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# THE ROYAL ARSENAL

ITS BACKGROUND, ORIGIN, AND  
SUBSEQUENT HISTORY

VOLUME II

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call before them such merchants and others who were known to be able to supply the goods required and to select the best offer. Articles when received and passed by the Surveyor-General were to be placed in store for future issue. Departmental wants were to be drawn from store and not from the open market in order to prevent a possible price ring against the government.

The Board in this respect carried out the duties which at its demise devolved upon the Director of Army Contracts, some of which in turn were transferred to the Director of Contracts, Ministry of Supply, when that Ministry was formed in 1939. These have now reverted to the Director of Army Contracts.

#### *Manufacturing Departments*

Since the Board was responsible for the provision of munitions, stores bought under contract had to be supplemented by those made by direct manufacture. The Board therefore had charge of the government factories. These were originally eight in number, situated in six localities; the powder mills at Faversham, Ballingcollig and Waltham Abbey; the small arm establishments at Lewisham and Enfield Lock; and the manufacturing factories at Woolwich. Early in the nineteenth century Faversham, Ballingcollig and Lewisham were abandoned, leaving only five factories to be administered by the Board during the last twenty odd years of its existence. These five were in 1855 handed over to the War Department and became known ultimately as the Royal Ordnance Factories. They were the Royal Gunpowder Factory, Waltham Abbey; the Royal Small Arms Factory, Enfield Lock; and the Royal Laboratory, the Royal Gun Factory and the Royal Carriage Department in the Royal Arsenal. It is the latter three which form the subject of this book.

The Ordnance did not manufacture gunpowder till 1759. Prior to that date supplies were obtained from the East India Company. On 11 May 1759, a warrant was issued<sup>20</sup> for purchasing the powder mills at Faversham from Mr Benjamin Price for the sum of £5,682. 1s. 7d. and the deed of conveyance for the factory was dated 16 May 1759.<sup>21</sup> A few months later another warrant under date 17 November 1759, set up the establishment at the Faversham Powder Mills. It was a very modest affair, the annual expenditure being only £398. 5s. od.<sup>22</sup>

Its details were as follows:

Storekeeper	£100 p.a.
Master Worker	£ 90 p.a.
Clerk of the Cheque	£ 54. 15s. od. p.a.
Extra Clerk	£ 36. 10s. od. p.a.
2 Carpenters (12s. p.w. each)	£ 62. 8s. od. p.a.
Hoy Master (12s. p.w.)	£ 31. 4s. od. p.a.
Hoy Master's Mate (9s. p.w.)	£ 23. 8s. od. p.a.

The powder mills at Faversham were sold in 1825, as on Friday 25 November of that year 'the Royal Powder Mills and Ordnance Lands and Premises at Faversham' came under the hammer at the Ship Hotel,

<sup>20</sup> P.R.O/WO/55/359. Warrants and Orders in Council.

<sup>21</sup> P.R.O/WO/55/360. Warrants and Orders in Council.

<sup>22</sup> P.R.O/WO/55/360. Warrants and Orders in Council.

Faversham, Messrs Stevens and Brenchley of 36 Old Jewry, London, being the auctioneers. The property, divided into 15 lots, was purchased by Messrs John Hall and Sons, who carried on the works for eighty years. They were then absorbed by Messrs Curtis and Harvey Ltd., who gave way to Nobels Ltd. and eventually to Imperial Chemical Industries Ltd.<sup>23</sup> Apparently, a certain portion of the Ordnance lands at Faversham, known as the 'Quarsh Works' comprising 86 acres, 3 roods and 4 perches, remained unsold, and this property was leased to Messrs John Hall and Sons in 1834.<sup>24</sup> Eventually, with Treasury approval, all the remaining lands belonging to the Board of Ordnance at Faversham, were sold to Messrs John Hall and Sons, the arrangements for the sale being concluded by 9 June 1854.<sup>25</sup>

Ballingcollig was sold in 1834.

Powder mills had existed at Waltham Abbey since the sixteenth century, and these were purchased by the Crown from Mr Walton on 18 October 1787 for the sum of £10,000. In the past they had had their ups and downs, their periods of calm and disaster. Thomas Fuller, who was connected with the living in 1641, says:<sup>26</sup>

'It is questionable whether the making of gunpowder be more profitable or more dangerous; the mills in my parish have been five times blown up in these seven years, but blessed be God, without the loss of anyone man's life.'

and from the Waltham Abbey parish register it appears that Thomas Guttridge and Edward Simons were 'killed with a powder mill' on 4 October 1665, and that Peter Bennet met his death by an explosion on 27 November 1720. Farmer<sup>27</sup> gives a view of the factory in 1735, then the property of John Walton, showing 22 buildings among which are certain stamping and horse mills. There were, in addition, a saltpetre refinery, a charging house, a composition house, a corning and glazing engine and several drying stoves. The horse mill was probably akin to the modern incorporating mill. Although horses continued to be used to help the labours and exertions of man, they were not the only form of motive power; water, in addition, was employed to drive the antiquated machinery, and in 1814 this prime mover eventually superseded the horse. When Government purchased the property it must have been in a shocking state of repair, as a further sum of £7,988. 18s. 8½d. had to be spent in putting the buildings in a serviceable condition. This necessitated the presence of builders and workmen for 18 months and completely prevented manufacture from proceeding during that period. The following letter shows production to have commenced in February 1789:

'Royal Powder Mills.  
6 Feb. 1789.

Sir,

We have (by a Messenger) received your directions to set the Mills to work, we beg leave to acquaint you that we mean to begin on Monday

<sup>23</sup> *Archaeologia Cantiana*, vol. LX, 1947, p. 66.

<sup>24</sup> P.R.O/WO/47/1663, p. 10,207.

<sup>25</sup> *Engineer Papers*, P.R.O/WO/55/764.

<sup>26</sup> *Worthies of England* 1662, vol. 1, p. 338, Thomas Fuller.

<sup>27</sup> *History of Waltham Abbey*, 1735, J. F. Farmer.

morning as it will take all day tomorrow to provide the horses for grinding the composition and various other small matters which will be necessary to adjust before we begin.

We beg to inform you that we have your directions of 8 July on the Mode of Working; but you took back the paper which you gave the store-keeper wherein the manner of marking the barrels was inserted. We likewise beg to acquaint you that we have no cooper which Mr. Forman intimated would be sent from the Laboratory.

We have no mode of drying mill samples at present as the Cylinder is not set in the Proof House, neither does Mr Sutton know how it is to be fixed, therefore the Master Worker thinks to work 35 and 32 pound charges until the samples can be tried and proved that some conclusion may be drawn on working 38 pound charges.

We are, Sir,  
Your most obedient servants,  
Jas Wright      Jno Clowdesly

Major Congreve'

Misfortune dogged the management's footsteps as six days later one of the mills blew up.

They were also not free from disciplinary troubles as witnessed by this second letter:

'Royal Powder Mills,  
Waltham Abbey.  
22 June 1789.

My Lord Duke and Rt Honble  
and Honble Gent<sup>m</sup>.

We beg to report that Donald M'Lean a Warder at this place has been obliged to quit these works on account of the treatment of a young woman servant to the Clerk of the Cheque, by forcing her into one of the Watch Houses and there cruelly treating and injuring her.

We beg to represent that it is not necessary to enter another labourer because the labourer you was pleased to order to be entered in the room of David Bonner will be spared from the Refining House until the saltpetre is ordered to be melted.

We are,  
My Lord Duke and Rt. Honble and Hoble gent<sup>m</sup>  
Your Most Obedient and Humble Servants,  
Jas Wright      Jno Clowdesly

His Grace the Master General and Board'

The land on which the factory stood, however, was not bought till 1795 as in September of that year Major (afterwards Sir William) Congreve—Comptroller, Royal Laboratory—was directed by the Duke of Richmond, Master-General of the Ordnance, to engage 14 or 15 of the best of Mr Walton's workmen to continue in the factory as government servants. When the Board of Ordnance acquired the mills on behalf of the Crown, the establishment of officials with their rates of pay considered

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necessary to run the factory was laid down on 16 February 1789 as follows:

Respective Officers (storekeeper)	1 at £150 p.a.	
(clerk of the check)	1 at £90 p.a.	
Clerks	1 at £70 p.a.	
Master Worker	1 at £60 p.a.	
Surgeon	1 at £90 p.a.	
Mixing House Man	1 at £54. 15s. p.a.	
Labourers for the Mixing House	1 at 21s. p.w.	
Millwright	3 at 10s. 6d. p.w.	
Carpenter	1 at 21s. p.w.	
Cooper	1 at 17s. 6d. p.w.	
Storehouse man	1 at 17s. 6d. p.w.	
Storeman	1 at 14s. p.w.	
Millman	2 at 10s. p.w.	
Labourers for Corning House and Glazing Engine	12 at 12s. p.w.	
Saltpetre Mill Men	11 at 10s. 6d. p.w.	
Charcoal and Sulphur Mill Men	2 at 10s. 6d. p.w.	
Dusting House Men	2 at 10s. 6d. p.w.	
Office Keeper	2 at 10s. 6d. p.w.	
Barge Man	1 at 12s. p.w.	
Barge Man	1 at 10s. 6d. p.w.	
Labourers {	To make Powder Barrels	1 at 9s. p.w.
	To set and draw, stoves, weigh powder, &c.	1 at 10s. 6d. p.w.
	To assist the Bargeman to cut weeds	3 at 10s. 6d. p.w.
Charcoal Burners	3 at 10s. 6d. p.w.	
Warders	2 at 10s. 6d. p.w.	
Watchmen	3 at 10s. 6d. p.w.	
Horsekeeper (to be found by the Contractor)	6 at 1s. per night	
Horses for Charcoal, Sulphur and Saltpetre Mills and a Corning Engine	1 at 8s. p.w.	
Refiner	1 at 17s. 6d. p.w.	
Labourers to refine Saltpetre	6 at 10s. 6d. p.w.	

APPRENTICES

To the Master Worker	1 at 7s. p.w.
To the refiner of Saltpetre	1 at 7s. p.w.
To the Mixing House Man	1 at 7s. p.w.
To the Millwrights	1 at 7s. p.w.
To the Carpenter	1 at 7s. p.w.

EXTRA ALLOWANCE TO OFFICERS, &C

Storekeeper, for House rent, Coals and Candles	£25 p.a.
Clerk of the Cheque, for House rent, Coals and Candles	£20 p.a.

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Clerks, for House rent, Coals and Candles	£15 p.a.
Master Worker. In lieu of Coals and Candles	£5. 5s. p.a.
Refiner of Saltpetre	£4. 4s. p.a.
Extra pay to the Stovemen for night work	2 at 6d. per night
Extra pay to the Millmen for night work	12 at 3d. per night
Extra pay to the Bargemen when employed in the Barge and absent from the Mills	2 at 1s. 6d. p.d.
Extra pay to Charcoal Burners when in the Country charring wood	Foreman 1s. 6d. p.d. Assistant 1s. p.d.

In 1791 double horse mills are mentioned; in 1796 powder appears to have been sent regularly to Purfleet for proof; in 1801 the horse corning house exploded killing 9 men and 4 horses; and in 1804 six horse mills were erected on Horse Mill Island. Notwithstanding these vicissitudes the Royal Mills were in 1804 turning out 20,000 barrels, i.e. about 800 tons of powder per annum. As a sequel to the explosion of 1801 the Board of Ordnance asked a Committee of the Royal Society to investigate and report upon the possibility of danger arising from electrical excitation caused by walking or rolling barrels on leather covered floors or by the use of silk covered dusting reels. The Committee reported on 23 July 1801 that no danger could arise from such causes. In 1811, another disastrous explosion occurred in a presshouse, corning house and reel house situated in the Lower Island Works which caused much loss of life and property. This led to a recommendation by the engineers entrusted with the work of reconstruction that Bramah presses should in future be used for pressing powder and that a machine be devised for breaking the pressed cake more gradually. This no doubt led to the invention of the granulating machine by Sir William Congreve, as in 1816 one of these machines was in operation in the Lower Island Works. In 1816 too, the present saltpetre refining house was built, though to the casual eye it looks like a relic from the Middle Ages; also, as before mentioned, water power completely eclipsed that of the horse as a driving force for the mills.

In 1829 three officers, Colonel J. Jones, C.B., Royal Engineers, Colonel Sir Hugh S. Frazer, K.C.B., Royal Artillery and Major Thomas Moody, Royal Engineers, were formed into a committee to report on the Ordnance Works at Waltham Abbey and to propose any improvements and arrangements necessary to give the Royal Manufactory of Gunpowder its utmost efficiency. The following are some extracts from the Committee's subsequent report:

'The water power vested in the Board of Ordnance, and allotted to the purposes of manufacturing gunpowder consists of rather more than four miles of the original channels of the River Lea commencing at the fall of the stream of the King's Weir fall above, and extending to Black Ditch below the town.

The three falls of water are:

Paynes Island averaging about 1 ft. 6 ins. in depth.

One at Upper Mill Head averaging about 6 ft. in depth.

One at Lower Mill Head     "     "     2 ft. 10 ins. in depth.



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The two latter falls only being available for the purposes of the manufactory.

This body of water is often insufficient to work the whole of the machinery (owing to frost or drought), so that on an average full working days should not be taken at more than 280 in a year. Adopting the conventional term used among mechanics of a *Horsepower* for the standard of composition it is calculated that when the manufactory was at its greatest height of efficiency in 1814, the stream did actually operate to the power of 79 horses, viz:

On 15 gunpowder mills equal to 60 horses power.

On 3 corning houses equal to 12 horses power.

On 1 glazing mill equal to 5 horses power.

On 1 dusting mill equal to 2 horses power.

The above mentioned machinery worked by water was in 1814 aided by five composition mills and seven mills for working the dust drawn by the animal labour of 50 horses on an average. These two powers united being made to work night and day, Sundays included, and very extraordinary exertions being used by the workmen, the produce of the manufactory was that year raised to 25,000 barrels. The animal labour being deducted from this calculation, it would appear to be equal to the manufacture of more than 15,000 barrels annually.

At the conclusion of the late war, two water mills deemed unserviceable were taken down, as were also nine mills and two corning houses worked by horse power, and the material was sold. None of the five horse composition mills still existing is in a state to be set to work. Further since peace the limited expenditure authorized by the Board for repairs has very prudently and judiciously been applied by the executive officer to keeping the more serviceable machinery of each nature of operation so far efficient as to ensure some power of reviving the manufacture whenever the demands of the Service shall require it, and at this period the only machinery in a condition to work consists of:

5 gunpowder mills in a state to do the work of 4 efficient mills.

1 gunpowder mill fitted up as a composition mill.

Half a gunpowder mill fitted up to break mill cake.

3 corning houses.

1 glazing mill.

1 dusting mill.

The gunpowder mills, however, are all much worn and very unstable and some of them are erected on very defective principles. The establishment of workmen is altogether unequal to the full employment of the machinery so that the extreme annual produce to be obtained from the manufactory in its present state cannot be calculated higher than 3,500 barrels.

A new mill head is recommended to be excavated in Queen's Mead.

Since no arrangement for charring wood exists at Waltham Abbey, and, as this is very important, it is recommended that the cylinders at Faversham should be removed to Waltham Abbey.

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Storehouses on Horse Mill Island (originally a stable) must be considered a crippled building owing to its having been injudiciously loaded with sulphur.

The Committee recommended that:

1. All mills newly erected should be placed angularly and not opposite to each other on their respective banks of the Mill Head.
2. Water wheels and shafts should be made of cast iron instead of wood.
3. Powder should be glazed in barrels instead of reels.
4. Self-registering thermometers should be introduced into the drying room to indicate to the Superintendent on each inspection the greatest and lowest degree of heat that has been applied to dry the powder.
5. Steam stoves rather than Gloner stoves should be approved.
6. As the duties of the several persons employed in responsible situations have never been defined on any general principle of subordination or mutual co-operation, and at this time the chief of each division or branch of the manufactory regulates his practice on partial instructions or established usage and the Service has not the benefit of perfect unit and accord, some person under the title of Superintendent and living on the spot should have such a general control over all the working departments of the Manufactory as to be able to continue and direct their efforts at all times and under all circumstances to the advancement of the public interests, provided each Master Worker or Refiner by means of instructions from the Board specifying his responsibility and charge over his particular department, be protected from all possibility of wanton innovation or vexatious interference on the part of the Superintendent.

In 1843 a further terrible explosion in two corning houses, a press house and a reel house shook the factory and caused the loss of seven lives. It originated in a building where one of the old corning machines with shaking frames was at work. No machine of this description has been used at Waltham since, and soon after the accident, Professor Faraday and Colonel Cockburn, Director of the Royal Laboratory, visited the factory to report on various matters connected with the safety of the buildings. Twelve years afterwards the factory was transferred to the War Department.

Faversham, Ballingcollig and Waltham Abbey were under the control of an artillery officer styled in 1811 the *Inspector of the Manufactory*.

As has already been stated, the connection of the Ordnance with the small arms trade dates from June 1631. This trade, originally carried out in London, moved to Birmingham in the eighteenth century or rather then commenced there *de novo*. As a result, the Office of Ordnance established a proof-house in that town to facilitate supplies. The business of the small arms department at the Tower was carried on by civilians deputed by the Surveyor-General and the Principal Storekeeper, assisted as necessary by the master furbisher. They received their orders, either directly from the Master-General and the Board, or through the Principal Storekeeper. Such means of supply were totally inadequate for the country's requirements and, therefore, by the end of the eighteenth century the armed forces of the Crown depended for their complement of arms primarily upon the trade. When such a source proved insufficient, recourse

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## THE WARREN DURING NAPOLEONIC TIMES

18 July 1804. The C.R.E. is ordered to report on the present position regarding the new proof-butts at Woolwich, and to state what portion still remains to be completed. He is to proceed on the work with all dispatch and report the probable date of completion. The Board wish all proof to be carried out at the new butts as soon as possible.<sup>100</sup>

27 July 1804. A pump is to be installed in the new lead rooms of the Royal Laboratory so that water may be available for cooling the bullet moulds.<sup>101</sup>

8 August 1804. The footpath between the barracks and the Warren to be paved.<sup>102</sup>

17 August 1804. Twenty-one foremen of artificers at 5s. per day and two foremen of labourers at 3s. 6d. per day to be established at the Royal Carriage Department from 1 August 1804. Pay not to be increased when these foremen attend the extra daily work of the artificers in the Warren.<sup>103</sup>

17 August 1804. A well to be sunk in the storekeeper's garden.<sup>104</sup>

17 September 1804. Repairs in the Royal Laboratory to be carried out as soon as possible.<sup>105</sup>

14 November 1804. Captain Dickinson allowed the services of a labourer for six months, after which time he shall report whether he still require him.<sup>106</sup>

16 November 1804. The Blue storehouses in the Warren are to be handed over to the Respective Officers as soon as they are vacated by the Field Train which is to move to the Barrack Field. Two ranges of sheds are to be erected in the Barrack Field.<sup>107</sup>

21 December 1804. The pay of the labourer who was killed by the explosion of a shell in the Royal Laboratory is to be continued to his widow until further orders. The paymaster is to defray the man's funeral expenses. The Comptroller R.L. is to inform the Boards of the man's name.<sup>108</sup>

24 December 1804. The paymaster is to pay such charges for beer at Woolwich as Captain Dickinson shall certify to have been given to the men who are employed in loading the transports with Ordnance stores which have been prepared for foreign service.<sup>109</sup>

The year 1805 was a notable year in the life of the Warren. It was the year in which its name was changed to the *Royal Arsenal*, and one which saw the second disastrous fire, the first application of steam to manufacturing processes, the placing of fire fighting on a better footing, the inauguration of rocket manufacture, and the beginning of the great storehouse development.<sup>110</sup>

<sup>100</sup> Extracts of Minutes, Series II, PRO/WO/47/2,579, p. 2,019.

<sup>101</sup> Extracts of Minutes, Series II, PRO/WO/47/2,579, p. 2,090.

<sup>102</sup> Extracts of Minutes, Series II, PRO/WO/47/2,580, p. 2,202.

<sup>103</sup> Extracts of Minutes, Series II, PRO/WO/47/2,580, p. 2,287.

<sup>104</sup> Extracts of Minutes, Series II, PRO/WO/47/2,580, p. 2,292.

<sup>105</sup> Extracts of Minutes, Series II, PRO/WO/47/2,580, p. 2,521.

<sup>106</sup> Extracts of Minutes, Series II, PRO/WO/47/2,581, p. 3,206.

<sup>107</sup> Extracts of Minutes, Series II, PRO/WO/47/2,581, p. 3,230.

<sup>108</sup> Extracts of Minutes, Series II, PRO/WO/47/2,581, p. 3,646.

<sup>109</sup> Extracts of Minutes, Series II, PRO/WO/47/2,581, p. 3,674.

<sup>110</sup> The Warren in the seventeenth century was called 'Tower Place'.

## ADOLESCENCE

It might be said to have commenced a new era.

On 29 January 1805 orders were issued to construct a mortar platform on the convicts' wharf in order to ascertain the range of mortars on the river Thames.<sup>111</sup> The witnessing of official payments came into operation about this time, for on 4 March 1805, the paymaster at Woolwich was directed to employ one of his clerks to witness his payments.<sup>112</sup> On 1 April 1805 the working day was shortened, thenceforward 2 hours were to constitute a quarter of a day's work in place of the 2½ hours formerly worked.<sup>113</sup> On 24 April 1805, the C.R.E. was ordered to erect a stockade in front of the 'great storehouse' on the Cadets' Green.<sup>114</sup>

We are afforded the first glimpse of the new Congreve rocket on 29 April 1805, a weapon which its inventor considered would supersede the gun. On that day Major-General Congreve, Comptroller of the Royal Laboratory, was ordered to afford William Congreve, his son,<sup>115</sup> such assistance as might be required 'in preparing the different articles so far as their provision is connected with the R.L., and that he (Major-General Congreve) be acquainted that the Board have given directions to Lieutenant-General Lloyd<sup>116</sup> that when the articles are ready, to cause experiments to be made with Mr. Congreve's invention before the Committee,<sup>117</sup> and Mr Congreve will give Major-General Congreve such information as may be required for forwarding the same'.<sup>118</sup> The Board took the new rocket seriously and ordered the project to be pushed forward with all possible speed. On 30 August 1805, the Comptroller R.L. was informed that the experiments with rockets by Mr Congreve were to be carried out immediately, and that the assistance of the Royal Laboratory together with certain R.L. stores would be required. Major-General Congreve was ordered to furnish all the assistance he could with the experiments which would be explained to him verbally by the inventor. At the same time Major-General Blomefield, Inspector of Artillery, was warned that Mr Congreve would require the use of a shed at the back of the old proof-butt at Woolwich as a temporary workshop for driving rockets, and was asked to render any aid that his staff, or that of the Royal Brass Foundry, could give.<sup>119</sup> This directive was followed next day by one to Captain Hayter to instruct twelve men of the Engineering Department to fit up that shed with all expedition on the ensuing Monday so that the driving of the rockets

<sup>111</sup> Extracts of Minutes, Series II, PRO/WO/47/2,582, p. 355.

<sup>112</sup> Extracts of Minutes, Series II, PRO/WO/47/2,583, p. 851.

<sup>113</sup> Extracts of Minutes, Series II, PRO/WO/47/2,583, p. 1,257.

<sup>114</sup> Extracts of Minutes, Series II, PRO/WO/47/2,583, p. 1,578.

<sup>115</sup> William Congreve was a Colonel in the Hanoverian Army.

<sup>116</sup> Lieutenant-General Vaughan-Lloyd was Commandant, Woolwich Garrison.

<sup>117</sup> The Colonels' Committee.

<sup>118</sup> Extracts of Minutes, Series II, PRO/WO/47/2,583, p. 1,805.

<sup>119</sup> Extracts of Minutes, Series II, PRO/WO/47/2,585, p. 3,244.

could be put into operation at once.<sup>120</sup> On 5 September 1805, Major-General Congreve was informed that the R.L. were authorized to obtain iron rocket heads for Mr Congreve by a contract or by any other means.<sup>121</sup> The flow once started surged to a flood, and the Board became quite overwhelmed with the magnitude of 'Operation Rocket'. Mr Congreve's requests grew in number and his experiments branched out in all directions, so much so that the Board admitted that 'they were much greater than they had first imagined'. To keep the problem regulated and to prevent duplication, the Board arranged that all future demands from Mr Congreve should reach the Master-General and Board through the Secretary of State. Meanwhile they had authorized the storekeeper at Dover to issue caronade stores and to hire a storehouse to accommodate the stores prepared for the launches fitting out under Mr Congreve's instructions.<sup>122</sup>

By the following year, Congreve's rockets were really getting into their stride. On 29 April 1806, the departments at Woolwich were asked to devote the maximum help to Mr Congreve in his new venture.<sup>123</sup> This was followed by two orders to Captain Hayter. First, on 21 July 1806 to construct a temporary shed of weather-board 60 feet long by 20 feet broad for the manufacture of rockets under Mr Congreve's superintendence, in place of the Laboratory tents in which up to then such work had been carried out. Mr Read, the draughtsman at the Royal Military Repository, was to be paid an extra 3s. 10 $\frac{3}{4}$ d. a day during the time he worked for Mr Congreve.<sup>124</sup> Secondly, on 8 August 1806, to erect another temporary shed at an estimated cost of £246 for rocket production in the Royal Laboratory.<sup>125</sup> Major-General Congreve was on 29 April 1808 ordered to afford Mr Congreve such assistance as he might want to alter rocket frames to satisfy service requirements, and to lend him the services of three or four R.L. artificers according to his choice to work under his direction.<sup>126</sup>

From then on rocket work steadily progressed and the manufacture of these missiles became for many years to come one of the standard productions of the Royal Laboratory.

Sir William Congreve, 2nd Baronet, as he afterwards became, brought a powerful imagination to bear on his project. To him, the chief advantage of a systematic construction of pyrotechnic missiles appeared to lie in the fact that the force compelling projection was exercised without any reaction on the point of departure. He therefore visualized 'boats' crews inflicting considerable damage with

<sup>120</sup> Extracts of Minutes, Series II, PRO/WO/47/2,585, p. 3,255.

<sup>121</sup> Extracts of Minutes, Series II, PRO/WO/47/2,586, p. 3,317.

<sup>122</sup> Extracts of Minutes, Series II, PRO/WO/47/2,586, p. 3,891, 21 October 1805.

<sup>123</sup> Extracts of Minutes, Series II, PRO/WO/47/2,589, p. 1,789.

<sup>124</sup> Extracts of Minutes, Series II, PRO/WO/47/2,591, p. 3,069.

<sup>125</sup> Extracts of Minutes, Series II, PRO/WO/47/2,591, p. 3,309.

<sup>126</sup> Extracts of Minutes, Series II, PRO/WO/47/2,601, p. 1,237.

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little effort, and individuals discharging with ease missiles equivalent in destructive power to those fired from the heaviest cannon of the day. He foresaw also the dispersing of large concentrations of men and the enfilading of trenches by the lightest of mounted troops suitably equipped. As Congreve himself says, 'The rocket carcass is not only fired without reaction upon the point from which it is discharged, but is also unencumbered with the necessity of heavy ordnance to project it as is the case with every other carcass. These are points which first induced me to speculate upon it; it is on these properties that depend its peculiar facilities for sea and land services, as will be hereafter more fully explained. It is ammunition without ordnance; it is the soul of artillery without the body; and has therefore from the first principles of its flight, a decided advantage for the conveniency of use over the spherical carcass.' Owing to the limitations of artillery in his day there is no doubt that Congreve was sound in his conclusions, but his vision, unrealized by him, penetrated further into the future, and has a peculiar significance for use in the twentieth century. Congreve did not invent the rocket *per se*, for as a weapon of war it has flashed through the pages of history like a comet across the starry heavens. It appears, reaches its zenith, declines, disappears and reappears with startling regularity. Its chief rival has been the gun, and for more than 600 years the struggle between the two systems of translation—jet propulsion and pressure projection—has endured. Both these destructive agents have had their advocates and much has been proclaimed on the virtues of each. The rocket was the first in the field, and if recent developments be any guide, it may well be the last, or failing the complete eclipse of its competitor, it will become entrenched as an alternative method of long range bombardment. Congreve's words had more truth and substance than he knew.

On 19 June 1805, Captain Hayter was ordered to build a larger office on the wharf for the use of Captain Dickinson and his assistants.<sup>127</sup> The storekeeper by now was evidently becoming 'precision-minded'. He objected, quite rightly, to the inaccurate method in force of weighing guns by means of a gyn and an old piece of ordnance instead of by some species of balance and standard weights. He therefore suggested to the Board on 21 June 1805, that a proper apparatus should be procured from the Carron Company together with a suitable crane. The cautious Board referred the matter to the C.R.E.<sup>128</sup> The latter must have reinforced the storekeeper's plea for, on 26 July following, a scale and beam to weigh up to 5 tons were ordered to be provided immediately.<sup>129</sup>

<sup>127</sup> Extracts of Minutes, Series II, PRO/WO/47/2,584, p. 2,342.

<sup>128</sup> Extracts of Minutes, Series II, PRO/WO/47/2,584, p. 2,377.

<sup>129</sup> Extracts of Minutes, Series II, PRO/WO/47/2,585, p. 2,835.



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should be fixed in place by screws and nuts instead of nails. The additional expense of the nuts and screws would only be  $2\frac{1}{2}d.$  per lb. and the felloes would be protected from damage since the nails when driven home had a tendency to split them. Major-General Cuppage was instructed to inform the Board of the extra cost involved.<sup>218</sup> The experiment was evidently a success as on 31 March 1815 the use of nuts and screws instead of nails for this purpose was adopted as standard practice.<sup>219</sup>

A shortage of craftsmen now occurred, a phenomenon only too familiar in war. On 22 December 1813, the Comptroller R.L. pointed out the great difficulty in obtaining the requisite number of turners.<sup>220</sup>

Colonel Congreve reported on 1 December 1813 that although he had 26,000 rockets on order, he could only manufacture 36 a day with the present means at his disposal. He therefore asked for further facilities in order to keep abreast of the demands made upon him. At the same time he suggested that all new buildings erected to this end should be equipped with machinery and form part of a plan to construct, apart from the Royal Laboratory, a permanent Rocket Establishment at Woolwich. He calculated that the substitution of machines in place of manual labour would save £6,500 on the 26,000 rockets awaiting manufacture. The C.R.E. was instructed to erect the temporary buildings required bearing in mind that they might ultimately form part of a permanent Rocket Establishment.<sup>221</sup> This was the first occasion on which such a proposal had been mooted and it took root in the mind of authority, the Rocket Establishment being set up in the fulness of time.

The estimate for the special buildings, the engine and the machinery necessary for the manufacture of rockets according to the views put forward by Colonel Congreve was dated 18 March 1814, and the plan accompanying it, 10 April 1814. The steam engine and machinery were to be supplied by Henry Maudsley.

The details of the estimate were as follows:

Two driving houses	—	£4,443.	12s.	8½d.
Engine house and machinery	—	£3,798.	4s.	1¼d.
Smiths' shop	—	£504.	5s.	4d.
Carpenters' shop	—	£447.	19s.	4¼d.
Total:		£9,194.	1s.	6d. <sup>222</sup>

A sum of £1,800 was included for this service in the abstract of 'Services ordered to be performed during the year 1813 in addition

<sup>218</sup> Extracts of Minutes, Series II, PRO/WO/47/2,633, p. 6,529.

<sup>219</sup> Extracts of Minutes, Series II, PRO/WO/47/2,640, p. 1,248.

<sup>220</sup> Extracts of Minutes, Series II, PRO/WO/47/2,633, p. 7,024.

<sup>221</sup> Extracts of Minutes, Series II, PRO/WO/47/2,633, p. 6,713.

<sup>222</sup> Engineer Papers, PRO/WO/55/757.

to those included in the annual estimate'. With this £1,800 in hand the sum included in the Annual Estimates for 1815 to defray the whole cost of the new establishment was £7,394. 1s. 6d.<sup>223</sup> The two driving houses, ordered to be built by the Board's order dated 1 December 1813, were under erection by April 1814. They were of weather-board construction, each 70 feet by 46 feet. The two workshops were of brick, their dimensions being 59 feet by 23 feet. This small rocket factory, which was the nucleus of the future Rocket Establishment of later times, is shown completed in a map of the Royal Arsenal as it appeared in 1815, though the map itself was not drawn till 29 November 1858.

The *Morning Chronicle* of 2 July 1814 referred to this rocket enterprise in the most scathing terms. The editor of the paper, much incensed, was most sarcastic about the manufacture of Congreve rockets and pyrotechnics in the Arsenal in place of orthodox munitions. He went so far as to suggest that 'an Address should be moved to ascertain who is responsible for the tomfoolery'. Progress, however, is never stemmed by abuse and conservatism of mind is not wholly unknown in our own day.

This new manufactory in Woolwich and the collapse of Napoleon together spelt the doom of the rocket establishment at Dover where the bulk of these stores had been assembled. The workshops there were ordered to be closed on 26 October 1818, the rockets being returned to the storekeeper, and the foreman and labourers discharged with a fortnight's pay.<sup>224</sup>

For those sufficiently interested to investigate more fully the history of the Congreve rocket there are, besides the inventor's own works, several bundles of papers in the Public Record Office devoted to the subject; notably those named 'Colonel Congreve's rockets', 'Congreve's life-saving rocket' and 'Colonel Congreve's rockets' establishment at Dover'. They are to be found under index numbers, PRO/WO/44/642 and PRO/WO/44/643.

Works Estimates for Woolwich for 1813 was £59,214. os. 10 $\frac{3}{4}$ d.<sup>225</sup>

The cloud which had for so long darkened the European scene lifted perceptibly in 1814 though the hope, undoubtedly held by many, that it had vanished was premature. The Peninsular War had been decisively won and France was facing virtual defeat that New Year's morning when the Allies, crossing the Rhine, swept into French territory, to be joined five days later by Murat. Two-thirds of the country capitulated without a struggle and Paris was entered on 30 March. Napoleon, abdicating on 11 April, was sent to the Island of Elba, and upon his departure, Louis XVIII ascended the

<sup>223</sup> Works Estimates, 1815, PRO/WO/49/134.

<sup>224</sup> Extracts of Minutes, Series II, PRO/WO/47/2,658, p. 3.469.

<sup>225</sup> Extracts of Minutes, Series II, PRO/WO/47/2,630, p. 228. Works Estimates 1813, PRO/WO/49/128.

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throne of France. The first Peace of Paris was signed 30 May 1814. All these joyous happenings had a profound effect upon the government and people at home, and the Royal Arsenal did not escape its repercussions. The engines of employment went into reverse, heavy discharges took place and money for the appurtenances of war shrank. Expansion was out and retrenchment was in. The discharges from the Royal Arsenal are given in Appendix VIII, and the tide rapidly receded from the peak figure of 5,000. Nevertheless, in spite of the shrinking economy, the life of the departments had to go on. The individuals still employed had to work and live and the future had to be safeguarded.

The Peace of Paris was celebrated by a firework display in St James's Park for which the Royal Laboratory under the Office of Ordnance was responsible. On 3 June 1814, two London artists—Mr Sadler Crumpton and Mr Monkham—were engaged at £100 each to assist in the preparation of the fireworks. Sir William Congreve, 2nd Bart., who had succeeded to the Comptrollership of the Royal Laboratory on 1 July 1814 after the death of his father on 30 April 1814,<sup>226</sup> having advanced money to these two gentlemen, had it refunded by the authorities.<sup>227</sup> Arrangements were made on 10 June 1814 to select special artificers and labourers to unload the fireworks in London, to take care of them and to assist in fixing them for the exhibition. They received the usual extra pay while so employed.<sup>228</sup> Captain By, R.E., the C.R.E. at Waltham Abbey, was asked to lend certain articles on 22 June 1814, to aid the erections in St James's Park and to give all the assistance he could in supervising such erections.<sup>229</sup> The display under the direction of Sir William Congreve took place on 1 August 1814, the day being chosen to mark the centenary of the accession of the House of Hanover to the English throne.

The bill for the officers and men of the Royal Artillery employed in the park during this national fete, amounting to £92. 19s. 6d., was paid by the paymaster. It was made up as follows:

Officers and men, R.A.	£66. 1s. 9d.
Corps of R.A. Drivers	£26. 17s. 9d. <sup>230</sup>

There was one fatality in connection with this celebration. John Taylor, a carpenter in the R.L., lost his life in the fire which broke out in the pagoda set up in St James's Park for that occasion. On 26 September 1814, the paymaster was ordered to pay his funeral expenses.<sup>231</sup>

<sup>226</sup> Extracts of Minutes, Series II, PRO/WO/47/2,630, pp. 1,971 and 1,794.

<sup>227</sup> Extracts of Minutes, Series II, PRO/WO/47/2,636, p. 2,297.

<sup>228</sup> Extracts of Minutes, Series II, PRO/WO/47/2,636, p. 2,403.

<sup>229</sup> Extracts of Minutes, Series II, PRO/WO/47/2,636, p. 2,575.

<sup>230</sup> Extracts of Minutes, Series II, PRO/WO/47/2,637, p. 3,375.

<sup>231</sup> Extracts of Minutes, Series II, PRO/WO/47/2,637, p. 4,000.

Board were evidently of opinion that Bennett's shot cleaning machine, which had been under trial in 1813 and 1814 was a good investment. Eleven of these machines were ordered under the Board's instructions dated 13 August 1813 and 13 July 1814. As the machines cost £90 each, a sum of £990 was involved. Of this amount £77. 8s. 2d. was included in the Estimates for 1813, while the remainder, i.e. £912. 11s. 0d. was taken up in the Works Estimates for 1815.<sup>261</sup>

On 28 September 1814, 1,000,000 S.A.A. cartridges for the English musket—the Brown Bess—were ordered from the Royal Laboratory by the Admiralty for despatch to Vice-Admiral Sir Alexander Cochrane, commanding the West Indian and American Station.<sup>262</sup>

Sir William Congreve stated on 20 October 1814 that, although climatic conditions in Ireland had demonstrated the superiority of quill over tin tubes in that country, and although such tubes were efficient for Sea Service, their priming was insufficiently protected to withstand the rough usage associated with the carriage of Land Service packed ammunition. He therefore recommended, not only for Ireland, but for the Land Service as a whole, that brass should be substituted for tin as the material for tube bodies, experience having shown that the former metal was more robust. He also suggested that all tubes for Ireland should be made in the Royal Laboratory, Woolwich, and be sent over to the Royal Laboratory, Dublin, for filling. This would cut the cost by one third, manufacture in Dublin being more expensive. The Board ordered 5,000 brass tubes for trial and instructed the Comptroller R.L. to render a report in due course, indicating the expense involved in the substitution.<sup>263</sup> In regard to rockets, Sir William Congreve was authorized to obtain the necessary cast-iron cases from Mr Kendrick, a founder in West Bromwich, on the express understanding that he was not to disclose the use to which such articles were to be put.<sup>264</sup>

To vary the monotony a horse instead of a cow was now killed by a rocket. On 9 December 1814, Mr Cook was awarded £63 damages for the loss of his steed.<sup>265</sup>

The new wharf, the raising of the ground level and the many extra buildings erected during the preceding hundred years had altered the old Arsenal water courses to such an extent as to render them incapable of carrying away surface water; and such drains as did exist were inadequate of purpose. Sluices and new drains were therefore required. Conditions having become more complex, a free

<sup>261</sup> Works Estimates, 1815, PRO/WO/49/134.

<sup>262</sup> Extracts of Minutes, Series II, PRO/WO/47/2,637, p. 4,047.

<sup>263</sup> Extracts of Minutes, Series II, PRO/WO/47/2,638, p. 4,405.

<sup>264</sup> Extracts of Minutes, Series II, PRO/WO/47/2,638, p. 5,289, 30 December 1814.

<sup>265</sup> Extracts of Minutes, Series II, PRO/WO/47/2,638, p. 4,986.

THE DOLDRUMS 1816-1839

The return, headed *Floating Magazines at Woolwich 1821*, contains the names of two vessels, *Manship* and *Lady Chatham*. Their particulars are given as follows:<sup>75</sup>

*MANSHIP* 900 tons

Crew	{	1 Master at £9 per month
		2 Mates at £7. 10s. od. per month
		1 Seaman at £5 per month
Total pay bill		£318. os. od.
Expense of repairs		82. 11s. 3d.
Total:		<u>£400. 11s. 3d.</u>

(Used as a floating magazine)

*LADY CHATHAM* 63 tons

Crew	{	1 Master at £9 per month
		1 Mate at £7. 10s. od. per month
		3 Seamen at £5 per month each
		1 Boy at £3 per month

The Master has also £20 p.a. house rent allowance.

Total pay bill		£434. os. od.
Expense of repairs		115. os. od.
Contingencies		33. 19s. 4d.
Total:		<u>£582. 19s. 4d.</u>

(Used as a powder vessel)

In the 'Ordnance Papers presented to the House of Commons 1821' also appears a complete return of the various departments in the Royal Arsenal dated 12 March 1821. Although it is somewhat lengthy it is worth recording in full for the information it supplies. In addition to the clerical establishment based on Woolwich, there were 9 assistant clerks working there on loan from the Ordnance Department. Of these one was in the Royal Laboratory and eight worked under the storekeeper.

ROYAL LABORATORY

<i>Comptroller</i>	Sir William Congreve, 2nd Bart., Salary £360, Quarters, Total: £360 p.a.
<i>Firemaster</i>	Lieut.-General George Rochfort, Salary £230, House, Total: £230 p.a.
<i>Assistant to Firemaster</i>	Lieut.-Colonel Charles Bingham, Salary £230, House, Total: £230 p.a.
<i>Inspector of Royal Manufactories of Gunpowder</i>	Captain William Maling, Salary £200, House, Total: £200 p.a.

<sup>75</sup> Ordnance Papers presented to the House of Commons 1821.

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<i>Paymaster</i>	John Henderson, Salary £400, Gratuities £100, House, Coals and Candles £25. Total: £525 p.a.
<i>Clerks to the Paymaster</i>	John Pitfield, Salary £70, Gratuities £35, House rent allowance £20. 16s. od. Coals and Candles £12. 10s. od. Total: £138. 6s. od. p.a.
	Thomas Mortimer, Salary £70, Gratuities £15, House rent allowance £12, Coals and Candles £8. Total: £105 p.a.
<i>Clerk of Works</i>	Thomas Weaver, Salary £182. 10s. od., Gratuities £50, House rent allowance £26, Coals and Candles £12. 10s. od. Total: £271 p.a.
<i>4 Clerks under the Storekeeper</i>	John Guest, Salary £100, Gratuities £50, Appartments, Coals and Candles £12. 10s. od. Total: £162. 10s. od. p.a.
	William Jones, Salary £80, Gratuities £50, Appartments, Coals and Candles £8. Total: £138 p.a.
	John Knight, Salary £80, Gratuities £35, House rent allowance £12, Coals and Candles £8. Total: £135 p.a.
	Cornelius Sharp, Salary £70, Gratuities £15, House rent allowance £12, Coals and Candles £8. Total: £105 p.a.

Total Salaries	£2,002. 10s. od.
Total Gratuities	£900. 0s. od.
Total House rent allowance	£82. 16s. od.
Total Coals and Candles	£132. 0s. od.
Grand Total	£3,117. 6s. od.

ROYAL MILITARY REPOSITORY  
(On the Common)

<i>Superintendent</i>	Sir William Congreve 2nd Bart. Salary £101. 5s. od.
<i>Modeller</i>	James Flarty, Salary £120
<i>Clerk</i>	George Chubb, Salary £80, Gratuities £15, House rent allowance £20. 16s. od., Coals and Candles £12. 10s. od. Total: £128. 6s. od.
<i>Draughtsman</i>	John Read, Salary £138. 12s. 6d., Gratuities £215, House rent allowance £26, Coals and Candles £12. 10s. od. Total: £392. 2s. 6d. p.a.

Total Salaries	£439. 17s. 6d.
Total Gratuities	£230. 0s. od.
Total House rent allowance	£46. 16s. od.
Total Coals and Candles	£25. 0s. od.
Grand Total	£741. 13s. od.

The return of the Assistant Clerks in the Ordnance Department is dated 15 March 1821.

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new time-piece was essential and referred the matter to Major-General Sir George Fisher, who had replaced Lieut.-General John Ramsey<sup>171</sup> as Commandant, Woolwich, on 10 February 1827, for his opinion as to its necessity, and, if so, his recommendation as to its most suitable position.<sup>172</sup>

On 28 January 1828, the renewal of wall plates at the saw-mill were approved at a cost of £41. 14s. 6½d.<sup>173</sup> On 22 February 1828 the R.L. boat was ordered to be repaired for a sum not exceeding £8. 8s. 1d.<sup>174</sup>

The Woolwich Estimate is once more recorded. It amounted to £48,096 for 1828.<sup>175</sup>

A Board's letter dated 16 June 1828 authorized the formation of a timber yard, railroad and floatage for lumber in connection with the saw-mill at an estimated cost of £339. 5s. 8½d. and £58. 8s. 6½d.; a total of £397. 14s. 3d.<sup>176</sup>

Various appointments, occasioned by the death of Sir William Congreve, 2nd Bart., on 15 May 1828, took place in the departments during the year.

Colonel Sir Augustus Frazer, K.C.B., Assistant Inspector Royal Carriage Department, was appointed Chief of the Royal Laboratory vice Sir William Congreve, at a salary of £350 p.a. with the title of *Director, Royal Laboratory*.

Colonel John S. Williamson, C.B., was appointed Superintendent of the Royal Military Repository vice Sir William Congreve.

Captain Richard Hardinge was appointed Assistant Inspector of the Royal Carriage Department vice Colonel Sir Augustus Frazer.

Colonel Charles Bingham, Assistant Firemaster R.L., was appointed Firemaster R.L. on his existing salary of £230 p.a. vice Major-General Joseph Maclean.

The appointment of Assistant Firemaster R.L. was left vacant for the moment.<sup>177</sup>

Another appointment was abolished on 31 December 1828. The post in question had only an indirect bearing on Woolwich, but it is worth recording as a matter of interest. It was that of architect to the Board. Mr Atkinson, the holder, who received a salary of £225 p.a. (salary £200 and gratuities £25) was in future to be employed by the Board as a civil architect or surveyor as occasion might demand.<sup>178</sup>

<sup>171</sup> Lieut.-General John Ramsey died 9 February 1827.

<sup>172</sup> Extracts of Minutes, Series II, PRO/WO/47/2,693, p. 112, 18 January 1828.

<sup>173</sup> Extracts of Minutes, Series II, PRO/WO/47/2,693, p. 169. Engineer Papers, PRO/WO/55/758.

<sup>174</sup> Extracts of Minutes, Series II, PRO/WO/47/2,693, p. 322.

<sup>175</sup> Extracts of Minutes, Series II, PRO/WO/47/2,693, p. 1,332.

<sup>176</sup> Extracts of Minutes, Series II, PRO/WO/47/2,693, p. 1,022. Engineer Papers, PRO/WO/55/758.

<sup>177</sup> Extracts of Minutes, Series II, PRO/WO/47/2,693, p. 926, 30 May 1828.

<sup>178</sup> Extracts of Minutes, Series II, PRO/WO/47/2,694, p. 1,862, 24 November 1828.

APPENDIX VI

*Superintendents Royal Gun and Carriage Factory*

1907-1912	Colonel H. C. L. Holden
1912-1917	Lieut-Colonel C. P. Martel, R.A.
1917-1919	Colonel M. J. C. Dennis
1919-1921	Lieut.-Colonel M. L. Wilkinson, R.A.
1921	J. Bowden, O.B.E.
1921-1931	F. W. O. Dean, C.B.
1931-1935	R. F. Hartley, O.B.E.
1935-1936	Charles N. McLaren
1936-1941	G. F. Masters
1941-1947	A. J. Golding
1947-1953	A. J. Crocker
1953-1956	J. A. Gordon
1956-1957	D. A. Luxton

*Superintendents Development and Experimental*

1957-	G. S. Fullerton
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*Superintendents Production*

1957-1959	D. A. Luxton
1959-1961	D. A. Luxton and S. R. Fraser
1961-	D. A. Luxton

*Superintendents Royal Arsenal Estate*

1953-1958	D. H. Mizen
1958-	J. D. Whitaker

*Royal Laboratory*

*Comptrollers of Fireworks*

30. 6.1688- 1. 7.1702	Sir Martin Beckman
1. 5.1706- 1.10.1734	Colonel John Henry Hopkey

(From 1716 till 1746 the Laboratory was under the care of a Bombadier.  
From 1716 till 1734 Colonel Hopkey was paid on the 'Sinking Establishment')

*Comptrollers: Royal Laboratory*

12. 2.1746-30. 5.1782	Sir Charles Frederick
31. 5.1782- 8. 4.1783	Colonel the Hon. George Napier
9. 4.1783-26. 5.1789	Colonel Thomas Jones
27. 5.1789-30. 4.1814	Lieut.-General Sir William Congreve, 1st Bart.
1. 7.1814-15. 5.1828	Sir William Congreve, 2nd Bart.

*Directors: Royal Laboratory*

30. 5.1828-11. 6.1835	Colonel Sir Augustus Frazer, K.C.B.
12. 6.1835-13. 9.1838	Colonel Stephen G. Adye
10.10.1838-15.11.1846	Colonel James P. Cockburn
16.11.1846- 1852	Lieut.-Colonel Richard Hardinge, K.H.
1. 4.1852-11. 8.1852	Colonel William Cator
12. 8.1852- 1855	Colonel John A. Wilson



APPENDIX VII

(3) *Revision of the Salaries of the Principal Officers of the Board to commence 1 July 1801*

(PRO/HO/50/391, pp. 177-187)

The warrant for this revision is dated 16 March 1802.  
The revised salaries are:

Master-General £3,000 p.a.; Lieutenant General £1,500 p.a.; Surveyor-General £1,200 p.a.; Clerk of the Ordnance £600 p.a.; Principal Storekeeper £500 p.a.; Clerk of Deliveries £500 p.a.; Secretary to the Board £1,000 p.a.; Secretary to the Master-General £500 p.a.; Under-Secretary to the Master-General £300 p.a. Total £9,100 p.a.

(4) *The salaries of Officers and Clerks in the Civil Department 1801*

(PRO/WO/47/2,380, p. 463)

This refers to Inferior Officers and Clerks. It is a printed document dated 13 June 1801. It cancels the regulations of 24 January 1797 with effect from 1 January 1801. Two Woolwich clerks are given the following salaries:

Clerk of the Survey at Woolwich £350 (maximum)  
Clerk of the Cheque at Woolwich £300 (maximum)

(5) *The proposed reductions in the establishment of the Civil Branch of the Ordnance Department 1821*

(PRO/WO/44/511)

This gives a complete list of officials, but only those relevant to the Board and Woolwich are given.

The following are the proposed reduced emoluments:—

Master-General	The Duke of Wellington	£3,235.	18s.	4d.	p.a.
Lieutenant-General	Sir Hildebrand Oakes	£1,591.	13s.	4d.	p.a.
Surveyor-General	Sir Ulysses Burgh	£1,261.	10s.	od.	p.a.
Clerk of the Ordnance	Robert Ward	£ 861.	10s.	od.	p.a.
Principal Storekeeper	Mark Singleton	£ 779.	15s.	od.	p.a.
Clerk of Deliveries	The Hon. Edmund Phipps	£1,043.	5s.	od.	p.a.
Treasurer	William Holmes	£1,265.	os.	od.	p.a.
Secretary to the Master-General	Lord Fitzroy Somerset	£1,500.	os.	od.	p.a.
Secretary to the Board	Robert H. Crew	£1,695.	os.	od.	p.a.
Comptroller, Royal Laboratory	Sir William Congreve	£ 360.	os.	od.	p.a. + quarters
Firemaster	Colonel Maclean	£ 230.	os.	od.	p.a. + house
Assistant Firemaster	Lieut.-Colonel Bingham	£ 230.	os.	od.	p.a. + house

APPENDIX VII

Inspector of the Royal Manu- factories of Gunpowder	} Captain W. Maling	£ 200. os. od. p.a. + house
Inspector of Artillery	Sir Thomas Blomefield	£ 402. os. od. p.a.
Inspector of the Royal Brass Foundry	} Sir Thomas Blomefield	£ 91. 5s. od. p.a.
Proofmaster	Lieut. Alexander Reid	£ 158. 10s. od. p.a.
Founder	Cornelius King	£ 271. os. od. p.a.
Inspector Royal Carriage Depart- ment	} Lieut.-General W. Cuppge	£ 400. os. od. p.a. + house
Storekeeper	John Geast	£ 700. os. od. p.a. + house
Deputy Storekeeper	Joseph Cheetham	£ 362. 10s. od. p.a. + house

(6) *Reorganization of the Civil Establishments of the Ordnance 1825*  
(PRO/WO/44/606)

This establishment was brought into force 1 January 1825, the Treasury approval being dated 2 December 1825.

The Master-General £3,175. 18s. 4d. p.a.; The Lieutenant-General £1,566. 13s. 4d. p.a.; The Surveyor-General £1,836. 10s. od. p.a.; Principal Storekeeper £734. 15s. od. p.a.; Clerk of the Ordnance £1,836. 10s. od. p.a.; Clerk of Deliveries £1,018. 5s. od. p.a.; Treasurer £1,540. os. od. p.a.; Secretary to the Board £1,400. os. od. p.a.; Secretary to the Master-General £1,500 p.a.; Comptroller R.L. £350-£500 p.a.; Firemaster £230 p.a.; Assistant Firemaster £200 p.a.; Inspector of the Royal Manufactories of Gunpowder £200 p.a.; Inspector of Artillery £350 p.a.; Inspector of the Royal Brass Foundry £100 p.a.; Proofmaster £150 p.a.; Inspector, Royal Carriage Department £400 p.a.; Assistant Inspector, Royal Carriage Department £250 p.a.; Deputy Storekeeper, Royal Carriage Department £250-£350 p.a.; Storekeeper, Woolwich £600-£750 p.a. and Deputy Storekeeper, Woolwich £250-£350.

(7) *Reduction of the Salaries of the Principal Officers of the Ordnance 1828*  
(PRO/WO/44/725)

The warrant effecting this reduction is dated 20 November 1828, and came into force on 1 July 1828. It abolished fees and fixed the all-inclusive salaries as follows:

Lieutenant-General £1,200 p.a.; Surveyor-General £1,500 p.a.; Clerk of the Ordnance £1,200 p.a.; Principal Storekeeper £1,200 p.a.; Secretary to the Master-General £1,200 p.a.

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found satisfactory, suggest that they be paid from 1s. 9d. to 2s. 4d. a day. The Board do not consider the arrangement suitable at present.

(PRO/WO/47/2,636, p. 1,553)

20 April 1814. Reduction of Artificers and Labourers in the R.C.D. to take place during the present month. The Respective Officers cannot reduce their establishment at the moment, even if peace should be proclaimed. They must wait till stores are returned. They will reduce establishment as and when they can.

(PRO/WO/47/2,636, p. 1,645)

22 April 1814. The R.L. report that they can reduce establishment as under from Saturday next (23 April):

13 Carpenters, 7 Turners, 6 Smiths, 14 Tinmen, 4 Painters, 4 Tailors, 2 Coopers, 175 Labourers and 600 Boys.

(PRO/WO/47/2,636, p. 1,650)

29 April 1814. The following were actually discharged from the R.L. on the Saturday in question:

6 Turners, 6 Tinmen, 6 Blacksmiths, 3 Painters, 120 Labourers and 180 Boys.

(PRO/WO/47/2,636, p. 1,761)

2 May 1814. Lieut-General Sir William Congreve, 1st Bart., died suddenly on 30 April 1814.

(PRO/WO/47/2,636, p. 1,794)

6 May 1814. More discharges are to take place from the R.C.D.

(PRO/WO/47/2,636, p. 1,873)

9 May 1814. The following to be discharged from the R.L. on 11 May 1814 (Wednesday):

18 Carpenters, 9 Turners, 6 Tailors, 10 Tinmen, 1 Cooper, 1 Smith, 1 Painter, 180 Labourers and 100 Boys.

(PRO/WO/47/2,636, p. 1,914)

11 May 1814. The following were discharged from the R.C.D.:—

100 Blacksmiths, 30 Carpenters, 20 Wheelers and 6 Labourers.

(PRO/WO/47/2,636, p. 1,942)

13 May 1814. Sir William Congreve, 2nd Bart., is appointed Comptroller, Royal Laboratory and Superintendent, Royal Military Repository, *w.e.f.* 1 July 1814 vice Lieut-General Sir William Congreve, 1st Bart. (his father), who died 30 April 1814.

(PRO/WO/47/2,636, p. 1,971)

23 May 1814. Thomas Gill to be apprentice to Thomas Lock, Foreman of Carpenters in the R.C.D. vice John Woodhead.

John Truewhellar, Foreman of Wheelers, R.C.D., leaves the service and his apprentice, Charles Cock, is transferred to Daniel Hitchcock, Foreman of Wheelers.

(PRO/WO/47/2,630, p. 2,124)

27 May 1814. The R.L. take on 50 additional labourers to assist in unloading transport and to prevent disappointment in the preparation of fireworks for Triumph now proceeding. Preference to be given to men recently discharged from the Departments at Woolwich.

(PRO/WO/47/2,636, p. 2,183)

30 May 1814. Owing to the reduction of Foremen consequent on the

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*Discharges*

1 Assistant Armourer	£	54.	15s.	6d.
1 Master Artificer	£	109.	11s.	0d.
1 Master Collarmaker	£	109.	11s.	0d.
1 Collarmaker	£	63.	18s.	1d.
1 Smith	£	54.	15s.	6d.
3 Painters	£	191.	14s.	3d.
1 Chief Foreman	£	86.	14s.	6d.
4 Assistant Foremen	£	255.	12s.	4d.
90 Labourers	£	3,276.	0s.	0d.
Total	£	4,202.	12s.	2d.

In order to cut the Incidental Expenses by half, a further reduction of establishment to the amount of £978. 2s. 6½d. was ordered. Six Assistant Clerks were also to be discharged.

*Inspector of Artillery*

The War Establishment is £6,790. 6s. 0d.  
 The Establishment of 1817 is £4,346. 14s. 0d.  
 The Establishment for 1818 is £3,774. 14s. 0d., by which a reduction of £572 is made on the 1817 Establishment.

Of the Establishment of 1817, i.e. £4,346. 14s. 0d., £1,644. 11s. 0d. is paid at the Tower, leaving total incidental charges at £2,682. 3s. 0d., of which half is £1,341. 1s. 6d.

The Inspector is therefore asked to propose further reductions so as to approximate half last year's expenses.

In regard to the Royal Brass Foundry, the War Establishment is £4,597. 6s. 0d. The Establishment of 1817 is £1,671. 2s. 0d. The amount of reduction £2,926. 4s. 0d. No further reduction is therefore required in the Royal Brass Foundry.

*R.C.D.*

The expenses of the R.C.D. for the year is	£10,616.	7s.	4d.
Of which is paid by the Tower	£ 2,335.	16s.	0d.
Total incidental charge	£ 8,280.	11s.	4d.
Reductions already proposed	£ 1,618.	10s.	0d.
Total future expenditure	£ 6,662.	1s.	4d.

In order, however, that the expenses in 1818 shall not exceed half those in 1817, Major-General Cuppage is asked to propose further reductions to those he has already submitted so as to increase their amount to £4,140. 5s. 8d., i.e. by an amount equalling £2,521. 15s. 8d.

(PRO/WO/47/2,653, p. 4,384)

8 December 1817. Sir William Congreve, Comptroller R.L., is ordered to reduce his wages bill by one half. The incidental charges at present are: £12,737. 2s. 3d. He must therefore propose reductions in staff amounting to £6,368. 11s. 1½d.

(PRO/WO/47/2,653, p. 4,411)

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5 May 1828. Thirteen boys to be discharged from the R.L. on 7 May 1828.

(PRO/WO/47/2,693, p. 766)

30 May 1828. Colonel John S. Williamson, C.B., appointed Superintendent Royal Military Repository vice Sir William Congreve 2nd Bart., who died 30 April 1828.

Colonel Sir Augustus Frazer, K.C.B., appointed Chief of the R.L. with the title *Director of the R.L.* with a salary of £350 p.a. vice Sir William Congreve, 2nd Bart., who died 30 April 1828.

Colonel Charles Bingham appointed Firemaster R.L. with his present salary of £230 p.a. vice Major-General Joseph Maclean.

The Post of Assistant Firemaster, vacated by Colonel Charles Bingham, is not to be filled at present.

Captain Richard Hardinge, R.A., appointed Assistant Inspector R.C.D. with a salary of £200 p.a. vice Colonel Sir Augustus Frazer appointed Director R.L.

(PRO/WO/47/2,693, p. 926)

4 June 1828. George Chubb, Clerk in the Royal Military Repository, to be attached to the Storekeeper's office vice Gordon Thompson.

(PRO/WO/47/2,693, p. 960)

4 June 1828. A second Foreman of Bricklayers to be employed in the Engineer Department during 1828.

(PRO/WO/47/2,693, p. 962)

11 June 1828. Three lads to be entered as apprentices in the R.C.D.

(PRO/WO/47/2,693, p. 1,002)

23 June 1828. Benjamin Johnston appointed Second Foreman of Bricklayers in the Engineer Department during 1828.

The employment of Gordon Thompson in the Storekeeper's office to be continued during the illness of the two clerks.

(PRO/WO/47/2,693, p. 1,054)

11 July 1828. Edward Russell, 9th Clerk in the Storekeeper's office, resigned.

(PRO/WO/47/2,694, p. 1,157)

23 July 1828. John Bisfer, Labourer under the Civil Officers, discharged for theft.

James Alexander Harvey appointed Clerk on the establishment of the Storekeeper's office vice Edward Russell, resigned.

(PRO/WO/47/2,694, p. 1,219)

30 July 1828. Joseph Carlisle appointed Master Turner in the R.L. vice Thomas Carlisle, his father.

John Ashdown appointed Cooper in the Storekeeper's Department vice William Powling, resigned.

(PRO/WO/47/2,694, p. 1,252)

18 August 1828. Peter Smith, Labourer in the R.L., appointed Turner in the R.L.

Alexander Agar appointed Labourer in the R.L. vice Peter Smith.

(PRO/WO/47/2,694, p. 1,357)

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<i>Four Clerks under the Storekeeper</i>	}	John Guest	£162. 10s. od.
		William Jones	£138
		John Knight	£135
		Cornelius Sharp	£105
<i>Clerk of Works</i>		Thomas Weaver	£271

*Royal Laboratory*

1821 <i>Comptroller</i>		Sir William Congreve, 2nd Bart.	£360 + house
<i>Firemaster</i>		Lieut-General Rochfort	£230 + house
<i>Assistant Firemaster</i>		Lieut-Colonel Charles Bingham	£230 + house
<i>Inspector of Royal Manufactories of Gunpowder</i>	}	Captain William Eyles Maling	£200 + house
<i>Four Clerks</i>			Henry Dugleby William Caffin
<i>Chief Foreman</i>		Charles Ellis John Piper William Castledine	£170 £170 £118. 12s. od.

*Inspectorate of Artillery and Royal Brass Foundry*

<i>Inspector</i>		Major-General Sir Thomas Blomefield, Bart.	£402
<i>Assistant Inspector and Draughtsman</i>	}	John Hookham	£438. 10s. od.
<i>Proofmaster</i>			Lieut. Alexander Reid R.A.
<i>Clerks</i>	}	R. White	£253. 6s. od.
<i>Searcher and Instrument Keeper</i>			Thomas Monk
<i>Modeller</i>	}	Thomas Walton	£100. 7s. 6d.
<i>Founder</i>			Samuel Eccles
<i>Foreman of Foundry</i>		Cornelius King William North	£271 £142. 15s. od.

*Royal Carriage Department*

<i>Inspector</i>		Major-General William Cuppige	£400 + house
<i>Assistant Inspector</i>		Lieut.-Colonel William Millar	£275 + house
<i>Junior Constructor of Carriages</i>	}	George Salter	£135
<i>Clerk of Cheque</i>			George Robinson
<i>Clerk in the Inspector's Office</i>	}	Adam Grinton	£183. 6s. od.
<i>Clerks under the Clerk of the Cheque</i>			Richard T. Russell
<i>Master Carpenter</i>	}	Edward Dell	£145
<i>Master Wheeler</i>			Peter MacDonald Charles Dibblin

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'misteries' of the fireworker's art. They were an expensive luxury, though no doubt it was money spent in a good cause.<sup>1</sup> They were normally exhibited in Hyde Park by artillerymen from the R.L. who proceeded to London, camped on the site, erected the stands and carried out the display.

*War rockets*

Events in the East drawing attention to the value of rockets in war, the Board of Ordnance applied to the Royal Laboratory for the services of someone conversant with their manufacture. Being unable to help, the Comptroller referred the Board to the Honourable East Indian Company; but without avail, no expert was forthcoming. This lack of talent induced Colonel Congreve of the Hanoverian Army and son of the Comptroller, R.L., to turn his attention to the subject. He did so with marked success and in 1804 became the pioneer of the Congreve, or first British war rocket. Congreve's original experiments, carried out at his own expense, were not too outstandingly successful. Try as he might, he could not succeed at first in attaining a greater range than 500 or 600 yards. After modification he managed to cover 1,500 yards. Further alteration to some 6 pdr rockets achieved a ranging distance of 2,000 yards. Finally in the spring of 1806 he amended his design fundamentally by substituting an iron for a paper case and decreasing the length of the stick. He also constructed some 32 pdr rockets with carcass heads which incorporated the latest features. Fortune smiled on him and possibly his expectations were surpassed when the range of these new patterns averaged 3,000 yards. This 32 pdr rocket had its composition completely encased in a stout iron cylinder terminating in a conically shaped head. It was 3 feet 6 inches long, 4 inches in diameter, 32lb. in weight and carried a stick 15 feet long. The carcass head contained an equivalent amount of incendiary matter to that in the ordinary 10 inch spherical pattern, a projectile which would have required a heavy gun to project it and then only to an approximate distance of 2,000 yards. No wonder that William Congreve considered that he had found the ideal weapon. The range of this rocket could be varied between 1,500 and 3,000 yards by altering the angle of projection, the maximum being achieved at an elevation of 55 degrees.

Congreve's service rockets were of the following sizes:

<i>Size</i>	<i>Maximum range in yards</i>
6 pdr case shot	2,000
9 pdr shrapnel	3,000
12 pdr case shot	2,000-3,000
32 pdr explosive	2,500-3,000
32 pdr case shot	2,500-3,000
32 pdr shell	3,000

<sup>1</sup> £190. 5s. od. was paid in additional wages to those employed in the preparation and display of fireworks in Hyde Park and other places on the occasion of the coronation of George IV, 19 July 1821.

(Extract of Ordnance Minute, Series II, PRO/WO/47/2,672, p. 2,167, 30 July 1821.)  
 £1,500 was spent on fireworks for the coronations of William IV and Queen Victoria.  
 (Ordnance Minutes, PRO/WO/47/1,790, p. 6,545, 30 May 1838.)

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32 pdr carcass	2,500-3,000
42 pdr shell	3,000
42 pdr carcass	3,000

though, in addition, larger experimental patterns were tried but without success. These were the 100 pdr, 200 pdr, and 300 pdr rockets; a heavy carcass headed rocket built of six rocket units; and a compound rocket. The weights were no doubt excessive for the power available from the charges. Congreve's rocket most commonly in demand as a general purpose weapon was the 32 pdr.

Although it had been hoped to use rockets in the projected attack on Boulogne harbour on 21 November 1805, a change of wind prevented the operation. Nevertheless on 18 October 1806, eighteen boats discharged 200 rockets into the town within half an hour and started a considerable conflagration without incurring the slightest opposition. In 1807, Copenhagen suffered serious damage from a rocket bombardment, and a similar occurrence took place at Walcheren. In 1813, the 2nd Rocket Troop, then just formed, vindicated at Leipsig Congreve's faith on the value of rocketeers in the field, and lastly rockets gave a good account of themselves against the French boats at the passage of the Adour. In 1821, 9 pdr, 12 pdr and 24 pdr fantail rockets were in existence. These had a shell in the head and carried a long detachable iron tail about 4 inches in breadth, shaped like a flat paddle or fin. On 14 September 1864, the 6 pdr, 12 pdr and 24 pdr Congreve rockets were provisionally superseded by those of Boxer's design which were sealed in August 1864.

These new rockets had two advantages over their predecessors:

(1) Their bodies were strengthened by altering the position of the vents. The Congreve rocket had the stick attached to a disc which closed up the end of the conical hollow, so that the vents, five in number, had to be made through the base of the composition around it. The composition was liable to give way on discharge and burst the rocket. This fault was remedied in the Boxer pattern by slotting three vents in the disc opposite the base of the conical hollow so as to leave the ring of composition strong and unbroken.

(2) Their accuracy was improved by the employment of a stronger composition. This caused the rocket to 'jump off' with a high initial velocity.

There were also several other minor improvements which the passage of time had demonstrated.

Boxer's 3 pdr rocket was provisionally approved on 1 October 1866, but on 24 April following it was decided to discontinue the use of war rockets as shell. Finally, Congreve's rockets were declared obsolete on 14 August 1866 and in the following year Boxer's pattern was replaced by Hale's which was considered to be superior in construction. Four sizes of Hale's rockets were originally made, being introduced into the service as under:

3 pdr, 6 pdr and 12 pdr, on 25 July 1867  
 24 pdr, on 31 August 1867



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The 3 pdr and 12 pdr rockets, however, soon fell into abeyance and only the 6 pdr and 24 pdr continued to be made, but the former actually weighing 9lb. its nomenclature was changed accordingly on 27 November 1867. It was adopted for general field service at the same time. Hale's rockets carried a considerable distance, some 24 pdrs fired in 1868 at 15 degrees elevation attaining a mean range of 1,896 yards.

By now it had become realized that war rockets, although formerly considered to possess great moral and incendiary effects, suffered from five main defects which, in view of the growing excellence of artillery, rendered their use less attractive.

These five defects were:

- (1) Liability to corrosion and rapid deterioration.
- (2) The gradual means by which their velocity is imparted to them renders their flight slow and erratic.
- (3) They are easily affected by gravity and wind, and are therefore constantly liable to change their direction during flight.
- (4) Rockets carrying a stick (such as Congreve's) increase the inaccuracies introduced by wind and air currents.
- (5) As their charge continued to burn during flight, their centres of gravity constantly altered and disturbed their steadiness.

The Hale rocket underwent several modifications during the course of its life. It consisted of a head, a case, a base-piece, a tail-piece and a safety cap. The case, originally of the best charcoal iron which soon gave way to Atlas metal, was fashioned by rolling the material into a cylinder with lapped edges. This was riveted and brazed along the longitudinal joint. The latest patterns substituted steel tubing cut to correct length. The head, conoidal in shape and of cast iron, with a hollow portion subsequently plugged with oak, was fastened to the case by rivets. The case was corrugated in three places better to grip the composition and prevent it from twisting under rotational stress. The composition, consisting of saltpetre, sulphur and charcoal, was separated from the head by a mill-board disc. It was introduced into the case in successive pellets and pressed down hydraulically, a conically shaped hole being then bored out for about two-thirds of its length. A mill board washer was then inserted before the base-piece of wrought iron was fitted into the end of the case and secured by screws. This base-piece, varying in thickness from 0.8 inches in the 9 pdr rocket to 1.25 inches in the 24 pdr, was bored out and screw-threaded internally to receive the tail-piece and externally to accommodate the safety cap. The tail-piece of cast-iron contained three conical vents, the largest portion of the cones being towards the interior of the rocket. The vents were cut away on one side; hence on ignition the gas issuing from the vents met with resistance on the sides where they were prolonged, and, there being no counterbalancing resistance where they were cut away, imparted a rotary movement to the rocket during flight. The safety cap of mild steel was screwed to the base-piece to prevent the rocket, by causing it to burst *in situ*, from becoming a dangerous missile should accidental ignition occur. These rockets, therefore, differed in principle from those of Congreve and Boxer in having turbine rotation

instead of a long stick to control their flight. The cases of the original marks of Hale's rockets were greased internally with tallow but this method of treatment was abandoned on 1 September 1870 in favour of two coats of paint. Originally, the cases were painted externally with Brunswick black but a red paint was substituted in 1870, the actual pigment being improved in 1873. Although the 24 pdr was the largest rocket introduced into the service, a series of experiments were carried out at Shoeburyness with a 6-inch rocket weighing 100lb. This had a charge of about 13lb. of wet guncotton in its head capable of being detonated by a 45 grain fulminate of mercury detonator operated by a fuze resembling *Fuze R.L. percussion*. During the trials a range of about 3,000 yards was obtained at 20 degrees elevation.

A machine or trough for launching Hale's rockets was introduced on 17 September 1867, a Sea Service apparatus being already in existence having been adopted on 13 June 1866. The latter was superseded by Hale's machine until that in turn was replaced by the *Sea Service rocket tube machine Mark II* proposed by Lieutenant Fisher R.N. and approved for the Royal Navy on 7 September 1869. Hale's machine did not long survive, few being made, but a special stand for firing Hale's 9 pdr rockets was provisionally approved on 19 November 1867 for the Abyssinian expedition. Finally, trough machines for launching 9 pdr and 24 pdr rockets were introduced respectively on 8 June and 10 July 1868. Thus these two sizes were the only survivals of war rockets of the past, and as artillery improved and better ballistics usurped their functions, their use more and more declined. However, these weapons lingered on and mark succeeded mark till World War I administered their *coup de grace*, and the Mark VII patterns of both rockets were finally declared obsolete on 11 September 1919.

#### *Life saving rockets*

'Peace hath her victories no less renowned than war' and in contrast to the rocket for offensive purposes was the *Rocket, life-saving*, introduced by Colonel Boxer. This was in use for many years, and mark succeeded mark, till it was finally superseded by the *Life-saving rocket apparatus* at present used by the Board of Trade.

#### *More modern pyrotechnics*

Although signal lights and coloured fire had long since been used for display purposes, no practical use of the illuminating as contrasted with the incendiary properties of fireworks appears to have been made until the middle of the nineteenth century, when signal or sky rockets were introduced as follows:

- (1) The 2lb., 1lb. and  $\frac{1}{2}$ lb. on 24 April 1863, finally sealed as Mark I on 27 January 1866.
- (2) A special  $\frac{1}{4}$ lb. rocket and stick provisionally approved for the Abyssinian expedition on 19 November 1867.

Rockets, light and sound followed, being approved for service on 25 April 1878.

There was little development in pyrotechnics after this date until the