sea-way, and I had pretended to improve upon his idea! But Sir W. Armstrong's modifications upon my carriage and slide were at once received as undeniable improvements.

These modifications were the substitution of iron for wooden baulks and an inside breeching of rope to stop recoil, in lieu of the gradually tapered baulks of wood to absorb it. Sir William further added to my plan of compressor a self-acting arrangement, differing little from that proposed by me in 1864 (See Fig. 12, plate xxvi), and in place of my endless chains for running the gun in and out, applied a rope (Figs. A and B, plate xxviii).*

Sir William's elevating gear was similar to that first introduced by the carriage department, but far more strongly and better made; and his carriage was of the box-girder construction.

The Armstrong slide was of double T-iron, admirably rolled, and was fitted with the new eccentrics.

* The proportions in this plate are smaller than those in Plate xxvii.—Ed.

This slide worked upon two racers, and had a third laid down to support its front.

The Arsenal also sent a slide of double T-iron, fitted with my running-in and -out chains, slightly modified, and fitted with five wooden baulks of smaller dimensions than mine. The compressor was also similar, but weaker, and the shaft was cut into two parts, which further reduced its strength.

In the carriage, the single-sided construction was adhered to, but the elevating gear was fitted with a wheel on one side in order to attain that nicety of aim which was found to be impracticable with lever handspikes, whose jerky and uncertain action, the eye could not follow.

The times of firing were as follows:—

Scott's quickest 10 rounds,	10' 45";	other 10 rounds,	11' 25".
Armstrong's do.	13' 21";	do.	15' 32".
Arsenal do.	15' 41";	do.	gearing broke.

In the "Minotaur," ten rounds were fired from Scott's gun-carriage in 4' 48", and deducting the extra time alike required for loading all the guns with heavy, elongated shot, viz., 6 minutes, the relative times of performing the other operations would be:—

Scott	4' 45".
Armstrong	7' 21".
Arsenal	9' 41".

These figures may therefore be fairly taken as representing the comparative facility afforded by each of the gun-carriages, for working them.

Unfortunately, the weather was too fine to fully develop the advantages which were so apparent in my mounting, when there was any motion in the "Minotaur;" and hence the competition was closed without any trial of firing in rolling or at the top of the roll. Such a trial would have afforded conclusive evidence as to the holding power of Armstrong's modified iron-compressor, and proved, in some measure at least, whether Professor Airy's demonstration of the intensity of the shock of one hard metal jarring against another, is borne out by practice. In facility and quickness of training by tackles, Scott's gun-carriage had a great advantage over both its competitors; and in running the gun in and out its gear performed the operation in 10"; while more than a minute was occupied by the Arsenal pattern, and more than two by Sir W. Armstrong's.

My elevating gear moved the gun with great steadiness, and quite as fast as the eye could follow, and, as it never ran down, the elevation was always certain in quick firing.

My gun had a preponderance of 6 cwt. in the breech; the two other guns had no preponderance, though how such guns can be elevated or depressed by quoins, if the gear be damaged, is a difficulty not yet solved.

The gun upon my mounting was several times fired with its muzzle

above the port, without injury to the elevating screw; but a further description of the mode of working will be found at the end of this paper. It is therefore only necessary to mention in this place, that with the shortest of these competitive slides the muzzle of my gun was a foot further outside the port, than the muzzles of either of the other guns, and that the arrangement of my racers, &c., while affording greater training with a smaller port, assisted in preventing so heavy a jar, as was noticed on the discharge of the guns mounted upon the Armstrong and Arsenal carriages. Behind the latter, the deck was in fact pressed down one-quarter inch by the shock.

The competition was concluded after 60 rounds from the Armstrong and Arsenal gun-carriages, and 70 from mine, which, with the 200 previously fired, made a total of 270 that my mounting had withstood, without the slightest appearance of damage or strain. Subsequently to the close of the competition, viz., on May 30th, 1865, the teeth of my training racks were tested by lifting up 250 lbs. shot, and letting them fall, and passed through this ordeal with credit, as also did the training machinery when tested against tackles on the same day by the Committee.

My gun-carriage was fitted for training, either with tackles (see Fig. 1 e and f, plate xxix), by single chain (Fig. 1 and 1a), or by rack and pinion (Fig. 1, plate xxvii).

I think the above is a fair statement of what took place, but the *Times* newspaper, immediately after the trial, considered it probable that neither plan would be adopted as a whole, but that the best features of each would be improved upon, and the *Times* reporter was right.

The Gun-carriage Committee recommended the adoption of racers of similar size and width with mine. They also recommended my box-girder form of carriage, and trucks nearly approaching mine in size, and similarly coned, with my running-in and -out gear; but accepted Sir William's compressor as an improvement on mine, doing away with the inner breeching, which is, I think, the safeguard of his compressor, and one of its most valuable parts. His elevating gear, and his modifications of my compressor are, however, to be reversed, and rollers and trucks of the size used by me, but attached, or rather detached, in the mode employed by Sir W. Armstrong, are to be adopted; the position of the lever which secures the elevating gear from running down is to be changed; my running in- and -out gear is to be employed, but is to be caught in an untried manner; and various amalgamations in the bollards and transporting irons upon the slides are to be made, and this amalgamation is to be called "The Committee Carriage."

I have now brought the story of the gun-carriages to the present date. If I have dwelt much upon my own difficulties, do not leave this theatre with the idea that I am uttering the complaints of a disappointed man. Do not think for a moment that I am discouraged. I confidently predicted, when others doubted, that 12-ton guns could be worked safely and with rapidity in a heavy sea. I now predict that when tried in a heavy sea, and with continuous discharges, my

gun-carriage will unmistakeably beat Sir W. Armstrong's, as well as the amalgamated carriage of the Committee.

DETAILS OF THE WORKING PARTS OF THE COMPETITIVE GUN-CARRIAGES, WITH THE
MODE OF THEIR CONSTRUCTION, &c.

Training.

Training heavy broadside guns by chains seems first to have been applied on board H.M.S. "Excellent," in the latter part of 1863.

As fitted there, the purchase was on one side of the gun, and the chain led as in Mr. Lynn's plan, the friction was consequently small, and the ease of training very much greater than that by tackles, which, as applied in the end of 1864 to a 12-ton gun in the "Excellent," required the full complement of twenty-four men to work the gun slowly.

In the "Minotaur," in December, 1865, Mr. Cunningham led his chain round sheaves on the deck, and took the purchase up to the ship's side to be more out of the way of the other men's operations; but the friction was then considerable; little, if any, advantage in power was gained over tackles fitted on the usual plan. Mr. Cunningham's chain is shown in Plate xxix, figs. 3, 3a, and Mr. Lynn's, which has a shaft under the deck, in the same Plate, figs. 2, 2a; the ends of the chains in both these plans being fastened to the slide. Neither plan requires any lengthened description, as the mode of working is apparent, and it is also sufficiently clear from the diagrams that the chains, as fitted to the guns in the two adjoining ports of the "Minotaur," on Mr. Lynn's and on Mr. Cunningham's plan respectively, were in the way of each other, each chain preventing the extreme training of the gun next to it. It is likewise evident, that any chains stretched over the deck, are much in the way of bringing up powder and shot to the gun.

The movement of these particular chains, especially the lengthened one of Mr. Cunningham, and the sudden tightening—either in a roll or in training the gun—of the slack part necessarily left for play, would always be dangerous to the legs of the crew, and probably cause serious accidents to the men carrying up 250 lb. projectiles to the muzzle of the 12½-ton rifled gun. This duty would be more critical at night, for the men in a roll might then, inadvertently, put their feet against these chains for steadiment. If chains be used at all, the least objectionable is probably the straight chain and oscillating pitch-wheel (Plate xxix, fig. 1, 1a), as it does not interfere with the training of the next gun, is not in the way of the loaders, and is kept stretched in one fixed position upon the deck. The motive power also is close to the captain of the gun, which would be of great advantage in action when the thick smoke would prevent men at the side from being seen, and the noise, the voice of the captain from being heard. The arrangement of the men pointing being close to the captain of the gun is likewise obtained by my rack and pinion movement, which enables the gun to be trained and kept bearing upon the object, not only in loading and running out, but also until its discharge.

The special advantages obtained by my rack and pinion movement were precisely those in which, as Captain Key informed the Turret Committee, the turret had a superiority over the broadside. He stated "that training while loading gave great advantage to the turret," and afterwards said that, "training by machinery gives the gun in the turret an advantage;" and in the lecture given by Mr. Cunningham, in 1854, already quoted, he concludes that, "the success, then, of the discharge of a gun will depend upon the quick and steady manner it can follow a passing object," which arrangements, he believes, "can only be provided by the application of steam power."

The tackles used by me were placed and hooked in the same manner as those which were applied to my iron carriage in the "Research." They are shown in Figs. 1e, 1f, plate xxix, but both chains and tackles, however good for preventer plans of training, are inferior means of laying the gun; for the accuracy aimed at in rifled ordnance cannot be secured by their use, neither with much motion can the rapid

touch, often necessary to make the gun cover the object, be given. In the case of tackles, late experience has shown that a sea shipped through port-holes causes men to drop them and to leave the gun adrift and unmanagable.

The Racers and Pivots.

My plan of raised racers, which had been so much approved in the "Research" was again adopted in the "Minotaur," and the same racers were subsequently laid down in the "Bellerophon," but in both the latter ships the centres of the racers were let down into the deck three-quarters of an inch, and their ends raised, so as to admit of the gun's being trained round on an horizontal plane. The edge nearest the ship's side of the front racers was slotted to receive a strong hook (Plate xxvii, Dd), which held the slide securely down to the deck and rendered the gun secure in any sea. In the "Minotaur," as well as in the "Research," the front of the slide was further secured by a massive metal block, working in a grooved racer; but after the trial of firing the 12-ton gun, nineteen times at the top of the roll in the "Minotaur," without this fastening, it was considered unnecessary, more especially as a special pivot-bar or flap of the same strength as the usual service elongated V-flaps had been fitted to the pivot-point in the port as a preventer.

The advantage of my racers consisted in their being employed to hold the slide, and in the power which they gave of fastening them, so as to afford the largest arc of training that could be obtained from the port aperture. They also strengthened the deck through which they were bolted, and, by means of the flanged rollers on the slide, spread the shock of discharge over a large space.

In the "Minotaur" the gun on my mounting trained 31° each way; but no gun with the V-flap and fixed pivot obtained so much as 29° .

A similar result was observable in the "Bellerophon" where, although the port was closed up from 2ft. 9in. to 2ft. 1in., the training was still 31° each way. The training of the other guns in a 2ft. 9in. aperture was only 30° .

In the diagram (Fig. 1, plate xxix) is shown the filling up of the "Minotaur's" port, which was closed on the lower side 14 inches, the corners being rounded and made much higher. The application of this important feature of my system of mounting had a similar effect to throwing the lower port-cill, a mean of 16 inches higher out of the water, thus adding greatly to a vessel's capabilities of fighting in a scaway.

In the "Bellerophon" the centre of the lower port-cill was filled up 7 inches, and the corners closed in the same manner as in the "Minotaur." With this arrangement about 11° of elevation were obtained by firing with the gun's muzzle above the port, and 5° of depression with the muzzle clear of the filling-piece on the lower port-cill.

Had a small half port been fitted, $7\frac{1}{2}^{\circ}$ of depression could have been obtained in the "Bellerophon," and 9° in the "Minotaur," when wanted; but as it was, the cheap wood was knocked away when, at the last, extreme depression was given to the gun. While the wood remained, it was a protection to the loaders against the spray and sea, nor was any disadvantage found, but the contrary, from closing up the port. The rapidity of fire in the "Minotaur," with the 150 lb. ball, being more than double that previously obtained, and the quickness in the "Bellerophon," with the 250 lb. rifled shot, being equally unmatched.

The Arsenal iron slide in the "Minotaur" was placed upon thin and narrow racers, only slightly thicker than those first used for 12-ton guns. It was held only by a single pivot-point on the top of the lower port cell, which was $17\frac{1}{2}$ inches from the deck. This pivot-point was much exposed, yet on this the whole security of the gun depended, and upon it the severe shock of the recoil was concentrated, and tended to drag away the ship's side from the armour plates affixed to it.

In the "Bellerophon" the racers were considerably thicker, but were still not utilised for holding the slide, or bearing any portion of the sudden shock backwards occasioned by the discharge of the gun. The pivot-point was, however, better supported and protected, the port-cill covering it, and reaching up to a height of 26 inches above the deck.

Sir W. Armstrong's slide was supported upon similar racers, but had an additional racer under the fore-end of the slide, which seemed not to be an advantage in training; like that of the Arsenal, it was held by a single pivot-point. The usual elongated pivot V-flap was used to fasten both the Arsenal and Armstrong slides to this point in the port-cill, and was in both cases found to be much in the way of the men loading the guns. The eccentrics first used upon the improved Arsenal slide tried in the "Research," were alike applied to these slides and carriages.

In training the slides, the defect of their always dropping the breech of the gun on slackening up and removing the eccentric levers before firing, and of generally letting it slip to the right or left, was observable, and the inability of using the slide-eccentrics to lift the slide when the gun was run in, was a further drawback to their use. The discharge of the gun also frequently upset these eccentrics, and put them out of working order.

The Elevating Gear.

My arrangement consisted of a screw working through a box, fitting inside another box, which was fastened to the gun. These boxes had a washer interposed between their surfaces, and the outer box was open at the bottom; hence when the gun was fired with its muzzle above the upper port-cill, the outer box lifted several inches up from its resting-place on the inside box when the muzzle dipped under the port-cill, and then dropped easily down again upon the washer on the top of the inner box. By this contrivance the weight of the breech of the gun was received without any damaging shock, and the jar of the discharge was likewise absorbed. Any fixed elevation could also be given and maintained with certainty in bombarding.

Motion was communicated to the screw through two bevelled wheels, suitably supported upon the bottom of the carriage, by means of handles worked upon each side, an arrangement which enabled a rapid touch to be given to the elevation in case the captain of the gun found that in rolling up or down, his sights would not come on with the object to be fired at.

The Arsenal elevating gear was somewhat more complicated, and consisted of a band under the gun, worked by a toothed rack and pinion, to which motion was communicated by means of gearing on the upper side of the carriage. The teeth of the rack being of brass, soon gave way, and the wheels became broken by the jar of firing.

The Armstrong elevating gear consisted of a similar rack and pinion, but of greater size, and of wrought iron. The lever for securing the elevation was on the lower side of the pinion, and, falling from the shock of firing, allowed the breech of the gun to move from its position.

In firing with the gun's muzzle above the port, the band was slackened from the gun; hence although the gun could be fired in this position with its breech resting upon the bottom of the carriage, a marked quoin or other means would have to be employed to give any intermediate and high elevation, which required the muzzle of the gun to be above the port. The shipping and unshipping of the lever elevating handles before firing was also found to be disadvantageous.

Running-in and-out Gear.

My gear consisted of two endless chains, stretched over two pitch wheels on each side of the slide, with a screw arrangement for tightening the chains. When the gun was required to be run in, the outside part or toes of the compressor-levers were pressed against the lower part of a box (Figs. 1 D and C, plate xxvii), which was serrated on its upper edge, so as to fit between the pins of the chain links, and press them up against the serrated edge of the upper box.

By this means several of the pins of the chains are securely held by the whole force of the compressor, and as both parts of the box which clutch them, are attached to the carriage, it is only necessary to turn the purchase at the rear end of the slide, to draw the gun in or out. When either operation is finished, the handle of the

compressor is turned, and the inner part or heel of the compressor levers then perform the work of compressing.

Thus one compressor performs the double duty of holding the gun on recoil, and of clasp ing the chains on both sides of the slide together, with equal certainty and security; and this gear, being always in place, and out of the way of every other working part, was at once adopted, as overcoming the chief difficulty previously experienced in working heavy guns.

The Arsenal gear also consisted of two chains of insufficient strength, which had to be caught by hand-levers, worked independently on each side of the slide. The result of this arrangement was, that the men were unable to work together, and the strain being generally borne by a single chain, soon broke one of them.

The Armstrong gear can be best understood by a reference to the diagram, Figs. A, B, D, plate xxviii. The running-in gear completely tired out the men, and hence during the competition, the gun was loaded at the point to which it recoiled, the men not unfrequently standing out on the port-cill to put in the powder and shot. Had there been much rolling, or any sea running, the men could not have loaded in this position; and even in this smooth water competition, it was attended with some risk. The running out was performed by tackles in the usual manner (see Fig. A, same plate).

Running in and out—"The Eccentrics."

For Scott's carriage, eccentrics which had a stop to allow them to pass the centre and remain fixed in that position, were devised. This prevented the necessity of the men's holding on to them in running in or out; but the arrangement also allowed the crew on each side to hold on by the ropes which were attached to the ends of the levers of the eccentrics, if required, and so keep the eccentrics ready to drop the carriage off its rear rollers or trucks.

The levers which work the eccentrics are upon the *sides* of the carriage, and as fitted would prevent injury to the crew in case of the gun going off in running out. Should the eccentrics be slacked up, the carriage would drop upon the slide, with a surface of wood everywhere touching a surface of iron, as dropping the rear of the carriage, lifts the front trucks off the slide; and as both these surfaces are rough, there would then be an absence of sliding sufficient to keep the carriage and gun from moving in a roll. The lever handles are fitted with bands round the drumhead of the eccentrics, which hold them securely when the levers are let drop out of use.

In consequence of these arrangements, every moving part of the mounting is in place, ready for use, and No. 1, having no mechanical labour to perform, can give his whole attention to keeping the gun pointed upon the object, which can be done by means of the rack and pinion, so steadily as not to interfere with the loading. The requisite elevation, in case of a change in the heel of the vessel, can also be given with the same ease and steadiness, and all these operations can be performed simultaneously.

In the evidence taken before the Turret Committee, Captain Powell speaks of the captain's undivided attention being given to the "pointing," as an advantage of much value to the turret.

The Arsenal carriage eccentrics, both in the "Minotaur" and "Bellerophon," are those now adopted into the service in the place of the Gordon eccentrics and levers, which had been so long used with revolving slide carriages, and which were also applied to broadside slide carriages until after the trial of the "improved" carriage on board the "Research" in June, 1865.

The Gordon levers, shewn in Fig. 1, plate xxv, were worked by the side tackles in running out, on slacking which, the carriage dropped off the eccentrics upon its blocks.

The Arsenal eccentrics are worked by lever-handles at the rear of the carriage, which compel Nos. 1 and 2 to go out with the gun, weighing down upon the handles with all or nearly all their strength. This work necessarily takes the captain of the gun (No. 1) from other duties, and obliges him to seek for his object, after removing and handing to another number his lever-handspike. In case of the guns going off

while running out, Nos. 1 and 2 would fare badly. Such an accident happily did not happen, but during the competition in the "Minotaur" one of the 12-ton guns went off just as the captain was laying over the breech and pushing the priming-tube into the vent. The fact of his touching the gun with so much of his body bent over it probably saved his life, and allowed him to escape with merely a severe shaking.

The Armstrong carriage was fitted with similar eccentrics to those of the Arsenal, but they were more difficult to work, owing to there being no platform for Nos. 1 and 2 to walk out upon (Plate xxviii B), for neither the tops of the iron plates substituted for wood baulks nor the top of the slide afforded a safe foothold. It is, I think, doubtful whether, in case of dropping the eccentric levers in a roll, the carriage would remain stationary, for its iron bottom would rest only upon a slippery iron slide.

The Compressors.

Scott's carriage is fitted with two compressors, under the idea that, however powerful and strong the working part may be, it is not safe to be dependent upon a single part. Reverting again to the important evidence given before the Turret Committee, Captain Preedy mentions the "great risk of trusting to one thing in a ship," and this was the view taken in constructing Scott's carriage, and therefore a second means has been prepared for performing every important operation for working the gun.

The fore compressor (Plate xxv, fig. 2c) is the more powerful of the two compressors, being placed on a higher level than the other; the upper lever arms are longer. The shaft upon which these arms work, passes through each side of the carriage and projects beyond; it is provided with a right and left handed screw, to which motion is given by turning a handle shipped upon the shaft at either side of the gun, and thus opening or closing the lever arms. This compressor is applied when extra-holding power is required, and is useful as an additional means of readily checking the gun when running in or out in a heavy roll.

The rear compressor being on a lower level than the spare one, and being also considerably below the level of Scott's proposed height of lower port-cill, would probably escape injury were the front compressor to be hit. Although the rear compressor is the less powerful, it is more important than the other, being employed to catch the chains in running the gun in or out, and being also the working compressor for holding the gun on firing. The only addition made to this compressor, to enable it to perform also the duty of clutching the chain, consists in small pieces or toes on the outside of the lever arms. These additions are seen at Fig. 1C, plate xxvii, where the compressor is shewn in section "compressing" the baulks preparatory to firing, and consequently with its toe-pieces clear of the lower box, the action of which has been already described under the head of "running-in and -out gear."

The baulks of wood upon which the compressors act are slightly tapered longitudinally towards the front of the slide, and are very much tapered in their depth. The object of this is, to allow the gun to move easily at first, from the compressors being slack, so that the sharp vibratory shock which would otherwise be given to the mounting is avoided, and the gun gradually arrested by increased friction, the whole of its momentum being utilised in the process. This result is much aided by the iron plates which pass between the interstices of the baulks in the slide being thicker at the bottom than at the top, so that, on the gun's discharge, they act as inclined planes to wedge the carriage closer down upon the slide and its baulks; and hence the desirable combination of the best properties of a holding-down compressor with that of a gradual and easy absorption of recoil, is attained.

There is practically a multiplication of power in this arrangement, for when by turning the compressor-handle a pressure of 1 lb. is brought against the outside of one baulk, the same force is exerted at each of the other five surfaces, making a total of 6 lbs. for frictional purposes.

The Arsenal compressor arrangement in the "Bellerophon" (Fig. 9, plate xxvi) differed from mine in the shaft being cut into two parts, which threw a very heavy strain upon the sides of a carriage, already too weak to bear the shock of the discharge. The baulks were of wood, but without taper, and in firing, as the gun warmed, it recoiled with much force upon the breeching.

The Armstrong compressor shaft was also in two parts, having on the one side a screw with a lever upon it, to regulate the amount of compression, and upon the other another screw of coarser pitch, having a handle or lever to compress with, before firing the gun (Plate xxviii, fig. O).

In case of the proper gun number omitting to pull this handle down, and so put on the compression, the lower part of the handle was caught by a projecting piece upon the slide, which pushed it down into place on the gun's recoil, and thus prevented the recoil of the gun, with a slack compressor (Plate xxviii Aa).

It has been already mentioned that Sir William's compressor baulks are of iron, and hence on the screwing up of the compressor by the self-acting arrangement, a check is necessarily given to the carriage, which may be found to have a more damaging effect upon its slide than the usual tight screwing up of his compressor by hand before discharge.

Construction.

The Armstrong slide is of double T-plate iron, and open at rear, but to prevent the carriage from running off the slide should the usual outside breeching carry away, it was furnished with an inner breeching, fastened to the slide and passing round, and supporting a strong wooden block, sliding in a groove. This block is placed close against the iron baulks in the slide, and serves the further purpose of aiding the compressor, for in case of the gun's recoil is not fully arrested, the block receives the shock, and, yielding, pushes against the breeching, which stretches gradually, and arrests the gun.

The carriage is of the box girder-form.

The Arsenal slide is of double T-iron, and the carriage single-sided, as shown in the sections upon Plate xxix, figs. 2c and d.

The carriage in the "Minotaur" was made in imitation of the wood pattern, with blocks across the bottom, &c. The carriage in the "Bellerophon" had an iron plate bottom.

Scott's slide is of the box-girder form (Plate xxix, figs. 1b, 1c); the end is closed. The carriage is of similar construction, and fitted with wood on its lower portion, precisely like the one tried in the "Research." See sections, fig. 1d.

The slide in the "Research" was of double T-iron, supported by thin plate iron rivetted against it, and its end was closed.

American Compressors.

It now only remains to describe Ericsson's turret compressor, and the disc compressor which he has applied to broadside guns.

The shaft of Ericsson's turret-compressor does not pass through the carriage, it has a single screw thread upon it, and the plates which are attached to the bottom of the carriage pass between four baulks, which rest upon the bottom of the turret. All these baulks are free to move laterally, and are parallel. The carriage is always upon its rollers, with its bottom plate clear of the baulks, and therefore its momentum is not used up for reducing recoil; this, there is only the single compressor worked on one side to check, and the result is, that the compressor cannot be unscrewed after firing without great difficulty, and a delay of two or three minutes. In the "Miantonomoh," the action of these compressors was far from satisfactory, although the charges were small.

The disc-compressor has been too recently introduced into America to have had much trial, but so much doubt seems to exist there as to its holding power, that air and water are both under consideration for use in cylinders to be placed under the slides for broadside guns to absorb the recoil.

Considerations.

I wish to point out that the most important questions suggested by this afternoon's lecture for your consideration are—

1st. The description of gun-carriage needed; whether it should be entirely of iron, and single sided, regardless of the vibration; or whether, for strength and durability, it would not be better to have double-sided carriages filed with wood to absorb the vibration.

2nd. Whether the heavy guns of the present day can or cannot be worked by the same means used for light guns a century ago, and whether it is not high time to avail ourselves of such mechanical appliances as will, with fewer men, enable us to handle the 12-ton guns with greater ease, and to use them more efficiently than was ever achieved with the long 24-pounder of 1805.

3rd. Whether the various compressors I have described indicate that we are in the track which will ultimately lead to the desired goal. In considering the matter I would request your attention to this, all parallel and side-plate compressors on parallel slides, such as that of Sir W. Armstrong's and the Arsenal, are, in my opinion, really non-recoil appliances, inasmuch as that compression and friction check the recoil, and then the force of recoil, which is in excess of the power of the friction, must be overcome by leverage compression; the blow, which is thereby delivered upon the slide and deck, must be sudden and destructive, but with tapered baulks and wedge plates, there is not only compression and friction, but the resistance of inclined planes to absorb the recoil, and that therefore much less leverage compression is needed.

The CHAIRMAN: Any questions that may be asked, Captain Scott will now be happy to answer them.

A MEMBER: I should like to know a little more about the running-in and running-out and the elevating gear.

Captain SCOTT: Diagram (see Plate, xxvii, fig. D) is an excellent drawing, which will, I think, show clearly how the running-in and out gear is fitted. I shall be happy to describe further the elevating gear, after hearing if there are any more queries.

A MEMBER: Do you use a rope sponge?

Captain SCOTT: No. I raise the lower half port as much as possible, and in the event of having to close the upper half port when the ship rolls, the gun should be loaded through a small scuttle, which should be cut for the purpose of letting the ends of the rammer and sponge staves pass through.

Captain HEATHORN, R.A.: When your gun is at its greatest elevation, do you find any great strain on the screw gear with which you elevate it?

Captain SCOTT: No; it was noticed that the gun jumped about very little, when fired with its muzzle considerably above the port, the breech being down upon the carriage. The gun gives 11° in this position, but a new carriage might easily be arranged for 16° . At the time I commenced my carriage it was affirmed that more than 9° of elevation were unnecessary.

Captain HEATHORN: What amount of depression?

Captain SCOTT: The depression allowed by the wooden checks with which the lower parts of the "Minotaur" and the "Bellerophon's" ports were filled up, was $5\frac{1}{2}^{\circ}$, but with an iron lower half port, 9° of depression could have been given in the "Minotaur's" port.

Captain HEATHORN: What I wanted to know was to what extent of depression has the gun been already fired, so as to test the screw?

Captain SCOTT: $7\frac{1}{2}^{\circ}$. Do you wish me to further describe my elevating gear?

A MEMBER: Sir William Armstrong's.

Captain SCOTT: Sir W. Armstrong's consists of a band under the gun, working in slots on the inside of either bracket of the carriage, motion is given to this band by a rack and pinion, which, as the gun has no breech preponderance, raises it rapidly, the only delay being that of getting the lever handspikes into their sockets, and in clamping and slackening the stop, or paul arrangement. In case, however, further elevation or depression is found necessary, the captain must wait till the handspikes are again re-shipped, the proper elevation given and the pinion clamped, and the handspikes removed clear of the carriage, before he can fire the gun. As the elevating and training are both involved in pointing the gun, I may mention the disadvantage of training with

tackles. In case of the ship's heeling over, the lee guns will have a great tendency to swing in towards the lee side in consequence of the slope of the deck, and to train the gun you have to send the crew from one side to the other; whereas with machinery you have sufficient power to train the gun at all times, retaining the gun numbers on their proper sides, and thus confusion in the dense smoke and excitement of an action at close quarters would be avoided.

The CHAIRMAN: You have stated the relative number of men in the first experiment. What were the relative numbers in the last competition?

Captain SCOTT: 14 men at my carriage in the "Minotaur," and 16 men at the other carriages; there were 16 men at all the carriages in the "Bellerophon"—this number of men at my mounting being only required for hoisting-up, carrying to the gun, and loading the 250 lb. elongated shot.

The CHAIRMAN: How many were necessary for the gun-carriages, apart from the question of shot?

Captain SCOTT: Loading with the round ball you *could* work my gun-carriage with four men, and do so very easily with six men; but the other carriages in the "Bellerophon" were trained with tackles, 16 men would be, in any case, requisite for them.

A MEMBER: Did you fire round shot as well as the elongated bolt?

Captain SCOTT: We fired no round shot in the "Bellerophon." We fired round shot in the "Minotaur;" the round shot were 150 lbs. weight, the elongated shot 250 lbs. The former were lifted up to the muzzle and then rolled in very easily; the latter had to be got up perfectly horizontal, and then the studs had to be accurately adjusted to the grooves of the gun.

A MEMBER: Was the ship rolling when you run out your gun in ten seconds?

Captain SCOTT: No; but the rolling would not have stopped it; there is sufficient power in the purchase to run the gun out with the ship heeling over considerably.

A MEMBER: Will you describe your training apparatus?

Captain SCOTT: The training apparatus is simply this—there is a shaft under the gun which carries two pinions working into a separate toothed rack under the fore part of the slide, and into a second toothed rack cast in one piece with the racer under the rear. This shaft is turned by a single wheel, or else by two handles (both are fitted) at the rear of the slide.

Admiral RYDER: What was decided as to the adoption of your's or Sir William Armstrong's carriage?

Captain SCOTT: The Committee said, I believe, that they were practically alike; and therefore, as it was recommended to make the carriage by contract at Elswick, that Sir William's should be adopted.

Captain SELWYN, R.N.: There is one observation which I should wish to make, in order that, as I see an engineer and mathematician present, he should not go away with a false idea of what Captain Scott stated in his paper. He was speaking of the one pound applied being distributed as one pound on each surface. I did not understand that he meant that one pound was distributed upon each surface. You may increase power by sacrificing time, but you cannot make one pound exerted over one minute, any more than one pound exerted over one minute.

Captain SCOTT: I was speaking of it as a frictional power. I did not mean a multiplying power.

Professor O. BYRNE: This is the question: that the wood that Captain Scott spoke of receives all the force and passes it forwards. He does not mean that that wood does any more than iron; but it passes the force applied over the parts equally; whereas the iron passes it by a rebound, a shock. The one receives it, swallows it, passes it; the other receives it and returns it, which causes mischief. I think Captain Scott is perfectly right in his explanation, although not exactly mathematical.

Captain SCOTT: It was not certainly mathematically expressed. I carefully guarded myself against using scientific terms, and, therefore, did not go into co-efficients of friction, &c.

Captain SELWYN: I was only anxious that no one should go away from this Insti-

tation with a false idea which might have arisen from the words used. I can only add my testimony to the very brilliant results which Captain Scott has shown us, and the great pleasure with which I have always listened to his very comprehensive and sound lectures on the subject of artillery generally.

The CHAIRMAN: With your permission, I will give our thanks to Captain Scott for his very interesting and lucid exposition of this question. The great merit appears to be in the simplicity and the security, which his plan seems to me, entirely to embrace. I can well understand why the preference was given to the other carriages, although at a glance it appears to me it was not necessary to have any competition. But I have observed, strange to say, that whatever is more ingenious is that which is adopted. And though it may seem strange to say so, I have observed, with respect to inventions, that they generally adopt the most ingenious and least practical as the best. That is the only way I can explain the case with respect to the carriages, and with respect to the guns. I do wish Captain Scott every success in this matter. I think he is entitled to immense credit for the perseverance with which he has worked out this question. It is quite evident that his plans have been clearly before his mind in the first instance, and hence he would not be put off his course by the constant difficulties which have been thrown in his way.