C.

Vessel on which mounted.	Date of injury.	Class.	Number.	Charge.	Kind of powder.	Kind of projectile at time of explosion.	Place of fracture.	Shells lined or not.	Premature explosion of shells at time of injury.	Previous premature explosion of shells.	Total number of fires.	Cause of failure.	Remarks.
	1863.												
Patapsco	July 22	VIII-in.	6				Slight crack at muzzle			1		Probable explosion of shell.	
	1864.												
Pequot	Sept. 12	..do....	59	16 lbs. No. 7	Dupont	Parrott's P. F.	3 ft. 10 in. from muzzle		1	5	57	Explosion of shell	
Hunchback	June 19	100-pdr.	2	10 lbs. No. 7		Schenkl	23 in. from muzzle		1		220	..do	Projectiles not greased.
	1862.												
Westfield	Oct. 31	..do....	4	Doremus's compressed powder had been used.			Burst				138	Use of compressed powder.	Burst at breech and opened the band in several places; last 18 rounds compressed powder.
	1863.												
Mahaska		..do....	6	10 lbs. No. 7	Dupont	Schenkl shell.	36 in. from muzzle		1	4	350	Explosion of shell	From 6th to 18th fire four premature explosions.
	1862.												
Com. Barney.	Apr. 10	..do....	11				At muzzle		2			..do	At 6th and 11th rounds premature explosion broke muzzle both times.
	1864.												
Cimarron	Feb. 15	..do....	21				22½ in. from muzzle		1		118	..do	Schenkl shell had been in the gun 40 days.
	1863.												
Paul Jones	July 18	..do....	24				Burst				78	Insufficient data	Fracture from trunnion to rear of band.
	1864.												
Juniata	Dec. 25	..do....	29				Burst					..do	
Com. Perry	June 17	..do....	44	10 lbs. No. 7			Burst at breech				226	..do	Projectile not greased; band broken in 3 pieces. 1 killed, 5 wounded.
Quaker City		..do....	137										
Mackinaw	Dec. 26	..do....	141	10 lbs			Burst; breech blown out.				177	No details to show cause, other than failure of gun from want of endurance.	
Ticonderoga	Nov. 14	..do....	162	10 lbs		Parrott L. S.	Burst at muzzle		1		12	Explosion of shell	
Yantic	Dec. 24	..do....	166	10 lbs. No. 7	Dupont	Per. shell	Breech blown out				19	No details to show cause, other than failure of gun from want of endurance.	
Mendota	July 24	..do....	238	10 lbs. No. 7		Parrott shell.	Cracked from trunnion to band.				159	..do ..do	At the time of injury the shell exploded 2½ miles from gun. Hotch. percussion fuze projectiles greas'd.

C—Continued.

Vessel on which mounted.	Date of injury.	Class.	Number.	Charge.	Kind of powder.	Kind of projectile at time of explosion.	Place of fracture.	Shells lined or not.	Premature explosion of shells at time of injury.	Previous premature explosion of shells.	Total number of fires.	Cause of failure.	Remarks.
	1864.												
Ticonderoga	Dec. 24	100-pdr.	311	10 lbs. No. 7	Hazard.	Shrapnell					49	Want of endurance	Burst at 37th fire. 8 killed, 12 wounded.
Montgomery	May —	30-pdr.	11				Cracked at vent				47	Unknown	Crack from vent, transverse
Connecticut	May 3	..do....	35	3¾ lbs. Dorem's comp'd powder.		Unload'd shell	Cracked thro' breech; band also cracked.				168	Compressed powder	Projectiles greased.
Calypso	Nov. 8	..do....	59			Shot	Burst					Probably from striking of shot.	This gun had been struck on band by a shot or shell. Had been in Monticello. 20 rounds fired on Calypso.
Quaker City	Feb. 4	20-pdr.	92	Doremus's compressed.			18 in. muzzle off					Explosion of shell	At same exercise a premature explosion occurred in another 20-pounder.
Union	Jan. 16	..do....	240	2 lbs		Schenkl shell	Over seat of shell		1			..do	Navy time fuze. 8 rounds had been previously fired at the time of injury to the gun.

D.

Questions asked Mr. R. P. Parrott, with his answers thereto.

Question 1. How do you know in banding your guns that the band may not be shrunk on too tight; or, in other words, that the shrinkage may not be so great as to compress the cast-iron beneath it, thus changing its structure by upsetting or displacing the crystals, and consequently diminishing or destroying its strength?

Answer. In my opinion it is not sufficient to do so. Every gun is turned, and band bored to the same gauge—that is, the difference between the diameter of the band and gun, *cold*, before band is put on, is always equal to one-sixteenth of an inch to the foot.

Question 2. Has it not actually occurred in practice at the foundry that the band has been shrunk on too tight?

Answer. No. In the first 30-pounder, in putting on the band, the bore was found to be reduced about 0 inch .01. A similar result was also found with a 100-pounder gun. On this account I prefer to do the finishing out and rifling of the bore after banding the gun. I have, however, finished bores entirely before banding, as was the case with all the old army guns banded for experimental purposes.

Question 3. If it should occur, will it not, in your opinion, be sufficient to account for the blowing out of the breech of so many of your guns?

Answer. If too much compressed it might damage the gun; but I do not think that a *band of the thickness we use* could be put on with sufficient force to do so. I think that if any excess in shrinkage exists the band would adjust itself. It is always put on at a uniform heat—what is called "red in the dark." I do not think that in any *case* the bands have been put on so as to weaken the guns. The band is intended to guard against longitudinal splitting, which is the manner in which guns usually fail; and, of course, if this is prevented, the gun fails in the next weakest place. We banded a lot of old army guns, and all the banded guns stood well, whilst several of the unbanded ones failed.

Question 4. Have you any experimental results relative to the amount or difference of shrinkage in similar bands? Have you any means of securing uniformity?

Answer. I have no experimental results to determine shrinkage, beyond daily practice in making guns. They are all prepared with a uniform difference of one-sixteenth of an inch to the foot. This difference is absorbed partly by the extension of the band, and partly by compression of the cast-iron. The band would be of no use if its effect was not felt at the bore.

Question 5. Would any modification of the form of the band, or method of putting it on, make it more uniform in its action, or give it greater strength?

Answer. I do not think it would be well to change the form of the band. Of course a longer and heavier band would be stronger; but I do not think the difficulties lie in that direction. I should be unwilling to depend on the band for giving longitudinal strength. It has not much strength in that direction. Bands shrink more in the centre than at the ends, and consequently there can be no "nip" at those places. I do not think that there would be any difficulty in lengthening the forward part of the band a little; but I think it would do little or no good in obviating the accidents in that part, which are caused by the explosion of shells. I think it would be a confession of weakness in that direction, which does not exist.

Question 6. Have you ever tried to band one of your guns cold—that is, by simple pressure, hydrostatic or otherwise?

Answer. I have never tried banding cold, because I do not think it so good and certain as banding hot. It is fully practicable, but the abrasion of the iron, if the band were forced on with the same tension as I obtain by putting it on hot, would deprive it of the expected accuracy.

Question 7. What is your opinion of the premature explosion of shells, and its effect upon the gun?

Answer. In rifle cannon there are many new elements and things to learn, which have not yet been solved by direct experiment. I think that the premature explosion of shells is the great cause, if not almost the only cause, of the bursting of these guns. Sand or dirt would wedge the shell in the gun, the windage being so small, which I have no doubt caused a few guns to burst at Morris island.

Question 8. What security have you that the shells are not frequently crushed in the gun by the shock of the discharge, independently of any premature explosion of the powder in the shells? Have no unloaded shells ever been broken in the guns?

Answer. I have no evidence that the shells want strength, after the experience of many thousand fires, to stand the direct shock of the discharge. No unloaded shells, so far as I recollect, have ever broken in the guns. A great many unfilled shells have been fired, and none broken in the gun. One hollow shot did break; but in these projectiles the cavity is in the rear end, and the base not quite so strong as that of the shells. Bands of shells sometimes fly off, or break, but I do not think that this endangers the gun. I think that imperfect forces may have sometimes caused accidents, but I have no knowledge that the spelter rings have ever failed; though, as first made, they might have been a source of accident by flame getting down alongside the thread of fuze-hole into the shell. I have never known, after hundreds of fires, a fuze of any kind to be driven into the shell.

Question 9. What advantage do you expect to derive by an increasing twist in the rifling, over the regular or uniform twist? Is there any danger of wrenching off the muzzle by the "nip" the projectile receives at that point?

Answer. The principal advantages to be gained by the increasing twist are that the projectile takes the grooves more readily, that a higher rotation may be more easily obtained, and a stronger band used with the projectile. Bands of hard metal take the grooves fairly, which they would not do so well with a regular twist. If the groove is straight, the band enters it directly; but if curved, it has a tendency to ride over the grooves before complete expansion. No gun has ever broken at the muzzle, except by the premature explosion of a shell, within my knowledge.

Question 10. Could the weight of the projectile, and the charge of powder for the 100-pounder, be reduced, say to eighty pounds for the former and eight pounds for the latter, without materially diminishing the efficiency of the guns, and would not such reductions increase materially the endurance of the gun?

Answer. The short shell is a good projectile, and its use would not materially diminish the efficiency of the gun, while the endurance would certainly be increased by such reductions. The heavy shell, and ten-pound charge, give greater power, of course, and in cases where very long range and great shell power are required it may be necessary to use them, and they were designed for such purposes.

Question 11. Are Parrott shells cast with a hole in the base, for the purpose of more readily cleaning them? If so, by what means is the hole plugged, or closed?

Answer. The Parrott shells, above 60 pounders, are now cast with a hole in the base for steadying and centring the core in the flask. This hole affords facility for cleaning them, and is filled by a rivet, having a head, which effectually prevents them being driven into the shell; no instance of it having been driven in, in many hundred recovered after having been fired.

Question 12. May not premature explosions be caused by the crushing of shells in the bores of rifled guns, when the shells are porous?

Answer. I do not believe that premature explosions occur by the crushing of my shells within the bores. By the mode of casting them with the base downward, the liability to have porous metal at the base is removed. There is a solitary instance known to me of crushing a projectile within a gun (a hollow shot) in many thousands that have been fired.

Question 13. May not the imperfect adjustment of the fuze, the weakness of the spelter rings, or the imperfect manufacture of the time-fuze, be another cause of premature explosion?

Answer. I think that the original spelter ring (cast) did admit the probability of the gas entering the shell and exploding it; but those now made by being *cut*, and having a "shoulder," removes that probability. Imperfect fuzes, or imperfect adjustment of fuzes, would, of course, be liable to admit gases into a shell; but not more so in the Parrott than in any other shell.

I would respectfully submit to the board the following remarks as due to the importance of the subject and to my own position.

R. P. PARROTT.

WASHINGTON, *January* 16, 1865.

I am unable to find, on revising my correspondence, that I have failed to express, on all proper occasions, my opinion that most of the accidents to my guns have resulted from premature explosions of loaded shells taking place within the bore; although I believe that the sand blown, or otherwise accidentally carried into the guns, was an operating cause of bursting at some of the positions on Morris island.

But I do find that I have failed to give as decided an expression to my views as the importance of the subject required. The partial success of the trials made experimentally at this place to prevent premature explosions of shells, and the prospect that means entirely efficacious would soon be found, have induced me to look upon the difficulty as one which would shortly be remedied; and indeed I can say that it has been by the precautions now taken in firing loaded shells, which consist in lining the interior with a substance effectually covering the rough surface of the iron.

The great danger connected with these premature explosions is the injury which the gun may suffer from a single one, not, probably, fatal at the instant, but leaving the gun impaired, and causing its destruction under subsequent firing. Thus doubt and distrust are thrown upon the character of the guns, which burst without any cause assignable at the time of failure. I do not suppose that one or many shells could not explode in the bore of rifled cannon without serious danger to the gun, but have no doubt that it *might* be destroyed by a single explosion of a shell, and fear that irreparable damage would be caused by some one out of not a very large number of such accidental explosions.

I must say that the apprehensions I have expressed on this subject have been received with not a little doubt, and that I found most persons skeptical in regard to the *causes* of the explosion of shells in the bores of rifle cannon, and some as to the *danger* of such explosions, from whatever cause.

In referring the premature explosions of rifle shells to the friction or attrition to the powder contained in them, I do not, of course, deny that such explosions may sometimes be the result of defects of the shells or of the fuzes; but I do say that with ordinary care taken in respect to the inspection and other points, few, if any, of my shells will explode prematurely, except by the friction of the powder within; and that, if the interior surface of the shell is effectually covered, these explosions will cease.

What I state has been derived from actual trial, and is substantiated by facts officially noted in the proof and inspection of rifle guns.

It has often been asked why should the rifle shell explode prematurely more frequently than the spherical? It may be answered that if the rifle shell is charged with only the same quantity of powder as suffices to fill the spherical of the same calibre, explosions will rarely, if ever, take place. But as the rifle shells hold from three to four times as much powder as the spherical, the greater weight of powder, and that in a long column, must, by its reaction on the firing of the gun, press with much greater force, and by friction, either on the bottom or along the sides of the cavity of the shell, (if left rough as cast,) cause an explosion.

Such being the facts in respect to the explosions of rifle shells, and the means of preventing them, are they the causes of the unequal endurance and unlooked-for bursting of the guns?

I am unable to trace any connexion between the bursting of guns and the time of manufacture. The difficulties of procuring supplies of material and of labor have been unexampled within my experience; but I am not aware of any deterioration in the work, and feel confident that there has been none which can possibly account for the failure of guns, though the supposed necessity for assigning *some* cause, such as would be applicable to ordinary cannon, has led to the supposition that a gun which fails must have been bad from the beginning.

It would be as unjust to expect of me to foresee all the difficulties which may arise in the use of a system of ordnance so new as that of rifle cannon, as it would be presumptuous on my part to pretend to do it. I cannot think, however, that the merits which mine have exhibited are merely accidental, but believe that, from the uniformity of plan and the results with the extreme sizes, no intermediate class can be wrong in principle. I know of no possible cause, other than the explosion of the shells, which would account for the bursting of my guns *near the muzzle*. It has been known to happen the very first round fired from the gun after a very few, after some hundreds; and in the two 10-inch guns destroyed in this way—one after twenty-seven, and the other after one thousand and four fires in actual service. In a very few instances it has happened with the 30-pounder guns after quite moderate use, and in one it did not take place up to four thousand six hundred and fifteen fires.

Again, as to those peculiar modes of bursting, by which portions of the cast-iron are blown off forward of the wrought-iron reinforce, or near the trunnions, after leaving all the rest of the gun still connected together, how can it be supposed that these accidents, occurring after very irregular periods of service, can be the results of any uniform and natural action of the charge? The explosion of so much additional powder as the shells contain, though undoubtedly adding materially to the strain upon the gun, might not seriously damage it; but as the base of the shell will probably be in one piece, with the ring connected, and the sides of the projectile driven laterally against the bore, it is not surprising that partial jamming of these should take place, and try the gun to a dangerous point.

I have portions of the front or curved end of a shell burst in the gun, which are so marked as to show these fragments to have been violently forced into the grooves. Although I conceive that the failure of the guns at any part forward of the reinforce is certainly due to accidents occurring with the projectile, I cannot conclude that similar accidents might not cause the bursting of the gun in another part depending on the position of the shell at the time. In one instance, at Morris island, the base of the shell was actually found in the gun after the blowing off the breech.

In other cases the cast-iron may be so injured by previous explosions as, in bursting, to carry the band with it.

In conclusion, I would express my belief that I have correctly assigned the causes of the bursting of my heavy guns. I do not consider that they are less safe than ordinary cannon when subjected to the same regularity of strain.

On account of the very uncertain action of shells prematurely exploded in the bores of rifle guns, we are unable to determine the extent of injury, therefore, and cannot judge of the number of rounds which the guns can subsequently be expected to endure with safety.

At the same time I am satisfied that the means now used do effectually prevent the premature explosion of the shells, and thus remove the greatest cause of danger to the guns, it is due to the subject and to myself that I should advert to the firing of other projectiles than my own in my heavy guns. I cannot but think that many shells much inferior to those which the same makers would now supply have been used in my rifle guns, as well as many projectiles of an experimental kind.

The action of powder in the rifle takes place under circumstances very different from those existing with the spherical projectile, and, in my judgment, far too little consideration has been heretofore given to this point as connected with the durability of the guns.

R. P. PARROTT

NAVY DEPARTMENT,
Washington City, June 30, 1865.

SIR: In accordance with the order of the Navy Department of the 12th instant, reconvening the board on rifle ordnance, (adjourned on the 18th January last, to await results of certain experiments suggested by said board, which have since then been conducted by Captain Joseph F. Green, under the particular instructions of the Bureau of Ordnance, hereto appended, and marked 1,) we have the honor to state that we reassembled here on the 27th instant, after having conducted several additional experiments, and inspected the condition of the guns and projectiles used in the recent trials at Cold Spring, New York, under the orders of the Bureau of Ordnance.

It appears by the course of the experiments of Captain Green that one thousand (1,000) rounds were fired from each of three 100-pounder Parrott rifle guns of nearly similar weight, density, and specific gravity of metal, and cast nearly about the same period of time, which were selected by the chief of the Bureau of Ordnance, and assumed to fairly represent the guns of that class and calibre now in service. One-half or five hundred rounds from each gun were fired with full charges of ten pounds Hazard rifle powder and the long shell of 100 to 104 pounds weight, and the remaining five hundred rounds with eight pounds of same powder and shells of 80 pounds weight, by your special order to Captain Green.

From one of these guns (No. 242) 1,000 shells "coated" were fired.

From another of these guns (No. 256) 1,000 shells not coated were fired.

From another of these guns (No. 239) 1,000 shells brought to weight by sand and sawdust were fired, and with the following results in premature explosions:

Coated shells, (long,) 8 exploded within the bore; coated shells, (long,) 3 exploded without the bore; coated shells, (short,) 3 exploded within the bore; coated shells, (short,) 9 exploded without the bore; not coated, (long,) 7 exploded within the bore; not coated, (long,) 1 exploded without the bore; not coated, (short,) 4 exploded within the bore; not coated, (short,) 18 exploded without the bore; and the same number (viz: 1,000) were fired from No. 239, filled with sand and sawdust, for the purpose of testing the relative endurance of this class of gun, independent of premature explosion of shells, and also to test the resistance of the shells themselves to rupture under the effect of the charge of the gun.

Four thousand and eighty (4,080) Parrott shells of 20, 30, 60, 100-pounder

and VIII-inch calibre, have been fired since the 24th June, 1863, in the proof of navy guns at Cold Spring foundry. These shells were either not loaded or had only a blowing charge—in no instance did any one of the shells break. The army during the same time fired a larger number of shells with the same results.

From this it may be fairly inferred that the Parrott shells are never crushed or broken in the gun by the shock of the discharge.

Of all these premature explosions thirty-four (34) occurred with shells prepared with the navy metal-stock time fuze, and ten (10) with the navy time fuze, with the safety plugs removed, in Parrott's metal stocks, and eleven (11) with the Parrott percussion fuze.

The annexed table gives a synopsis of the report of Captain Green:

Date.	Gun No. 239, coated shell—No. of fires.	Gun No. 256, uncoated shell—No. of fires.	Premature explosions of shells		Enlargement of bore, in. from muzzle.	Enlargement of bore.	Temperature of air.	Kind of fuze—percussion.	Kind of fuze—time.	Remarks.
			In.	Out.						
1865.										
April 17	.....	3	1	.....	66¼	.009	51	1	....	
20	.....	35	1	.....	82½	12	60	1	....	
	.....	37	1	.....	87	9	55	1	....	
24	.....	80	1	.....	85½	5	45	.....	1	No fuze in P. stocks.
25	158	.....	.....	1	64½	8	67	1	....	
26	.....	166	1	.....	69½	12	65	1	....	
27	244	.....	1	....	58 to 115¾	5	82	.....	1	
28	294	.....	.....	1	.....	0	75	.....	1	
29	.....	278	.....	1	117	4	58	.....	1	
	332	.....	1	.....	112	4	70	.....	1	
May 8	343	.....	.....	1	39	4	70	.....	1	N. M. S. F. fuze.
15	403	.....	1	.....	71	8	76	1	....	
	415	.....	1	.....	.....	0	74	1	....	
16	.....	416	1	.....	44½	19	72	1	....	
	427	.....	1	.....	59½	4	80	.....	1	N. fuze in P. stocks.
	432	.....	1	....	35½ and 36	8	80½	.....	1	
	438	.....	1	.....	36½	5	79	.....	1	
17	.....	430	1	.....	64½	6	87	.....	1	
16	447	.....	1	.....	27	4	93	.....	1	
20	526	.....	.....	1	118¾	5	79	.....	1	N. M. S. F. fuze.
22	.....	552	.....	1	.....	.....	72	1	....	
	.....	575	1	.....	82½	5	67	1	....	
23	.....	599	1	....	81 and 93	7	66	.....	1	
25	681	.....	.....	.....	56	4	64	.....	1	Doubtful if in or out.
	.....	681	.....	1	118½	5	64	.....	1	
26	.....	755	1	.....	95½	2	74	1	....	
27	.....	777	.....	1	98	2	66	.....	1	
	.....	786	.....	1	100	5	64	.....	1	
	791	.....	.....	1	.....	0	62	.....	1	
	796	.....	1	.....	118	3	68	.....	1	
29	.....	789	.....	1	82	4	62	.....	1	
	.....	793	.....	1	40	6	62	.....	1	
30	.....	833	.....	.....	64	3	72	.....	1	Doubtful if in or out.
	.....	845	.....	1	.....	0	76	.....	1	

SYNOPSIS—Continued.

Date.	Gun No. 239, coated shell—No. of fires.	Gun No. 256, uncoated shell—No. of fires.	Premature explosions of shells. In.	Premature explosions of shells. Out.	Enlargement of bore, in. from muzzle.	Enlargement of bore.	Temperature of air.	Kind of fuze—percussion.	Kind of fuze—time.	Remarks.
1865.										
May 30	848	.....	.....	1	119	5	72	.....	1	
	.....	847	.....	1	80	.006	76	.....	1	
31	.....	880	.....	1	79	4	82	.....	1	
	.....	882	.....	1	.....	0	82	.....	1	
	881	.....	.....	1	113¾	5	78	.....	1	
	886	.....	.....	1	83	6	80	.....	1	
	891	.....	.....	1	.....	0	82	.....	1	
	892	.....	1	.....	115	6	82	.....	1	
	897	.....	1	.....	110	8	84	.....	1	
June 2	.....	891	.....	1	81	5	70	.....	1	
	.....	894	.....	1	68	8	70	.....	1	
	933	.....	.....	1	.....	0	70	.....	1	
	939	.....	.....	1	120¾	9	76	.....	1	
	947	.....	.....	1	.....	0	78	.....	1	
3	.....	926	.....	1	.....	0	80	.....	1	
	.....	939	.....	1	51	4	80	.....	1	
	.....	941	.....	1	114	6	80	.....	1	
	.....	950	.....	1	.....	0	80	.....	1	
5	.....	992	.....	1	114	4	74	.....	1	
	.....	993	1	.....	85½ and 87	5	74	.....	1	
	.....	996	.....	1	88	5	74	.....	1	

Gun No. 239:

From 1 to 200 rounds, Parrott shells, percussion case, from metal stock.
201 to 334 rounds, Parrott shells, percussion case, from New York.
335 to 401 rounds, ordnance shells, metal-stock fuzes.
402 to 476 rounds, Parrott shells, percussion case, from New York.
After 476 rounds, navy metal-stock fuzes.

Gun No. 256:

From 1 to 200 rounds, Parrott shells, percussion case, from metal stock.
201 to 333 rounds, Parrott shells, percussion case, from New York.
334 to 400 rounds, ordnance shells, percussion case, from New York.
401 to 475 rounds, Parrott shells, percussion case, from New York.
After 475 rounds, navy metal-stock fuzes.

In all the firing there were fired alternately twenty-five rounds from each gun fitted with percussion and time fuzes.

The board added the following experiments (by authority of the bureau) to the foregoing:

Fifty (50) rounds were fired with loaded long shells without fuzes, and securely plugged with wood and metal to exclude from the shells the flame of the discharge, of which number forty-three (43) exploded by concussion in striking the bank, at 1,760 yards distant, one (1) *in* the gun, six (6) failed to explode on striking the bank, and but one, therefore, exploded prematurely.

Five of these shells had one to five 6*d* nails placed in them to determine the effects of fragments of iron therein; the one having five nails exploded within the gun, and the remainder exploded on striking the bank at 1,760 yards distant. (Appendix A.)

The board also fired ten (10) loaded 100-pounder Parrott shells *without* fuzes, and with the fuze-holes open; seven of which exploded *outside* the muzzle, and none *inside*, and three by concussion on striking the bank, at 1,760 yards distant. (Appendix B.)

There have also been fired by the board several series, consisting, in all, of one hundred and eight 100-pounder shells, placed successively at 5, 10, 15, 20, up to 75 inches, from the full charge of 10 pounds of powder, (as per appendix,) which show that the position of the projectiles so placed lessen the recoil, and does not endanger the gun, while it does materially lessen the range of the projectiles.

It also fired ten 100-pounder Parrott long shells, loaded with the fuze-hole securely plugged, and the base-hole open, each of which (of course) exploded within the gun, near the seat of the charge, and were found in each instance, by "star gauge," to have produced an expansion of the bore equal to .028 of an inch. Recovered fragments of shells were also found to have been deeply indented by the grooves of the bore, into which they had been pressed, (as per appendix D,) thus showing the immense lateral pressure which an exploding shell exerts upon the walls of a gun, and its tendency to rupture it explosively when it occurs in discharging a gun. This tendency to rupture, we conceive, must always be reduced to certainty when the fragments of the broken shell wedge within the bore, as was the case on a recent occasion at Cold Spring with a 100-pounder fired for proof in presence of a member of this board. A fragment of the shell which burst this gun was recovered and inspected by all the members of the board, and its forward rounded end was indented by the rifling of the gun to the depth of .08 of an inch, clearly showing the great force with which it had been turned and jammed into the grooves.

In the foregoing trials all the precautions prescribed by the Bureau of Ordnance for loading rifle guns were carefully practiced, and impressions and measurements of vents and bores made at every twenty-five fires, and always after an explosion within the bore, to ascertain the commencement and progress of defects. And it further appears that all of these trial-guns have withstood the tests of the thousand fires and more to which they have been subjected, under rapid and, when circumstances permitted it, of very rapid firing, frequently averaging two to the minute, and seldom less than one to the minute, which is far in excess of action firing in ships-of-war.

Of the three guns used in these trials all were more or less scored or cracked around the lower part of the bore, while No. 239, that from which the sand-loaded shells were fired, was the most deeply so. This gun (by the authority of the Bureau of Ordnance) has been opened, and found to have four cracks, as per appendix annexed (E,) clearly demonstrating that the wrought-iron band materially aided in its endurance.

That this gun should have exhibited deeper cracks than those subjected to the straining effects of premature explosions of shells within the bores in addition to the strain of 1,000 fires, we attribute to a slight variableness in the qualities of the metals composing them, although their fabrication and composition, as exhibited by their recorded history, (appendix F,) and by mechanical tests, show them to be as exactly alike in every respect as it is possible to make them.

After due deliberation upon all the facts elicited by these experiments, and especially on the effect produced upon the three 100-pounder rifle Parrott guns used in this series of firing, with the former trials of this class of gun, where due care has always been observed in loading, we are of the opinion that the Parrott rifle guns of 6·4 inches calibre, and those of lesser calibres, are as reliable as any

guns at present within our reach, especially as the 100 pounder, as now used, with the short shell of 80 pounds, and 8 pounds of rifle powder, which charge and projectile have been verified in practice (upon the enemy since the report of the first attack upon Fort Fisher) as having been very accurate and free from accident, during a course of 15 hours' firing, as appears from the reports of Rear-Admiral Porter, of February 10 and 22, 1865. (Appendix G.)

The subject of wrought-iron guns, and other methods of manufacture, have not yet reached that point of perfection in this country as would justify our recommendation of their introduction into the naval service in substitution of the Parrott system—the Ames gun, heretofore recommended to the bureau for experiment, having failed to meet the expectations heretofore formed of them.

The method of Mr. Ames, although producing a gun of great strength, appears, from the results of the trials already made, to be deficient in certainty of welding, and no means exist of discovering or remedying these defective welds; two out of fifteen of these guns having burst explosively, in proof, by blowing out the breech.

When the board was at West Point foundry the members inspected a wrought-iron gun in progress of manufacture, which was very favorably considered, as the parts of which it is composed can be examined in all the stages of manufacture, and defective parts rejected or replaced. For this reason we recommend that a trial be made of a gun on this principle, with a view to test its endurance, under the supervision of ordnance officers.

With respect to foreign rifled cannon of wrought-iron, a semi-official notice has appeared, that the charge of the English naval 110-pounder has undergone a further reduction, and is now established at 10 pounds of powder, with a shell of 80 pounds, reducing this gun to the equivalent, in power, of the Parrott 100-pounder, so far as we have any information.

With regard to the accidents to the 100-pounder Parrott rifle-guns, which have elicited the convention of this board, the board can only say that where a failure to lubricate occurs, a residuum (of a slaty texture) of the powder forms so rapidly as to soon afford a means of jamming the projectile, and so completely, as to resemble the iron itself.

It is within the knowledge of the board that guns have been returned from service with their bores decreased by that cause, and where it was extremely difficult to detect a difference between the highly polished residuum and the iron itself, thus inducing error as to the actual condition of the bore.

As a point, having a direct bearing on the premature explosion of shells, we think it proper to here refer to some experiments conducted at Cold Spring since the first meeting of the board, by authority of the bureau, with a view to determine the effect produced on the powder charge of the shell in firing.

A 60 pounder shell (recovered) filled with powder, the fuze hole plugged with wood, was cut lengthwise, and exhibited perfectly the action that takes place at the moment of discharge while the shell is in the gun. The powder is driven to the base of the shell (or, strictly, the shell is driven upon the powder) with such violence as to compress it to the hardness of slate, the form of the grains almost entirely disappearing.

Fortunately, the driving in of the wood plug and sand, when the shell struck the bank, retained the powder almost entirely in the place it occupied after the first action of the charge of the gun, being only broken a little towards the fuze hole. The coating remained perfect between the hard mass of powder and the shell.

In shells recovered, where the powder had not been retained in its place by the driving in of the sand and plug on striking the bank, the powder was found completely pulverized.

This would, in our opinion, indicate that the heat generated by the compression of the powder in the shell by the shock of the discharge must be sufficient

to raise the temperature of the powder nearly to the explosive point, viz: 600° Fahrenheit, and that but little more would be needed to produce explosion, which may be effected by any slight abnormal cause, such as unusual friction, &c.

From the great number of premature explosions which occurred in shells fuzed with the navy metal-stock time fuzes, referred to, page 4, the board tried a number of unloaded shells fuzed in this manner, in which, on their being recovered, the safety plug was found in all cases at the bottom of the shell *flattened*, (having passed through an inch of the composition lining,) which may be another cause of premature explosions.

All of which is respectfully submitted.

J. S. MISSROON, *Commodore U. S. N.*
R. B. HITCHCOCK, *Commodore U. S. N.*
T. A. HUNT, *Commodore U. S. N.*
R. AULICK, *Commander U. S. N.*
WILLIAM N. JEFFERS, *Commander, U. S. N.*

Commander HENRY A. WISE,
Chief of Bureau of Ordnance, Washington, D. C

BUREAU OF EQUIPMENT AND RECRUITING.

NAVY DEPARTMENT, BUREAU OF EQUIPMENT AND RECRUITING.
November 6, 1865.

SIR: I have the honor to submit herewith the estimates for this bureau for the fiscal year ending 30th June, 1867. The cessation of hostilities and the consequent reduction of the naval forces will leave a surplus in the appropriations at the end of the present fiscal year, which enables the bureau to ask for comparatively small appropriations for the ensuing year.

An appropriation for fuel is not required. The contract price of coal the present fiscal year is $5 21 per ton, at Philadelphia, against $8 42 per ton last year. The cost of coal for the navy, including the incidental expenses of freight, demurrage, and payment of war risks for captured and destroyed coal vessels, during the past two years, is $11,452,155 49. Three coal vessels have been captured and destroyed by the enemy. The number of coal vessels, during the past two years lost, destroyed and never heard of, was twenty-one (21.)

Notwithstanding the extent of coast blockaded, the interruptions of winter, disturbances at the mines, want of vessels at times, and large quantity supplied to the army, no serious inconvenience has been experienced from want of coal. A coal depot has been established at St. Thomas, W. I. Supplies of coal for the use of the Brazil squadron will have to be sent from the United States. The commanding officer of the Brazil station has been directed to examine the Falkland islands with the view to establish a depot there for the supply of coal to vessels on that station and to those bound to the Pacific. Coal can be purchased on the Pacific station cheaper than to transport it, and the same probably with the East Indies. The bureau is not yet advised as to the necessity of a coal depot for the Mediterranean squadron.

The ropewalk has consumed during the last year 2,204 tons of Russian and other hemp, amounting to $971,442 67, and has supplied the greater part of cordage for the navy.

The rendezvous and recruiting stations have been reduced to correspond with the present requirements of the service. Reviving commerce is absorbing the seamen and firemen, and although at present there is no particular want of men, it may be that an increase of pay will be required to induce skilful firemen to enlist in the navy.

The general introduction of the use of wire rope in the navy for rigging in

duces me to refer to your consideration the propriety of establishing a manufactory of this rope at one of the navy yards.

Fraudulent withholding of bounties, and deceptions practiced upon enlisted men, especially in the west, have given rise to much complaint and dissatisfaction. A board of naval officers, recently convened at Cairo, Illinois, to investigate claims for bounty, have recommended reimbursements in many cases, which are being speedily settled, and it is believed that the amount of these claims will not exceed the amount of bounty money left by deserters and credited to the appropriation for bounty.

The number of men enlisted in the naval service from the 4th of March, 1861, to the 1st of May, 1865, was one hundred and eighteen thousand and forty-four, (118,044.)

Very respectfully, your obedient servant,

A. N. SMITH, *Chief of Bureau.*

Hon. GIDEON WELLES,
Secretary of the Navy

BUREAU OF CONSTRUCTION AND REPAIR.

NAVY DEPARTMENT, BUREAU OF CONSTRUCTION AND REPAIR,
November 3, 1856.

SIR: In compliance with your instructions, I have the honor herewith to enclose the estimates of the appropriations necessary for the civil purposes of this bureau.

I would respectfully state that, in consequence of the prompt reduction of expenditures resulting from the close of the war, no further appropriations for construction and repairs will be required, as there will remain an unexpended balance amply sufficient for the fiscal year ending June 30, 1867.

A considerable number of the vessels on the navy list are unsuitable for foreign war, should the country be engaged in one; and to supply this deficiency, new classes of steamers adapted to that purpose have been authorized and are in course of construction, for all of which the steam machinery is under contract and in progress of manufacture. Nine vessels of these classes are now launched, and there are thirty-two others of similar classes, as well as four wooden vessels, to be iron-clad, that have not been launched, but are in various stages of construction. It is obligatory on the part of the government to provide these vessels, on account of the contractors for their machinery; but they will not be pressed to speedy completion, and those vessels for which the machinery is being manufactured in the navy yards will be still more retarded, giving an opportunity for selecting more seasoned materials.

The appropriations that have been made from year to year have been strictly limited to the maintenance of the vessels in commission, and to those actually building, and there has been no surplus fund from which a stock of materials for future use could be provided; so that our vessels, particularly those built within the last eight or ten years, have been mostly made with unseasoned timber. The supply of yellow pine in the navy yards is quite exhausted, and the white oak is but little else than the refuse of the past years. Of white-oak knees we have no supply, as they are procured with much difficulty, and at exorbitant prices. If means are not provided for the manufacture of these knees, as has been already suggested, the work on some of the vessels must be suspended.

Our navy yards are liberally provided with shops and storehouses for all the other bureaus, but the timber sheds and shops connected with and necessary for building ships are far from adequate to the wants of the navy which we now have and will be compelled hereafter to maintain.

Vessels built of timber, and particularly of unseasoned timber, much of which we are compelled to use, will, when plated with iron, soon decay, and they cannot be repaired at a reasonable cost; and notwithstanding some of the disadvantages that attend iron vessels, ultimate economy will lead to their adoption, more especially for the heavily armored vessels intended for sea service.

There are many purposes to which vessels of wood are adapted, and they will form no inconsiderable part of our navy for years to come; and for them it is proper that materials should be collected and stored, so that in case of a foreign war we may not be found unprepared.

It is earnestly recommended that preparations be made at some suitable place for the construction of iron vessels, as it will require several years for the proper tools and appliances to be gradually collected.

The tools, machinery, and appliances used by the Bureau of Construction and Repair in building and repairing ships in the navy yards are nominally provided by another bureau; and it is submitted that hereafter all those articles actually used for the purposes of the construction and repair of vessels be estimated for and provided by this bureau. The estimates for these objects have always been insufficient, and the deficiency has been supplied from the appropriations for this bureau, and thus the estimates and expenses of one bureau appear light, because a considerable portion of the expenses are paid by another.

It is again respectfully suggested that the corps of naval constructors be placed by law in respectable connexion with the navy, there being no class of persons employed in the naval service on whom a greater responsibility is thrown, or who influence the expenditure of so large a sum of money, and on whose skill the efficiency of the navy more depends.

I would again respectfully recommend an increase of compensation to the clerks employed in this bureau,

Very respectfully, your obedient servant,

JOHN LENTHALL, *Chief of Bureau.*

Hon. GIDEON WELLES, *Secretary of the Navy.*

BUREAU OF STEAM ENGINEERING.

NAVY DEPARTMENT, BUREAU OF STEAM ENGINEERING,
October 12, 1865.

SIR: I have the honor to submit to the department the following remarks on the present condition of the operations of this bureau:

Of new work, there was contracted for in October and November of 1863 twenty pairs of screw engines, with cylinders of sixty inches diameter and three feet stroke of piston, all of which were to have been completed within eighteen months from date of contract. None of them have been erected in a vessel at this date, with the exception of the pair for the United States steamer Pensacola, which will be ready for steam in about six weeks; of the remainder, about six are ready for erection in the vessels, and the balance are in every stage of construction, from the rough casting to erection in the shop.

The screw engines of the United States steamer Madawaska, designed and contracted for by Mr. John Ericsson, are now being erected in the vessel. They have cylinders of 100 inches diameter, with a stroke of piston of four feet.

Of the four pairs of screw-geared engines, contracted for in September and October, 1863, with cylinders of 100 inches diameter and a stroke of piston of four feet, none are completed. They were to have been finished in twelve months from date of contract. They are in every stage of construction, from the rough castings to erection in the shop.

The screw engines of the wooden turreted vessels, Passaconomy, Quinsigamond, Kalamazoo, and Shackamaxon, are in progress of construction, and may be considered about half finished. They were contracted for in December, 1863, and are built from the designs of Mr. John Baird, who is employed by the contractors for that purpose, they being responsible for their successful operation.

New boilers are also in progress of construction for the Lancaster, Iroquois, Minnesota, three screw gunboats, and three paddle-wheel steamers of the Paul Jones class.

The above is all the contract work remaining unfinished.

The new work in progress at the navy yards consists of two pairs of screw gunboat engines, with cylinders of thirty-six inches diameter and three feet stroke of piston, at the Kittery navy yard; four pairs of screw engines, with cylinders of fifty inches diameter and three feet six inches stroke of piston, at the Boston navy yard; four pairs of screw engines, with cylinders of fifty inches diameter and three feet six inches stroke of piston, at the New York navy yard; and at the Washington navy yard, one pair of screw-geared engines, with cylinders of 100 inches diameter and four feet stroke of piston, and one pair of screw engines, with cylinders of sixty inches diameter and three feet stroke of piston. This latter pair of engines is to replace the present ones in the United States steamer Richmond, condemned by a board of survey.

The new work at the navy yards is being very slowly prosecuted. The repairs of the machinery of vessels in commission require a certain number of workmen to be retained permanently, but as the amount of repairs fluctuate from time to time, it is judicious economy to have new work ready on which the men can be employed during the intervals of repairs.

The experiments which are being made at the New York navy yard by the board of civilian experts, under the direction of the department, on a horizontal fire-tube boiler and a vertical water-tube boiler, of the best proportions which practice has thus far determined, both having the tubes arranged above the furnaces to ascertain their relative efficiency for the naval service, are rapidly progressing. A very great number of experiments has already been made, and the results are of the most valuable character. The board has not confined itself to simply ascertaining the relative evaporative efficiency of the two types of boilers as constructed, but have modified their proportions in every possible way to determine the effect of such modification. It has also extended its inquiries into the effect of different modes of managing the fires, of different rates of combustion, of different forms and locations of steam jets in the smoke-pipe, of different proportions of heating to grate surface, and of calorimeter to grate surface. In brief, it aims, by means of these experiments, to treat the subject in an exhaustive manner, resolving in a purely practical way all the questions connected with the generation of steam in marine boilers of the two types experimented on, and which are conceded to be the only two proper for the naval service.

It will be some time before these experiments can be finished, and a final report rendered; but it is believed that the value of the results not only to the navy, but to the whole world, will be so great as to warrant any amount of time, labor, and money that may be required to complete them in a thorough and unexceptionable manner, for the efficiency of the boiler is the real basis of all successful steam-engineering.

The experiments directed by Congress for ascertaining, by practical means, the relative economic efficiency of steam used in a steam engine with different measures of expansion, are making fair progress; but considerable time must necessarily elapse before they can be completed and a report rendered. They are being made by a board composed of gentlemen unconnected with the navy, and of the highest scientific and practical talent. The apparatus used is so admirably adapted for the purpose, that it is believed the results will be hypercritically accurate. It was devised by Mr. Horatio Allen, the president of the board, and the experiments are conducted by him at the "Novelty Works," New York, assisted by a number of assistant engineers of the navy. The determination of this question is the solution of the most important problem in steam-engineering, and really underlies the whole industrial interest of the world. Steam power is so extensively used for abridging manual labor, and for producing effects to which no amount of manual labor would be competent, that it may be said to be the basis of modern society and civilization; and everything which cheapens its cost, adds to the comfort and development of the whole human race. If an important economy of fuel can be obtained by high rates of expansion, it is of the utmost consequence to the navy and mankind to know both the fact and the amount; if no considerable economy of fuel can be thus obtained, it is none the less necessary to know it, in order that the steam-engine may be simplified, and its cost reduced.

The solution of this problem in a manner so complete as to produce conviction in all is tedious, laborious, and expensive. It cannot progress rapidly, nor be done cheaply, and to those causes must be ascribed the fact that no experiments of the kind have ever before been instituted. It is believed the present experiments will give an answer to every question that can be put on the subject. They will be made with both high and low pressure steam, with steam saturated and with steam superheated, with steam used with condensation and without condensation, and with different kinds of valves. This brief enumeration will show the extent and completeness to which it is designed to carry them, and from it will easily be understood the labor and time involved.

While the above described special experiments on boilers and on the expansion of steam are in progress, the bureau has lost no opportunity in experimenting largely in the same direction with the boilers and engines of such of the naval steamers as could be used for the purpose without interfering with their regular service.

These experiments have the great advantage of being made on the largest scale, and under the exact conditions of actual practice. They have extended to almost every type of marine boiler, and to every variety of boiler proportion, kind of coal, and manner of consuming it; also, to a great variety of steam-engines and valve gear, using steam with widely varying rates of expansion, with great differences of pressure, and in both the saturated and superheated states. A complete record of these experiments will be found published in two quarto volumes, with the title of "Experimental Researches in Steam Engineering." The bureau has been greatly governed in designing steam machinery by the practical information thus obtained, and the results given by that machinery in competition with the numerous machinery designed by others for the naval service has been such as to fully sustain the soundness of the principles deduced from the experiments.

The accommodations at the navy yards for the repairs and construction of steam machinery are not sufficient for the requirements of the service. There is a want of proper facilities for moving large masses about the yard and for placing them on board vessels. The accommodations for engineer's stores are very deficient, so much so that no proper storage can be made, or account kept of them, and great inconvenience, deterioration, and delays result. The necessity for storehouses and special storekeepers is pressing; and it is respectfully suggested whether, in view of the very limited space occupied by the navy yards, and of the enormous increase in the engineer department of the yards, caused by the transformation of a sailing into a steam navy, the space and building now appropriated to the paymaster's department could not, with great advantage, be transferred to the engineer department. All that is wanted for the paymaster's stores is ordinary storehouses, and they can be provided outside the yards, as well as inside. The articles are neither heavy nor bulky, and are easily transported. There is not only not the slightest necessity for