THE RISE AND PROGRESS
of the
BRITISH EXPLOSIVES
INDUSTRY
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OF THE
BRITISH EXPLOSIVES
INDUSTRY.
FIG. 1. SIR ANDREW NOBLE, BART., K.C.B., F.R.S.
(From a portrait painted by H. Harries Brown. Photographed by Paul Laib.)
THE RISE AND PROGRESS
OF THE
BRITISH EXPLOSIVES
INDUSTRY

PUBLISHED UNDER THE AUSPICES OF THE
VIth INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY
BY ITS
EXPLOSIVES SECTION

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NEW YORK: 64 & 66, FIFTH AVENUE
1909
AT a meeting of the Committee of the Explosives Section of the 'Seventh International Congress of Applied Chemistry held on 5th December, 1908, it was proposed by Mr. Guttmann, and carried unanimously, that a history of the rise and progress of the Explosives Industry in the British Isles should be compiled. A publication sub-committee was formed, consisting of:

Captain T. G. Tulloch, late R.A. (ex officio).
Major Cooper-Key, late R.A., H.M. Chief Inspector of Explosives.
Oscar Guttmann, M. Inst. C.E., F.I.C.
W. R. Hodgkinson, Ph.D., J.S., F.I.C., Ordnance College, Woolwich.

The Executive Committee of the Congress was approached for a grant in aid of the expenses, and very cordially responded.

The sub-committee succeeded in securing the services of Mr. E. A. Brayley Hodgetts as Editor.

The preparation and compilation of the vast amount of information embodied in this book has been a labour of considerable magnitude, and has involved an amount of research, investigation and cross-reference, which can only be appreciated by those who have worked in similar fields.

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I therefore feel that not only the Explosives Industry, but also posterity, are under obligation especially to Mr. Guttmann, to whom the book owes its inception in the first instance, and to whose great energy, vast stores of knowledge, and exceptionally complete library the successful compilation of this elaborate work is chiefly due.

Nor are his colleagues on the publication sub-committee, Major Cooper-Key and Professor Hodgkinson, less deserving of gratitude. Despite the arduous nature of their official engagements, they have greatly assisted in the successful carrying out of this task.

Mr. Brayley Hodgetts may, I think, be congratulated on the manner in which he has very successfully surmounted the difficulties of compressing the large quantities of material at the command of the publication sub-committee into a form which suffers neither from redundancy nor incompleteness. He has dealt with the large amount of scientific matter placed in his hands with much literary skill, whilst the task of editing the historical and manufacturing details could not have been done with more tact and ability.

I say advisedly that posterity is under obligation to these gentlemen, because in years to come I hope that this book will be looked upon as a work of reference connecting the past with the future, for it is, to the best of my knowledge, the only work of the kind containing so complete a history of the manufacture of explosives in this country.

The ready response to the inquiries of the sub-committee for material for the work was most gratifying, some gentlemen and firms going considerably out of their way to write articles which testify to the time and labour they must have bestowed
upon them, and the Committee of the Explosives Section of the Congress take this opportunity of expressing to all these gentlemen their grateful thanks for the great assistance they have given.

The Committee also desire especially to mention, in addition to the names of the gentlemen who appear as the authors of special articles in the Table of Contents, Professor P. Philips Bedson, Mr. Herbert Blanch, Mr. J. W. Gordon, Mr. Rhys Jenkins, and Mr. E. H. Stone, who have rendered valuable services.

It will be noticed that specific reference to the latest type of machines, processes and methods of manufacture, have been advisedly avoided, primarily because the work deals with past history, and also because it would be invidious to mention any one machine, process or method, without mentioning all—an impossible task in the space available. For such latter information the reader is referred to current literature.

The portraits which appear are confined to those who were connected prominently with the epoch-making events in the past of the Explosives Industry. It is, however, a source of pride and gratification to the Committee that among the portraits should be that of their revered President, Sir Andrew Noble, whose researches and labours in the Explosives field, and in many contiguous ones, are so deservedly renowned.

The illustrations of works, etc., are merely intended to serve as types, or are of historical interest.

In conclusion, I wish to add a word of thanks to the publishers, Messrs. Whittaker and Co., who undertook to
PREFACE

carry out all the wishes of the publication sub-committee on terms which indicated their desire to lighten as much as possible the work and responsibility.

T. G. TULLOCH,
Vice-President (Explosives Section)
VIIth International Congress of Applied Chemistry.

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\(^1\) Reproduced from "Monumenta pulveris pyrii," by Oscar Guttmann.
HISTORICAL PART
THE RISE AND PROGRESS
OF THE
BRITISH EXPLOSIVES INDUSTRY

HISTORY OF GUNPOWDER

By E. A. Brayley Hodgetts

The highest development of civilization has synchronized with
the increase and growth of the means of destruction at the
disposal of mankind. To the superficial untrained mind, and more
particularly to the loose-thinking satirist of modern progress, the above
statement will appear as at once a paradox and an additional argument
against the highly organized and artificial structure of contemporary
society. But dispassionate reflection will show that the better the
means possessed by society of self-preservation, and consequently of
defence and offence, the more assured must be its continuance, the less
exposed to disturbance and interruption its natural growth. The
evolution of society has, however, proceeded from stage to stage
by conflict, for, as the late Sir W. R. Grove, the discoverer of the
correlation of the physical forces, postulated, the law of antagonism is
the foundation of progress. It is by his superior means of destruction
that man has conquered the wild beasts of the field and forest, and it
is thanks to the same means that the cultured races have succeeded in
imposing their civilization on barbarians and savages. If, however, the
increased power of destruction possessed by modern society makes our
means of defence and offence more deadly, the actual effect of the
invention or discovery of these destructive methods has been to render
modern warfare increasingly humane. In the old days of hand-to-hand
combat, the proportion of killed and wounded in a battle was far greater
than has been the case since the invention of gunpowder, and to-day the terrific destructive force of modern high explosives is such as entirely to revolutionize military tactics, the object of the attacking force being to make itself invisible, and by an extended front offer no target to the enemy, indeed it might almost be said that in the modern art of war more importance is attached to the preservation of the lives of one's own troops than to the destruction of those of the enemy. Certain it is that the carnage of modern warfare, in spite of the infinitely greater efficiency of engines of war, is incomparably small and almost insignificant by the side of the wholesale devastations of the middle ages.

Still more beneficent in its influence on humanity has been the effect of the development of the industrial uses of explosives. By means of blasting powder, and particularly of dynamite, mankind has been enabled to transform the face of the earth. An exhaustive inquiry into the first uses and applications of the explosive which is still commonly called gunpowder, though its employment as a military propellent has been discontinued by civilized countries, still presents fascinating features to the antiquarian.

In the "Handbook on the Manufacture of Gunpowder," by Captain F. M. Smith, R.A., printed by the Government in 1871, gunpowder is stated to have been used in the earliest ages, "principally amongst the Eastern Nations." Captain Smith refers to "a code of Indian laws," supposed to have been compiled in the time of Moses which contains "reference to cannon and guns," as well as to the claim laid by the Chinese to the early invention of powder; thus, according to the writers who insist on the fabulous antiquity of gunpowder, Schwartz or Roger Bacon, who had hitherto been regarded as entitled to the merit of the invention, had only re-discovered what had been known thousands of years before. Captain Smith, while admitting that substances resembling gunpowder, but composed principally of saltpetre, may have been used in the East at a very early period, considers it extremely improbable, however, for gunpowder proper to have been known and used as such

1 The Gentoo Laws.
before comparatively modern times. He argues that although the deflagrating properties of saltpetre, which is found as a natural product in many parts of Asia, must have attracted early attention, and although its employment as an ingredient of burning compositions was probably general, it is too much to believe that the use of firearms, which would have given one nation such an advantage over another, should ever have been forgotten after it had once become known. He therefore concluded that the terms used in ancient manuscripts must have received modern interpretations which were foreign to their original meaning, for, as he points out, even if gunpowder were known thousands of years ago, it had little interest until used as a propellant; and as the use of firearms in Europe dates from about the beginning of the fourteenth century, he maintains that their employment in other parts of the globe could not have been general at a much earlier date.

Oscar Guttmann, in "The Manufacture of Explosives," asserts that the Arabians knew of saltpetre as early as the eighth century, but adds that "it is not until the time of Roger Bacon, in the thirteenth century, that we find any mention of the property that saltpetre has of deflagrating with burning bodies." He also discredits the supposed antiquity of gunpowder. That the Chinese did not know of it appears plain to him from the fact that they were frightened when three pieces of ordnance, which the Portuguese of Macao had presented to them, were tried.

With regard to the Hindus, he demonstrates the correctness of Captain Smith's shrewd suspicion as to the inaccuracy of translators, and points out that had the Hindus really invented gunpowder, the inhabitants of Mozambique would very probably have been less alarmed than they were by the report of the guns of Vasco de Gama in 1497, seeing that close trading relations existed between India and these parts, and that the eastern coast of Africa was inhabited by Malays. Professor P. C. Ray, in his "Hindu Chemistry," from a careful study of the question, also comes to the conclusion that the Hindus did not know of gunpowder.
Guttmann adds: "It is equally hard (on the existing evidence) to believe that the Arabians knew of gunpowder as a propelling agent before the year 1313."

He cites from the Annals of the Town of Ghent an entry to the effect that the use of gunpowder was invented in the fourteenth century by a German monk; but considers that although Berthold Schwarz, the Franciscan monk of Freiburg, was without doubt the inventor of firearms, there is nothing to prove that he also invented gunpowder.

Guttmann sums up a very careful and exhaustive review of all the available evidence, and comes to the conclusion that gunpowder was developed from Greek fire and known years before cannon or guns were thought of. The use of purer materials in making it developed its propulsive power and led to the subsequent invention of cannon and guns. The Arabians were the first to make compounds resembling gunpowder about 1280, whilst the idea of utilising the propulsive force inherent in the same, that is the invention of guns and cannon, was originated by Berthold Schwarz, a monk of Freiburg, in about 1313.

Lieutenant-Colonel Henry Hime, R.A., in his "Gunpowder and Ammunition," published in 1904, whilst admitting that the attention of the ancients was naturally attracted by the efflorescences which form on certain stones, on walls, and in caves and cellars, and that the Hindus and nomad Arabs must have noticed the deflagration of at least one of them when a fire was lit on it, points out that these efflorescences consisted of various salts, so similar in appearance and taste, that early observers succeeded in discriminating only one of them, common salt, from the rest. He shows that the radical difference between potash and soda was not finally established by Du Hamel before 1736, and maintains that no trace of saltpetre has hitherto been found anywhere before the thirteenth century; for the Greek alchemists of preceding centuries are silent, and in the earliest recipe we possess for Greek fire, No. 26 of the "Liber Ignium," ascribed to Marcus Graecus (Paris MS. 1300; Munich MS. 1438), there is no saltpetre. Although sal coctus is translated in M. Hoefer's "Histoire de la Chimie" by salt-
FIG. 2. ROGER BACON.
(Photograph of a painting at Knole Castle.)
petre; MM. Reinaud and Favé contend that such a rendering was unjustifiable. Colonel Hime then proceeds to the demolition of the theory that the Arabs knew saltpetre in the ninth century by showing how Berthelot had discovered two Gebers; the real original Arab Geber knowing nothing of saltpetre, whilst the other, who was a Western and did, lived about the time of the year 1300. Turning from the Arabs to the Hindus, Colonel Hime finds that there is no word for saltpetre in Sanskrit. Although the Egyptians called it Chinese snow, Colonel Hime does not think this justifies the conclusion that saltpetre was discovered by the Chinese. Friar Bacon, whose "De Secretis" was written before 1249, and Hassan-el-Rammah, who flourished 1275-95, were thoroughly acquainted with the salt. Yet Bacon speaks of it as one would speak of a substance recently discovered and little known.

Space will not permit us to follow Colonel Hime's closely reasoned chain of destructive criticism, nor to reproduce his ingenious reading of Bacon's cryptogram, of which he says that the method Bacon appears to have adopted was that known long afterwards as the "Argyle cipher," of which an example from Thackeray's "Esmond" is given by him. The result is so overwhelmingly conclusive that his reading has received prompt and universal acceptance.

Chapters IX and X are proved by him to give instructions for refining saltpetre, and his interpretation of Bacon's famous anagram in Chapter XI, is equally brilliant. The passage runs as follows:

"Item pondus totum 30. Sed tamen salis petrae LURU VOPO VIR CAN UTRIET sulphuris; et sic facies tonitruum et coruscationem, si scias artificium. Videas tamen utrum loquor aenigmate aut secundum veritatem."

Which interpreted into English, and omitting the anagram, means:

"Let the total weight (of the ingredients) be 30. However, of saltpetre . . . of sulphur; and with such a mixture you will produce a thundering noise and a bright flash if you know 'the trick.' You may find (by actual experiment) whether I am writing riddles to you or the plain truth."
Colonel Hime then re-arranges the letters of the anagram as follows:

RVIPARTVNOUCORULVET,

or, since v and u are interchangeable, makes the whole passage in the original read:

“sed tamen salis petrae recipe vii partes, v novellae coruli, v et sulphuris” etc., that is—

“but take 7 parts of saltpetre, 5 of young hazelwood, and 5 of sulphur,” etc.

But Colonel Hime does not base Bacon's claims on these anagrams and shows on grounds independent of the steganogram and the anagram, that Bacon was in possession of an explosive. Colonel Hime, while destroying Marcus Graecus, whose tract he says was the work of neither one author nor one period, and of whom he concludes that he was “as unreal as the imaginary Greek original of the tract which bears his name,” does not claim for Bacon more than that he discovered but did not invent gunpowder; and maintains that though he knew it exploded, Bacon was not aware of its projective force.

This conclusion, while amply vindicated, will hardly satisfy the adherents of Schwartz, who will no doubt continue to maintain that the discovery of gunpowder as an incendiary only was of comparatively small utility, and that by burying his invention in a cipher, Bacon had forfeited the gratitude of humanity. At least, it does not appear that Bacon's invention was of great benefit to his own country, for previous to the reign of Queen Elizabeth most of the gunpowder used in England was imported from abroad. John Barbour, Archdeacon of Aberdeen, writing his metrical life of Robert Bruce in 1375, says describing the invasion of Scotland by Edward III in 1327.

Twa noweltys that dai thai saw,
That forouth in Scotland had been nane,
Tymmris for helmys war the tane,
That thaim thought than off grete bewte
And alsua wondere for to se;
The tothyr crakys war off wer,
That thai before herd nevir er.
HISTORY OF GUNPOWDER

If Edward III used "crakys" of war in 1327, and Schwarz is to have the credit claimed for him, there seems to be no alternative but to accept the theory adopted by Colonel Hime and expounded in his paper on "Our earliest Cannon" before the Royal Artillery Institution in 1900. He there gives the date of Schwarz's invention as 1313, as in the Ghent annals, and shows that in 1314 the Commercial Records of Ghent contain more than one entry to the effect that guns and powder had been despatched during that year to England.

In the plate on p. 13 is shown a bottle-shaped mortar (Hime calls it a dart-throwing vase), reproduced from an illuminated Latin MS. belonging to Christ Church, Oxford, dated 1326, and dedicated by its English author, Walter de Millemete, to Edward III.

When the Scotch defended Berwick against Edward II, in 1319, the soul of the defence was John Crab, "a Flemyne of gret subtilte," Peter van Vullacre, who had been "Maitre des ribau dequins" at Bruges in 1339, took service with the English force which was to have invaded France in 1345, but did not actually set out until 1346; and he it was who in all probability commanded the guns at Cressy, for which Napoleon III gave us credit.

Whatever the date of the invention of cannon, artillery was evidently known in 1380, because Chaucer, in his "House of Fame," written at that date, has the following lines:

As swift as pelet out of gunne,
When fyr is in the poudre runne.

There is unquestionable testimony that cannon, both brass and iron, were employed on board English ships of war in 1338, testimony at least sufficient to satisfy General Sir H. Brackenbury, as a reference to vol. iv, p. 291 of the "Proceedings of the Royal Artillery Institution" will show. Two years later the English Navy employed guns at the battle of Sluys, but without effect.

The gun depicted by Froissart, which may be taken to be a fairly accurate representation of the type used at Cressy, shows a great
advance on the *pot de fer* of 1326-7; it is a breech-loader which should certainly have fired iron or leaden case balls, and may even have fired stone shot the size of the bore.

To return to powder, the first distinct reference to gunpowder occurs in 12 Edward III, 1338, when it is mentioned in an indenture. Francis Grose in his "History of the English Army" (1801), makes us suspicious of these early records, and shows how Cotton, who in his "Abridgement of the Records of the Tower of London," says that "pardon was made out 14 Edward III to Thomas de Brookhall for a debt of 32 tons of powder," misread the original entry where the word *pomadre*, meaning cyder, is used.

William Henry Hart of the Public Record Office, in his very interesting pamphlet on the "Early Manufacture of Gunpowder in England," published in 1855, tells us that John Cook, clerk of the king's great wardrobe, in an account dated 10th May, 1346, stated that 912 pounds of saltpetre and 886 pounds of quick sulphur were supplied to the King for his guns.

The old method of obtaining saltpetre was to collect vegetable and animal refuse containing nitrogen, the sweepings of slaughter-houses, weeds, etc., into heaps and to mix this with limestone, old mortar, earth and ashes. These heaps were sheltered from the rain, and kept moist from time to time with runnings from stables and other urine.

As late as in the reign of James I (1624), we find in an indenture between the King and Thomas Warricke, Peter Sparke, Michael Townshend and John Fells, the statement that "for making of the saltpetre which hath been formerly and now is made . . . it has been found a matter of mere necessity to dig houses, cellars, vaults, stables, dovehouses and such like places, wherewith divers of his Majesty's subjects have found themselves grieved." We are also informed that the conveyance of the liquors, vessels, tubs, ashes, etc., from place to place in carts had been a frequent source of nuisance and litigation.

The above persons purporting to have invented a new process for making saltpetre undertake to make it "as good and perfect as any
FIG. 3. FROM WALTER DE MILLEMETE'S MANUSCRIPT. A.D. 1326.

(By kind permission of the Dean of Christ Church.)
hath formerly been, and shall be vented at cheaper and easier rates than formerly his Majesty or his loving subjects have paid for the same, which said saltpetre as His Majesty is informed is to be or may be made of an artificial mixture or composition of chalk, all sorts of limestone and lime, marl, divers minerals, and other nitrous mines and other kind of ordinary earth, street dirt, or rubbish, stable dung, emptying of vaults, the excrements of all living creatures, their bodies putrified, all vegetables putrified or rotted, or the ashes of them, and these or any of these mixed together in proportion as they may be most conveniently had, and shall be found most useful in such places where the said works shall be thought fit to be erected, which said artificial mixture or composition of any or all the foresaid ingredients is often times moistened with urine of men and beasts, petre, or nitrous wells, and springs, and all other concrete juices and blood of all sorts as can be gotten, and shall be fit and convenient for it, and divers times turned and removed, by which means the mixture in time digesteth, fermenteth, and ripeneth, from whence there is engendered the seed or mine of saltpetre which afterwards is to be extracted with common water, urine, the water of petre or nitrous wells, and springs, and then either breathed away in the sun or air, or stoved with gentle heat or boiled with a stronger fire with his proper additament of ashes, lime, and such like for separating the common salt and other mixtures naturally growing in the liquor and afterwards refined into perfect saltpetre."

The King then granted the patentees licence to exercise their invention for a term of twenty-one years and to set up houses for preparing the artificial earth, etc.

On 26th December of the same year "was issued a proclamation, commanding that no dovehouses or cellars be paved, except that part of the cellars where the wine and beer is laid, in order that the growth of saltpetre might not be obstructed." (Patent Roll, 22 James I, part 4, No. 9 dorso.)

In March, 1378, in the first year of Richard II, Thomas Norwich
This is a powder mill, the movement whereof is of such fashion, that after it be set once in his motion, the workman, which turneth the said mill, may intend any other business $\frac{3}{4}$ of an hour or more, and yet the mill shall not cease in his motion, but both the blade and the mill turn it all at once. For the handle A being moved the wheel B and the axle-tree E, with the lantern C moueth also. In which lantern C moueth the wheel F, the axe-tree O and the wheel G, which redwheel I moueth the lantern H. The axe-tree K, the wheel L and the wheel and branch M. The axe-tree M moueth the arm I by means of the cogger T. The wheel L moueth the lantern S within the swingle T, about which swingeth, by reason of the weight at the end of the barres, suchwise the easy movement of the said mill. The wheel M being fast to the branch M, causeth the easy movement of the stroke O. Which be in the case N, standing upon the branch M. By means wherof the powder assisted, the figure R sheweth that the movement may be adapted to an iron mill or flint mill, or grist mill, as well as a powder mill.

FIG. 4. ENGLISH STAMP MILL IN THE SIXTEENTH CENTURY.
was ordered to buy saltpetre, sulphur, and charcoal to be sent to the Castle of Brest, and in 1414 Henry V decreed that no gunpowder should be taken out of the Kingdom without special licence. Henry VI in 1457 appointed as Master of the Ordnance for life John Judde, merchant of London, who was skilled in the devising of warlike instruments, and had made at his own expense sixty guns called serpentines, and twenty tons of "stuff for gunpowder of saltpetre and sulphur."

We find in 1512 a Th. Hart making gunpowder in Rochester Castle, and in 1514 a house let by the new Hospital of our Lady Bishopsgate Without for the making of gunpowder; further, the appointment of Hans Wolf, a foreigner, to be one of the King's gunpowder makers in the Tower of London and elsewhere, and in 1531 Thomas A Lee, one of the King's gunners, to be principal searcher and maker of saltpetre. In 1555 Henry Reve erects a gunpowder mill on a parcel of pasture ground called "The Crenge," in Rotherhithe, and in 1559 there are already tenders by the powder makers for the supply of gunpowder. In 1562 John Thomworth of Waltham is in treaty, on behalf of Queen Elizabeth, for the purchase of saltpetre, sulphur and bow staves for barrels, and presumably a powder-mill existed there at that time. In 1562 three gunpowder makers, Bryan Hogge, Robert Thomas and Francis A Lee tendered for the supply of gunpowder, the same Lee being described in the particulars of leases of Elizabeth in 1578 as gunpowder maker to the Queen, and having a gunpowder mill and pond "in the tenure of Thomas Lee, deceased and now of Francis Lee, his son, in Rotherhithe, near the Thames." This was probably the mill erected by Reve in 1555. It is to be noted, however, that in a petition in 1575 Lee calls himself "Francis Leigh, gunpowder maker to the Council," and says that he and his father and brother have been for fifty years "The greatest dealers therein, and he has all the implements." The gunpowder mill at Leigh Place, near Godstone, in Surrey, which existed about 1560, and was later on the property of the Evelyns, may well have also been erected by the Lees or Leighs. In 1576 one John Bovyat seems to
This mill is also for making of powder, and yeoth double and struche where the commodity of water is to be had. The water running through the cask A falls in the wheel B turning the gear C and the wheel D. The wheel D turnseth the latten E and F and also the wheels G and H. Each side amongst the hammer J and K. Which hammer beat the powder. This wheel D in his motion moveth the latten L. The wheel M week somewhat assisteth the facility of the motion, it moveth consequendy the fores N and the branches O. Whereon the stone P stand in the case Q by which meaneth the stone is pointed. The wheel M, through to make swords, blades and knives. When the mill standeth fast.

FIG. 5. ENGLISH STAMP MILL IN THE SIXTEENTH CENTURY.
have received a patent for making saltpetre and gunpowder "from stone, mineral and other substance not now used therein," and in 1580 one Sebastian Orlandini and John Smithe seem to have erected clandestinely a glass furnace in a gunpowder mill in Ratcliffe.

Until the latter end of Queen Elizabeth's reign there had been free trade in gunpowder, but then as now, the country became subject to war scares, and the menacing attitude assumed by Spain compelled the Government to take a serious view of the question of national defence. Commissions or monopolies were therefore granted to private persons for the manufacture of gunpowder; and so we find that in 1588 George Evelyn, Richard Hills and John Evelyn were given licence and authority for the term of eleven years "to dig, open and work for saltpetre," anywhere they liked except in the City of London and two miles outside it and the northern counties of York, Northumberland, Westmoreland, Cumberland, and the Bishopric of Durham. George Constable was given in 1589 a similar licence for these northern counties. John Grange and Ralph Hockenhull were also engaged in making gunpowder, and in the following year Thomas and Robert Robinson were given the right over London and Westminster. These patentees or monopolists appointed their own saltpetre men under their respective licences to dig and search for saltpetre, and to call upon the local authorities to provide carriage for the liquors "fit for making saltpetre." These saltpetre men often abused their privileges and were hated and abhorred by the rest of the community, their conduct frequently giving cause for litigation.

The Evelyns appear to have been the first manufacturers of gunpowder on a large scale in the United Kingdom, and the licence conferred on the Robinsons was transferred to them in 1596, so that they practically held the monopoly. George Evelyn is said to have learned the art in Flanders, and was the grandfather of the famous John Evelyn.

There are numerous covenants on record wherein various members of the Evelyn family undertake in conjunction with partners of different
names to deliver yearly to the Tower of London certain quantities of
gunpowder. In 1620 James I granted a license "to make and work
for saltpetre and gunpowder" to George, Marquis of Buckingham,
High Admiral of England, George, Lord Carew, Master of the
Ordnance, and Sir Lionel Cranfield, Master of the Court of Wards and
Liveries. In the letters patent, dated 24th January, reference is made
to the "many abuses of sundry inferior persons" who had been
engaged in the saltpetre industry, and the frequent complaints to which
these had given rise; and to the determination to import this material
from abroad in consequence, but "finding that the same cannot be
performed wholly "from foreign parts without much inconvenience," it
was deemed expedient, whilst not excluding foreign importations, "to
continue the making thereof using such vigilance and care in the
ordering and managing thereof as may best tend to the reformation
and repressing of those enormities and abuses wherewith such inferior
persons did most infest our loving subjects."

In 1623, ostensibly for the prevention of weak or defective powder,
a proclamation was issued by James I prohibiting its manufacture, as
well as that of saltpetre, except under the King's commission, and also
its export, and directing that all gunpowder be proved and marked by
the sworn proof-master.

At last in 1626 we find the East India Company importing salt-
petre. The Company erected powder-mills in Surrey, and its renewed
Charter in 1693 stipulated for the annual provision of 500 tons of
saltpetre to the Ordnance. From this time forward we hear of no
difficulty, at least in England, of obtaining this chief ingredient of
gunpowder.

Guttmann is of opinion that gunpowder was originally prepared in
stone mortars by hand, and that as the consumption increased, mill-
stones were used. That the quantities were very small at first, is shown
by the fact that the King issued a writ, dated 25th November, 1346,
commanding that all the purchasable saltpetre and sulphur should be
bought, and that the quantity thus obtained did not amount to more
FIG. 7.
CHARCOAL CYLINDERS IN 1798. BACK VIEW.
Fig. 8. Sulphur subliming chamber in 1798. Front view.
FIG. 9. SULPHUR SUBLIMING CHAMBER IN 1798. SIDE VIEW.
FIG. 10. POWDER MILL IN 1798. OUTSIDE VIEW.
than 750 pounds of saltpetre and 310 pounds of quick sulphur; whilst in the September of the following year a further quantity of 2,021 pounds of saltpetre and 466 pounds of quick sulphur was purchased.

It may be interesting to inquire into the ingredients of the earliest gunpowder. Bacon's recipe, as interpreted by Colonel Hime, gives the following proportions of the ingredients in one hundred parts:

Saltpetre 41.2, Charcoal 29.4, Sulphur 29.4.

The next complete recipe is given by Dr. John Arderne, of Newark, who commenced to practise as a surgeon before 1350. He says: "Prenez j.li. de souffre vif; de charbones de saulx (i. weloghe) ij. li; de saltpetre vj. li. Si les fetez bien et sotelment moudre sur un pierre de marbre, puis bultez le poudre parmy vn sotille couerchief; cest poudre vault à gettere pelottes de fer, ou de plom, on d'areyne, oue vn instrument que l'em appelle gonne." This works out in hundred parts at:

Saltpetre 66.6, Charcoal 22.2, Sulphur 11.1.

This recipe, while interesting, as being one of the earliest authentic prescriptions on record, is, however, discredited by Hime, who describes it as a literal translation of a recipe for rocket composition given by the apocryphal Marcus Graecus, and points out that its proportions are entirely out of keeping with those of the French powder of 1338, which, however, is incomplete, the quantity of charcoal being omitted. It is interesting to compare this composition with the oldest German one contained in "Cod. membr. Saec. XIV, Rothenburg, o. T." It was:

Saltpetre 58.2, Sulphur 23.6, Charcoal 18.2.

According to Nathaniel Nye ("The Art of Gunnery," 1648), gunpowder was made in the following proportions:

In 1380. Saltpetre, brimstone, and charcoal, in equal parts.
In 1410. Saltpetre 3 parts, brimstone 2 parts, charcoal 2 parts.
In 1480. Saltpetre 8 parts, brimstone 3 parts, charcoal 2 parts.
In 1520. Saltpetre 4 parts, brimstone 1 part, charcoal 1 part.
In 1647. Pistol powder: Saltpetre 6 parts, brimstone 1 part, charcoal 1 part.
   Musket powder: Saltpetre 5 parts, brimstone 1 part, charcoal 1 part.
   Cannon powder: Saltpetre 4 parts, brimstone 1 part, charcoal 1 part.

Colonel Hime gives an interesting chronological table of English gunpowder, in which, however, he includes Dr. Arderne's powder as well as Bacon's. We shall get a juster view of the constancy of the proportions by eliminating these two columns. His table would then
show the steady increase of saltpetre, the most important of the ingredients, thus: for cannon powder

<table>
<thead>
<tr>
<th>Year</th>
<th>Saltpetre</th>
<th>Charcoal</th>
<th>Sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>1560</td>
<td>50.0</td>
<td>33.3</td>
<td>16.6</td>
</tr>
<tr>
<td>1647</td>
<td>66.6</td>
<td>16.6</td>
<td>16.6</td>
</tr>
<tr>
<td>1670</td>
<td>71.4</td>
<td>14.3</td>
<td>14.3</td>
</tr>
<tr>
<td>1742</td>
<td>75.0</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>1781</td>
<td>75</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

An equally interesting investigation of the prices of gunpowder calculated on the prices of the raw materials, leads the same author to the conclusion that English powder cost, in 1378, 1s. 3½d. per pound, equal to about 11s. 4½d. in current coin of our own times. The other prices are quoted from Thorold Rogers's "History of Agricultural Prices," and mark a steady decline from 1s. in 1462, equal to about 10s. to-day, to 10½d. in 1695, and 7d. in 1865. The introduction of corned powder brought with it a slight increase of price; but when the concomitant fall in the purchasing power of money is taken into consideration, the price of 1s. 1d. per pound in 1595 compares favourably from the point of view of the purchaser with that of 10d. in 1482. According to Hart, the price of powder seems to have fluctuated between 1s. and 10d. in the sixteenth century. The high price of gunpowder was largely, if not entirely, due to the difficulty of obtaining, and the consequent dearness of, saltpetre.

The gunpowder in use at the time was commonly called Serpentine Powder, and was merely a loose mechanical mixture of three substances, and was necessarily more or less dusty or crumbly in nature. Its combustion was slow and irregular, and much gas escaped through the vent, so that a low velocity was imparted to the shot, with the result that the gunners made but poor practice.

The obvious remedy for these evils was of course to corn the powder. It is not surprising therefore that the old fireworks books already mention lump powder, and Colonel Hime asserts that long before 1560 it was in use for hand-guns in England. While its rapid combus-
tion caused little or no waste of gas through the vent, and the resultant greater strength enabled 2 lb. of corned to do the work of 3 lb. of serpentine powder, it was at first too strong for cannon, and Whitehorn represents that, if used in pieces of ordnance “without great discretion, it would quickly break or marre them.”

Commenting on the lawlessness as to the proportions of the ingredients, in what he calls the ancient period, Colonel Hime contends that the introduction of corning made confusion worse confounded, the size of the grain being variable. However, during the second half of the fifteenth century, the suitability of large-grained powders for big guns was discovered, and in the seventeenth century we already find three or four kinds of sieves in use, differing in the size of their meshes, so that the coarseness of the grain could be graduated to suit the size of the gun for which the particular powder was required.

With regard to the manufacturing process, the oldest method of mixing the ingredients of gunpowder was with mortar and pestle by hand, later the pestle was suspended from a spring beam and ultimately stamp mills were introduced, driven at first by hand, and later by horses or water-power. Two illustrations of such mills, from a book in the possession of Messrs. E. G. Hulme and Rhys Jenkins, are reproduced on pp. 15 and 17, together with the quaint explanation contained in the book. Incorporating mills were also used at an early date, and the use of stamp mills, except for fine sporting powder, was prohibited in this country on account of their danger by 11 George III, cap. 61 (1772).

We have been fortunate in finding a MS. book, evidently compiled by John Ticking, Master Worker of the Royal Faversham Mills in the year 1798, now owned by Messrs. Curtis's and Harvey. It is beyond the scope of this book to copy in detail the regulations and proof for the manufacture of powder, as given in these notes. It

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1 The hammer mill, R on Fig. 4, represents an iron hammer; but it is well known that similar stamps were used by the Cossacks, and the illustration is very much like that published in Siemienowicz's "Great Artillery," which was translated into English.
FIG. 13. PRESSING, BREAKING AND CORNING POWDER IN 1798.
FIG. 14. CORNING-SIEVE IN 1798.
FIG. 15. SIFTING-SCREEN IN 1798.

The other side of the Screen

M.E. the Screens at Sifertham worked on a larger scale. Sifertham worked by horses.
The first dusting screen, 1798.

FIG. 16. DUSTING-SCREEN IN 1798.
FIG. 17. INTERIOR OF A DRY STOVE IN 1798.
seems that at that time three kinds of "King's Powder" were made, and respectively marked L G in red for a strong powder, L G in blue denoting a powder which was uniform and very durable, and L G in white, one that in general was stronger than the blue, but more liable to become dusty.

Charcoal was already made in cylinders as shown in Fig. 6, and the products of distillation were recovered at the back of the cylinders both from the top and the bottom, as shown in Fig. 7. The sulphur was sublimed in a large chamber, of which views are given in drawings 8 and 9, and the powder was worked in incorporating mills, two of which were attached to a water-wheel, as shown in Fig. 10. The view of the incorporating mill is given in Fig. 11, and it shows the complicated way in which the power was transmitted from the water-wheel to the mills by means of cog-wheels. The incorporating mills had stone runners, and a photograph of such a mill still in existence at Waltham Abbey is shown in Fig. 12. The incorporated powder was put into a screw press and the press cake broken up by hand as shown in Fig. 13; after this the powder was corned in a corning-sieve, shown in Fig. 14, and reeled as shown in Fig. 15. The dusting-screen, as used in Faversham, after the drying, is shown in Fig. 16.

The drying-house shown in Fig. 17 is very interesting. The room was semi-circular, and the powder laid out on racks arranged along the wall in a semi-circle, with a circular rack in the middle. The heat was communicated to the room by means of a stove in the shape of an iron pot set into the wall in an adjoining room, in such a manner, that the bottom was inside the drying-room, and the coal was put into it from the adjoining room. A sheet of copper was placed over the pot when the powder was charged or discharged, and this was protected by a canvas screen.

Fig. 18 shows on the left side a fixed musket barrel, from which a steel ball is shot through 17 wet elm boards shown on the right hand side of the illustration; these were \( \frac{1}{2} \) inch thick and \( \frac{3}{4} \) inch apart, the musket barrel being 39 ft. 10 in. away.
FIG. 19. CHARLES BERWICK CURTIS.
The King’s powder usually shot through 15 or 16 boards.

Further improvements in the manufacture of gunpowder were made by Colonel Sir William Congreve, who worked out many of the modern manufacturing details.

Until an instrument was devised for measuring the comparative strength of different powders, no standard for the proportions of the ingredients and the size of the grain could be established. Bourne’s “engine or little boxe” (1578), is believed to be the earliest instrument of this kind, but is described as “wretched.” It consisted of a small metal cylinder in which the powder was ignited, and was fitted with a heavy hinged lid held in position at the point to which it was raised by means of iron teeth. The angle through which the lid was raised by the explosion indicated the strength of the powder. In the instrument described by Furtenbach in “Halinitro Pyrbolia” in 1627, the lid of the cylinder is movable along two vertical wires, and is also kept in position after explosion by iron teeth. Nye, in 1647, recommended in addition measuring the penetration of pistol balls into clay, and the ranges of projectiles fired from a small mortar. By 1686, the French had adopted the mortier éprouvette, and in 1697 Saint Remy invented his pistol éprouvette, but it was not till 1742 that gunnery was placed upon a strictly scientific basis by the invention—described in General H. Müller’s “Entwicklung der Feldartillerie” (Berlin, 1893), as “epoch-making”—of the ballistic pendulum. This invention, which Benjamin Robins for the first time gave to the world in his “New Principles of Gunnery” made possible the measurement with considerable accuracy, of the muzzle-velocity of projectiles.
RESEARCHES ON GUNPOWDER

By G. W. MacDonald, M.Sc.

Anderson (1) in 1674, and Halley (2) in 1686, supported Galileo's view that the air resistance to projectiles was practically negligible. Newton (3) in 1687, dissented from this view, and was in 1690, supported by Huygens. The first work in England on the velocity of projectiles, air resistance, and the force of gunpowder was carried out by Benjamin Robins (4). He was a noted mathematician, an authority on fortifications, and Engineer-General to the East India Company. He was born at Bath in 1707, and died in India in 1751, shortly after his arrival there, where he had gone to superintend the erection of fortifications which he had designed. His work was translated into French and German, and was continually referred to as authoritative by subsequent writers. He mentions de la Hire as being, in 1702, the first worker on the subject. De la Hire supposed the force of gunpowder to be due to the increased elasticity of the air contained in and between the grains, in consequence of the heat and fire produced at the time of the explosion. Robins found that air was expanded by white-hot iron to about four times its original volume; that gunpowder, fired either in a vacuum or in air, produced by its explosion a permanent elastic fluid; that the volume of this elastic fluid was 244 times that of the original powder; and hence argued that at the exploding point the elasticity of the fluid produced from fired gunpowder, when contained in the space which was taken up by the powder before the explosion, was about 1,000 times greater than the elasticity of common air (the atmospheric pressure). He noticed that a cold barrel sensibly diminished the force of the powder in the first
RESEARCHES ON GUNPOWDER

shot. He made comparative tests of various powders, and placed them in the following order of merit as regards force: Dutch, Portuguese, Spanish, English. He introduced what is now known as the Ballistic Pendulum for determining the velocity of the shot. Using a barrel 45 inches long and 0.275 inch in diameter, a ball 0.25 inch in diameter, and a charge of powder of 36 dwts., he obtained a velocity of 2,400 feet per second. He showed that the resistance of air to projectiles was much beyond what was generally believed, and consequently that the track described by the flight of these projectiles was very different from what was usually supposed by writers on the subject. He found that the elasticity of the fluid produced by fired gunpowder was directly as its density. The experiment by which this was confirmed was by “letting fall separately two quantities of powder, the one double the other, on red-hot iron included in an exhausted receiver, and it appeared by the descent of the mercury that the elasticity of the fluid produced from double the quantity of powder was nearly double the elasticity of that produced from the single quantity.”

In discussing his results he assumed: (1) That the action of the powder on the bullet ceases as soon as the bullet is out of the piece. (2) That all the powder of the charge was fired and converted into an elastic fluid before the bullet was sensibly moved from its place.

He concludes by stating that “the ascertaining of the force of powder and thence the velocity of bullets impelled by its explosion, and the assigning of a method of truly determining their actual velocities from experiments, are points from which every necessary principle in the formation and management of artillery may be easily deduced. Considering, further, the infinite importance of a well-ordered artillery to every state, the author flatters himself that whatever judgement may be formed of his success in these enquiries, he will not be denied the merit of having employed his industry on a subject which, though of a most scientific nature, and of the greatest consequence to the public, has been hitherto almost totally neglected.”

Charles Hutton (5), Professor of Mathematics at the Military
Academy, Woolwich, worked on the same subject in 1778. He revised and edited Robins's "Principles of Gunnery" in 1805. Hutton used a ballistic pendulum consisting of a block of dry elm, a cube of 20 inches. The length from the middle of the axis to the ribband which measured the chord of the arc, was 102\(\frac{1}{2}\) inches. The gun was constructed of brass, with a muzzle diameter of 2.16 inches, and a breech diameter of 2.08 inches. A cast-iron ball weighing 19 oz., or a lead ball of 1\(\frac{3}{4}\) lb. was used, and sometimes a long or cylindrical shot of 3 lb. weight. The length of the barrel was 42.6 inches.

He fired charges of 2, 4, and 8 ounces of powder at a distance of 29 to 30 feet from the pendulum, and obtained the following results:

<table>
<thead>
<tr>
<th>Charge of Gunpowder</th>
<th>2 oz.</th>
<th>4 oz.</th>
<th>8 oz.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocities</td>
<td>612*</td>
<td>879</td>
<td>1164</td>
</tr>
<tr>
<td>do.</td>
<td>622</td>
<td>871</td>
<td>1154</td>
</tr>
<tr>
<td>do.</td>
<td>605</td>
<td>870</td>
<td>1169</td>
</tr>
<tr>
<td>Mean</td>
<td>613</td>
<td>873</td>
<td>1162</td>
</tr>
</tbody>
</table>

From his experiments he concluded that the maximum pressure of gunpowder was about double that given by Robins, or a little more than 2,000 atmospheres (13 tons) per square inch. His conclusions were as follows:

1) "Powder fires almost instantaneously, seeing that nearly the whole of the charge fires, though the time be much diminished.

2) "The velocities communicated to shot of the same weight, with different quantities of powder, are nearly in the sub-duplicate ratio of those quantities.

3) "When shot of different weights are fired with the same quantity of powder, the velocities communicated to them are nearly in the reciprocal sub-duplicate ratio of their weights.

4) "So that, universally, shot which are of different weights and impelled by the firing of different quantities of powder, acquire velocities which are directly as the square roots of the quantities of powder, and inversely as the square roots of the weights of the shot, nearly."
RESEARCHES ON GUNPOWDER

(5) “It would therefore be a great improvement in artillery to make use of shot of long form, or of heavier matter; for thus the momentum of a shot, when fired with the same weight of powder, would be increased in the ratio of the square root of the weight of the shot.

(6) “It would also be an improvement to diminish the windage, for by so doing, one third or more of the quantity of powder might be saved.

(7) “When the improvements mentioned in the last two articles are considered as both taking place, it is evident that about half the quantity of powder might be saved, which is a very considerable object. But, important as this saving may be, it seems to be still exceeded by that of the guns: for thus a small gun may be made to have the effect and execution of one or two or three times its size, in the present way, by discharging a long shot of two or three times the weight of its natural ball, or round shot: and thus a small ship might discharge shot as heavy as those of the greatest now made use of.”

In 1783 the “cylinder” charring of charcoal was suggested by Bishop Watson, and acted on by the Duke of Richmond, then Master General of Ordnance. In 1788 George Napier (6), Superintendent of the Royal Laboratory, Woolwich, presented to the Irish Academy of Science, through the Earl of Charlemont, a report on gunpowder. He considered Russian saltpetre to be the best for the manufacture of gunpowder, but did not think it advisable to make gunpowder with saltpetre refined oftener than four times, as it was probable that on repeated evaporation part of the elastic and expansive fluid contained in the nitre might be liberated.

He tried various forms of charcoal with scarcely any perceptible difference in their effects, provided they were completely charred and equally well pulverized. Dogwood and alder were preferred by powder makers, but he had not been able to discover any cogent reason for this preference. He mentions the “cylinder” method for preparing charcoal. He dwells forcibly on the necessity for resublimation of
sulphur, and states that it was found to be frequently adulterated with wheat flour. An analysis of some Chinese powder obtained from Canton is given as follows: Potassium nitrate, 75.7; charcoal, 15.1; sulphur, 9.2.

In 1797 the classical experiments of Count Rumford (7) were communicated to the Royal Society. He was previously known as Sir Benjamin Thompson. On being created a Count in 1792 by Kurfürst Karl Theodor of Bavaria on account of his services rendered as a Bavarian general, he took his title from the town in America where he was born. He published several books, and although his experiments were made in Munich in 1792, they were communicated to the Royal Society. In prosecuting his remarkable experiments Rumford had two objects in view:

(1) To ascertain the force exerted by explosive powder, when it completely filled the space in which it was exploded.

(2) To determine the relation between the density of the gases and the tension.

The apparatus used by Rumford consisted of a small wrought-iron vessel 0.25 inch (6.3 mm.) in diameter, and containing a volume of 0.0897 cubic inch (1.47 c.c.). It was terminated at one end by a small closed vent filled with powder, so arranged that the charge could be fired by the application of a red-hot ball; at the other end it was closed by a hemisphere upon which any required weight could be placed.

When an experiment was to be made, a given charge was placed in the vessel, and a weight considered equivalent to the resulting gaseous pressure was applied to the hemisphere. If, on firing, the weight was lifted, it was gradually increased until it was just sufficient to confine the product of explosion, and the gaseous pressure was calculated from the weight found necessary. The powder experimented with was sporting of very fine grain; and as it contained only 67 per cent. of nitre it differed considerably from ordinary powder. Its gravi-metric density was 1.08; but in his experiments Rumford appears to have arranged so that the weight of a given volume of
gunpowder was nearly exactly equal to that of the same volume of water. The charges with which Rumford experimented were very small; the largest, with one exception (by which his vessel was destroyed), was 18 grains (1.17 gramme). The total quantity of powder required to fill the vessel was about 28 grains (1.81 gramme). Rumford calculated that the tension of exploded gunpowder, such as that employed by him, when filling completely the space in which it is confined, is 101,021 atmospheres (663 tons on the square inch). He accounts for this enormous pressure by ascribing it to the elasticity of the steam contained in the gunpowder, the tension of which he estimates as being doubled for every addition of temperature equal to 30° F. He further considered the combustion of powder in artillery and small arms to be comparatively slow, and hence he assumes that the initial tension is, in their case, not attained.

In 1832 a book was published by John Braddock (8). He was a master refiner of saltpetre and Deputy Commissary of Ordnance. After working at Waltham Abbey he was sent to India by the Board of Ordnance in 1813, and remained there some twenty years. He deals in his book very fully and practically with all manufacturing operations, tests and proof as carried out in England and India. Until the appearance of Braddock's book there was no work in English which dealt in any adequate way with the subject.

Scoffern (9), in 1859, traced in his book the history of gunpowder; his practical details are largely quoted from Braddock. He mentions that some varieties of gunpowder, especially those manufactured for the African market, are made to shine with black-lead; "the negroes seemingly thinking that gunpowder which approaches their own complexions most is surely best."

Airy (10), the Astronomer Royal, in 1863 published work on the comparative destructive effect of steam in boiler explosions, and the destructive energy of gunpowder.

Gale, in 1865, invented a non-explosive gunpowder. It consisted of gunpowder mixed with from three to four times its weight of
powdered glass. This protected powder could not be exploded in any way, and on removal of the powdered glass, by a sieve, it was ready for use again. Gale's invention, at the time, created an extraordinarily widespread interest, not only in official quarters, where many experiments were made, but also throughout the entire press of the country, and on the continent.

Noble (11) in 1871 published the first of his researches on the tension of fired gunpowder. His further classical work, carried out partly in conjunction with Abel (12), is so well known and so extensive, that any attempt at a summary in a short space, is not only unnecessary, but impossible.

In 1882 Debus (13), in the Bakerian lecture at the Royal Society dealt with the chemical theory of gunpowder, and criticized some of the work and conclusions of Noble and Abel.

(1) "Genuine Use and Effects of the Gunne" (1674).
(2) Phil. Trans. (1686), No. 179, 19.
(3) Principia, lib. ii, 7 (1687).
(4) "Principles of Gunnery" (1742).
(6) Trans. Irish Acad. (1788).
(8) "Memoir on Gunpowder" (1832).
(9) " Projectile Weapons of War and Explosive Compounds"
  (1859).
(10) Phil. Mag. (1863), 329.
NITROCELLULOSE

BY G. W. MACDONALD, M.Sc.

SINCE Schöenbein's discovery in 1846, Great Britain has contributed largely, not only to the chemistry of nitrocellulose, but also to improvements in manufacturing processes. Schöenbein, in March of 1846, sent samples of guncotton to Faraday, Herschel, and Grove, and the latest, at the British Association at Southampton in that year, exhibited samples of Schöenbein's guncotton, and gave demonstrations of some of its properties. Schöenbein came to England in August, and, through Herschel's help, he succeeded in having the first experiments carried out at Woolwich Arsenal on 25th August, in conjunction with Colonel Sabine, R.E. These were so satisfactory that, at Colonel Sabine's request, a commission of officers was appointed to witness further trials at Woolwich and Portsmouth. Schöenbein was invited to carry out experiments with his guncotton before the Queen and the Prince Consort. The first pair of partridges shot with the new powder were sent to the Prince Consort. The Government paid £1,500 for carrying out experiments, which were begun on 9th October, in the presence of Schöenbein and many personages of importance, with great success. These experiments aroused great interest among miners and powder-makers. He also carried out, in conjunction with Richard Taylor, before the members of the Royal Geographical Society of Cornwall, demonstrations of the value of his discovery for mining purposes. The first trial was made in a granite quarry at Spargo near Penrhyn. It is stated that the surprise and incredulity of the miners was very great, and when Taylor charged a hole with guncotton they thought that he was doing a very absurd thing, one of them offering to sit on the hole for a pint of beer. Two holes were charged, the one with the ordinary amount of gunpowder, and the other with a quarter
the weight of guncotton. In the latter case the rock was torn into fragments. It did more work than was required, the charge being too great. Schönbein took out a patent (1) in 1846, not in his own name, but in that of his friend, John Taylor. He states that the vegetable matter which is best suited for the purposes of the invention is cotton, cleaned from any extraneous matter, as it is desirable to operate only on the clean cotton fibre, which should be dry. The acids employed were 3 parts sulphuric acid (1.85) and 1 part nitric acid (1.45 to 1.5). The cotton was to be immersed in the mixed acid, so as to become thoroughly impregnated therewith. In this same year he also entered into negotiations with Messrs. John Hall and Sons, of Faversham, and on the 13th of October an agreement was made for the erection of a factory for the manufacture of guncotton.

Teschemacher's (2) work in 1846 is worthy of notice, because he showed from his experiments that it is nitric acid, alone, which in the mixed acids enters into the reaction in the guncotton formation. He immersed South American cotton in a mixture of equal parts of strong nitric and sulphuric acids, and the increase of weight of the cotton waste on conversion into guncotton was determined. On removing the excess of acid and washing out the adherent acid, he showed, by precipitation as barium sulphate, that the whole of the sulphuric acid originally used was recovered, and that the increase of weight of the cotton-waste corresponded to the loss of nitric acid. The real object of his work was, he states, to ascertain how far Schönbein's discovery would be likely to affect an important branch of trade—the production and value of saltpetre and sodium nitrate. He came to the conclusion that, considering the original cost of the cotton, the expensive manipulation of the conversion of the nitrate into nitric acid, and the additional weight of nitrate required to produce the same weight of guncotton, that the latter substance must be more expensive than gunpowder, taking weight for weight. Ransome (3), in 1846, prepared and analysed guncotton. He used carded cotton, and immersed it in a mixture of 2 volumes of nitric acid and 1 volume of sulphuric acid.
FIG. 20. CHRISTIAN FREDERICK SCHÖNBEIN.
30 W 5101 N
AMERICA?
The ratio in weight of cotton to acid was as 1 to 19. The increase of weight was found to be 1 to 1.64. By investigating the ratio of nitrogen to carbon dioxide on combustion with copper oxide he found his product contained 10.33 per cent. of nitrogen. Bowman (4), in 1846, first drew attention to the property possessed by guncotton of becoming electrified. He was struck, whilst employing it for some physical experiments, by the tenacity with which it adhered to his fingers; and further, that when drying some guncotton yarn and drawing it out, a crackling noise was heard, and on applying it to a goldleaf electroscope a strong diversion of the leaves was instantly caused.

The work of Crum (5), in 1847, is of very great interest, not only on account of his thorough chemical investigation of guncotton, but also because he devised and standardized the method which is now in universal use, for the estimation of nitrates, nitric acid, and guncotton—the nitrometer. He used a graduated glass tube, 8 inches long and 1½ inch wide, filled with, and inverted over, mercury. Fused potassium nitrate was used for standardizing the method. Ten grains of the nitrate were introduced into the tube, and afterwards 50 grains of water. As soon as it was dissolved, sulphuric acid (125 grains), ascertained to be free from nitric acid, was added. At the end of two hours, after occasional agitation, no further evolution of gas was obtained, and the volume of gas was measured and corrected. Crum proved that the gas obtained consisted wholly of nitric oxide, by introducing into the tube a boiled solution of ferrous sulphate, which completely absorbed the whole of the gas. The mean of his results for potassium nitrate was 13.85 per cent. of nitrogen, the theoretical being 13.86 per cent. With commendable foresight, before proceeding to the analysis of guncotton, he showed that the presence of cotton, in admixture with nitrate, did not interfere appreciably with the liberation of nitric oxide. The result obtained under these conditions was 13.80 per cent. of nitrogen. For the preparation of his guncotton he used Sea Island cotton-waste, which had been boiled in caustic soda, and treated with dilute nitric acid. The ash in the sample so prepared was only 0.09
per cent. For nitration he used a mixture of 1 part of sulphuric acid (1.84) and 3 parts of nitric acid (1.517). The ratio of cotton to acid was 1 to 86. The yield obtained was 1.779, and when his product was dissolved in nitric acid, and tested with barium chloride, it gave no evidence of the presence of sulphuric acid. He analysed his compound by combustion, and the figures which he obtained are of such interest that they deserve to be quoted. The following gives the results:

<table>
<thead>
<tr>
<th>For cellulose trinitrate.</th>
<th>Calculated.</th>
<th>Obtained by Crum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>24.24</td>
<td>24.92</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>2.36</td>
<td>2.49</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>14.14</td>
<td>13.69 (by nitrometer)</td>
</tr>
<tr>
<td>Oxygen</td>
<td>59.26</td>
<td>58.90</td>
</tr>
</tbody>
</table>

In his own words he concluded that guncotton was lignin in which 3 atoms of water were replaced by 3 atoms of nitric acid. The work of Gladstone (6) in the same year stands on the same level as that of Crum, with regard to thoroughness. He investigated the action of various solvents on his product, and states that it was found to be practically insoluble in strong alcohol, and also in ether, and even in a mixture of 10 parts of ether and 1 part of alcohol. Acetic ether, however, instantly destroyed the fibre, and dissolved it in large quantities, the solution yielding, on spontaneous evaporation, a white powder of the same weight as the original guncotton. By analysis he showed that his product contained 12.75 per cent. of nitrogen. In this year also, Messrs. John Hall and Sons of Faversham had erected their factory for the manufacture of guncotton, but a very disastrous explosion on the 14th July, 1847, destroyed the factory, which was never rebuilt. This disaster appeared to have acted as a deterrent, in England, of any further work on guncotton, for the next sixteen years. Meanwhile Austria had persevered in the manufacture through the initiative of von Lenk. Hoffmann (7), in 1861, investigated the products of the spontaneous decomposition of guncotton, prepared at Messrs. Hall's works at Faversham in 1847, and subsequently kept by Percy in glass-
FIG. 21. GENERAL WILHELM FREIHERR LENK VON WOLFSBERG.
stoppered bottles. Red vapours had appeared in the bottle. The guncotton had crumbled to a light brown semi-fluid gum-like mass, whilst the sides of the bottle were coated with a network of fine crystals, which were proved to be oxalic acid. Von Lenk, in 1862, took out a patent, not in his own name but in that of Révy (8), for the manufacture of guncotton, in which he mentions the use of sodium silicate solution for purification, and states, that guncotton treated in this way is entirely free from self-combustion. Again, in 1863, von Lenk, in the name of Révy (9), claimed in a patent the purification of cotton waste by washing with alkali, and a process for steeping the cotton in mixed acids contained in a specially arranged apparatus. Divers (10), in 1863, on investigating the products of the spontaneous decomposition of some cellulose nitrate which he had prepared, found that pectic and para-pectic acids were present, but did not obtain the slightest evidence of the presence of oxalic acid. The influence of Schönbein’s experiments in the Cornish mines can perhaps be traced in the fact that in 1862 Tonkin (11), in Cornwall, claimed the use of pulped guncotton as an ingredient in explosives. His description of the preparation of guncotton is taken verbatim from Schönbein’s original patent quoted above. The following passage is, however, significant:—“The fibre is then taken in the wet state and converted into pulp in the same manner as is practised by paper-makers, by putting the fibre into a cylinder having knives revolving rapidly, working close to fixed knives.” In 1863 a Committee of the British Association for the Advancement of Science (12), composed of some ten of the best-known scientists of the day, reported on the question of guncotton. The Committee was put in possession of the fullest information on the subject, mainly from two sources: (i) A report by Abel, by permission of the Secretary of State for War, containing information given by the Austrian Government to the English Government, of the method of manufacture in the Austrian factory. (ii) Von Lenk, on the invitation of the Committee, and by permission of the Emperor of Austria, paid a visit to England, with the object of answering any enquiries the Committee might make, and
explaining his system of manufacture thoroughly; and for this purpose he brought over drawings and samples from the Imperial factory. In the same year, Messrs. Prentice and Co., of Stowmarket (now the New Explosives Co., Ltd.), commenced the manufacture of guncotton, according to Von Lenk's system, but a serious accident occurred not long after starting manufacture. Abel also, about the same time, began the manufacture, on a small scale, at Waltham Abbey, and communicated to the Committee the results of his experiments. Abel (13), in 1864, communicated to the Royal Society the first of his papers on the chemistry of guncotton. In 1865 he took out a patent (14) for the simultaneous pulping and compressing of guncotton into blocks. This pulping process is now in universal use, for by its means the acids and acid products can be easily and completely eliminated from the fibre. In this year the Stowmarket factory was rebuilt and enlarged, and recommenced the manufacture of guncotton, introducing Abel's improvements. In 1866 Abel (15) communicated to the Royal Society the first of his classical papers entitled "Researches on Guncotton." The second memoir (16) was published in 1867, and these two communications contain an enormous amount of experimental work, and many far-reaching conclusions based upon the results obtained. It is impossible, in a short space, to attempt to summarize this work. Mention, however, should be made of the fact that it was found necessary to introduce a test of a chemical nature in order to ascertain whether or not the finished guncotton had been thoroughly purified in manufacture. This "heat test," as it was called, invented and perfected by the late Dr. Dupré, Chemical Adviser to the Home Office, is in universal use to-day; it is a test for the purity of guncotton, nitroglycerine, and freshly-made explosives, and the Home Office has, so far, found nothing to supersede it. Again, in 1869, Abel (17) once more published researches on guncotton, in which he drew attention to the importance of the discovery made by his assistant, Brown, that guncotton could be readily detonated when in the wet, compressed state. On 14th August, 1871, a disastrous explosion took place at the Stowmarket
FIG. 22. EUSTACE PRENTICE.
(From a photograph by the London Stereoscopic Co.)
Factory, when nearly fifteen tons of finished guncotton, stored in the factory magazine, exploded spontaneously. At the inquiry, which lasted seven days, the Home Office were advised by Dupré and Keates; Abel gave evidence on behalf of the War Office, and Odling appeared for the Company. An exhaustive report on this explosion was made by Majendie (18). In 1872 manufacture was begun at Waltham Abbey on a scale sufficiently large to turn out 250 tons per annum. The British Government gave the German Government an opportunity of inspecting the guncotton works at Waltham Abbey, and supplied them with plans for the erection of a similar factory, which is still in existence in Kruppamühle in Upper Silesia. With the introduction of the Explosives Act of 1875, a new era in explosives work commenced, and from this time forward, much of interest may be found in the communications of Dupré (19) contained in the Annual Reports of the Inspectors of Explosives, and also in the special reports upon accidents and explosions in the various factories. Dupré also laid down the specific conditions for carrying out the heat tests for guncotton and other explosives, and introduced later, though not officially, what is known as the "vapour tension" test. With the exception of his work, practically nothing was published in Great Britain or elsewhere during some twenty years.

In 1895 Guttmann (20) published his work on explosives, which covered, with the then state of knowledge, the whole field. In 1897 Guttmann (21) reviewed and criticized the heat test, showing how it can be masked, and proposed the introduction of the diphenylamine test. Luck and Cross (22) made an investigation of the effect of dilute acetone in stabilizing and disintegrating nitrocellulose. Cross, Bevan, and Jenks (23) published work on the production of mixed esters in the preparation of nitrocellulose. The heat test was again the subject of review and criticism by Cullen (24) in 1901. An investigation of the Will test was published in 1902 by Robertson (25) who gave an account of the results of the application of this test to the British Service guncotton, during the stages of purification, and in the
finished condition. A modification in the manufacture of guncotton was patented in 1903 by the Messrs. Thomson (26) of Waltham Abbey, known as the displacement process, which dispensed with the use of acid and water wringers, greatly reduced the number of workpeople required for the nitration of guncotton, and also reduced the loss of nitric and sulphuric acids, carried away in the wash water, for all practical purposes, almost to a minimum. The difficult subject of the microscopy of nitrocellulose has been very ably and fully dealt with by H. de Mosenthal (27) in two communications. Hake and Lewis (28) in 1905, published work on the production of mixed esters in the nitration of cellulose, and pointed to the fact that the presence of cellulose sulphuric ester might be a possible cause of the deterioration of nitrocellulose. Silberrad and Farmer (29) made an examination of the decomposition products of gelatinized nitrocellulose, at an elevated temperature, in a moist atmosphere. They also investigated the question of the hydrolysis of nitrocellulose and the deterioration of nitrocellulose powders on storage. In 1906 Robertson (30) published work on the effect of acid hydrolysis in the purification of guncotton. This work is of far-reaching importance in reducing the time that is required for stabilizing guncotton, by boiling with water, and producing an ultimate product of high stability. Robertson and Napper (31) in 1907 made an interesting investigation of the composition of the gases produced, on the decomposition of guncotton, as regards the percentage of nitrogen peroxide present. They showed that when guncotton is heated in vacuo at 135° C, some 25 per cent. of the nitrogen contained in the gaseous products of decomposition exists as nitrogen peroxide; whilst in the Will test upwards of 40 per cent. was found to be present in the same condition. Guttmann (32) in his lecture in 1908 before the Society of Arts, showed the progress made during the last twenty years, and criticized various theories and manufacturing details, whilst Nathan (33) in 1909 gave a review of the present position of the manufacture of guncotton.

In 1864 Schultze (34) introduced his sporting powder made from
FIG. 23. SIR FREDERICK ABEL, K.C.B., F.R.S.
NITROCELLULOSE

nitrated wood, and Griffiths patented improvements on it in 1877 (35) and 1884 (36).

In 1865 (37) Abel patented the production of grains of guncotton. He introduced guncotton pulp and a small quantity of binding material into a vessel, to which a vibrating motion was imparted, whereby the pulp was formed into grains. In place of water, other fluids such as wood spirit, spirits of wine, ether, or a mixture of these liquids, with or without some binding material, such as shellac, gums, or resins could be used. Mention is also made of the use of collodion, in the form of a solution, to bind the insoluble guncotton and coat the grains.

In 1866 Kellner (38) is also stated to have made a granular smokeless powder.

In 1882 Reid (39) patented the agglomeration of nitro-cotton into grains, moistening them with ether alcohol for the purpose of hardening the grains—now known as "E.C." powder. Further improvements to this powder consisting of the use of emulsions of solvents and moderators were patented by Borland (40) in 1900.

In 1891 Curtis and Andre (41) patented a sporting powder, since known as "amberite," though the nitroglycerine stated to be used in the original specification is no longer retained.

A number of smokeless powders, known as Rifleite, S.S. powder, etc., were made under F. W. Jones's patents (42) by the Smokeless Powder Co., at Ware in Hertfordshire, but an action for infringement of Engel's patent (43) having been brought and won by Heidemann, the factory was taken over by the Schultze Gunpowder Co.

Luck and Cross in 1898 (44) patented the hardening of powder by treatment with a diluted solvent, and Cocking and Kynoch, Ltd., proposed (45) the addition of olive oil and of alkali salts.

(1) Brit. Pat., 11,407, 8th October (1846).
(4) Phil. Mag. (1846), 500.
(7) J. Chem. Soc. (1861), 76.
(8) Brit. Pat. (1862), 1090.
(9) Brit. Pat. (1863), 2720.
(12) Reports B.A.A.S. (1863).
(14) Brit. Pat., 1102, 20th April (1865).
(22) J.S.C.I. (1901), 642-44.
(23) Ber. (1901), 2496.
(26) Brit. Pat. (1903), 8278.
(32) J. Soc. Arts (1908) and Manufacture of Explosives (1909), Whittaker and Co.
(34) Brit. Pat. (1864), 900.
(35) Brit. Pat. (1877), 3294.
(36) Brit. Pat. (1884), 11808.
(37) Brit. Pat. (1865), 1102.
(38) Buch der Erfindungen, Leipsic (1866).
(40) Brit. Pat. (1900), 4593.
(41) Brit. Pat. (1891), 11383, 19068.
(42) Brit. Pat. (1897), 1154, (1898), 15553 and (1901), 18161.
(43) Brit. Pat. (1887), 6022.
(44) Brit. Pat. (1898), 18233.
(45) Brit. Pat. (1905), 15565 and 15566.
NITRO-GLYCERINE AND NITRO-GLYCERINE EXPLOSIVES

By Henry de Mosenthal, F.I.C., F.C.S.

Nitro-glycerine was invented by Sobrero in 1846, but remained a scientific curiosity for many years until Alfred Nobel and his father devoted themselves to its study from 1859 to 1861. In the latter year Alfred Nobel erected works at Heleneborg near Stockholm, and there nitro-glycerine was manufactured on a commercial scale in 1862.

The manufactured article was conveyed in tin-plate canisters. The method adopted in blasting was to pour a quantity of nitro-glycerine into a bore-hole. The primer used by Nobel to fire the nitro-glycerine was at first a black powder cartridge. Later, he employed a glass tube filled with gunpowder, and this he subsequently replaced by a cone-shaped receptacle made of tin plate filled with fulminate of mercury. This was known as Nobel's igniter.

In 1864 an explosion, in which the head chemist and Nobel's youngest brother lost their lives, destroyed the Heleneborg works. Nobel nevertheless continued his manufacture, and resumed operations on a barge in Lake Mälaren, pending the erection by him of a new factory at Wintervijken, near Stockholm. This was completed in 1865, in which year he also built explosives works at Krümmel on the Elbe.

At Krümmel the manufactured nitro-glycerine, which was also called pyro-glycerine, glonoine oil, or Nobel's Blasting Oil, was encased in tin canisters, which were packed in wooden cases.

In consequence of the large number of accidents which occurred
FIG. 24. ALFRED NOBEL.
in the transport of nitro-glycerine in this liquid state, a scare was created which led to prohibitive or practically prohibitive legislation in various countries, Acts regulating its manufacture and use being passed in Great Britain in 1866 and 1869.

In those days nitro-glycerine was not manufactured in Great Britain, but Nobel appointed an agent in London and sent him samples to try to introduce it, with unsatisfactory results.

There can be little doubt that nitro-glycerine would have ceased to be used as a practical explosive had not Nobel in 1864 conceived the idea of absorbing it in Kieselguhr, thus converting it into a dough which could be cartridgeed and handled safely. This explosive, which he called Dynamite, was manufactured at Wintervijken and at Krümmel, and new works for its production were also built at Lysaker, near Christiania, in Norway.

In 1867 Nobel improved his firing method by embedding in the dynamite cartridge a copper fulminating cap or detonator, a method of initial ignition which distinguishes high explosives from those of the black powder class. Thanks to this mode of ignition dynamite was converted into a useful and convenient explosive.

There is no exaggeration in saying that the great extension of mining operations and the construction of public works, more particularly of tunnels in recent years, could not have been possible of execution but for the invention of dynamite. Nobel placed in the hands of mankind an agent which has played a prominent part in the advancement of modern civilization.

In 1867 Nobel went to America where explosives works were erected in the vicinity of San Francisco. Passing through London on his way to America he tried to dispose of his British patent rights, and offered them to several of the leading black powder makers, more particularly to Messrs. John Hall and Sons, with whom he opened negotiations for the sale of his patents for £500. They ultimately, however, declined the offer, showing as they did with the other powder makers a general disbelief in the value of the invention.
In 1868 works were erected at Zamky, near Prague, in Bohemia, and in 1870 at Hangö in Finland, but it was not until 1871 that Nobel, finding financial support in Glasgow, formed the British Dynamite Company, Limited, which was afterwards reconstructed under the name of Nobel's Explosives Company, Limited, of Glasgow. He selected a site between Irvine and Ardrossan, at Ardeer, in Ayrshire, and there erected small works for the manufacture of his explosive. The method of manufacturing which he introduced into that factory was that elaborated by him with the assistance of his friend Liedbeek, a method which was followed there, with minor alterations only, until 1902. A complete description of this method can be found in the evidence given by Mr. Downie, the manager and secretary of the British Dynamite Company, before the Select Committee appointed at the instance of the Inspector of Gunpowder, Captain Vivian Majendie, in 1874, under the chairmanship of Admiral Sir John Hay, to inquire into the law relating to the making, keeping, carriage, and importation of gunpowder, nitro-glycerine, ammunition, fireworks, and substances of an explosive nature. It was the report of this Committee which led to the introduction of the Explosives Act of 1875. In his evidence before it Nobel stated that he had thirteen factories and was building two more, while there were eight or nine additional factories in existence, in which he had no share. Among these factories not owned by the Nobel companies was that of the firm of Krebs and Company, near Cologne, erected as early as 1868. An explosive was made there under the name of Lithofracteur, which consisted of fifty-five parts of nitro-glycerine and forty-five parts of a dope consisting of one part by weight of charcoal, bran, or sawdust, \(3\frac{1}{2}\) parts by weight of Kieselguhr, and \(2\frac{1}{2}\) barium nitrate or bicarbonate of soda with half a part of magnesium sulphate. This explosive was imported into the United Kingdom in 1871 and the years following, but in 1878 the courts of this country declared it to be a colourable imitation of dynamite. This was the only instance of an attempt to evade the patent in this country, so that from 1871 to
1878 the Ardeer factory alone manufactured dynamite, and Nobel's Explosives Company held the monopoly.

In 1875 Nobel invented an explosive which he called Blasting Gelatine. He had tried to dissolve guncotton in nitro-glycerine as early as 1867, but abandoned the idea until one day he discovered that by pouring collodion into nitro-glycerine a jelly could be formed. At first the assisting solvent used in the manufacture of blasting gelatine was ether-alcohol; later, however, Nobel's factories on the continent, and more particularly the Pressburg factory in Hungary, which had been erected in 1873, ascertained that a certain class of nitro-cotton could be incorporated with nitro-glycerine by warming and kneading without the aid of a solvent.

It is a curious coincidence contributive to the success of this explosive that the amount of nitrocellulose required to convert nitro-glycerine into a stiff jelly is from 7 per cent. to 8 per cent., which is the exact proportion which furnishes the excess of carbon necessary to convert the excess of oxygen of the nitro-glycerine into carbon di-oxide. Blasting gelatine is therefore a perfect explosive, inasmuch as the constituent elements are present in the correct percentage to be entirely converted into carbon di-oxide, nitrogen and water, exercising thus the greatest amount of power without any deleterious fumes.

Nobel, in accordance with the agreement by which, in addition to transferring his dynamite patents to the British Dynamite Company, he was also bound to give them the benefit of any improvements, transferred his patents for blasting gelatine to Nobel's Explosives Company, the successors of that company.

Blasting gelatine, however, proved too powerful for certain works, and potassium nitrate and wood meal were added in different proportions to a nitro-glycerine which was only thickened with nitrocellulose to the consistency of a thin jelly. Two of these modifications of gelatine explosives were introduced in this country; one, with 80 per cent. of thickened nitro-glycerine, was called gelatine dynamite, a name first given to it by the continental factory, and another containing 60 per
cent. of thickened nitro-glycerine, for which Nobel's Explosives Company devised the name of gelignite.

Blasting gelatine and the other gelatinous compounds made very slow headway in Great Britain, for they were seriously hampered by the stringency of the Home Office regulations. A small committee, consisting of Sir Frederick Abel, Dr. Dupré, and Professor Odling was appointed to determine the test with which these new explosives had to comply, and this test was modified on various occasions until, in 1884, it reached its definite form. Thus blasting gelatine, the manufacture of which developed rapidly on the Continent, was still being imported into this country by Nobels as late as 1878. Its manufacture was, however, started at Ardeer in 1879, but was interrupted from 1882 to 1884 on account of the difficulties of complying with the physical test. The work done at Ardeer in connection with this manufacture was very considerable, and there can be little doubt that whilst the prescribed test hampered the factory, it led to considerable improvements in the preparation of the explosive.

In this country the manufacture of nitro-glycerine and nitro-glycerine explosives between the years 1871 and 1881 was confined to the Ardeer factory. In the latter year the Explosives Company (afterwards the New Explosives Company, Limited) erected works at Pembrey in South Wales with the assistance of Mr. Walter F. Reid, and there nitro-glycerine was manufactured according to the Boutmy-Faucher process. The manufacture on this method was visited by a serious explosion in 1882, in consequence of which the factory was closed. In 1888 the National Explosives Company, Limited, was formed, and works were erected at Hayle in Cornwall by Mr. Oscar Guttmann. He introduced there the continental method of making nitro-glycerine, which differs from that followed at Ardeer by separating the nitro-glycerine from the acids in a closed vessel and drawing off the acids from below, instead of separating in an open vessel and skimming the nitro-glycerine from above. He also introduced the use of Werner and Pfleiderer kneading machines for making blasting gelatine.
NITRO-GLYCERINE

After the lapse of the dynamite patent in 1878, the continental factories exported dynamite into this country. In 1884, by an arrangement with Nobel’s Explosives Company, some of the continental companies also exported blasting gelatine, gelatine dynamite, and gelignite to this country. In 1889 the blasting gelatine patent lapsed, and blasting gelatine was made at Hayle and also at Perranporth in Cornwall, where a factory was erected by Mr. Percy F. Nursey and Mr. Walter F. Reid for a company formed under the style of the British and Colonial Explosives Company, Limited. In 1893 the British Explosives Syndicate was formed in Glasgow, and erected works for the manufacture of dynamite and gelatine explosives at Pitsea in Essex under the superintendence of Mr. McRoberts. In the same year the manufacture of nitro-glycerine blasting explosives was started at the works of the Cotton Powder Company at Faversham, where, up to then, cotton powder or tonite had been made.

In 1887 Alfred Nobel, guided no doubt by the study of celluloid, found that by greatly increasing the percentage of nitrocellulose in blasting gelatine he could produce an explosive which could serve as a propulsive agent. He suggested incorporation by kneading and with the assistance of heat of from 33 to 66 per cent. of nitro-glycerine, the balance being soluble nitrocellulose of the same kind as that used in the manufacture of blasting gelatine with the addition of camphor, and he called this new powder ballistite. The various Nobel factories developed this explosive, prominently among them the factory at Ardeer, where it was first produced in 1889, Messrs. Lundholm and Sayers advancing the manufacture considerably by a new method of incorporation of nitro-glycerine and nitrocellulose with the assistance of water. Nobel submitted his invention to the Explosives Committee, which had been appointed by the British War Office to recommend the best powder to be used by the Service, and was composed of three chemists, Sir Frederick Abel, Mr. (now Sir) James Dewar, and Dr. Dupré. They modified Nobel’s invention by substituting service guncotton for the soluble nitrocellulose, using acetone as an
Assistant solvent to bring about the incorporation. They fixed upon 58 per cent. of nitro-glycerine, 37 per cent. of guncotton, with the addition of 5 per cent. of mineral jelly. The paste thus produced was squirted through a die to form cords. This explosive, under the name of cordite, was adopted as the British service powder. Later on the percentages were reversed, and cordite, known as Modified Cordite or MD, was adopted, with 30 per cent. nitro-glycerine and 65 per cent. guncotton and 5 per cent. mineral jelly incorporated by means of acetone. This is the ordinary British service powder of to-day, whilst the first powder is still retained for small arms. A patent suit brought by Nobel's Explosives Company against the Government in 1894 was unsuccessful, the Courts holding that Nobel's patent did not cover the use of insoluble nitrocellulose, but that he had limited himself to the use of soluble nitrocellulose. Mr. (now Sir) Hiram Maxim, who in 1889 had patented a smokeless powder consisting of guncotton, nitro-glycerine, and castor oil, incorporated by using acetone as an assisting solvent, also unsuccessfully contended that the Government cordite was an infringement of his invention. The manufacture of ballistite in this country was restricted to the production of a sporting powder known as Nobel's Sporting Ballistite, which is the only nitro-glycerine sporting powder at present in the market.

The introduction of cordite as a service explosive in 1893 brought about a great development in the nitro-glycerine production in this country. The Royal Gunpowder Factory at Waltham Abbey erected for the production of this powder a nitro-glycerine plant, which has been developed there under the direction of Colonel Sir Frederic Nathan, R.A., who quite recently described the evolution and present method of manufacture in a paper read before the Society of Chemical Industry. Further particulars as to this can be found in the "Treatise on Service Explosives" issued from time to time by H.M. Government. The factories at Ardeer and Hayle took up the manufacture of cordite, and so did a little later the factories at Faversham and Pitsea. But in addition to these existing factories a number of gunpowder and
guncotton makers were led to manufacture cordite, and as was to be expected they also manufactured in connection therewith nitro-glycerine blasting explosives. Thus Messrs. Kynoch erected works at Arklow in 1895, and in 1897 at Thames Haven in Essex. In 1898 the Stowmarket factory, belonging to the New Explosives Company, which had confined itself to the manufacture of guncotton, took up the manufacture of nitro-glycerine blasting explosives, and cordite, and so did Messrs. Curtis's and Harvey in 1901 at their works at Cliffe in Kent. From time to time a number of companies were formed for the manufacture of nitro-glycerine explosives, such as the Carbo-Dynamite Company, the Welsh Explosives Company, the International Explosives Company, the Gelatines Company, the Dynamite Company, and the Essex Explosives, Limited, but only one factory was actually erected, and that in 1898 by the High Explosives Company at Bramble Island in Essex. This factory was afterwards taken over by the Standard Explosives Company, and at the present day is worked by the Explosives and Chemical Products, Limited.

In 1902 the Ardeer factory first introduced oleum (fuming Nordhausen acid) into the manufacture of nitro-glycerine, a system which was four years later independently introduced at Waltham Abbey, and has since been adopted by some other manufacturers in this country.

As the history of so-called safety explosives, i.e. explosives designed for use in fiery coal mines, will be dealt with in another chapter, it will no doubt suffice to say here that the first nitro-glycerine explosive of this kind was Carbonite, invented by Mr. C. E. Bichel. It contained 27 per cent. of nitro-glycerine, and was made in 1887 at the Carbonite Company's works at Schlebusch, near Cologne, and at Ardeer in 1897. Other explosives of this class, of which considerable quantities were used, were practically gelignite or gelatine dynamite with an admixture of ammonium oxalate. These explosives were invented by Messrs. Greaves and Hann, and were first manufactured at Ardeer in 1900. The first ammonium nitrate nitro-glycerine explosive
was made at Ardeer in 1903. It was first called Nobel's ammonia powder, and afterwards Monobel. Since then the number of explosives containing nitro-glycerine, mostly however in small proportions, which appear on the list of explosives permitted to be used in coal mines, is very numerous.

Nitro-glycerine contains in its molecule all the constituents of an explosive substance which, rapidly convertible from the solid to the gaseous form, produces nothing but carbonic acid, nitrogen, and water, with a slight excess of oxygen. This excess of oxygen is utilized in blasting gelatine and other gelatine compounds by the addition of nitrocellulose and dope. To this and the high specific gravity (1.6) of nitro-glycerine explosives, their extensive and increasing use must no doubt be ascribed.

A disadvantage of nitro-glycerine explosives is that they freeze in winter, and have consequently to be thawed before they can be used. Within the last few years a number of suggestions have been made for the preparation of nitro-glycerine explosives in which the freezing point has been lowered. The addition of nitrated hydrocarbons of the aromatic series has been proposed, and explosives have been made on the Continent containing these ingredients, and sold under the name of anti-gel, anti-frost, etc. Mikolajczak has patented the manufacture of dinitro-glycerine, and claimed that explosives made with it would not congeal at ordinary temperatures. Lastly, the additions to nitro-glycerine of chlorhydrine and nitrated chlorhydrines have been patented. Up to the present, however, so-called unfreezable nitro-glycerine explosives have not been made in this country.
RESEARCHES ON NITRO/GLYCERINE

BY G. W. MACDONALD, M.Sc.

The discovery of nitro-glycerine was announced by Sobrero to the Royal Academy of Science in Turin in 1847. In 1851 de Vrij, Professor of Chemistry in the School of Medicine in Rotterdam, communicated to the British Association for the Advancement of Science: (1) A preliminary account of the results of his investigation of this body, and a full account of his work was published later in the Dutch "Journal of Pharmacy" in 1854. (2) He nitrated glycerine by adding it to well-cooled strong nitric acid, and then precipitated it by an addition of strong sulphuric acid. The acids were separated from the nitro-glycerine by means of a tap funnel—the laboratory forerunner of the method universally employed on a large scale until recent years. De Vrij obtained a yield of 184, and concluded that nitro-glycerine was a dinitrate. His method naturally gave low yields, and this misled him as to the composition of nitro-glycerine.

In 1855 Railton (3) worked on the composition of nitro-glycerine and investigated its decomposition by potassium hydroxide. He used Liebig's method for the estimation of the relative quantities of carbon and nitrogen produced on combustion. The formula of nitro-glycerine being taken as $C_3H_5(NO_3)_3$, the ratio of the volumes of carbon dioxide and nitrogen should be as 2 to 1. Railton obtained results varying from 2.156 to 1 down to 1.912 to 1. While these results were, on the whole, in favour of the formula, they were not altogether satisfactory. Railton made no attempt to estimate the carbon and hydrogen absolutely, as he found it impossible to dry his nitro-glycerine, even in an exhausted receiver, on account of its great tendency to decompose—sufficient proof that his sample was impure. Railton boiled nitro-glycerine for several hours with an aqueous solution of potassium
hydroxide, specific gravity 1.6; the liquid became homogeneous, and was then neutralized with sulphuric acid. Potassium nitrate was found to be present, and glycerine was also stated by Railton to be identified in the products of decomposition. He therefore concluded that nitroglycerine was decomposed by potassium hydroxide with the formation of potassium nitrate and reformation of glycerine.

\[ C_3H_5(NO_3)_3 + 3 KOH = C_3H_8O_3 + 3 KNO_3. \]

Gladstone and Dale (4) in 1863 examined the refractive index, dispersion, and specific refractive energy of nitro-glycerine as compared with glycerine.

Kern, in 1874 (5), investigated the phenomena exhibited by nitro-glycerine on heating at various temperatures. He found that at 187° C. it boiled, evolving orange vapours; at 220° C. strong explosion; 262° C. strongest explosion; and at 294° C. a feeble explosion with a yellow flame.

In 1875 Alfred Nobel read a paper on "Modern Blasting Agents" (6) before the Society of Arts, which contains a large amount of interesting information on the subject of nitro-glycerine, and much originality of view.

In 1887 Hay and Orme Masson (7) made by far the most complete investigation ever carried out as regards the composition of nitro-glycerine. All investigations agreed in regarding it as a nitrate of glycerine; but while some considered it a trinitrate, others held that it was a mixture of tri, di, and mononitrate. Previous analyses were quite insufficient to establish one or the other conclusion, and were mainly confined to the estimation of nitrogen. By combustion and estimating the nitrogen by Dumas' method, they obtained the following results:

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<th>Found by</th>
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<td>Glycerine trinitrate.</td>
<td>Hay and Masson.</td>
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<td>C.</td>
<td>15.86</td>
<td>15.91</td>
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<td>H.</td>
<td>2.20</td>
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<td>N.</td>
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RESEARCHES ON NITRO-GLYcerINE

By decomposing an alcoholic solution of nitro-glycerine with an alcoholic solution of potassium hydroxide, and reducing the nitrate and nitrite so formed with ferrous chloride and hydrochloric acid they obtained as a mean of their results from samples of nitro-glycerine prepared under very varying conditions of acid composition, etc., 18.07 per cent. of nitrogen.

Hay (8), in 1887, carried out a very complete investigation of the decomposition of nitro-glycerine by potassium hydroxide and other re-agents. It is interesting to note that for some thirty-two years Railton's equation, referred to previously, was considered by chemists to be in the main correct, i.e., that nitro-glycerine was decomposed by a solution of potassium hydroxide with the production of potassium nitrate and the reformation of glycerine. It is true that some subsequent workers noticed the presence of nitrite, but it was apparently considered to exist in relatively small proportion. All the workers appear to have accepted as a fact that there was a reformation of glycerine. Hay found that no trace of glycerine was obtained by decomposition with potassium hydroxide, and that an amount of nitrous anhydride was formed, corresponding to 35 per cent. of the nitro-glycerine used, which corresponded to a reduction of two out of the three nitrate groups which theoretically would yield 33.48 per cent. The decomposition of nitro-glycerine by potassium hydroxide is represented by the following equation:

$$C_3H_5(NO_3)_3 + 5 KOH = KNO_3 + 2 KNO_2 + HCO_2K + CH_3CO_2K + 3 H_2O.$$  

Ammonia and alkali carbonates were found to decompose nitro-glycerine in the same manner. The yield of nitro-glycerine was determined, as obtained under very varying conditions of acid mixture, and the proportion of glycerine employed. The highest yield, 233.3 being found on using glycerine (10.5) nitric acid (30), sulphuric acid (30), and fuming sulphuric acid (30) parts.

Perkin (9) in 1889 determined the specific rotation and molecular
rotation of nitro-glycerine and concluded that had nitro-glycerine contained its nitrogen in any combination of oxygen other than \( O < \frac{N}{O} = O \)

the rotation compared with propyl nitrate would be abnormal.

In 1904 Marshall (10) investigated the question of the vapour tension of nitro-glycerine.

In 1908 Nathan and Rintoul (11) gave a complete account of the method of manufacture of nitro-glycerine as carried out at Waltham Abbey, and contributed very interesting work on the chemistry of the process.

(2) *Tijdschrift voor wetensch pharm* (1854).
(3) *Or. J.C.S.* (1855), 222.
(6) *Journal Soc. Arts* (1875).
(10) *J.S.C.I.* (1904), 185.
PERMITTED EXPLOSIVES
By Henry de Mosenthal, F.I.C., F.C.S.

As far back as 1812 a society was formed in Sunderland for the prevention of accidents in coal mines. At that time the question of lighting in collieries was specially investigated, candles and oil lamps being in general use. Dr. William Reid Clanny suggested the first safety-lamp. In 1815 Sir Humphry Davy undertook his classical investigation, showing that marsh gas mixed with six to ten times its volume of air formed an explosive mixture, and as the outcome of these experiments he devised the lamp which bears his name, and which is still in extensive use.

Shot-firing in coal mines was carried out with black powder until the introduction of dynamite in 1870, but it was years afterwards before steps were taken seriously to combat the dangers of blasting in coal.

By the Coal Mines Regulations Act of 1872 the appointment of a competent shot-firer was made obligatory, and it was enacted that he should not allow the shot to be fired unless he found it safe to do so, this provision applying to any mine three months after any inflammable gas had been found. If the inflammable gas issued so freely that it showed a blue cap on the flame of the safety-lamp, explosives were only to be used in stone drifts, stone-work, and sinking of shafts in which the ventilation was so managed that the return air from the place where the powder was used passed into the main return air course without passing any place in actual course of working, or when the persons ordinarily employed in the mine were out of the mine or out of the part of the mine where the explosive was used.
Shortly after the passing of this Act, Dr. Macnab suggested inserting a cylinder filled with water in front of the charge. Sir Frederick Abel, who was a member of a Commission appointed to investigate accidents in mines, read a paper in 1873 before the Royal Society on a method of surrounding the explosive by a comparatively large quantity of water. The difficulty connected with this method of safety blasting was that the explosive charge was liable to touch the side of the waterproof envelope containing the water, thus rendering the precaution nugatory. In 1877 Heath and Frost suggested using a plug or cylinder consisting of 90 per cent. of water made into a kind of jelly by the addition of 10 per cent. of soap, glue, and starch. Wet moss tamping was also tried and liquid carbon dioxide was substituted for water.

In 1882 Miles Settle, the Managing Director of the Madeley Coal and Iron Company, patented a method for holding the cartridge suspended in water in the middle of a waterproof bag by means of a small circular metal support, a wire retaining this metal ring equi-distant from the ends of the envelope, so that the cartridge was absolutely surrounded by water. This device, in conjunction with blasting gelatine, was used to a considerable extent, but proved very costly and cumbersome, and, of course, necessitated a much larger bore-hole.

George Trench, works manager of the Cotton Powder Company at Faversham, patented in 1887 a fire-extinguishing compound, consisting of sawdust saturated with a solution of alum salt and sal-ammoniac, which was pressed round the cartridge in the bore-hole.

The first testing station and trial gallery was built in 1885 by the Prussian Government at Neunkirchen, and it was in this first trial gallery that the first experiments were made to determine the relative safety of explosives in fire-damp and coal-dust. The trial gallery was supplied from a neighbouring coal-mine with pit-gas obtained from carefully tapped "blowers," i.e., pockets in the coal-seam in which pit-gas regularly collected. Black powder was first tried, and was found to ignite pit-gas as well as coal-dust. At first the method consisted solely of suspending pellets or cartridges in the gallery. Later, the explosives
were fired from a mortar, without tamping, into explosive mixtures of varying proportions of pit-gas, air, and coal-dust. Kieselguhr dynamite was shown to be safe up to about 100 grammes, gelatine dynamite up to about 80 grammes. Nitrate of ammonia explosives and Carbonite gave much better results. The other explosives tested were in the first instance Hellhoffite, consisting of nitric acid and nitro-benzene, and Carbonite, which then consisted of saltpetre, nitro-glycerine, and sulphuretted oil. In 1886 Securite was tested, and in 1887 Roburite, and so-called Wetter-Dynamit.

Coincidently with these experiments a number of explosives were devised, based on a theory propounded by Dr. Sprengel in 1873. He had shown that any combustible substance combined with an oxygen carrier would produce an explosive. In the beginning of 1885 Arthur Favier patented an explosive of this kind consisting of ammonium nitrate and a hydro-carbon of low melting point, such as paraffin. This explosive was introduced into Great Britain in 1889 under the name of Miners' Safety Explosive, being manufactured at Stanford-le-Hope, in Essex. To-day it bears the name of Ammonite, and now consists of ammonium nitrate and dinitro-naphthalene.

In the year 1885 Carl Lamm patented Bellite, and in 1886 Carl Roth Roburite, and Hermann Schöneweg Securite. Explosives of this class contained ammonium nitrate, and different devices were resorted to in order to obviate the disadvantages due to the hygroscopicity of that salt. Dipping the cartridge into paraffin, ozokerite or beeswax, or mixtures of these was a favourite means of packing, others used metal cartridge cases. In some patents it is claimed that the grains of ammonium nitrate become coated during manufacture with the other ingredient or ingredients thus rendering the salt impervious to the moisture of the air. These explosives were not specially devised for use in coal mines, but, as already mentioned, the Prussian trials proved them to have some advantage in this respect over dynamite, gelatine explosives, and black powder.

The credit for the first serious attempt to produce an explosive
specially suited for fiery mines belongs to C. E. Bichel, who submitted various modifications of Carbonite for trial at Neunkirchen in 1885.

In 1887 Mr. Emil Müller, of Cologne, conceived the idea of making a safety explosive for fiery mines by the addition of a salt containing a large proportion of water of crystallization. To such explosives he gave the name of Wetter-Dynamit. He first selected soda crystals, and then alum, and, as we shall presently see, a modification of Wetter-Dynamit was introduced into this country under the name of Ardeer Powder.

In 1887 a Coal Mines Regulation Act amending previous Acts was passed, and the use of explosives underground was further regulated, one provision being that whenever inflammable gas was reported as present in any mine, the shot was not to be fired unless a competent person appointed for the purpose had examined the place where the gas was reported to be, and had found that such gas had been cleared away, and that there was not at or near such place sufficient gas issuing or accumulating to render it unsafe to fire the shot; or unless the explosive employed in firing the shot was so used with water or other contrivance as to prevent it from inflaming gas; or unless the explosive was of such a nature that it could not inflame gas.

In 1888 the North of England Institute of Mining and Mechanical Engineers appointed a Committee to make investigations and report upon the subject of flameless explosives. It took them four years before they were in a position to carry out their experiments, having had to construct a trial gallery. The representative safety explosives which they selected for their experiments, which lasted from March, 1892, till the end of 1895, were Roburite, Bellite, Securite, Ammonite, Carbonite, Ardeer Powder, and Westfalite.

Roburite was the first ammonium nitrate explosive introduced into this country. It was imported in 1887, and first manufactured at Gathurst, near Wigan, in 1888. At that time it consisted of ammonium nitrate with chlorinated dinitrobenzol. Bellite and Securite, both
FIG. 25. DR. HERMANN SPRENDEL, F.R.S.
PERMITTED EXPLOSIVES

described as consisting of ammonium nitrate and meta-dinitrobenzene were imported in 1888. Bellite was manufactured at Whitnell in 1894, where it is still made. Securite was manufactured at Denaby from 1889 to 1890. Carbonite was first licensed in 1888, and described as consisting of 25 per cent. nitro-glycerine, 41 per cent. wood meal, and 33 per cent. of potassium or barium nitrate, ½ per cent. sulphuretted benzol, and ½ per cent. sodium carbonate. Ardeer Powder, which was first manufactured in 1891, was a Wetter-Dynamit, in which, instead of soda crystals or alum, magnesium sulphate was added to Kieselguhr dynamite. Westfalite was first licensed in 1894, and described as consisting of ammonium nitrate and resin soluble in alcohol.

The report of the experiments carried out by the Committee above referred to was published in 1896 by Mr. A. C. Kayll. According to a communication received from Professor Bedson, who was connected with that Committee, the site for the trial gallery was chosen near Hebburn Colliery, a supply of natural gas being conveniently obtainable there. It was, indeed, from this very colliery that Sir Humphry Davy obtained in 1815 the pit-gas required for his experiments. In these trials the explosive was fired from a cannon, a cylindrical steel block (hooped with five steel rings) 4 feet 6 inches in length and 18 inches in diameter at the breech for a length of 18\(\frac{1}{2}\) inches, and 15\(\frac{3}{4}\) inches for the remaining length of 3 feet. The bore of the cannon was 42\(\frac{1}{4}\) inches in length and 1\(\frac{3}{4}\) inch in diameter drilled out of the solid block. The tube into which the cannon was fired was 101 feet in length and 3 feet in diameter, and was made of wrought iron plates \(\frac{1}{4}\) inch thick. It was built in five sections bolted together. The recommendations of the Committee, based on experiments with pit-gas and air and coal-gas and air with stemmed and unstemmed shots led up to the passing of the Coal Mines Regulation Act of 1896, which is still in force. The provisions of that Act as to explosives are as follows:

"The Secretary of State on being satisfied that any explosive
is or is likely to become dangerous may, by Order, of which notice may be given in such manner as he may direct, prohibit the use thereof in any mine or in any class of mines either absolutely or subject to conditions."

This brought the regulation of shot-firing in coal mines under the authority of the Secretary of State, and consequently under the Department of H.M. Inspectors of Explosives at the Home Office.

As an outcome of a Departmental Committee appointed in 1896 to inquire into the testing of explosives for use in coal mines, a trial gallery was constructed by the Government at Woolwich in 1897. The late Captain Thomson, H. M. Chief Inspector of Explosives, who was a member of that Departmental Committee, and had seen the pioneer work done at Hebburn by the North of England Mining Institute, was entrusted with the design of the apparatus. The gallery consisted of a circular steel tube $27\frac{1}{2}$ feet long by $2\frac{1}{2}$ feet in diameter. A paper disc is fixed at one end to form an explosion chamber of $134\frac{3}{4}$ cubic feet capacity. The cannon was movable, and was mounted on a trolley, so that it could be moved along to the open end of the gallery when charged, ready for firing. The cannon consisted of a cylindrical steel block $4\frac{1}{2}$ feet long and 18 inches in diameter. The bore-hole, drilled along its axis, was 30 inches long and $1\frac{7}{8}$ inch in diameter. The cannon was so placed that its axis was horizontal. For getting the requisite explosive mixture, recourse was had to ordinary coal-gas, the mixture used containing 10 per cent. of coal-gas. Major Cooper-Key, now H.M. Chief Inspector of Explosives, was in charge of the Woolwich Testing Station when it was first erected, and carried out experiments which determined the method of testing. His exhaustive report, dated 31st December, 1897, shows the care bestowed on every detail.

The relative strength of the explosives was determined in the Trauzl lead block. The arbitrary standard of 3 to 1 based on experience was taken to compare high explosives with explosives of the gunpowder class, i.e., those which are not fired with a detonator. In
the case of high explosives, a tamping of dry sand was found sufficient, whereas with gunpowder it was found preferable to ensure more thorough confinement by using another lead cylinder for this purpose. Taking then the standard charge as 2 oz. of dynamite No. 1, the equivalent of the highest grade of fine grain gunpowder, namely, R.F.G.\textsuperscript{2}, was taken at 6 oz., so that all explosives which are fired by a detonator are compared with 2 oz. of dynamite No. 1, and all those which are not fired with a detonator with 6 oz. R.F.G.\textsuperscript{2} gunpowder. The equivalent charge is not derived from the result of firing equal charges of each in a lead block, but calculated from the weight which is required to give equal expansion of the cavity to that given by the standard. The stemming or tamping was done with a white pottery clay carefully dried and in a fine state of division. All shots were stemmed with 9 inches of that clay well rammed. No explosive was placed on the Permitted List unless:

1. Twenty shots were fired without a single failure, or
2. Thirty shots were fired with only one failure, or
3. Forty shots were fired with only two failures.

The number of the shots was restricted to forty. A shot was regarded as a failure if it ignited the gaseous mixture or left an appreciable amount of the charge unexploded.

The first Order under the 1896 Act was issued in December, 1896, and a list of permitted explosives was therein given. That list contains the names of ten explosives, and prescribes for each the minimum strength of detonator to be used and the nature of the cartridge wrapper. Further orders were issued from time to time.

In October, 1899, the Home Office decided to make the test at Woolwich more severe, placing such explosives as passed this more stringent test on a special list, the reason given being that while mine-owners had been left to select the best explosive from the Permitted List, there was nothing to distinguish in any way between those which had barely passed the test and those which could be fired safely under much more stringent conditions. The trial was limited to twenty
shots, of which ten were fired with charges one and a half times as large as in the previous test with 9 inches of stemming, and ten with double the charge and 12 inches of stemming. The gas mixture taken was rendered more sensitive by increasing the proportion of coal-gas to 15 per cent., and no less than twenty consecutive shots had to be fired without a single failure, i.e., without ignition and without leaving an appreciable amount of the charge unexploded.

In 1900 the lead block was abandoned as a means of determining the relative strength of explosives, and the ballistic pendulum was adopted. This consists of a 5-ton mortar of 13 inches calibre suspended on roller bearings in an iron frame worked from an overhead beam. One of the guns used in the test is fired at a determined distance from the muzzle of the mortar, with a charge of the explosive stemmed with a fixed weight of clay and the extreme swing of the mortar measured to the hundredth of an inch, indicates the relative strength.

From 1899 to the end of 1901 there were two schedules to the Order in Council, the Permitted List and the Special List. In November, 1901, the Permitted List of explosives was withdrawn, and only the explosives in the Special List, which was henceforth called the Permitted List, could be used in fiery and dusty mines. Since 1901 the conditions of the test have subsisted without alteration, except that the explosives prior to trial must be stored for thirty days.

The Permitted List, as it stood on 20th August, 1908, contains the names of sixty-one explosives. These explosives can be classed as follows:

1. *Nitro-glycerine Explosives.*
   
   (a) Mixtures of nitro-glycerine gelatinized or not with nitrocellulose, and a dope of carbonaceous matter and nitrates.
   
   (b) the same explosive with the addition of a flame-quenching salt.
   
   (c) mixture as (a) or (b), with the addition of a nitrated aromatic compound.
2. *Ammonium Nitrate Explosives.*

Mixture of Ammonium Nitrate with:

(a) a carbon compound (resin, naphthalene, etc.).
(b) an oxidizable material (aluminium, etc.).
(c) an aromatic nitro-compound.

3. *Chlorate and Perchlorate Explosives.* Mixtures in which chlorates and perchlorates are used as oxygen carriers.

4. *Gunpowder Class.* The only representative of this class is Bobbinite, consisting of black powder made with a special charcoal, rich in hydrogen with the addition of starch and paraffin wax.

It is interesting to note that a class of explosives largely used on the continent, more particularly in France and Belgium, and known there as Grisoultite or Grisoutine, consisting chiefly of ammonium nitrate and nitrocellulose, have not till now found their way into this country.

Of late, explosives have been made in Germany with the addition of common salt in order to attain safety, but these explosives have not yet been introduced here.

The fact that Bobbinite, virtually a black powder, should figure on the list, caused considerable discussion, and several ignitions in fire-damp ascribed to this explosive led to the appointment, in 1907, of a Departmental Committee to investigate the behaviour of Bobbinite in coal mines. As the outcome of this enquiry, Bobbinite was maintained on the Permitted List.

The tests for safety applied on the continent differ from those applied by the Home Office at Woolwich. Explosives which have passed the test on the continent have failed to do so in this country, and *vice versa.* Captain Desborough, H. M. Inspector of Explosives, classifies the different methods of testing, as follows: (1) the theoretical or French test; (2) the firing of unconfined charges, or Austrian test; (3) the firing of partially confined charges, the Belgian or German test; (4) the firing of completely confined charges, or British test. The main difference in the methods of carrying out these tests lies in the size of
the tube or gallery, and its shape. As a rule, the continental galleries are of greater diameter than that at Woolwich, and it is generally admitted that the smaller the diameter of the gallery, the more severe the test. In the continental testing stations, natural gas, artificial marsh gas or benzoI are used mixed with air. The mixture of coal-gas and air used at Woolwich is regarded as the most sensitive of any of the gas mixtures used. On the continent, in most of the trial galleries, no tamping is used; unstemmed shots are fired into the explosive mixture, and the small sectional area gallery at Woolwich renders it absolutely necessary to stem the shots. The relative safety of explosives is determined on the continent by fixing the "charge limit," which is the charge which just fails to ignite the gas mixture. H. M.'s Inspectors of Explosives, Major Cooper-Key in his first report in 1897, as well as Captain M. B. Lloyd and Captain A. P. H. Desborough, in a special report, have stated that the primary object of the British testing station is to enable an empirical line to be drawn between such explosives as may and such as may not be used in mines to which the Explosives in Coal Mines Orders apply, or in other words to eliminate the more dangerous explosives from those used in fiery and dusty collieries. They state that it is impossible in a single test to reproduce all the varying conditions which may occur in practice. In fact it was recognized from the very first that no test could possibly imitate the conditions of use of an explosive in a mine, and therefore the object of the British Government Test has been to devise a method of testing which should be as uniform as possible.

The testing of explosives for safety has formed the subject of discussion on many occasions, and a great number of attempts have been made to determine why under certain conditions one explosive should behave differently in fire-damp or in a mixture of gas and air than another.

It is generally admitted that the safety of the explosive depends on the length, duration, and temperature of the flame, but the contributory factors are the subject of controversy. No explosive is
PERMITTED EXPLOSIVES

absolutely flameless, and none absolutely safe in fire-damp; flamelessness and safety being relative terms.

The explosives here dealt with are also used for other purposes besides coal-mining, more particularly for quarrying and for blasting in soft rock. The low specific gravity of ammonium nitrate and the alkali chlorates is a bar to their use in hard rock where the bore-hole is necessarily costly.
FULMINATES of gold and silver were known before the year 1799, but not put to practical use. Samuel Pepys mentions in his diary under date

"Nov. 11, 1663. At noon to the Coffee-house, where with Dr. Allen some good discourse about physick and chymistry. And among other things I telling him what Dribble the German Doctor do offer of an instrument to sink ships; he tell me that which is more strange, that something made of gold, which they call in Chymistry Aurum Fulminans, a grain I think he said, of it put into a silver spoon and fired, will give a blow like a musquett and strike a hole through the silver spoon downward, without the least force upward and this he can make a cheaper experiment of, he says, with iron prepared."

A number of fulminating compounds either with mercuric oxide and sulphur, or mercuric nitrate and phosphorus, or mercuric oxide and potassium chlorate, and others were proposed, but none of them could be used. It was at a meeting of the Royal Society on the 13th March, 1800, that Edward Howard, F.R.S., announced the discovery of what is now known as fulminate of mercury. He analysed his fulminate of mercury according to every method then known to chemists and, in one of his experiments, treated "the mercurial powder by means of dilute sulphuric acid." He was severely injured by an ensuing explosion, which led him to confess, that "he would feel more disposed to prosecute other chemical subjects."
FIG. 26. EDWARD CHARLES HOWARD, F.R.S.
Howard's experiments show that fulminate of mercury was useless as a military powder, but suggest the possible use for breaking up ordnance. As a primer, he points out that gunpowder laid over the fulminate was not inflamed by the explosion of the latter.

The application of detonating powder to the discharge of firearms came later; at first chlorate powder was used, the mercuric fulminate cap is of a later date. It made the cartridge possible, the success of which is largely due to the labours of William Eley. Since the question of priority in this invention is in dispute, the following notes, which are the result of a careful investigation of the subject, will be of interest.

ALEXANDER JOHN FORSYTH.

Forsyth's experiments with detonator locks were first made in the year 1805, when he constructed a lock for a sporting gun with which he shot "with safety during the whole season." In the spring of 1806 he submitted the invention to the Master-General of the Ordnance, by whom he was requested to adapt his principle to the requirements of the military service. After some £600 had been spent in experiments, Forsyth claimed to have succeeded in applying his system both to the musket and a three-pounder, and negotiations were opened at the inventor's suggestion, for basing his remuneration on the saving of gunpowder effected by the new mechanism. This gave the Government a loophole for escape. A change of ministry took place, and Lord Chatham, the successor of the Marquis of Hastings in the Mastership of the Ordnance at once discharged Forsyth from further experimenting on the Government's behalf. The inventor's bare expenses were paid, but no other remuneration was given until 1843, after the percussion system was adopted officially, when a sum of £1,000 was divided amongst Forsyth's relatives—the inventor having died in that year. To return: however, in 1807, Forsyth, acting on the suggestion of the Government, took out a patent drafted as stated by himself, "in the most general items," i.e., he claimed all forms of per-
cussion locks with all suitable detonating mixtures. These claims after arduous fighting, were finally sustained in Forsyth v. Riviere in 1819, after which trial the trade appears to have accepted some form of licence. Great as the merits of Forsyth's invention unquestionably were, the effect of the patent was prejudicial to the development of the industry. Forsyth was obstinately wedded to his detonating mixture, viz., potassium chlorate, charcoal and sulphur, and he persisted in retaining the original design of his lock. It is stated that his guns were manufactured at Liège, which would have made the efficient supervision of improvements difficult. According to Mr. Blanch, we find in the "London Directory" of 1812, Forsyth and Co., Patent Gunmakers, 10, Piccadilly, and in 1818 at 8, Leicester Square, where they remained until 1852. The original gun as invented by Forsyth was exhibited at the 1851 Exhibition in Hyde Park, London.

Probably the enforcement of his patent rights occupied most of the leisure hours of the Scotch Minister, who to the last (viz. in 1843) failed to recognize the superiority of the cap and nipple mechanism. Be that as it may, Forsyth's resistance to improvements in the percussion lock during the term of his patent accounts for the obscurity which has shrouded the history of the invention of the fulminate of mercury percussion cap. The period and country of origin of the invention are fairly well defined, the number of claimants to the honour are considerable. In the present essay it is not pretended that all difficulties have been solved, or that all avenues of research have been finally explored, but something, it is hoped, has been done towards stating with precision the relative claims of those who were instrumental in the introduction of the new system between 1818 and 1823.1

The Forsyth lock was both original and ingenious. In place of the priming pan outside the flush hole, a round plug, having a small cavity on the top which led to the flash hole, was fitted into the barrel,

1 The following description of the Forsyth and Manton locks has been kindly supplied by Mr. Herbert J. Blanch.
FIG. 28. FORSYTH MAGAZINE (ASSEMBLED).

FIG. 29. FORSYTH MAGAZINE (DETACHED).
and upon this plug was pivoted a magazine in the shape of a small scent bottle with two necks opposite each other. In one neck was mounted a striker rod held up by a light spring, and in the other neck was a hole drilled down to the central plug, to contain enough detonating powder for about twenty discharges, covered by a sliding lid. In this lid, opposite the hole containing the powder, was a similar hole fitted up with a plug of horn or leather, to act as a safety vent in case the entire contents were discharged by friction or jar. This perhaps only rarely happened, but the great objection to the system was the necessity of handling the loose detonating powder, and, although pellets or pillules of various compositions were tried, as soon as the copper tube and copper cap had been invented, which obviated the necessity of actually handling the detonating powder, and cut it up into very small quantities, which were quite safe for ordinary handling, and yet sufficiently sensitive when placed in position on the lock and fired by a blow from the hammer, all attempts to work with the loose powder were abandoned.

The operation of priming with the Forsyth gun was to rotate the magazine primed until the hole containing the detonating powder was over the small cavity in the top of the plug leading to the touch-hole, when a small quantity fell by gravity into the cavity of the plug, assisted by the jar of the primer being arrested in its rotation against a stop pin on the lock plate.

The primer was then rotated into the opposite position, which brought the small striker rod over the cavity now containing the detonating priming, and ready to be fired on the fall of the hammer on the striker.

In 1816 "Joe Manton" patented a gun having a copper tube containing detonating powder held "fore and aft" in a hole in the head of the hammer, which, in falling, struck the open end into a cavity in a plug, containing the flash hole, projecting from the barrel.

In 1816 he improved on this in another patent, by placing the
copper tube in the flash hole itself, where it was held by a spring cover, and was struck in the middle, through a hole in the cover, by the hammer which had an axe-shaped striking piece.

This gave a very powerful flash and certain ignition, and could not blow the hammer back again, as might happen with the other system, the only drawback being that the fired tube might blow out to the right or left with considerable force, to the danger of any one near.

E. Goode Wright, of Hereford.

In 1823 Wright published his classical paper on the preparation of fulminate of mercury caps. In this paper he strongly asserts the superiority of the fulminate over the chlorate of potash mixture of Forsyth. Wright was led to make his experiments after hearing a series of lectures in chemistry delivered by Murray at Hereford in November, 1822, at which date the copper cap was well known. Indeed, Wright's statement contains an admission of the fact. "After he (i.e. the lecturer) left us I was induced to make the powder and try it with the copper cap." In the same paper, however, Wright refers to experiments made by him "several years ago" with fulminate of mercury as a primer for guns, and this statement is carried back by the compilers of the "Temple Anecdotes" to the year 1805, the year of Forsyth's original experiments. In confirmation they quote an undated letter from the Duke of Wellington to Wright to show that Wright was at that time advocating the use of fulminate of mercury in copper caps in the military services. A search through the Board of Ordnance papers from 1806-26 shows that the paper correspondence has not been preserved. It may have perished in the fire at the Tower of London circa 1840, in which the original correspondence, re Forsyth's invention, was lost; or the Duke may have treated the letter as personal correspondence. The letter, however, can be dated

1 "Phil. Mag." vol. lxii, p. 203.
approximately as not earlier than 1820, for the Duke's answer refers to an official report condemning the percussion system, which has been preserved, and which is dated 12th May, 1820. This correspondence therefore cannot affect the main issue, for the copper cap was already the subject of a French patent prior to this date. Nor can the early experiments of Wright have been of such a nature as to invalidate Forsyth's patent, for in 1819, in Forsyth v. Riviere, the question of novelty was exhaustively treated, and the only apparent anticipation alleged by the defendant was that of a clergyman named Butler, of Okeford, near Blandford in Dorsetshire, who had invented a lock of similar description, and communicated the idea to a gunmaker named Symonds, but the judge directed that the disclosure was insufficient to affect the validity of Forsyth's patent.

F. Joyce, Chemist.

Wright's paper was followed in 1824 by the experimental manufacture of copper caps by the chemist, F. Joyce. In an excellent monograph, entitled "The Sporting Cartridge" (London, 1906), Messrs. Joyce and Co. claim an earlier date, but the correct date is, I venture to assert, settled by the following quotation from the third edition of Colonel Hawker's "Instruction to young Sportsmen" (1824): "Since the first part of this work was printed off, a letter has been received from Mr. Joyce, chemist, 11, Old Compton Street, Soho, inclosing a specification of a new 'anti-corrosive percussion powder.' All he can say is that he has fired twenty-four copper caps with this new powder after dipping each cap for some time in water, and not one of them missed fire." In the fifth edition of Hawker (1826) the writer further states: "It may be hardly fair to say publicly what the composition is (because Mr. Joyce candidly told me, though I believe it is pretty well known), and although it was long ago adopted by Mr. Goode Wright, of Hereford, according to a statement which, as an utter stranger, I was favoured with by the gentleman;" and he goes on to give Joyce credit for having overcome many obstacles before bringing
the percussion caps to perfection. Obviously the quality of the copper, the tempering and water-proofing of the fulminate were all matters which would require careful working out before the manufacture could be established on a large scale. The evidence of the London Postal Directories supports Hawker's statement. Joyce's name appears from 1823-27, as "Operative Chemist, 11, Old Compton Street." In 1828 F. and E. Joyce are styled "Percussion powder manufacturers," and in 1831 they re-appear under the same description at 55, Bartholomew Close. In 1843 F. Joyce describes himself as "practical chemist, inventor and sole manufacturer of the anti-corrosive gun cap," etc. The facts suggest a close connection between Wright's paper in 1823 and the manufacture of the copper cap by Joyce in 1824.

**Joseph Egg.**

Our examination of Wright's claims has tended to prove that the invention of the copper cap and nipple mechanism preceded by some years the practical information required for the manufacture of the fulminate of mercury. Wright appears to have been the first to give this information to the public. Apart from the question of the fulminate two individuals have directly claimed the invention of the copper percussion cap and nipple mechanism, viz., Joshua Shaw, the naturalized American, and Joseph Egg, the Piccadilly gunmaker. The latter engraved his claims on his own gun-locks, and it is probable that he was one of the first London gunmakers to put this class of lock upon the market. As late, however, as 1821 he was pushing a percussion gun-lock, which is thus described in the "Sporting Magazine," 1821:

Of magazine some did complain,  
And vowed it threatened senseless brain,  
A safer mode by tube and peg,  
Is offered to the world by Egg.

His adoption of the cap and nipple mechanism was probably subsequent to this date. In 1841, when public interest was again aroused by the adoption of the percussion cap by the military authorities,
Mr. H. Wilkinson, of Pall Mall, took great trouble to ascertain the truth as to the invention of the copper cap, and published the result of his researches in his "Engines of War," page 187, from which the following abstract is taken:

"Mr. Egg, I believe, purchased the invention from Mr. Roantree, a gunmaker at Barnard Castle, Durham, who had it from a workman employed by Mr. Joshua Shaw, now residing at Philadelphia. I can trace it no further. Mr. Shaw assured me that in 1814 he invented a steel cap, which, when fired, was retained to be primed again; that in 1815 he made a pewter cap, which was thrown away after using; and, lastly, that in 1816 he used a copper cap precisely similar to those at present employed. He made application for a patent in England; but the solicitor, to whom it was referred, decided that it could not be obtained without infringing Forsyth's patent then in force."

Joshua Shaw.

Before discussing Shaw's claims, we must now turn to the French specifications, which contain the earliest description of the invention. On the 29th July, 1818, Prélat, a Paris gunmaker, patented a hollow cock and a conical nipple, which was charged by dropping a few grains of fulminate of mercury into the cavity of the cock. On the 28th July, 1820, he filed a certificate of addition, in which a flanged copper cap charged with a secret composition is substituted. A month later, Deboubert, also a Paris gunmaker, patented a cylindrical copper cap charged with fulminate of silver. Both these patents are believed to be merely copies or modifications of models made by the London gunmakers. It is also stated that the manufacture of fulminate of mercury started in France in 1819. Now let us turn to Shaw's statements. The dates of his first visit to the United States, of his return to England, and his final settlement in the States are uncertain. The dates of his alleged applications for English and American patents are also unknown, and the specification of his first American patent, dated 1822, was destroyed by fire. In July, 1824, however, a committee of
the Franklin Institute reported favourably on his copper and pasteboard primers ("Mech. Mag.," vol. iii, p. 142). These were charged with Forsyth's compound, "which had been the only vehicle in use till within some few months, when a new discovery was made of a metallic preparation, perfectly neutral, and indeed less corrosive than gunpowder itself, and of this Mr. Shaw has availed himself." The committee goes on to show that Shaw was using his detonating compounds in waxed pasteboard primers, which were pressed into a recess in the breech of the gun. At this date, therefore, Shaw was using Forsyth's compound and fulminate of mercury in the form of flat caps. His earlier experiments with the cylindrical metal caps had been laid aside until Wright's paper had shown a practical method of manufacturing and applying the fulminate of mercury. This view is supported by Shaw's letter in the "Franklin Journal" for 1829 (pp. 271-73), in which he defends Wright against a foreign critic who had written in favour of the chlorate of potash primer. After the expiration of Forsyth's patent, he writes: "Wright introduced the fulminating mercury, since which there have been no complaints whatever of the corrosion of the locks," and he goes on to state that percussion guns were more generally used in America than in England, "although the guns themselves are the manufacture of that country," owing to the superiority of the American copper caps. As regards the latter, Shaw states: "I have been in the habit of using copper caps for at least the last thirteen years (i.e., from 1816), and for the last seven years (i.e., from 1822) have manufactured and sold them at the rate of two millions annually." Shaw's claim to the invention of the percussion cap are restated somewhat differently in "The Scientific American" for 7th August, 1869, which contains his memoir, but in our present state of imperfect information it is safer to regard his claims as not proven. As in the case of Joyce, it is probable that Shaw's manufacture of percussion caps on a large scale was subsequent to and inspired by Wright's paper in 1823, and in spite of a statement to the contrary, it is doubtful whether the copper percussion cap was included in his patent of 1822. It is greatly to be wished that some American
investigator would ascertain the whereabouts of the MS. autobiography which Shaw is said to have compiled. It is impossible to doubt, however, that he was closely connected with the first trials of the copper cap—that he was present at the birth of the invention, if not actually the inventor, and that these experiments took place in this country about 1816, the year when Manton unsuccessfully contested the validity of Forsyth's patent. If it could be shown that these experiments were conducted in London, Manton's workshop would be the likeliest place; and mention is made by Colonel Hawker, in the seventh edition of his work, of one of Manton's workmen, "J. Greenfield one of Joe's very best workmen and his cabinet counsellor in all matters of difficulty (than whom) no man in London has invented more little articles for other people to get the credit of." This individual had recently been taken into the service of F. Joyce, the percussion cap maker. If some connection could be established between Greenfield and Shaw, the mystery of the copper cap would perhaps be over; but too many links in the chain of evidence are wanting to warrant any definite conclusion.

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(i) Metallic Fulminate and the Copper Percussion Cap

1794. Experiments on combustible and explosive compounds. Minutes of the Society for Philosophical Experiments. (London, 1795, pp. 315-30.) Include experiments on gold and silver fulminates.


1833. On fulminates and the manufacture of the percussion cap. (Lardner's Cabinet Cyclopaedia: Manufactures in Metal, vol. ii, pp. 119-23.)

Describes the process of making percussion caps at Waterbury.

(2) Alexander John Forsyth (1769-1843)


1805-6 and 1840-3. Forsyth’s original correspondence (1805-6) with the Ordnance Office was destroyed by fire, but the substance is preserved in

(a) The Mechanic's Magazine, vol. xxxii, 1839-40, which contains a reprint of an article in the Aberdeen Herald; (b) his Brief Statement (Ordnance Office Papers “Inventions”) preserved at the Record Office, in which his claim to remuneration by the Government is stated. Forsyth’s claims were supported by Lord Brougham “his counsel in all his law suits” whose certificate is in the same file.

1811-19. Forsyth’s Law Suits:

1816. Forsyth v. Manton. (“The Times,” 13th and 16th July.)
1818. Forsyth v. Manton. (Ibid., 14th December. Full report.)
1819. Forsyth v. Levier. (Ibid., 3rd May. Injunction.)
1819. Forsyth v. Riviere. (Ibid., 5th June.)
1819. Forsyth v. Hall. (Ibid., 14th August.)

Forsyth v. Riviere being the most important case as regards evidence of prior user, some pains have been taken to trace a fuller report than that in “The Times.” The King’s Bench records are of no value for the purpose and the Affidavit series yielded little of value. Messrs. Crowders, Vizard, Oldham and Co., 51, Lincoln’s Inn Fields, successors of Vizard and Blower,
solicitors for the plaintiff in this action state that their predecessors destroyed a quantity of papers about forty years ago including probably the briefs, etc. in this case. Application was also made to the successors of the defendants' solicitor, Jenkyns, but hitherto without result.

(3) E. Goode Wright, of Hereford

1823. 18 Sept. Wright, E. G., on the firing of gunpowder by fulminating mercury (Phil. Mag., vol. lxii, p. 203). Reprinted in Gill’s Techn. Repos., vol. iv, pp. 313, 316, with an editorial, which elicited a further statement from Wright (Ibid., pp. 370-72). Wright’s experiments were repeated in Germany by Lieut. Schmidt, who came to an opposite conclusion. (Schweigger’s Journal, 1824, p. 66, translated in Franklin’s Journal, 1829, p. 100.) For further controversy, see Shaw, 1829.

1869. Temple, R. and C. The Temple Anecdotes, Invention and Discovery, pp. 93-95. (The Duke and the Inventor.) There is no trace of Wright’s letter to the Duke of Wellington, referred to here, in the Ordnance Papers “Inventions” or in letters preserved at the Record Office.

(4) Joshua Shaw (1776-1860)


1827. Shaw, J. Remarks on the properties essential in good gunpowder, and upon the methods of testing its strength. Franklin Journal, vol. iv, pp. 127-29. (Recommends a slow powder for percussion guns.)

1827. Shaw, J. Description of a method of testing the quickness of
gunpowder (Franklin Journal, vol. iv, pp. 282-4). Shaw here refers to apparatus constructed by him in 1814, to test the advantage “of using the copper caps or primes which I had then invented” with the percussion gun, his conclusion being that the slowest powder was the best for that class of gun. The copper cap referred to was probably a flat cap covered with copper foil. There is no suggestion of the cap and nipple mechanism.

1829. Shaw, J. Remarks on an article . . . on fulminating powders (a reply to Lieut. Schmidt). (Franklin Journal, N.S., vol. iii, pp. 271-3.)


(5) Shaw's Patents

There is no trace of Shaw's alleged applications for an English and American patent prior to 1820; probably an application here would have brought him into conflict with Forsyth, while in the U.S. a term of two years' residence was required of an alien. The Specification of his first U.S. patent, 1822, was destroyed by fire at Washington.
BICKFORD'S SAFETY-FUSE

BY SIR GEORGE J. SMITH

THE frequent accidents resulting from the use of explosives in tin and copper mining, chiefly owing to the uncertain duration of the time between the lighting of the rush or quill and the exploding of the charge, led Mr. William Bickford, of Tuckingmill, in or about 1830, to turn his thoughts towards the invention of some method whereby blasting operations could be conducted with the minimum of risk to the miner. Mr. Bickford’s motives were purely philanthropic; it remained for his successors to turn his invention into an extensive and legitimate commercial enterprise.

On the 6th September, 1831, Mr. Bickford took out his first Patent (No. 6159) for the Miner’s Safety-Fuse. His object was to provide a protected core of powder, thin and continuous, along which the fire might travel slowly at a uniform and determinate rate of speed. This result he obtained by causing a number of jute threads, passed through an orifice and stretched by means of a weight attached to their extremities, to rotate slowly while, at the same time, a small current of fine powder fell into the tube thus formed, and was retained therein as a slender core. To use his own words in the specification of his process:

"I embrace in the centre of my fuse, in a continuous line throughout its whole length, a small portion, or compressed cylinder, or rod of gunpowder, or other proper combustible matter, prepared in the usual pyrotechnical manner of fire-work for the discharging of ordnance; and which fuse, so prepared, I afterwards more effectually secure and defend by a covering of strong twine made of similar material, and wound
thereon, at nearly right angles to the former twist, by the operation which I call 'countering,' hereinafter described: and I then immerse them in a bath of heated varnish, and add to them afterwards a coat of whiting, bran, or other suitable powdery substance, to prevent them from sticking together or to the fingers of those who handle them; and I thereby also defend them from wet or moisture or other deterioration, and I cut off the same fuse in such lengths as occasion may require for use: each of these lengths constituting, when so cut off, a fuse for blasting of rocks and mining, and I use them either under water or on land, in quarries of stone and mines for detaching portions of rocks, or stone, or mine, as occasion may require, in the manner long practised by, and well known to, miners and blasters of rocks."

Previous to the invention of Safety Fuse, the devices for conveying the fire to the charge were of the most crude and primitive description. Sometimes a small trail of gunpowder from the charge to an extemporized slow-match, such as impregnated paper: and sometimes quills plucked from geese, filled with fine grain powder and lengthened where needful by an insertion of one quill into another, while, oftener still, rushes were used, the rush having been first split, the pith scooped out, its place filled with powder, and the two halves bound together again by fine string.\(^1\)

The reference to the use of the powder quill as a former means of conveying fire to the charge, recalls an amusing point of provincial philology observed in the West of England for many years after the introduction of the Bickford Fuse.

The inventors of the new method decided, early in its history, that 8 yards, or 24 feet, was a convenient unit of length in which to issue their fuse, and Mr. Bickford designated that length "a coil," the name by which fuses are still known throughout the Anglo-Saxon world, although, in countries under American influence, the 24 feet length has been altered to 25 and 50 feet for convenience of reckoning under the decimal system.

\(^1\) "Victoria History of Cornwall."
Those familiar with Cornish and Devon pronunciation will be aware that the words "coil" and "quill" have, or at least had, half a century ago, a very similar intonation, and as "the coil" in scores of mines substituted "the quill," the old miners and many of their agents assimilated the one word to the other, the writer of this memorandum having executed many orders for Bickford's Fuse, some within the present century, described as "100 queals"—this typically Cornish association between the old and the new surviving through more than two generations.

To the inventor's son, Major John Solomon Bickford, and to the late Dr. George Smith, antiquarian and historian, who married the inventor's daughter, belongs the credit of laying the foundations of safety-fuse as a commercial undertaking. They directed its manufacture throughout their lives, and were succeeded by the inventor's three grandsons, the late Mr. Bickford Smith, M.P., Sir George J. Smith, of Treliske, and Mr. H. Arthur Smith, M.A., Barrister-at-Law; with the two latter are now associated five great-grandsons of Mr. Bickford. To Mr. Thomas Davey, of Tuckingmill, belongs the larger share of the credit for the original mechanical appliances, and to other members of the Davey family, some descendants and relatives of whom are still identified with the industry, the credit for bringing chemical science to bear upon the manufacturing processes. At the Tuckingmill factory, where between 200 and 300 hands are employed, there has also been a remarkable hereditary succession of the original employees, including to-day grandchildren and great-grandchildren of those who made the first safety-fuse under the guidance of Mr. William Bickford.

Mr. Bickford's colleagues and immediate successors naturally confined their attention, for the first few years of their business, to the preparation of fuses suitable to the mines of Cornwall and Devon, amongst which they lived, and the varied and somewhat exacting demands made by the requirements of those mines, furnished a good school for the development of an invention which was destined later to be adopted throughout the mining world; thus, the original Single
FIG. 30. WILLIAM BICKFORD.
BICKFORD'S SAFETY-FUSE

Fuse, briefly described above, was soon found to require an additional coat of tape, applied spirally, and insulated in an extra varnish, for use in damp and wet places, whilst the exigencies of shaft sinking and other rough and very wet conditions, soon suggested the addition of another coating of tape and varnish, resulting in the well-known Double-Tape Fuse.

It was early in the eighteen-forties that Mr., afterwards Dr. George Smith, brought the Bickford Fuse under the notice of the War Office and Royal Engineer authorities, where he was favourably received by Colonel, afterwards General, Pasley, and by Colonel, afterwards Sir John F. Burgoyne. Dr. Smith used to relate with amused interest how General Pasley, after examining and testing the little instrument, denounced himself, with military emphasis of language, for having been too stupid to have invented so simple a thing himself. "Here have I," said he, "with the Arsenal behind me been all these years trying to scheme a safe and simple means of conveying fire to the blasting charge, and never thought of trying to make black gunpowder burn slowly and regularly, which a Cornishman has discovered in a rope walk."

One result of these official tests was that the Government Departments adopted the Bickford Fuse with more than their usual promptitude, and it has been largely employed in the Services for engineering and military purposes ever since, the gradual and pronounced improvements in electric firing not having displaced it to the present day.

Soon after its first adoption by the Government, the advantages of the Bickford Fuses were also brought before a Committee of the House of Commons, during one of the earlier of the long series of examinations as to means for minimizing the danger in mines; the principal witness before the Parliamentary Committee in favour of the great diminution of danger which the invention had conferred, being Mr. John Taylor, the founder of the firm of John Taylor and Sons, who had already, for several years, experienced its efficacy in the

Probably resulting from this House of Commons inquiry, a Commission, including eminent surgeons, visited Cornwall and Devon in the early forties to report on improvements in means for the protection of life and limb, and their testimony was very pronounced as to the very largely decreased ratio of blasting accidents directly resulting from the adoption of Mr. Bickford's invention. The principal local surgeons—the Messrs. Lanyon of Camborne—stated before this Commission that their long experience as surgeons, in the mining district, warranted their estimate that the introduction of the safety-fuse had diminished the "number of killed and wounded from blasting accidents in West Cornwall by fully 90 per cent.;" this testimony amply justifying the inventor's beneficent design.

The requirements of the Government for blasting and military operations in various climates; and the extension of the Bickford manufacture to America in 1836, where its headquarters are still at Simsbury, Connecticut; to France in 1839, where its headquarters are near Rouen; to Germany in 1844, and successively to other countries, naturally led to the successive evolution of different types of fuse in varying diameters, methods of waterproofing and varieties of finish for adaptation to tropical or arctic climates. One of the most important of these was the adoption of gutta-percha some time before 1840 to render fuse impermeable for subaqueous blasting, although it should be observed that, without the aid of this expensive material, the inventors had already produced fuses, protected only with the cheaper hydrocarbons, which had been successfully used even for submarine purposes, and their successors have still preserved the art of obtaining a high degree of resistance to water by the old and cheaper methods. One of the first uses for subaqueous fuses coated in some cases with gutta-percha and sometimes with the other Bickford varnishes, was in the blasting operations for deepening Kingstown Harbour Works, Dublin, during the third decade of the last century. It was soon found,
however, as many a consumer may have learnt to his cost, that the best gutta-percha is liable to rapid deterioration from exposure to the air, especially in high temperatures, and the Bickford firm met this requirement by an exterior coating protecting the gutta-percha itself, originally adopted for the Government of India, which will preserve the gutta-percha thus additionally insulated for several years in perfect efficiency.

We need not dilate on the obvious expedients which resulted from the introduction of gutta-percha to the trade, such as the reduplicating of coats into double, triple, and even quadruple coverings to meet the extreme exigencies of deep-sea blasting, the largest kind ever made—of more than half an inch diameter—locally known as "Jumbo," having been produced for the Dutch Government for their harbour operations in the Dutch East Indies. More than 1,000,000 yards of one of these forms of protected gutta-percha fuse were used in driving the Severn tunnel, and more than 600,000 yards in excavating the Manchester Ship Canal.

Shortly after the introduction of gutta-percha fuse, a Cornish miner named Carbines, of Hayle, thought he had hit upon a system far preferable to any of these waterproof coatings, namely, by the manufacture of the Metallic Safety-fuse, in which the old black fuse-powder, or an easy adaptation of the same, was used as the centre of the lead or composition pipe, drawn out to the proper diameter. This invention was some years later brought to mechanical perfection by the Brothers Tangye, founders of the great Birmingham firm of that name. But, with all the advantages claimed for it, it never succeeded in seriously displacing the textile and varnished production known as the "Bickford Fuse."

A critical period in the history of safety-fuse was reached when the invention of Higher Explosives led to the adoption of the fulminate capsule, now termed the detonator, as a universal intermediary between the fuse and the charge. It is obvious that an exactitude and regularity of diameter for fitting these detonating caps thereupon became essential, for which there had been no previous necessity.
The principal manufacturers promptly met the new circumstances by providing a series of fuses for different classes of operations, but all fitting the detonating tubes with sufficient accuracy, the result being that the Bickford fuses were soon, and are still, more uniformly used with the Higher Explosives than had previously been the case with gunpowder.

Omitting minor improvements and modifications, the next important invention in fuse manufacture worth mention is that of the Bickford Instantaneous Fuse in 1855 by Mr. Simon Davey, head of the Bickford House, near Rouen, it having been originally requisitioned by the French Government; and in an improved form this article was employed during the Franco-German war.

In appearance this variety is like a large safety-fuse, but is usually coloured bright red to distinguish it as being of the very rapid burning—or explosive—kind, its speed ranging from 100 to 300 feet per second. It is fired in the Services by means of a special pistol, originally with a percussion cap, later by a small guncotton cartridge.

Although originally designed for military use the Instantaneous Fuse was soon adopted also for civil purposes; the grouping of several such fuses in a so-called Volley-firer, or the extension of a series by successive connections on the rock face to be blasted, being found an effective and economic means of producing simultaneous ignition of several charges.

The enormous charges employed in the great blasts at the Dinorwic Slate Quarries, Llanberis, North Wales (October, 1893), in which 6,850 lb. of Blasting Gelatine were used, displacing 235,000 tons of granite; and at the Penrhyn Quarries (April, 1895), in which seven tons of gunpowder were used, displacing 200,000 tons of granite were fired by Bickford's Instantaneous Fuse and Volley-firers specially made for these operations.

Although belonging to a later period, it is convenient here to insert that one of the managing partners of the Bickford French
establishments—M. Jean Harle, great-grandson of Mr. Thomas Davey, of Tuckingmill, and grandson of Mr. Simon Davey, before referred to, has patented during the past year, a form of Instantaneous Fuse of an ingenious description, the fire-bearing material being chiefly trinitrotoluene, which is timed to produce a detonating speed of more than 4,000 metres a second! This fuse is issued in single- and double-acting forms and various diameters.

About the year 1880 the occurrence of several fatal explosions of fire-damp in British collieries called public attention to the necessity of reforming the means of firing charges in gaseous mines, resulting in the appointment of a Royal Commission of enquiry in 1881; and, electric firing being then still more expensive and less effective than now, Messrs. Bickford turned their attention to the production of a special article for the purpose. After previous modifications, Sir George Smith in 1886 patented a Colliery Fuse, warranted to burn without emitting laterally any flame or spark.

The desirable complement of this fuse was obviously a means of igniting it without any exposed flame, and this was soon supplied by the Bickford Safety Lighter and Nippers (Patents of 1887) the former being a small metal tube covering the end of the fuse and containing chemical means of internal ignition; the latter, a form of pincers which covers the head, and by pressure actuates the means of ignition. (See paper read before the Manchester Geological Society, 9th January, 1891, by James Grundy, H.M.I.M.)

In the year 1904 the Colliery Safety-Fuse with certain prescribed modifications was officially authorized as the "Permitted Igniter Fuse."

One of the latest developments in the fuse trade consists of a combination of electric fuses and Bickford fuses; the first firing the second, which, in turn, explode the charge. This combined system is now in use in a few important mines in this country and Germany, and is alleged to give excellent results in the accurate timing of shots.
Such is the brief story of the little article which, invented in a remote Cornish village, solely from humanitarian motives, has become a primary necessity throughout the Mining World, and is now made in fifteen factories, distributed through many countries, by the inventor's descendants, and in others by their numerous imitators.
MILITARY FIREWORKS

BY Colonel J. R. J. Jocelyn, (late) R.A.

During the sixteenth and seventeenth centuries, certain early writers on "Artillery" indulged in descriptions of various curious applications of explosives to warlike purposes, all of which may be dismissed as of no account, nothing of any importance being achieved until the appearance of the carcasses, light balls, and rockets of later times; indeed, our first native military author, one William Bourne, professional gunner, effectually disposed of such pretensions when, writing in 1578, he said: "Divers gunners and other men have devised sundry sorts of fireworks for the annoyance of their enemies; yet as far as I have ever seen or heard, I never knew any good service done by it either by sea or land, but only by powder, and that has done great service . . . but for their other fireworks, it is rather meet to be used in the time of pleasure in the night than for any service." It is then with "pleasure fireworks," or "artificial fireworks,"—feux d'artifice—that we are mostly concerned when considering the early aspect of the explosives industry. "Fireworks in England," says Strutt, "were little spoken of previous to the reign of Elizabeth and seem to have been of a very trifling nature." There are, as a fact, only two very meagre allusions to them in the whole of Shakespeare. They may have been associated with those curious fire festivals of pagan origin, the traces of which yet remain, or plays or pageants may have been the source of their first employment. Thus in the "Mysteries" Hell or Hell-Mouth was represented by a gigantic head out of which flames were made to issue; and again, in the civic river procession which went to greet Henry VII and Elizabeth of York at their coronation in 1487, the Bachelors' Barge was garnished and appareled
beyond all others, and carried a dragon spouting flames of fire into the Thames.” A similar barge was also seen at the coronation of Anne Boleyn in 1538; it was said to contain “a great red dragon continually moving and casting forth wild fire and round about were terrible monstrous and wild men casting fire and making a hideous noise.” The wild men wore green tunics and fantastic masks, and were known as “green men.” Sometimes, armed with fire-clubs, they cleared the way at processions, but this was at a later date. An extract from the City Books of 1538 may be of interest:

“Paid to John Kellock for the charge of the foyste and a galley and for his service with men, shot, powder, cassocks and all other necessaries, £32 10s. od.

“paid and given in benevolence to the fireman or green man over and above his agreement, £0 11s. od.”

But firework displays, properly so called, were not given in this country before the days of Elizabeth; that they were then a novelty
here is apparent from a well-known contemporary romance, Barclay's "Angenis," in which they are spoken of as a new invention. Amongst the earliest of these displays was that at Warwick Castle in 1572 when the Queen was on one of her Progresses: it was under the superintendence of Ambrose Dudley, Master-General of the Ordnance, and was carried out with no small danger to the good people of the town; a full description of it is preserved in the "Black Book" in the Warwick Archives. The effect of the Kenilworth fireworks of two years later upon the worthy Laneham is well known from Scott's novel, where his quaint letter to his friend, a citizen and merchant of London, is quoted in a modernized form.

Elizabeth, no doubt, was fond of fireworks, but it was under the Stuarts that the provision of public or royal fireworks took tangible shape, and became part of the duties of the Master-Gunners and Gunners of the Ordnance, and in the early years of the seventeenth century there was quite an outbreak of pyrotechnical literature, where fireworks "for triumph" and for "wonder and delight" were discussed. These consisted of wheels, squibs, rockets, shells full of stars, then called "balloons," which were fired from mortars or other contrivances, and such-like things which are familiar to-day, but in addition there were other matters which claimed the attention of the Jacobean fireworker. He was supposed to be somewhat of a scenic artist who could devise a romantic background and fill it with shapes bizarre, beautiful or terrific. He had to make his castle, his cave or his rocky ravine, and people his stage with distressed damsels, errant knights or devouring dragons: he had also to put his figures in motion; sometimes the dragon or what not ran down an incline on wheels which were hidden from the spectator; sometimes it was suspended from a line, when motion was given mechanically by attaching a rocket to it; sometimes double rockets were employed, which carried the figure forward and back again. The fireworker also had to be somewhat of a comedian who could devise and perform firework combats; thus he would make for this purpose helmets from which flames would issue, swords and clubs
that would scatter sparks, bucklers that when struck would give forth detonations, and lances with fiery points.

On the occasion of the marriage of the daughter of James I to the Prince Palatine in 1613, an elaborate fête, in which most of these artifices were used, was devised and carried out by four of the King's gunners, when the Thames was blocked from Lambeth to the Temple to give them an uninterrupted space for their efforts; a full account will be found in the Somers Tracts, vol. iii.

From these days forward, specialists in pyrotechny became necessary in the Ordnance Department, and began to fill permanent appointments, while the art itself entered seriously into the duties of high-placed military officials, nor were the displays themselves without political importance; during the seventeenth and following centuries, up to quite recent times, fireworks on a grand scale were in vogue, and usually formed a conspicuous part of the public expression of thanksgiving or of triumph.

As time went on a more refined taste rejected the bizarre features of the old displays; artistic merit began to creep into the designs; it was the object of the fireworker not only to make a noise and a blaze, but to introduce something appropriate to the occasion, and soon architectural features and emblematic figures gave national fireworks a grand and stately appearance. In 1650 Casimir Siemienowicz, Lieut.-General of the Ordnance of the King of Poland, published his "Great Art of Artillery," and thenceforward was regarded as the "father of sound and intelligent pyrobolists"; his work may be regarded almost as a classic; it was translated into English by order of the Surveyor-General of the Ordnance as late as 1729, and in it will be found every detail of construction, together with accounts of the "performance" of famous fireworks known to the author.

Very large sums were spent upon national fireworks, sometimes with a purpose. Thus says Butler in 1663:

To set the rabble in a flame,
And keep their governors from blame,
FIG. 32. SIR WILLIAM CONGREVE, BART.
(From a painting by T. Lonsdale, in the Royal Artillery Institution, Woolwich.)
Dispense the news the pulpit tells,
Confirm with fireworks and with bells.

"Hudibras," p. iii, c. iii.

The display for the Peace of Ryswick cost £12,000, that for the Peace of Aix la Chapelle £14,500. Prints representing the more important fireworks, from James II to Victoria, will be found in the Crace collection in the British Museum.

In addition to the fireworks made in the Royal Laboratories, squibs, crackers, and small rockets were doubtless articles of commerce in Jacobean and Carolian times; for example, the "Water Poet" gives a vivid description of the hilarious doings of the citizens of London when Prince Charles returned safely from Spain in 1623; he tells us "there were excellent fireworks, with squibs, crackers, rockets, which most delightfully flew every way." The volatile Pepys also, writing some forty years later, describes how he and some of his friends provided themselves with an abundance of serpents and rockets, and took to flinging their fireworks and burning each other and the people over the way. Even in the case of such a sober body as the old Mathematical Society of London, a rule existed which imposed a fine of sixpence on any member who should let off fireworks in the place of meeting. Repressive legislation with regard to fireworks was introduced in 1697, and they were totally prohibited at the coronation of George III; the citizens had suffered from too much licence in regard to them; thus on a recent royal birthday a boy had thrown a squib and frightened a pair of carriage horses; in the confusion a man had been killed. At the inquest the carriage and horses were conveyed as a deodand to the Duke of Bedford, on whose property the accident had happened. The last public firework display in London was on the occasion of the proclamation of the peace in 1856; more recent displays have been confined to the ships of the Royal Navy.

Carcasses containing incendiary composition, smoke-balls and light balls, were used in the Peninsula, and many carcasses were fired in the...
Crimea; these projectiles may now be regarded as obsolete; the light ball, however, has a successor in the modern star shell, which is a subject of present investigation. But of all fireworks ever used in the British Service, the Congreve rocket was in its time the most important. Up to quite recent times its composition was kept strictly secret, and, as far as is known, has never been published. Congreve was the developer, not the inventor of the rocket. They were used for the first time against Boulogne in 1806, but it was at the battle of Leipsic, in 1813, that they became historic; they were employed in the Crimea and in the Indian Mutiny, and now, as modified by Hale, who got rid of the stick, still exist in the Service, but would be seldom used.
PLEASURE FIREWORKS

By Phillip Pain

As far as fireworks in foreign countries are concerned, it is quite clear from various records and references in books that fireworks in crude forms came into use not long after the introduction of gunpowder. Several references are made to them in works of the fifteenth century. As regards England, however, the question seems obscure. Even here, however, from works published in 1634 and 1696, various popular forms of fireworks such as rockets, crackers, wheels, bombs, saucissons, are fully described with diagrams and methods of manufacture.

The earlier of these works, written under the initials J. B., printed by Thomas Harper for Ralph Mab in London in 1634, describes at some length how to choose and prepare the ingredients and substances for the making of fireworks, and gives particulars and diagrams for their preparation. This includes aerial fireworks (such as operate in the air), viz., rockets, serpents, raining, wire, stars, petards, dragons, gyronels, or firewheels, etc., earth fireworks, such as crackers, trunks, saucissons, etc., water fireworks, such as rockets, dolphins, etc.

The illustrations of rockets and sticks are quite easily recognizable, being in most respects similar in principle to those of the present day.

The method of making quick-match and stars is made quite clear. The dragons or rockets flying along from one end of a line to the other are similar to line rockets or pigeons of the present day.

The moulds and tools for rockets, although old-fashioned, are illustrated and described. One interesting passage may be transcribed as
showing that the use and making of certain fireworks were widely spread:

"How to make crackers.

"It is well known that every boy can make these, therefore I think it will be but labour lost to bestow time to describe their making. Only this much, if you would make a cracker to give 40, 50, 100, or two hundred blows, one after another then binde so many crackers upon a stick so that the end of the one may joyne to the mouth of the other."

Another work, dated 1696, by Robert Anderson, printed by Robert Norden at the Atlas in Cornhill, deals chiefly with the making of rockets, and is dedicated to Baron Hilton, Master-General of H. M.'s Ordnance. In the preface the writer refers to the many volumes great and small he had read, relating to Pyrotechnia, in his own and foreign languages. He describes at length the rules of rocket making; the mould, rolling cases, composition drivers, and other parts and tools of the rocket; the stars and other contents of the head, the sticks and how to fire them. The writer deals with the theoretical and practical sides of the question and states that the work is for firework or exhibition. Rocket making is shown by the preface in which he addresses himself to the problem of the making of rockets for the young artist at 8d., 1s., and 1s. 6d. in value. That some considerable business in ordinary firework making was carried on at this time is clear from the fact that the author gives the names of certain makers of the necessary implements.

We are told that rocket moulds were made by Mr. Guggley, just without Cripplegate; that taper bits for rockets were made by Mr. Goode, just within Cripplegate; and that rods for rockets were made by Mr. Stateham in Token House Yard, Lothbury: all three right good workmen.

To come down to less remote times an important treatise on fireworks was published by Lieutenant Jones in 1760. This was a much more exhaustive and complete work than any of its predecessors,
and dealt with most kinds of fireworks, whether simple or compound, or set pieces. Many of these are made to-day in the same manner as there described.

The diagrams, drawings, and formulae are very complete for the period. From internal evidence, however, it would seem that the work was largely taken from the French; and the illustrations, names, and formulae given confirm this conclusion. Moreover, the names of French authorities for various formulae and directions are cited on several pages.

As regards the passages relating to rocket making Lieutenant Jones has made good use of Mr. Anderson's work, the part relating to the cause of rockets rising being taken word for word from the earlier work. Later works are largely founded on Lieutenant Jones's book, allowing for modifications rendered necessary by later discoveries, especially in relation to the use of colours in pyrotechnic effects and Exhibition Fireworks. Much of the matter is now rendered obsolete because many of the substances and materials formerly prepared by firework makers themselves, can to-day be purchased ready-made at less cost and even better in quality; a good deal of drudgery being thus avoided.

For clearness of arrangement and general scope of information Mr. Jones's book, although largely out of date, has not yet been surpassed.

As far as we are able to judge, the English makers originally learnt their business chiefly from the French. The English have in modern days, however, gone beyond their teachers and improved upon them. As far as the simpler forms of old-fashioned fireworks, such as rockets, squibs, crackers, and the like are concerned, it is quite probable that the English were on an equal footing with other makers. With regard, however, to the later developments and higher branches up to the beginning of the nineteenth century, a great deal was due to the French, who in their turn borrowed from the Italians. Many of the names and processes even are translated literally.
Previous to about the middle of the seventeenth century there seems to have been little done in the way of public firework displays unless in connection with events of national rejoicing. After this period, however, various public Gardens in London were opened, such as Ranelagh, Vauxhall, etc.

The displays arranged for in these Gardens were the origin and forerunners of modern fireworks exhibitions and artistic displays in this country, which have in recent times attained so high a degree of perfection that English fireworks manufacturers may claim to rank as the first in the world.

From works of the eighteenth and nineteenth centuries and contemporary newspaper announcements and reports, it is clear that French and Italian fireworks artists (chiefly French) were regularly employed to give the displays exhibited in this country during the summer seasons over a long series of years. In fact, down to 1827 an anglicised French fireworks manufacturer (d'Ernst) was giving displays at Vauxhall. Nevertheless, the English makers were not idle, and whilst perfecting themselves, also gave many of the displays. They were always good craftsmen and accurate workers, but their real progress dates from about 1820, after which year their improvement was marked, until eventually they surpassed and beat their foreign rivals. During the last thirty or forty years of the existence of Vauxhall Gardens the displays were exclusively by Englishmen, who have ever since continued to improve.

Up to the middle of the nineteenth century the great public displays on national occasions were arranged and supervised by the Government authorities from Woolwich Arsenal.

For instance, in the Peace Rejoicings, Hyde Park, 1814, the Coronation displays, down to the last of such public displays which was made on the conclusion of the Crimean War in 1856, the military authorities had the official supervision, but they did not disdain to employ, or avail themselves of, the brains and skill of English makers.

These English makers, although competent in all other respects,
had, however, neither the resources nor the appliances for giving displays on a large scale necessitating the use of hundreds of mortars, expensive chemicals and apparatus, gear of all kinds and a large number of hands. To-day all this is changed and the principal English firms could carry out displays of any magnitude from their own unaided resources.

During the last forty years, British pyrotechny has made great strides. It has penetrated to every country in Europe, except Russia, and broken down the practical monopoly formerly held by French firms. In the United States of America an English manufacturer is facile princeps in all great public displays. English firms have given displays in Australia, Canada, New Zealand, India, Siam, Brazil, Egypt, Zanzibar, Morocco, South Africa, Jamaica, Cuba, Bermudas, Chili, Iquique, Argentine, West Coast of Africa, and many other places, embracing the chief centres of each continent. In the United Kingdom the results achieved have been the work of a gradual progress extending over a long period of years. Great advance has been made and new effects in set pieces, aerial works, and simple and compound fireworks have been produced year after year in constant succession. The chief British pyrotechnists are now easily first in the world whether in artistic effects, novelty of design and method, or magnificence and grandeur of scale.

A great feature of modern British pyrotechny is the perfect safety which has been gradually and laboriously evolved in the manufacture and use of fireworks. Processes, compositions, and methods have been brought into use which have removed many dangerous features, and it may be said that the fine results obtained by English manufacturers are produced under much severer restrictions than those to which the continental makers, who have a freer hand as to means and methods, are subjected, and that a large immunity from damage to life and limb is enjoyed both by the worker and the spectator. In Italy and other countries compositions and methods are freely used, which, although well known to English makers, are now dispensed with. At first
English makers were severely hampered by being thus compelled to abandon unsafe methods; but it may be truthfully said they are now reaping the advantage. This is the opportunity for adding a word regarding the Explosives Department of the Home Office. Since the passing of the Explosives Act in 1875, great improvements in safety have been made, and under the enlightened administration of this department, by the broad-minded, tactful and sympathetic inspectors originally appointed and their successors, the industry has generally greatly benefited.
WRITERS on explosives have expatiated with justice on the contempt and loathing akin to horror with which gunpowder was regarded by the knights of old, who felt for it an instinctive hatred, very much as the expert sailor hated steam, and for much the same reason. By the introduction of gunpowder the spirit of chivalry received its death-blow, it died slowly and died hard, but its final overthrow was predestined. The armoured knight with sword and lance, mounted on his armoured charger and attended by his esquires and indifferently equipped retainers, became an anachronism, the entire feudal system collapsed, for the aristocratic principle, on which it was based, had been undermined. The superior prowess of an individual or a caste, on which rested the theory of society called feudalism, lost importance; hence to give lands and influence as a reward of personal valour and skill in arms, ceased to have a rational justification. Artillery and volley-firing made the solitary knight in armour as ridiculous and helpless as Cervantes made Don Quixote. The finest swordsman ever trained in the courts of chivalry could be laid low by a bullet from the gun of the merest yokel. Gunpowder was the great leveller in more senses than one, and while it made possible a return to the scientific warfare of the ancients, it helped to break down the social restrictions of the middle ages and to prepare the way for the democracy of to-day which has triumphantly permeated every modern civilized state without regard to the prevalent system of government.

Politicians owe a greater debt of gratitude to the evolution of the use and application of explosives than they care to acknowledge. While the unreflecting are prone to lament the invention of what they glibly
call wholesale means of destruction, the future historian will dilate on
the benefits which these have conferred.

However, every change and every improvement usually brings
some difficulties and inconveniences in its train. In the chapter devoted
to the history of gunpowder we have seen how great a grievance
and nuisance to the public the saltpetre men had become, and presently
we shall find public opinion exercised by the danger resulting from
explosions of stores or powder-magazines, and later even more alarmed
by the explosion of mills and factories. There is a Russian proverb to
the effect that people who like to ride in sledges must be prepared to
take a hand at drawing them, and another which wisely recommends
those who fear wolves to refrain from frequenting forests; but such
fatalistic philosophy has never found acceptance with the practical spirit
of British public opinion; our legislature, with indomitable optimism,
again and again attempts the impossible, and even endeavours to
reconcile opposing and incompatible interests in a spirit of wise and
charitable compromise. Thus we constantly find the interests of the
state at variance with the comfort and convenience of the individual,
and in its practical efforts to remedy abuses, Parliament has not infre-
quently to contradict itself in quite a perplexing, though to us, at this
distance of time, not an entirely unenteraining manner. As we proceed
in our review of the Acts dealing with Gunpowder which Parliament
has from time to time passed, our meaning will become clearer, and
the admirable intentions of our legislators brought into full relief.

The earliest Act of Parliament dealing with gunpowder that we
have been able to trace was passed in the sixteenth year of Charles I
(1641), and establishes the principle of absolute free trade in this com-
modity. It is entitled an "Act for the free bringing in of Gunpowder
and Salt Petre from Forraign parts and for the free making of Gun-
powder in this Realme." The preamble sets forth that "Whereas the
importation from forraign parts hath of late times beeene against Law
prohibited and the making thereof within this Realme ingrossed whereby
the price of Gunpowder hath beeene excessively raised many powder
makers decayed this Kingdom very much weakened and indangered the Merchants thereof much damnedified many Mariners and others taken Prisoners and taken into miserable Captivity and Slavery many Ships taken by Turkish and other Pirates and many other inconveniences have thence ensued and more are likely to ensue if they be not timely prevented:" the Act then goes on to say:

"Be it therefore declared and enacted by the King's most Excellent Majestie and the Lords and Commons in this present Parliament assembled and by the Authoritie of the same that it shall and may be lawfull to and for all and singular persons as well strangers as naturall born subjects of this Realme to import and bring into this Kingdom any quantities of Gunpowder whatsoever paying such Customs and Duties for the same as by Authority of Parliament shall be limited and set downe,

"And be it further Declared and Enacted by the Authority aforesaid that it shall and may be lawfull to and for all and singular His Majestie's subjects of this His Realme of England to make and sell any quantities of Gunpowder at his and their will and pleasure and alsoe to bring into His Kingdom any quantities of Salt Petre Brimstone or any other Materialls necessary or requisite for the making of Gunpowder.

"And lastly be it enacted by the authority (aforesaid) that if any person or persons from and after 10th August 1641 shall put into execution any Letter Patents Proclamation Edict Act Order Warrant Restraint or any other Inhibition whatsoever whereby the Importation of Gunpowder Salt Petre Brimstone or other Materialls or any of them from Forraign parts or the making of Salt Petre within this Realme shall be any way prohibited or restrained that then the said person or persons so offending shall incurre and sustain the pains penalties and forfeitures contained and provided in the Statute of provisions and premunire made in 16 Richard II."

This Act may therefore be regarded as repealing the various monopolies, licences and proclamations under James I.
Nevertheless, and in spite of this Act, the famous Long Parliament ordered, on the 3rd December, 1642, "that neither the Commissioners of Customs nor any other Officer or servant of the Customhouse within the City of London, take any Entries, or passe any Warrants for Gunpowder, to be exported without warrant from the greater part of the Committee of Citizens appointed to take care for that Commodity, and that no Carrier, Waggoner, Watchman, Wharfinger, or other person whatsoever shall carry or convey out, or suffer to be carried or conveyed out any Gunpowder to any place without warrant from both Houses of Parliament or of the Committee of Lords and Commons for safety of the Kingdome, or of the Lord General, or of the said Committee of Citizens before mentioned." The Committee of Citizens was, by another order of the same date, authorized "to enquire, search, and examine, what quantities of Gunpowder is, or shall be in the hands of any Merchants, Ship-chandlers, Grocers, Societies or Companies, or any others . . . as likewise to seize upon whatsoever Gunpowder shall be so found for the use of the Parliament."

After the Restoration, in the twelfth year of Charles II (1672), a general free trade Act (Chapter 4) was passed in which gunpowder is specially included in the following passage:

"And be it further enacted by the Authority aforesaid that it shall and may be lawfull immediately after the passing of this Act for any person or persons to ship carry out and transport by way of merchandize these severall sorts of Goods following that is to say Gun-powder when the same doth not exceed the price of £5 the Barrell. . . . Provided always that it shall be free and lawfull for His Majesty at any time when he shall see cause to doe, and for such time as shall be therein expressed by Proclamation to prohibit the (Transportation) of the powder or any sort of Arms and Ammunition into any parts out of the Kingdom. Anything in this Act contained to the contrary notwithstanding."

But here the king reserves himself the right of prohibiting traffic in Gunpowder and Arms and Ammunition.
In the first year of James II (1685), however, an Act was passed “Against the Importation of Gunpowder Arms and other Ammunitions of War.” This quaintly worded Act sets forth:

“Whereas to the great Prejudice of this Kingdom and the Discouragement and Impoverishment of the Gunsmiths and other Artificers great quantities of Arms and Ammunition have of late yeares beene Imported to the endangering of the Peace and quiet of this Kingdome.

“For Remedy whereof Be it enacted by The Kings most Excellent Majestie by and with the Advice and Consent of the Lords Spirituall and Temperall and the Commons in this present Parlyament Assembled and by the Authoritie of the same that it shall not at any Time from and after the 10th July 1685 be lawfull to or for any person or persons whatsoever without Licence from His Majestie His Heires and Successors to Import or bring into this Kingdom of England Dominion of Wales or Town of Berwicke upon Tweede by way of Merchandize any Gunpowder Arms Ammunition or Utensils of Warr upon Paine and Forfeiture of all and every that Goods be Imported as aforesaid to His Majestie His Heires and Successors and the person or persons who shall soe Import or bring in the same or in whose Custodie any such Gunpowder Arms Ammunition or Utensils of Warr shall be found being hereof lawfully Convicted shall forfeit Trible the Value of the Goods so Imported One moyety thereof unto His Majestie His Heires and Successors, and the other to such person or persons who will sue for the same by Action of Debt Bill Plaint or Information in any of H. M. Courts of Record at Westminster wherein noe Essoigne Protection or Wager of Law shall be allowed.

“Provided always that if any person or persons whatsoever Bodyes Politique or Corporate shall by colour of this Act or otherwise obtain from H. M. His Heires or Successors any Letters Patents Licence or Grant for the sole Making or Importing any Gunpowder, Arms Ammunition or other Utensills of War and shall putt the same in execution or by whom henceof molest or hinder any person or persons who lawfully make any of the things before mentioned in this Kingdom or shall
obtain any Letters Patent Licence or Grant for the Importing of Gunpowder Arms Ammunition or other Utensils of Warr by way of Merchandize to make Profit thereof other than for the immediate furnishing of the Publique Stores of H. M. His Heires or Successors that then the person or persons so offending shall incur and sustaine the Paine Penalties and Forfeitures contained and provided in the Statute of Provision and Premunire made 16 King Richard II and be disabled to hold any Office or Employment under His Majestie His Heires and Successors and all and every such Letters Licence Patent and Grant and every of them for the sole Making and Importing the said Commodities shall be void to all Intents and Purposes as if the same had never beene had or had or made Any Clause of Non obstante or other Provision or Covenant to the contrary thereof in any wise notwithstanding."

The next legislative measure is 9 and 10 William III (1698-9), c. 7, which is an Act to prohibit the throwing and firing of "Squibbes Serpents or other Fireworks."

But it is not until the reign of George I that we come across any serious attempt at a measure at all resembling in its scope and purport the more recent Explosives Act. Hitherto we have seen that gunpowder was regarded by the legislature solely from the point of view of the needs of the state, the convenience of the public is but indirectly and incidentally alluded to. The Act passed in the fifth year of George I (1719) is, however, an "Act for Preventing the Mischiefs which may happen by keeping too great Quantities of Gunpowder in or near the Cities of London and Westminster, or the Suburbs thereof."

The Act sets forth that:

"Whereas great Quantities of Gunpowder are frequently Lodged and Kept in Warehouses and other Places in and about the Cities of London and Westminster, and the suburbs thereof, to the apparent Danger, if not utter Ruin and Destruction of several Publick Offices, and of the Lives and Fortunes of many Thousands of his Majesties Subjects:"
For preventing these mischiefs it was enacted:

That from and after the first day of August, 1719 it shall not be lawful for any Person or Persons to have or keep more than Six hundred Pounds of Gunpowder, each Hundred containing Fivescore Pounds Net Weight, at any time, in any Storehouse, Warehouse, or other Place, within the Cities of London and Westminster, or either of them, or within the Suburbs thereof, or within Three Miles of the Tower of London, or within Three Miles of His Majesties Palace at St. James's or within Two Miles of any Magazine now Erected for Keeping Gunpowder, belonging to His Majestie, His Heirs or Successors, for the Use of the Publick."

Further, from and after the 1st August, 1719, it was made lawful "for any Two or more of His Majesties Justices of the Peace, living within any of the Limits aforesaid, to Summon before them any Person or Persons, Making, Dealing, or Trading in Gunpowder, or who shall be suspected to have in his or their Custody or Possession, or in the Custody or Possession of any other Person or Persons, in any Storehouse, Warehouse, or other Place, within the Limits aforesaid, and to Examine such Person or Persons upon Oath touching the Premisses, and in case of Refusal to be examined, to Commit such Person or Persons to the County-Gaol, there to remain without Bail, or Main-prize, until he, she, or they shall conform or submit to Answer, and be examined as aforesaid, and if it shall appear upon such Examination or by the Oaths of any Two or more Credible Witnesses, (which Oaths such Justices are hereby Impowered and Required to Administer) that such Person or Persons have or hath in his, her or their Custody or Possession, at any one Place within the Limits aforesaid, more than Six hundred Pounds of Gunpowder, as aforesaid, such Justices shall forthwith cause all and every the Persons aforesaid carefully to Remove the same out of the Limits aforesaid, and if such Person or Persons shall refuse or neglect to Remove such Gunpowder out of the Limits aforesaid, by the Space of Twenty four Hours after Notice of any order made by any such Justices for Removal thereof, every such
Person or Persons so offending, shall, for every such Offence, forfeit the Sum of Twenty Shillings for every hundred pound of Gunpowder, with full Costs of Suit, to any Person or Persons who shall, within Six Calendar Months next after such Notice, Inform or Sue for the Same, by Action of Debt, Bill, Plaint, or Information, in any of His Majesties Courts of Record at Westminster, wherein no Essoign, Privilege, Protection, Order of Restraint, Wager of Law, or more than One Importance shall be granted or allowed."

It was further enacted “That it shall be Lawfull for any Two or more of His Majesties Justices of Peace, living within the Limits aforesaid, after 1st August, 1719, from time to time, to Issue their Warrant or Warrants for Searching in the Day-time any Storehouse, Warehouse, or other Place, Used for Keeping Gunpowder within the Limits aforesaid, and for the purpose to Break open any such Storehouse, Warehouse, or other place aforesaid, if there shall be occasion, and that every Person who shall Oppose or Hinder any such Search, shall, for every such Offence, Forfeit the Sum of Five Pounds to any Person or Persons who shall Inform and Sue for the same within Six Calendar Months next after the Offence Committed, in any of His Majesties Courts of Record at Westminster, by Action of Debts Bill, Plaint, or Information, wherein no Essoign, Privilege, Protection, Order of Restraint, Wager of Law, or more than one Imparlance shall be granted or allowed.” In the case of more than 600 lb. of gunpowder being found, Justices shall “forthwith cause the same to be carefully removed out of the Limits aforesaid, at the Charge of the Owner or Owners of such Gunpowder, or other Person or Persons having the Custody or Keeping thereof, to be Levyed by Distress and Sale of the Offenders Goods and Chattels, by Warrant under the Hands and Seals of such Justices, rendring the Overplus to the Owner.”

The Act contains provisions “for Preventing Dangerous Carriages of Gunpowder in and through the Streets of London and Westminster and the suburbs thereof” not more than 2,000 lb. of gunpowder, each 100 lb. containing “Fivescore Pounds Net Weight”
being allowed to be carried or conveyed in or through any of the streets or lanes of London and Westminster and their suburbs at a time, and all such gunpowder was to "be Carried in Covered Carts or Carriages, and the Barrels in which such Gunpowder is Carried shall be close Joynted and hooped, and shall be put into Bags or Cases of Leather or Canvass; and Gunpowder Carried by Man or Horse shall be put into Cases of Leather or Canvass, and entirely Covered therewith, so as that no such Gunpowder be Spilt or Scattered in the Passage thereof," any gunpowder carried or conveyed in any greater quantity or in any other manner to be forfeited, "and shall and may be Seized by any Person or Persons to his or their own Use and Benefit, the Person or Persons so offending being thereof lawfully Convicted before Two Justices of the Peace."

This Act did not extend to Government Stores or Magazines or to the carriage of "Gunpowder to or from any of His Majesties' Magazines, or with Forces in their Marches."

The Act, however, recognized the possible necessity of erecting new warehouses for keeping gunpowder outside the stipulated limits but at a convenient distance from the City of London, "from whence sufficient Quantities of Gunpowder may with greater Safety be Supplied as occasion requires," and points out that there are "large Tracts of Marsh and Meadow Grounds in the Counties of Essex, Kent and Surrey, where New Warehouses may be commodiously Erected, such Marsh and Meadow Grounds being at Good Distance from Dwelling Houses or Habitations, and therefore, and by reason of their Adjacency to the River Thames, are convenient for such Warehouses," but as persons desirous to erect such warehouses "may be liable to Actions or Disturbances on that Account, or may be unreasonably Imposed upon in the Purchase thereof," the Justices of the Peace for the Counties of Essex, Kent, and Surrey were empowered to appoint at their General Quarter-Sessions "some proper and convenient Plot or Plots of Ground out of the Limits aforesaid, not exceeding Two Acres in any one Place in each County" and adjacent to or near the
river Thames, on which it shall be lawful to erect warehouses for keeping gunpowder, first agreeing with the owner and proprietors of the said ground for the same; in case of refusal or neglect to agree, the Justices of the Peace shall impanel a sufficient Jury to inquire into the true value of the ground, and the judgments and decrees of the Justices thereupon shall be final and conclusive to all parties. The sums of money to be assessed, not exceeding thirty years' purchase, shall be paid to the respective proprietors of the ground. "All other Warehouses for Gunpowder, which shall be erected on or near the River Thames, shall be Built and Secured, from time to time, in such manner as shall be Prescribed and Directed by the Principal Officers of His Majesties Ordnance."

By this Act all "Leases, Covenants, Articles and Agreements Made or Entred into" of any warehouses or storehouses within the Cities of London and Westminster and its suburbs are annulled.

Six years later it was found necessary to amend this Act, and so in the eleventh year of George I (1725) an Act was passed "for making more Effectual an Act passed in the Fifth Year of His Majesty's Reign, Intituled, An Act for preventing the Mischiefs, which may happen by keeping too great Quantities of Gunpowder in or near the Cities of London and Westminster, or the Suburbs thereof." From the preamble of which it appears that "since the making of the said Act many Dealers in Gunpowder, and others, have divided their Houses and Warehouses into several small partitions or Apartments, and there keep great Quantities of Gunpowder, whereby and by other Evil and Indirect Means and Practices the good Designs of the said Act are notoriously eluded and evaded, to the apparent Danger of several Publick Offices, and the Lives and Fortunes of many Thousands of Your Majesty's Subjects." It was moreover felt to be necessary "for Publick Safety to lessen the Quantity of Gunpowder allowed by the said Act to be kept within the Limits aforesaid." This second Act therefore provides that after 1st June, 1725, it shall not be lawful to have or keep within the limits aforesaid,
more than 200 lb. of gunpowder at any time in any house, storehouse, warehouse, shop, cellar, or other place, under one or the same roof, or in any yard or yards, within the limits aforesaid, for more than the space of twenty-four hours, upon pain of forfeiting all such gunpowder, and the value thereof, with full costs of suit, to any person who will inform and sue for the same. The Justices of the Peace authorized to issue warrants of search after dangerous quantities of gunpowder, were compelled upon demand made by any parish officer, or by any two or more householders, to issue such warrants gratis. Upon such search it was lawful for the searchers to seize and remove within twelve hours all gunpowder found within the limits aforesaid, exceeding the quantities allowed. Every person wilfully hindering such seizure to forfeit £5 to the Informer.

A very important provision is the "preventing the dangerous Use of Iron Hammers, or Hammers Shod or Plated with Iron or Steel, in any Warehouse or other Place, used for keeping Gunpowder." Any person presuming to work with such a hammer, in any warehouse or place, while gunpowder is there, shall, for every such offence, forfeit twenty shillings to the Informer, to be levied (in case of non-payment) by distress and sale of the offender's goods and chattels by warrant and for want of sufficient distress, every such offender shall be sent to the House of Correction, there to be kept to hard labour for not more than one month, nor less than fourteen days.

Under George II further progress was made, and in 1732, the fifth year of that monarch's reign, an Act was passed for "the better regulation and government of pilots licensed by the Corporation of Trinity House of Deptford Strond in the County of Kent and to prevent mischiefs and annoyances upon the river of Thames below London Bridge," which contained a stipulation to the effect that: "No Master or Commander of any ship or other vessel whatsoever outward bound, shall receive, or cause or permit to be received, on board any such ship or vessel any gunpowder either as merchandize, or as store, or ammunition for the voyage (except for His Majesty's Service), before
such ship or vessel shall be at, over against, or below Blackwall, upon pain of forfeiting for every 50 lb. weight of gunpowder to be so shipped or received on Board such ship or vessel the sum of £5, and so in proportion for a greater or lesser quantity.”

The Act also made it compulsory on “the master or commander of every ship or vessel coming into the River Thames” to “land or put on shore or cause to be landed and put on shore, all the powder on board such ship or vessel” either before its arrival at Blackwall or within twenty-four hours, weather permitting, after casting anchor there, or at “the place of her unloading,” under a similar penalty.

In the same year an Act was passed by the Parliament of Ireland (5 George II, c. 12) against the throwing of fireworks.

Two further Acts were passed in the 15th and 22nd years of the reign of George II (1742 and 1749) “for preventing mischiefs which may happen” by keeping gunpowder; the first, referring only to the Cities of London and Westminster; the latter, a general Act including carriage as well.

In 1771, the eleventh year of George III, an Act was passed for reducing into one Act of Parliament the several laws relating to the keeping and carriage of gunpowder, and for more effectually preventing mischiefs by keeping or carrying gunpowder in too great quantities.

This legislative Act very honestly admits in its preamble that “the several Acts which regulate the keeping and carriage of gunpowder in England” were defective and required amendment; and wisely sets forth that “the reducing them into one law would facilitate their execution.” The preamble also states that “there is no regulation for the keeping and carriage of gunpowder in Scotland.” By this Act dealers were not allowed to keep in one place and at any one time more than 200 lb. of gunpowder, and private persons not more than 50 lb., “any river or other water” being included in the word place. “Carriages loading or unloading or passing on the land,” and “ships, boats or vessels loading or unloading, or passing on any river or other water, or detained there by the tide or bad weather,” being expressly
excepted. Such storage of gunpowder is however permitted "within the following limits" only: "Within the Cities of London and Westminster, or within three miles of either of them; or within any City, Borough or Market Town of Great Britain, or within one mile of the same; or within two miles of any palace or house of residence of the King or his successors, or of the Queen Dowager, the Queen Consort or any further queens," or within one mile of any gunpowder magazine belonging to His Majesty, his heirs or successors, or within half a mile of any Parish Church; or in any other part of Great Britain," except in such places specially provided for by the Act, where unlimited quantities may be kept. The penalties are the "forfeiting of all the gunpowder in specie beyond the quantity hereby allowed to be kept, and the barrels in which such Gunpowder shall be, and also one Shilling for every pound of Gunpowder beyond such allowed quantity."

The Act prohibits the carriage within Great Britain of "more than 2,000 lb. of Gunpowder in any waggon, cart, or other carriage, by land or more than 5,000 lb. of Gunpowder in any barge, boat, or other vessel, by water (except in vessels with gunpowder on board imported from or to be exported to any place beyond sea); and all gunpowder conveyed" in this manner, except for import and export, "shall be in barrels close joined and hooped without any iron about them, and so secured that no part of the gunpowder be scattered in the passage, and each barrel shall contain no more than 100 lb. of Gunpowder; and when conveyed by land, shall be entirely enclosed in a leather bag, or a bag commonly called a Salt-petre bag; and every carriage or vessel (except such vessels as aforesaid), in which gunpowder shall be conveyed by land or water, shall have a compleat covering of wood, painted-cloth, tarpaulin, or wadmill-tilts, over all that part . . . in which the gunpowder barrels shall be placed."

The Act provides for the right of search, and expressly stipulates that no person shall be liable to any penalty under it until the expiration of six calendar months after judgment, following upon a complaint lodged by a householder of the parish or place.
Lessees of magazines for unlimited quantities of gunpowder may terminate their Agreements by three months' notice. No outward bound vessel shall carry more than 25 lb. of gunpowder before reaching Blackwall.

This Act, which came in force on the 1st August, 1771, repealed: Act 5, George I, Act 11, George I, the clause referring to gunpowder in 5 George II, and Acts 15 and 22 of George II.

The first Act of Parliament affecting the manufacture of gunpowder was passed on the 22nd January, 1772, and came into force on the 1st July of the same year. It is chap. 61, 11 George III, and is entitled: "An Act to regulate the making, keeping and carriage of gunpowder, within Great Britain and to repeal the Laws heretofore made for any of those purposes."

To judge by the preamble this Act would seem to be a sort of legislative afterthought, for it states that: "Whereas the manufacture of Gunpowder within Great Britain, though necessary to be encouraged in respect of the Value of Gunpowder as an article of defence and commerce, yet ought to be regulated by law in order to prevent the great mischiefs which may arise from explosions occasioned by the improper construction and use of the mills, engines, and buildings, employed in the making of Gunpowder, and for keeping and carrying Gunpowder in too great quantities, or in an improper manner; and whereas the Act passed in the last session of Parliament" contained no such provisions, and was moreover defective, "the said is repealed."

This new Act provides: "That no person or persons shall use, or cause to be used any mill or mills or other engine or engines for the making of Gunpowder, or in any manner manufacture Gunpowder" except where such manufacture is actually being carried on, "or where it shall afterwards become lawful to carry on such manufacture by obtaining a licence for that purpose, under the provisions hereinafter contained." The penalty being the forfeiture of all the powder manufactured contrary to law, and two shillings per pound fine.

The Act then goes on to prohibit the use of stamp mills, "com-
monly called a pestle-mill,” and provides that no more than 40 lb. of
gunpowder shall be manufactured at one time or “under any single
pair of Mill Stones.” Fine “fowling gunpowder,” known and
“distinguished by the name of Battle Powder,” manufactured by the
powder mills “erected in the Parishes of Battle, Crowhurst, Seddels-
comb and Brede in the County of Sussex,” being specially exempt
from the operation of the Act.

No person is allowed to “dry or cause to be dried at any one
time, in any one stove or place, used for the drying of Gunpowder, any
quantity of gunpowder exceeding 40 cwt.”

The keeping “in any corning-house, drying-house, dusting-house or
other place, etc. (except magazines or store-houses constructed with
stone or brick, and situated 50 yards at least from the Mill or Mills),
any greater quantity of gunpowder than shall be necessary for the
immediate work then carrying on” is also prohibited.

Manufacturers shall “besides the Magazine or Magazines and
store-houses near their Mills, have or provide a good and sufficient
Magazine or Magazines remote from their respective mills for the
purpose of safe-keeping” the manufactured article, as soon as this can
be “conveniently removed thereto.” These magazines “shall be well
and substantially built with brick or stone near the River Thames and
below Blackwall or in some other convenient place to be licensed by
the Justices of the Peace.” The penalty for not having such a magazine
is £25 per month. The legislators of those days, not being unreason-
able, provided that Justices of the Peace should, upon application at
Quarter Sessions, “appoint proper and convenient pieces of ground
with the use of convenient roads thereto” for the erection of magazines,
seeing that manufacturers failing to erect the same were subject to
penalties, and that “in some cases they may not be able to agree for
the purchase of pieces of ground proper for such magazines.” No char-
coal to be kept within 20 yards of any mill. In this Act, while dealers
may not keep more than 200 lb. of powder, collieries are expressly
allowed to store as much as 300 lb. within 200 yards of the colliery.
The steps to be taken before a licence for such mills can be obtained are laid down at length, and are calculated to afford the public ample protection. Petitioners who are refused a licence by the Court of Quarter Sessions may appeal to the King's Bench.

Persons smoking on board vessels carrying gunpowder are liable to a fine of £5, and persons protracting time in loading or unloading powder by land or water to a penalty of £10.

This Act especially exempted from its operation any mills or buildings existing or future on land belonging to the King, neither was it to extend to the keeping of gunpowder at any royal magazine, or to hinder the trial of gunpowder by His Majesty's officers, "or to the Keeping of Gunpowder at the Magazines now erected for that purpose, of Barking, Creeksmouth in the County of Essex and Erith Level in the County of Kent, or to the Keeping of Gunpowder at the Magazines or Storehouses now erected near Liverpool in the County of Lancaster, or the City of Bristol, or to the carriage of Gunpowder to or from the King's Magazine under an express order of the King's Board of Ordnance; such order to contain the quantity of Gunpowder so to be carried and the time for which such order shall be in force; or to the carriage of Gunpowder with forces on their march, or with the Militia during their annual exercise, or which shall be sent for the use of such forces of Militia."

This part of the Act was repealed in the 14 and 15 Victoria, cap. 67 (7th August, 1851), the magazines at Liscard being abolished, and "The Lord High Admiral, or the Commissioners for the Time being for executing the Office of Lord High Admiral" being empowered, "with the approval of the Master General of Her Majesty's Ordnance, and of the Commissioners for the Conservancy of the River Mersey," to appoint suitable places for mooring vessels or floating magazines in that river. The Master General of Ordnance to appoint an Officer to enforce such regulations as the Board of Ordnance may deem necessary. The Corporation of Liverpool to pay the lessees of the Liscard magazine the sum of £9,780.
By the Acts 2 and 3 Victoria, cap. 47, and 9 and 10 Victoria, cap. 25, powers were given to every superintendent or inspector of police of the metropolis "to search vessels in the river Thames and the Docks and Creeks adjacent thereto," and "for any Justice of the Peace to issue a warrant for searching in the daytime any place or vessel in which gunpowder or other explosive dangerous or noxious substance is suspected to be made or kept for the purpose of being used in committing an offence."

In 1855, 18 and 19 Victoria, cap. 117, an Act was passed for "transferring to one of H. M. Principal Secretaries of State the Powers and Estates Vested in the Principal Officers of the Ordnance," the secretary in question to be H. M. Principal Secretary of State for the War Department.

It was not until 1860 (23 and 24 Victoria, cap. 139) that the first Gunpowder Act of the last century was passed. This contains a number of regulations for the manufacture and keeping of gunpowder, among which there is the first provision for protection against lightning, every maker of gunpowder being enjoined to "cause to be erected or provided good and sufficient thunder rods or lightning conductors in connexion with every Store Magazine where Gunpowder is kept by him."

The Act also provides regulations to be "observed with regard to the manufacture of loaded percussion caps, and the manufacture and keeping of Ammunition, fireworks, fulminating mercury or any other preparation or composition of an explosive nature; and makes it lawful for Justices of the Peace in quarter Sessions to licence places for the manufacture and storage of such articles and to grant licences to persons to sell fireworks." The Act recapitulates nearly all the provisions of the earlier Acts, especially with regard to carriage, etc. This is "the Gunpowder Act, 1860."

In the following sessions of Parliament, 24 and 25 Victoria, cap. 130 (1861), the licensing power is transferred from Justices of the Peace at their General Quarter Sessions to Justices in Petty Sessions assembled, and special reference is for the first time made to safety fuses.
There is nothing in the "Gunpowder Act Amendment Act, 1862," 25 and 26 Victoria, cap. 98, that calls for special reference, beyond the substitution of Police Magistrates for Justices as licensing authorities in Ireland, nor do the succeeding Acts, passed respectively in 1865 and 1866, require mention.

An Act was passed in 28 and 29 Victoria, cap. 278 (The Liverpool Gunpowder Regulation, etc., Act, 1865), authorizing the Corporation of Liverpool to make Bye-laws regulating the transit of gunpowder from the vessels in the Mersey to the magazines and the carriage of gunpowder in the borough.

"The Carriage and Deposit of dangerous Goods Act, 1866" (29 and 30 Victoria, cap. 69), is the first to deal with nitro-glycerine or glonoine oil, which is thereby declared "to be specially dangerous," and is ordered to be so marked on each package. Nitro-glycerine also came under the operation of 25 and 26 Victoria, cap. 66 (1862), an Act "for the safe keeping of Petroleum."

The Nitro-glycerine Act of 1869, 32 and 33 Victoria, cap. 113, stands by itself; it prohibits the importation of nitro-glycerine because the carriage and conveyance of this article had "been found to be attended with great risk and danger to the lives and property of H.M.'s subjects." In this Act nitro-glycerine is also defined as glonoine oil, and the Act extends to every substance having nitro-glycerine in any form or as one of its component parts or ingredients. Any person bringing into any port or harbour of the United Kingdom, or shipping or unshipping on, from or near the coasts of the United Kingdom, any nitro-glycerine, shall be liable to imprisonment, with or without hard labour, for a term not exceeding one year, or to a fine of not more than £500, the nitro-glycerine being forfeited. One of H.M.'s Principal Secretaries of State was, however, empowered to authorize the importation or export by general or special licence of any substance having nitro-glycerine in any form as one of its component parts or ingredients, provided it could be shown to his satisfaction that the same could be safely handled.
No person was allowed to manufacture, sell, carry or otherwise dispose of or have in his possession any nitro-glycerine in any part of the United Kingdom except in accordance with a general or special licence issued by one of H.M.'s Principal Secretaries of State.

The above is a brief recapitulation of the legislative measures passed in this country in connection with explosives prior to the epoch-making Explosives Act of 1875, of which the two Gunpowder Acts of George III and Queen Victoria, of 1771 and 1860 respectively, were the direct precursors.

But the Gunpowder Act of 1860 had many defects, the most serious of which no doubt was the difficulty of enforcing its provisions. Public attention was first directed to this subject by the now historical explosion on 1st October, 1864, at Erith, which resulted in much loss of life and destruction of property within a radius of ten miles, and led to the presentation of a Memorial by the inhabitants of the neighbourhood to Sir George Grey, the Home Secretary, pointing out that existing legislative enactments regulating the manufacture and handling of gunpowder were inadequate, and praying for the appointment of a special commission of inquiry. At the same time, or rather exactly one week before the date of the Memorial, Colonel Moody, Commanding R.E. at Chatham, made his report to the Horse Guards upon the state of the embankment at Erith and the powder magazines in the neighbourhood. This report is so interesting that we may be pardoned for giving the following extracts. Colonel Moody says: "My inspection revealed to me a condition of affairs in respect to the existing magazines in the neighbourhood that, I submit, necessitates the immediate consideration and action of Government. I found the magazines uniformly built as close as possible to the river bank; in fact partly on the inner slope of the embankment. The doors of the magazines fronting straight to the river, doors, stage with tramways, and the jetty all in a direct line." All these were neither roofed, closed nor guarded. While the stage and door of each magazine were on the same level as the top of the embankment, along which a public thoroughfare, free and open,
passed at a distance of two yards from the door of the magazine. He found one of these doors open without anybody in charge. A man actually passed smoking his pipe, and boys were in the habit of selling matches "from open door to door of the magazine." Steamers passed within moderate distance of the river bank, sparks streaming from the funnels. Sparks were also emitted from the chimneys of a number of adjacent factories. We will spare our readers minor details such as grit on the stage, "pitched" wooden tramway rails, and the presence of straw, dry grass, and pieces of loose paper. There were beds of reeds close to the doors; when the reeds were cut down the stubble was frequently set fire to, in order to improve the next crop.

In the following month, Lieut.-Colonel Boxer, R.A., Superintendent of the Royal Laboratory, made his report on the explosion, which corroborated all Colonel Moody had said, and concluded with these words: "I respectfully submit that further restrictions in relation to gunpowder magazines, etc., than those already imposed, are required for the due protection of the public, and that all magazines and gunpowder factories, etc., ought to be subject to the same sort of inspection and control as that authorized by Act of Parliament in the case of the floating magazines in Liverpool."

This report of Colonel Boxer's marks the beginning of the present system of inspection, and Colonel Boxer may be described as the first Government Inspector of Explosives, for on the 31st October, 1864, Sir George Grey authorized Colonel Boxer "to inspect and examine any mill, magazine or place" in which any kind of explosive was manufactured or kept. Thereupon Colonel Boxer inspected a number of gunpowder mills and magazines and issued a report, dated 31st January, 1865, making recommendations, the spirit of which appears from the concluding sentence: "In the absence of legislative restrictions of universal and compulsory applicability it would be unreasonable to expect the adoption by individual firms or manufacturers, or the voluntary imposition by the trade at large, of more than ordinary precautions, when extra precautions entail extra cost. In no trade,
FIG. 33. COLONEL SIR VIVIAN DERING MAJENDIE, K.C.B.
probably, are the prevailing recognized risks more carefully guarded against; but in dealing with a substance like gunpowder, this is not sufficient; not only ordinary but extraordinary risks must be considered for the due security of the persons and property of the public, if not for the ultimate benefit, commercially speaking, of the manufacturers themselves."

The late Col. Sir V. D. Majendie, K.C.B., appointed in a similar capacity in 1870, following upon an explosion at Messrs. Ludlow's, at Birmingham, by which fifty-three lives were lost, carried the evolution of legislation a step further by recommending, in 1871, the appointment of permanent Inspectors. In a report to the Home Secretary dated 16th May, 1872, he again urges this recommendation, and says: "If I succeed in showing that the law is, as I have stated, habitually disregarded, and that many necessary precautions are, as I have stated, generally neglected, I shall, I think, have established the necessity for the appointment of one or more permanent inspectors of Gunpowder Factories, etc., quite irrespective of the numerous very important duties not connected with the actual work of enforcing the law which the inspectors ought to be required to perform."

The summoning of a Royal Commission and the passing of the 1875 Explosives Act have brought us, humanly speaking, within finality; at any rate, legislation with regard to explosives is now based on lines which are not likely to be altered for some time at least to come.

We are indebted to H.M. Inspectors of Explosives for the following lucid description of the working of this Act.

The Explosives Act, 1875, deals only with the manufacture, keeping, conveyance, and importation of explosives as defined in that Act, and does not directly regulate in any way their use.

Before, however, any general traffic in an explosive can take place it must be placed on the List of Authorized Explosives, and the following is a brief outline of the method by which such authorization is obtained. In the first place the inventor or his agent is requested to
submit a sample amounting to a few ounces of the proposed explosive for examination by the Chemical Advisers to the Explosives Department, the exact composition being forwarded at the same time. Should the preliminary tests of the sensitiveness to percussion and friction be satisfactory, a notification to this effect is sent to the inventor, and if the compound contains any substance with which the Chemical Advisers are not fully acquainted the explosive is then submitted to further tests to ascertain its keeping properties, a fee of varying amount being charged for this examination. If this further test is satisfactory the explosive is placed on the list of authorizeable explosives, that is to say, on the list of those explosives for the importation or manufacture of which a licence will be issued on application.

When fully authorized the explosive is added to the List, which is signed by a Government Inspector, and kept at the Home Office. For many years this List, with the definitions of the explosives, was published annually; but for the last eight or nine years, owing to representations from the trade, this is no longer the case, the names only being published and the composition being kept confidential.

Manufacture.—With certain trifling exceptions no explosive can be lawfully manufactured without a license or a continuing certificate. The latter, however, affects such factories only as were in existence before the passing of the Explosives Act, and although in the case of some of these, the construction of the buildings, the distances between the buildings and the number of workpeople employed in each building, could scarcely be described as harmonizing with modern ideas, it was felt at the time the Act was passed, that interference to any considerable extent with factories which had been in existence for many years was not feasible.

The applicant for a factory licence must in the first instance submit a plan showing the position of each building of the proposed factory, and stating at the same time the amount of explosives and the number of workpeople he desires in each. A draft is then prepared at the Home Office and forwarded to him for observations. If every-
FIG. 34. VIEW OF OLD WALTHAM FACTORY IN 1735.
(Reprinted by kind permission from the "Victoria County History of Essex," vol. ii.)
thing is found to be satisfactory the Secretary of State gives his "assent" to an application to the Local Authority, under whose jurisdiction the site of the proposed factory is situated, for their consent to its erection, such application to be made by the applicant. Any local objections can thus be put forward and investigated—and for this purpose, and in order to give local residents sufficient time to prepare their statements, every application for a factory licence shall be freely advertised for one clear month before the date fixed by the Local Authority for the hearing. The consent of the Local Authority having been obtained, the applicant is informed that he may proceed with the erection of his factory; the buildings must, however, be inspected and passed by one of the Government Inspectors before the draft licence can receive the confirmation of the Secretary of State; and it is not until this has been given that manufacturing operations can be undertaken. Licences are drafted in such a manner as to meet the wishes of the applicant, as far as possible, subject always to the due protection of the lives of those employed. The trade generally understand that, except in special circumstances, the quantity of explosives allowed in a building depends entirely on the distances that can be maintained between this building and those adjacent to it, whereas the number of workpeople engaged there at any one time is regulated by the measure of risk that is attached to the particular operation carried on there and the facilities for escape.

The construction of the danger buildings of a factory is governed by the general principle that a working building, where explosives are not kept over-night, should be built of the lightest materials possible, such as matchboarding and corrugated iron, whereas magazines in which the explosives are stored should be substantially built so as to give reasonable security against unauthorized entry; and preferably of concrete, brick or masonry, except in cases where a night-watchman is employed, when a lighter construction may be sufficient.

The terms of the licence must be strictly adhered to, and periodical inspections are made in order to see that this is done, the Government Inspectors appointed under the Act visiting factories and magazines at
FIG. 35. PLAN OF STOWMARKET FACTORY.
unstated times and without notice. It is satisfactory evidence of the conscientiousness of the trade and the fairness of the regulations that only on very exceptional occasions does an inspector find any material infringement of a licence.

Keeping. — There are four methods in which explosives may lawfully be kept, viz. in magazines, stores, on registered premises, and lastly, in small quantities for private use. The method of licensing a magazine is practically identical with that applying to a factory, and the quantity of explosives which may be so kept, depends practically on the distances that can be maintained from protected works, i.e. houses, roads, etc.

Store licences are issued by Local Authorities. Provided the situation and construction of a store conforms to the requirements of the Act the Local Authority has no option but to issue a licence. There are four divisions of stores, according to the distances that can be maintained from protected works, the quantity of explosives varying from 300 lb. to 4,000 lb. of gunpowder, or an equivalent of other explosives. The quantities are, as a rule, sufficient for the service of a large colliery or quarry, and the only objection that can be urged is a certain want of elasticity in special circumstances. No unauthorized explosive may be kept in a store; and high explosives, such as dynamite, blasting gelatine, etc., may not be kept without a certificate from a chief officer of police, to the effect that the licensee is a proper person for the purpose.

Retail dealers must keep small quantities of explosives in specially suited registered premises. As in the case of a store licence a Local Authority has no option but to accept a registration, which is merely a notice that the applicant proposes to keep explosives on his premises; it is, however, the duty of the Local Authority to see that the explosive is kept in conformity with the provisions of the law, for which purpose a properly appointed officer is employed. There are two methods by which explosives may thus be kept; in accordance with Mode A they may be stored in a small detached building, in which quantities up to 200 lb. of gunpowder may be kept and a proportionate amount of other explosives; Mode B provides for keeping in a receptacle in a building
FIG. 36. VIEW OF A PART OF THE NOBEL WORKS AT ARDEER.
up to 50 lb. of gunpowder, or a proportionate amount of other explosives. In cases where an officer of the Local Authority is zealous in enforcing the law this method of keeping appears to be very satisfactory; but unfortunately in many places the provisions of the Act in regard to Registered Premises are almost, if not entirely, disregarded, with the result that accidents occur from time to time which, from the nature of the surroundings, give rise as a rule to considerable local panic, although from the limited quantities allowed on these premises the loss of life outside the building in which the explosives are kept has been very small in the thirty years or so during which the Act has been in operation.

The keeping of explosives for private use is limited to small quantities of such explosives as are generally required for purposes of sport, firework displays and blasting on private property. Thirty pounds of gunpowder may be kept, or 10 lb. of small arms nitro-compounds such as those used for the loading of sporting cartridges; 5 lb. of fireworks are allowed, or, for use in display within 14 days, an unlimited quantity; 10 lb. of blasting explosive, other than gunpowder, and 100 detonators may also be kept under a police certificate, such as those which apply to stores and registered premises.

Conveyance.—The carriage of explosives by rail and canal, and in harbours and docks, is regulated by by-laws made by the Companies concerned, subject to the sanction of the Board of Trade. Model Codes of by-laws have been prepared by the Explosives Department of the Home Office, and in most cases accepted, so that there is a certain degree of uniformity throughout the United Kingdom. Carriage by road is regulated by an Order of the Secretary of State made under the Act. As regards conveyance in general, however, much dependence is placed on the method of packing, and it is considered that the immunity from accident enjoyed in this country is largely due to the excellent packages required by law. During the thirty-three years of the existence of the Explosives Act there has been only one serious accident in conveyance, viz., that in connection with the importation of so-called percussion caps in the SS. Manitoba on 6th July, 1898.
**Importation.**—No explosive other than gunpowder and explosives of Class VI, Division 1,\(^1\) may be imported without a licence, for which a small fee is charged irrespective of the quantity imported in any one cargo. Importation Licences are only granted for certain ports at which the Customs Authorities have established facilities for taking samples, and transmitting them to the Explosives Department in London. Until these samples have been examined by the Chemical Advisers to the Department, and released by a Government Inspector, the explosive is held in bond in licensed magazines or other authorized places of storage and may not be distributed.

**Accidents.**—It is satisfactory that as far as accidents in manufacture, conveyance, and storage are concerned, \textit{i.e.}, in connection with such part of the traffic in explosives as is regulated by the Explosives Act, there has been a very material decrease as compared with the years before the passing of the Act.

During the three years from 1868 to 1870 there occurred in the manufacture of explosives in England and Wales only, no less than 64 accidents, causing the death of 129 persons, and injury to 85 others, giving an average per annum of 43 deaths.

From 1871 to 1874 inclusive, a period during which an incomplete system of inspection existed, 128 persons were killed, giving an average of 32 per annum.

For the last thirty years, during which there is a fairly complete record of the accidents which have occurred in manufacture in the whole United Kingdom, the figures of the three decades are as follows:

<table>
<thead>
<tr>
<th></th>
<th>No. of accidents</th>
<th>Killed</th>
<th>Injured</th>
<th>Employed</th>
<th>Average per thousand.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Killed</td>
</tr>
<tr>
<td>1878 to 1887</td>
<td>648</td>
<td>75</td>
<td>172</td>
<td>7,500</td>
<td>1</td>
</tr>
<tr>
<td>Average per annum</td>
<td>64.8</td>
<td>7.5</td>
<td>17.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1888 to 1897</td>
<td>499</td>
<td>52</td>
<td>194</td>
<td>10,000</td>
<td>.5</td>
</tr>
<tr>
<td>Average per annum</td>
<td>49.9</td>
<td>5.2</td>
<td>19.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1898 to 1907</td>
<td>528</td>
<td>69</td>
<td>258</td>
<td>14,500</td>
<td>Under .5</td>
</tr>
<tr>
<td>Average per annum</td>
<td>52.8</td>
<td>6.9</td>
<td>25.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) This class embraces safety cartridges, safety-fuses for blasting, railway fog signals, percussion caps.
From the above it would appear that the number of accidents has largely increased, but this apparent increase is to be attributed to the fact that since the trade has been under efficient regulation, all accidents, of whatever nature, are reported, even though no personal injury or damage to material be incurred, whereas formerly only such accidents were reported as entailed serious consequences.

In connection with the storage of explosives in magazines, stores, there is only one fatal accident to record during the time that the Act has been in force, the explosion of a floating magazine on the Thames on 30th June, 1877, causing the death of two persons, but the same cannot be said about registered premises and private use. Accidents occur from time to time in connection both with dealers' premises and in private houses, but owing to the quantities allowed to be so kept it is most exceptional for any person to be injured outside the premises on which the accident occurs. All things considered, it is perhaps surprising that accidents of this kind are not more frequent. The position in this country with regard to accidents from explosives in transit is most satisfactory and may be reasonably ascribed, to the very careful methods of packing required under the Explosives Act. In factories and magazines, or even on registered premises, it is possible to a certain extent to allow for the effects of an accident and take precautions accordingly, but during conveyance the quantities concerned are as a rule large, and the conditions may be such as to involve injuries to a very large number of persons, and to much valuable property, and as has frequently been shown in other countries, the effects of an explosion in these circumstances may be appalling.

The use of explosives as already stated does not come within purview of the Explosives Act, although by advice, by special rules under the Mines and Quarries Act, and similar means every effort is made to reduce the number of accidents. In relation to the quantities of explosives now used in engineering works, the accidents are not excessive, but they are considerably higher than they need be, as in nine out of every ten cases they could have been prevented by the
exercise of ordinary care. Many accidents used to be caused in connection with the thawing of nitro-glycerine explosives, but the number is gradually growing less as the danger of this operation is impressed on those who handle explosives.

The above description of the working of the Explosives Department of the Home Office and the administration of the 1875 Act, for which, as already stated, we are indebted to that Department, does not make mention of the Explosives Substances Act, 1883, relating to the unlawful use of explosives, which has a political bearing, and therefore scarcely comes within the scope of the present work.

The Coal-Mines Regulation Act is referred to in the chapter devoted to Permitted Explosives, whilst the Dynamite Fishing Act of 1877 scarcely comes within the scope of this work.

The gratifying success of the administration of the Explosives Act under the Home Office must be largely attributed to the tact, discretion, and especially to the strict impartiality and fairmindedness of H.M. Inspectors. Recruited as these gentlemen are from the scientific branches of the Army they have loyally maintained the great traditions of the late Colonel Majendie's original administration. On the other hand, however, the manner in which the trade have accepted and observed the regulations as by law provided, and have conscientiously endeavoured to the best of their ability and often at great expense, to carry them out, not only in the letter but in the spirit also, has been a large contributing factor, and one of which the nation as a whole may be justly proud.

Our illustrations show by way of contrast an old gunpowder mill as it existed in the eighteenth century, the plan of a modern factory laid out in accordance with Home Office regulations, and a partial view of one of the largest high-explosives factories in the world. The two last will give some idea of the difficulties and labour of modern inspection.
THE subjoined complete list of books on explosives, published in England, has been added in the hope that students may find it useful. In some cases the name of the publisher could not be ascertained, no copy of the book in question having been found in the British Museum, or elsewhere in London. The references to books published before 1800 are all to the first editions, these alone having antiquarian interest; the references to books printed after 1800 are to the latest editions only.


No date. Christopher Grotz, Real Engineer. The Art of making fireworks, detonating balls, etc. London, Dean and Munday.


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1661. Anonymous. The compleat canoneer, shewing the principles and grounds of the art of gunnery, as also of fireworks for sea and land. London.

1670. William Clarke. The Natural History of Nitre; or, a Philosophical Discourse of the Nature, Generation, Place and Artificial Extraction of Nitre, with its Virtues and Uses. London, Nathaniel Brook.


1676. Capt. Thomas Binning. A Light to the Art of Gunnery; wherin is laid down the true weight of powder both for proof and action, etc. London, Andrew Forrester.


1684. Sturmy. Mariner's magazine, with the art of gunnery and artificial fireworks. London, W. Fisher and others.

1684. John White. A rich cabinet with variety of inventions ... as also Variety of recreative Fire-works both for Land, Air and Water. And Fire-works of Service, for sea and shore. London, William Whitwood.

1688. J. S. The Souldiers Companion; or, Military Glory Display'd. ... Together with the Art of Gunery, and preparing Artificial Fire-works for Ear or Recreation, with other things and Matters necessary to be known on like Occasion. London, Nath. Ponder.


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CHRONOLOGY
(1242-1700)

1242. Roger Bacon in “De mirabili potestate artis et naturae” gives anagrammatic composition of Gunpowder.

1327. A manuscript in the Christ Church library in Oxford by Walter de Millemete, written for King Edward III and entitled “De officiis regum” contains a picture of an armoured man firing an arrow-like heavy missile from a bottle-shaped cannon.

1338, 22nd June. Indenture between John Sterlyng, formerly clerk of ships, galleys, barges, balingers, and other King’s vessels and Helmyng Liget, Keeper of the same (12 Edward III, 1338), which mentions “un petit barrell de gonpoudre le quart plein.” (Trail, “Social England,” ii, 129.)

1340 (?). Middle of fourteenth century. Fragment of a roll containing medical and other recipes, some in French and some in Latin. The third line is “Expliciunt signa mortis hominis.” The fourth line is the heading of a recipe, “Pour dolour et duresse de ventre.” It contains a recipe for making gunpowder, in Latin, as an experiment for the laboratory; but makes no mention of its use for military purposes. The battle of Crecy had not been fought. There are altogether 141 lines. (Hist. MSS. Comm. MSS. belonging to the Ewelme Almshouse, in the county of Oxford, rep. 8, p. 625 a.)

1346, 10th May. Edward III obtains 912 lbs. saltpetre and 886 lbs. of quick sulphur, and pays for it to Thomas de Roldeston through William of Stanes. (Public Record Office L.T.R. Enrolled Wardrobe Account, No. 4.)

Note. A last of gunpowder was 24 hundredweights of 100 lb. each. A hundredweight of saltpetre was, however, 112 lb., of which 12 lb. were allowed for the loss in refining. 180
1346, 25th November. King's writ to buy all saltpetre and sulphur. 750 lbs. and 310 lbs. respectively were obtained.

1344-47. Thomas de Roldeston, Clerk of the King's private Wardrobe in the Tower of London accounts for 40 shillings for the manufacture of powder for guns and repairing various arms. (Account of the wardrobe of Edward III. 25th December, 1344, to 18th October, 1347.)

1347, 21st September. King's writ to buy all saltpetre and sulphur. 2021 lbs. saltpetre and 466 lbs. sulphur obtained, at 18d. per lb. of saltpetre and 8d. per lb. of sulphur.

1378, 16th March. Order to all sheriffs, mayors, etc., to aid Thomas Norwich, appointed by the King to buy and provide (under the oversight of Thomas Restwold) in the city of London and elsewhere, two great and two smaller engines called "canons," 600 stones for the same, bows, arrows, iron, steel, and 300 lbs. of "sal petre," 100 lbs. of live sulphur, one barrel "carbonium de salugh"... for the defence of the King's castle of Brest. (Treaty Roll, 62, mem. 15.)

1387. Among the munitions bought for Cherbourg we find: 100 pounds of nitre at 2s.; 702 pounds of nitre at 1s. 8d.; 50 pounds of sulphur vivum at 10d.; 252 pounds of sulphur vivum at 4d. (Roger's "Agriculture and Prices," vol. i, p. 649.)

1404, 21st October. Commission to Nicholas Mauduyt, sergeant at arms, to take men, horses and carts for the carriage of the King's guns and certain tins containing powder called "gunpowdre" and other instruments pertaining to the guns from the castle of Pontefract to other places. (Patent Roll, 6 Henry IV, pt. i, mem. 28d.)

1412. Gunpowder is now manufactured in England. In this year its exportation was prohibited. A licence is granted to the Ambassadors of the Earl of Alençon to carry home with them 400 lbs. of saltpetre and 100 lbs. of sulphur. Gunpowder when first made was not corned or granulated but used in its mealed
state, and was then called "Serpentyne Powder." (Meikleham, Progress of Machinery, etc., 1846, p. 34.)

1414, 26th September. Writs to the Collectors of customs in the ports of London, Hull etc. etc. directing that no person whatsoever, merchant or otherwise shall export "gunpoudre" to foreign parts, without special mandate from the King. (Close Roll, 2, Henry V, mem. 16.)

1424. Assignment to Henry Lord Fitz Hugh, Walter Hungreford, Walter Beauchamp, Lewis Robessart, William Porter, Robert Babthorpe, John Wodehouse and John Leventhorp, executors of the will of Henry V in satisfaction of the £8266 13s. 4d. still due to them under the ordinance made in the Parliament held in the King's first year of the following sums, of which tallies are said to have been levied at the receipt of the Exchequer, viz. £45 10s. for saltpetre at Cales in the custody of the King's treasures there or the saltpetre itself. (Patent Roll, 2 Henry VI, pt. 2, mem. 33.)

1449 (circa). "Paid the maker of the pellet-powder (pulveris librillarum) for the gounnys (guns) for his labour 3s. Paid for a quart of vinegar to test the saltpetre 1½d. Paid John Bayle for making a little sack of sheeps leather, and for the leather for the sack, which sack was provided to carry sulphur and saltpetre for the pellet powder. Paid John Bayle for a certain strainer through which the charcoal was sifted or cleansed for the pellet powder. Paid Robert Lubard for making the pellets of iron. (Rye Municipal Records, Chamberlain's Account Book, fol. 14a. Hist. MSS. Comm. Report V, p. 490.)


1456-8. . . . Paid to William Growte for di3ting (preparing) of 3 dyners, and for his labour to Sandwiche sachyng ther gunne

1466-7. . . . Paiede for gunne powther, set at Sandewhiche 5s. 4d. . . . (Hist. MSS. Comm. MSS. of the Corporation of Lydd, rep. 5, p. 523.)

1467, 29th August. Westminster. Grant to John Nicoll of London, "grocer" and his executors and assigns, in payment for a quantity of powder called "gunpowdre" to the value of £559 10s. 8d. delivered for the King's use to John Wode, master of the King's ordnance (of 40 marks yearly from Easter last from the issues of the county of Lincoln, 40 marks yearly from Easter last from the issues of the counties of Bedford and Buckingham, £40 yearly from Easter last from the issues of the county of Cornwall, £20 yearly from Easter last from the issues of the counties of Oxford and Berks and £26 11s. yearly from Easter last from the issues of the counties of Somerset and Dorset, until he be fully satisfied). (Patent Roll, 7 Edward IV, pt. i, mem. 3.)

1469, 20th June. Appointment, during pleasure, of Roger Ploweden to take carpenters, plumbers, and other workmen for the works of the King's ordnance and bombards, cannons, Sulphur, powder, Saltpeteyr, etc. The like to 4 others and in 1470 to 3 others. In 1471 similar appointments for 3 persons. In 1472 3 others. (Patent Roll, 9 Edward IV, pt. i, mem. 6.)

1469-70. . . . Paied to Richard Barle for beryng of a pot of gunne-powder to the Nesse 1d. (Hist. MSS. Comm. MSS. of the Corporation of Lydd, rep. 5, p. 525.)

1512. For gunpowder and saltpetre to Francis de Errona, Spaniard, for 707 pounds of gunpowder at 3½d. per pound, and 103 qr. 22 lbs. of saltpetre in rock at 4d. per lb. To John Stanget of Ipswich, for making saltpetre. (Exchr. T. R. Misc. bk. i, p. 29.)

1512, 29th December. John Stile at Burgos to Henry VIII. [In cipher.] Howbe that, and yt plese your grace, by fore the comyng of your sayd letters, the Kyng your good fader had commandyd his commandment of restraynte of the sayd salte-peter for to be releecyd; for as muche, and hyt plese your grace, as that y had knowlyche that the sayd saltepeter was provydeyd yn the ream of Napulys for yowr hyzghnys, and also a two monythys passyd, the factorys of the marchantys pur-vayors of the sayd saltepeter for yowr grace landyd at the porte of the Passage, and cam to me, then beyng yn San Sebastyans, schawyng to me that the cause of thayre comeyning yn to thys partys was fir to have the sayd saltepeter at thayr lyberty, so that thay myzghte performe thayr promysys concernyng the same to yowr hyzghnys and yowr royal cowsayl; upon the whych, and yt plese your grace, y wrate and sent a letter unto the Kyng yowr good fader, the whych ynmedeatly relecyd hys royal commandment; and the sayd factors, Flor-entynys, retwryned to the Passage, and there frayzghted a schyp wythe the said saltpeter and bromstone, the whych saltpeter and bromstone so laden, the sayd schyp departheyd from the porte of the Passage towardys yowr realme of Yngland on the sevyntyn day of November, the whych my trust yn Almyzghty God ys, that by fore thys time be yn yowr realme of Yngland in savyte. (S. P. Henry VIII. Vesp. C. i, 69, British Museum.)

1513, 15th January. John Stile to Henry VIII. [In cipher.] Date yn Valadolyd the fowrtyn day of Jenyver. 1513. . . . The saltpeter that was here restraynyd y had made suche labors by fir the comeyng of your Royal letters for the same, that the
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Kyng your good fader had commandyd the same fir to be delyverd and was ladyn yn to a schyp, the whych, by Godys grace, ys yn yowr relm of Yngland byfore thys tyme. . . . (S. P. Henry VIII, Vesp. C. i, f. 24, British Museum.)

1514, 2nd April. St. Mary’s Bishopsgate. Receipt by Richard Cressall, prior of the New hospital of our Lady Bishopsgate Without, for 20 marks had of Sir John Cutte, under treasurer, for the rent of a house near the said hospital, for making gunpowder. (Reference, S. P. Henry VIII, sec. 7, p. 152.)

1515. For Hans Wolf, foreigner. To be one of the King’s gunpowder makers in the Tower of London and elsewhere. He is to go from shire to shire to find a place where there is stuff to make saltpetre of; and “where he and his laborers shall labor, dig or break in any ground” he is to make compensation to its owners. (S. P. Henry VIII, sec. 10, p. 154.)

1517, 1st April. “Obligations delivered” and “Obligations bound for saltpetre.” (These are obligations of Italian merchants, most of whose names have been given above. The greater part of them is struck through.) (S. P. Henry VIII. Exchequer T. R. Misc. Books, 216, p. 325-50 [under date].)

1531, 8th July. Thomas a Lee, one of the King’s gunners, to be principal searcher and maker of saltpetre, with power to search and dig for the same in the King’s lands and elsewhere. The said Thomas is to “replenish and make up plain” all ground broken, at his own cost, so that the owner be not injured. He is, however, authorized to hire workmen in the King’s name, and to take wood for burning and trying the saltpetre, with carriage for the same by land and water, and to take any house or houses at reasonable rent, with all other necessaries and commodities for the same. (S. P. Henry VIII. Privy Seal.)

1537, 19th January. Sir Ralph Ellerker the younger to Henry VIII. Desires a speedy supply of gunpowder, gunners and guns for Hull. (S. P. Henry VIII, sec. 114, p. 224.)
1537, 4th February. John Travers to Cromwell. Has delivered half a last of powder to Sir Rafe Elder car's deputy, of which he and the mayor of Hull were right joyous, for they had not 20 lbs. till it came, which was last Saturday before noon. Will not meddle with the ordnance. (S. P. Henry VIII, sec. 115, pp. 193-4.)

1537, 12th February. Sir Ralph Ellerker, Jun., to Cromwell. . . . His deputy received only half a last of gunpowder at Hull from Mr. Travers. . . . (S. P. Henry VIII, sec. 116, pp. 13-16.)

1537, 22nd March. Norfolk to Cromwell. "A Declaration for Robert Aske, concerning any profit of any spoils by him had during the time of this last commotion to the Duke of Norfolke grace. Never himself took any spoils. Certain of the King's lead of Merton Abbey, suppressed, was assigned to Mr. Copyndall to sell, to pay for carriages, gunpowder, etc. Aske received £9 13s. 4d.; the rest remains with Mr. Copyndall. Aske declared this to the King who was gracious to him therein. . . . (S. P. Henry VIII, sec. 117, pp. 80-87.)

1537, 23rd August. Confession of Dermond O Dermond that was left in Mydrennye. . . . Bought powder of Lord James' servant and guns at Kilkenny. (S. P. Henry VIII, Ireland 7, p. 104, 19.)

1538. The King's Payments. Jerom Bruyn, merchant, on warrant of 28 March "for certain demi haks complete, gunpowder with certain matches and javelins," delivered into the Tower, particulars in a bill annexed signed by Sir Chr. Morrice and Ant. Anthony £504 6s. 8d. (S. P. Henry VIII, Arundel MS., 97 f. 14, British Museum.)

1538, 24th January. Harvel to Cromwell. The league between the Emperor, the Venetians, and the Cp. of Rome against the Turk was lately confirmed at Rome. Both the Emperor and Venice make great preparations. There have lately come to Trent 40,000 pikes, many hackebusshes, and 15 carts of powder with other ammunition. (S. P. Henry VIII, sec. 128, p. 154.)
1538, 16th March. John Over to John Demock. I have received your letter of the 11th inst. about powder and “hackboses” for the King’s service. I have accordingly spoken to Hans Ruckardes, and we can supply from 1,000 to 2,000 (quintals) of powder at from £4 to £4 16s. st. a Kyntell according to the quality. Three or four months will be required, as it must be bought (in) Do(cheland) and brought to Hamburgh or Antwerp. . . . Saltpetre here is dear at £3 the cº. . . . Cannot send samples of powder as there is none here. (S. P. Henry VIII, Galba B., x, 74, British Museum.)

1539, March (?) A Purchaser of Armour for the King. . . . Has 22 lasts of powder at London ready to deliver. (S. P. Henry VIII, Royal MS. 7, C.xvi (125) British Museum.)

1539, 17th March. James Hawkyssworthe to Lord Lisle. . . . My Lord Admiral was at Portsmouth 17. March, and the master of the Ordnance and Sir Thos. Spart came to the castle “and aveyd all the bowys and arros” and also looked on the saltpetre which they liked very well. Thinks the saltpeter will be looked to shortly, for the master of the Ordnance took a copy of the indentures “that langys to yt” and made a bill of all the bows. (S. P. Henry VIII, sec. 144, pl. 125.)

1539, 22nd March. Sir Geo. Carew to Cromwell. . . . Found the fortress of Risbanck as raw and bare a house of war as ever was seen, with good artillery but not half a barrel of powder and no bows and arrows. (S. P. Henry VIII, sec. 144, pp. 156-7.)


1539, 2nd April. Antwerp. Wm. Laye to (Wriothesley). My duty remembered unto your good mastership. On Sunday last the
Emperor's Ambassador,\(^1\) which came out of England dined at one Gerald Starkes, sometime tolner here, where he said more harness, powder and gunstones were conveyed into England than remained here. In so much that on Monday last, search was made in the ships laden for England and 2 maunds of harness belonging to a man of Antwerp and 3 maunds, containing 6 barrels of gunpowder of Mr. Over's were taken out. Mr. Colyns and he have ridden to Brussels to inform Mr. Ambassador of it. The 56 hulks which be in Holland are to follow their fellows into Bretayn to St. Paul's Island. (S. P. Henry VIII, sec. 146, p. 249.)

1539, 9th April. Bewmares. Sir Richard Bulkeley to Cromwell. . . . The King's castles in North Wales are wholly unfurnished with means of defence, saving only 8 or 10 small pieces in the castle of Bewmares, with 2 or 3 barrels of powder and some short for them. . . . I beg I may have a couple of gunners and some good ordnance and powder sent me, for the defence of the King's house of Bewmares, which stands in most jeopardy. (S. P. Henry VIII, sec. 150, p. 111-2.)

1539, 23rd April. Antwerp. News from Antwerp. Has sent to Almayn to his fellow for patterns of hawks harnesses, and halberds, but there is no powder to be had thence. . . . (S. P. Henry VIII, sec. 150, p. 190.)

1539, 21st May. John Over to Cromwell. . . . Asks Cromwell to help him to recover 12 barrels of gunpowder, which he bought here, for the King, and which is arrested. Mr. Vaughan, the Ambassador, has written to Cromwell about it. . . . The Emperor's ships be still in Zealand, and they send daily gunstones, powder and other things thither. (S. P. Henry VIII, sec. 151, pp. 230-1.)


\(^1\) Chapuys.
Over, as the Queen has promised to write to the Ambassador in England thereof. (S. P. Henry VIII, sec. 151, pp. 228-9.)

1539, 26th May. Thomas Wusle, constable of Cragfergus, to Mr. Laurans, constable of Ardglass. . . . Requests "a cowpull of passawalans of your ordunans with sum powder" against the coming of the Scots. (S. P. Henry VIII, Ireland, 8, pp. 35-38.)


1540, 19th January. (Council in the North) to John Heron of Chipchase. . . . Enclose a bill from Sir George Lawson to the mayor of Newcastle to furnish you with 20 bows, 20 sheaff of arrows and half a bushell of gunpowder as you desire. . . . (S. P. Henry VIII, sec. 157, f. 67-68.)

1540. Works at Calais. (The month 14th April, 31 Henry VIII to 11th May, 32 Henry VIII.) "Empsyons" Payments to John Dosyn fer iron work . . . a stock lock fer the dungeon, and a cupboard lock for a window "where as the gunpowder lieth." (S. P. Henry VIII, Accounts, etc., Exchequer, Q.R., 206/10.)


1541. Scotland. . . . Workmen in Edinburgh Castle have long been making guns and other ordnance and they have a mill there that has made six barrels of gunpowder within three weeks since Easter. (S. P. Henry VIII, Add. MSS. 32, 646, f. 167. British Museum. Hamilton Papers, No. 70.)

1541, 3rd July. The Privy Council. . . . Business: Letter sent to Mr. Chancellor of the Tenths to deliver a demi "fowrre" of lead to Bernardyn de Valois, a like letter to the Master of the Ordnance to give him quarterly a barrel of saltpetre "to make powder and
pellets for their use whom the King's Majesty had appointed him to teach to shoot in a gun. . . .” (S. P. Henry VIII, Nicholas P. C. P. vii, 207.)

1542, 7th July. Wallop to the Council. On Saturday 1 July at 10 a.m. passed by the King's forest, towards Fiennes, five waggons laden with little barrels, like gunpowder barrels, and one with a short barrel like a puncheon, conducted by Mons. de Vervin, with 120 of Du Bies's horse. (S. P. Henry VIII, sec. 171, f. 104-7.)

1542, 22nd, 23rd August. The Privy Council. . . . Business: Letter sent to Sir Chr. Morres to get ready for shipment to Berwick . . . ½ last of corn powder and 1 last of serpentine powder. (S. P. Henry VIII. Dasent's A. P. C., 22.)

1542, 27th Sept. The French are preparing Ships at Havre to send into Scotland, and a Scot has conveyed powder and munition in a hoy from Flanders. (S. P. Henry VIII. Add. MS. 32, 647, f. 240. British Museum. Hamilton Papers, No. 184.)

1543(?). Ammunition in Ireland. Commission (issued in view of the dangerous practice of selling munitions of war to "Irishmen and other foreign persons") to John Travers, master of the Ordnance, to view what store of powder and guns is in Dublin and other cities to port towns, and to take order with the governors for its safe keeping. . . . Endorsed: "A commission touching selling of guns, powder bows, arrows and other munitions to the Irishmen." (S. P. Henry VIII. Ireland, vol. ii, No. 19.)

1543, 1st May. The Queen of Hungary, to Chapuys. . . . Chapuys must again write plainly whether he holds it certain that the King will make the enterprise at the time mentioned, and what she is to furnish either of men of war victuals, powder or other munitions and carriage. . . . As for powder from Almain, it is obtained with great difficulty. Will willingly permit it being brought here, for the enterprise, but fears that it will be ill to
get. (S. P. Henry VIII. Transcripts from Vienna. Spanish Calendar; VI, ii, No. 132.)

1543, 28th May. The Privy Council. Meeting at Hampton Court. . . Letters sent to Sir Chr. Morres to deliver to Nic. Gainsforth, deputy of Lord Gray, captain of Hampnes castle, certain powder, etc. (detailed). (S. P. Henry VIII. Dasent’s A. P. C., 140.)

1543, 17th June. Bruscelles. Seymour of Wotton to Henry VIII. . . . She (the Queen) rejoiced at the tidings of Scotland, and that as to the gunpowder and saltpeter, she would, on knowing the quantity pass it. . . . (S. P. Henry VIII, sec. 179, f. 47.)

1543, 28th June. Spires. Mont to Henry VIII. . . . 120 great pieces of ordnance which he (the Emperor) had forged at Augsburg were brought to Spires eight days ago, and much powder and ball comes daily. . . . The Protestants have given the Emperor some waggon loads of powder, and permitted him to purchase much more in their cities. (S. P. Henry VIII, sec. 179, f. 142.)

1543, 3rd October. Bruxell. Wotton to Henry VIII. . . . A Hollander of Mein Clyke has taken at sea a great ship of Abarden in Scotland, having on board gunpowder, and 50 hackbushes and two-hand swords belonging (as the master Andrew Bucke says) to the Governor of the North part of Scotland. . . . (S. P. Henry VIII, sec. 181, f. 209.)

1544. Ordnance at Newcastle. . . . Fine corn powder 1 last, serpentine powder 3 last, gross corn powder, 1 last. . . . (S. P. Henry VIII. Shrewsbury MS. B., p. 221. Herald’s College.)

1544. The War. Warrant to Matthew Colthurst as treasurer of the Ordnance for the Middle Ward to pay to . . . Charles Wolman, his expenses incurred during the time he was at Antwerpe choosing the King’s powder. (S. P. Henry VIII. Add. MS. 5753, f. 92. British Museum.)

1544, 14th March, Westminster. Sir Thomas Seymour to the Earl of Hartford. . . . As for the powder, perceives by Barweke “they
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have found to be sold in the town as much as shall serve him. (S. P. Henry VIII. Hatfield MS. 231, No. 65. Cal. of Cecil MSS., Part i, 91.)

1544, 8th June. The Queen of Hungary to Chapuys. . . . Has just had news that the French have gone out from Luxemburg, as capitulated, and that the Emperor's men have entered and found there 40 pieces of artillery of which 22 are cannons and demi-cannons, with 80 barrels of powder. (S. P. Henry VIII. Transcripts from Vienna. Spanish Cal. vii, No. 120.)

1544, 11th June. The Queen of Hungary to Chapuys. . . . As she advertised him by her last, the French went out from Lutzelbourg on the 6th inst. between 6 and 7 a.m. to the number of 1,400 (having previously allowed a list to be made of the artillery and munitions, being 41 cast pieces and 140 barrels of powder) without having spoilt anything. (S. P. Henry VIII. Transcripts from Vienna. Spanish Cal. vii. 121.)

1544, 17th June. (4 o'clock in the morning in the Great Pynow(ce) Russell to (the Council). . . . Mr. Wyndham, captain of the New Barke, has just come to him, with others, saying that they are commanded to go Westwards but "they neither have powder, bows nor pikes. With so goodly a vessel, well furnished with ordnance, Wyndham has but half a barrel of powder which is (not) able to discharge four of his pieces." The captains have such scarcity of munition that they cannot help each other. Commanded Woodhouse to help Wyndham with two firkins of powder, as he is thus appointed to serve Westwards. (S. P. Henry VIII, sec. 188, f. 196.)

1544, 3rd July. Commission to take the receipt by Sir John Gresham by warrant to Lord Chancellor Wriothesley 17 April. 35. Henry VIII of £4,200 st. to be made over by exchange to Wm. Damessell in Antwerp for provision of gunpowder, and by warrant to Sir Ric. Riche, 22 May 36. Henry VIII of £3,800 likewise to be made over for gunpowder. (S. P.
1544, 8th July. Portsmouth. Sir Anthony Knyvet to the Council. . . . Only half a last of powder is come, but good store of bows, arrows, bills and pikes. . . . (S. P. Henry VIII, sec. 189, f. 233.)

1544, 10th July. Camp at Whitsande Baye. Suffolk, Gage and Browne to Henry VIII. . . . Departed when their number was still very small and they had only 14 small pieces and one barrel of powder. (S. P. Henry VIII, sec. 189, f. 251.)

1544, 27th July. Henry VIII to Mary of Hungary. Having laid siege to Monstreul and encamped in person before Boulogne, although hoping soon to accomplish his purpose, he cannot tell how long his expedition will afterwards last; and therefore begs to have for his money 40 lasts of powder, or as much as she can spare. As she has the means of re-making it within her Government sooner than he has, and her countries are protected by his armies she will not herself need much store of powder. (S. P. Henry VIII, sec. 190, f. 165.)

1544, 1st August. Annyk. Sir Ralph Evers to Shrewsbury. . . . Begs a warrant for 2 half-barrels of corn powder for Mr. Crowche and his 100 gunners, with 100 matches. They could not serve on Thursday last for lack of powder and matches. (S. P. Henry VIII, Add. MS. 32, 655, f. 129, British Museum. Hamilton Papers, II, No. 298.)

1544, 4th August. Camp before Monstrell. Norfolk and others to the Council. . . . Have great lack of the things contained in the enclosed bill, especially corn powder, of which is much occupied here.

"An estimate of provision to be made for munition and Artillery" viz.

Cornepowder 30 last at £40, serpentyne powder 70 last at £35.
On the back, in the same hand, are jottings of the amounts of bowstaves, etc., given in Section 2, and the price of powder. (S. P. Henry VIII, sec. 191, f. 30.)

1544, 4th August. Vaughan to Henry VIII. . . . The Council, by their letter brought by William Damsell, command payment to Damsell, of £3,000 for 50 lasts of powder. . . . (S. P. Henry VIII, sec. 191, f. 36.)

1544, 4th August. Andwerpe. William Damesell to Paget. Mr. Stephen Vaghanne, for whom Paget gave him letters for £3,000 st. for provision of 50 lasts of gunpowder will only pay £3,000 Fl. saying that he is charged only for Flemish money. . . . If any further provision shall be made here the bargain should be made now as the price will rise shortly “because of the scarcity of saltpetre.” (S. P. Henry VIII, sec. 191, f. 40.)

1544, 10th August. Camp before St. Digier. Wotton to Paget. . . . Describes how, on the 1st inst. 30 French horsemen, each with a sack of gunpowder behind him, attempted a dash from the woods into the town; of whom 13 got through, 2 were slain and 10 taken. (S. P. Henry VIII, sec. 191, f. 79.)

1544, 27th August. Bruxelles. Mary of Hungary to Henry VIII. Has received his letter about having 40 lasts of gunpowder for the furniture of his two camps, and much regrets that she is unable to satisfy him, because of the great quantity with which she has had to furnish the Emperor, for use against the places he has conquered, and in which he found very little. The Emperor still presses for more; but she has told Henry's ambassador that if any can be obtained from private merchants in Antwerp or elsewhere she will lend every assistance. (S. P. Henry VIII, sec. 191, f. 183.)

1544, 28th August. Bruxelles. Corne to Paget. On the afternoon of the 26th inst, received Paget's of the 25th with a letter from the King to the Queen here by Francis the courier; and immediately delivered the letter to the Queen, who said it was for
certain lasts of powder wherein she would consult the officers who provide powder for the Emperor. Begged her to help, either for love or money as the lack of powder now might be a great hindrance. and she answered that if it was to be had, she would not fail. . . . Could not get the answer until next evening, when Skyperus came to say that she found that all the powder ready outside the Emperor’s camp, was not a fourth part of what the King desires, and it is sent to the Emperor daily as fast as it can be made, and so she would write to the King, but she would send to Andwarp, Hampsterdamme and Dordricke to take up for the King as much as could be found at the Emperor’s price. If Mr. Damesell were sent thither something might be had, but here, “it goeth to th’ Emperor faster than it is made.”

(S. P. Henry VIII, sec. 191, f. 186.)

1544, 29th August, Andwerpe. William Damesell to Paget. . . .
This afternoon at 3 p.m. coming from Macline, where he had been for 150 barrels of gunpowder, received Paget’s letter. Since coming hither, has so hasted the makers that all the 55 lasts of powder is here ready, waiting only for the 85 wagons to be sent from the master of the ordnance for its transport. Has just learnt that 40 of these wagons are come, which he will lade and despatch to-morrow if the weather is not too foul. Paget should see that the other 45 wagons are sent. . . . Has 2,000 morispikes of good ash with well steeled irons ready to be sent with the gunpowder. . . . (S. P. Henry VIII, sec. 191, f. 190.)

1544, 31st August. Benjamin Gonson’s Account. Paid to Wm. Bull-eye, owner and captain of the Martene of London, appointed wafter of the wool fleet diets for 14 days from 18th August, wages etc. (including 66 lbs. of gunpowder “Spent in the same time of wafting”) £29 8s. 7d. (S. P. Henry VIII. Add. MS., 7,968 of 3 f.)

1544, 1st September, Andwerp. Vaughan to Paget. Whereas you lately wrote to Mr. Damsell for the speedy sending of gun-
powder to the camp, no more is to be had here than Damsell had already bought. When you send for gunpowder it were good to send wagons to carry it, for here are none. . . . (S. P. Henry VIII, sec. 191, f. 231.)

1544, 2nd September, Camp before Bullen. Hertford to the Council with the Queen. "(My Lords, wh)eres I wraght unto yo\r Lordshippes in mi layte letares that I trustid the Kynges Ma\te shuld have Bulleyn bi Munday last att the fard(est). . . . you shall undarstand that bi (reson of moche f)owlle wethers that felle here and allso (our) lak off powdar hath causid the tyme to be defarid, the which I assur you in mi jugment and . . . in others, it canot be long after the cuming of the powdar the which I trust shalbe here w* in towe dayes. . . ." (S. P. Henry VIII, sec. 191, f. 233.)

1544, 2nd September. Bruxelles. The Queen of Hungary to De Courrières and Chapuys. The English ambassador here re-
sident, being with her the day before yesterday, said that his master desired provision made here of 100 lasts of powder, and that she should despatch commission to the person charged therewith to obtain that powder at the Emperor's price, and grant him a good quantity of wagons to convey it to the King's camp. Finding the powder excessive, viz. 1,200 barrels, each of about 300 lbs. she caused him to be shown yesterday that the King's last demand was only for 40 lasts, which still was a great deal, and she doubts that it will be ill to get here. How-
ever, because he persisted for the 100 lasts, she has been content to grant it, but as for decreeing commission for the King's clerk, it was not the custom, even for the Emperor's provision, the bargains must be made with the merchants, but she would charge the receiver of the Emperor's artillery to go with the King's servants and assist them; and as for the wagons it was impossible to get them, considering the excessive quantity levied as well for the Emperor's camp as the King's
and that daily, others had to be levied to furnish the Emperor's camp, for the sending of money, beer, and other necessaries and that there was much better commodity of sending the powder by sea, if wagons could be had she would not hinder it, but give every assistance, and that she could not be pressed beyond what was possible.

At first the Ambassador did not seem very well satisfied, and let out that if the King could not have what he needed he must raise his camp, since from his own realm, he could not obtain it. Finds this language troublesome, indicating that upon any want at the King's camp he would raise it and make her his excuse, and she requires them, very instantly, to speak of it to the King; moderately, and make him understand that she has given every assistance possible to his affairs, and is still ready to do so; in proof of which she has charged the said receiver of artillery to assist his men in obtaining powder and transport for it, either by ship or wagons. Prays them to make every good endeavour in this, and advertise her fully of the issue. (S. P. Henry VIII. Transcript from Vienna, Spanish Cal., vii, 192.)

1544, 2nd September, Andwerp. Vaughan to Paget. Here is no gunpowder to be had in all these quarters unless the King will tarry the making thereof; and if Mr. Damsell is to have charge to buy any hereafter, we must leave him money, being commanded to bring what we have to the camp. We appointed Damsell lately to receive £5,000 to pay for what he has already bought, and cannot leave him money for more until we know whether the King will tarry the making of it; But I could come and leave the rest of the money in the hands of Dymock and Locke to bring after. Desires instruction by bearer whom Damsell sends. . . . P.S. It is a great cost to carry gunpowder by land; it were far better to send it by water, and would be sooner there. (S. P. Henry VIII, sec. 191, f. 237.)
1544, 3rd September. Camp before Bologne. Chapuys and De Courrieres to Charles V. . . . Presented the Queen of Hungary's letters containing the excuse of the 40 lasts of powder which he had demanded, with which excuse he was greatly satisfied, especially as the Queen offered all possible assistance for the getting of all that could be got in private hands. (S. P. Henry VIII. Transcript from Vienna. Spanish Cal. vii, 193.)

1544, 4th September. Bruges. John Husee to Paget. Came hither yesternight, and found Henry Atkinson and certain wagons laden with powder, eight more of which came this morning, making in all 44 laden with 215 barrels. Took two barrels out of every wagon laden with five, and therewith laded some of the wagons he brought and saw them safely out of the town, trusting that they will be at Calece on Saturday night. Sent the residue of the empty wagons toward Eclowe where the wagons last laden in Antwerp will be to-night, which shall likewise be sent forward in all haste. . . . (S. P. Henry VIII, sec. 192, f. 15.)

1544, 5th September. Camp before Bulleyn. The Council with the King to the Council with the Queen. The King has bestowed upon his sieges so much powder, that all he brought is spent and also a great proportion lately provided out of Flanders and borrowed from Callais or Guisnes, and he is forced to make a further furniture out of Flanders and to send Ant. Auchar yesterday into England to see what may be spared out of castles and bulwarks within the survey of the Cinq Portes. Lest all may not be sufficient, it is to be declared to the Queen that the powder there in charge of the Master of the Ordnance is to be sent hither, with as much as may be spared from the bulwarks of Gravesend; and also all ships, strangers or English, in the Thamise are to be searched, and their powder bought or borrowed. All gunpowder makers are to be set to work to make a great proportion. The King has bargained in Flanders for 200 last to be made. . . . (S. P. Henry VIII, sec. 192, f. 18.)
1544, 6th September. Camp near Bullen. Sir Richard Riche to Wriothesley. . . . If powder come, we shall make the assault the latter end of this week and “the town must be the King’s.” (S. P. Henry VIII, sec. 192, f. 30.)

1544, 7th September. Oking. The Council with the Queen to the Council with the King. Send letters herewith which arrived this day from the North. Their letters just delivered signify that the powder remaining here in the Tower or in the ships, except a mean furniture, is to be sent over, and the Queen has thereupon dispatched Sir Thomas Arondell to London to take order for the sending of the powder in the Tower (nigh 20 lasts) and also like order for the ships and bulwarks. . . . (S. P. Henry VIII, sec. 192, f. 38.)

1544, 8th September. Henry VIII to the Queen. . . . Detained her servant so long, hoping to send by him good news of the taking of the town, which has been delayed by the not coming of the powder out of Flanders. Looks for the powder in two or three days, and then to write some good news. . . . (S. P. Henry VIII, Calig. E. iv, f. 55. British Museum. Rymer, xv, 50.)

1544, 9th September. Gunpowder. Memorandum of delivery into the ship Clement of London 9 Sept. 36 Hen. VIII of 2½ lasts of fine corne powder, 4 lasts of coarse corne powder and 23½ lasts of serpentyn powder. (S. P. Henry VIII, sec. 192, f. 55.)

1544, 16th September. Camp before Monstrell. Norfolk, Russell and Cheyney to the Council. . . . Candische says that the 20 last of powder now received with all that was here already, will not last the ordinance here for four day’s battery, and therefore no more great pieces should be sent unless powder and bullets come with them. . . . (S. P. Henry VIII, sec. 192, f. 99.)

1544, October 16th. Calays. The Privy Council at Calais to Sir Ric. Southwell. Require him to pay Jas. Moyer master of the John Baptist of Lee, for freight of 270 barrels of gunpowder
from Andwerp to Boulloyn £14. (S. P. Henry VIII. Add. MS. 5,753, f. 28. British Museum.)

1544. 20th November. Andwerp. William Damesell to Sir Thomas Seymour. "A copy of a letter sent unto your mastership the 27. of the last month, whereof I have yet no answer." His letter dated Dover 11th inst. came to hand only this day showing that the powder to be provided from hence is to be sent to the Tower of London. Will do his utmost to accomplish this, when the seas are more clear of the French ships of war. Has only 730 more barrels of powder to receive upon his bargain. The money he received from Stephen Vaghan for another 1,000 barrels he was commanded by Norfolke, Suffolke, and others of the Council at Calleis the 6th inst. to pay to the Count of Buren here, in full contentation of his soldiers that have served against France. Has practised to see what further quantity may be had here, and learns from men who have factors in Ducheland and at Hambrough, Breme and Lubecke, from whence the saltpetre comes, that they can deliver 100 lasts in six months beginning the last of February as follows: on 28 Feb. 38 lasts, 15 April, 25 lasts, 31 May 25 lasts, and 30 June 12 lasts. If possible they will deliver 50 lasts more, but they will only be bound for the 100. Desires to know the King's pleasure whether to go through with this bargain and from whom to receive the money; for £2,000 is required in prest. If the King will have 50 or 60 lasts of saltpetre besides, Damesell will provide it some other way; for if these men knew it, they would not be bound for the 100 last, no, not if he offered "30 guilderns for every honderthe." Must answer these men within 14 days. Andwerpe 27. Oct.

Sent the above letter on the 27th ult. and sends the copy as he has had no answer to it. Has since laden 400 barrels of gunpowder and 300 hacquebutes to be delivered at the Tower of London, and has sent to the Council at Calais for wafters for it, which he expects in Zelonde to-day or to-morrow. Desires to
know if the King will have any further provision of gunpowder or saltpetre and that order may be taken for the payment of it. (S. P. Henry VIII, sec. 195, f. 148.)

1544, 3rd December. Bruxelles. Carne to the Council . . . Has obtained a passport for 60 lasts of powder and 1,000 hacquebutes, and sent it to Wm. Damesell at Andwerp . . . (S. P. Henry VIII, sec. 195, f. 190.)

1544, 9th December. Andwerp. Vaughan to the Council . . . The Scots make many voyages to Hamborough, where they have bought 20 lasts of gunpowder and make all their provision. It were "an easy thing to lighten them by the way, either coming or going." (S. P. Henry VIII, sec. 195, f. 204.)

1544, 15th December. Andwerp. Vaughan to the Council . . . Mr. Damesell is perplexed between two commissions from their Honors, one to buy gunpowder and the other to buy saltpetre and no gunpowder, because, upon his first commission, he had bargained for the powder. As it is not possible to provide any quantity of saltpetre from hence, Vaughan has counselled him not to depart from his bargain of the powder until sure of the saltpetre; for otherwise he should neither buy the same powder at the same price nor be trusted any more by the merchants he bought it from . . . (S. P. Henry VIII, sec. 196, f. 4.)

1545. Shrewsbury, Tunstall and Sadler to Henry VIII. Enclose a letter from Sir John Lowther, captain of Carlisle castle, showing the lack of powder, shot and munition there which "cannot be supplied in these parts." (S. P. Henry VIII, sec. 199, f. 192.)

1545, 5th January. Andwerp. Vaughan to Paget. . . . Wm. Damesell has great quantity of powder to be sent into England and abides to know whether wafters will be appointed for it. "It were time I promise you, that it were gone from hence; for the people murmur and grudge at the conveyance of so great a quantity from hence, themselves not knowing what need they may have; and what toy may fall in th' Emperor's head to stay or prohibit
the conveyance of powder hereafter, even when ye should much need it who can tell? (S. P. Henry VIII, sec. 197, f. 28.).

1545, 10th March. Bruxelles. Paget to Henry VIII. Scory came . . . to say that the Emperor would not deny license to send hence Henry's munition, provided that he was not himself dis- furnished of powder thereby, as he was like to be, since Damoy- sel demanded 100 last, a quantity not to be gotten in all this country. (S. P. Henry VIII, sec. 199, f. 3.)

1544(5), 14th March. Darneton. Shrewsbury, Tunstall, and Sadler to Henry VIII. . . . The Spaniards being all hacquebutiers, will consume much gunpowder, and there is here great lack of corn powder, matches and spears . . . all the Border holds are very slenderly furnished with powder. (S. P. Henry VIII, Add. MS. 32, 656, f. 203; British Museum, Hamilton Papers, II, No. 426.)

1545, 19th March. Andwarpe. William Damesell to Henry VIII. Has attended Mr. Secretary Paget, at Bruxels, by whose motion he is set at liberty and has passport to convey hence 1000 barrels of gunpowder provided for the King, and also 4000 pikes and certain hacquebutes. With these has, by Paget's advice freighted two ships of Andwerpe which will be ready to depart in five days. Begs that ships of war may be sent to the Zeland coast to waft them; for if the powder lie long laden it will be both dangerous and chargeable. This bargain, as he has advertised sundry of the Council and the Master of the Ordnance amounts to £12,000 sterling, of which he has only received £1,400. Begs that £4,000 or £5,000 more may be sent hither by Sir John Gresham or other, so that he may pay what is owing, most of which should have been paid long since. (S. P. Henry VIII, sec. 199, f. 63.)

1544(5), 25th March. William Damesell to Paget. . . . A French gentleman . . . intends to buy in Zeland a small pynke, wherein he will, with a dozen mariners, go into England (as if to serve
the King) in company with the hoys laden with gunpowder among which he will at sea "cast certain fireworks to destroy the ships." . . . I desire you, if it seem good and the time serves, to demand another passport, before your departure, for more powder. (S. P. Henry VIII, sec. 199, f. 95.)

1545, 4th April. Andwerpe. Wm. Damesell to Wriothesley and Petre. As the 1,000 barrels of powder and other the King’s munition could not conveniently be laden in two ships he freighted one more, and these three ships laden with powder . . . lie in Zeland in company with the King’s ships sent to conduct them, waiting for a fair wind. As the value amounts to £8,000 st. and could not be so secretly laden but that it is known both to Frenchmen and others, he doubts “that there is some ships of war appointed to lie in wait for these said ships,” and thinks two ships very few to waft so great a charge. Suggests that the Council might command other of the King’s ships in the Narrow seas to lie about Zeeland until these are passed out of danger. Concerning “the stay for the provision of any more powder” cannot conveniently do anything until these ships are gone, when he will, if possible, decline the receipt of any more. (S. P. Henry VIII, sec. 199, f. 186.)

1545, 20th April. Andwerp. William Damesell to Paget. As for the rest of the powder to be received, lately desired Paget’s favor that, after his faithful service herein, he might not now sustain any such “soyle or spott” to his rebuke; and desires to know the King’s answer. It will not be prejudicial to his Majesty to have store of it, the price being so reasonable that the Prince himself here cannot be served better cheap. (S. P. Henry VIII, sec. 200, f. 39.)

1545, 28th April. Andwerpe. William Damesell to Paget. Has by sundry letters desired Paget to learn the King’s pleasure concerning “a rest of powder” to be received here and also for £2,000 st. required to pay debts for powder and munition, for
which he is daily pressed. Requires the said £2,000 or rather £6,000 for payment both of what he owes and what he will receive, so that he need not trouble the King further. . . .
(S. P. Henry VIII, sec. 200, f. 103.)

1545, (May ?). The Isle of Wight. "Munitions assigned and appointed by the King's Majesty to be delivered out of his Highness's store within the Tower of London, to the hands and charge of Richard Woorsley, captain of the Isle of Wight, for the more strength and better furniture of the said Isle" viz. bows, 100, sheaves of arrows 200, bowstrings "aftre the rate" bills 200, pikes 200, hagbuttes furnished 60, cornpowder for the same 4 half barrels, serpentyne powder half a last. (S. P. Henry VIII, sec. 212, f. 185.)

1545, 18th June. The Privy Council. Meeting at Greenwich. Warrant to the Master of the Ordnance for delivery of 3,000 lbs. of old saltpetre to Mr. Bowes and Mr. Knight vice treasurers of the Tower. (S. P. Henry VIII, Dasent's A. P. C. 196.)

1545, 2nd July. London. Van der Delft to Mary of Hungary. The King is indescribably annoyed at the refusal of a trifle like the license to export from Antwerp the powder he has bought. To gratify him in this would have a great effect. (S. P. Henry VIII, Spanish Cal. viii, No. 84.)

(1545), 2nd July. Wormbs. Bucler and Mont to Henry VIII. He (the Emperor) yesterday despatched an officer to Argentine to buy all the gunpowder in those parts." . . . (S. P. Henry VIII, sec. 203, f. 46.)

1545, 4th August. Stephanus de Haschenpergk to Henry VIII. . . . Has invented . . . a way of making saltpetre, otherwise called black vitriol, in one place without going about the realm searching for it. . . . (S. P. Henry VIII, sec. 205, f. 70.)

(1545) 18th August. Lyncoln Place. Corn powder for the North. Warrant by the Council in London to the treasurer and chamberlains of the Exchequer, to pay Michell Mathewe servant of
Sir Ant. Knevett, lieutenant of the Tower, £10 10s. for transporting certain corn powder to the Earl of Hertford. (S. P. Henry VIII, sec. 206, f. 17.)

1545, 19th August. Andwarpe. Chamberlain to Paget. This day on his return from Bruxelles with Pagets mares and wagon, and passport for them, a woman who serves in a house, where certain Frenchmen or French practisers lodge, came to him declaring that... Joseph Chevalier, John Oldrino and Michael van Rosendale, lodgers in the house where she dwells have hired three persons to offer service at Bolloigne as gunners or gunners' mates and there set fire to all the gunpowder when the French army shall be before the town. ... (S. P. Henry VIII, sec. 206, f. 39.)

(1545), 22nd August. Andwerp. Vaughan to Paget. ... Hear daily of the French King's practices, now to fire the gunpowder in Bulleyn and other towns, now to corrupt those in charge of the powder, and now to corrupt Italians and Spaniards to deceive the King. (S. P. Henry VIII, sec. 206, f. 194.)

1545, 27th August. Andwerpe. Wm. Damesell to Paget. According to your letter, I have travailed in the receipt of £22,000 sterling, and it may please you to thank the Bonnvise and Salvage, whose respondents here have taken great pains. This day we shall finish the receipt. Since my last letters to you I have despatched three hoys laden with 210 barrels of powder, and have news that they are arrived in London; so that now 454 barrels are safely there, and 146 remain to be despatched in two other hoys, "dum (?) iiiij' lasts of salt and iiiij' polder."¹ (S. P. Henry VIII, sec. 207, f. 24.)

1545, 3rd September. Andwerp. Wm. Damesell to Paget. Has this day laden the residue of the King's powder and munition in three sundry hoys which shall be full laden with other merchants' goods and ready to depart within two or three days, by

¹ The words are interlined, apparently in a different hand.
which time the writer will have finished all his business here. . . . (S. P. Henry VIII, sec. 207, f. 79.)

1545, 9th September. Andwerp. Vaughan to Henry VIII. . . . By gathering so great a heap of money, and buying up all the gunpowder in Almayn, and conveying artillery hither, he (Emperor) means "somewhat." . . . (S. P. Henry VIII, sec. 207, f. 115.)

(1545), 15th September. Franckforde. Bucler and Mont to Henry VIII. Riffenbergh bought at the fair here, 1,200 pikes, 3 centeniers of gunpowder and 600 harness, but could get no more. (S. P. Henry VIII, sec. 207, f. 199.)

1544, 6th October. Windsor. John Bowyer, senr. and John Bowyer, junior saltpetre makers. Fee of 6d. a day for life from the Anunciation of St. Mary last and from Easter last, respectively. (S. P. Henry VIII, Patent Rolls, 37 Henry VIII, pt. 16, mem. 10.)

1545, 10th October. Kilmaynam. St. Leger to the Council. Those (bows) sent out of England were so worm eaten that they would scant hold the bending, and the cornpowder such that it would only mar the guns, so that all last year we were driven to buy what we occupied. . . . (S. P. Ireland, Henry VIII, vol. xii, No. 22.)

(1545), 19th October. Andwerp. Vaughan to the Council. . . . The Commissaries write to him to send 10 barrels of corn powder to Mowns in Henault, as there is none in all the army. Will send it away this day. . . . (S. P. Henry VIII, sec. 209, f. 69.)

1545, 22nd October. Florines. Fane and Chamberlain to the Council. Showed Riffenbergh he that this protracting of time might be suspected to be a practice of the enemy, and had consumed the money, albeit that they looked for more by Mr. Averie "laying" to him his negligence in saying nothing about victuals or the lack of powder until now at the enemy's doors. His excuse is that he was led out of the way and that everywhere he sought
for provision but could not get it. Lying here these three days, they have, through a gentleman sent by the Cp. of Liege, got six barrels of powder; and Riffenberghe has six more from Andwarpe. . . . (S. P. Henry VIII, sec. 209, f. 94.)

1545, 29th December. The Privy Council. Warrant to Sir Thos. Seymour to deliver to Edm. Modie 2 barrels of corn powder, and . . . last of serpentine powder for "the shot of the ordnance at Arclif Bulwerk and the basilisco there." (S. P. Henry VIII. Dasent's A. P. C., 300.)

1550, 19th September. A warrant to deliver £180 to Hance Lange, merchant stranger for 3 lasts of Serpentyne powder at £60 the last. (Acts of the Privy Council, Cal. iii, 127.)

1550, 5th November, and 1552, 2nd April. References to fine salt-petre of Naples. (Acts of the Privy Council, Cal. iii, 153, and Cal. iv, 11.)

1551, 13th March. A letter to Sir Francis Fleming and Anthony Anthony to receive into the tower such powder as Mr. Yorke shall deliver them and to bestow it well. (Acts of the Privy Council, Cal. iii, 235.)

1551, 6th April. Letter to William Dansell (the English agent in Flanders)—he is removed from his office for his slackness—but he is to receive and pass certain powder into his warehouse. (Acts of the Privy Council, Cal. iii, 252.)

1552, 3rd August. The Tower. Sir P. Hoby to Cecil. Miseries in the office of ordnance for want of money, particularly in the case of Ch. Wolman, the gunpowder maker. (S. P. Dom. Edward VI, vol. xiv, No. 56.)

1552, 7th August. Letter to William Dansell—he is to confer with Sir Thomas Chamberlayn (the King's Ambassador to the Regent) as to the disposal of the King's gunpowder in Flanders. (Acts of the Privy Council, Cal. iv, 108.)

1552, 16th October. Letter to Mr. Dansell. He is to deliver to Ranff Chamberlain the King's powder remaining in his hands
for transport to England. (Acts of the Privy Council, Cal. iv, 144.)

1554, 27th March. Thomas Gresham to be instructed to purchase in Flanders "salte petre in roche and 20 laste of well chosen serpentyne poulder." (Acts of the Privy Council, Cal. v, 3 and 4.)

1554-1555, February. Henry Reve is said to have erected a gunpowder mill upon a parcel of pasture ground called "The Crenge" in Rotherhithe, which had formerly belonged to the Abbey of Bermondsey, and to which Reve was alleged to have no just title. He was accused, too, of having weakened the banks against the mill by reason of the great abundance of water which came in at the flood gates and sluices made for it, etc. (Court of Requests, Proc. Phil. and Mary, Bundle 24, No. 119.)

1556, 23rd November. Letter to Gresham to send over gonnepoulder. (Acts of the Privy Council, Cal. vi, 22.)

1558, 18th April. Letter to Gresham. Thanking him for his diligence in providing saltpetre. (Acts of the Privy Council, Cal. vi, 306.)

1558, 12th December. Sir Richard Southwell to Sir William Cecill. Is busy with the offers of serving the Queen with saltpetre; he will make his report next day. (S. P. Dom. Elizabeth, vol. i, 30.)

Memorial of the supply of saltpetre, powder, etc., remaining in store, and of the quantities required from abroad. (S. P. Dom. Elizabeth, vol. i, 31.)

1559. The Powder Makers to the Privy Council. They state the prices at which they can undertake to supply Her Majesty with gunpowder. (S. P. Dom. Elizabeth, vol. viii, 12.)

Note of a tender for the supply of gunpowder, by a manufacturer. (S. P. Dom. Elizabeth, vol. viii, 13.)

(1560.) Suit of the town of Plymouth shewing that they have to maintain the fort on St. Nicholas' Island, with 8 pieces of great ordnance, receiving only £20 worth of gunpowder etc. yearly, whereas (by grant of Henry VIII) they used always to have
1560, 18th April. Gresham writing to Cecil. “Sir, I wrote you in my last of the great scarssite of powdvr that ys here to be hade. The Quene’s Majestie should do well to macke out of hande, iij or vi mylles for the macking of powdvr for the servize of her Highness’ turne, if the warres contynew, or this breach of amytie should channce betwixt her Majestie and King Philipe.”

(S. P. Foreign, Elizabeth, vol. xiii under date.)

1560, 16th June. Survey of Gunpowder in the Tower, etc. (Hist. MSS. Comm. MSS. of the Marquis of Salisbury, rep. 4, p. 205.)

1560, 4th October. Particulars of sundry parcels of powder, saltpetre and match received into the office of Ordnance within the Tower, for the queen’s service, from 24th July. (S. P. Dom. Elizabeth, vol. xiv, 3.)

Sir William Cecill to Lord Ambrose Duddeley. To furnish certain strangers, at the request of Sir T. Gresham, with a quantity of sulphur, at an advanced price, to finish a certain amount of gunpowder. (S. P. Dom. Elizabeth, vol. xiv, 4.)

1561 (about). Gunpowder Mills at Long Ditton by George Evelyn, grandfather of Sir John. Also mills at Leigh Place, near Godstone. Mills at Faversham existed at the same time. (Hart, loc. cit.)

There is also a lease in the reign of Elizabeth for a gunpowder mill and a great pond at Rotherhithe in the occupation of Francis Lea, but late in the tenure of Thomas Lee, deceased (see 1563, 23rd January.) (Lee was in later documents referred to as Lea, a Lee, and Leigh.)

1561, March. Tender (by Marco Antonio) for supplying the Queen with, amongst other things, brimstone and saltpetre of Naples. (S. P. Dom. Elizabeth, vol. xvi, 32. Acts 33-34 relate to same tender.)
Remarks by William Bromefield on the above tender, and on the prices demanded. (S. P. Dom. Elizabeth, vol. xvi, 35.)

1561, 2nd March. John Thomworth, of Waltham, is in treaty, on behalf of Queen Elizabeth, for the purchase of saltpetre, sulphur, and bow staves for barrels. Saltpetre was offered to him at £3 10s. 0d. per cwt., which he declares to be too dear. (S. P. Foreign Series, under date.)


Statement of the true and perfect art of making saltpetre grow in cellars, barns, etc., or in lime and stone quarries. (S. P. Dom. Elizabeth, vol. xvi, 29. Printed in "Engineer.")

Articles of agreement between the Queen and Gerard Honrick, a German captain, who understands the making of saltpetre. (S. P. Dom. Elizabeth, vol. xvi, 30. Duplicate, Ibid., 31.)

1561, 15th March. William Bromefield to Sir William Cecill. Advises him to conclude a bargain with Mark Antonio, for a certain quantity of saltpetre and bow-staves at reduced prices. (Ibid., 36.)

Particulars of prices at which Mark Antonio has finally agreed to deliver certain quantities of bow-staves, brimstone, and saltpetre. (Ibid., 37.)

1561, 10th August. Queen Elizabeth gave her bargain with Gerard Honrick to Philip Cockeram and John Barnes. ("Engineering," loc. cit.)

1562, 26th February. The Marquis of Winchester to Sir William Cecill. A scheme has been presented to himself and the Lieutenant of the Ordnance for making gunpowder. Encloses—Tender of three gunpowder makers, who had erected five new
powder mills (Bryan Hogge, Robert Thomas, and Francis a Lee) for supply of gunpowder for the Queen’s service. (S. P. Dom. Elizabeth, vol. xxi, 561.)

Lee is in 1578 described as of Rotherhithe (Redriff), and was still gunpowder maker to the Queen. It is possible he then owned the mill which Reve had set up some time before 1555. (S. P. Dom. Elizabeth, vol. cxxiv, 8. See also 1563, 23rd June.)

1562, 25th August. An original royal licence to John Mangleman, a German, and Gerebrand Floris, for finding out earth proper for making brimstone. (Lansd. MSS., No. 5, Art. 64.)

1563, 23rd June. Particulars for a lease for 21 years to Francis Lee of one tenement and mill, with the buildings thereto adjacent, called the “gonpowder myll” together with the wharf opposite the said tenement (100 feet by 42 feet) together with a large pond called “the Gonpowder myll ponde,” and a watercourse leading therefrom to the mill, late in the tenure of Thomas Lee deceased, and now of Francis Lee, his son, lying on the East of the town of Rotherhithe, near the Thames there, and newly built by the said Thomas, at his own cost, upon an empty pightell of land there, enclosed with a ditch, containing ½ acre of waste land.

The premises have been occupied by the said Lees, and by William, brother of Francis, for 20 years, for “the only use of making gunpowder.” Francis Lee has produced “writing” under the signet of Henry VIII signed by the King dated 19th March and supposed to be in the 27th year of his reign erected to the Bishop of St. Asaph, then Abbot of Bermondsey, requiring him to make out a lease of the premises to the said Thomas Lee, then servant to His Majesty, which lease the said Abbot never made, nevertheless the said Thomas Lee, upon the King’s direction builded up the premises at a cost of £200, and since his death his sons expended about £40 in the repair of the same, especially about the wharf.
The art of making gunpowder is so casual and dangerous, and the land otherwise valueless, so petitioner begs, etc. etc.

(Augmentation Office: Particulars for Leases (Surrey) Roll 139, No. 23).


1566, 12th November. Patent for Francis Lee, gunpowder maker, to have the office of one of the 4 master gunners in the Tower of London, lately occupied by Christopher Gold, deceased, with a fee of 12d. a day. (Exchequer of Receipt, Auditors' Patent Book, ix, fol. 140.)

1567, 27th July. Clough writing to Gresham. Upon Wednesday past was proclaimed here, that no man, uppon payne of (loss of) lyfe and goods, shall either make or sell any powder,—neither here, nor in no part of thys country, saving at Macklyn, in the King's mills, (where) all the powder (is) to be made. And for that every honnest man should have powder to journey withal, there shulde be appointed one or two in every town to sell powder; and these to come to Macklyn for the powder, by 1,000 li. weight, or 2,000 li. at the most; and to wryte up all their names that the powder is solde unto, and when they do fetch new, to bring the names of them that the olde was sold unto. So that, from henceforth, there shall no powder be made here to be sold; so that they were wont to live by making of powder are now undone. Wishing that and if they would come into Englande they might have a place appointed to make powdyr and lysence to sell the same to all men that cometh! Which if they had, I wolde not doubt but they wolde go into Englande; and where they go, the great quantity of saltpeter and brymstone wyll follow. For that and if they do bring it here, they
must sell to the Court at such a price as they will; which the merchants cannot away withal. (S. P. Foreign, Elizabeth, vol. xcii, under date.)

(1569), 19th June. Articles to be considered by the commissioners of musters. 1½ lb. of lead will make 30 bullets for a calliver, and 1 lb. of powder will serve for 30 times shooting, ... powder at 9d. per lb. (S. P. Dom. Addenda Elizabeth, vol. xiv, No. 83.)

1572. Some dealers in brimstone to the Lords of the Treasury are contracting with the (Keswick?) copper mines to extract brimstone from their copper, etc. (Lansd. MSS., No. 14, Art. 13.)

1572, May. A Certificate of how the last supply of corn and serpentine powder brought into the North parts was spent, and by whose warrants, since the 28th of November, 1568. Corn powder, 11 lasts, 620 lb.; serpentine powder, 11 lasts, 1,620 lb. (Hist. MSS. Comm. Cecil MSS., pt. ii. p. 18.)

1574, 1st May. Note of corn powder bought of Henry Dale, haberdasher, with the prices of the same. (S. P. Dom. Elizabeth, vol. xcv, 84.)

1575 (?) Note of the money that may be saved by the purchase of powder, saltpetre, and other ordnance stores abroad. (S. P. Dom. Elizabeth, vol. cvi, 41.)

1575. Petition of Francis Leigh, gunpowder maker to the Council. No powder being made in England, provision has to be made in foreign parts, which in the Duke of Alva's time was stayed. Petitioner then made 100 lasts with saltpetre gathered in this realm, and sold it for 8d. and 9d. a pound, by which on the whole £4,000 was saved; but the Queen prefers paying £10 a last more to having her subjects houses digged for saltpetre. Yet the powder sent over often spoils, through not being made of refined saltpetre. The redress would be to send for saltpetre from beyond sea, of which powder could be made as required, thus avoiding such mishaps as happened at Malines and Venice, by the firing of powder. It would not waste if sent with skill.
Requests a licence to import 20 or 30 lasts of saltpetre yearly, and have the making of the powder, in recompense of the former saving of him of £4,000, because he and his father and brother have been for 50 years the greatest dealers therein, and he has all the implements which will otherwise be useless. (S. P. Dom. Elizabeth, Addenda, vol. xxiv, No. 50.)

1576. William Herlle's account of a grant for 20 years to one Buckholt for making sulphur. (Lansd. MSS., No. 22, Art. 21. See also Ibid., Art. 20, 23-28, 30. For Wade and Herlle's patent, see Hulme, "Law Quarterly Review," April, 1896.)

1576, February. Proposed bill in Parliament for confirming a patent to John Bovyat, of London, of the making of saltpetre and gunpowder of stone, mineral, and other substances not now used therein, instead of earth and mudwall, the same being without moisture and not furring ordnance. (S. P. Dom. Elizabeth, Addenda, vol. xxiv, No. 68.)


1577, 19th August. Sir Francis Walsyngham to Lord Burghley. Has nominated Christopher Huddesdon to receive the £20,000 appointed by Her Majesty for the purchase of gunpowder and saltpetre. (S. P. Dom. Elizabeth, vol. cxv, 7.)

1577, 20th August. Warrants for the payment and employment of the sum of £20,000 to the person nominated by Mr. Walsyngham for the purchase of gunpowder and saltpetre. (S. P. Dom. Elizabeth, vol. cxv, 8.)

1578, 24th March. Warrant under the Privy Signet for the transport- ation to Portugal of forty quintals of gunpowder at the request of the Ambassador of the King of Portugal. (Hist. MSS. Comm. Cecil MSS., pt. ii, p. 174.)

1578, 3rd April. Warrant under the Privy Signet to the Marquis of Haurech for the transportation of gunpowder and bullets of iron. (Hist. MSS. Comm. Cecil MSS. pt. ii, p. 175.)
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1578, 6th May. Licence for Portuguese Ambassadors to transport 1,000 weight of gunpowder. (Hist. MSS. Comm. MSS. of the Marquis of Salisbury, rep. 4, p. 217.)

1578, 15th May. Examination of Francis Lee of Redreff, gunpowder maker to the Queen, relative to the debts owing to him by Mr. Henry Howard. (S. P. Dom. Elizabeth, vol. cxxiv, No. 8.)


1580, 19th February. A letter to Barnard Randall, Thomas Gardner, and the Connestable in reference to the patent for glass granted to Jacomo Vertolini—"Complaint is made unto their Lordships by the said Jacomo that one Sebastian Orlandini and one John Smithe have verie lately sett up a furnace at the gopowder mille by Ratcliffe, intending to make glasses." They are, therefore, "to repeire unto the said gopowder mylle" and destroy the furnace. (Acts of the Privy Council, xii, 337.)

1581, January. Petition of John Bovyat to the Queen, praying that his grant for the making of saltpetre and gunpowder may be confirmed by Act of this present Parliament. (S. P. Dom. Elizabeth, vol. cxxvi, No. 42.)

1581, 11th February. Note of powder received from Christopher Hudson and others into the office of Ordnance. (S. P. Dom. Elizabeth, vol. clxvii, No. 50.)


1582, 9th August. Warrant for exporting ordnance, etc., with annexed List including 48 hundred of powder. (Hist. MSS. Comm. Cecil MSS., pt. ii, p. 514.)

1583, 10th June. Henry Pope to Sir Francis Walsyngham. Reports
the success of experiments tried at Fulstone for the manufacture of saltpetre from a mineral substance found in the cliff. Hopes to make a ton of saltpetre by Midsummer. (S. P. Dom. Elizabeth, vol. clxi, No. 11.)

1584 (?) Brief notes of a project for the making of brimstone out of certain stones found in the coasts of the Isle of Sheppey, Whitstable and parts adjacent. (S. P. Dom. Elizabeth, vol. clxvii, No. 56.)

1585, 26th June. Note of powder and saltpetre remaining on hand in the City of London. (S. P. Dom. Elizabeth, vol. clxxix, No. 40.)

1585, 26th June. Warrant under the Privy Signet for the transportation of Gunpowder. Greenwich. (Hist. MSS. Comm. Cecil MSS., pt. iii, p. 100.)

1585, October. Petition of Henry Dale and William Hall to the Council. They state that they had laid in a great store of powder according to their Lordship's directions. They desire that letters may be sent to the several towns and shires commanding them to provide their powder of them. (S. P. Dom. Elizabeth, vol. clxxxiii, No. 78.)


1586. Articles to be considered of and answered to Henry Dale, as to the provision of powder from abroad, with a staple to be made in certain towns for supply of the adjacent counties. (S. P. Dom. Elizabeth, vol. cxxv, No. 112.)

1586, 6th March. Sir Owyn Hopton to the Council asks that Mr. Henry Dale may be commanded to remove his storehouse of powder, wherein is 40 lasts of powder, to some other place of less danger, because the house stands on Tower Hill, where rogues and vagabonds oftentimes lodge in the night and burn straw to warm themselves. (S. P. Dom. Elizabeth, vol. clxxxvii, No. 19.)
1586, 22nd March. “Paide, the same day to Henry Webster for towne poundes gun pouther to kylle hawkes meat, ijs., vjd.” (Hist. MSS. Comm. MSS. of the Duke of Rutland at Belvoir Castle, vol. iv, p. 392.)

1587, December. Note of such proportions of powder and match as are to be made by the Cinque ports and corporate towns in various counties, and which have made provision accordingly. (S. P. Dom. Elizabeth, vol. ccvi, No. 63.)

1588, 14th January. Certain persons petition for charter to search for saltpetre, and offer to supply powder at 8d. per lb. (British Museum, Lansd. MSS. 58, Art. 63.)

1588, 25th January and 1589, 28th January. George Evelyn, Richard Hills (? Willes) and John Evelyn obtained licences for 11 years to dig for saltpetre and make gunpowder. (Letters Patent in Patent Office, the latter date in Patent Roll 31, Elizabeth, pt. viii, mem. 10.)


1588, September. Petition of Henry Dale to Sir Francis Walsyngham. Offers to provide a sufficient supply of powder for Her Majesty’s service, and desires that no other factor may be appointed. (S. P. Dom. Elizabeth, vol. ccxvi, No. 71.)

1588, 20th October. Christopher Coult at Elbing to Lord Burghley, states that he is an Englishman, and a traveller for 22 years in divers countries, and has seen many things worth learning; but the grossness of his capacity is such that, out of all, he has learned the smallest and least worthy of commendation, which is for a perfect way to find out saltpetre, and the making of powder,
both good and profitable; and as in this time of trouble there has been want of powder, or it has been at most unreasonable rates, he has wondered thereat, considering the climate of our country, the situation of our ancient buildings, and so many of these prowling fellows, who have her Majesty's commission, but rather take bribes than seek to serve their Prince and Country, or else most of them are ignorant in that profession.

As he knows Lord Burghley to be a father to our country, a husband to Her Majesty's affairs, and a continual carer for the Commonwealth he writes that for the service he owes to his Prince and Country, he would have come over, but having married a gentleman's daughter of good calling, and being in a powder mill, with freedom to seek and sell saltpetre, he has £300 or £400 a year so that he cannot so lightly alter his being. Notwithstanding, to pleasure his country upon good grounds of promised maintenance by Her Majesty or Lord Burghley, as his deserts shall merit, he will show the way to find out more Saltpetre and powder than all England shall need, and at reasonable rates, or lose his life. (S. P. Dom. Elizabeth, Addenda, vol. xxx, No. 112.)

1588, 3rd December. Survey of the powder and saltpetre in the Tower and in London. Quantities of saltpetre to be delivered to Evelyn and Hill, the gunpowder makers, to perform their bargain. (S. P. Dom. Elizabeth, vol. ccxix, No. 7.)

1589, 28th January. Patent for George Evelyn, Richard Hills, and John Evelyn to dig, open and work for "saltepeeter" anywhere in the queen's dominions, or crown lands, or the land of any subject (except in the City of London, and 2 miles distant from the walls thereof, and in the counties of York, Northumberland, Westmoreland, Cumberland, and the Bishopric of Durham) and the same saltepeeter to try out and make into powder for the queen's provision, for eleven years to come. They to restore any buildings, etc., taken down for the purpose, as they were before.
This commission to make void all such commissions theretofore granted. (Patent Roll, 31 Elizabeth, pt. 8, mem. 10 (25).)

1589, March. A discourse touching Russia and Persia, and how they may be traded; experienced men to be sent out to establish trade and learn the manufacture of saltpetre. (S. P. Dom. Elizabeth, vol. ccxxiii, No. 52.)

1589, 26th April. George Constable, Esq. obtains licence to dig for saltpetre and make gunpowder in York, Nottingham, etc. for 11 years. (Patent Roll, 31 Elizabeth, pt. xv, mem. 10.)

1589, 9th May. Sir Robert Constable to Lord Burghley. Information of powder newly arrived from Stoad. Desires that it may be taken up for her Majesty’s service. (S. P. Dom. Elizabeth, vol. ccxxiv, No. 28.)

Encloses—Note of such powder as is at present in London, and what is expected to come by the next voyage from Hamborough. (Ibid., No. 28, 1.)

1589, June. Petition of Thomas and Robert Robynson to Lord Burghley. For grant of the privilege of making saltpetre within the City of London, offering to supply 20,000lbs. weight yearly without troubling her Majesty’s subjects for the same. (S. P. Dom. Elizabeth, vol. ccxxiv, No. 114.)

1589, June. Note of powder brought from abroad into H.M.’s store in the office of ordnance in May and June, at 12d. per lb. (S. P. Dom. Elizabeth, vol. ccxxiv, 110½.)

1589, July. Note of all saltpetre delivered into the Tower by George Shepard and Josias Pett, saltpetre men. (S. P. Dom. Elizabeth, vol. ccxxv, No. 46.)

1589, July. Petition of John Grange to Lord Burghley. Had been bereaved of his employment of making of saltpetre within the City of London by Ralph Hockenhull who for his own gains had employed unskilful persons to carry on the work. Requests a grant of the working of saltpetre in London for eleven years. (S. P. Dom. Elizabeth, vol. ccxxv, No. 47.)
1589, 21st July. Note of such powder, arms and munition as Randall Symmes offers to furnish upon twelve days' warning. (S. P. Dom. Elizabeth, vol. ccxxv, No. 45.)

1589, 7th August. Articles objected by John Grange against Ralph Hockenhull for abuses in the manufacture and supply of saltpetre within the City of London, under a deputation from the Earl of Warwick granted to one George Sheppard. Grange's offer to supply the Queen's stores with 20,000 lbs. weight of saltpetre yearly. (S. P. Dom. Elizabeth, vol. ccxxv, No. 55.)

Reasons stated by John Grange for maintenance of his late petition delivered to Lord Burghley against Ralph Hockenhull for abuses in the making and sale of saltpetre. (Ibid., No. 56.)

Further complaints of John Grange against Ralph Hockenhull for preventing him in the exercise of his letter of deputation for the making of saltpetre, and placing therein his servant George Sheppard, the said petre to be delivered to Mr. George Evelyn for the making of gunpowder. (Ibid., No. 57.)

1589, 10th August. Ralph Hockenhull to Lord Burghley. Thanks for sending him the articles preferred against him touching the supply of powder and saltpetre. Requests a strict examination of the matter. (S. P. Dom. Elizabeth, vol. ccxxv, No. 61.)

1589, 13th September. Ralph Hockenhull to Lord Burghley. In answer to the accusations of Mr. Grange. It is no small grief to him that he ever came in question with so bad and busy a fellow. Only desires to live in his Lordship's good opinion. (S. P. Dom. Elizabeth, vol. ccxxvi, No. 31.)

Encloses—His answers to the accusations of John Grange. (Ibid., 31, 1.)

1589, 1st October. Note of the powder remaining in Her Majesty's storehouses. (S. P. Dom. Elizabeth, vol. ccxxvii, No. 2.)

1589, 1st October. Amount of the quantities and prices of the saltpetre brought into the Tower since the last composition; and the
names of the saltpetre men supplying the same. (S. P. Dom. Elizabeth, vol. ccxxvii, No. 3.)

1589, 1st October. Bond of Thomas and Robert Robynson, wherein they stand bound to deliver annually 20 thousand weight of saltpetre to John Evelyn, for the working of saltpetre within the City of London to be converted into gunpowder. (S. P. Dom. Elizabeth, vol. ccxxvii, No. 4.)


1589, 17th December. Indenture between Richard Hill, George Constable, and John Grange, saltpetre and gunpowder makers of the one part, and George Hogge of the other part, granting to the said Hogge an annuity of £30 for the term of eleven years, according to the patent granted to George Evelyn, Richard Hill, and John Evelyn for the getting, working and making of saltpetre. (S. P. Dom. Elizabeth, vol. ccxxix, No. 33.)

1590, 2nd January. The Council to Lord Burghley, Lord Lieutenant of Lincolnshire. General directions for putting in readiness the forces of the shire. . . . Provisions of shot, powder and match. Adulteration of powder, by putting shot into it to increase the weight.

Inclosing . . . Proportion of match and powder to be supplied for the town of Boston and city of Lincoln. (S. P. Dom. Elizabeth, vol. ccxxx, No. 1.)

1590, 8th January. Thomas Robinson and Robert Robinson licence for 10 years to dig for saltpetre in London and Westminster. (Patent Roll, 32 Elizabeth, pt. 20, mem. 31.)

1591. Giles de Vischer, merchant stranger, to the Council. Complains, among other things that he lost £1,100 by delivering 40 lasts of saltpetre to the Tower. (S. P. Dom. Elizabeth, vol. ccxl, No. 134.)

1591, 24th June. Estimate of the shot of the great ordnance. A
bastard cannon shoots 20 lbs. at a shot, for 5000 shots will require 40 lasts and 200 lbs. of powder. A demi-cannon, 18 lbs., for 5000 shots requires 37 lasts, 160 lbs. of powder. A whole cannon, 27 lbs., which for a last of powder will be only 85 shots, and for 5000 shots about 55 lasts. (Calculation not quite correct). (S. P. Dom. Elizabeth, vol. ccxxxix, No. 55.)

(1592.) Note that one company of 150 foot spends 80 lbs. of powder every 6 weeks, or 640 a year, so that 3 lasts, of 2400 lbs. each, will serve 10 companies for one year, with an overplus of one cwt. That 4 lasts have been sent out of the Tower since June 1590, and 2 have been provided by Christopher Keysell. (S. P. Dom. Elizabeth, vol. ccxliii, No. 109.)

1592, 16th February. Attested statement by J. Grange that he, George Constable and Richard Hill were partners in making saltpetre and gunpowder, and agreed to pay Mr. Hogg £30 yearly to keep, as clerk of the deliveries, a true account of saltpetre, delivered out or brought into the Tower by them, and to see that Mr. Hill had his just third of what was delivered, to save him £200 which he was to have made before the partnership. Relinquished the partnership, and the bond was then cancelled, but Constable and Hill made a new one; has heard that it was only on the above conditions. (S. P. Dom. Elizabeth, vol. ccxli, No. 48.)

1592, October. Reynold Hoxton obtains a patent for making powder- and shot flasks. (Patent in Patent Office under date.)

1595. Statement that the saltpetre men, if they may have a commission as liberal as Mr. Evelyn, will give a penny a pound for 21 years, so that if 300 lasts be made yearly there will be a gain of £3,000; and will get their saltpetre for 5 or 6 years from Wales, without troubling the subject. The gunpowder men offer two pence a pound, and to provide the Queen 80 lasts of powder at 8d. a pound, and 80 lasts at 7½d. (S. P. Dom. Elizabeth vol. cclv, No. 63.)
1575(?). Should be 1595. Grant to John Bovyat of the exclusive privilege of manufacturing saltpetre and gunpowder of stone minerals for 21 years. (S. P. Dom. Elizabeth, cvi, 53.)

(For the petition of the above individual to the Privy Council, see Lansd. MSS. 80, Art. 35.)

1595. A warrant to pay Symyon Turner of London, Merchant £1,481 11s. od. for certeine fine corne powder. 12 lasts 831 pounds at xiiid. the pound. (Acts of Privy Council, xxv, p. 137.)

1594-5, 21st March. Ottywell Smyth to the Earl of Essex. At my being in Paris I did desire the King some good assignation for the money due unto me and to other merchants of London, for apparelling sundry times of the Swisses, and furnishing the King with powder this six years, to the sum of £9,715. . . . Dieppe. (Hist. MSS. Comm. Cecil MSS., pt. 5, pp. 150-51.)

1595, 30th July. The Lords of the Council to Lord Burghley, Lord Treasurer, and Lieutenant of the County of Essex. . . . "Where likewise there was of late years a proportion of powder, match and bullet appointed to be kept in divers places within that county, we pray you to cause the same to be reviewed what doth remain of the store, and if serviceable; and for such quantity as is spent, you may, by some reasonable contribution of that county, cause the same to be supplied, for which purpose we will give direction that out of her Majesty's store such quantity as you shall send for shall be delivered at such prices as her Majesty doth pay and allow. . . . From the Court at Greenwich." (Hist. MSS. Comm. Cecil MSS., pt. v, pp. 295-6.)

1595, 14th November. "Memorial of sundry things to be considered and ordered for Her Majesty's service and the realm." Amongst other things, the following: To conclude bargains for 120 lasts of powder and some saltpetre from beyond seas in which Engelstedt's offer to have 4 in the 100 is to be remem-
bered; since then he has offered to make the provision upon his own charges, to be paid upon his accounts, but this is uncertain and he has not set down the price.

Turner and another merchant offer to deliver the quantity in London, at 12d. the pound for powder and 13d. for petre, on condition that if it is allowed by the office, it be received and payment made accordingly; but if refused, that they shall be at liberty to sell it in the realm; toward the bargains they require an imprest of £3,000. (S. P. Dom. Elizabeth, vol ccliv, No. 64.)

1596 (February). Statement by Sir John Peyton as to the prepared Spanish invasion of England. In England every musketeer should be supplied with 10 lbs. of powder, every arquebuser with 6 lbs. and bullets and matches proportionable. (S. P. Dom. Elizabeth, vol. cclvi, No. 70.)

1596, 22nd April. A proportion of munition to be supplied to a town not mentioned, but most probably Calais. Among other items: 3,000 lbs. corn powder at 1s. per lb. (S. P. Dom. Elizabeth, vol. cclvi, No. 39.)

1596, 15th May. The Robinsons assign their rights to Robert Evelyn.

1597, 28th April. Sir George Carew, and four other ordnance officers, to the Master of Requests. States that a suit is depending before them between the bearer Robert Robinson and Thomas Aldworth, is to be heard this next term. There is great need of Robinson's service for making saltpetre, to be used by Mr. Evelyn for making gunpowder, which cannot be so conveniently done as in summer, and if he is forced to attend about that suit, his endeavours will be much hindered. They pray that it may be deferred till Michaelmas term. (S. P. Dom. Elizabeth, Addenda, vol. xxxiii, No. 80.)

1597-8. . . . Paid more for the carriage of gunpowder, matche, and some parte of the armor from Hartland to South Tavistocke, when the soldiers went firste to Plymmouthe iis. vid. (Hist.
MSS. Comm. Parish Documents of Hartland, N. Devon, rep. 5, p. 573.)

1598, January. "The proportion of powder for the furnishing of her Majesty's ships in this last voyage, 1597."

The charge of powder, 53 lasts 6 cwt., the waste 28 lasts 17 cwt.; the remain 24 lasts, 13 cwt. (Hist. MSS. Comm. Cecil MSS., pt. viii, p. 34.)

1598-9. Account of Thomas Screvin. (Disbursement made in France by Ed. Yate.) "Item for powder & bullets to say (i.e. assay, test) the armour, & in reward for the armourer's men, xjs. vjd." (Hist. MSS. Comm. MSS. of the Duke of Rutland at Belvoir Castle, vol. iv, p. 416.)

1599. Certain reasons to move her Majesty to sign the books for the making of saltpetre and gunpowder. Refers to a new patent which has been drawn in accordance with her Majesty's pleasure, and is ready for her to sign. It was yielded, upon the motion of the Council, that 20 lasts of powder should be delivered monthly for her Majesty's service, upon hope that the book should be presently signed, it being so signified by Sir George Carew; and the difficulties are detailed of keeping up this supply, as well as the supply for her Majesty's subjects, without the new patent; the principal one being that many more new furnaces must be set up at a large cost, which cannot be recouped under the short term now to run of the old patent. (Hist. MSS. Comm. Cecil MSS., pt. ix, p. 429.)

1599. Manufacture of saltpetre and gunpowder. (Hist. MSS. Comm. MSS. of the Marquis of Salisbury, rep. 6, p. 262a.)


17th and 21st January. "John Hebbe for mache and three pound of gonpoulder for the ryder to trayne the greate horses, iiijs. ijd."

28th October. "For one pound of gonpoulder used by
them, that went to London with mony, xvjd.” (Hist. MSS. Comm. MSS. of the Duke of Rutland at Belvoir Castle, vol. iv, p. 426.)

1599. Cancellation of indenture between the queen and John Evelyn and Richard Hardinge, esquires and others. This indenture together with the letters patent therein mentioned were cancelled because John Evelyn, Richard Harding and Robert Evelyn, having acquired the interest of their former colleagues Simeon Furner and John Wrenham on 18th October, 2 James I surrendered the same. (Patent Roll, 41 Elizabeth, pt. 4, mem. 12.)

1599, 6th August. The Privy Council to Sir George Carew. Request to deliver such saltpetre as is at this present remaining in store to John and Robert Eveling, for converting it into gunpowder. Also instruction to make some bargain and agreement with them “to new make... that it may be serviceable... great quantity of gunpowder in her Majesty’s Store that is decayed and unserviceable.” (Hist. MSS. Comm. F. J. Saville Foljambe MSS., rep. 15, App., pt. v, p. 88.)

1599, 25th August. Robert Evelyn, also George Evelyn, John Evelyn and Richard Hills surrender their licences to the Queen. (Close Roll, 41 Elizabeth, pt. 29.)

1599, 7th September. Patent to make saltpetre and gunpowder for 10 years to John Evelyn, Richard Hardinge, Robert Evelyn, John Wrenham, and Symeon Turner. They also covenant to supply yearly 100 lasts of powder at 7d. per lb. (Patent Roll, 41 Elizabeth, pt. iv, mem. 8.)

1600. Note of powder and saltpetre required to remain in store, of that which now remains, and of that to be supplied, the cost of which will be £12,870, £3,000 to be allowed from the ordnance and £9,870 by privy seal; with note of £1,000 worth of salt-petre in store still unpaid for. (S. P. Dom. Elizabeth, vol. cclxxvi, No. 53.)
1600. September. A remembrance of certain benefits to Her Majesty and her subjects, by making saltpetre and gunpowder within this realm:

Firstly. There is infinite security to Her Majesty and the State, that the land has means in itself, to defend itself, and offend enemies, otherwise she would be forced to depend upon foreign princes who have refused to suffer this provision to pass out of their dominions for any money whereof experience was had in 1595, when Mr. Turner, a merchant of London, now a patentee in this behalf, being commanded to provide 100 lasts of saltpetre, which he undertook to deliver within six months, to supply the provision that went out of the stores for the Cadiz voyage, could not perform it, as the Duke of Pomerland would not suffer his country to be weakened of a matter of such strength, so that Her Majesty was disappointed and could get but six lasts, two months after the time appointed, whereby a supply was of necessity made within the land.

Secondly. Although this provision could be had in foreign parts, it cannot be brought in without danger of being intercepted, and of delay and loss.

Thirdly. Her Majesty has usually paid one shilling a pound for foreign powder, and has saved by the making of saltpetre and gunpowder within the realm, which has been delivered at eight-pence, £4,000 in every 100 lasts during the former patent, whereby there were 80 lasts delivered ordinarily and upon especial occasions far greater quantities. Her subjects have saved nearly as much, so that altogether has been saved by the last patent in 11 years little less that £100,000.

Fourthly. Her Majesty is now served 100 lasts of powder yearly at 7d. per lb. and has saved therein, under the said price of foreign powder, £5,000 a year, and has indented for 20 lasts more yearly to be delivered if required, viz. for 40 lasts yearly more than was usually delivered by the former patent, so that she may save
by this patent in 10 years above £60,000 under the price of foreign powder, and her subjects in like proportion as much.

Fifthly. The making of saltpetre and gunpowder within the land raises a hidden benefit, the want whereof would carry great sums of money or other commodities of like value to foreign parts, and sets many people to work.

Sixthly. It appears by the accounts of the ordnance that Her Majesty, before the last two patents, never had above 20 or 30 lasts of English gunpowder delivered into the stores, partly because men of skill were wanted to make it, but chiefly because there was no certain person enjoined to bring any certain quantity into the store, but the matter was left at large, until the want of powder in 1588, notwithstanding all the provision that could then be had amongst the merchants of foreign powder hazarded the land. This occasioned the then Council to contract that the provision in this behalf might be chiefly made within the land, of which contract the then Lord Treasurer oftentimes spoke as the greatest service that could be done for the security of the kingdom, the strength of the wars being altered from bows and arrows to ordnance. As by this patent 120 lasts of powder are indented for yearly, viz. 40 lasts more than had usually been delivered for her Majesty's provision, besides that for her subjects it could not be made without dealing with the grounds of the better sort, not before meddled with, as well as with those of inferior persons, and thus is stirred up that discontent which has appeared in Parliament. The making of saltpetre will be complained of, though performed in the best manner that can be devised, as breaking of earths and taking of carriages needful by many of the ruder sort cause great discontent.

Seventhly. As there are said to be great grievances in the digging of houses, what just cause of grief, or rather what punishment had been sufficient for the leaving of houses undigged and so the land unfurnished of this munition in these perilous seasons? If
there be any just cause of offence let it be punished; but if all these petty matters were compared to that infinite security which the performance of this service brings to Her Majesty and her subjects, they have little cause of offence, and should think it their great happiness that thereby their houses, goods, lands and lives are protected. (S. P. Dom. Elizabeth, vol. cclxxv, No. 76.)

1600, 2nd September. Thomas Crompton to Edward Reynolds. Since writing my letters, there came a messenger from Mr. Evelyn to demand the payment of £360, which my Lord oweth, with threats that if it were not paid before the term, he would put the bond in suit. I told the messenger to tell Mr. Evelyn that when we came to reckoning he would be indebted to my Lord.

I pray you acquaint my Lord herewith, and learn his pleasure whether I shall not use means to force them to pay that they promised out of the benefit of their grant for making saltpetre and gunpowder. (Hist. MSS. Comm. Cecil MSS., pt. x, p. 312.)

1602. Action by John Evelyn, Hardinge, Robert Evelyn and Wrenham, Licensees, against certain persons for failure to supply carts. (Bills and Answers in the Exchequer, Elizabeth, Kent, No. 126A.)

1602. Arguments to prove that the letters patent of Sept. 7, 1599, for the sole making of saltpetre and gunpowder are maintainable not only in policy for the preservation of the state, but also in equity, and by the common laws of the land, viz. 1, that the use of saltpetre and gunpowder is necessary; 2, that they should be made in the country; 3, that the sole making belongs to the Crown, and should not be exercised without the Queen's grant; with objections thereto, and their answers; 4, statement of the benefits of granting the sole making of saltpetre and powder. Conclusion therefore that the patent is not a monopoly but useful in policy, equity, and by common law; therefore that the proclamation of 28 Nov. 1601 does not impeach it, but only
prohibits its abuse, and that all who call it in question should be punished. With note that the patent was drawn by Attorney-General Coke; this discourse approved by Solicitor-General Fleming, Francis Bacon, and by Councillors Andrew Blundon, John Dodderidge, John Walter and John Hele. (S. P. Dom. Elizabeth, vol. cclxxxvi, No. 42.)

1602, 11th May. G. Harvey deputy Lieutenant, J. Linewray, and John Lee, officers of ordnance to Lord Buckhurst. At the request of Mr. Evelyn and the other patentees for making powder to be brought into the stores, they certify that monthly from the commencement of their patent, they have, according to covenant, brought in 8 lasts and 8 cwt. of good corn powder. They have divers times offered to serve a much greater quantity if required, in respect whereof, and of the great stock which has long lain dead, and is daily increasing in their lands, it is thought that the demand made by Sir Noel Caron for 30 lasts of powder and 10 of saltpetre for the States General may be granted without prejudice. (S. P. Dom. Elizabeth, vol. cclxxxiv, No. 10.)

1603, April. Petition of the Patentees for the manufacture of saltpetre and gunpowder to the Council, requesting letters of assistance to confirm their Patent, the validity of which has been vexatiously questioned since the late Queen’s death. With reference to Lord Chief Justice Popham and his opinion thereon. (S. P. Dom. James I, vol. i, No. 64.)

1604, 9th January. The arrear account of John Evelyn and Robert Evelyn, esquires, of decayed and unserviceable gunpowder and saltpetre received by them by warrant from the late Queen’s privy Council, or otherwise, by appointment of the officers in the Tower of London, out of the H.M.’s stores, to be dried in stoves, or wrought and made into good and serviceable powder, for re-delivery into the same stores, between 22nd September, 1595, and 9th January, 1604. (A long account, the totals

1604, 18th October. John Evelyn, Richard Harding and Robert Evelyn surrender the 1599 licence and obtain a fresh one for 21 years, and also contract for 120 lasts at 8d. per lb. and additional powder at 10d. per lb. (Patent Roll, 2 James I, pt. vii, mem. 25, also Patent in Patent Office.)

1604, 18th October. Indenture between the King of the first part, and John Evelyn, Richard Harding, and Robert Evelyn, esquires, of the second part. Whereas by letters patent of this date the King has granted to the said parties of the second part license to make and work for saltpeter and gunpowder in England and Ireland, with licence to break ground, etc. for 21 years, they hereby undertake to deliver 120 lasts of good, perfect and serviceable corne powder yearly into the King's store in the Tower of London, half to be callyder corne powder, the other half cannon corne powder, at the rate of 8d. per lb. (Patent Roll, 2 James I, pt. vii, mem. 20.)

1606, 17th December. The 1604 patent was revoked. (Patent Roll, 4 James, pt. xxiv, mem. 13.)

1607, May. The Earl of Worcester obtains a patent and covenant for 80 lasts of powder at 8d. and more at 9d. for the term of 21 years, revocable within 18 months. (Patent in Patent Office.)

1607, 8th May. A licence granted to the Earl of Worcester for the sole making of saltpetre and gunpowder in England and Ireland for 21 years, revocable at pleasure. An indenture signed between the King and the Earl of Worcester, the latter agreeing to deliver 80 lasts of gunpowder per annum at the Tower of London at 8d. per lb. and as much more as might be required at 9d. (Patent Roll, 5 James I, pt. xi, mem. 41d.)
1607, 11th May. Patent for Edward, Earl of Worcester, to make and work for saltpetre and gunpowder, with power to dig, etc. etc. for 21 years. (Patent Roll, 5 James I, pt. xi, mem. 41, d.)

1610, January. The King to the Lord Treasurer. Refers to the composition with the Earl of Worcester and others as have the patent for the making of gunpowder within this realm, for delivery of powder monthly into the Tower worth £500, which provision has continued some time, and the store has been so replenished that of late it has only been able to take in one half of the quantity contracted for, whereby there remains a large quantity in the hands of the makers. The King, therefore, by advice of the Council has licensed the said Earl to transport, to such parts beyond seas as are in amity with us, 1,200 barrels of powder for the present year, and thereafter all such as shall not be required in the King's stores; such licence to continue so long as the Lord Treasurer, by conference with the officers of ordnance, shall not think fit to take into the said stores the whole proportion which they are bound to deliver. The Lord Treasurer is therefore required to give order to the officers of the port of London or elsewhere to suffer the said Earl to transport such gunpowder accordingly, reserving to the King the customs. (S. P. Dom. James I, Add. vol. xxxix, No. 114.)

1612, 25th August. The Earl of Northampton to Lord Rochester. On account of the mischiefs likely to arise by the establishment, in certain inhabited places, of houses for making gunpowder, the Council have given orders for their suppression. (S. P. Dom. James I, vol. lxx, No. 59.)

1613, September. Letter from the Earl of Worcester to the Lord Mayor, informing him that the King had by letters Patent committed to his charge the making of all saltpetre and gunpowder for the use of His Majesty, within his dominions, with power to appoint deputies, and requiring the Lord Mayor and Aldermen to prevent any persons from digging for or working saltpetre
within the City and liberties, except John Evelyn, Esquire, of Godstone, Surrey, or his factors, servants, etc. to aid him in the performance of the business, and in the event of any other persons being found working, to require them to cease, taking bond from them either to do so, or offer before the Privy Council. (City of London, Remembrancia, iii, 108.)


1616. Another grant to the Earl of Worcester (vide 1607) with some alterations.

1617. Patent of Earl of Worcester cancelled in 1617, on voluntary surrender of the patent by the said Earl.

1617, 26th February. Grant to the Earl of Worcester for payment of money on delivery of gunpowder and other things touching the same. (Patent Roll, 15 James I, p. 20.)

1617, 29th March. Indenture of covenant between the King and the Lord Privy Seal, concerning the making and delivery of salt-petre at the Tower, according to former rates, etc. with some differences from the former indentures. (S. P. Dom. James I, Sign Manual, vol. viii, No. 36.)

1617, 13th June. Letter from the Earl of Worcester to the Lord Mayor stating that, being by the King's Letter Patent appointed by himself or his assigns, to make all saltpetre and gunpowder within the Kingdoms of England and Ireland, for 31 years from the 13th March last, he had appointed as his deputy, Richard Fisher of the Inner Temple, Gentleman, and requesting the Lord Mayor and Court of Aldermen to be aiding to his said Deputy, factors, workmen and servants. (City of London Remembrancia, iv, 78.)

1619, 20th September. Extract from the Churchwarden's accounts of
Croydon, that town being oppressed in the carriage of saltpetre to Kingston-on-Thames, has had the road measured, and found it 10 miles 62 roods. Also that Richard Gilbert is threatened with ruin by the saltpetre men, who wish to dig for saltpetre in his shop. (S. P. Dom. James I, vol. cx, No. 67.)


1620, 21st September. Licence to the Lord Admiral, the Master of the Ordnance, and the Master of the Court of Wards, to make and work all manner of saltpetre and gunpowder in England and Ireland. (S. P. Dom. James I, Docquets, vol. ii.)


1620, 4th November. Statement of the annual expense of the Ordnance Office, as returned by the Commissioners, total £14,204 2s. 6d., of the modes by which they propose to effect a saving of £10,330 4s. 2d. therein, viz., suppression of offices, the King's resumption of saltpetre manufacture by which he can provide his own gunpowder, and reduction of the allowances for supplies of munition and wages. With replies by the officers of Ordnance showing the fallacies in the above statements and propositions. (S. P. Dom. James I, vol. cxvii, No. 54.)

1620, December. Note of charges against John Evelyn, for non-fulfilment of his contract with the Commissioners for Ordnance, relative to delivery of gunpowder at the Tower, which he excuses on the ground that the agreement is not ratified. (S. P. Dom. James I, vol. cxviii, No. 72.)

Accounts by John Evelyn, of saltpetre received and gunpowder manufactured by him, and delivered to the Tower since
the Earl of Worcester relinquished his patent Feb. 17, 1620. (S. P. Dom. James I, vol. cxviii, Nos. 73 and 74.)

1621, 28th January. Sir George Shirley to Sir Thomas Edmondes. The saltpetre men, under colour of letters of deputation from the Earl of Worcester, have injured him and his tenants at Ragdale, Leicestershire, by digging in their houses for saltpetre, contrary to the exception in their patent against disturbing dwelling houses. Begs his assistance to obtain recompense for the loss, or the punishment of the offenders. (S. P. Dom. James I, vol. cxix, No. 45.)

1621, 21st April. Conditions upon which the three Lords, Buckingham, Carew, and Cranfield depute to Mr. Evelyn their patent for the sole refining of saltpetre and making of gunpowder. (S. P. Dom. James I, vol. cxx, No. 102.)

1622, May (?). Suggestions (by Sir Robt. Heath) as to the mode of establishing a bank; . . . with notes about saltpetre and the customs. (S. P. Dom. James I, vol. cxxx, No. 29.)

1622, 22nd June. Note of a Council held at Whitehall, signed by Alb. Morton. The King allows the Ambassador of the Emperor of Russia to transport certain Gunpowder, 200 barrels bastard musket boare, and 11,250 pieces of 8 in english coyne valued at £2,250. The Lords ask the Lord Treasurer to give orders to officers of the Port of London to suffer them to pass. (Hist. MSS. Comm. MSS. of the Earl de la Warr at Knole Park, Kent, rep. 4, p. 283.)

1622, 30th September. Warrant of payment of £742 14s. 2d. to Sir Richard Morrison, to be paid over to John Evelyn for exchanging certain damaged and unserviceable gunpowder, returned from the King's castles, forts, etc. for good powder, at the rate of 2½d. per lb. (S. P. Dom. Docquets, vol. xii, under date.)

1622, 11th October. Earl of Middlesex to (Marquis of) Buckingham. Draft of a letter on the System to be adopted in Ireland, reform and payment of the King's household and the quantity of Gun-
powder in the public stores (corrected by Middlesex). (Hist. MSS. Comm. MSS. of the Earl de la Warr at Knole Park, Kent, rep. 4, p. 278.)

1623. Petition to the Lord Treasurer by the East India Company. They want 200 barrels of powder; dare not go to sea without it. They can only get it of Mr. Evelyn, and he has received orders not to part with any until the fleet is furnished;—they ask that Evelyn may be at liberty to sell. (Hist. MSS. Comm. MSS. of the Earl de la Warr at Knole Park, Kent, rep. 4, p. 314.)

1623, 16th January. Proclamation, that no person make gunpowder except with saltpetre made by warrant of His Majesty's commission, King's powder maker to receive 10d. per lb. and all gunpowder made by him to be priced and marked by the sworn proof master. The marks are explained at the same time. (Patent Roll, 20 James I, pt. xvi, No. 18 dorso.)

1623, 16th January. Proclamation that—for prevention of abuses in the manufacture of gunpowder and saltpetre, by which the King's ships and subjects are endangered, all powder made or imported shall go to the King's powder maker, where the proof master shall stamp it with marks specified, according to its quality, any counterfeiting of such stamps to be punished in the Star Chamber. (S. P. Dom. James I, Proclamations, under date, printed, No. 110.)

1623, 22nd July. Grant to Thomas Warwick and others, of London, of license to make saltpetre in a new manner in England and Ireland, with provisos of not interfering with the present commission, selling only to the King's storehouse etc. (S. P. Dom. Sign Manual, vol. xv, No. 52.)

1624, January. John Evelyn to the Commissioners of the Navy. Reports the quantities of saltpetre brought into the King's stores by the saltpetre men to whom the several counties are assigned, and how far it falls short of or exceeds the proportions
assigned to be brought in by each. Endorsed with notes of offenders who are to be examined. Annexing names of the offenders above reported, and of the quantities of saltpetre which were agreed to be delivered weekly to the King's stores. (S. P. Dom. James I, vol. clviii, No. 78.)

1624, 21st March. Statement by John Coke of the terms of the contract made April 16, 1621, with Mr. Evelyn for the supply of gunpowder; also that he has since then supplied only 100 lasts, and is 135 lasts behindhand, whereby the present store is deficient, and the King has lost his ratio of 3d. in the lb. on a large quantity. (S. P. Dom. James I, vol. clxi, No. 13.)

1624, 18th April. Sir Francis Nethersole to Sir Dud. Carleton. The heaviest charge against the Lord Treasurer is his neglect to pay the gunpowder makers, so that the present supply of powder is very small. His Lordship is confident of his justification. (S. P. Dom. James I, vol. clxiii, No. 3.)

1624, 4th May. (Sec. Conway) to Att. Gen. Coventry. A ship is stayed at Dover, laden with gunpowder bought by English merchants for export, on a question whether such merchandise is lawful. Requests him to resolve the query if it belongs to common law, and if to civil law, to get a reply from the King's advocate, or some other civilians. (S. P. Dom. James I, vol. clxiv, No. 17.)

1624, 5th May. Sec. Conway to Lord Zouch. Has informed the King, Prince, and Duke of his care in staying the ship laden with gunpowder. Inquiries have been made, and the export of gunpowder appears to be unlawful, therefore the restraint is to continue till orders are taken thereon. . . . (S. P. Dom. James I, vol. clxiv, No. 24.)

1624, 15th May. John Evelyn to Lord Carew. Is fulfilling his contract to supply the Tower with 20 lasts of gunpowder monthly, and requests present payment of £2,000 promised to be advanced for new buildings, and a settled assignment for the monies that
become due for the powder. (S. P. Dom. James I, vol. clxiv, No. 84.)

1624, 6th June. Memorial of points to be considered by the Council of War viz. The Contract with Mr. Evelyn for supply of gunpowder. (S. P. Dom. James I, vol. clxvii, No. 22.)

1624, 24th June. Statement by Mr. Evelyn of the gunpowder delivered by him into the Tower during the past three months, and of monies paid or due to him therefor: £2,000 was promised him in advance, for erection of fresh powder mills. (S. P. Dom. James I, vol. clxviii, No. 38.)

1624, 28th June. Secretary Conway to Attorney General Coventry, directing him to prepare a bill for renewal to Buckingham and Lord Carew of the patent for making saltpetre. (The sign manual for the commission is dated 13 July following. Conway's "Letter Book," p. 132.)

1624, 1st July. Covenant with John Evelyn the younger, of Godstone in Surrey that he should have for 3 years from 1st April last the sole converting of saltpetre into gunpowder. He would erect a store at Southwark and pay the saltpetre men £3 3s. 4d. per cwt. of saltpetre. He was to deliver 240 lasts (each last 24 barrels each barrel 100 lb.) powder at 8½ per lb. and he obtained a loan of £2,000 for 3 years for erecting new mills (Hart. loc. cit.).


1624, 29th July. Licence granted to Thomas Warrwicke, Peter Sparke, Michael Townshend and John Fells of London, merchants, for 21 years to work a new way of making and refining saltpetre, and to make yearly 150 tons of saltpetre at the rate of 55s. per cwt. (Close Roll, 22 James I, pt. xx, No. 3.)

1624, 26th December. Proclamation that no dove-houses or cellars be
paved, except where wine or beer is laid. (Patent Roll, 22 James I, pt. iv, No. 9 dorso.)

1624, 26th December. Proclamation ordering the preservation of grounds suitable for producing saltpetre etc. and the restoration of such as have been destroyed; commanding assistance to be given to his Majesty's saltpetre makers in digging in the grounds of any of his subjects. (S. P. Dom. Proclamations, 1624, No. 127.)

1624, 30th December. Sec. Conway to Lord Carew. Sends a warrant from the King for delivery of gunpowder to the East India Company. He is to see that his Majesty is not prejudiced thereby. (S. P. Dom. James I, Minute Conway's "Letter Book," p. 178.)

1624, 31st December. Warrant for delivery to the East India merchants of 20 lasts of good gunpowder, fit for long voyages, from the King's stores, on their delivery of the like quantity of good powder fit for shorter voyages. (S. P. Dom. James I, Docquets, vol. xii.)

1625, 2nd March. Lord Carew to Sir John Coke. Has sent Mr. Evelyn to attend the Commissioners of the Navy. If the East India Company erect powder mills, it will open a flood-gate, and diminish the King's profit, as he receives a poundage on all powder made by Evelyn. (S. P. Dom. James I, vol. cxxxv, No. 6.)

1625, March (?). Conditions and covenants in the Commissions authorising certain persons to dig for saltpetre. (S. P. Dom. Charles I, vol. i, No. 15.)

1625, 13th April. Proclamation for the maintenance and increase of the mines of saltpetre, and the true making of gunpowder. (Proclamation, Charles I, No. 7; Rymer's "Foedera," vol. xviii, p. 23.)

1625, August. Memorandum for the Duke of Buckingham to enjoin Mr. Evelyn to continue his monthly supply of powder; Sir
Thomas Bludder undertakes to give His Majesty 48 barrels of powder and pay Mr. Evelyn £1,700. (S. P. Dom. Charles I, vol. v, No. 111.)

1625, 25th August. Sir John Coke to the Duke of Buckingham. Among the things, Mr. Evelyn is to proceed in making powder in as great quantities as he can. (S. P. Dom. Charles I, vol. v, No. 77.)

1625, 26th August. Sir John Coke to Secretary Conway. The King is in debt to Mr. Evelyn for gunpowder £2,550; and the Treasurer answers that there are no monies for him. His estate will not afford to deliver any more. Mills of the East India Company set up in the skirts of Windsor Forest, stopped by command, because the deer receive prejudice. This order should be enquired into. (S. P. Dom. Charles I, vol. v, No. 85.)

1625, 28th August. Sir John Coke to the Duke of Buckingham. He is requested to intimate to the Lord Treasurer what prejudice it is to the kingdom, that Mr. Evelyn stays his hand from supplying gunpowder. (S. P. Dom. Charles I, vol. v, No. 92.)

1625, 31st August. Secretary Conway to Sir John Coke. Mr. Evelyn will receive satisfaction. No cause why the East India Company may not proceed in their powder works. (Conway's "Letter Book," p. 226.)

1625, 7th September. Sir John Coke to Secretary Conway. The interruption of the manufacture of gunpowder by the East India Company proceeded from Sir Arthur Mainwaring. Wishes Conway to inform the King how much the interest of his service is of more consequence than private profit or pleasure; also to procure a warrant for the resumption of the manufacture. (S. P. Dom. Charles I, vol. vi, No. 25.)

Encloses: Sir Maurice Abbot, Governor of the East India Company, to Sir John Coke. One of Sir Arthur Mainwaring's officers forbade the making of powder, and the preparing of any works for the same. (Ibid., No. 25, i.)
1625, 22nd September. Thomas Style to Secretary Coke. Solicits a warrant on behalf of the East India Company for the manufacture of gunpowder. Sir Arthur Mainwaring objects, alleging that the King's deer are hindered from their feeding, and that the poor people will want a corn-mill which the proposed mill used to be. (S. P. Dom. Charles I, vol. vi, No. 94.)


1625, 4th October. Thos. Eldred to Thos. Styles. Robt. Deering had shipped on board Eldred's ship 75 barrels of powder, but the King of Denmark had taken away 66 barrels at the rated price. Gentlemen of Ipswich desire to buy the remainder. (S. P. Dom. Charles I, vol. vii, No. 14.)

1625, 4th October. Officers of the Customs in Ipswich to Thomas Styles. They intreat him to sell to the gentlemen of that county the gunpowder which Thomas Eldred had brought for him from Elbing. (S. P. Dom. Charles I, vol. vii, No. 17.)

1625, 12th November. The Council of Scotland to the King. They solicit licence to buy and transport from England 20,000 weight of powder for the use of the former kingdom. (S. P. Dom. Charles I, vol. ix, No. 53.)

1625, 14th November. Francis Lord Russell to the Council. Urges the necessity for a supply of powder. The scarcity arises from no powder makers being as heretofore suffered to make powder in the county of Bedford. (S. P. Dom. Charles I, vol. ix, No. 57.)

1625, 6th December. Secretary Coke to Secretary Conway. He states his opinion on the question of setting free the making of gunpowder, and breaking the contract with Mr. Evelyn. He was favourable to the maintenance of a restraint on the manufacture; but urged the propriety of increasing the supply of
saltpetre by compelling ships homeward bound to bring saltpetre and ballast. (S. P. Dom. Charles I, vol. xi, No. 24.)

1625, 6th December. George Lord Carew, Master General of the Ordnance, to the Council. Being prevented by ill health from attending the Council, he writes his opinion on the question of dissolving the contract with Mr. Evelyn and permitting a free manufacture of gunpowder. He suggests ways of increasing the supply of saltpetre, especially from Ireland, in which country it had been the wisdom of former times to keep the manufacture of powder from the people. (S. P. Dom. Charles I, vol. xi, No. 27.)

The same to Secretary Coke. He had written to the Council on the subject of dissolving the contract with Mr. Evelyn. (Ibid., No. 28.)

1625, 7th December. Commissioners of the Navy to Sec. Coke. Send their opinion respecting the dissolving the contract for making powder. (S. P. Dom. Charles I, vol. xi, No. 33.)

1625, 8th December. Sec. Conway to Sec. Coke. His excuse made. His advice swayed the resolution for keeping up the contract for powder. . . . (S. P. Dom. Charles I, Minute Conway's "Letter Book," p. 239.)

1626, 2nd January. Sir John Brooke and Thomas Russell obtain the sole privilege of making saltpetre. It is commanded to preserve all urine. (Rymer's "Foedera," xviii, p. 813.)

1626, 2nd January. George Lord Carew, Master General of the Ordnance to Lord Treasurer Ley. Reports what has been done between the officers of the Ordnance and the Merchant Adventurers and the Eastland Company, concerning the importation of gunpowder and saltpetre. The store of powder and all other munitions is very weak, but that of powder must first be specially had in consideration. (S. P. Dom. Charles I, vol. xviii, No. 6.)

Encloses: 1. Officers of the Ordnance to Lord Carew.
The Merchant Adventurers had replied that, through their foreign agents, they would enquire what store of petre or powder might be had in those parts, but they recommend the King to commend the service to his ambassadors. 1626, Jan. 2. (Ibid., 6, i.)

2. The answer of the Eastland Merchants. They will in like manner inform themselves what quantity of powder can be bought in the East parts; its quality may be tested by some now at Blackwall. (Ibid., 6, ii.)

1626, 27th January. Memorial of George Lord Carew, Master General of the Ordnance, to the Council. The Lord Treasurer had agreed with Burlamachi for 100 lasts of powder from Amsterdam and Hamburgh, and with Mr. Evelyn for 20 lasts monthly, but it is suggested that the shires and maritime towns should be warned to make provision for themselves without depending upon the King’s stores, and that liberty should be given to manufacture gunpowder for home consumption from foreign saltpetre. (S. P. Dom. Charles I, vol. xix, No. 63.)

1626, 22nd March. Proffers of Burlamachi and others to supply gunpowder, with copy of Mr. Russell’s proffer for making of gunpowder. (MSS. of the House of Lords, Hist. MSS. Comm. iv, 7.)

1626, 31st March. Memorandum that Mr. Evelyn can get no sea coals, and cannot therefore proceed with the making of gunpowder. Compare Lords’ Journals, iii, 547. (House of Lords’ Papers. Hist. MSS. Comm., rep. 4, p. 9.)

1626, 2nd April. Sir John Brooke and Thomas Russell, having discovered a new method of making saltpetre, obtain licences for 21 years. They are to supply 300 tons to the King at £3 35. 4d. per cwt. (Patent Roll 2 Charles I, pt. xvii, No. 17.)

1626, 22nd April. Draft of an Act for preservation of the mine of saltpetre and increase of the means of making saltpetre and for the ease of the subject from the grievance which they now bear
by digging their houses and taking their carriages by saltpetre men. (Method discovered of enriching the earth with refuse and aquafortis and other acids and animal matter.) Bill provides that as soon as the new process can supply the demand the present powers to the saltpetre men shall cease. (Lords' Journal, iii, 569, 574; Hist. MSS. Comm. Rept. 4, p. 10, etc.)

1626, 7th June. List of saltpetre men with their several counties, and the quantities delivered by them into store for one year ending May 31, 1626. (Amongst them is John Milton, saltpetre man for Yorks, Northumberland and Durham.) (S. P. Dom. Charles I, vol. xxix, No. 40.)

1626, 8th June. Petition of William Ashwell to Buckingham. In December, 1624, certain barrels of gunpowder and brimstone, worth £1,000 were returned by the petitioner from Hamburgh, for the service of this state; these goods were taken by a man-of-war of Enckhuysen in Holland, on the coast of Kent; prays redress. (S. P. Dom. Charles I, vol. xxix, No. 47.)

1626, 9th July. Note of the powder remaining in store in the several halls of the City of London; 22,667 lb. (S. P. Dom. Charles I, vol. xxxi, No. 40.)

1626, 16th July. Petition of the East India Company to the King. In obedience to the King's command, they have dissolved their powder mills in Surrey, and discharged their servants, but having arranged for the purchase of large quantities of saltpetre, and been at great charge in erecting their mill, they pray for liberty to erect a mill in Kent or Sussex. Underwritten is a reference to the Attorney General to prepare a grant for carrying out their desire. (S. P. Dom. Charles I, vol. xxxi, No. 85.)

1626, 22nd July. Commissioners of the Navy to Buckingham. Thomas Burleigh, Gunner of the Assurance, and George Cadman, Gunner of the Mary Rose, had embezzled five barrels of gunpowder. They had been committed to custody until his Grace's pleasure was known. (S. P. Dom. Charles I, vol. xxxii, No. 11.)
1626, 7th August. East India Company have imported saltpetre and erected powder mills in Surrey which were pulled down, asked leave to erect mills in Surrey, Kent, and Sussex and to convert into powder the saltpetre they import. (Patent Roll, 2 Charles I, pt. xxi, No. 31.)


1626, 25th September. Wm. Viscount Mansfield to John Oldsworth, secretary to the Earl of Pembroke. To procure the Earl's warrant to Mr. Evelyn maker of gunpowder, to furnish 48 barrels of gunpowder at the King's price of £4 3s. 4d. per barrel, for the use of co. Nottingham. (S. P. Dom. Charles I, vol. xxxvi, No. 52.)

1626, 7th December. Wm. Earl of Northampton to Secretary Conway. Suggests that if the saltpetre men that worked in that county (Worcester) might make their saltpetre into powder there, it would be a great ease to the country, and a ready way to procure a supply of powder for the public defence. If this be agreed to directions should be sent to Wm. Richardson, who had the patent for those counties. (S. P. Dom. Charles I, vol. xli, No. 44.)

1627 (?) Note of the several kinds of cannon and field pieces, with their weight, and that of the bullets and powder required for each. (S. P. Dom. Charles I, vol. lxxxviii, No. 24.)

1627. Petition of John Evelyn the King's powder maker, to the Council. Petitioner is bound to deliver great quantities of powder to the King's stores on payment of £1,700 per month. That payment has not been continued for above six months, wherefore he has been obliged, for the maintenance of his works, to sell to other persons. But by reason of the manufacture of gunpowder by the East India Company, and one Michael
Waring, there is no sale for the powder made for the King. Prays that his monthly payment may be continued, or the other powder makers may be restrained, no such liberty having been given for above 60 years to any but the petitioner and his ancestors. (S. P. Dom. Charles I, vol. lxxxix, No. 9.)

1627. Addresses of Mr. Stonestreet and Mr. Samuel Jennings, two purchasers of gunpowder. (S. P. Dom. Charles I, vol. lxxxix, No. 10.)

1627. Memoranda by Secretary Coke respecting a course to be taken to suppress unauthorized powder making. The powder makers designed to be suppressed are stated to be in Bristol, Dorsetshire, and Battle in Sussex. (S. P. Dom. Charles I, vol. lxxxix, No. 11.)

Proposition to restrain the sale and retailing of gunpowder to his Majesty’s magazine. (Ibid., No. 20.)

1627, 2nd January. Proclamation for the better making of saltpetre, and enforcing the privilege for the sole making thereof granted to Sir John Brooke and Thomas Russell by letters patent dated April 26 last. (Proclamations, Charles I, No. 57.)

1627, 10th February. De Proclamatione contra inutilem consumptionem sulphurei, a proclamation to prevent the useless saluting with gunpowder. (Rymer’s “Foedera,” xviii.)

1627, 2nd July. George Earl of Totness to Secretary Coke. On the complaint of Lord Strange of many abuses committed by Robert Leight, a deputy saltpetre man at Hawarden, co. Flint, the Duke of Buckingham and the writer wrote to certain justices to examine the business. Encloses their certificate, and the articles proved against Leight and begs the Secretary to dismiss him. (S. P. Dom. Charles I, vol. lxx, No. 12.)

Encloses: Justices of Flint to the Duke of Buckingham and the Earl of Totness. Send articles proved by inhabitants of Hawarden, against Leight, the saltpetre man. Hawarden 1627, June 20. (Ibid., No. 12, i.)
Enclosing the articles above mentioned. Leight was accused of breaking open the locks of the stables of Lord Strange, also those of the castle of Hawarden; and digging therein in search of saltpetre; also of employing a body of mean persons as agents, who committed similar acts throughout the town. (Ibid., 12, i, 1.)

1627, 20th July. George Earl of Totness to Secretary Coke. He knows not what distraction has fallen out among the saltpetre men, who now refuse to take out new deputations, whereby the works must fall, which will be a great detriment to the King's service. Has signed warrants to send for them, but doubts his power in the absence of the Duke of Buckingham. Leaves Coke to settle that question and act accordingly.

Encloses: Commissioners to the Navy to the Earl of Totness. Complain of the conduct of the saltpetre men and enclose warrants to send for them. (S. P. Dom. Charles I, vol. lxxi, No. 54.)

1627, 23rd July. George Duke of Buckingham, Lord High Admiral, and George Earl of Totness, Master of Ordnance, to be Commissioners for the carrying out of a proclamation similar to that issued 13 April 1625. (Rymer's "Foedera," xviii.)

1627, 23rd July. Proclamation for maintaining and increase of the mines of saltpetre, and for the true making and working of saltpetre and gunpowder. (S. P. Dom. Proclamation Charles I, No. 67.)

1627, 25th July. Special commission issued to the above two. (Rymer, loc. cit.)

1627, 28th July. Secretary Coke to Secretary Conway. The saltpetre-men are now settled under the government of the officers of the ordnance. (S. P. Dom. Charles I, vol. lxxii, No. 32.)

1627, 20th August. General letter from the King to various cities and towns, encouraging them to advance money to enable Sir John Brooke and Thomas Russell to carry on a royal privilege
granted to them for procuring saltpetre, without the inconveniences then common. The money advanced was to be laid out in the erection of works, and to be repaid out of the first profits. (S. P. Dom. Charles I, vol. lxxiv, No. 45.)

1627, 3rd October. George Earl of Totness, Master of the Ordnance to the King. In the memory of man that office was never so weak in powder as now. Difficulty of obtaining it. Beseeches the King to refer it to the Council to advise what course is to be taken in a cause of so great importance. (S. P. Dom. Charles I, vol. lxxx, No. 17.)

Encloses: Brief of Powder issued out of the King’s store from March, 1625, to September 22, 1627. Total, 653 lasts; remaining in store, 24 lasts. (Ibid., No. 17, i.)

1627, 9th October. The King to the towns of Reading and Oxford, to erect saltpetre works there. (S. P. Dom. Charles I, Docquet 1627, Oct. 9.)

1627, 17th October. Resolutions of the Council Board upon articles propounded by the Earl of Totness; in the handwriting of Secretary Coke. Measures to be taken to procure supplies of saltpetre from Barbary, Eastland, Hamburgh, and the Low Countries; a check to be put upon spending powder in riot, by taking the accounts of gunners on oath. (S. P. Dom. Charles I, vol. lxxxii, No. 2.)

1627, 30th November. George Earl of Totness to the Duke of Buckingham. There is a necessity for contracting for a supply of saltpetre from Hamburgh or Amsterdam, to be sent when those ports are open from frost. (S. P. Dom. Charles I, vol. lxxv, No. 72.)

1627, 27th December. George Earl of Totness to the Duke of Buckingham.

coming from Newcastle to London, with coals for boiling salt-petre, prays that the ship and mariners may be free from impressment. (S. P. Dom. Charles I, vol. lxxxvii, No. 54 and 54 i.)

1628 (?) Memorandum concerning the agreement with John Evelyn, the gunpowder maker, for supply of H.M. Stores. Evelyn contracted to bring into the store 20 lasts of powder monthly, to be paid for by the Lord Treasurer within 14 days of delivery at 8½ per lb. amounting to £1,700 monthly with liberty to sell it at large, to his best advantage, if not duly paid for. This bargain was to begin in May 1627.

For want of payment Mr. Evelyn brought in till Jan. (1628) but 4 months' proportions.

Sir Thomas Bludder made a proposition to the Lords concerning Mr. Evelyn's contract, upon a mistaken notion that Evelyn was tied by his contract to sell the powder to the subject at 10d. per lb.

That Sir Thomas Bludder sold his presumed interest to Sir Paul Harris at 10d. per lb. who transferred the same to Mr. Jones, a merchant.

Objections to these transactions and the answers.

If the committee, having authority to examine all abuses of gunpowder making, would permit the hearing, it shall be made appear that Mr. Evelyn, and his agent Pigott, by their monopoly for the sole making and selling of gunpowder, giving of bribes, deceiving the King, abusing the subject, and out of other men's labours, have got an estate of near £40,000 within 4 years. (S. P. Dom. Charles I, vol. dxxix, No. 88.)

1628. Computation of damage sustained by the King in 7 years by the contracts made for converting saltpetre into gunpowder, total, £106,925. Touching the making of 240 lasts of gunpowder yearly, according to a contract, with explanations thereon. (S. P. Dom. Charles I, vol. dxxix, No. 89.)
1628. Letters patent whereby the King releases to John Evelyn the younger of Godstone, co. Surrey, £2,000, paid to him by way of imprest under the Indenture of July 1, 1624. (Copy, S. P. Dom. Charles I, vol. cxxiv, No. 9.)

1628. Project for provision of a sufficient quantity of saltpetre for the public use out of barren and almost unpeopled islands belonging to the King. (S. P. Dom. Charles I, vol. cxxvi, No. 54.)

1628, January. Proposition for enabling the Lord Admiral to purchase the powder manufactured by Mr. Evelyn, whenever the Lord Treasurer did not do so, and after supplying the King’s wants to sell the powder at reasonable prices to the public. The proposers offer to find all the money necessary to be paid Mr. Evelyn, and to pay the Duke £300 for every month in which they obtain the powder. (S. P. Dom. Charles I, vol. xci, No. 103.)

1628, 12th January. George Earl of Totness to the Duke of Buckingham. The fleet cannot be armed on account of the want of powder. Mr. Evelyn sinks under the burden of the great sums due to him. They are to expect no more from him until he is satisfied. At this hour there is not above 50 lasts of powder in store. (S. P. Dom. Charles I, vol. xc, No. 64.)

1628, February. Report by Captain John Heydon on the quantity and character of the powder brought into the King’s stores by Philip Burlamachi and Mr. Evelyn since November, 1626. (S. P. Dom. Charles I, vol. xciv, No. 105.)

1628, 3rd March. Henry Holt to Nicholas. Has borrowed three barrels of powder out of the King’s stores for the gentleman that makes the fireworks; he wants 27 barrels of powder more. (S. P. Dom. Charles I, vol. xcv, No. 22.)

1628, 3rd March. Note of questions which will necessarily fall in debate on consideration of the proposition for supply of powder. (S. P. Dom. Charles I, vol. xcv, No. 27.)

1628, 13th March. Minutes of proceedings of the Council of War.
The subjects treated of are, information of Blyth against Mr. Evelyn, the powder maker; bill preferred by Mr. Evelyn in Parliament concerning saltpetre; proposition in the Council for encouragement of the Deputies authorised for making saltpetre in Ireland; Thomas Procter's proposal for defeating a battail of pikes. (S. P. Dom. Charles I, vol. xcv, No. 80.)

1628, April. Petition of Roger Parr to the Duke of Buckingham. Petitioner by warrant from the Duke and the Earl of Totness as Commissioners for saltpetre and gunpowder, was appointed to take the weight of all the saltpetre delivered into the King's storehouse, at the Bell in Southwark. During the Duke's absence in Rhè he was dispossessed and Mr. Hocker appointed in his room, whereby besides his office he has lost a good sum of money due to him from the petremen. Prays redress. (S. P. Dom. Charles I, vol. cii, No. 77.)

1628, 2nd April. Capt. John Heydon to the same. They have found convenience to convey the 120 barrels of powder on horseback. Put into double casks, and conducted by a careful messenger, with particular instructions every night to keep a guard upon it, they doubt not of the safe arrival. (S. P. Dom. Charles I, vol. c, No. 15.)

1628, 21st April. Cornbury Park. Henry Earl of Danby to the Duke of Buckingham. The saltpetre men having grievously oppressed the people of these parts, even exceeding the limits of the large patent granted to the Duke and Earl of Totness, were convicted at the Quarter Sessions; but the Earl, to prevent delay of supplies of saltpetre, and to withhold complaint which might distract the Parliamentary proceedings, advised the suspense of punishment presuming the Duke will take care to reform their lewd courses; and the rather because Stevens, the principal master of this rabble, privately confessed that he pays the Duke yearly £1,700 rent for this exorbitant commission which made the Earl much more willing to interpose as not forgetful of the

1628, 23rd April. Account of saltpetre brought into His Majesty's store by the saltpetre men from August 3, 1627, to the last of December following. John Milton stands third in the list of saltpetre men. His deliveries had amounted to 73 cwt. 2 qr. 23 lb., which is said to be 47 cwt. 1 qr. 5 lb. less than his required proportion. (S. P. Dom. Charles I, vol. ci, No. 68.)

1628, 24th April. George Earl of Totness to the Duke of Buckingham. He sent, by Sir Thomas Stafford, a letter of reasons to induce the Duke to be the means of dissolving the decree of the Council for sale of the powder made by Mr. Evelyn. Beseeches him to take it into his serious consideration that its continuance may not evermore keep the King's store weak. (S. P. Dom. Charles I, vol. cii, No. 2.)

1628, 25th April. Report of Officers of the Ordnance to the Lord President of the Council, concerning the 120 barrels of powder to be sent to Plymouth. Have made diligent enquiry after the most speedy conveyance by land, but can find but six oxen teams, and those of Somersetshire, the owners being willing to undertake the service, yet alleging their cattle to be unable to travel those hard ways, and that it is impossible for their wains to pass Exeter, from whence the powder must be conveyed to Plymouth on horseback. Suggest the transfer of the powder required from Portsmouth by sea. (S. P. Dom. Charles I, vol. cii, No. 17.)

1628, 5th May. Petition of Hugh Grove to both Houses of Parliament. The causes of the decay in the supply of saltpetre are asserted to be the disorderly conduct of the saltpetre men, and the consequent endeavour of all people to destroy the generation of saltpetre within their possessions. The petitioner offers to prove these assertions, if thereunto commanded. (S. P. Dom. Charles I, vol. ciii, No. 31.)
1628, 16th May. Petition of Nicholas Lillye, Purveyor for co. Worcester to the Council. He has been employed by the deputy Lieutenants of the county to find powder and match for the magazine therein for his Majesty's service. Prays for a warrant for two lasts of powder from Mr. Evelyn. (S. P. Dom. Charles I, vol. civ, No. 1.)

1628, 17th May. Notes concerning the supply of powder in the King's stores, and the state of accounts with Mr. Evelyn. He has brought in no powder for three months, for want of payment of an arrear of £2,400. (S. P. Dom. Charles I, vol. civ, No. 12.)

1628, 20th May. Sir Randolph Mainwaring and others to the Lord Keeper and Secretary Conway. Being informed that a stranger was lately come to Hocknell, a private place, some four miles from Chester, and was there making gunpowder, they had repaired thither, and found the man, who calls himself Robert King, with about 40 lb. of powder. They have committed him to Chester Castle. (S. P. Dom. Charles I, vol. civ, No. 33.)

Enclosing: William Blyth to Mr. Leite. Answers complaints of his omitting much good ground. Had been before the Council with Mr. Evelyn, face to face; the Council said the saltpetre men must have their places for life, and that it must be lawful for any man to make powder. 1628, March 15. (Ibid, No. 33, i.)


1628, 23rd May. Captain John Heydon and others of the Ordnance office to George Earl of Totness, Master of the Ordnance. They have perused the examinations touching the powder made by King (see ante). It being free for any one to make powder so that the same be not made of petre prohibited by virtue of
His Majesty's commission, except it can be proved that King knew that the petre he had of Cooper was such, he is in little fault. Cooper and Blyth should be summoned to answer the charge against them in that particular, and King is discharged. (S. P. Dom. Charles I, vol. civ, No. 71.)

1628, June. Lieutenant and other officers of the Ordnance to the Council. They report the quantity of powder (49 lasts and 12 lb.) remaining in the hands of the merchants and the East India Company. Have drawn them to be content to sell at the rate of £5 5s. per barrel or hundredweight for ready money. (S. P. Dom. Charles I, vol. cviii, No. 77.)

1628, 11th June. Among "the causes of our disaster" No. 5 is the want of powder in the Tower, for there is but now 60 last of powder when there should be 300 last always, and the King buying powder there was sold the last year 864 barrels, and the King paid £8 for powder, whereas he might have it for £3 3s. 8d. (Hist. MSS. Comm. MSS. of the Earl of Lonsdale, rep. 15, App., pt. vii, p. 45.)

1628, 24th June. Sir Paul Harris, Surveyor of the Ordnance to Secretary Nicholas. He found in the Artillery Garden almost 30 lasts of powder, and going to Mr. Evelyn's storehouse in Southwark, he was at first much daunted with the Council's warrant, and made as if they should not see his storehouse, but afterwards was content, where they found 15 lasts, besides seven that he has lately brought into the Tower. He undertakes to make it up to 40 lasts, so he may have payment. He was unwilling they should go to his country house, protesting he has no storehouse there. (S. P. Dom. Charles I, vol. cviii, No. 14.)

1628, 4th July. John Doughty and John Barker to Nicholas. Answer from Capt. Heydon, that he could deliver no powder, until more store brought into the Tower. (S. P. Dom. Charles I, vol. cix, No. 28.)
1628, 10th July. John Evelyn to Secretary Nicholas. Prays him to move the Duke of Buckingham that he may have £2,000 that week, so that he may be able to keep together the 40 lasts of powder with which he has promised to supply the King's stores. He has borrowed £1,700 of one man, and is weekly to pay to the petre men £300 at least. Either he must make no more powder until he is paid, or, if he make powder, must sell it away to pay the saltpetre men and maintain his own works. (S. P. Dom. Charles I, vol. cix, No. 80.)

1628, 31st July. Certificate of Captain John Heydon and Sir Paul Harris, Master and Surveyor of the Ordnance, that they had found 40 barrels of powder in the storehouse of Mr. Felgate of Houndsditch, 20 of which were marked with the broad arrow, and were said to be part of 100 barrels sold by Mr. Evelyn to the Lord Chamberlain. The 40 barrels are kept in safe custody until further order. (S. P. Dom. Charles I, vol. cxi, No. 45.)

1628, 19th November. Petition of John Giffard to the Council. He has authority for making saltpetre in the counties of Gloster, Somerset, Devon, and Cornwall, with power to take up carts and carriages for the said service. In September last he charged the Constable within the county of Gloucester to provide certain carts, but he was refused. He prays for letters of assistance. (S. P. Dom. Charles I, vol. cxxi, No. 10.)

1629 (?). Substance of the covenants with the saltpetre men since 1624. (S. P. Dom. Charles I, vol. clv, No. 51.)

1629. Prince Rupert, son of Queen of Bohemia, nephew of Charles I obtains a grant for £300 per annum. He is said to have brought the practice of blasting to England, but this is doubtful, 1670 being a more probable date of its introduction. (Rymer's "Foedera," xviii.) (The first shot was fired on 8th February, 1627, in the Royal Mines at Schemnitz in Hungary; vide Guttmann, "Blasting.")

1629, 5th April. Commission to Lord Richard Weston and others to
work for saltpetre. (Patent Roll, 5 Charles I, pt. viii, No. 7 dorso.)

1629, 10th April. The officers of the Ordnance to Lord Treasurer Weston. They report that there were 100 lasts of powder, and 422 lasts of saltpetre in the Ordnance office. (S. P. Dom. Charles I, vol. cxl, No. 38.)

1629, 21st April. Secretary Coke to Attorney General Heath. To renew the Commission for making saltpetre granted to the late Duke of Buckingham and Earl of Totness, to the Commissioners for the Admiralty and the present master of the Ordnance. (S. P. Dom. Charles I, vol. cxli, No. 22.)

1629, 25th April. Secretary Coke to Attorney General Heath. Notwithstanding the message sent by Sir Francis Cottington the saltpetre commission is to proceed according to the writer’s former direction. (S. P. Dom. Charles I, vol. cxli, No. 37.)

1629, 6th May. Petition of John Skinner and various other persons to the Saltpetre Commissioners. Robert More, of Southwark, flax dresser, having obtained a deputation for making saltpetre in Essex, Suffolk, and Norfolk, and having no experience, knowledge, or discretion, wasted and disabled the grounds, vexed and troubled the King’s subjects, and kept back the hire of the petitioners, his servants. They pray the Commissioners to commiserate their case. (S. P. Dom. Charles I, vol. cxlii, No. 32.)

Annexing: Particulars of some of the wrongs done by Robert More, ready to be proved by several of the preceding petitioners. (Ibid., No. 32, i.)

1629, 7th May. Note of the division of the shires among the petre-men, made by the Lord Treasurer, Lord Steward, and Sir John Coke. There were eight saltpetre men, among whom the whole kingdom was divided, and who were bound to a weekly supply of certain quantities. (S. P. Dom. Charles I, vol. cxlii, No. 42.)
1629, 9th May. Minute of application of John Giffard for direction to apprehend Thomas Guy, who having made quantities of saltpetre and gunpowder in Devon to the prejudice of Giffard, the Council granted a warrant for attaching Guy and seizing his goods and chattels. The latter was effected, but Guy himself escaped. (S. P. Dom. Charles I, vol. cxlii, No. 57.)

1629, 12th May. William King to the Lord President Conway. Prays him to solicit Lord Vere to appoint the writer to the Saltpetre works for the City of Gloucester and county of the City. (S. P. Dom. Charles I, vol. cxlii, No. 67.)

1629, 31st October. The council to the officers of the customs of the Port of London. Warrant to suffer the East India Company to export 50 tons of saltpetre, brought from the Indies, and 1,000 barrels of gunpowder, the King's stores and Mr. Evelyn being sufficiently supplied. (S. P. Dom. Charles I, vol. cl, No. 108.)

1629, 14th November. Petition of William Richardson the younger to the Lords Commissioners for the Admiralty and Saltpetre. He gave £100 for a commission for making saltpetre in the counties of Worcester, Hereford, and Salop, and bestowed £200 in necessary victuals; but on the death of the Earl of Totness was supplanted by John Giffard and Thomas Hilliard. Prays to be restored to his place. Endorsed is a note by Secretary Nicholas of the answer to this petition. The Lords displaced the petitioner, because he never brought in his proportion of saltpetre, but sold it away. (S. P. Dom. Charles I, vol. cli, No. 64.)

Account of the saltpetre brought in by William Richardson the elder, and William Richardson the younger from 1 August, 1627, to 30 April, 1629. (Ibid., No. 65.)


1630(?). Undated. Considerations on a proposal for making a store of saltpetre, in which the whole details of its production are stated. (S. P. Dom. Charles I, vol. clxxx, No. 4.)

1630(?). Lords of the Admiralty to the Mayor of Huntingdon etc. David Stevenson, Deputy for making saltpetre, having abused the country . . . the persons addressed are to certify what has been his misbehaviour or corruption, or that of his workmen. (S. P. Dom. Charles I, vol. clxxx, No. 6.)

1630(?). Computation what his Majesty has been endamaged in seven years by the contracts made for converting saltpetre into gunpowder. (S. P. Dom. Charles I, vol. clxxx, No. 9.)

1630. Account by Sec. Coke of the various patents for the manufacture of gunpowder in England, from 3rd. Elizabeth, when she gave £500 to a Dutchman to teach two of her subjects to make saltpetre, down to 1630. There is added a suggestion for new contracts, both with the saltpetre men and the gunpowder maker. (S. P. Dom. Charles I, vol. clxxx, No. 10.)


Petition of David Stevenson a saltpetre man to the Council. Stevenson has taken Leonard Pinckney to be his partner. (Ibid., No. 5.)

A proposal for the supply of 240 lasts of gunpowder at 8d. per lb., provided the King's officers would furnish the undertakers with a sufficient supply of saltpetre. (Ibid., No. 8.)
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Suggestions for a new contract with the powder makers. (Ibid., No. 11.)

Estimate by Mr. Collins of the charge of making 240 lasts of gunpowder, showing that the gain thereon to the contractors, if sold at 8d. per pound amounted to £4,192 15s. (Ibid., No. 13.)

Another estimate of the cost of converting 50 lasts of saltpetre into gunpowder. Total, £4,751. (Ibid., No. 14.)

Another similar estimate, more complete. It shows a profit on the 50 lasts, at the then present prices, of £1,139 17s. 4d. (Ibid., No. 15.)

1630, January. Petition of David Ramsey, 1 "Your Majesty's Servant" begging for patents for divers new inventions, viz. To multiply and make saltpetre in an open field in 4 acres of ground, to serve all your Majesty's dominions. (S. P. Dom. Charles I, vol. clxxv, No. 58.)

1630, 14th February. Sir Francis Seymour to Secretary Coke. The saltpetre men care not in whose houses they dig, threatening men that by their commission they may dig in any man's house, in any room, and at any time, which will prove a great grievance to the country. In the town where the writer lives they have digged up some malting rooms, and threaten to dig more. They dig up the entries and halls of divers men. If any oppose them they break up men's houses and dig by force. They make men carry their saltpetre at a groat a mile, and take their carriages in sowing time and harvest, with many other oppressions. Hopes that these men may not be allowed to strain their commission. The saltpetre man's name for Wilts is Hellyer. (S. P. Dom. Charles I, vol. clxi, No. 1.)

1630, 20th February. Petition of Hugh Grove, Deputy for making saltpetre to the Lords of the Admiralty. Complains of Thomas Stallam and others of Thetford for refusing to carry saltpetre

1 The clockmaker, courtier, and occult scientist.
liquors. Prays that they may be sent for by warrant. (S. P. Dom. Charles I, vol. clxi, No. 35.)

1630, 20th February. Petition of the deputies of the Lords of the Admiralty for making saltpetre to the same Lords. The powder maker refusing to weigh or pay for the saltpetre they delivered, they pray that if present order be not taken for relieving them, they may have leave to make their cause known to the King. (S. P. Dom. Charles I, vol. clxi, No. 36.)

1630, 6th March. Gabriel Dowse and others to the Lords of the Admiralty. The complaints of wrongs committed by Stevens the saltpetre man are so great that they had not been able to reduce them into method. Pray a respite of their certificate for a fortnight or three weeks. (S. P. Dom. Charles I, vol. clxii, No. 40.)

1630, 20th March. Petition of Thomas Thornhill, saltpetre maker for London to the Commissioners for Saltpetre and Powder. Complains of the practice of Hugh Grove, by which petitioner was left out of the last commissions for London and is now sued for £24 per annum, and also for not delivering saltpetre. Prays a hearing, and the discharge of Grove's unjust suits. With a reference to Sir William Russell and others to certify what they conceive to be just. (S. P. Dom. Charles I, vol. clxiii, No. 23.)

1630, 23rd March. Thos. Bond to Nicholas. Understands that the Lords of the Admiralty have referred the collection of the proofs against the saltpetre men to two knights. . . . Hears that the saltpetre men make their vaunts that they will get their liberty and carry themselves in the country as formerly. . . . If the saltpetre men go down without redress of wrongs it will strike despair into the heart of the country. . . . (S. P. Dom. Charles I, vol. clxiii, No. 40.)

1630, April (?). Notes by the same (?Sec. Coke) respecting the way in which the saltpetre men had performed their contracts. (S. P. Dom. Charles I, vol. clxv, No. 53.)

1630, April. Articles proposed to be inserted in a new contract with
Mr. Evelyn for the supply of powder. (S. P. Dom. Charles I, vol. clxv, No. 50.)

Names of the saltpetre men, with the allotment amongst them of the several counties, and the proportions they were to furnish per week. (Ibid., No. 51.)

Minutes of returns respecting the saltpetre men to be obtained through Mr. Evelyn from Hocker; with notes as to stipulations to be introduced into their contracts. (Ibid., No. 52.)

Statement entitled "Directions for the Saltpetre business" of the course fit to be adopted with Mr. Evelyn and the saltpetre men. (Ibid., No. 54.)

1630, 20th April. Petition of the deputies for making saltpetre to the Lords of the Admiralty. They have often made known that they have so far engaged their estates and credits for the King's service that they are no longer able to continue the doing thereof. If they are suffered to be undone by doing his Majesty's service, the example would be so remarkable that men would be fearful to contract or lay out their estates in the King's or kingdom's service. They pray for payment or permission to sell to others.

Secretary Nicholas has written upon this petition that there is order taking for the petitioner's satisfaction. (S. P. Dom. Charles I, vol. clxiv, No. 77.)

1630, 30th April. Sir William Russell, Sir John Wolsterholme, and Sir Kenelm Digby to the Lords of the Admiralty. Report on consideration of the complaints and examinations sent in against Mr. Hilliard and Mr. Stephens, saltpetre men and their servants. According to the proofs there is no part of their commission which they have not extremely abused. As in digging in all places without distinction, as in parlours, bedchambers, threshing and malting floors yea, God's own house they have not forborne; so they respect not times, digging in the breeding time in dovehouses, and working sometimes a month together,
whereby the flights of doves are destroyed; and without respect to harvest time in barns and in malting houses, when green malt is upon the floor; and bedchambers, placing their tubs by the bedside of the old and sick, even of women in childbed, and persons on their death-beds. They have undermined walls, and seldom fill up the places they have digged. In taking up carts they observe no seasons, and charge more carts than are needful, discharging some again for bribes, and overload the carts they employ. They do not pay the prices for carriage required by the commission. They take up coals not only where they are sold but from those that have fetched them 20 or 30 miles by land for their own winter's provision. They recommend that the offenders should be punished, and that the commission be taken in, and a new one made out, with restrictions designed to put an end to the abuses complained of. (S. P. Dom. Charles I, vol. clxv, No. 38.)

1630, 26th June. Petition of Nicholas Stephens, Deputy saltpetre man to the Lords of the Admiralty. The Lords having directed the Attorney-General to proceed against him in the Star Chamber, especially in the charge of digging in the church of Chipping Norton, he begs them to consider the declaration annexed, and to withdraw the order for proceeding in the Star Chamber.

Annexing the declaration above alluded to. At a time of great want of saltpetre he removed only some waste and unnecessary part of the soil of the church of Chipping Norton, as with the concurrence of the parishioners and ministers he had done in the churches of Coventry, Warwick, and Oxford. Other digging was done in his absence by his servant, whom he cast into Oxford gaol, and made satisfaction to the parishioners. (S. P. Dom. Charles I, vol. clx, No. 46.)

1630, 26th June. Petition of Richard Bagnall to the Lords of the Admiralty. Stephens the saltpetre man has expended £1,600 in increasing the mine of saltpetre. Petitioner having married
Stephen's daughter, prays that he may succeed him in his place. (S. P. Dom. Charles I, clxix, No. 47.)

1630, July. Petition of Thomas Hilliard, one of the saltpetre men, on behalf of himself and his servants to the Lords of the Admiralty. By commission dated April 28, 5 Charles I, they were authorized to work for petre in the houses of any of His Majesty's subjects, and within privileged places. About January last, petitioner's workmen endeavoured to dig in the pigeon house of Thomas Bond, who disobeyed the commission, and complained against petitioner, and in February last procured him and his workmen to be sent for by warrant. They have ever since remained prisoners. Pray to be dismissed. (S. P. Dom. Charles I, vol. clxxi, No. 79.)

1630, 5th August. Alexander Feris to Sir John Heydon, Lieutenant General of the Ordnance. He appears to have made offers to the Lord Treasurer to supply gunpowder, but it does not state the rate and price. Mr. Evelyn had offered to serve in all the powder at 8½d. the lb. (S. P. Dom. Charles I, vol. clxxii, No. 23.)

1630, 15th November. Petition of David Ramsey to the King. Has found out new inventions to make saltpetre in an open field of four acres to serve all His Majesty's dominions, with a minute that the King grants the letters patent solicited. (S. P. Dom. Charles I, vol. clxxv, No. 58. The patent is enrolled. Patent Roll, 7 Charles I, pt. xxii, 18 dorso.)

1631 (?). Answer of some unnamed persons desiring to contract for supply of powder; offering to do the work at 8d. per lb. (S. P. Dom. Charles I, vol. ccvi, No. 53.)

1631 (?). Division of the counties, with the proportions for making saltpetre per week, conceived to be most for the advancement of His Majesty's service. Annexed is a statement for the surplusage of three of the saltpetre men, contracted to be supplied above the proportions mentioned in this paper. (S. P. Dom. Charles I, vol. ccvi, No. 35.)

1631, 21st January. In List of Proclamations 21 Jan. 1631. David Ramsey and others; licence to make saltpetre in an open field of four acres, sufficient to serve the kingdom, with other inventions and discoveries. (S. P. Dom. Charles I, vol. clxxxvii, No. 46.)

1631, 2nd February. John Evelyn to Secretary Coke. Notwithstanding the commands given to the East India Company, Collins their workman proceeds in the making of gunpowder, having repaired two of their mills wherewith he makes 30 barrels of powder weekly. His Majesty's deputies will not be able to continue that employment if this course be permitted. (S. P. Dom. Charles I, vol. clxxxiv, No. 4.)

1631, 16th March. Thomas Thornhill to the Lords of the Admiralty. He complains of endeavours made to prevent the search for saltpetre, by laying soap ashes on the earth, paving cellars with stone, or filling them with gravel. (S. P. Dom. Charles I, vol. clxxxvi, No. 102.)

1631, April. Requests of Stephen Barrett, John Vincent, Thomas Hilliard, and five others, the Deputies of the Lords of the Admiralty for making saltpetre, to the same Lords. It being the pleasure of the Lords to renew or alter the Commission under which the Deputies act, they set forth certain provisions which they desire to have inserted in the new Commission for their defence. Among other things, if forbidden to dig in bedrooms, they desire not to be debarred from digging in other rooms in dwelling houses; also that owners of dove houses and stables should be prohibited from adopting measures which prevent the growth of saltpetre; that owners of carriages may still be compellable to carry the saltpetre at 4d. a mile; that the
Deputies may take wood ashes wherever found at a certain reasonable price; with other provisions framed in the same spirit. (S. P. Dom. Charles I, vol. clxxxix, No. 89.)

1631, 16th April. Minute by Nicholas of business to be considered by the Lords of the Admiralty at their meeting this day . . . a new commission for saltpetre. (S. P. Dom. Charles I, vol. clxxxviii, No. 76.)

1631, 20th May. Petition of the Deputies for making saltpetre to the Lords of the Admiralty. About two years since petitioners contracted with the Lords of the Admiralty to furnish saltpetre for seven years whereupon they provided utensils of great value. It being their Lordships' pleasure to renew the contract with reduced proportions and increased price of carriages, and conditions so restrictive that, as may appear by the annexed reasons, they are not able to do the service, they pray for such a commission as shall enable them to perform the service and if the Lords raise the price of carriages, that they will give a proportionable price for petre. Annexed is paper giving further details. (S. P. Dom. Charles I, vol. cxcii, No. 73.)

1631, 14th June. Matthew Goad, Deputy Clerk of the Star Chamber, to the Judges of the same Court. Certificate that in the cause of John Morley and others against Thos. Hilliard and others, it is confessed in the answers of the defendants that some of them dug for saltpetre under the beds of persons who were sick therein, that compositions were taken for discharge of carts commanded to carry saltpetre, that Hilliard hired horses to draw his wife's coach up and down the country at the King's price, and caused the country to carry coals for the work of saltpetre, and sold the same again to his own advantage. (S. P. Dom. Charles I, vol. cxcii, No. 83.)

1631, 17th June. Commission to the Lord Treasurer and others to work and make saltpetre and gunpowder, by themselves or their deputies, within England and Ireland, according to former
commissions, with alterations thought fit for the better furtherance of this service. (S. P. Dom. Charles I, Docquet 15.)

1631, 1st July. Commission to Lord Treasurer Weston, the Earls of Lindsey and Dorset, Secretary Dorchester, Horace Lord Vere, and Secretary Coke, to make saltpetre and gunpowder, with a variety of limitations of the power to be exercised by their deputies for making saltpetre, framed with the view of obviating recent complaints. (S. P. Dom. Elizabeth, vol. ccxxxvii, fol. 102b.)

1631, 24th September. Robert Dreive and John Foyle to the Lords of the Admiralty. Have received information that John Coslett (Corseley) and William Baber, two powder makers of Bristol, have of late bartered with Thomas Hilliard, the saltpetre man, for the great quantities of his Majesty's saltpetre and have caused the same to be conveyed secretly in the night, in close sacks and barrels to Bristol, and have there converted the same into powder for their private benefit. The writers required Coslett and Baber by warrant to appear before them, but Baber, having some private foreknowledge, could not be spoken with, and Coslett refused to appear. (S. P. Dom. Charles I, vol. cc, No. 26.)

1631, 30th September. Petition of the saltpetre makers to the Lords of the Admiralty. Pray for some order that the saltpetre they have made for the King's service may be received and paid for, or leave granted to petitioners to sell, and to his Majesty's subjects to buy the same, with the vessels and materials that lie useless upon loss and decay. (S. P. Dom. Charles I, vol. cc, No. 47.)

1631, 3rd December. Attorney-General Noy to the Lords of the Admiralty. Has had conference with John Corseley and William Baber, powder makers and examined them. Baber has been a powder maker 12 years, and never licensed. Corseley was awhile licensed for provision of the shipping at Bristol....
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There are other makers about Bristol. Enclosed examinations of William Baber and John Corseley. (S. P. Dom. Charles I, vol. cciv, No. 9.)

1632, 11th February. Petition of the saltpetre makers to the Lords of the Admiralty. Have for a long time attended and been suitors to have their petre received, and to know how they were to be appointed and disposed of, with their vessels and materials provided for the King's service. They pray the Lords to hear their grievances. (S. P. Dom. Charles I, vol. ccxi, No. 35.)

1632, 24th February. Note of agreement with Mr. Evelyn, for supplying the King with powder for three years at 8d., the King to have the whole sale, and Evelyn to leave the business at a year's warning. (S. P. Dom. Charles I, vol. ccxi, No. 78.)

Memorandum to take the name of the powder makers in Bristol from Mr. Evelyn, and to send for them by warrant, and also to give Mr. Attorney order about prohibiting the East India Company from making powder. (Ibid., No. 79.)

1632, 5th May. The Council to all Mayors, Justices, etc. Warrant of assistance to Thomas Thornhill, authorized for the sole making of saltpetre in London and Westminster. (S. P. Dom. Charles I, vol. ccxvi, No. 20.)

1632, 7th June. Indenture made between Lord Treasurer Weston, Robert Earl of Lindsey, Edward Earl of Dorset, Horace Lord Vere, Master of the Ordnance, and Secretary Coke on His Majesty's behalf, on the one part, and John Evelyn of Godstone, co. Surrey on the other part. Contract for converting all the saltpetre obtained for his Majesty in any part of his dominions into gunpowder, and delivering the same in certain quantities and at certain times and prices in this indenture stated. (S. P. Dom. Elizabeth, vol. ccxxxvii, fol. 122.)

1632, 27th June. Examinations of petitions of Robert Powell, and others concerning the sale of saltpetre to private powder
BRITISH EXPLOSIVES INDUSTRY


1632, 30th June (?). Notes by Nicholas of business to be transacted by the Lords of the Admiralty. The saltpetre men and powder makers have been examined and attend their Lordships pleasure for their discharge. (S. P. Dom. Charles I, vol. ccxix, No. 53.)

Petition of Sir John Hungerford and Sir William Sandys, deputy Lieutenants for co. Gloucester, to the Council. They have undertaken to provide powder and match for the magazine of the Seven Hundreds of Cirencester. Pray a warrant to be furnished with 13 barrels of powder and match from Mr. Evelyn. (S. P. Dom. Charles I, vol. cclvii, No. 59.)

1633, 20th March. Account of all the saltpetre brought into His Majesty's store, and delivered to Mr. Evelyn, from July 20, 1632, to March 20, 1633; total brought in, 1,541 cwt. 3 qr. 12 lb. being a deficiency of 297 cwt. (S. P. Dom. Charles I, vol. ccxxxiv, No. 28.)

1633, 12th November. The Lords of the Admiralty to Attorney-General Noy. By the deaths of the Earl of Pembroke and Viscount Dorchester the number of commissioners for making saltpetre and gunpowder (under commission of 8 April 5, Charles I) is diminished. A new commission is to be prepared, to the surviving commissioners, with Lord Cottington, Sir Henry Vane, Controller of the Household, and Sir Francis Windebank. (S. P. Dom, Charles I, vol. ccxxviii, f. 90.)

1633, 16th November. The Lords of the Admiralty to John Hungerford and other J.P.s for Wilts, to enquire concerning complaints received, that divers persons make saltpetre in Sherston Magna, Wilts, without authority, and sell the same to Gunpowder makers in Bristol. (S. P. Dom. Charles I, vol. ccxxviii, f. 94a.)

1633, 20th November. Account by Richard Poole of the saltpetre
brought into His Majesty's store by the saltpetre men, and
delivered to Mr. Evelyn, from 20th March, 1632, to this day.
Total quantity 1,404 cwt. 2 qr. 22 lb. (S. P. Dom. Charles I,
vol. ccli, No. 3.)

1634. Notes, by Nicholas, on the King's gain upon the sale of

1634 (?). Petition of Richard Bagnall, saltpetre man, as to one hogshead
of saltpetre lost in transit, value £21 11s. 8d. (S. P. Dom.
Charles I, vol. cclxxix, No. 52.)

1634, 14th March. A proclamation for the preservation of the mines
of saltpetre. No dovehouse or dovecot or cellar to be
paved, and no stables pitched paved or gravelled, where horse
feet stand, but planked only. (Rymer's "Foedera," xix, p.
601.)

1634, 18th March. The Lords of the Admiralty to the Governor and
Company of Soapboilers. Give orders that the saltpetre men
are to have the pre-emption of wood ashes, on the ground that
saltpetre is a commodity of such necessary use for the King and
Public that it ought to be preferred before the making of soap.

1634, 18th April. Commission to Richard Earl of Portland to work
for saltpetre. (Patent Roll, 10 Charles I, p. 9, No. 2 dorso.)

1634, 19th April. Petition of John Carsley to the Admiralty. In
1 Charles I the King granted the city of Bristol leave to make
400 or 500 barrels of powder yearly, to furnish their shipping.
Petitioner was appointed by the city to make part of their
powder, and spent £200 in building a powder house. Because
there is much old powder to be mended and no petre to be had,
he begs that he may either have "200" of petre appointed to
him weekly from some petremen adjoining Bristol, or that he
may have Somerset or South Wales appointed him to make
petre. (Endorsed that the petitioner enter into a bond of £500
not to make any more powder without licence, or else to be

1634, 24th April. Conditions offered to consideration touching the undertaking to make powder. (These are probably terms offered by Sir John Heydon, and submitted to the King. They comprise all such conditions as were binding on Mr. Evelyn, with some additions.) (Ibid., Nos. 31 and 31(i) are questions on the same matter. S. P. Dom. Charles I, vol. cclxvi, No. 30.)

1634, 3rd May. Account, by Richard Poole, of saltpetre brought into store by the saltpetre men and delivered to Mr. Evelyn from May 3, 1633, to this day. Total, 115 lasts, 11 cwt. 3 qr. 27 lb. (S. P. Dom. Charles I, vol. cclxvii, No. 29.)

1634, 8th May. Statement by John Evelyn of the division of shires among the various saltpetre men, and the amount to be returned by each weekly, according to a single proportion in 1625, and a double proportion in 1629. (S. P. Dom. Charles I, vol. cclxvii, No. 59.)


1634, 18th May. Petition of Sir Philiberto Vernatti and John Battalion, of Yardley, co. Herts, to the King. Battalion had about a dozen years since been often admitted into the late King's presence, acquainting him with the secret of making excellent saltpetre and powder, of which also his Majesty has within these few days been likewise made acquainted by Sir Philiberto. They complain of certain impediments, the chief being that the King had granted a patent for making of petre out of the city excrements to Thomas Russell, and he was to furnish the storehouses with 300 tons of petre every year, but has never served any at all. They pray that Russell's patent
may be disannulled and granted to them. (S. P. Dom. Charles I, vol. cclxviii, No. 24.)

1634, 22nd May. Petition of William Burrowes, one of the deputies for making saltpetre to the Lords of the Admiralty. He has for many years been deputy in cos. Notts, Leicester, Stafford and Derby, and has delivered a fuller proportion than was ever raised out of these counties, until, by the last commission he was restrained from most part of the ground fit for the same. He has always in the summer time performed this service, but in the winter could not, because all the men have their barns filled with corn; most of the dove-houses in those counties are lofts built from the ground, which, in other counties, afford much petre, of late, also, 2 potash works have been set up on either side of him, so that ashes are to be had only at double rates. (S. P. Dom. Charles I, vol. cclxviii, No. 49.)

1634, 31st May. Ordered that Timothy Thornhill may be associated with his father Thomas in the deputation for London for working saltpetre; and Thomas's son John, in the deputation for the counties that Hilliard formerly had. (S. P. Dom. Charles I, vol. cclxiv, f. 19.)

1634, 3rd June. Certificate of the swearing of Walter Parker to be King's servant in ordinary for the manufacture of gunpowder for the King's own use. (S. P. Dom. Charles I, vol. cclxix, No. 38.)


1634, 9th June. Richard Bagnall of North Morton, Berks, deputy for making saltpetre in Berks, to Secretary Nicholas. His difficulties in being denied access to pigeon houses, etc. He is tied to 8 lbs. a week, but will not be able to perform 3 lbs. (S. P. Dom. Charles I, vol. cclxix, No. 57; Ibid., 57, i. Deposition of the said Bagnall.)
1634, 14th June. List of the Saltpetre men.

Order by the commissioners on petition of Stephen Barrett, a saltpetre man for 20 years, but restrained by the late commissioners. John Evelyn to certify as to his ability. (S. P. Dom. Charles I, vol. ccxci, p. 219.)

1634, 16th June. Bond in £200 by Richard Watts alias Martin; Roger Powell of Sherston Magna, Wilts, husbandmen, and Thomas Davis of do. yeoman, to deliver 2 cwt. of saltpetre within 40 days at the King's storehouse for saltpetre in London, or in Southwark at the Bell. (S. P. Dom. Charles I, vol. cclxix, No. 91.)

1634 (?) July. Statement (by Nicholas ?) of the various prices paid by the King for gunpowder and saltpetre, under contracts with the gunpowder maker and saltpetre men in 1632 and 1634, and the greater advantage derived by the King under the latter. (S. P. Dom. Charles I, vol. ccxcii, p. 223.)

1634, 11th July. Certificate that since 16 May John Giffard had delivered 97 cwt. 27 lbs. of saltpetre into the King's store. (S. P. Dom. Charles I, vol. cclxxi, No. 60.)

1634, 17th July. Order by the commissioners for saltpetre on complaint of Thomas Thornhill, saltpetre man for the greatest part of Co. Somerset, that John Giffard the saltpetre man appointed for Bristol and 10 miles round, had set up his works in Bath.

Giffard to continue his works for this season, and when seasonable to work the same grounds again, Thornhill to have the working thereof. (S. P. Dom. Charles I, vol. ccxcii, p. 222.)

1634, 3rd November. Account by Richard Poole, of saltpetre brought into His Majesty's store by the saltpetre men, and delivered to Mr. Evelyn from May 3 last to this day. Total, 1,406 cwt. 2 qr. 20 lb. which was 75 cwt. 1 qr. 8 lb. less than the assigned proportion. (S. P. Dom. Charles I, vol. cclxxvii, No. 9.)

1634, 15th November. Richard Bagnall, saltpetre man to Nicholas.
Sends enclosed list of names of those who have lately carried forth their earth in their pigeon houses. If some course be not taken others will do the same, and it will be impossible for the saltpetre men to supply their great proportions, besides destroying the mine. (S. P. Dom. Charles I, vol. cclxxvii, No. 52.)

Annexed list (52. i) above mentioned.


1634, 22nd November. The Lords of the Admiralty to the Attorney directing him to consider the new commission for making saltpetre and gunpowder, giving, in minute detail, the directions to be issued to J.P.s with regard to the preservation of grounds for making saltpetre. (S. P. Dom. Charles, vol. cclxiv, f. 52.)

1634, 26th November. The Lords of the Admiralty to Montjoy Earl of Newport. His Majesty is resolved to take into his hands and disposition all the gunpowder made of the saltpetre of the kingdom, for better furnishing his occasions and those of his subjects. (S. P. Dom. Charles I, vol. cclxxvii, No. 96.)

1634, 2nd December. Petition of John Giffard, saltpetre man to the Lords of the Admiralty. His hindrances by refusal of people in Gloucester to carry coal from the adjacent pits to his boiling-house in Thornburg; also because they carry off the earth from their pigeon-houses to manure their lands. (S. P. Dom. Charles I, vol. cclxxviii, No. 4.)

1635. Proposal of Mr. Evelyn, that if the sole making and selling of gunpowder were taken into the King’s hands, the stores being first furnished, the residue might be sold to the subject at 1od. per lb. which would give the King a profit of £3,000 per annum. (S. P. Dom. Charles I, vol. cccvi, No. 110.)

Report from the Lords of the Admiralty as Commissioners of saltpetre to the Council. It was not fit at this time to break the contract for powder, lest the present supply should be a-wanting. Mr. Evelyn could make a larger proportion of gun-
powder, if he might receive a greater quantity of saltpetre. They suggest that the Lords should permit any man to make powder of foreign saltpetre. (S. P. Dom. Charles I, vol. cccvi, No. 112.)

Estimate of the cost and profit of converting 50 lasts of saltpetre into gunpowder. The cost of materials and manufacture for 50 lasts is estimated at £3,280; the return at 7d. per lb. is put down at £3,500; the clear gain would therefore be £220. Upon 100 lasts the profit would be £600, or if the powder were sold at 7½d. per lb., £1,100. Upon 240 lasts the profit at 7d. is £1,994 15s., or at 7½d., £3,194 15s. (Ibid., No. 113.)

Notes and calculations relating to the supply of saltpetre and the manufacture of gunpowder. To make 240 lasts of gunpowder requires 240 lasts of saltpetre. Italian brimstone varies in price from 22 shillings, to near 30 shillings a cwt., and coal of alder wood is worth two pence per lb. (Ibid., No. 114.)


1635, 7th February. Petition of Thomas Thornhill, saltpetre maker, complaining that Toby Atkins of Hazelburg, Somerset, wrought all about Wells and Bridgewater, and sold the saltpetre to the powder makers of Bristol. Henry Goodman does the same all round Taunton, so that petitioner has no ground left to work upon, but such as they refuse. In London the cellars and vaults, where the mine of saltpetre used to grow, are so destroyed with paving and pitching, that, if some speedy course be not taken, all the mines will be destroyed. (S. P. Dom. Charles I, vol. cclxxxiii, No. 18.)

1635, 4th March. Minute of a treaty between the Lords of the Admiralty and John Evelyn concerning the renewing of his contract for making gunpowder. Evelyn offered to supply
20 lasts of gunpowder every month, provided a sufficient quantity of saltpetre were delivered to him for that purpose. He would pay the saltpetre man after the rates expressed in his former contract. He stipulated for the sole making of powder in this kingdom. If not paid by the King within 14 days after delivery he desired permission to sell the powder for his own benefit. He told the Lords that he could not deliver powder at 9d. per lb. by reason the King takes the sale thereof into his own hands. Thereupon the Lords thought not fit to treat any further with Evelyn, but rather to deal with others who offered to contract at easier rates. (S. P. Dom. Charles I, vol. cclxxxiv, No. 18.)

1635, 13th March. Order of Council. The Lords Commissioners for Gunpowder and Saltpetre with the Master of the Ordnance are to treat with Mr. Evelyn or any other they shall think fit, for making gunpowder for his Majesty. (S. P. Dom. Charles I, vol. cclxxxiv, No. 71.)

1635, 14th March. Proclamation for preservation of grounds for making saltpetre, and to restore such grounds as are now destroyed, commanding all to give assistance to the saltpetre makers. Paving of cellars and vaults, flooring of dovehouses, is strictly prohibited. (S. P. Dom. Charles I, Proclamations No. 189.)

1635, 25th March. Special commission to the Earl of Arundell and others for the sale of gunpowder. (Rymer's "Foedera," xix, p. 603.)

1635, 1st April. Entry on the Admiralty register of the appearance of Walter Parker gunpowder maker of Stockwood, Dorset. (Ibid., vol. cclxiv, f. 104.)

1635, 4th April. Petition of said Walter Parker, who has been a gunpowder maker since '88. If he has transgressed the King's command it was done in ignorance. The King himself has made trial of the petitioner's powder, and upon approbation thereof
caused Parker to be sworn his servant in ordinary. (S. P. Dom. Charles I, vol. ccxxxvi, No. 27.)

1635, 16th April. At a meeting of the Commissioners for Trade, the King told the Commissioners that Sir Arthur Mainwaring and Pitcairn will serve powder within half a year at 8d. per lb. The Earl of Newport and Sir John Heydon offer to make it, with a stock at 7d. the lb. “Six, one and one” is six parts of saltpetre, one of coal, and one of brimstone. If upon His Majesty’s stock of £4,000, the Earl of Newport and Sir John Heydon will serve it for 7d.; if upon their own stock, they will serve it for 8d. Evelyn to furnish powder at 8d. for six months after the contract ended. 16 lasts the month. (S. P. Dom. Charles I, vol. cclxxxiii, No. 13.)

1635, 18th April. Parker is ordered to find security not to sell powder to any but the King. (S. P. Dom. Charles I, vol. ccxxxvii, No. 1.)

1635, 18th April. Admiralty order to enquire concerning complaints of Thomas Thornhill that divers persons in Somerset, contrary to proclamations, have carried forth the earth out of their dove-houses, and divers inn-keepers have paved their stables, by which practices the mine of saltpetre is destroyed. (S. P. Dom. Charles I, vol. cclxiv, f. 115.)

1635, 25th April. Note of business transacted by the Lords of the Treasury. The East India Company desiring to send a quantity of saltpetre beyond sea, the Lords thought the King should have the quantity he is to buy of them at £3 3s. 4d. per ton, before they transport theirs. (S. P. Dom. Charles I, vol. cclxxxv, No. 7.)

1635, 3rd May. Account by Richard Poole of saltpetre brought into His Majesty’s store by saltpetre men, and delivered to Mr. Evelyn from Nov. 3, 1634; total 1,290 cwt, 3 qr. 18 lb. which is 71 lasts 12 cwt. 3 qr. 18 lb. and is 321 cwt. 10 lb. less than the assigned proportion. (S. P. Dom. Charles I, vol. cclxxxviii, No. 27.)
1635, May 28. Draft renewed contract of John Evelyn of Godstone, Surrey, with the King. Evelyn stipulates to deliver monthly for six months from the 1st inst. 16 lasts of gunpowder at 8d. per lb. and to take all saltpetre made in the realm, paying for the same £3 3s. 4d. per cwt. (S. P. Dom. Charles I, vol. ccclxxxix, No. 61.)

1635, June 6. Proposition of Sir Arthur Mainwaring and Andrew Pitcairn, touching the manufacture of gunpowder. They will contract to supply 240 lasts of gunpowder yearly, if a sufficient quantity of saltpetre be delivered to them. They are to be paid 8d. per lb. for the gunpowder, and will pay £3 3s. 4d. for every 112 lbs. of saltpetre. His Majesty having present occasion for 40 lasts of saltpetre to be converted into gunpowder, over and above the contracted proportion of 240 lasts per annum, the proposers engage that within 14 days they will work upon the said petre with their three mills, and make six lasts monthly, and complete the 40 lasts by the end of October. (S. P. Dom. Charles I, vol. ccxc, No. 42.)

1635, 20th June. Order on petition of John Reynolds, master gunner of England and proof-master for gunpowder, who for 12 years has had an allowance of 6d. every barrel of one cwt. (S. P. Dom. Charles I, vol. cclxiv, p. 137.)

1635, 4th July. The commissioners of saltpetre cancel Stephen Barrett’s appointment, because he has failed to bring in his proportion; Hugh Grove appointed in his stead. Barrett is therefore to strike his works and return his deputation. (S. P. Dom. Charles I, vol. ccxcii, p. 230.)

1635, 4th July. Warrant to pay the Governor and Committees of the East Indian Company for 40 lasts of double refined saltpetre, after the rate of £4 per hundred, or for so much as shall be delivered to his Majesty’s powder maker. (S. P. Dom. Docquets, vol. xvi, under date.)

1 For cos. Cambridge, Hunts, Lincoln etc., ibid., vol. ccxcii, p. 231.
1635, 14th July. Notes by Nicholas of proceedings at a meeting of the commissioners for ordnance.

John Evelyn to be spoken with about powder sold to the King at £2d. per lb., the retailer in London was to sell the same at £3d., and in the country at 14d.; also about the supply of musket, pistol and birding powder. (S. P. Dom. Charles I, vol. ccxcii, No. 112.)

1635, 9th October. Deed of covenant between the Earl of Lindsey and others, on the King's behalf of the one part and John Evelyn of Godstone, Surrey, of the other part. Evelyn to have the sole making of gunpowder from Nov. 1 next for one year; to pay £3 3s. 4d. a cwt. for all saltpetre brought in by the saltpetre men, to convert the same petre into gunpowder to be delivered to his Majesty's stores in the Tower by 20 lasts a month, every last containing 24 barrels, and every barrel 100 lb., such powder to be paid for at the rate of 8d. per lb. and to be made of six-eight parts of double refined saltpetre, one eighth part of Naples brimstone, and the remaining eighth part of coal. (S. P. Dom. Charles I, vol. ccxcii, p. 191.)

1635 (?) November. Draft of Indenture between the Lords of the Admiralty as commissioners for saltpetre and gunpowder on the part of his Majesty and Edward Collins of Chilworth, Surrey.

His Majesty having contracted with the Company of London Merchants trading to "East Indies" for a quantity of saltpetre to be brought from foreign ports, it had been agreed with Collins that he should for one year have the sole making into gunpowder of the aforesaid foreign saltpetre to the quantity of 100 lasts.

He is to pay £3 3s. 4d. per cwt. for the gunpowder, and to receive 7d. per lb. for the manufactured powder. (S. P. Dom. Charles I, vol. cccii, No. 119.)

1635 (November). Indenture between (the Lords of the Admiralty as
Commissioners for Saltpetre and Gunpowder) on the part of his Majesty and Edward Collins of Chilworth, Surrey. His Majesty having contracted with the company of London Merchants trading "to East Indies" for a quantity of saltpetre to be brought from foreign parts, it had been agreed with Collins that he should for one year have the sole making into gunpowder of the aforesaid foreign saltpetre to the quantity of 100 lasts. The present deed contains the stipulations deemed necessary for carrying out this agreement. Collins was to pay for the saltpetre at the rate of £3 3s. 4d. per cwt. and was to receive 7d. per lb. for the gunpowder which he was to manufacture. (Draft with many blanks.) (S. P. Dom. Charles I, vol. cccii, No. 119.)

1635, 3rd November. Account by Richard Poole of all saltpetre brought into his Majesty's store from May 3 to this day. Besides the amount brought in by the saltpetre men, the East India Company had brought in 801 cwt. 19½ lb. which made the total brought in 2,259 cwt. 2 qr. 16½ lb. which was 93 cwt. 2 qr. 3 lb. less than the quantity assigned to be brought in by the saltpetre men only. (S. P. Dom. Charles I, vol. ccci, No. 10.)

1636 (?) Francis Vincent, saltpetre man, to the Lords of the Admiralty. Complains against Nicholas Carpenter and Richard Tiler, who being warned to furnish carts to carry liquor from Cheam to his Majesty's saltpetre house in Kingston, being four miles, denied the same, and being called before Sir Nicholas Carew, stood upon a privilege they had. Sir Nicholas bound them to answer before the Lords, who ordered them to perform the service and to give Vincent satisfaction for his loss and charges, which latter they still refuse to do. (S. P. Dom. Charles I, vol. cccxli, No. 69.)

1636 (?) Petition of Robert Davies to the Council. According to their order petitioner had delivered all the saltpetre he had in hand to the Officers of the Ordnance amounting to 7 cwt. and a half
and 8 lbs. Much of it was of the same sort as the Lords buy from the Barbary merchants at 45s. a cwt. but it cost petitioner £3 15s. 0d. Prays payment according to the rate he gave for it. (S. P. Dom. Charles I, cccxli, No. 70.)

1636. Minutes of Mr. Evelyn's petitions. He prays allowance for 1,135 barrels of gunpowder made with his own saltpetre, also for losses by pounds, mills, and other workhouses erected for the public service; also for a legal discharge of his contracts for making gunpowder. (S. P. Dom. Charles I, vol. cccxli, No. 79.)

1636, 5th January. Petition of the corporation of Norwich to the commissioners of Saltpetre, as to endangering of the foundations of Norwich by Nathaniel Sykes and his workmen digging for saltpetre. There are other papers connected with this matter, showing detail of damages, etc. (S. P. Dom. Charles I, vol. cccxi.)

1636, 19th January. Order of Council. The King is resolved to take to himself all saltpetre made in England and Wales, and to sell such powder as is made thereof, over and above that which shall be necessary for his own service. Order is therefore made to carry out the same. (S. P. Dom. Charles I, vol. cccxi, No. 84.)

1636, 11th February. Notes by Nicholas of business transacted by the Lords of the Admiralty. Order on the petition of the saltpetre men concerning ashes for want whereof their works are at a stand. (S. P. Dom. Charles I, vol. cccxiii, No. 84.)

1636, 20th February. Prohibition of importation of gunpowder. Also to sell at 1s. 6d. per lb. within 30 miles from London or any of H.M. Ports, otherwise at 1s. 8½d. per lb. (Rymer's "Foedera," xx, p. 107.)


1636, 3rd April. Account rendered by Richard Poole of all the salt-
petre brought into His Majesty's stores, and delivered to Mr. Evelyn, from Nov. 3, 1635, to April 3, 1636. The sum total was 1,288 cwt. 1 qr. 15½ lb. which was 193 cwt. less than the proportion assigned. (S. P. Dom. Charles I, vol. cccxviii, No. 13.)

1636, 7th April. The Lords of the Admiralty to Attorney General Bankes, directing him to prepare a bill for the royal signature containing a like commission for making saltpetre and gunpowder as was renewed in April, 1634, to be directed to Lord Treasurer Juxon, the Earls of Lindsey, Dorset and Newport, Lord Cottington, Mr. Comptroller (Sir Henry Vane), and secretaries Coke and Windebank. (S. P. Dom. Charles I, vol. cccxviii, No. 38.)

1636, 7th April. Richard Poole to the Lords of the Admiralty. According to command he certified the reasons of the petremen's failings in their proportions.

(1) That wood ashes are so scarce, they can hardly be got at all. Those the petremen get cost 10½d. or 11d. a bushel which theretofore they got for 4d.

(2) The unwillingness of most of the King's subjects to do anything for this service.

(3) The destruction of dove cotes.


1636, 29th April. Proposition for making gunpowder by new contractors. They offer to make 240 lasts of powder yearly by 20 lasts a month, at 7½d. per lb. for seven years from Nov. 1, 1636. They stipulate for £2,000 to be impressed by His
Majesty towards the building of mills and furnishing utensils, which at the expiry of the contract are to be delivered to His Majesty's use; they are to have the sole making of gunpowder in England and Ireland, to pay for saltpetre at £3 3s. 4d. the cwt. The King will thereby save £1,200 per annum. (S. P. Dom. Charles I, vol. ccxxi, No. 69.)


1636, 11th May. Order of Council. The contract made with Mr. Evelyn for furnishing gunpowder being almost expired, it is ordered that the Commissioners for gunpowder and saltpetre forthwith contract with Samuel Cordwell and Thomas Collins or with any other they shall think best. (S. P. Dom. Charles I, vol. cccx, No. 72.)

1636, 17th May. Minute by Nicholas of proceedings at a conference between the Governor and company of soapmakers and the saltpetre men. The latter proposed

(1) That the potash makers be restrained from gathering ashes within 12 miles of any of the saltpetre men's pitches.

(2) That a strict course be taken to prevent the exportation of ashes.

(3) That no ash-gatherers be permitted, unless licensed by the potash makers and saltpetre men.

There are other papers relative to the rivalry of the soapmakers and saltpetre men for ashes. (S. P. Dom. Charles I, vol. cccxxi, No. 33.)

CHRONOLOGY

Francis Windbank to be Commissioners for Ordnance with authority to sell powder according to their discretion. (Rymer's "Foedera," xx, p. 17.)

1636, 9th June. Westminster. Warrant to the Exchequer to pay out of the £3,000 lately received by Sir John Heydon, Lieutenant General of the Ordnance, from Sir William Russell, £854 15s. 8d., viz. to the East India Co. £170, and to Edward Sherborne, Clerk of the Ordnance, £571 os. 10d. for unrefined saltpetre delivered by them, upon the King's command to Edward Collins to be double refined for the King's service, and to the widow and executrix of the said Collins £100 14s. 10d. for his pains in such double refining, and £13 more for his pains in making one last of powder. (S. P. Dom. Charles I, vol. 325, No. 83.)

1636, December. Petition of Samuel Cordewell and George Collins, his Majesty's powder makers to the Lords of the Admiralty. The Lords have covenanted with petitioners that no person, from the end of October last past, during the existence of petitioner's contract, shall make any powder besides petitioners. Yet Mr. Evelyn, the late powder maker, still continues working, to the prejudice of his Majesty's service and disabling petitioners to perform their contract, for Mr. Evelyn works out the saltpetre which petitioners should have. Pray order that Mr. Evelyn may be suppressed from making more powder. (S. P. Dom. Charles I, vol. cccxxxviii, No. 49.)

1636, 24th December. Contract made with "our gun powder makers" Samuel Cordwell and George Collins for the sole making and converting into gunpowder of all saltpetre for the space of 13 years. Powder to be bought at 7½d. per lb. (Rymer's "Foederæ," xx, p. 96. See also Patent Roll, 12 Charles I, pt. ii, No. 19 dorso.)

1637 (?) Petition of Deputies for saltpetre to the Commissioners for saltpetre and gunpowder. Mr. Cordewell, the powder maker,
contrary to the contract made by you with us your Deputies, refuses to pay for our saltpetre. Having laid out our estates in this service, having great store of petre in hand, and this being the time to make our provisions to go on with the work in winter, we are enforced to represent that, except our salt-petre be taken off our hands, and money paid for the same, we must strike our works, and discharge our servants, which will be to our extreme loss, besides the prejudice to the King's service. (S. P. Dom. Charles I, vol. cccxvi, No. 155.)


1637, 4th April. Officers of the Ordnance to Montjoy, Earl of Newport, Master-General of the Ordnance. By Letters of the Lords of the Admiralty of 2nd of last month, the writers are required to search for all Mr. Evelyn's contracts from 20th James I, and to certify whether any moneys were imprested to Mr. Evelyn, whether Mr. Evelyn was not obliged when the King did not take off his powder, to sell it to the subject at a certain price; whether upon sale of powder he was accountable in any sort to His Majesty; and, lastly, whether the former contracts have been duly performed. The writers report fully on the contents of all the contracts, and the variations between them, and on all the other points indicated. They also insert tabular statements of all the powder Mr. Evelyn was bound to bring in, and how much he had actually delivered. Upon the whole contracts they report that there was wanting of the total quantity which Mr. Evelyn contracted to bring in, 1480 lasts. (S. P. Dom. Charles I, vol. ccclii, No. 27.)

1637, 25th April. Mountjoy Earl of Newport and others authorized
to make choice of and license retailers for gunpowder. (Patent Roll, 13 Charles I, pt. xxx, No. 7 dorso.)

1637, 3rd May. Whitehall. Lords of the Admiralty to Montjoy, Earl of Newport, Master of the Ordnance.

To issue 28 barrels of gunpowder at 18d. per pound to the Mayflower, William Beddiloe, Master, and 36 barrels to the Pleiades, James Hall, master, employed in His Majesty’s service. (S. P. Dom. Charles I, vol. ccclv, No. 60.)

1637, 3rd May. Whitehall. Draft minute of same for entry in book of such warrants. (Ibid.)

1637, 3rd May. Entry of the same. (Ibid.)

Draft minute of similar warrant for 36 barrels of gunpowder to be supplied to the Richard and Mary, Nicholas Hilson, Master. (S. P. Dom. Charles I, vol. ccclv, No. 61.)

1637, 3rd May. Entry of the same. (Ibid.)

1637, 22nd May. London House. Minute of agreement between the Lords of the Admiralty and Alderman Garraway and others, on behalf of the East India Co., that they shall have £3 10s. per cwt. for the foreign saltpetre they now have; and of a further agreement with Samuel Cordewell that he shall have £4 11s. 8d. per cwt. for so much of the said saltpetre as he should refine. (S. P. Dom. Charles I, vol. ccxcii, p. 48.)

1637, 22nd May. Samuel Cordewell to the Lords of the Admiralty. That such saltpetre as the East India Merchants have brought over may be had, for otherwise “my mills must stand still.” That he may renew the powder taken out of the Anne. (S. P. Dom. Charles I, vol. ccclvii, No. 38.)

1637, 3rd June. Articles exhibited to the Commissioners for Saltpetre by Christopher Wren, Dean of Windsor, and Rector of Knoyle Magna or Epicopi, Wilts, against Thomas Thornhill, saltpetreman, for damage done by digging for saltpetre in the pigeon-house of the said rectory. There have been two diggings in this pigeon-house, one by Helyar, whom Thornhill then
served, about eight years ago, the other by Thornhill in March, 1636-7. On the first occasion, the pigeon-house, built of massy stone walls 20 ft. high, was so shaken that the Rector was forced to buttress up the east side thereof. On the last occasion the foundation was undermined, and the north wall fell in. The loss to the Rector had been that of three breeds, whereof the least never yielded fewer than 30 or 40 dozen, and of the whole flight, which forsook the house, and the Rector stands endangered to the law for dilapidations. Thornhill has refused all recompense, telling the Dean that the King must bear him out. The Dean desires that Thornhill may make full recompense according to the King's pleasure signified on behalf of the Dean, who is registrar of the Garter, at the last chapter of the Order in Whitehall on 18th April last. Underwritten:

8.1. Order of the Lords that Thornhill answer these articles by that day sennight. Whitehall, 3rd June, 1637. (S. P. Dom. Charles I, vol. ccclxi, No. 8.)

1637, 7th June. Bishop of London and others obtain authority similar to that of 18/4/1634 for digging saltpetre and making it into powder. (Patent Roll, 13 Charles I, pt. xxx, No. 3 dorso. Also House of Lords Papers, Hist. MSS. Comm., rep. 4, p. 22.)

1637, September. Petition of William Felgate, Edmund Beane, Robert Russell, Thomas Frere, and others, provisioners of gunpowder for shipping to the Lords of the Admiralty. His Majesty having taken into his hand the sale of powder to his subjects at 12d. per pound, petitioners took out of his store in one year to the value of near £10,000. His Majesty has lately set the price at 18d. per lb. and ordered that none be bought or sold without licence, from the Earl of Newport, unto whom petitioners addressed. He referred them to his Secretary, Mr. Barnard, to make their conditions, which were to pay His Majesty 18d. per lb., and to Lord Newport 1d. per lb. besides petty charges, which rate is so great that petitioners refused to
take licences. Pray leave to buy or sell powder at such price as you think fit. (S. P. Dom. Charles I, vol. ccclxviii, No. 112.)

1637, 1st November. Account by Richard Poole of saltpetre brought into his Majesty's store, and delivered to Samuel Cordewell, the powder maker, from 1st May 1637, to this day. The total brought in was 128 lasts, 1 quarter and 13 lbs. of which 35 lasts 15 cwts. had been brought in by merchants and the remainder by the saltpetre men. (S. P. Dom. Charles I, vol. ccclxxi, No. 3.)

1637, 6th November. John Evelyn on account of faithful and honest dealing was discharged of the £2,000 lent him having released the King of £989 owing for gunpowder. (Patent Roll, 13 Charles I, pt. xvii, No. 5.)

1637, 17th November. Office of Ordnance. Officers of Ordnance to Lords of the Admiralty. Mr. Cordewell has brought into his Majesty's Magazine from 1st November 1636 to 7th November 1637 several quantities of good corn gunpowder, of which a detailed account is given, and which amount in the whole to 240 lasts, which is his full year's proportion according to his contract. (S. P. Dom. Charles I, vol. ccclxxi, No. 117.)

1637, 16th December. Whitehall. The Lords of the Admiralty to the Earl of Newport. About 20 tons of saltpetre, being by a Dutch merchant bought in Barbary of English factors, after his Majesty had contracted for all that should be made there, is unladen and put into the Custom House, London. As H.M. gunpowder maker complains that he wants saltpetre to keep his mills in work, we pray you to order the officers of the ordnance to appoint persons to set an indifferent price on the said saltpetre, that we may take order for payment and for delivery thereof, to be made fit for His Majesty's use. (S. P. Dom. Charles I, vol. cccliii, f. 75.)

1638, 26th June. Earl of Worcester to Cromwell. Keeps from him nothing that was in the ship except one piece of ordnance and
two barrels of powder which Sir Thomas Spert gave him. Has used part of two other barrels of powder, for which he has offered to make recompense. (S. P. Henry VIII, sec. 133, p. 210.)

1639, 9th February. Whitehall. Order to the commissioners for saltpetre. All the saltpetre made in the Kingdom is not enough by above 40 lasts, to make the proportion of gunpowder which H.M. gunpowder maker is by contract obliged to make yearly for his Majesty's service, insomuch as there is necessarily every year to be bought a great quantity of foreign saltpetre. The Lords did this day order that, on any contract made for any foreign saltpetre, notice shall be given to the office of ordnance, how much is contracted for, of whom, at what rate, to the end entry may be made in the said office accordingly, to remain upon register as a charge for the said gunpowder-makers account.

Likewise that Mr. Poole, who keeps account of all the home-made saltpetre, shall be hereby requested to keep a distinct register of the product of each parcel of foreign saltpetre that shall be delivered to His Majesty's gunpowder maker. (S. P. Dom. Charles I, vol. ccxii, p. 97.)

1639, 27th April. Office of Ordnance. Officers of ordnance to Sec. Windebank. Upon information that there was secretly brought into the house of Robert Davies, of Thames Street, divers barrels of powder which we conceived might be either foreign or embezzled out of some of His Majesty's ships, we granted a search warrant to our messenger, and perceive by his return that he has found the following: 8 cwt. saltpetre, about 10 bushels small coal, some sulphur, 4 mortars of wood and pestles, 2 brass pans, 6 bushels wood ashes and one searcher or sieve, whereby it is probable that Davies privately makes powder having all things necessary, and in regard he heretofore used that trade in Whitechapel parish, where by accident he had his
house blown up. The neighbours near Davies are very fearful that some unhappy accident may befall if he be suffered either to keep any great quantity of powder in his house or to make powder there, and therefore they have entreated us to make known the same to you that such order may be taken with him as you shall think fit, he having formerly been questioned before the Board for the like occasion and bond taken of him not to make any more powder. (S. P. Dom. Charles I, vol. cccccxviii, No. 69.)

1639, 12th November. Office of Ordnance. Officers of Ordnance to the Council. According to your direction we have examined our book of accounts, and find that Mr. Cordewell, his Majesty’s gunpowder maker has brought into the Tower of London from the 17th Nov. 1638 to the 10th inst. being the third year of his contract 240 lasts of gunpowder. (S. P. Dom. Charles I, vol. ccccxiii, No. 45.)

1639-40, 2nd January. Answer of Francis Coningesby, surveyor of the Ordnance to the Lords’ directions signified by Nicholas the 16th Dec. 1639. He never received any fee from any artificer or others delivering provisions into his Majesty’s stores, except occasionally a small voluntary gift. He has never upon any consideration advanced the King’s price for any private ends. His fee in the exchequer is £36 10s. and his allowance upon the ordinary of the office of ordnance £56 making a total of £92 10s. per annum of which he is at this time 1½ year in arrear. Hopes the Lords will conceive this to be only a competent allowance for his daily pains and attendance in these times. There was formerly paid to his predecessor by the gunpowder maker £200 per annum and since his coming into the office he has received of Mr. Evelyn £50 per annum, but this has been discontinued by Mr. Cordewell. (S. P. Dom. Charles I, vol. ccccxli, No. 11.)

1639-40, 2nd January. Office of Ordnance. Answer of Edward
Sherburne, clerk of the Ordnance. The fees attaching to his office are, out of the exchequer £36 10s. and out of the ordinary upon the quarter books £68 5s. making a total of £104 15s. per annum, of which he is at this time 1½ year in arrear. There was formerly paid by Mr. Evelyn £40 per annum which has been discontinued since the present gunpowder maker (Mr. Cordewell) has been employed. Does not doubt, but that the Lords, taking into consideration the continued and extraordinary pains and attendance which His Majesty's service has required for these four last years both by sea and land, and the dearness of provisions, house, rent, etc. when in former times 12d. would go further than 10s. now, will vouchsafe their mediation. Travelling charges 25s. per diem when employed, besides 10s. per diem for his clerk. (S. P. Dom. Charles I, vol. cccxli, No. 12.)

1639-40. Answer of Richard Marsh, keeper of the stores in the office of ordnance. His fees out of the exchequer are £54 15s. and out of the ordinary £60, making a total of £114 15s. per annum. The fees of the keeper of small guns formerly held by his predecessors was £65 5s. but from which he is excluded. There was formerly paid by Mr. Evelyn £40 per annum, which has been discontinued by the present gunpowder maker. Submits to the Lords consideration whether his standing fee, which was settled in the time of Henry VIII, when 12d. went further than 10s. now, be a competency for his daily attendance in his office. (Travelling charges as Edward Sherburne's, No. 12.) (S. P. Dom. Charles I, vol. cccxli, No. 13.)

1639-40. Samuel Cordewell, the King's gunpowder maker to the Council. It is humbly offered for your consideration. 1. That the home-made saltpetre falls short about 80 lasts to make 240 lasts yearly. Therefore if you think fit, now that the East India Co. are suitors for some privileges, they may be covenanted with to bring over a certain quantity of saltpetre yearly, at the
rate they have formerly sold it for to the King. (Margin. It is held fit that when the Charter shall be passed there be a clause to enjoin the East India Co. accordingly.) 2. That Bristol cannot but vend much powder in respect that it is the greatest town for shipping except London. So that if Bristol and other seaport towns had powder sent them to sell, your Lordships might have the money and accompt returned by those who return the formers (of the customs) money and from these places the towns and country thereabouts might be supplied. (Margin. That this be ordered as was directed for the County of Southampton and that all powder makers be suppressed.) 3. For the quiet settling of a work of such advantage, as this is like to be to His Majesty, and for avoiding of dispute when the leases now in being shall expire, his Majesty may be pleased to purchase such lands and waters as are in the occupation of the mills, and whereof the work will always have need. (Margin. The Surveyor General is to view these some time this vacation and to certify what he thinks they may be worth, and thereupon Mr. Cordewell is to attend the Attorney General about buying in the same.) (S. P. Dom. Charles I, vol. cccccxliv, No. 22.)

1639-40. Samuel Cordewell, the King's Gunpowder maker to the Council. That by an order of Council of 22nd May 1639, petitioner was commanded to make fine corn powder for pistols which he has ever since done, but prays allowance towards his charges. (In margin by Nicholas. This costs him £40 per annum.) That they would make him some allowance for his loss sustained by fire, whereby he lost his stove and above 2,000 cwt. of powder. (Margin. This loss was £300 to the powder maker.) That he received £2000 by way of impressed, as Mr. Evelyn likewise did for erecting the works which he has effectually done. Prays the Lords to be a means to his Majesty to pardon petitioner the repayment thereof, who in lieu of the
same will disclaim all his interest in the mill-houses, work-houses and all other buildings by him now used for the making of gunpowder, and will leave the same in serviceable repair at the expiration of his contract. (Margin. The Surveyor General is to view these works and to certify what he conceives they have cost, whereupon the Lords' referees will take further order.) (S. P. Dom. Charles I, vol. cccxliv, No. 23.)

1640, 8th June. Extract from a newsletter from Edmund Rossingham to Lord Conway.

A Discovery has been made of a great quantity of gunpowder and other ammunition stored in some place close by the place where a sessions was to have been held in Southwarke, for trying some that were apprehended in the late tumults at Lambeth and Southwark.

The house was searched and some quantity of gunpowder and arms found; but it appears the gunpowder was secretly made here to sell abroad to make profit of, since powder bears so great a price, now that his Majesty is the only merchant of powder. (S. P. Dom. Charles I, vol. cccclxi, No. 44.)

1640, 28th July. Report to the King by the Commissioners for Saltpetre and Gunpowder on the want of sale for gunpowder. We conceive it necessary: (1) that a proclamation be prepared to reduce the price of gunpowder from £7 10s. to £6 per barrel, and that liberty be given to retailers to sell it for 16d. a lb. or £6 13s. 4d. a barrel, being sufficient gain; and that it be left free to every man that will buy to resort to Sir John Heydon, and, on payment of your Majesty's price, to have such gunpowder as he shall desire, either for sale or his own occasions; and that in such case instruction be given to Sir John Heydon what gunpowder shall always remain in store.

(2) That speedy course be taken for the restraint of the exportation of foreign powder by way of composition for half custom with strangers at Dover, and that the Lord
Treasurer and Lord Cottington be desired to speak with the Farmers how the same may be best effected.

(3) That Parker, a gunpowder maker near Bristol, who has obtained a royal licence for making powder, be forthwith suppressed, and also all that make powder by stealth, or mend decayed powders.

(4) That the Earl of Newport's commission for the sale of powder within the Kingdom, which he has not made any benefit of, and which it is thought has been a great impediment to the sale of powder, be recalled.

(5) And whereas by proclamation those who seize any powder imported or made by stealth are to have the moiety for their discovery, but because the same is carried into the magazine they complain they can get no recompense, and so are discouraged from doing their endeavours therein; we conceive it fit that, on seizure of any gunpowder hereafter the officers of the Ordnance upon trial shall value the powder, and that Sir John Heydon shall pay to the discoverer the value of the moiety thereof, as soon as the same shall be legally confiscated; and that the gunpowder maker shall refine so much of such powder as shall not be found to be of the height it ought.

(6) Whereas Mr. Cordwell has £4,000 owing him by you for powder, by means whereof he is not able to pay the salt-petre men, and whereas Mr. Fletcher, a merchant, has furnished you with a good quantity of saltpetre (to the value of about £1,150) for which he is unpaid, so that, from the want of these sums, the gunpowder works are in danger presently to stop; we conceive it very necessary that the proclamation for abating the price of powder be with all speed set forth to raise money to discharge these debts, and to pay the gunpowder maker for the future. (S. P. Dom. Charles I, vol. ccclxii, No. 35.)

1640, 9th October. The Deputy-lieutenants of Devon to the con-
stables of the several hundreds, giving directions for the preparation of beacons, etc. It is ordered that you warn the chief officers of the magazines in your hundred for the keeping of powder, match, and lead for the forces of this country, that they forthwith fully replenish their proportions of munition. You are likewise to give them to understand that His Majesty’s store at the Tower of London is now open, where they may be furnished with powder at 12d. the pound. You are to be careful, according to our former order, to cause your petty constables to have ready 7 lb. of powder for every soldier, which they may have from the magazines with match and bullets proportionable. (S. P. Dom. Charles I, vol. cccclxix, No. 73.)

1640, 8th December. Certificate by the officers of the Ordnance of the gunpowder delivered into His Majesty’s stores by Mr. Cordwell, His Majesty’s gunpowder maker, from 1 Nov. 1636 to 8 Dec. 1640, viz.:

<table>
<thead>
<tr>
<th>Date (1636)</th>
<th>Date (1637)</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 1636</td>
<td>Nov. 1637</td>
<td>240 lasts</td>
</tr>
<tr>
<td>Nov. 1637</td>
<td>Nov. 1638</td>
<td>200 lasts (or 40 less than the amount contracted for per annum.)</td>
</tr>
<tr>
<td>Nov. 1638</td>
<td>Nov. 1639</td>
<td>240 lasts</td>
</tr>
<tr>
<td>Nov. 1639</td>
<td>Nov. 1640</td>
<td>214 lasts (viz., 16 less than the contracted amount, which is still deficit this year.)</td>
</tr>
</tbody>
</table>

(S. P. Dom. Charles I, vol. cccclxi, No. 35.)

1640, 14th December. Certificate of the commissioners for gunpowder that they accept the proportion of gunpowder delivered by Mr. Cordewell, his Majesty’s gunpowder maker, for the year Nov. 1639 to Nov. 1640, the 4th year of his contract, though under the proportion required by his contract; Mr. Poole having certified that the saltpetre delivered to Mr. Cordewell was not sufficient to enable him to make the 240 lasts of gunpowder as required by his contract. (S. P. Dom. Charles I, vol. ccxcii, p. 123.)
1641, 31st March. Petition of Samuel Cordewell, His Majesty's gunpowder maker, to the King.

Petitioner about 4 years since was contracted with by the Commissioners for Saltpetre and Gunpowder, for converting your Majesty's saltpetre into gunpowder, and delivering the powder into your store in the Tower. Now, by reason of a petition to the House of Commons that every man that will might make gunpowder, petitioner dares not make his provisions, as about this time of year he useth to do; for if he should make them, and the manufacture of gunpowder continue not in your Majesty's hands, he will be ruined by reason of the great stock he already has and must further provide and if he make not his provisions, he then renders himself unable to perform the contract, and greatly fears punishment. So that, in his extremity, and in a business so much concerning your Majesty as the having a store of gunpowder, which the Parliament in the year '23 or '24 by their remonstrance thought fit to be 300 lasts in the Tower, petitioner beseeches you to refer consideration hereof to the Council. (So referred by the King's order.) (S. P. Dom. Charles I, vol. cccclxxviii, No. 81.)

1641, 27th July. Abstract of Bill for the free bringing in of gunpowder and saltpetre from foreign parts, and for the free making of gunpowder in this realm. (16 Charles I, cap. 21.) (House of Lords' Papers. Hist. MSS. Comm., rep. 4, p. 91.)

1641, 28th July. List of committee on the Gunpowder Bill. Compare Lords' Journals, iv, 332. (Idem, p. 92.)

1641, 10th August. Letter from Thomas Smith to the Earl of Northumberland, Lord High Admiral. The King made account to be gone this morning by 4 o'clock, but divers things in the House not being ready for his signature, they prevailed with him to stay this day. His Majesty, before his going, passed six bills. . . . 4 For putting down the restraint for making gunpowder. (S. P. Dom. Charles I, vol. cccclxxxiii, No. 34.)
1641, 18th August. List of committee appointed to consider of the making of gunpowder. See Lords' Journals, iv, 367. (House of Lords' Papers. Hist. MSS. Comm., rep. 4, p. 98.)

1641, 1st November. Account by Richard Poole, receiver of gunpowder and saltpetre, of all the saltpetre brought into his Majesty's stores and delivered to Samuel Cordewell, his Majesty's gunpowder maker, from 1 Nov. 1640 to 1 Nov. 1641. Giving the names of the saltpetre men, the quantity each supplied, what they ought to have supplied, and how much they are in arrears. Total received, 100 lasts, total arrears, 89 lasts. Three saltpetre men, who delivered some saltpetre on 27th Oct. 1641, desired notice might be taken they did not deliver it to Mr. Cordewell as petre made by virtue of any commission or authority derived from his Majesty, but as a commodity sold to him by way of merchandize, so Mr. Cordewell hath received from the saltpetre men as commission petre, according to contract, within the last 12 months, only 95 lasts. (S. P. Dom. Charles I, vol. cccclxxxv, No. 45.)

1641, 11th November. Draft list of committee appointed to draw up heads for the Bill concerning gunpowder. See Lords' Journals, iv, 435.

Annexed, 1. Another draft list of a committee on the same subject. (House of Lords' Papers. Hist. MSS. Comm., rep. 4, p. 105.)

1642, 22nd July. A petition from the great Inquest for the County of Leicester for the removing of the magazine, and the King's assent July 24th. (London, 1642, printed by A. N. for William Gay.)

1643, 6th March. Order for Mr. Samuel Cordwell to carry saltpetre and other materials necessary for the making of gunpowder to his works near Guildford. (MSS. of the House of Lords, Hist. MSS. Comm., v, 75.)

1654, 2nd March. Petition by Vincent Randall of Chilworth Surrey,
to the Admiralty Committee. My late father, Sir Edward Randall, let a lease to the East India Co. of several powder mills near his dwelling, at Chilworth for 21 years. After this Caudwell, surveyor of the mills, rented them for a year, but died and left them in possession of his wife; she, being unable to manage so great a work, sold her stock to merchants, who begged leave to be my yearly tenants, which I granted, and their time is now expired.

I beg leave to serve the State with the same quantity of powder as the mills served before, on security to make it as good and cheap. (S. P. Dom. Interregnum, vol. lxvii, No. 7).


Grant advised. (Ibid., cxxvi, 100.)

1660. Daniel O'Neale entered into a contract to supply the King with gunpowder in 1660. Stroud and Wandsford objected on the ground of a prior patent. Up to 1663 there are a number of entries relating to payments to him, etc. (Treasury Warrants, Early XV, pp. 330-1, 396-7.)

1661 (January). Petition of William Baber, gunpowder maker to the King, for payment of the balance due to him of £532 3s. 6d. granted him by the late King in recompense for powder mills erected by him at Oxford, to supply his Majesty with powder, which were taken from him; only £40 was paid to him, though he lost £3000 in the service. (S. P. Dom. Charles II, vol. xxix, No. 76.)

1663, 17th March. Proclamation prohibiting exportation of saltpetre for 3 months. (Hart., loc. cit.)

1663, 13th April. Dublin. Propositions of John Middleton, gent., with respect to manufacture of powder in Ireland and searching for saltpetre. (Hist. MSS. Comm. MSS. of the Marquis of Ormonde, rep. 4, p. 564.)
1664, 25th October. Henry Rumbold to Sec. Bennet. Hearing of the death of Col. Dan. O'Neale, who had a patent for gunpowder for 21 years, he begs that he and his brother William may succeed in the management of it, as the profits will only be considerable if well managed.

Thinks Sir Richard Ford will want the patent for himself and Mr. Coventry. (S. P. Dom. Charles II, vol ciii, No. 125.)

1666, 15th June. Commission to John Lord Berkeley and others to dig for saltpetre and make it into powder. (Patent Roll, 18 Charles II, pt. iv, No. 6.)

1666, 16th July. Proclamation commanding all mayors, bailiffs, constables and others to aid in execution of above commission. (Patent Roll, 18 Charles II, pt. v, No. 3 dorso.)

1668, 20th January. Whitehall. Petition of William Baber, gunpowder maker to the King. He furnished the late King with large quantities of gunpowder at Bristol, with £1500, and received no payment from Sir George Strode and John Wansford, who employed him, and were themselves secured by a grant of Marybone Park and other places, but it has since been disposed of to two other persons. Part of £800 is also still due to him from the Ordnance Office, for powder delivered at New College, Oxford.


1669, 11th August. Sign manual for a privy seal for £9,000 to Philip Earl of Chesterfield, and Charles Henry Lord Wotton in full discharge of the annuity of £3,000 per an. granted for 21 years to Katherine Countess of Chesterfield in return for the surrender by her of the contract made 1664, Dec. 5, with the Crown by Daniel O'Neale, one of the grooms of the Bedchamber, for the sole making of gunpowder, said Countess being the relict and executrix of said O'Neale, and she having by her
 Chronology

will dated 1666, Dec. 15, devised the said annuity to William Lord Arlington and Anthony Samuel in trust for her two sons, Philip Earl of Chesterfield and Charles Henry Lord Wotton, who have agreed to surrender said patent in return for said £9,000. (Privy Seals, 1669, August.)

1673. "Not far from my brother's house (Wotton) upon the streams and ponds, since fill'd up and drain'd, stood formerly many Powder Mills, erected by my ancestors who were the very first who brought that Invention into England; before which we had all our Powder out of Flanders. My Grandfather transferred his Patent to the Late Sir John Evelyn's grandfather of Godstone, in the same County; in whose family it continued 'till the late Civil Wars. That which I would remark upon this occasion, is, the breaking of a huge Beam of 15 or 16 inches Diameter, in my Brother's House (and since crampt with a Dog of Iron) upon the blowing up of one of those mills, without doing any other Mischief that I can learn; but another standing below towards Shire, shot a Piece of Timber thro' a cottage which took off a poor Woman's head as she was spinning." (Mr. John Evelyn's letter to John Aubrey, re his "Natural History of Surrey," prefaced to vol. i of "The Natural History and Antiquities of the County of Surrey," begun in the year 1673 by John Aubrey, 1719.)

1676. Enfield. John Sadler's map of Hertfordshire shows a powder mill below Enfield Lock.

1677, 1st January. Sir Polycarpus Wharton takes a lease for 21 years of the great powder works at Chilworth and makes a contract with the Ordnance. After 10 years he was asked to relinquish this contract and enter into a new contract. ("The Hard Case of Sir Polycarpus Wharton Baronet." Broadside in the possession of the Chilworth Gunpowder Company.)

1680 (circa). John Seller's map of Middlesex shows a powder mill between Hounslow and East Bedfont near the point at which the
road crosses a stream. John Seller's map of Surrey shows a powder mill between Merton and Carshalton.

1680, 18th January. German powder being in esteem for its great strength Sir Polycarpus was asked "to provide two able persons to go into Germany, there to inform themselves of the best way of making Strong Powder, and to receive His Highness Prince Rupert's instructions thereupon." This was, however, not done. Sir Polycarpus could "instate it here," and upon trial it far exceeded the German powder in strength and could be afforded much cheaper." He thereupon "By H. M.'s encouragement, erected mills and works near Windsor (much differing from the common sort) sufficient to make 40 barrels of that powder weekly." (Wharton, loc. cit.)

1687, 17th December. Sir Henry Sheere, Surveyor General, and Thomas Gardiner, Storekeeper, appointed by Lord Dartmouth, Master General of the Ordnance, to take a survey of all powder works in the Kingdom. (Wharton, loc. cit.)

1687, 22nd December. Sir Polycarpus Wharton was to make a proportion of the gunpowder production of the whole kingdom, which according to his calculation should have been 51,685 barrels out of 98,920 whilst he only was allotted 32,852. He actually supplied from Chilworth 328 barrels weekly throughout the year more than the other works together could make. (Wharton, loc. cit.)

1689, 22nd July. Proclamation prohibiting exportation of saltpetre. (Hart., loc. cit.)

1689, 21st December. Draft of a bill to restrain the exportation of gunpowder, saltpetre, lead, brimstone, arms or any ammunition whatsoever. (House of Lords' Papers. Hist. MSS. Comm., rep. 12, App., pt. vi, p. 408.)

1692, 29th October. Company formed under the name of "The Governor & Company for making and refining of saltpetre within the Kingdoms of England and Ireland and the Dominions thereunto belonging." They were to deliver 200 tons best white saltpetre in the first year and afterwards in every year as required, not exceeding 1,000 tons yearly at £70 per ton or the market price, and to pay yearly £1,000 to the Treasurer of the Navy for the relief of seamen. (Hart., loc. cit.)

1695, 2nd December, O.S. Queen in Cadiz Bay. Sir G. Rooke to Shrewsbury. . . . At my coming from Portsmouth there was, by my lord Romney's direction to the officers of the Ordnance, 210 barrels of powder shipped for a present for the Dey and Government of Algier; and though I have no other order for its disposal, yet, having seen several advices from the Consul there, that a present of that kind is very earnestly expected by the new Dey from his Majesty, I shall presume to send it by Capt. Clarke in the Humber, who commands the ships going upon that service. . . . (Hist. MSS. Comm. MSS. of the Duke of Buccleuch and Queensberry at Montagu House, Whitehall, vol. ii, pt. i, p. 269.)

1695, 16th-26th December. Queen at Cadiz. Sir G. Rooke to Shrewsbury. Sends copies of what he wrote to the Government and (the) Consul of Algiers. It was what was earnestly expected, and what the French "some time since expressed to them."

Enclosures:

1. Copy of a letter from Rooke "to the most illustrious the Bashaw, the Dey, and Dewan of the ancient, powerful, and famous City and Kingdom of Algiers.' Compliments. Sends them 210 barrels of powder as a present from his Majesty.

2. Copy of a letter from Rooke to Mr. Robert Cole, Consul at Algiers, on the same subject. . . . (Hist. MSS. Comm. MSS. of the Duke of Buccleuch and Queensberry at Montagu House, Whitehall, vol. ii, pt. i, p. 278.)
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1698, 24th June. Sir Polycarpus Wharton's lease expired and was not renewed. He got into debt and was imprisoned. (Wharton, loc. cit.)

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LIST OF GUNPOWDER MAKERS UP TO 1800

1457 John Judd in the Tower of London.
1512 Th. Hart in Porchester Castle.
1514 (? The King) in Bishopsgate Without in London.
1515 Hans Wolf, a foreigner, one of the King’s gunpowder makers in the Tower.
1531 Thomas a Lee, one of the King’s gunners, makes gunpowder.
1535 Thomas a Lee in Rotherhithe (see 1563, 23rd June, in chronology).
1540 Charles Wolman (also mentioned in 1552).
1541 Mill in Edinburgh Castle worked by “some workmen.”
1555 Henry Reve on the “Crenge” in Rotherhithe.
1561 (circa) George Evelyn at Long Ditton.
   (? Francis a Lee) at Leigh Place, near Godstone.
   (? At Faversham.)
John Tomworth at Waltham.
Note.—Francis a Lee, Thomas a Lee’s son, is variously mentioned later on as Lea, Lee, and Leigh.
1562 Bryan Hogge (his successor in 1589 was George Hogge) and Robert Thomas had, together with Francis a Lee, erected 5 mills.
1576 John Bovyat of London (see also 1581 and 1595).
1580 Sebastian Orlandini and John Smithe have a mill at Ratcliffe.
1588 George Evelyn (of Wotton, Surrey), Richard Hills (?) Hill, and John Evelyn.
1589 George Constable, licensed for York, Nottingham, etc. Hill, Constable, and John Grange enter into partnership, and put George Hogge on an annuity.
LIST OF GUNPOWDER MAKERS UP TO 1800

1599 John Evelyn, Richard Hardinge, Robert Evelyn, John
Wrenham, and Symeon Turner are in partnership.

1607 Earl of Worcester; he relinquishes his patent in 1620.

1615 Christopher Newkirk (a Polish surgeon) knows how to make
"still" powder.

1617 Richard Fisher of the Inner Temple, deputy of the Earl of
Worcester.

1620 Manufacture taken over by the King, but John Evelyn ap-
pointed the sole maker.

John Baber (see also 1631).

1623 John Reynolds, master gunner of England and proof master
for gunpowder.

1624 John Evelyn, the younger, Godstone, Surrey.

1625 East India Company outside Windsor Forest.

John Corseley, powder-maker to the City of Bristol.

Former powder makers in Bedford mentioned.

1626 East India Company licensed in Surrey, Kent and Sussex.

(? Thomas) Russell.

1627 Michael Waring in (?).

Bristol, Dorsetshire, and Battle powder makers to be sup-
pressed.

1628 Robert King at Stockwell, near Chester.

1629 John Giffard in Devonshire, Thomas Guy made it without
licence.

1631 Collins mentioned as the "workman" of the East India Com-
pany.

John Coslett and William Baber of Bristol.

1634 Sir John Heydon offers to make gunpowder.

Sir Philiberto Vernatti and John Battalion in Yardley, co.

Herts.

Walter Parker, Stockwood, Dorset (since 1588?).

1635 Edward Collins, Chilworth.

Powder factories mentioned in Taunton.
1635 Sir Arthur Mainwaring and Andrew Pitcairn have 3 mills. (Place not stated.)
1636 Samuel Cordwell and George Collins, gunpowder makers of the King.
   Robert Davies makes gunpowder in Thames Street, London; made it formerly in Whitechapel, where "he had his house blown up."
1640 Parker, near Bristol.
1643 Samuel Cordwell, works near Guildford.
1654 Sir Edward Randall succeeds Cordwell.
1660 General Daniel O’Neale (in Wotton?).
1661 William Baber, Oxford.
1663 John Middleton, in Dublin.
1666 John Lord Berkeley and others. (Place not stated.)
1677 Sir Polycarpus Wharton at Chilworth.
1700 (about) Smith in Hounslow, successors were Hill, Isaac Butts, and Harvey and Grueber.
1719 Gruebarr of Ospringe, at Devington, near Faversham (in 1820 Harvey and Gruebarr at Hounslow dissolved partnership).
1728 Thomas Brock, fireworks maker.
1732 Pike and Edsall, Dartford.
1735 John Walton at Waltham.
1750 (?) at Hastings.
1751 (?) at Malden, Surrey.
1760 Faversham Works sold to Government.
1770 (?) at Brede, Sussex.
   Bouchier Walton at Waltham.
1772 (?) at Battle, Crowhurst, Seddlescomb in Sussex.
1778 Dartford sold to Frederick Pigou and Miles Peter Andrews.
1780 (about) Merricks and Christie, Gorebridge, near Roslin.
1787 Government bought Waltham from John Walton.
1790 John Merricks, Roslin.
1794 Royal factory erected at Ballincollig in Ireland.
DESCRIPTIVE PART
EXISTING GOVERNMENT ESTABLISHMENTS

THE ROYAL LABORATORY, WOOLWICH

By Col. Sir Hilaro W. W. Barlow, Bart., R.A.

The term “Laboratory” as applied to the Royal Laboratory at Woolwich is calculated to mislead, for this establishment is only incidentally connected with chemistry. It is the Government establishment in which, with a few exceptions, every article fired from a gun or rifle, or which is used in firing a gun or rifle, is made. The Royal Laboratory, though it handles enormous quantities of explosives in the course of a year, does not actually make the explosives, which are supplied by the Royal Gunpowder Factory at Waltham Abbey, or by contract.

The Laboratory also provides, or can provide, all stores in connection with torpedoes and mines, whether for naval or land warfare. A Chemical Laboratory has, of course, formed part of the Royal Laboratory for many years as of any other large modern manufacturing establishment.

It is but right to add that the Royal Laboratory makes also one store by which many thousands of lives have been saved, and that is the Life-Saving Rocket whereby a line is thrown to vessels stranded at distances up to about 200 yards from the shore. By means of this line stout ropes are ultimately made fast to the ship on which life-saving apparatus travels backwards and forwards. Some 1,700 life-saving rockets are made annually in the Royal Laboratory.
For some of the earlier part of the ancient history which follows I am indebted to Mr. Vincent's admirable "Records of Woolwich."

The date of the actual commencement of the Royal Laboratory (R.L. as it will be usually termed in the notice which follows) has not as yet been definitely fixed.

The earliest reference bearing on the matter which I have seen is contained in a King's Warrant to the Board of Ordnance dated 2nd December, 1670, which speaks of "the great encrease of our Navy," and, as a consequence, of "The employment of more storekeepers, clerks, labourers," etc., at "Ye Tower Place neare Woolwich," I think, for the reason given a little later, that a laboratory must have formed a part of this establishment. That a "Royal Laboratory" existed somewhere on the 11th August, 1688, is quite evident from the King's Warrant to the Board of Ordnance of that date appointing Sir Martin Beckman, Knt., "Comptroller of our said Fireworks as well as for war as Triumph, Firemasters, Fireworkers, Bombardiers, Petardiers, and all others that now are or hereafter shall be employed in our said laboratories." The Warrant speaks of the Firemasters, etc., being occupied in our "Royall Laboratory." Unfortunately, it does not say where this Royal Laboratory was situated; and, although I think that there is little doubt that it was at Woolwich, it must be remembered that a laboratory undoubtedly existed at Greenwich Palace, close to the old Tilt Yard, which was taken down in 1695 and re-erected at Woolwich, and no doubt became the "Greenwich Barne" shown in General Borgard's map of 1701 as part of the Royal Laboratory.

The first quite definite mention of it is in a Treasury paper dated 1694, mentioning an estimate for "building a Laboratory in the Warren at Tower Place at Woolwich." The Royal Arsenal, it may be remarked, was called "The Warren" for years, and was only officially named the Royal Arsenal in 1805.

I do not think that this could have been the first laboratory at Woolwich, as it is clear from a deed by which the Lieut.-General of
the Ordnance was given a residence in Tower Place in 1683 that proof of "great" guns had been going on at Woolwich prior to that date (formerly gun proof was carried out at Moorfields, but it was transferred to Woolwich between 1665 and 1680), and it is natural to suppose that there was a laboratory close at hand in which the charges for the guns were prepared.

While, as already stated, a laboratory certainly existed at Greenwich, it appears somewhat unlikely that the cartridges required for the proof of guns were made up and brought from Greenwich, which is some three miles from Woolwich whether by land or water. It may be added here that there is quite reliable evidence of ordnance stores existing on part of the site of the Woolwich Arsenal and R. L. from 1588. No doubt the Dockyard, which has existed at least since 1500 (closed in 1869), and the Rope Walk or Yard, which was built in 1572 (taken down in 1835) influenced the choice of the site.

In 1694, however, we come into historical times, and we have maps of the Royal Arsenal dated 1700, 1717, 1748, and 1810. From these, and from the information of living witnesses, it would seem that the Royal Laboratory altered very little during the first hundred and fifty years of its existence. As far as I have been able to ascertain only one large building ("The Sea Storehouse") was added to it; and it is doubtful, having regard to its name, whether this building, though it indubitably became R. L. property at latest some sixty years ago, was originally built for the R. L. The same applies to "The Tower House," which was the first home of the Royal Military Academy at the birth of the latter in 1741, and remained part of it until 1806, when it probably became part of the R. L.

But the Royal Laboratory did some fine work in the great wars at the close of the eighteenth and commencement of the nineteenth century, for it is stated by Sir W. Congreve in 1816 that it employed "upwards of 2,000 people" during a portion of that period, which establishment was reduced, in the wholesale reductions after the peace
of 1815, to about 126 by 1835. A table of the numbers of workpeople employed at various times is given below.

The original Laboratory consisted of about nine large buildings, of which six were grouped three on each side of “the Square,” about 100 yards by 70 yards in area, which appears to have been laid out as a garden, and to have had a fountain in the centre—a charming condition which one looks back to with some envy. The garden lies now beneath the floor of the present main factory; and there are very few traces that the Warren was once what its name implies; and, judging from old engravings, also a pretty place. In 1810 the nine buildings had increased to about eleven, of which one (the Sea Storehouse already mentioned) was very large, and had altered scarcely at all by 1851. Shortly after 1854 (the Crimean War) the R. L., in common with other departments, much more than doubled its size. The really magnificent shell foundry and factory, and several fine ranges of Danger Buildings date from the commencement of this period, and as the years went on the department has steadily grown. Just after the close of the South African War (1901) it was decided to move those of the R. L. Danger Buildings which lay nearest to the other manufacturing departments of the Arsenal to a greater distance. This was gradually done and the present Danger Building establishment completed in 1908.

It is unfortunate that the records existing in the Royal Laboratory only date back to 1760, and that the most complete are the letter books of the Government Gunpowder Factory at Faversham, which, like that at Waltham Abbey up to 1855, was once under the Royal Laboratory. Faversham was leased to a private firm by the Government in 1832 and was sold, I believe, some twenty-one years later.

Moreover, the records, such as they are, are very incomplete; and it is to the printed reports of the commissions on Army expenditure of 1828 and 1849 that one must often look for important and authentic information.

It is not possible, for instance, to give a table of the establishments at various selected interesting periods of history prior to 1813,
EXISTING GOVERNMENT ESTABLISHMENTS

nor the output during the great French wars; but figures have to be accepted as they may occur in the records, and the more interesting of these are given in Table I below.

As will be seen from the detailed Table II below, the Royal Laboratory is a great manufacturing concern and deals with a very large number of different stores; but, apart altogether from the fluctuations in numbers due to peace and war, it would be still larger had it not been deemed advisable to transfer from it the Government Torpedo Factory in 1890, and the manufacture of wood (usually also metal lined) packages for explosives in 1893. It may be incidentally remarked that the Laboratories at Portsmouth and Plymouth were under the superintendence of the R. L. up to 1870. At the present moment the Royal Laboratory has in its possession the approved designs of about 3,000 articles which it must be prepared to manufacture at short notice; moreover, the complexity of manufacture of war stores, and the severity of the tests to which they are subjected have grown out of all knowledge in comparison with those of even recent times. Unfortunately, but unavoidably, the cost has correspondingly increased.

As showing the contrast between the cost of the war stores of to-day and of those of sixty years ago, the Commission on Army and Ordnance Expenditure of 1849 appear almost shocked at the fact that the filled, finished and packed shell for the then newly introduced 8-inch (smooth bore) gun cost 11s. 3½d. as compared with the projectile previously used which cost 4s. 4d. What would have been their feelings had they had to accept the cost of a modern shell for the 7.5-inch which is about £9 empty? Taking the comparison, however, as it should be taken, i.e., between the 8-inch as the heaviest projectile of its period and the 12-inch of to-day, the relative costs would be 11s. 3½d., and about £29 for the 12-inch shell filled complete. It is almost superfluous to say that the difference in cost is due to the fact that the modern 12-inch shell is called on to perforate a hardened steel plate, against which the 8-inch shell of 1849 would have an offensive efficiency not much exceeding that of a cricket ball.
The total number of hands employed 31st January, 1909, was 4,800. Some 138 women, widows of R.L. employés, were also given a certain amount of work on cartridge bags to be done at their homes.

**TABLE I**

**BRANCHES OF THE ROYAL LABORATORY**

*West Laboratory*

- Iron and Steel Foundries.
- Projectile manufacture.
- Gauge and Machine making.
- Iron Plate Workers and Smithery.
- Metal Cases to hold heavy gun cartridges.
- Manufacture of Fuses.
- Engines and Boilers, and erection and maintenance of machinery, shafting, gearing, etc.
- Leather work.
- Chemical and Metallurgical Branch.
- Drawing Office.
- Printing Establishment.

*East Laboratory*

Manufacture of Brass strip for quick-firing gun cartridge cases and small-arm cartridge cases, and Cupro Nickel strip for bullets, etc.

- Brass Foundry.
- Quick-Firing Cartridge Case manufacture.
- Small-Arm Cartridge Case manufacture.
- Bullet manufacture.
- Manufacture of Electric and Percussion Tubes, Detonators, etc.
EXISTING GOVERNMENT ESTABLISHMENTS 313

Tinmen's Shop.
Wood Department.
Painters.
Repair, etc., of Quick-Firing Cartridge Cases after firing.
Founders' Ash-Washing Plant.

Danger Buildings
Filling and finishing Small-Arm Cartridges.
Filling and finishing Quick-Firing Cartridges.
Filling and finishing Shells and a limited number of Gunpowder Cartridges.
Filling and finishing High Explosive Shell.
Filling and finishing Caps, Detonators, and Percussion tubes.
Filling and finishing Fuses and Electric Tubes.
Filling and finishing Mines and Torpedoes (wet guncotton).
Filling and finishing Smokeless Powder Cartridges for heavy guns.
Manufacture of Cartridge Bags, etc.
Manufacture of Paper fittings.
Mechanics' Shop (Danger Buildings).
Velocity Range.

Miscellaneous
Rate Fixers.
Estimate Branch.
Order and Issue Branch.
Correspondence and other clerical work.
### TABLE II

**Numbers Employed in the Royal Laboratory at Various Periods**

<table>
<thead>
<tr>
<th>Year</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1757</td>
<td>169</td>
</tr>
<tr>
<td>1762</td>
<td>234</td>
</tr>
<tr>
<td>1776</td>
<td>140</td>
</tr>
<tr>
<td>1786</td>
<td>90</td>
</tr>
<tr>
<td>1792</td>
<td>98</td>
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<td>1793</td>
<td>482</td>
</tr>
<tr>
<td>1798</td>
<td>895</td>
</tr>
<tr>
<td>1803</td>
<td>984</td>
</tr>
<tr>
<td>1805</td>
<td>1,133</td>
</tr>
<tr>
<td>1813</td>
<td>1,451</td>
</tr>
<tr>
<td>1817</td>
<td>461</td>
</tr>
<tr>
<td>1825</td>
<td>272</td>
</tr>
<tr>
<td>1829</td>
<td>139</td>
</tr>
<tr>
<td>1835</td>
<td>126</td>
</tr>
<tr>
<td>1849</td>
<td>455</td>
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No figures available between 1849 and 1870.

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<th>Year</th>
<th>No.</th>
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<td>1870</td>
<td>2,674</td>
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<tr>
<td>1875</td>
<td>2,791</td>
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<td>1880</td>
<td>2,996</td>
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<td>1885</td>
<td>5,694</td>
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<td>1890</td>
<td>6,354</td>
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<tr>
<td>1895</td>
<td>6,155</td>
</tr>
<tr>
<td>30th Sept., 1899</td>
<td>7,701</td>
</tr>
<tr>
<td>31st Decr., 1899</td>
<td>8,635</td>
</tr>
</tbody>
</table>
EXISTING GOVERNMENT ESTABLISHMENTS

<table>
<thead>
<tr>
<th>Year</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>30th June, 1900</td>
<td>10,634</td>
</tr>
<tr>
<td>31st Decr., 1900</td>
<td>11,621</td>
</tr>
<tr>
<td>31st Decr., 1901</td>
<td>10,111</td>
</tr>
<tr>
<td>31st Decr., 1902</td>
<td>7,825</td>
</tr>
<tr>
<td>31st Decr., 1906</td>
<td>5,720</td>
</tr>
<tr>
<td>31st Jan., 1909</td>
<td>4,800</td>
</tr>
</tbody>
</table>

TABLE III

LIST OF COMPTROLLERS, DIRECTORS, AND SUPERINTENDENTS ROYAL LABORATORY

Comptrollers

1688. Sir Martin Beckman, Kt.
1716. Office abolished and re-introduced by King's Warrant in 1746.
1748. Sir Charles Frederick, K.B.
1782. Ralph Ward.
   The Hon. George Napier.
1783. Sir Charles Frederick.
   Colonel T. Jones.
1814. Sir William Congreve, 2nd Bart.

Directors

1828. Colonel Sir Augustus Frazer, K.C.B.
1835. General Stephen G. Adye, C.B.
1838. Major-General James P. Cockburn.
1847. General Richard Hardinge, K.B.
1852. General Sir William Cator, K.C.B.

Superintendents

1855. Major-General Edward M. Boxer, F.R.S.
1870. Colonel Thomas W. Milward, C.B.
1880. Colonel Francis Lyon.
1885. Colonel William R. Barlow.
1892. Colonel Edmond Bainbridge, C.B.
1902. Colonel Sir Hilaro W. Barlow, Bart.

THE ROYAL GUNPOWDER FACTORY, WALTHAM ABBEY

By Col. Sir Frederic L. Nathan, R.A.

The earliest known record relating to the Waltham Abbey Powder-mill bears date 2nd March, 1560-1. It is of interest as showing that, even thus early, the factory was of considerable extent, and was engaged in producing gunpowder for the English Government. The substance of this record, given below, is extracted from the Essex volume No. 2 of "The Victoria History of the Counties of England." The historical details of the Waltham Abbey Gunpowder Factory which follow, are taken from the same source. On the date mentioned above, viz., 2nd March, 1561, one Marco Antonio Erizzo,
an Italian, writes \(^1\) to John Thomworth (or Tamworth) at Waltham Abbey in reference to a tender he had made \(^2\) to supply the Government with material for making powder. Thomworth was the executor of the widow of Sir Anthony Denny (who had died in 1549) and was probably the owner or manager of the powder-mill. The tender in question was referred for consideration to William Bromfield, Master of the Ordnance, who advised \(^3\) that Neapolitan saltpetre at £3 10s. per cwt. was 10s. per cwt. too dear, and that the offer of 2,000 cwt. of Italian brimstone should be “respyted,” as there were “in store at this present 120,000 c. weight, whiche wyll make foure hundrythe lasts of corne powder and wyll not be wrought yet into powder this fowre yeres.” Ultimately, large quantities of powder-making materials were purchased from Erizzo, to the value of £6,000, including Italian brimstone at 18s. per cwt. and Neapolitan saltpetre at £3 5s. per cwt.; all to be delivered in England.\(^4\) From that date, at any rate (and, doubtless, even earlier), the manufacture of gunpowder on a large scale has been carried on continuously at Waltham Abbey.

In his notice of the manufactures of Essex, Fuller, who became perpetual curate of Waltham Abbey about 1648, says that “More [gunpowder] is made by mills of late erected on the River Ley, betwixt Waltham and London, than in all England besides. . . . It is questionable whether the making of gunpowder be more profitable or more dangerous; the mills in my parish having been five times blown up within seven years, but (blessed be God!) without the loss of any one man’s life.”\(^5\)

The first deaths from an explosion at the powder-mills are recorded in the register of burials of the parish of Waltham Holy Cross, under date October, 1665: “Tho. Gutridg, killed with a powder mill, ye 4 day: Edward Simons, carpenter, so killed, ye 5 day.”

Farmer, in his “History of Waltham,” gives a view of the factory as it was in 1735. From this view, it appears that there were some twenty buildings as named thereon. Of the factory, Farmer says: “Near the Town on one of these rivers [i.e., on one of the branches of the Lee] are curious Gunpowder Mills, which supply the nation with great quantities of gunpowder, being esteemed the largest and completest works in Great Britain, and are now the property of Mr. John Walton, a gentleman of known honour and integrity.”

This John Walton was a relative of Izaak Walton, the angler.

In 1770 an Essex historian wrote of the factory as “several curious gunpowder mills, upon a new construction, worked by water, (the old ones having been worked by horses). They are reckoned the most complete in England, and will make near one hundred barrels weekly for Government service, each barrel containing one hundred weight. They are now the property of Bouchier Walton, Esquire.”

Horse power would appear, however, to have been introduced as early as 1739, and was used to some extent to a considerably later period than 1770.

In 1787 the factory was acquired by the Government from another member of the family, a later John Walton. A pillar sundial, which belonged to this John Walton, and has his name engraved on it, still stands in front of the offices of the factory. The surrounding lands were not finally purchased till 1795. Upon becoming Crown property, the factory was enlarged by the Board of Ordnance, under whose management it fell. Some fourteen or fifteen of the old hands were retained, and workmen were brought also from the King’s Powder-Mill at Faversham, both the Faversham and Waltham Abbey factories being worked under the superintendence of Major (afterwards Sir William) Congreve, Deputy-Controller of the Royal Laboratory at Woolwich. Forty-six hands were employed in October, 1787, at which date stone runners and beds, such as are still occasionally employed, were in use for the process of “incorporating” (i.e., mixing).

1 Reproduced on p. 161.
In 1791 the factory records speak of double horse-mills being in use; and in 1795, powder appears to have been sent regularly from Waltham Abbey to Purfleet, for proof. Sometimes it went overland in ammunition wagons, at other times by water in barges.

Explosions seem to have occasionally occurred at this period; but, as a rule, they did no serious injury. In 1801, however, a horse "corning-house" exploded, killing nine men and four horses. In consequence of this explosion, a committee of the Royal Society visited the works to examine and report on the possibility of danger arising from electrical excitation, caused by walking or rolling barrels on the leather-covered floors, or by the use of silk-covered "dusting reels," in which the fine dust is removed from the grain powder. The committee reported, however, that there could be no danger from such causes.

The introduction into the manufacture of gunpowder of charcoal burnt in retorts or "cylinders" instead of in "pits," occurred about this time. In 1804 and for some years afterwards, Government cylinder works, in connection with the Waltham Abbey factory, were maintained at Fisher Street and at Fernhurst, in Sussex. In the same year occurs the first mention of iron runners and beds for incorporating mills. The annual yield of the factory at this period was about 20,000 barrels.

In 1805 the Board of Ordnance purchased the Cheshunt corn-mill, and in 1809 the Waltham Abbey corn-mill, for the sake of their water-power rights.

In 1811, in order to show that the manufacture of gunpowder could be carried on more economically at the Royal Gunpowder Factories at Waltham Abbey and Faversham than by private merchants, General (afterwards Sir William) Congreve addressed a statement on the subject, dated 20th April, 1811, to the Master-General of the Ordnance. This statement showed that the profit, between 1st January, 1789, and 31st August, 1810, on 407,408 barrels of gunpowder of 100 lb. each, made at Waltham Abbey and Faversham, amounted to
£288,357 6s. 0½d.; and that the profit on "regenerating" 127,419 ¼ barrels, between 1st January, 1790, and 31st August, 1810, was £53,091 11s. 3d., or a total profit of £341,488 18s. 3½d. The same statement gives the whole amount expended by the Government on the original purchase, and on new erections, repairs, and improvements, up to 31st December, 1799, as £45,683 2s. 7½d.

On the morning of 27th November, 1811, there was another serious explosion, a press-house and a corning-house being blown up and eight men killed. After this Sir William Congreve substituted Bramah hydraulic presses for the old screw-presses used previously for giving the requisite density to the gunpowder. On October, 1814, it was ordered that, for working the machinery, water-power was to be substituted entirely for horse-power. At this time, in all probability, horse-power was finally disused. In 1810, according to Winters ("Centenary Memorial," pp. 67 and 78), there were in use nine water-mills and seven horse-mills; and in 1813 (when the war was at its height), twenty-four water-mills and nine horse-mills. In 1816 the old corning-frame was replaced by a new granulating machine, patented by Sir William Congreve, Patent No. 3937 of 1815 (3rd July). It was erected on that portion of the factory known as the Lower Island.

During the war with France, very large quantities of gunpowder were produced at Waltham Abbey, the figures for the later years being as follows:

<table>
<thead>
<tr>
<th>Years</th>
<th>No. of Barrels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1809</td>
<td>20,050</td>
</tr>
<tr>
<td>1810</td>
<td>20,688</td>
</tr>
<tr>
<td>1811</td>
<td>21,252</td>
</tr>
<tr>
<td>1812</td>
<td>21,000</td>
</tr>
<tr>
<td>1813</td>
<td>25,060</td>
</tr>
<tr>
<td>1814</td>
<td>10,161</td>
</tr>
<tr>
<td>1815</td>
<td>15,790</td>
</tr>
</tbody>
</table>
On the conclusion of peace, the output was much reduced. In 1816 it amounted to about 4,000 barrels only; in 1819 it had fallen to about 1,000 barrels; and in some succeeding years, it was even less. In addition, however, large quantities of old powder were “regenerated” each year at this period. In 1822 the establishment was fixed at thirty-four persons. In 1813, during the war, it had exceeded 250 hands, and the wages paid to them had amounted to £17,212 (see Winters, “Centenary Memorial,” pp. 75-8).

In 1832, the Royal Factory at Faversham was sold, and shortly afterwards the Royal Factory at Ballincollig, in Ireland, was disposed of also. Waltham Abbey thus became the sole royal gunpowder factory, and has remained so to the present day.

From April, 1858, to the end of March, 1859, the factory produced 10,683 barrels of gunpowder and was capable of storing 5,000 tons of saltpetre and sulphur. The value of the buildings, land and water rights was estimated at £230,000.

Colonel Askwith was the first Superintendent independent of the Royal Laboratory. He was appointed from the 18th August, 1855.

In 1858, Sir W. Snow Harris, F.R.S., after an inspection of the factory, drew up a report for a system of lightning conductors for all the houses in it. They were subsequently installed.

In 1870 the factory contained thirty-two pairs of incorporating mills, some driven by water and some by steam. These could incorporate annually materials for about 27,580 barrels of large grain, or 13,690 barrels of fine grain gunpowder. The number of men employed was about one hundred and fifty. All the processes preparatory to the actual manufacture of the powder were carried on in the factory, in order to ensure the absolute purity of the finished article. These processes included the refining of sulphur and saltpetre, and the burning of charcoal in cylinders.

For many centuries black gunpowder was the only explosive. Nothing else was made at the Waltham Abbey Factory until 1872,
when the production of guncotton was commenced on a manufacturing scale.

The original guncotton factory consisted mainly of old buildings, which had formed part of the saltpetre refinery, and abutted on the principal street of the town. It was capable of turning out about two hundred and fifty tons of guncotton per annum. In 1885 one hundred acres of land, known as Quinton Hill, were purchased by the Government, and a new guncotton factory, which started work in 1890, was erected there.

The kind of gunpowder known as "brown" or "cocoa" powder, was introduced from Germany in 1883, and a number of new buildings were erected in the old part of the factory for its production, which was commenced in 1885.

Smokeless powders for military purposes were first produced in France, in 1886. In 1890 the Explosives Committee recommended a smokeless powder, to which the name of "Cordite" was given, and its manufacture was commenced at Waltham Abbey in 1891. For its production a nitro-glycerine factory was put up on Quinton Hill, where the necessary buildings for making cordite were also erected. In 1898 a second nitro-glycerine factory in the old portion of the factory, started work, and the majority of the houses formerly used for the manufacture of gunpowder were adapted for the manufacture of cordite in consequence of the larger output. The introduction of modified cordite entailed considerable additions to the factory, and 94½ acres were acquired for the erection of the necessary buildings.

The factory at the present time covers 411½ acres, and comprises about 300 separate buildings. It is under the superintendence of Colonel Sir Frederic L. Nathan.

Gunpowder, fine grain powder for fuses and for the priming of cordite cartridges, picric powder, nitric acid, nitro-glycerine, guncotton for torpedoes, mines, etc., as well as for cordite, and cordite, are manufactured at Waltham Abbey. In addition to the above the waste acids resulting from the manufacture of nitro-glycerine and guncotton are
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recovered, as is also a large proportion of the acetone used in the manufacture of cordite. The saltpetre and sulphur used in gunpowder are bought in the rough state and are refined in the factory, and the charcoal is made from wood mostly grown on the spot.

The four main departments of the Royal Gunpowder Factory are: Gunpowder, Nitro-glycerine, Guncotton, and Cordite. There are also a Machinery Department and a Central Laboratory.

Electrical power is almost universally employed, supplied from a central generating station in which are three 200 K.W. generators, and three smaller ones. The factory is electrically lighted from the same source. Alongside the Power House is a Main Boiler House, containing fifteen 30 feet by 8 feet 100 lb. pressure Lancashire boilers. These boilers supply steam for the boiling of guncotton as well as for the generators. For heating purposes there are three other smaller boiler houses in different parts of the factory.

All raw materials, as well as the finished explosives, are tested and examined in the Central Laboratory, and in the laboratories attached to the Nitro-glycerine and Guncotton Departments, under the Chemists-in-Charge. Research work of a varied nature is also carried out at the Central Laboratory.

The whole of the work in connection with the manufacture of explosives is carried out under the strictest supervision, and every possible care is taken that all finished products issued from the factory shall be of the greatest purity, stability, and uniformity, as these are factors of paramount importance to the Services. Every precaution tending to reduce the risk of accident during manufacture is also most stringently enforced.
THE RESEARCH DEPARTMENT

By Major J. H. Mansell, R.A.

The Research Department, Royal Arsenal, Woolwich, is, as at present constituted, only two years old. It combines, under one superintendent, two departments, which existed previously, both doing research work, which approached very closely along certain lines, and both mutually dependent on each other on other lines.

These two departments were the Proof and Experimental Branch of the Proof Butts and the Chemical Research Department.

Of these the Proof and Experimental Branch is the older. As the name indicates, its work consisted of testing explosives, ordnance, etc., before issue to the Service, as well as of experimental work, connected generally with questions of internal ballistics. The name of this branch was comparatively new, and it is still familiarly known by its more ancient one of the Butts.

The Proof Butts is probably co-existent with the Royal Arsenal. The date of the origin of the Royal Arsenal is lost in obscurity, though it is put by one authority at 1667, but Vincent places it a century earlier. Be that as it may, the earliest plan existent of the Royal Arsenal is dated 1701, and in this is marked the Proof Butts, then called the "Proof Parapet." It is interesting to note as these plans are followed through the succeeding years how the site of the Butts has been steadily pushed farther east with the ever-growing demand for space for manufacturing purposes, this growth advancing from its small beginning at the west of the Proof Parapet. To the east of the Arsenal lie Plumstead Marshes, on which work of reclamation has ever been proceeding. The last move of a Butt was in 1898, and the present site is a mile from the one of 1701. At the eastern end of Plumstead Marshes magazines have now been built, and buildings are moving

1 "Records of Woolwich," vol. i, p. 297 et seq.
towards the Butts from the east. The days of pushing the Butts further into the Marshes are numbered, and it is for the future to say whether this eastern push will carry them to the mouth of the Thames, whither the sister establishment for conducting long range trials has preceded them by many years.

In 1701 the Butt was a grass-covered mound into which the shots were fired. This in time was replaced by a sand-heap, the sand being retained in position by a framework. From this sand fired shots are easily dug out. With the growth in power of ordnance the sand has steadily increased in depth, and with the increase in armaments the Butts have had to be widened to enable more guns to be fired side by side.

There are now two Butts—the north and south. Each Butt is divided into four partitions known as bays, and the two Butts are separated by an earthen traverse to enable work to proceed simultaneously at both Butts.

In the earlier days the proof of a lot of gunpowder consisted in the firing of a small charge of it in a mortar and noting how far it threw the ball. This system had the advantage of avoiding any question as to the maximum pressure necessary for a given muzzle-velocity, and possibly spared the powder manufacturer many of the troubles of his present-day descendants. The gun-caster on his side tried to avoid trouble by keeping up the thickness of his metal. That he did not always succeed is evidenced by the records of occasional bursting of cannon. On 9th March, 1770, for instance, we find at proof that “two of the cannon burst into pieces and were forced into different parts of the Warren” (the old name for the Arsenal).

In 1740 Robins invented the ballistic pendulum, by which striking velocities could be measured, and attempts were also made to measure muzzle velocities on the same principle. Some old ballistic pendulum sheds were still standing in 1900, though the pendulum had long been removed.

Electricity was not employed in ballistic experiments until a
century later, Navez in Belgium being the first to devise an instrument. The records do not show when the well-known Le Boulengé Chronograph was first installed at the Butts, but the instruments now in use for measuring muzzle-velocity are still of this type, although various improvements for their adjustment were introduced by Captain Holden, R.A., about 1888.

In 1857 the first attempt to measure the pressure developed in a gun was made by Rodman in the United States, though Rumford had carried out experiments in a closed vessel in 1792, and Robins had attempted to calculate the power of fired gunpowder.

Rodman's gauge was tried in this country but was quickly superseded by Captain Noble's crusher gauge, which was first tried in 1860, and perfected by him in the following eight years. It is this gauge which is still used for determining the maximum pressure developed in the chambers of guns.

But we had yet to learn how gunpowder developed its maximum pressure and imparted the velocity at the muzzle to the ball. It was in 1868 that the great advance came with the classic work of Captain Noble and F. Abel. The experiments with Noble's chronoscope and gauges were carried out at the Butts, and now a solution was offered as to the rise and fall of pressure in the gun and the velocity of the projectile at every point in the bore of the gun. It was thus that the influence of size of grain, etc., on the pressure in the gun was determined, and the foundation laid for the scientific design of the gun so that its strength at various points could be proportioned to meet the pressures it had to withstand.

Down to 1894 guns with Noble's crusher gauges placed at various points along the bore were used at the Butts, whenever new powders were being experimented with. The two chief propellents introduced into the Service during that period were prism brown powder and cordite. A disadvantage of this system of determining forward pressure is that guns have to be specially prepared by having holes bored through them at intervals to take the gauges.
EXISTING GOVERNMENT ESTABLISHMENTS

Since 1900 other methods have replaced Noble's system of forward gauges. In 1896 the experimental side of the Proof Butts was developed. Closed vessels of the Vieille type were procured and other apparatus for research of internal ballistic problems was provided.

In 1903 M.D. cordite was introduced, and this apparatus quickly enabled internal ballistic problems with the new propellant to be solved; a solution, however, that cannot be arrived at in a laboratory, but requires also experiments in the gun.

The science of artillery has made great and rapid progress in the past forty years, a progress greatly accelerated by the invention of smokeless powder. During this period armaments have increased, as also have inventions worthy of investigation, if not adoption, by the Government. The Butts have necessarily developed also. The guns come down for whatever proof or experiment is required in the morning and go back at night, to be replaced next day. This is the great advantage of having the Butts near the arsenal.

Earth traverses are now placed behind the guns and from each side of the firing position up to the butt, so that in the event of an accident, pieces may not be "forced into different parts of the" Arsenal. Happily, however, there has been no case of a burst gun for at least twenty years.

The Chemical Research Department was formed in 1904. On the formation of the Explosives Committee, under the Presidency of Lord Rayleigh, in 1900, a few chemists were engaged to carry out research work, and were found a temporary habitation at the Proof Butts, and two years later buildings were erected south of the Butts. Though the Chemical Research Department is of comparatively recent origin the employment of chemists in research work is of much older date.

About 1837 the first Arsenal chemist, Mr. Marsh, was appointed. He was the inventor of "percussion tubes for cannon," and we see thus early the connection between the chemist and the gun.

Marsh died in 1846, and in 1854 Mr. Abel was appointed "War
Department Chemist" in the Arsenal. It is not clear if the position was vacant from 1846 to 1854.

Abel at first can have had little routine work. He was certainly engaged mainly on research up to at least 1870, and he was engaged in research up to 1885, but routine work must have increased. His work with Captain Noble has already been referred to, a work which only found its ultimate expression of practical utility when the research was extended to the gun.

The department of the War Office chemist was more and more weighted with routine work for inspection purposes with the ever-growing increase in war-like supplies.

The introduction of Poudre B.N. in France led to the foundation, in 1888, of an Explosives Committee with which Sir F. Abel and Dr. Kellner, the then War Department Chemist, were closely associated. This committee of research ceased to exist after introducing cordite in 1891.

Research now began to develop at the Proof Butts, as I have shown, and in 1900 Lord Rayleigh's Committee was formed with provision of chemists unweighted by routine work.

In order to achieve progress in artillery, research on explosives destined for a gun—whether as propellant or high explosive—must have its ultimate appeal to the gun. The chemist and the artillerist, if they are to learn each other's needs and limitations, must therefore be in close touch. This is the principle which crystallizes from the history of the past, and underlies the organization of the Research Department.

The Chemical Research Department had also been engaged on questions involving metallurgical research. On formation of the Research Department, a distinct branch, called the Mechanical Research Branch, took over the study of these questions.

We have now followed the developments which led to the formation of the Research Department in 1907, and which consists of three branches: the Proof and Experimental, the Chemical Research, and
EXISTING GOVERNMENT ESTABLISHMENTS

the Mechanical Research, under the control of one Superintendent. The various buildings, etc., of this department are situated together, and personal contact between these branches is thus secured.

Amongst the buildings is included a factory for the manufacture of explosives on an experimental scale. Facilities also exist for testing high explosive shell, either at rest or in smaller natures when fired from a gun.

Samples may be submitted for examination. These are first analyzed and tested by a stability test. This preliminary examination includes for high explosives the determination of power and sensitivity, and for propellents determination of calorimetric value and power in closed vessels. An apparatus for measuring the rate of detonation of high explosives is being installed, and an apparatus exists for the gas analysis of the products of explosion of propellents.

When an explosive is followed up beyond this preliminary stage, it undergoes a more extended trial in climatic huts. These huts are kept at 120° Fahr. and 115° Fahr., the 120° huts being dry and the 115° huts 75 per cent. saturated with moisture. The huts are of special design with a view to their yielding at once, and so relieving the pressure should a flare result. They are of course strongly traversed and well isolated. The explosive is also more particularly examined as to the special purpose for which it is intended.
PRIVATE ESTABLISHMENTS

AMMONAL EXPLOSIVES, LIMITED, LONDON

Head Office: 29, Great St. Helen's, London, E.C.
Capital: £120,000.
Factory: Gathurst, Wigan.

Recently new arrangements have been made for the manufacture of this explosive at the works of the Roburite Company.

SIR W. G. ARMSTRONG, WHITWORTH AND CO.

The Elswick Works of Sir W. G. Armstrong, Whitworth and Co., Limited, were started in 1847.

In 1854 the outbreak of the Crimean War brought Elswick, perhaps for the first time, into connection with the War Office. Mr. Armstrong, who had some experience of the class of work required, was asked to design some submarine mines to blow up the Russian ships which had been sunk in the harbour of Sebastopol. The drawing of this explosive machine, which was never actually used, shows a wrought-iron cylinder loaded with guncotton and fitted with arrangements for firing by electricity. Experiments were carried out, and Mr. Armstrong invited the principal Elswick employés to witness a trial in his field at Jesmond. It was a very pleasant function, and greatly enjoyed by all the guests. The mines, planted in different parts of the field, exploded in the most exhilarating manner, and after
tea had been served out, the party separated, delighted with the afternoon's entertainment. There is something refreshing in the remembrance of this genial little exhibition, and the informal friendliness between employers and employed to which it testified.

The Ordnance Works at Elswick were started, in the first instance, solely to undertake Government orders, and the Secretary of State for War was a party to the contract.

Between 1859 and 1863 the orders given by the War Office to Elswick amounted to £1,067,000. In the course of the next fifteen years they were £54,000. But in 1864, the supply of foreign orders for artillery gradually grew greater, with Denmark, Turkey and Egypt among the customers.

The Ordnance Works consist of 93 buildings, including 40 large workshops, fitted with the most modern machinery, exclusively employed in the manufacture of war material, and equipped for the following work: Gun construction, naval gun mountings, land-service gun mountings, field-service carriages, shot and shell, cartridge cases, forgings, cast-iron castings, blacksmitheries, gun-sights and fittings, brass finishing, electric work, gun inspection, pattern making, material testing rooms, stores, engine and boiler houses. In the main offices are large and well-lit drawing offices, chemical laboratory, plan printing and photographic studios, etc.

The Scotswood Works are situated on the north bank of the Tyne, three miles from Newcastle, and a full mile from Elswick. They have a frontage of half a mile, and the area occupied is about 37 acres.

A bridge connects the yard with the North-Eastern Railway system, and a jetty on the river front enables water transport to be made.

The Fuse Shop, having an area of 45,240 square feet, is equipped with automatic machines, lathes, milling tools, drilling machines, presses, etc. In all there are 360 machines, driven by a 250 H.P. gas engine. The work done in this shop comprises the making of fuse bodies, primers, shell plugs, bolts, nuts and screws, electrical
fittings, motor car detail, tinsmiths' work, night-sights for guns, small shell, powder-cases, hydraulic motors, lubricators, etc.

The Shell Shop, comprising an area of 37,440 square feet, is devoted to the manufacture of shot and shell for all sizes of guns from 12-inch downwards. There are 115 machines in this shop, driven by a 250 H.P. gas engine.

The Fuse Factory comprises an area of 48,800 square feet. In this factory the work of filling fuses, primers, etc., with explosives is undertaken. It is fitted with the necessary machinery for this work; there are 30 machines in all.

The Forge comprises 14,400 square feet.

The High Explosives Factory, comprising an area of 88,000 square feet, is set apart for the filling of shell with high explosives, the buildings being erected on the most modern principles for this special purpose, and isolated from the other parts of the works with mounds and screens.

The Thames Ammunition Works, founded in 1879, were acquired by the Company early in 1902. They cover a site of about 40 acres, and are situate on the spit of land between the Thames and the Darenth rivers, where the latter joins the main stream at Dartford Creek. The Thames forms the northern boundary, and, by means of a pier, material can be shipped directly to and from the factory into barges for transport to Woolwich or Hole-Haven. A narrow gauge line connects the pier with all buildings in the enclosure.

On the land side, the Works may be approached by rail from Erith or Slades Green stations on the South-Eastern Railway through Slades Green Village, and thence by a private road across the marsh.

The factory is divided into two portions by a main road, carefully fenced in on either side. All persons entering must pass along this road, and cannot reach the danger areas without passing through one of the "changing rooms," whence, having donned the proper clothes, they proceed on platforms leading to the ammunition sheds. The enclosures are intersected by dykes, which would serve to diminish
the risk of a fire spreading should there be, at any time, an outbreak.

For the manufacture of ammunition, filling of cartridges and similar purposes, there are 13 buildings, separated from each other by the regulation distances, according to the amount of explosives allowed in them. These buildings are devoted to the filling of shell or cartridges of all descriptions, and the filling of fuses. They are steamed by a system of pipes which are served from two Cornish boilers, which also supply the steam for an engine for driving the dynamos for lighting the factory and supplying the power.

There are nine buildings devoted to the manufacture and storage of electric detonator fuses for blasting purposes. These are supplied with steam from an auxiliary workshop in an isolated building outside the danger area.

The factory is licensed for the storage of 83 tons of explosives in nine mounded magazines, of which six are built, and the remaining three can be put up under the licence at any time whenever required.

A large building serves the purposes of receiving and unpacking material, and storing empty cases; it is also used as a workshop. The factory is equipped with a small forge, and dining-room for the operatives, together with a lodge, waiting-room and stabling at the entrance gates.

There is also a platform from which small guns can be fired along a covered range into a stop butt.

The Government licence in the factory covers the filling of all kinds of fuses and primers, shell, cartridges, and quick-firing ammunition.

WILLIAM BENNETT, SONS AND CO., LIMITED

HEAD OFFICE: Roskear, Camborne, Cornwall.
 CAPITAL: £36,000.
 FACTORY: Roskear Fuse Works, Camborne, Cornwall.
BRITISH EXPLOSIVES INDUSTRY

PERSONNEL: 1 Chemist.
      1 Scientific Engineer.
      6 Manufacturing, Commercial, and Administrative employés.
      20 Male workers.
      206 Female workers.

PRODUCTS MANUFACTURED: Patent Safety-Fuse for Blasting.

PRIME MATERIALS USED: Jute, Flax and Cotton Yarns, Gutta-percha,
      Glue, Tar, Pitch, and Gunpowder.

The Goods are manufactured for home consumption and for export.

SPECIALITIES MANUFACTURED: Blasting Fuse of all descriptions.

This firm was founded in 1871 by the late Mr. William Bennett; after his decease in 1890 it was continued by the survivors of his family. It was converted into a limited company in June, 1907.

BICKFORD, SMITH AND CO., LIMITED, TUCKINGMILL

HEAD OFFICE: Tuckingmill, Cornwall.

CAPITAL: £200,000.

FACTORIES: Tuckingmill, and elsewhere in Cornwall.
      St. Helens Junction, Lancashire.
      Bendigo, Victoria, Australia; with numerous foreign connections.

PERSONNEL: The Resident Directors are Sir George J. Smith
      (Managing Director) and George E. Stanley Smith, with a
      numerous technical and commercial staff under them.

PRODUCTS MANUFACTURED: Every kind of Blasting Fuses, e.g., Bickford's
      Safety, Bickford's Instantaneous, Bickford's Colliery Fuses,
      Electric Fuses, Permitted Igniter Fuses, Metallic Fuses, etc.

      The capacity of the works has been largely increased during
      recent years, and is at present in process of further development.

PRIME MATERIALS USED: The principal materials are Gunpowder of
      several descriptions, Jute, Cotton, and other yarns, Gutta-percha
and other hydro-carbons, used in varnishes, and other insulating and chemical materials.

The manufactures are both for home and foreign consumption. The exportation arrangements consist of established agencies of the Company in most of the important Colonies and some foreign countries. Bickford's Fuses are also largely purchased in this country by merchants exporting abroad.

Specialities manufactured or invented: The Bickford Fuse in practically all its varieties is the invention of William Bickford, of Tuckingmill, and his successors. The Company's most recent specialities have been the Colliery Safety-Fuse and Permitted Igniter Fuse, the Bickford Instantaneous Fuse, and the recent development of that idea in the tri-nitro-toluene fuse, patented by their French partner, M. Jean Harlé, (No. 1820/08).

Benevolent Institutions: Bickford, Smith and Co., Limited, subscribe to and utilize general hospitals and charities in Cornwall and elsewhere.

Distinctions obtained: Bickford's Fuses have obtained the First Awards of Merit at practically all the great Exhibitions since the first of 1851 in London, including those of Paris, Vienna, Philadelphia and Chicago.

Birmingham Metal and Munitions Company, Limited

General Manager: John H. Barker, M.Inst.C.E., M.Inst.E.E.
Head Office: Adderley Park, Birmingham.
Capital: £600,000.

The shares of this Company are held by Nobel's Explosives Company, Limited, Glasgow.
Factories: Adderley Park and Streetly.
BRITISH EXPLOSIVES INDUSTRY

(a) Adderley Park

Works Manager: V. E. Greenwood, A.M.I.M.E.

Size of Factory: About 3½ acres.

Number of Buildings: 1 three-storey Building; 1 two-storey Building, with Offices (about 690 feet frontage); 18 Metal-Casting Shops; 12 other large Buildings.

Hospital: 1 fully equipped Surgery with trained Nurse as Matron.


Recreation: Cricket and Football.

Number of Officials: Officials and General Office Staff = 28; Works Staff and Foremen = 21.


Number of Workpeople: Average, 500 to 600 men; 300 to 400 women.

Number of Boilers: Each department, including two Metal-Rolling Mills, is now electrically driven, taking the electrical power from the Corporation—about 1000 Kilowatts. Four boilers are used for Hydraulic Pumping Engines, and for heating purposes, etc.

Number of Engines: All Steam Engines for driving purposes were removed on Electrical equipment being installed, excepting five double-acting Hydraulic Pumping Engines.

Pumps: Two deep well pumps, electrically driven (with automatic starting and stopping gear attached). One pair of vertical hydraulic pumps electrically driven with Morse chain drive belt and auto starting and stopping gear attached for Hydraulic Lifts.

Tramway: One ton overhead electric Transporter running through the main walk of each department on ground floor.

Products of Manufacture: Ammunition, Breech-Loading Cartridges, for Ordnance and Small Arms, Percussion caps, etc. Manufacturers and Rollers of Copper, Brass, Nickel Silver, and other Metals; Stampings and Drawings, Wire, etc.

Medals: Grand Prix, Paris Exhibition, 1900; Grand Prix, St. Louis, 1904; Grand Prix, Franco-British, 1908.
PRIVATE ESTABLISHMENTS

(b) Streetley

Works Manager: Harold Harris, F.C.S.

Size of Factory: About 98 acres.

Number of Buildings: 3 rows of Workmen's cottages, 2 dwelling-houses, 1 block of buildings comprising Offices, Mess Rooms and Stores, 64 sheds for loading purposes, etc., 500 yards Range and Workmen's Hut; Velocity Range, Firing Shed with guns, Chronograph Room, etc.; 2 large magazines.

Hospital: 1 fully equipped ambulance outfit with Staff.


Recreation: Cricket and Football.

Number of Officials: Officials and General Staff = 5.

Chemists: 2.

Number of Workpeople: Average 25 to 30 men; 100 to 150 women.

Number of Boilers: 2 Lancashire Boilers.

Number of Engines: 1 horizontal Steam Engine; 1 double cylinder high speed vertical Steam Engine.

Tramway: 3 overhead Transporters with carrying-cages connecting loading-sheds, etc.

Products of Manufacture: Cartridge and Detonator Loading, Fog Signals.

These factories were at one time owned by the Birmingham Small Arms and Metal Company. There are extensive rolling-mills equipped for the manufacture and loading of military ammunition of every kind, to which has been added the manufacture of commercial articles made from brass.

OSWALD BRADLEY, PYROTECHNIC ARTIST, RIPON

Head Office and Factory: Skelton-on-Ure, Ripon, Yorkshire.

Products manufactured: Fireworks, large and small.

Capacity of Works: Four magazines, one for Chlorate compositions,
capacity 300 lb.; one for non-Chlorate, capacity 600 lb.; one Gunpowder magazine, capacity 300 lb.; one factory magazine for finished goods, capacity 5,000 lb.; and a drying-room, capacity 500 lb.

**Materials used:** Ordinary pyrotechnical materials.

**Goods are manufactured for Home consumption.**

**Number of buildings on the Factory:** 11.

**Engines:** One ½ H.P. oil engine.

**Specialties manufactured:** Flash-light Rockets and Roman candles.

Mr. Oswald Bradley discovered or rather invented a Chlorate but non-sulphur composition, which will in all cases take the place of Meal Powder. It is used for priming Chlorate stars, lances, or little coloured lights used in large designs, and for making quick-match for pill-box stars or for lance work. The use of this composition does away with the liability to spontaneous combustion, always present when Meal Powder is used to prime anything containing a Chlorate. The following is the formula:

- Fine Saltpetre, 6.
- Pot Chlorate, 8.
- Shellac substitute (George Boor and Co.), 2.
- Finest Charcoal, 3.
- To be passed thrice through a 30-mesh sieve.

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**F. Brain, East Dean, Forest of Dean**

Manufacture of Electric Detonators, Fuses, and Electric Fuses. Licensed in 1878 and 1892.
THE BRITISH EXPLOSIVES SYNDICATE, LIMITED,
GLASGOW

The British Explosives Syndicate, Limited, was formed in September, 1891, with a capital of £100,000, made up of 7,500 Ordinary and 2,500 Deferred Shares.

The operations of the Syndicate commenced in the same year and a suitable site for a Factory was obtained on the Pitsea Hall Farm in the County of Essex, and in close proximity to the mouth of the river Thames.

In 1894 the necessary Buildings and Machinery for the Manufacture of Nitro-Glycerine were completed, and in the same year orders for Cordite Paste were obtained from the British Government. In 1895 additional Buildings and Plant were erected for the Manufacture of No. 1 Dynamite.

In 1896 the Syndicate made provision for the manufacture of Gelatine Compounds, as it was being proved that Gelignite, Gelatine Dynamite, and Blasting Gelatine were gradually taking the place of No. 1 Dynamite in many parts of the world.

Negotiations quickly followed for the representation of the Syndicate in various Colonial Markets, and early in 1896 first consignments of Dynamite and Gelatine Explosives were shipped to Australia and South Africa.

In October, 1896, additional Capital was raised by the issue of Debenture Stock in order to further develop the business of the Syndicate, and from that period up till the present the operations of the Syndicate continue to extend.

In 1902 Buildings, Plant, and Machinery were laid down for the manufacture of finished Cordite, and since then the Syndicate has regularly supplied this Military Powder to the British Government.

Besides the Explosives above referred to the Syndicate manu-
facture two "Permitted" Explosives called "Britonite" and "Frac-
turite."

In 1904 the Capital of the Syndicate was reduced and a new Com-
pany registered in August of that year.

The Registered Office of the Syndicate is now at 124, St. Vincent
Street, Glasgow, and the present Directors are:

Douglas Cairney, Stockbroker, Glasgow (Chairman).
James B. Gibson, Chartered Accountant, Glasgow.
William Shaw, Warehouseman, Glasgow.

The Syndicate has now Agents in all the Australian Colonies, and
in Chili, Peru, and Bolivia, and they have also numerous Agents
throughout the United Kingdom.

THE BRITISH AND FOREIGN FUSE SYNDICATE,
REDRUTH

Manufacture of Safety-Fuse. Licensed in 1877.

THE BRITISH ELECTRIC DETONATOR COMPANY,
LIMITED, PARR, NEAR ST. HELENS, LANCAS-
SHIRE.

Manufacture of Electric Detonators and Fuses. Licensed in 1907.

THE BRITISH WESTFALITE, LIMITED, DENABY,
NEAR DONCASTER

Manufacture of Westfalite, Electric Detonators, and Fuses. Licensed
in 1889.
C. T. BROCK AND CO., SUTTON.

Head Office: Sutton, Surrey.

Factory: (No. 190 Surrey) situated at North Cheam, Sutton, Surrey, comprises about two hundred acres, and is considered a model Firework Factory.

Norwood Factory, at South Norwood, in the Parish of Croydon, Surrey, absorbed by Sutton Factory in 1902, and people, sheds, and explosives removed to Sutton.

Harold Wood Factory, in the Parish of Hornchurch, Essex, absorbed by Sutton Factory in 1907, and people, sheds, and explosives removed to Sutton.

The Hulks "Alfred" and "Bluebell" moored at Higham Bight, on the Thames below Gravesend, in the Parish of Chalk, Kent.

Personnel: 1 Chemist, 3 Artists.

1 Scientific Engineer.

25 Manufacturing, Commercial, and Administrative employés.

150 Male workers.

90 Female workers.

Products manufactured include Fireworks of every kind for public and private display, for expert and amateur handling, ships' signals, Admiralty and War Office night and day signals, and illuminants.

Prime Materials used: Pyrotechnic chemicals and paper.

Goods are manufactured for home and foreign use. Floating magazines at Gravesend with fully equipped vessels, staff, and appliances for unloading, storing, re-loading, transhipping and forwarding explosives. Agents in the principal cities and ports of commerce and war throughout the world.

Number of Buildings licensed: 200.

Engines: Two 12 H.P., one 5 H.P., one 1½ H.P. nominal.

Machinery: includes frame saw, circular saws, band saw, power
printing machine, grinding mills, lathes, and special technical machines.

**Specialities manufactured or invented:**

Inventions and patents under many heads, including the blasting explosive "Brockite"; patent Pyrotechnic Signals adopted by the War Office; pyrotechnic Morse Code Signals approved by Admiralty, and other light, sound and colour signals for use by hand ashore or afloat, in rockets, shells, Roman candles and other special manufactures to suit particular purposes, such as zareba lights for bush camp alarms, hunting, yacht racing, Army and Navy manœuvres and field operation signals, Merchant shipping and Company private code signals, life-saving line-carrying rockets and apparatus, alarm and distress signals, etc., etc. Living Fireworks and colossal fire portraiture; representation in lines of fire without background or scenery of current events, naval engagements, national, patriotic and historical happenings and celebrations, one single pyrotechnic masterpiece having measured one-eighth of a mile in length.

**Distinctions obtained:** Medals, Diplomas, Distinctions, and honourable mention have been obtained with unvarying regularity since 1865. These include: Diploma of Honour, London, 1884, and Paris, 1887, and a large number of other gold medals and special diplomas of honour.

Royal and other official and important displays carried out during the last forty years include Prince of Wales's Indian Tour, 1875, Philadelphia Exposition, the Delhi Durbars, Jubilee and Coronation Official Colonial displays in India, Australia, South Africa, etc., Danube Imperial Fêtes at Budapest, Quebec Battlefields Centenary, Royal Command Displays before T.M the King, Queen, Royal Family and Court, and for the visits of the German Emperors, Czars, Shahs, Sultans, etc., etc.

The records of the earlier Brocks, from A.D. 1700 to the
present date, show that Thomas Brock, who was born in the year 1700, made the first distinctive position in the history of "Brock's Fireworks;" his successors in the family and parish registers are given as Benjamin Brock, born 1728; Thomas Brock, 1750, with a factory at North London; William Brock, 1779, who established a factory to the east of the City of London, and where the earliest recorded accident in the firm of Brock appears to be that of 1825, when "seven persons were seriously injured"; William Brock (the son), 1813; Charles Thomas Brock, 1837, who founded the first model factory under the Explosives Act, 1875, at Nunhead, which was subsequently moved to South Norwood; and Arthur Brock, 1858, the present proprietor, who established the existing factory at Sutton.

The "Grand International Pyrotechnic Competition among six of the best fireworks manufacturers," took place at the Crystal Palace in 1865.

Brock's Firework Display material at the Crystal Palace probably exceeds in one season the whole of the other private and public displays in the United Kingdom during the year. Calculations based upon official records show that the amount paid by the public to see the Fireworks at the Crystal Palace since the great Competition of 1865 is £2,250,000, which justifies the newspaper statement to the effect that "there is no form of entertainment which pleases so many persons far and near at so small a cost as Fireworks."

Brock's Fireworks Series at Philadelphia Exhibition in 1876, for which £1,000 per display was paid, brought 250,000 payers to the turnstiles in one day, and founded the knowledge of and taste for Firework Displays on the American Continent.

A branch factory of Brock was established in Turkey in 1870 by command of H.M. the Sultan.
W. BRUNTON AND COMPANY, BRYMBO, NEAR WREXHAM

Manufacture of Electric Detonators and Fuses and Safety-Fuses. Licensed in 1877.

THE CHILWORTH GUNPOWDER COMPANY, LIMITED, LONDON

HEAD OFFICE: 54, Parliament Street, London, S.W.
CAPITAL: £100,000.
FACTORIES: Chilworth, Surrey; Fernilee, Derbyshire.
PERSONNEL: 1 Head Chemist, 1 Assistant Chemist.
   2 Chief, and Assistant Engineers.
   20 Manufacturing, Commercial and Administrative employés.
   Approximately 300 Male workers.
   Approximately 6 Female workers.
PRODUCTS MANUFACTURED: All classes of propellent smokeless powders for military and sporting purposes, and Gunpowder ordinarily so-called.
PRIME MATERIALS USED: Guncotton, Nitro-Glycerine, Mineral Jelly, Acetone, Saltpetre, Sulphur, Charcoal, etc.
EXPLOSIVES are manufactured for home and foreign consumption.
   Magazines and Agents in all the principal Colonies of the Empire, also Agents in all principal foreign countries.
NUMBER OF BUILDINGS ON THE FACTORIES: 143.
Boilers and Engines (steam) aggregating about 1,500 H.P. Also water-power of about 100 H.P.
Electric lighting by arc lamps and incandescent lamps.
Air compressors in Smokeless Powder factory.
Ten steam pumps, two water pumps.
The machinery installed consists of over 200 separate machines of recent pattern. Much of it was specially designed.

About 5 miles of Tramway, 2 feet 7½ inches gauge.

Three 10-ton weighbridges.

Specialities manufactured or invented: Brown Prismatic Powder, which was introduced into the British Government Services for Navy and Army through the Chilworth Gunpowder Company, Limited.

C. S. P. 2, a propellent powder of the “nitro-glycerine-nitrocellulose” type, specially designed to give great stability, which gives no back flash in large guns, whilst in small guns and howitzers no flame is apparent at the muzzle.

This C. S. P. 2 has lately been adopted by several foreign Governments.

Benevolent Institutions: The Company provides for those employés who are past work.

Distinctions obtained: The Company does not advertise either directly or through the medium of Exhibitions, although on the introduction of Brown Prismatic Powder into the British service, the Company consented to exhibit at the Royal Naval Exhibition of 1891, and was awarded a special Diploma.

The Chilworth Gunpowder Company, Limited, was formed as such in the year 1885, but previous to that date the works at Chilworth, which they then acquired, had been in practically continuous work since their erection. The exact date of erection is lost, but it certainly cannot have been later than early in the seventeenth century, judging from actual official documents, and is generally supposed to have been in 1570.

The Company may, therefore, claim to own not only the oldest established gunpowder mills in the United Kingdom, but probably also in the world. The mills themselves were not the first erected in this country, as it appears that in the year 1560 gunpowder mills
were built at Thames Ditton, and also at Godstone,¹ but these and
other previous ones no longer exist on their original sites.

From old records it appears that even in those early days the
Chilworth Mills produced not only very large quantities of gun-
powder, but the product seems to have been renowned for quality,
which attracted large Government orders, in fact, on 1st November,
1636, the Government signed a contract appointing the Chilworth
Mills to be the only authorized gunpowder makers in the kingdom.

The smokeless Powder factory, which adjoins the gunpowder
factory, was erected early in 1892; and it is of interest to note that
it was in this factory that cordite was first manufactured (apart from
the manufacture at the Royal Gunpowder Factory at Waltham Abbey)
the Company having supplied private Clients with this class of pro-
pellent in 1892, before the Government had finally adopted it.

CLAYTON AND COMPANY (HUDDERSFIELD), LIMITED,
HOYLAND SWAINE, PENISTONE

Manufacture of Railway Fog Signals. Licensed in 1896.

COTTON POWDER COMPANY, LIMITED, LONDON

Head Office: 32, Queen Victoria Street, London, E.C.

Capital: £50,000 in 7 per cent. Preference Shares and £60,000 in
Ordinary Shares, of which £40,000 and £50,000 respectively are
issued and fully paid. There is also an issue of £20,000 in
Debentures paying interest at 6 per cent.

Factories: The Company has two factories, the larger, their Oare

¹ There were gunpowder mills in this country at a much earlier date. (See the
chronological table.)
PRIVATE ESTABLISHMENTS

Works, being situated on the banks of the Swale near Faversham, Kent, and the smaller at Melling, in Lancashire.

PERSONNEL: The complete personnel employed by the Company is approximately as under:

- 10 Chemists.
- 3 Scientific Engineers.
- 25 Commercial and Administrative Employés.
- 325 Workmen, including Foremen.
- 75 Workwomen.

PRODUCTS MANUFACTURED: At Faversham—Nitro-Glycerine, Nitric Acid, Guncotton, Guncotton compressed for submarine and military purposes, Nitro-Cotton, Cordite, Nitro-Glycerine Blasting Powders, Fulminate of Mercury, Detonators, Electric Detonator Fuses, Signals, Socket Distress Signals for marine use, Sound Signals for Lighthouse purposes, Flash Sound Signals for Lighthouse purposes, Hale’s Patent Hand and Rifle Grenades, Nitrate of Ammonia, together with the usual subsidiary output of cases, boxes, etc.

The principal products manufactured at the Company’s Melling Works are:—Nitrate of Ammonia Safety Powders, but principally Rexite and Faversham Powder, both of which are on the Home Office Permitted List.

The CAPACITY of the Company’s Works in its principal products is:

- Nitric Acid per annum, 1,250 tons.
- Guncotton, 850 tons.
- Nitro-Glycerine, 850 tons.
- Cordite, including M.D. and Mark I, 800 tons.
- Nitro-Glycerine Blasting Explosives, 500 tons.
- Nitrate of Ammonia Blasting Explosives, 300 tons.
- Tonite, 350 tons.
- Fulminate of Mercury, 7 tons.
- Detonators, 3,000,000.
- Electric Detonator Fuses, 750,000.
Distress Signals, 40,000.
Sound Signals of all descriptions, 1,000,000.
Nitrate of Ammonia, 200 tons.

Prime Materials Used: Acetone, Aluminium, Ammonium Chloride (Sal-ammoniac), Ammonia liquor, Ammonium Oxalate, Ammonium Perchlorate, Antimony Regulus, Arsenic Sulphide (realgar), Barium Nitrate, Charcoal, Cotton Waste, Cotton Wool, Glycerine, Kieselguhr, Mercury, Methylated Ether, Methylated Spirit, Mineral Jelly, Muriatic Acid, Nordhausen Oil of Vitriol, Potassium Chlorate, Potassium Nitrate (Salpetre), Potassium Perchlorate, Shellac, Sodium Carbonate (Crystals), Sodium Carbonate (Soda Ash), Sodium Chloride (Salt), Sodium Nitrate (Chili Saltpetre), Sodium Silicate, Sodium Tungstate, Strontium Nitrate, Sulphur, Sulphuric Acid, Trinitro-Toluene, Wood flour.

The only By-Product obtained and sold as such is Nitre Cake—other by-products are utilized for various purposes in the Company’s subsidiary manufactures.

Markets: The larger portion of the Company’s trade is in the United Kingdom, but they also supply military explosives to the Governments of New Zealand, Australia, Canada, Chili, Peru, Argentine, India, and Japan.

They manufacture very extensively Sound Signals for Lighthouse purposes, and Socket Distress Signals for marine work.

The Company are also represented for the sale of their Blasting Explosives and commercial manufactures in the following countries:

Argentine, British Columbia, British Guiana, Canada, China, Gibraltar, India, Japan, Newfoundland, New South Wales, Nigeria, New Zealand, Straits Settlements, Siam, the Gold Coast, United States of Columbia, Victoria, and West Africa.

Factory Arrangements: The Company’s Oare Works are situated on the banks of the Swale, about four miles from the town of Faversham.
They comprise about 400 acres of land, buildings being situated on about 250 acres. They have a good water frontage, with convenient wharf accommodation, and a good water carriage with special facilities for loading goods for export.

There are at these Works about 227 buildings of various sorts.

There are seven Lancashire Boilers in three separate Boiler Houses.

The working pressure throughout is 100 lbs. per square inch. Each boiler has a "Bolton" Downtake Super-heater fitted, and the average temperature of the steam on leaving the Superheater is 580° F.

The total H.P. the boilers are capable of developing is about 1,800. A very large portion of the steam, however, is used for drying and boiling purposes, particularly in the manufacture of the large sizes of Cordite. In this Department alone there are approximately three miles of large size steam-pipe above ground connecting with the drying-houses.

Owing to the marshy nature of the ground it is impossible to build chimney stacks, and each set of boilers is fitted with a 30-inch Sirocco Fan arranged for induced draft.

Alexander Wright and Co.'s Patent CO₂ Recorders have been installed in two of the boiler batteries as a means of regulating the coal consumption, and the results after six months' working have been very satisfactory.

*Engines (Steam)*: Owing to the scattered nature of the factory there are a number of steam-engines of various descriptions, 25 being installed in various departments of the Works capable of developing in all about 400 H.P.

*Engines (Gas)*: The power for the Guncotton Beating House is supplied by a Kynoch Engine and Suction Gas Plant with a capacity of 120 B.H.P.

*Lighting*: Electric Light Plant is installed in one department only
of the Faversham Works, the plant for the recovery of volatile solvents being lit in this manner. The plant is a small one.

The lighting of the main factory, together with the heat required for the Laboratories and other minor purposes, is supplied from the Company's Gas Works, which are situated at some little distance from the main factory buildings, and is capable of supplying about 20,000 cubic feet of gas per day.

Machinery: The main items of plant on this factory are as under:

Air Compressors, 3; in all about 180 H.P.

The works have two systems of compressed air mains, respectively 80 and 40 lb. pressure.

Deep Well Pumps: Three direct-acting deep well pumps drawing from one 12-inch, one 10-inch, and one 5-inch artesian well, and capable of pumping in all about 14,000 gallons of water per hour.

Hydraulic Plant: Three sets of Hydraulic Accumulators and Pumps supplying one high-pressure and two low-pressure services to different portions of the factory.

Hydraulic and other Presses for Cordite, 17 of various sizes.

Hydraulic Presses for Guncotton, 4.

Hydraulic and Mechanical Presses for Tonite and Signals, 6.

Fire Installation: There is a complete hydraulic pressure Fire Installation, consisting of a powerful stationary pump with mains and hydrants throughout the factory. A full head of water can be turned on to any building within the danger area in the course of two minutes.

The Works are also equipped with a mechanic's machine and fitting shop complete with lathes, drilling and planing machines, etc., also with Tinsmith's, Carpenter's, Joiner's, Wheelwright's, and Lead Burner's shops.

They also have their own dock and slip, and can carry out any necessary repairs to their barge fleet.

The tramways throughout the Works are 3 feet 3 inches gauge. They are so arranged as to be convenient for the conveyance of
PRIVATE ESTABLISHMENTS

all raw materials from the point of landing at the wharf and of all manufactured and partially manufactured products. There are in all about 4\(\frac{1}{2}\) miles of this road on the factory with a suitable equipment of rolling stock.

The principal receipts of raw materials and deliveries of manufactured goods from these works are made by water, and for this purpose the Company possess a fleet of eight vessels.

The following specialities are at present manufactured by the Company:

Tonite, used principally for submarine blasting and also as a detonating charge in Sound and Distress Signals and the bursting charge in the Company's grenades.

Socket Distress Signals.—These signals are specially sanctioned for use by the Board of Trade.

Sound Signals and Flash Sound Signals, for lighthouse purposes.

Faversham Powder, Rexite, and Normanite.—These powders are on the Home Office Permitted List.

Faversham Powder is a nitrate of ammonia explosive.

Rexite contains nitrate of ammonia with a small percentage of nitro-glycerine.

Normanite contains rather a larger proportion of nitro-glycerine.

Grenades.—The Company are also manufacturing Marten Hale's Patent Hand and Rifle Grenades. The latter is a recent invention of considerable interest. It is capable of throwing a 5 oz. bursting charge surrounded with a shrapnel ring a distance of about 425 yards, and can be thrown from the muzzle of a Service Rifle by means of a specially constructed tail rod which is inserted in the barrel of the rifle, the propelling charge used being the ordinary Service cartridge but without the bullet.

Benevolent Institutions: The Company have a Sick Fund and a Bonus System for its employés, based on the amount of the Dividends returned to the Shareholders.

Distinctions obtained: The Company have taken a large number of
Medals, Diplomas, etc., in London, Paris, and elsewhere, but for the last eight years have not exhibited any of their various products.

**Historical.**—The Company was registered in 1872, and was originally formed for the manufacture of Punshon's Patent Controllable Guncotton. This was a mixture of guncotton finely granulated and closely mixed with sugar. Owing, however, to the extremely hygroscopic nature of the finished product, this explosive proved a complete failure and had to be abandoned.

After a great number of experiments, the then manager—Mr. Trench—invented the explosive known as Tonite, which is used particularly for submarine work.

A few years later the Socket Distress Signal was also invented by Mr. Trench and its manufacture on a considerable scale commenced.

In 1880 the Works at Melling were formed to take up the manufacture of Tonite in the north of England, and almost immediately afterwards the Company commenced the manufacture of nitrate of ammonia powders, and brought out their Faversham Powder.

In 1892 the Company commenced the manufacture of nitroglycerine explosives at their Faversham Works, and in 1896 commenced the manufacture of cordite.

The most recent developments of the Company's manufacture have been in the direction of subsidiary requirements for blasting purposes, such as fulminate of mercury, electric fuses, detonators, etc., all of which are made at Faversham.

**CRANE AND CO., BRISTOL**

**Head Office:** St. James' Barton, Bristol.

**Factories:** Warmley and Bridgyate, near Bristol.

**Personnel:** Manufacturing, commercial, and administrative employés, 5; Male workers, 5; Female workers, 35.
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Products manufactured: 5th November and Display Fireworks, Shipping goods, and Smoke Testing-Rockets for Drains.

Prime materials used: The usual materials for fireworks.

Goods are manufactured for home consumption.

Works: Number of buildings: 6 Magazines, 9 Danger Buildings, 2 Mixing shops, 2 Drying shops, 2 Casemaking shops, 1 Packing shop, 3 Chemical stores, 2 Paper stores, 1 Woodwork store, 2 Display framework warehouses, 1 Charcoal and Lampblack store, 2 Packing case stores, 1 Carpenter's workshop, 1 Shipping goods store, 1 Testing shop.

Heating apparatus connected with the workshops.

Guillotine Cutting Machine and numerous Pinching and Dubbing Machines.

The whole of the factory is connected up with a Tramway.

Specialities: Electric Sparkling Fireworks, Transformation Designs, Whistling Fireworks; and Repeating Shells.

The business was established in 1887 by Mr. I. Crane (the present Proprietor), and when he commenced manufacturing Fireworks he succeeded in obtaining a permanent License from the Secretary of State, but it took him fifteen months to obtain the License and build the Factory in accordance with the Government regulations under the Explosives Act for the establishment of a Firework Factory. Since then, three amended Licenses have been obtained for the enlargement of the Factory, which has been rearranged. During the past few years there has been a continual enlargement of the Magazines at the Factory, Warmley, and these enlarged Stores having proved insufficient, additional land about a mile from the Factory has been secured, and Firework Magazines for the storage of 100,000 lb. of manufactured fireworks have been erected.

The Factory is situated near the Midland Railway Station at Warmley, one of the suburbs of Bristol, and consists of 40 Workshops and Magazines. The Workshops are heated with hot-water pipes.
The buildings are all isolated by means of Screens, those around the Magazines being of brickwork, while additional protection is given to the Powder Magazine by a strong embankment, with which the Screens are backed.

Being situated in the west, the Factory has a large trade in the West and South Wales.

CURTIS’S AND HARVEY, LIMITED,
3, Gracechurch Street, London, E.C.

This Company is divided into 600,000 authorized Shares of £1 each, of which 458,000 are issued. The Company has besides first Mortgage 4½% Debenture Stock to an amount not exceeding the issued Share Capital.

The Works of the Company are situate at Hounslow, Faversham, Cliffe-at-Hoo, Tonbridge, Dartford, Glyn Neath (South Wales), Kames (Kyles of Bute), Roslin, Camilty (Midlothian Gunpowder Co.), Ballincollig (Co. Cork), Glenlean (Argyllshire), Kennall (Cornwall), and employ about 1,500 hands in all.

Every variety of explosive and incandescent gas mantle is manufactured, besides the usual materials and waste products that are incidental to the manufacture of explosives.

The Company manufacture for every market, and have agents throughout the world.

They possess 175 mills driven by steam, water, or suction gas, for the manufacture of Gunpowder, while their factory for High Explosives at Cliffe-at-Hoo is one of the largest and most completely equipped in the Kingdom. They also have factories at Tonbridge for Smokeless Sporting Powder, at North Feltham for Sporting Cartridges, at Dartford for Guncotton and Incandescent Gas Mantles, and at Faversham for Electric Fuses and Detonators. Cheddite, a chlorate explosive for quarry work, is manufactured by this Company.
The Company's "Permitted" Explosives comprise:

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<th>Dragonite</th>
<th>Excellite</th>
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<tr>
<td>Bobbinite</td>
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all of which are the invention and sole property of the Company. "Bobbinite," for which there is a great demand both in this country and abroad, is the only low explosive of the gunpowder type which has succeeded in retaining its place on the "Permitted List" for use in gaseous and fiery coal-mines.

The "Ironclad" Incandescent Gas Mantle, with a metal top in place of the usual asbestos loop, is also a speciality of this firm.

The firm has obtained numerous distinctions, amongst these are as early medals at international exhibitions as: Philadelphia, 1876, and Paris, 1878.

Messrs. Curtis's and Harvey, Limited, were constituted a public company in 1898, and incorporated the following firms:

Curtis's and Harvey, with factories at Hounslow, Tonbridge, Glyn Neath, Kames, Glenlean.

John Hall and Son, Ltd., Faversham.

Pigou, Wilks and Laurence, Ltd., Dartford.

Ballincollig Royal Gunpowder Works, Ltd., near Cork.

Hay Merricks and Co. Ltd., Roslin, near Edinburgh.

The Kennall Vale Gunpowder Co., Perranwell Station, Cornwall.

The East Cornwall Gunpowder Co., Liskeard, Cornwall.

The Midlothian Gunpowder Co., Ltd., West Calder.

The War and Sporting Smokeless Powder Co., Ltd., Trimley, near Ipswich.

Hounslow.—It is difficult to say when Hounslow, the original factory of Messrs. Curtis's and Harvey, on the estate of the Duke of Northumberland, was first devoted to the manufacture of Gunpowder. There is no doubt, however, that it possesses a very considerable antiquity, and at all events in the early part of the eighteenth century
the powder factory was occupied by a person of the name of "Smith." After him came "Hill," who was succeeded by "Isaac Butts," followed by "Harvey and Grueber," who in the year 1820 dissolved partnership when the present firm of Curtis's and Harvey was established through the instrumentality of the famous Alderman Sir William Curtis, the first partners in the concern being Mr. Charles Berwick Curtis his son, Mr. Thomas Curtis, his nephew; Mr. W. G. Harvey, representing the older firm. It is recorded that a Harvey was previously in the occupation of part of the well-known powder works at Battle. From that day to this the history of the factory has been one of continuous progress, more particularly in the manufacture of high-class small-arms powders for military and sporting purposes.

The adjoining factory of Bedfont, then carried on by Messrs. Taylor and Alcock, was very early added to the Hounslow Works.

In March, 1850, six houses exploded with the loss of seven lives. Subsequent to this, with a view to minimize the risk of communicated explosion, most of the danger buildings were fitted with tank-roofs filled with water. This, however excellent in theory, proved disastrous in practice, for when the Lower Press and Corning House exploded in March, 1859, the weight of the tank-roof gave a lateral direction to the wave of explosion, consequently causing immense damage to the rest of the factory and to the surrounding neighbourhood. Eight lives were lost in this explosion.

In May, 1866, a very serious fire occurred, by which eighty-five tons of dogwood and fifty stacks of alder were destroyed, though, fortunately the flames were prevented from spreading to the danger buildings.

In 1871 the War Office was devising ammunition for the new Martini-Henry rifle, and it is a tribute to the excellence of the Hounslow powders that "Curtis's and Harvey's T.S. No. 6" was taken as the standard powder by the Special Committee for the Boxer-Henry Cartridge, from which the powder subsequently known as "R.F.G.2," was developed.
PRIVATE ESTABLISHMENTS

A very complete cartridge-loading factory has been established by Messrs. Curtis's and Harvey at North Feltham, adjacent to the Hounslow Works.

_Glenlean._—The earliest outside factory to be acquired by the firm was that of the Clyde Mills Co., at Glenlean, by Sandbank, Argyllshire, which was purchased about the year 1844. Originally a black-powder factory for supplying blasting powder mainly for the Scotch trade, it was in 1893 devoted to the manufacture of a new smokeless sporting powder, "Amberite," which Messrs. Curtis's and Harvey were then bringing out. Owing to the inaccessibility of the site, which was at one time considered an essential for powder factories, the manufacture of this explosive has now been transferred to Tonbridge, and the factory at Glenlean has been closed.

_Tonbridge._—In 1859 Messrs. Curtis's and Harvey purchased the Tonbridge factory from Alfred Burton. This factory is one of very considerable antiquity, for we read in Hasted's "History of Kent" that in 1772 an Act was passed to enable certain persons therein named to continue to work a "pestle mill" heretofore employed and used in making "Battle Gunpowder" at Old Forge Farm in this parish (Tonbridge).¹

The factory was largely employed in the manufacture of military powders, and in 1885 very heavy and expensive machinery was installed for the production of the various descriptions of Government "Prismatic." With the introduction of cordite as the Service propellant, the factory ceased to be used for black powder, and is now appropriated to the manufacture of the smokeless sporting powders, "Amberite" and "Smokeless Diamond."

_Glyn Neath._—In the year 1864 the factory at Glyn Neath in Glamorganshire was acquired, and has ever since done a large local business in all kinds of blasting powders for the Welsh mines. The factory was first founded by a local company in 1858.

_Kames._—In 1876 Messrs. Curtis's and Harvey purchased the

¹ Compare Chapter on "Legislation," p. 150.
business of the Kames Gunpowder Co., Kyles of Bute, which had been established in 1839. This factory has now a large output of Blasting and Sporting powders both for the Home and Export trade.

_Faversham._—Both Hasted’s “History of Kent” (1782) and Jacob’s “History of Faversham” (1764) assert that the manufacture of gunpowder was carried on at Faversham ever since the days of Queen Elizabeth, if not before her time. If Faversham is not the oldest in the country, it can certainly claim the second place. In 1561 George Evelyn received the royal licence to set up powder mills at Long Ditton and Godstone, and the mills at Faversham were established about the same time as those of the Evelyns, though the latter were of the greater importance.

The Faversham works continued in private hands until 1760, when Thomas Pearse conveyed the premises now known as the Home Works to Charles, Duke of Marlborough, Master-General of the Ordnance, for the use of the public. Thus this portion of the present Faversham Works became a royal factory under the charge of His Majesty’s Storekeeper, for whom a suitable residence and offices were built at St. Ann’s Cross in 1764. The output of the factory is stated to have been about eighty barrels of service powder per week. The mills were worked both by water and by horses, and Jacob in his “History of Faversham” gives an account of “a contrivance for the preservation of the horses that grind the powder” in the shape of a sort of suit of leather armour to protect them from the frequent explosions that occurred.

What are now known as the Oare (or, in older times, the Daving- ton) Works, seemed never to have formed part of the Royal Factory, though they are of equal, if not greater antiquity. Hasted says “they have been employed for many years in the manufacture of gunpowder in private hands, much for the use of the East India Company. They have recently been much augmented and improved at a great expense by Miles Peter Andrews and Frederick Pigou, Esqs., the present lessees and occupiers.” It is curious to note in this connection the
name of Pigou, which is usually entirely associated with the Dartford Powder Works. It is also on record that a Mr. Gruebarr was at an earlier period (1719) in occupation of the Oare Works; he may very well have been an ancestor of one of the members of the firm of Harvey and Grueber, of Hounslow.\(^1\)

Oare Works seem to have been the first to introduce the modern method of stoving in place of the primitive and dangerous "gloom-stoves" which not infrequently became red-hot! Jacob says "the act of drying the gunpowder is there effected by the means of a constant stream of hot water, conveyed under the copper frame whereon it is placed to dry. This new contrivance is said to answer the purpose exceeding well."

In 1781 the Corning-House and Dusting-House of the Royal Factory (which were situated almost within the town of Faversham) exploded, killing three men, and doing much damage to the north-west side of the town, and destroying one of the two towers of the neighbouring church of Davington. The explosion is said to have been heard in Hyde Park! After five years an Act was passed for the removal of Corning-Houses and other dangerous buildings from the town, and a new site was secured for them about a mile away, which is the origin of the present Marsh Works.

In 1794 a company of volunteer soldiers, called the "Powder Mill Volunteers" was enrolled. From that day to this the employés of the powder works have always been conspicuous supporters of the volunteer movement.

In 1812 Mr. John Hall, an engineer of Dartford (where he founded the business of J. and E. Hall, Limited) turned his attention to gunpowder making, being no doubt attracted thereto by the fame of the Dartford powder made by Pigou and Wilks. In this year he accordingly acquired the Oare Works at Faversham from their private owner (a Mr. Stephen Gillow or his son, of Cooks ditch, Faversham), and commenced manufacture. He seems at first to have rather traded

\(^1\) In 1719 these works were stated to be capable of producing 800 barrels per week.
on the fact that he resided at Dartford, as he always alludes to himself on early bill-heads and show-cards as "John Hall of Dartford," and even goes so far sometimes as to describe his manufacture as "Dartford Gunpowder."

After the peace of 1815 the Government thought it desirable to remove the royal factory from Faversham, its proximity to the sea being supposed to render it an easy prey to an invading force. The manufacture was consequently concentrated at Waltham Abbey, which was already a royal factory. John Hall took this opportunity to obtain a lease of the Home Works, subsequently purchasing them outright in 1825. The Government, however, appear to have retained the Marsh Works for some years, using them for breaking up unserviceable powder, and extracting the saltpetre. They were, nevertheless, leased from the Government not very long afterwards, and ultimately purchased by Messrs. W. and P. B. Hall (John Hall's sons) in 1854.

In 1847 Professor Schönbein, the inventor of guncotton, entered into an agreement with the Messrs. Hall for the first manufacture of the new explosive in England, and here considerable quantities of guncotton were produced.

On the 14th July of the same year a disastrous explosion occurred, in which twenty-one lives were lost, the destruction to property being great. This disaster led to the abandonment by Messrs. Hall of the manufacture, and the entire stock of guncotton was disposed of by burial in the vicinity. Sixteen years later a sample of the cotton was disinterred at the request of Professor Abel for analysis and examination, and was found to have undergone very little deterioration.

During the Crimean War (1854-58) the factory was very largely engaged in the manufacture of Government powder, the three firms—Curtis's and Harvey, John Hall and Son, and Pigou and Wilks—supplying the bulk of the Government requirements. At this time the Marsh Works were very considerably extended.
On the 1st October, 1864, occurred the disastrous explosion of the Erith magazine belonging to John Hall and Son. It would appear that the accident originated in one of the two powder barges that were lying alongside the jetty, the explosion of which communicated first to the adjacent large magazine of Messrs. Hall and then to a smaller magazine of the Lowwood Gunpowder Company about 300 yards off. It is estimated that from 1,200 to 1,500 barrels of powder exploded, and although fortunately few lives were lost, the damage to surrounding property was considerable, and a company of Royal Engineers had to be promptly called out to repair the damage to the river wall.

In 1867 a very serious explosion occurred at the press-house and corning-house of the Marsh Works, after which that factory was completely remodelled.

In 1875 Messrs. Hall commenced the manufacture of compressed cartridges (or blasting pellets) under licence from Messrs. Davey and Watson, of Rouen, the original patentees, this form of blasting powder becoming very popular.

In 1879 the firm acquired the works of the Loch Fyne Gunpowder Company at Furnace, in Argyllshire, but after an explosion in 1883 the works were not restarted, the Home Office raising difficulties about the licences.

In 1894 John Hall and Son introduced a new smokeless powder called "Cannonite," manufactured by the War and Sporting Smokeless Powder Company, Limited, at Trimley, in Suffolk; this is to-day represented by "Smokeless Diamond," which Messrs. Curtis's and Harvey, Limited, now manufacture at their works at Tonbridge.

In 1896, on the retirement of the existing partners in the firm, John Hall and Son was converted into a limited company, which two years later, after protracted negotiations, was incorporated with Curtis's and Harvey, Limited.

The Faversham factory is remarkable for having evolved in conjunction with Messrs. Hay, Merricks and Co., of Roslin, the only
explosives of the gunpowder type which have successfully passed the Woolwich tests for the “Permitted List.” The earlier examples of the “Elephant” cartridge, “Bull-dog” and “Special Bull-dog,” developed into the present coal-getting explosive “Bobbinite,” which maintains its position on the “Permitted List,” and continues to be very popular.

Dartford.—The town of Dartford has long been connected with gunpowder making. Hasted’s “History of Kent” (1778) mentions “Mr. Edsall’s powder-mills,” 1 and early in the nineteenth century the firm of Pigou and Wilks were in possession of the factory, and achieved a very high reputation for their military and sporting powders. They subsequently amalgamated with the firm of Charles Laurence and Son, of Battle, and ultimately became a limited company under the style of Pigou, Wilks and Laurence, Limited.

About 1890 a guncotton factory was erected on land adjacent to the old black-powder factory, and a nitrocellulose powder on the “Troisdorf” system manufactured.

In 1898 the company was incorporated with Messrs. Curtis’s and Harvey, Limited.

The black-powder factory has now been given up, and has reverted to the Pigou family, who are owners of the freehold. The guncotton factory is, however, still retained and worked by Messrs. Curtis’s and Harvey, who have also installed a factory for the manufacture of incandescent gas mantles.

Ballincollig.—The works at Ballincollig were established as a royal factory in 1794 on land adjacent to the Cavalry Barracks, and with very excellent water-power provided by the River Lea. It continued to be worked for Government purposes until 1834, when it was sold to Sir Thomas Tobin, of Liverpool, and subsequently took the style of the “Ballincollig Royal Powder Works, Limited.” As such

1 The factory was instituted in the old Spilman paper mills in 1732 by Pike and Edsall. In 1778 Edsall became bankrupt, and the factory was sold to Mr. Pigou.
PRIVATE ESTABLISHMENTS

it did a large business in Ireland and in export powder shipped from Liverpool for the African market.

In 1898 it passed into the possession of Messrs. Curtis's and Harvey.

For the last few years it has been standing idle.

Roslin.—These works were established in 1790 by Mr. John Merricks, who had previously, in association with a Mr. Christie, owned mills at Gorebridge, a few miles off. Owing to frequent mis-haps at Gorebridge, the mills were closed, and Mr. Merricks founded with Mr. Hay the new firm of Hay, Merricks and Company at Roslin.

The factory is half driven by water and half by steam, and is very picturesquely situated on the river Esk, in close proximity to the celebrated Roslin Chapel. It did a large business in sporting and blasting powders both for home and abroad, and towards the end of the last century obtained a considerable share of the Government contracts which had hitherto been practically monopolized by the three firms of Curtis's, Hall, and Pigou.

The factory passed into the hands of Curtis's and Harvey, Limited, in 1898, and does a considerable business in black powder and "Bobbinite" (the credit for the invention of which belongs largely to the late manager, Mr. A. F. Hargreaves, F.R.S.E.

Extensive additions have been made to the factory in connection with the manufacture of "Cheddite."

Midlothian.—This factory, situated some four miles from West Calder, was established in 1889, for the purpose of supplying the blasting powder used in the district. In 1895 a saltpetre factory was added, for the cheaper production of that essential ingredient of black powder.

The factory is the most modern black-powder works in the country, being the only one established since the passing of the Explosives Act in 1875.

It was incorporated with Curtis's and Harvey, Limited, in 1898, and continues to do a large local trade in blasting powder.
Kennall.—The Kennall Gunpowder Company was established in 1811, though there is little doubt that a powder-mill was working there long before that time.

The factory was then at Cosawes, and the owners, Messrs. Sampson and Lanyon, purchased, in 1821, the lower part of the present Kennall factory, and worked the two. In 1843 the higher part of the property at Kennall was added.

Considerable quantities of powder at a good profit were made during the Crimean War.

Subsequently a descendant of Mr. Sampson bought out the Lanyons, and ultimately mortgaged the whole of the property to Mr. Shilson, in whose hands it remained until the factory was acquired by Messrs. Curtis's and Harvey in 1898.

East Cornwall Gunpowder Company.—The works of this Company at Liskeard, Cornwall, were taken over by Messrs. Curtis's and Harvey in 1898, but were subsequently sold, and have since been acquired by the Ammonal Company.

War and Sporting Smokeless Powder Company, Limited.—This factory was taken over as a going concern by Messrs. Curtis's and Harvey, Limited, in 1898; it had been established about four years previously at Trimley, near Ipswich, for the manufacture of a smokeless powder called "Cannonite."

The Trimley works were subsequently closed, and the manufacture of all smokeless sporting powders was concentrated at the Tonbridge factory.

Cliffe at Hoo.—This is the only factory of Curtis's and Harvey, Limited, which has been established since their incorporation as a limited company. Started in 1900, in the Cliffe marshes adjoining the Thames, on ground that had originally been acquired by Messrs. Hay, Merricks and Company, it has been continuously extended, and is now very large and well equipped, possessing nearly a mile of frontage on the river, with two jetties and a loading wharf.
F. C. DICKSON AND CO., BLACKBECK

Head Office and Factory: Blackbeck, Haverthwaite.
Personnel: 80.
Products manufactured: Gunpowder.
The Powder is manufactured for home and foreign consumption.
Established 1861.

THE “E.C.” POWDER COMPANY, LIMITED, LONDON

Head Office: 20, Bucklersbury, London, E.C.
Capital: £49,500 in £1 shares. The last dividend was 3s. per share, equal to 15 per cent. per annum.
Factory: Green Street Green, near Dartford, Kent.
Products manufactured: All varieties of Nitrocellulose and Smokeless powders of nitrocellulose base.
Agents throughout the world, who hold stocks of powder for immediate requirements, but large orders are always shipped direct to consumers.
Specialities invented: Powders known as E.C. No. 2 and E.C. No. 3 the latter having now entirely superseded the earlier products.
Distinctions obtained: The Company's products have only been exhibited three times, viz., at the International Inventions Exhibition, 1885, the Edinburgh Exhibition, and the Franco-British Exhibition, London, 1908, the highest possible award being granted each time.

THE ELECTRIC AND ORDNANCE ACCESSORIES COMPANY, LIMITED, ASTON MANOR, BIRMINGHAM

ELEY BROTHERS, LIMITED, LONDON

HEAD OFFICE: 254, Gray's Inn Road, London, W.C.
CAPITAL: £300,000 nominal. £250,000 issued.
FACTORIES: Angel Road, Upper Edmonton, London, N.
   Harty Ferry, Faversham, Kent.
PRODUCTS MANUFACTURED: Sporting and Military Cartridge Cases and
   Cartridges for every description of Small Arm, Percussion Caps,
   Gun Wads, Lead Shot, Fulminate of Mercury.
PRIME MATERIALS USED: Brass, Copper, Cupro Nickel, Lead, Gun-
   powder, Paper, and Felt.
PRODUCTS are manufactured for home and for foreign consumption.
   Agents and Depots in Birmingham, Glasgow, Exeter, Liège
   (Belgium).
   Agents in Gothenburg (Sweden), Florence (Italy), Winnipeg,
   Canada, Buenos Ayres, Argentina, Sydney, N.S.W., Cape Town,
   Cape Colony.
NUMBER OF BUILDINGS ON THE FACTORIES: Five main buildings in
   which manufacture is carried on. Four magazines and a number
   of isolated wooden buildings specially arranged to meet the
   requirements of the Explosives Act.
   The works are built upon an estate of sixty acres.
SPECIALITIES MANUFACTURED OR INVENTED: "Pegamoid" (Waterproof)
   Cartridge Cases and Cartridges.
BENEVOLENT INSTITUTIONS: Sick and Benefit Society.
   Three classes of subscriptions—6d., 3d., and 2d. per week.
   Sick benefits respectively—10s., 5s., and 4s. for thirteen weeks,
   5s., 2s. 6d., and 2s. for a further thirteen weeks.
   Free medical attendance.
   Payment at death—£10, £5, and £2 10s.
   Firm contributes 50 per cent of members' subscriptions up to a total
of £300 per annum. Dividend shared out at end of each financial year.

Superannuation Fund for skilled Engineers. Each contributes 2s. per week, with £4 per member, per annum, added by the firm.

Distinctions obtained: At the International Exhibitions, in Paris, 1900, Liège, 1905, and the Franco-British Exhibition, 1908, Grand Prix have been obtained, whilst numerous distinctions were received ever since 1876.

The discovery of new agents of ignition which towards the latter half of the eighteenth century were applied to firearms, closed a period of nearly 200 years, during which scarcely any important advance in projectile weapons had been made. Among the notable inventions evolved at this period was the detonating lock. From this, by imperceptible process of evolution, sprang the percussion cap, and ultimately the cartridge, the genesis of all the vast progress made in firearms during the last century. Much as the percussion cap facilitated the construction of the cartridge, no less did the latter expedite the development of breech-loading firearms, by providing, in its expansible case, the means of securing that complete obturation of the breech which had for centuries defied the efforts of generations of gunsmiths.

Until about the year 1800, the gunsmith, in conjunction with the powder maker, provided practically all the accessories appertaining to the use of the gun, but, curiously enough, the latter appears to have been indifferent to the progress accomplished in allied branches, so that the manufacture of detonators, percussion caps, wadding, and cartridges, became at this period the subject of new and separate commercial enterprises.

By 1828 the demand for these accessories gave promise of opening an almost unlimited field for inventive ingenuity. William Eley, the founder of the present firm, was early attracted to this interesting branch, and literally devoted his life and fortune to mechanical inventions. To him is attributed the once-famous wire cartridge,
which, by delaying the dispersion of the pellets, effected the same purpose in the guns of the period as is now produced by choke-boring. At the age of forty-seven he fell a victim to a disastrous explosion of fulminate of mercury, which simultaneously destroyed him, his laboratory, and its contents. The business initiated by Mr. William Eley was continued by his three sons under the style, Eley Brothers, until 1874, when it was converted into a joint-stock enterprise, with limited liability.

Established at a period in the last century when the evolution of modern firearms was in the first stages, Messrs. Eley Brothers, as makers of an infinite variety of caps, detonators, wads, and cartridges, have since been closely associated with every successive advance. The displacement of the flint-lock by the percussion muzzle-loader was attended by a rise in the demand for percussion caps, which attained its height about the year 1865, and has, since the introduction of breech-loading weapons, about that period, steadily declined, while in its place has developed a correspondingly increasing demand for breech-loading cartridges. Changes in military weapons were generally somewhat anticipated by similar changes in sporting-guns, and some of these are well illustrated by means of the annexed diagram, in which the curves relating to the output of pin-fire and central-fire sporting-gun cartridges indicate how the former have been superseded by the latter.

Similarly, the curves, commencing with the introduction of smokeless propellents about the year 1886, illustrate the still growing preference for smokeless over black gunpowder.

In an undertaking involving, from the first, the use of vast quantities of explosives in combination with metal and paper, each prone to exercise some deleterious influence upon the other, the chemist is an important factor, and more especially has this been the case since the introduction of smokeless sporting and military powders. A laboratory replete with modern testing plant is a feature of the factory, and continues to advance in importance as the materials employed in cartridges became more numerous and more complex.
As the last decade of the eighteenth century evolved new agents of ignition which revolutionized firearms, so history repeated itself almost exactly a century later, by which time smokeless nitro-compounds began to exhibit unmistakable signs of extinguishing the older black gunpowder, and bringing about another revolution. Advantage has already been taken of the increased energy of modern explosives to reduce the size and weight of military cartridges, thereby enabling many more to be carried, and imparting practicability to magazine and automatic reloading rifles.

The nickel-jacketed, pointed projectile of the '280 calibre Ross-Eley cartridge, of 140 grains weight, having a muzzle velocity of 3,050 feet per second, affords, when compared with the '577 Snider-Enfield bullet, of 480 grains weight, with a velocity of 1,100 feet per second, an interesting example of the progress of military rifle ballistics of the last fifty years.

Another interesting feature incidental to the introduction of smokeless sporting powder is that whilst forty years ago three cases satisfied the requirements of the 12-bore shot-gun, upwards of a dozen are now deemed necessary.

To what extent the cartridge maker has contributed to progress in firearms is scarcely perhaps fully appreciated. When the manufacture of guns and cartridges became independent industries, the necessity of co-ordinating the dimensions of guns with those of cartridges became apparent, and by the influence naturally appertaining to an immense business, Eley Brothers were able to induce the adoption of measurements common to guns and cartridges, which have since achieved so much towards facilitating the manufacture of both. The inventive ingenuity of William Eley was inherited by his son William Thomas Eley, and subsequently found expression in the production of machines by which the construction of cartridge cases was immensely simplified and cheapened, and it is particularly to a machine devised by him, which entirely revolutionized the manufacture of percussion caps, that much of the early success of the firm may be attributed.
PRIVATE ESTABLISHMENTS

Seeing that for a period of nearly fifty years the firm shared with but one competitor almost a monopoly of the British cartridge-making industry, while to every nation it has supplied cartridges in countless numbers, it has exercised a direct influence upon the design and development of the firearms of the world.

For quite a long period it rested with the cartridge maker to advance or retard the progress of the gun by making, or declining to make, any modification in cartridges which might be necessary. To what extent the firm has responded to continuous changes in the interests of the gun is indicated by the fact that since its inception upwards of 1,000 sizes and types of cartridges have been produced, and to-day some 400 different cartridges are made at its factory at Edmonton.

This firm has frequently been called upon to supplement the resources of the national arsenals, and maintains the plant and organization essential to the production of military cartridges.

THE ELTERWATER GUNPOWDER, CO., LTD.
ELTERWATER, NEAR AMBLESIDE, WESTMORLAND.

CAPITAL: £51,000.
FACTORY: Elterwater.
PERSONNEL: 100.
PRODUCTS MANUFACTURED: Blasting Gunpowder.
OUTPUT: 1,400 tons per annum.
PRIME MATERIALS USED: Saltpetre, Sulphur, and Charcoal.
BENEVOLENT INSTITUTIONS: Medical Club.

This Company was established in 1824.
THE EXPLOSIVES AND CHEMICAL PRODUCTS, LTD.

This Company was founded in 1905 by Mr. E. J. Barbier, Chairman of the Explosives Companies on the Continent, which are known under the general title of "Sociétés d'Explosifs et de Produits Chimiques (Groupe Barbier)," and which possess seven other factories in France, Italy, Spain, Russia, and Greece for the manufacture of explosives and chemical products.

The Company was registered with a capital of £50,000 divided into 50,000 shares of £1 each. The object of the Company is the manufacture and sale of all chemical products and explosives.

The Company possesses the works of Great Oakley, and the freehold property of Bramble Island, Essex, which covers 170 acres. This factory is situated between the two railway lines from Colchester to Harwich and from Colchester to Walton-on-the-Naze, on the North Sea, five miles from Harwich.

The estate is protected from the sea by a strong sea-wall, designed to resist the violent storms of the North Sea. It possesses a dock fitted to receive and despatch by boat the raw materials and the manufactured goods.

The factory is licensed by the Home Office for the manufacture of the following: Dynamite No. 1, Dynamite No. 2, Blasting Gelatine, Gelatine Dynamite No. 1, Gelatine Dynamite No. 2, or Gelignite.

Permitted explosives: Oaklite No. 1, Oaklite No. 2.

The factory is at present fitted up to turn out 500 to 600 tons of explosives annually.

The Company also manufacture non-freezing dynamites after a special process of their own; concentrated nitric acid, nitrate of lead, etc., and possess special processes for the manufacture of the two last-named substances.

A plant has been erected for the recovery of waste acids.

It is intended to start at this factory the manufacture of a patented
PRIVATE ESTABLISHMENTS

shot-firing tape, which assures the complete detonation of all explosive charges. This tape is manufactured by the Groupe Barbier at one of its two French factories, and possesses the advantage of giving complete detonation of the explosive used in the bore-holes.

The Company is managed by: Mr. E. J. Barbier, Chairman of the Board of Directors; Mr. E. Colon, General Manager.


C. L. HAMILTON, DUBLIN

Manufacture of Fireworks. Licensed in 1877.

HENRITE EXPLOSIVES, LIMITED, DARTFORD

Manufacture of "Henrite" Explosive. Licensed in 1906.

“HODSMANS,” DUBLIN

Office, Laboratory and Factory: Cremorne, Donore Avenue, Dublin.

Products manufactured: Fireworks.

Established: 1849.

This factory is now closed down.

T. JENKINS AND COMPANY, YARDLEY, NEAR BIRMINGHAM

Manufacture of Railway Fog Signals. Licensed in 1881.

JENNISON AND CO., BELLEVUE, NEAR MANCHESTER

Manufacture of Fireworks. Licensed in 1876.
A. JESSOP AND SONS, HUDDERSFIELD

Manufacture of Fireworks. Licensed in 1876.

BEN. JESSOP AND COMPANY, ROWLEY HILL

Manufacture of Fireworks. Licensed in 1898.

F. JOYCE AND CO., LIMITED

General Manager: Percy Newton.
Head Office: Kingsway House, Kingsway, London, W.C.
Capital £60,000; Debentures £10,000.

The shares of this Company are almost exclusively held by Nobel's Explosives Company, Limited, Glasgow, who have purchased the Company in order to have their own manufacture of cartridge-cases for their sporting ammunition.

Factory: Waltham, Essex.
Works Manager: H. D. Hodge.
Size of Factory: 85,000 square feet (6 acres 2 roods).
Number of Buildings: 48.
Benevolent Institutions: 1.
Number of Officials: 6.
Number of Chemists: 1.
Number of Workpeople: 118 male; 247 female.
Number of Boilers: 4.
Number of Engines: 4, 176 H. P.
Number of Air Compressors: 2; pumps, 2; and other machinery, 334.
Length of Tramways: 700 feet.
Products manufactured: Cartridge cases.
Established in 1820, F. Joyce and Company's progress is practically contemporaneous with the introduction of the present form of ignition now common to all classes of ammunition.

The identity of the first and original invention of the percussion cap is very difficult to determine, and it is probable that the percussion cap was produced as an obvious variation of the tube principle, for we see the introduction in 1816 of a pellet gun in which the cock supported the socket, inside which a plunger detonated a priming pellet when the cock fell. Thus instead of fire flashing through the nipple, it flashed through the cap, and instead of the cock falling on the cap, the cap fell on the cock. In 1818 the tube-gun was introduced, and in this the cock, now provided with a sharp nose, fell on a copper tube held in a prime holder at right angles to the touch-hole, detonating the priming it contained. The association of the percussion cap with a fulminating substance whereby the corrosion from the use of the chlorate mixture was materially lessened, and the life of percussion guns correspondingly increased, was first attributed to the Rev. A. J. Forsyth, of Belhelvie.

Until then, oxymuriate of potash seems to have been the composition mostly used. Mr. Frederick Joyce, the founder of the firm, who was a chemist, applied Forsyth's researches commercially. He conducted a series of experiments, which led in 1820 to the introduction of what was known as "Joyce's Anti-corrosive Percussion Powder." The cap and the anti-corrosive powder, which was a mercurial fulminate, instead of a chlorate, were evolved at very nearly the same time, and a combination of the two had the very best results. Indeed, it is not too much to say, that the Joyce cap of 1821 was the key to the arch of the entire system of modern sporting and military firearms, nor do the caps now used differ in essentials from the caps then introduced.

Mr. Joyce established in 1820 his factory at 55, Bartholomew Close, West Smithfield. The works were soon afterwards destroyed by fire, but rebuilt on the same site, and the percussion cap industry was there conducted with such success that in 1842 larger premises had to be acquired. An extensive factory was consequently built at
Waltham Abbey, Essex, on the same site (though greatly extended by the purchase of surrounding land), where the present factory of Joyce and Co. now stands. The percussion cap for arms of precision was gradually superseded by the breech-loading cartridge, which Joyce and Co. also manufactured, following with alert attention the successive stages in the evolution of the modern cartridge from pin-fire to central-fire, all of which were made at the Waltham works.

The progress of F. Joyce and Co. has been especially marked of late years. In 1903, Nobel's Explosives Company, Limited, who were then seeking means for the manufacture of cartridge-cases as a natural ally to their powder, took up a large holding in Joyce and Co. and placed with them the manufacture of the bulk of the cartridge cases they required for their trade. Gradually this holding was increased, until in 1908 they completely absorbed the whole of F. Joyce and Co., Ltd., which is now a branch of their own organization.

With this complete absorption, the necessity for much larger premises occurred, and accordingly an entire new factory, equipped with all modern machinery, and utilizing every existing mechanical device, was built in 1908.

This factory, which is now completed, and will be in full working order in the course of the present year, is designed to treble the output of the old works. Messrs. Joyce and Co. have also established themselves in Paris, and judging by the success which has accompanied their first efforts, hope soon to make the Joyce Cartridge as well known on the Continent as it is in this country.

KING'S NORTON METAL COMPANY, LIMITED.

Head Offices: For Share and Transfer work only—16, Great George Street, Westminster.

For Business purposes—King's Norton, near Birmingham.

Capital: £250,000. All the Mortgage Debentures have been re-
deemed and the Capital issued at present is 6,000 7 per cent. Cumulative Preference Shares of £10 each, and 14,000 Ordinary Shares of £10, total called up £200,000. The average Dividend from the commencement has been well over 10 per cent.

Factories: The Metal Works are at King's Norton, near Birmingham, and the Ammunition Works at Abbey Wood, Kent.

Personnel: 1 Chairman, 2 Managing Directors, 2 Ordinary Directors, 1 Secretary, 1 Superintendent of Ammunition Works, and about 6 Scientific Engineers, Chemists, etc.

The combined number of employes when the Works are in fairly good employment would be about 3,000 (males and females).

Products Manufactured: The King's Norton Works are concerned chiefly in the manufacture and manipulation of Yellow and White Metals for commercial purposes, and also in metallic components for Cartridges, Fuses, Primers, Caps, etc.

The manufacture of the non-metallic Cartridges, and the assembling and loading of all Munitions of War, which are filled with Explosives, etc., are carried out at the Abbey Wood Factory.

The Company call particular attention to their success in the manufacture of Quick-Firing Cartridge Cases, as well as Small-Arms Cartridge Cases, etc., which they attribute to a great extent to the fact that they were one of the first to recognize the value of Laboratory investigation as regards the micro-examination of the structures, and other methods by which the workman of "life experience" was replaced by scientific men and methods.

The same remarks apply to the Ammunition Works at Abbey Wood. These works were constructed in 1901, in accordance with the latest scientific methods.

The general construction of the buildings was arranged to give as much space and light as possible, and electric power and light were installed throughout.

The drying of high explosives, such as Fulminate of Mercury,
Percussion Caps, Rim Fire Cartridges, etc., was performed by electrically heated air.

The storage of cordite was carried out on a multi-cellular system of magazines, by which the storage of great bulk in one compartment was avoided, and many other precautions have been adopted to ensure the safety of the workpeople dealing with explosives.

The principal manufactures at Abbey Wood are Small-Arms Cartridges, and the capacity of output for Cordite Cartridges requiring special loading machines, is about one and a half millions per week. The output for Flake Powder Cartridges is practically unlimited.

Prime Materials used: The Company use a good deal of raw material and manufactured explosives. They blend some of their explosives with various ingredients, including some with aluminium. All their Waste Products are consumed or utilized by themselves. Most of the Company's War Stores are manufactured for the British and Colonial Governments. Many of their orders come from abroad.

Works: The area of land covered by the Ammunitions Works is 62 acres, and the number of Buildings authorized by the Home Office on this site is upwards of 100, at the present time, however, only rather more than half of them have been erected. There are 6 Magazines, 2 Velocity Ranges with Instrument Houses, 1 Covered Range for .22 ammunition up to 100 yards, and open Ranges to 300 metres. The Company have also range arrangements for proving up to 2,000 yards.

The whole of the works at Abbey Wood are lighted and power-driven by electricity which is taken from the Municipal Electric Light Station. The buildings are all heated by steam, but the fulminate, cap, and other manufacturing drying is also done by electricity. The whole of the buildings were designed by the company, and are on the most recent lines, which provides very
ample space, light, and heat for the workpeople. All the danger-building employés are provided with non-flammable linen clothing, which is washed weekly, and also special boots, etc., at the Company's expenses. Mess room, dressing rooms, and all appliances for prevention and security of the workpeople in dealing with explosives, are provided.

The works are alongside the South Eastern and Chatham Railway, where a siding is available.

All the danger buildings are connected with a raised platform, 4 ft. 6 in. wide, with 16 in. gauge rails laid thereon.

**Specialities manufactured:** The Company own numerous Patents for Fuses, Small Arms Ammunition, Q. F. Cases and other details in connection with their business, Metal Containers for Shell being one of the most recent and important developments.

This Company were the first to develop the pointed bullet in this country, and also the first to demonstrate the success of M.D. Cordite for Small-Arms Cartridges, and for many years they have had an unrivalled reputation for Match Rifle Cartridges, it being an understood thing in this country that the encouragement of Match Rifle Work is for the purpose of demonstrating new forms of cartridges and propellents by actual practice, which may be of value to the Government in designing any changes for military requirements. The Company have specialized in the removal of metallic foulings from rifles and heavy ordnance, the pioneer solution being invented by Dr. Hodgkinson, which is also possessed by this Company, with other patents.

**Benevolent Institutions:** There is a Sick and Dividend Club for the Workpeople, which is supported by them by weekly contributions and annual contributions by the Company which provides in case of sickness or death, the balance being returned annually, less the maintenance of the Reserve Fund. In addition to this a Benevolent Society exists at each Factory for the purpose of supplying letters
to Homes of Rest, Convalescent Homes, and granting assistance where desirable.

DISTINCTIONS OBTAINED: The Company have many Gold Medals, Diplomas, etc.

KYNOCHEL, LIMITED

WORSBOROUGH DALE.
Manufacture of Gunpowder. Licensed in 1876.
Packing Factory. Licensed in 1899.

HANDESWORTH.

WITTON.
Manufacture of Detonators, Cartridges, Fog Signals, etc. Licensed in 1876.

ARKLOW.
Manufacture of Nitro-glycerine Explosives. Licensed in 1895.

KYNOCHTOWN.
Manufacture of Explosives of all kinds. Licensed in 1897.

THE LANCASHIRE EXPLOSIVES COMPANY, LIMITED,
WITHNELL, LANCASHIRE

F. A. LUDLOW, LITTLE BROMWICH

Manufacture of Cartridges and Fog Signals. Licensed in 1884.

THE MINERS’ SAFETY EXPLOSIVES COMPANY, LIMITED.

Head Office: 16, Great George Street, Westminster.
Nominal Capital: £50,000 in £1 shares, of which £46,500 is fully paid.
Personnel: This Company employs permanently in addition to casual and contract labour, 2 Chemists and Engineers, 49 Men and Boys, and 18 Women, with an official staff and agents of ten permanent people.

For the purpose of the business the Company manufactures Dinitro-Naphthalene, for which the Plant is equal to an annual output of 100,000 lb.

Its marketable commodity is Ammonite, a Permitted Explosive.

The capacity of buildings, etc., erected and in use, is equal to 750,000 lb. per annum, and the site upon which the works is situate is capable of admitting the extension of the Factory to meet any possible demands of the trade.

In connection with the production of Dinitro-Naphthalene the materials in use are: Naphthalene, Nitric Acid, Sulphuric Acid, Nitrate of Soda, and Soda Ash; and for the production of Ammonite Cartridges, Ammonium Nitrate and Dinitro-Naphthalene, as set out in the Home Office Schedule of Permitted Explosives.

For the manufacture of Cartridge cases, lead and tin are used.

Ammonite Cartridges are chiefly used in this country, although for specific purposes they are sold for export.
The Buildings comprise:

(a) Danger buildings, consisting of a block containing mills, engine, and Sifting rooms with Expense Magazine connected, Cartridge-filling rooms, waxing-room, packing-room, and three 10-ton Magazines.

(b) Non-Danger Buildings, Boiler House, Ammonium Nitrate Store, Dinitro-Naphthalene Store and Store for stock of lead cartridge cases, Boiler House with two Cornish Boilers; there are three Engines—one of which is an Oil Engine—with total H.P. of about 60. Block of buildings, comprising complete plant for the manufacture of Dinitro-Naphthalene, consisting of open shed for acid-converting pans, range of washing and drying-rooms, offices and laboratory, mess and changing-rooms for workers in danger buildings. A further range of buildings equipped as factory for producing patent Metallic Cartridge cases, consisting of Melting House, Engine Room and Press Room; Carpenter’s Shop with Steam Saws complete, and Engineer’s Shop and separate Mess Room, changing and washing-rooms for use by men and boys in connection with the case-production industry. The Factory occupies a site of 28 acres, and the whole of the buildings are connected by a network of tramway of about one mile in length. This tramway is connected with the jetty upon the Thames river side, and with the London, Tilbury, and Southend Railway.

Specialities manufactured: The Company devotes itself to the manufacture of Ammonite, and also to the manufacture of Patent Metallic Cartridge cases for its own use.

The formation of the Miners’ Safety Explosives Company, Ltd., was the outcome of various experiments made at the instigation and expense of the late Sir George Elliot, Bart., in the early part of 1888, upon various forms of the Ammonium Nitrate explosives, which owed their origin to the investigations of Dr. Sprengel. At that period public opinion in this country was greatly exercised by the accidents
arising from explosions in Coal Mines, and a variety of remedies were suggested, whilst a large number of new explosives of more or less merit were evolved, all claiming the advantage of flamelessness and all more or less of the Sprengel ammonium nitrate type.

In these circumstances it was natural that a man of the enterprise of Sir George Elliot, who had large colliery interests, should be one of the first to make investigations, and after considerable expenditure of time and money the Favier patent was acquired, and in 1888 the above Company registered, Sir George Elliot supplying the necessary capital, the object of the Company being the manufacture of the explosive now known as Ammonite.

Many difficulties were encountered in connection with the choice of a site for a factory, and the general arrangement of the works to meet the requirements of the various Explosives Acts, etc., but these difficulties having been overcome, the Industry referred to was started.

Manufacturing operations were practically commenced from the date of inauguration, and, as in most new departures from the beaten track, a considerable amount of experience was laboriously acquired in practice. The original intention was to produce pressed cylindrical cartridges having a central cavity for the reception of a definite proportion of loose explosive to be in immediate contact with the detonator. These cartridges did not find favour amongst practical miners, firstly on account of their rigidity, and, secondly, because they did not remain damp proof for a sufficiently long time. These objections were overcome by the introduction of a patent Metallic Cartridge case.

The solving of these difficulties still left something to be desired. Practical working demonstrated the fact that the cartridges were uneven, and showed a tendency towards hardening. This condition, no doubt, arose from the low melting point of mononitro-naphthalene, one of the constituents of the explosive, and, in consequence, it was decided to alter the composition of the explosive. After exhaustive experiments in September, 1892, the mononitro-naphthalene was
replaced by dinitro-naphthalene, and the Ammonite Cartridge, as at present manufactured, was produced. From that date the gradual growth of the Industry necessitated the provision of plant for the manufacture on a large scale of dinitro-naphthalene, and additional machinery for incorporating and granulating the explosive. Frequent extensions of the works had also to be made in consequence of the growth of the business.

Among the initial difficulties were those of carriage. Explosives of the nature of Ammonite being practically unknown to the Railway Companies, the Miners' Safety Explosive Company, Ltd., started by carting its first consignment from Thames Haven to South Wales. Subsequently, however, and after many efforts, the Railway Companies gave their attention to this trade, and finally all obstacles to the carriage of Ammonite were removed.

The constant fluctuations in the lead market and uneven deliveries of the metallic cases were for a considerable time a source of difficulty. In 1901 the Company therefore put down its own complete plant for the manufacture of the metal cartridge cases. Important improvements have from time to time been made in the machinery as well as the cartridge case, and the Company can turn out an average of 20,000 cartridge cases per day, the whole tube factory being capable of inexpensive extension.

Ammonite was one of the first of the high explosives to be placed upon the special permitted list; the date of the certificate issued by His Majesty's Chief Inspector of Explosives being 15th June, 1900. It may here be stated that it has not been found necessary or desirable to alter in any particular the composition of this explosive.

The growth of the manufacture of Ammonite has been steady, and to-day the Industry is a quiet, but conclusive example of what can be accomplished by persistent effort in the face of great difficulties.
THE NATIONAL EXPLOSIVES COMPANY, LIMITED

HEAD OFFICE: 14, Queen Victoria Street, London, E.C.

The National Explosives Company's Works are situated on the north coast of Cornwall, about two and a half miles from the town of Hayle, and about three miles from St. Ives. Since the factory was erected in the year 1889 it has been gradually extended and improved, until it now occupies a space of some 500 acres, extending to St. Ives Bay, the waters of which form a natural boundary on the north. The formation of the land also affords natural protection to the buildings.

The factory was erected by Mr. Oscar Guttmann. It was originally designed for the manufacture of about 500 tons of kieselguhr dynamite per annum.

Shortly after starting, in 1890, the works were enlarged, and the manufacture of gelatine explosives commenced.

In 1894 a guncotton and cordite factory were added. This plant was enlarged in 1899, and again in 1901, and now contains about 200 buildings.

The factory is at present practically self contained and capable of turning out per annum about 2,000 tons of blasting explosives consisting of dynamite, gelignite, gelatine dynamite, blasting gelatine, Cornish powder, and Haylite, the last two named being "Permitted Explosives," i.e., suitable for use in collieries, and coming within the scope of the Coal-Mines Regulations Act.

In addition to blasting explosives, the factory is also able to turn out about 1,000 tons of cordite per annum.

The plant and equipment of the factory is of the most extensive and modern description, and the works provide employment for a large number of persons in the vicinity, and are consequently, owing to the decline of shipbuilding in the Port of Hayle, greatly appreciated by the inhabitants of that part of Cornwall.
THE NEW EXPLOSIVES COMPANY, LIMITED, LONDON


Capital: £100,000 in 100,000 shares of £1 each.
   Debentures, £28,000.


The Directors of the Company are:
   E. H. Hindley, Chairman.
   Henry Compton.
   W. W. De Buriatte.
   Major-General Sir Frederick Maurice, K.C.B., R.A.

The General Manager is L. G. Duff Grant, and

The Secretary, A. R. Berry.

The Company employs at the Factory a Works Manager,
7 Chemists, 2 Scientific Engineers, 10 Foremen, and about
300 Hands.

Products Manufactured: Guncotton; Guncotton pulp, to British
Government Cordite Specification; Guncotton pulp for other
smokeless powder (Nitrogen content, 12.8 to 13.3 per cent.);
special mixtures of soluble and insoluble Guncotton for smokeless
powders; compressed Guncotton in slabs or discs of various
shapes and sizes, also charges for shell, torpedoes, submarine
and other mines; soluble Guncotton for smokeless powders
(Nitrogen content, 12.0 to 12.7 per cent.); soluble Guncotton for
blasting gelatine; Collodion Cotton for celluloid, artificial silk and
leather, lacquers, varnishes, waterproofing solutions, etc.

The Company has always held a high reputation for the
excellence of its Guncotton productions. Being the original manu-
facturers of Abel's compressed Guncotton, they have from time to
time enlarged and improved their plant to meet the progressive
requirements of the Naval and Military Services.
Smokeless Powders, Naval and Military.
Cordite for rifles, revolvers and artillery.
Pure Nitrocellulose powders for rifles and artillery.
Smokeless Powders for shot-guns.
"Felixite" and "Primrose Smokeless" are of the 42 grain type, and are very little affected by variation in wadding, cases, and guns.
"Red Star" and "Stowmarket Smokeless" belong to the 33 grain type of powders, having been designed for shooting at driven game.
"Neonite" carries the improvements which followed from the introduction of 33 grain powder a step further, the weight of the charge being reduced to 30 grains.
"Neonite" Smokeless Powder is made for Rifles and Revolvers.


The last three explosives are for use in fiery and dusty coal mines. "Stowite" and "Pitite" are nitro-glycerine compounds, whilst "Odite" is an explosive of the ammonium nitrate class, and can be used in the most tender coal.

Loaded Cartridges: The Company have a loading department attached to their factory at Stowmarket, where cartridges to meet all requirements are loaded under strict supervision.

The prime materials used at the Stowmarket factory are Sulphuric Acid, Cotton Waste, Sodium Nitrate, Glycerine, Acetone, Potassium Nitrate, Barium Nitrate, Sodium Carbonate, Lime, Ammonium Oxalate, Mineral Jelly, Wood Meal, Ether, Methylated Spirit, Lubricating Oil and Wax.

The waste products are Waste Acid from Guncotton manufacture and Nitre Cake.

The Company manufacture for both home and foreign con-
sumption, and have agents in most of the British Colonies and foreign countries.

Works:
(a) Number of Buildings, 120.
(b) Number of Boilers, 7 Lancashire; approximate H.P., 1,750.
   Number of Engines, 15; approximate H.P., 500.
(c) The factory is lighted by electric light (arc and incandescent lamps).
   Three separate generating plants, together with a number of electric motors.
   Air compressors in the Guncotton factory and the Cordite works.
   Six pumps.
   Water-softening plants for 11,000 gallons per hour total.
   Three economizer plants.
   Mechanical stokers fitted to all boilers.
(d) Railways and Tramways: Railway siding, approximate length 1,050 yards; 24-inch gauge light railway, approximate length 2 miles.

Specialities Manufactured or Invented:
- Compressed Guncotton (Hollings's process).
- Guncotton Shell Charges, pressed in halves (Carter's patent).
- Soluble Guncotton for industrial purposes.
- Nitro Gelignite (non-freezing).
- "Neonite" Smokeless Powder for shot-guns.
- "Neonite" Smokeless Powder for rifles and revolvers.

Compressed Guncotton (Hollings's Process).

Prior to 1900, the large charges of compressed Guncotton used for torpedoes, submarine mines, etc., had to be built up from a number of suitably shaped blocks of small dimensions, the limit of weight for a single block being about 8 lb. This method necessitated the loss of a considerable amount of space, and rendered it difficult to obtain a uniform density and equal distribution of moisture throughout the
charge. Under the new process, single blocks, for torpedoes and submarine mines, can be produced, weighing from 300 to 500 lb. This enables an increased amount of Guncotton to be fitted into the available space, and at the same time ensures a uniform density.

_Guncotton Shell Charges (Carter's Patent)._ The Company have recently erected a plant for the production of Guncotton Shell Charges, pressed and moulded in one operation, thus doing away with all turning and shaping. The charges are produced ready shaped in longitudinal halves, the two halves cemented together forming a solid block ready for insertion into the shell cavity.

_Soluble Guncotton for Industrial Purposes._ Of late years there has been a considerable increase in the demand for Soluble Guncotton for such purposes as artificial silk and leather, celluloid, lacquers, varnishes, waterproofing solutions, etc. Each of the above necessitates the manufacture of a special form of Guncotton, as the material which suits one manufacture has been found to be quite unsuitable for others. The New Explosives Company have for many years made a special study of the requirements of the different classes of manufacture, and have recently enlarged and improved their plant for the production of this material. Solutions of Soluble Guncotton in amyl acetate, wood spirit, etc., for use as varnishes, dipping-fluids, leather dressings, etc., are also supplied.

_Nitro-Gelignite (Non-Freezing)._ This explosive has now been on the market for two winters, and has been largely and successfully used in different parts of the country.

_STOWMARKET EXPLOSIVES WORKS._ The factory at Stowmarket has an interesting history, and ranks as the oldest of its kind in this country.
Originally erected in 1861 by Messrs. Thomas Prentice and Co., it was designed by the late Sir Frederick Abel, for the manufacture of guncotton according to the Von Lenk process.

In 1863 the then Professor Abel delivered a lecture before the British Association at Newcastle, on his researches into guncotton at Stowmarket. In 1865 he patented his guncotton pulping and compressing process, and arrangements were made for working it on a manufacturing scale. On the 21st February, 1870, the new factory at Stowmarket was licensed for the manufacture of explosives under the control of the

**Patent Safety Guncotton Company, Limited,**

Mr. Eustace Prentice being managing Director, Mr. Trotman, Works Manager, and Mr. Slater, Chemist. In August, 1871, a disastrous explosion wrecked the factory, which was however soon rebuilt on an enlarged and improved plan, under the auspices of the

**Stowmarket Guncotton Company, Limited.**

After further extensions, this Company was, on the 18th November, 1881, transformed into

**The Explosives Company, Limited,**

which, in July, 1885, was given its present title:

**The New Explosives Company, Limited.**

The manufactures of the Company were at first confined to the various forms of guncotton, but in 1896 an additional forty acres of land was secured, and a completely equipped factory for the manufacture of other explosives, such as cordite and blasting compounds, erected.

The Company commenced the manufacture of cordite in September, 1898, and shortly afterwards a further twenty acres of land were
acquired, mainly for the erection of drying-sheds of the most modern design, so as to meet the British Government requirements.

In 1904 a further departure was made, and the factory was again extended to include the manufacture of smokeless powders for shot-guns, rifles and revolvers.

Historical Account of the Manufacture of Guncotton and other explosives at Stowmarket.

1861.—Guncotton, made according to the Von Lenk process, was chiefly manufactured from long staple cotton in the form of yarn, dipped in a mixture of nitric and sulphuric acids, and afterwards put into cages or wire baskets, placed in running water and left for several weeks, until sufficiently purified from free acids, so as to be comparatively stable. Guncotton made by this process had a nitrogen content of 12.80 per cent., and contained 6 per cent. of soluble guncotton.

If required for mining purposes the yarn was twisted and made into ropes of various sizes, chiefly from half an inch to one and a quarter inch diameter, according to the size of the bore hole for which it was intended. It was afterwards cut into lengths of from four to five inches and dried; each length formed a charge for blasting purposes, was bound at each end with copper wire to prevent the strands untwisting, and covered with parchment paper. These charges were fired with a squib or fuse, in a similar manner to black powder. The trade done in the above form of charge was more particularly with slate quarries in Wales. Experiments were also conducted with a view to adapting guncotton for use in shot-guns, rifles and cannon, the principal form being that of a braided rope or coil, similar to engine packing, the sportsman being supposed to cut off an inch or more to charge his gun or cartridge cases as required. For rifles, the guncotton yarn was sometimes tightly pressed into paper or wood in tubes which were then covered with guncotton braid, and designed to occupy the same space.
as a charge of black powder. Charges for cannon were also made, but the results in gun, rifle and cannon were equally unsatisfactory and erratic.

1865.—At about this time the whole manufacturing process was revolutionized by Abel’s patent, by means of which guncotton of a density and purity hitherto unattainable, could be made from cheap cotton waste. This process was immediately taken up at Stowmarket.

With the introduction of the pulping process a fresh impulse was given to experiments with guncotton for ballistic purposes. The first form adopted was a mixture of guncotton pulp and ordinary paper pulp, which was pressed tightly into the cartridge case. This form of charge proved very uncertain, and was given up in favour of a soft

FIG. 38. OLD GUNCOTTON CARTRIDGE.
paper charge, the paper being made from a mixture of guncotton pulp and ordinary pulp. The sheets were cut into strips of about one inch width and rolled tightly into a coil, to fit the cartridge case. These

![Old Guncotton Yarn and Charges](image)

FIG. 39. OLD GUNCOTTON YARN AND CHARGES.

gave excellent results, when freshly made, but, after a time, the variation in the proportion of moisture, of which the paper pulp in the composition took up a considerable quantity, made the charges give variable results. To remedy this defect the rolls were coated with a thin film of india-rubber, but this soon dried and cracked.
Granulated guncotton pulp, the grains being coated with paraffin, was next tried, but the granules were soft and brittle.

1882.—In this year a patent was taken out, No. 61988, at Stowmarket, in the names of Walter F. Reid and Johnson, for hardening the grains by ether-alcohol, the product being the now well-known "E.C." (Explosives Company) powder. The portion of the works used for the manufacture of the original "E.C." powder is at the present time used by the New Explosives Company for carrying out several of the operations connected with the manufacture of their smokeless shot-gun powders. This "E.C." powder was manufactured at Stowmarket for a few years, when it was found necessary to erect a new factory. A separate company was consequently formed, which took over the patent, and new works were erected.

1888.—About this time experiments were carried out at Stowmarket, and eventually a patent (B.P. 13,308. 1888) was taken out for a gelatinized rifle powder in the form of threads, rods or tubes. The powder was made from guncotton, dissolved in acetic ether or other solvent, and then squirted through the various shaped dies.

The Stowmarket Explosion, 1871

A disastrous explosion occurred at the Stowmarket guncotton works on Friday, 11th August, 1871.

The explosion first took place in the magazines, all three being exploded almost simultaneously. The amount of guncotton in the magazines at that time was about thirteen and a half tons, in the form of dry compressed discs. The crater formed by this explosion was oval in form, and thirty-five yards long, twenty-two yards wide and from nine to ten feet deep. About an hour afterwards a second explosion occurred which caused the death of Messrs. Edward and William Prentice who were assisting in the rescue work. The second explosion occurred in one of the packing-houses, and is supposed to have been caused by the rough handling of packing cases containing heated dry
guncotton. The quantity which exploded was a few hundredweights. The crater formed by this explosion was about eight yards in diameter and three to four feet deep. The noise of the explosion was heard at a distance of thirty miles, and the shock was felt over a radius of about seven miles.

The conclusion arrived at by Colonel Vivian D. Majendie, who reported on it, was that the explosion was due to the spontaneous decomposition of some impure guncotton, the impurity consisting of sulphuric acid which had been wilfully added to the guncotton after it had passed through the usual processes of manufacture and testing. He considered there was no danger in the manufacture of guncotton, but that the works should be subjected to constant Government inspection.

The factory was soon rebuilt and enlarged, and during the thirty-eight years which have elapsed, no lives have been lost, nor has any serious accident occurred which could be attributed to the nature of the business, and the Company has frequently earned the high approbation of H.M.'s Inspectors of Explosives.

**Nobel's Explosives Company, Limited**

**Head Office:** Nobel House, Glasgow.

**Chairman:** Colonel Sir Ralph W. Anstruther, Bart., of Balcaskie, Fifeshire.

**General Manager:** Thomas Johnston, J.P.

**Assistant Manager:** F. J. Shand.

**Deputy Assistant Manager:** H. McGowan.

**Capital:** £800,000 in 80,000 Shares of £10 each, fully paid; £500,000 4 per cent. Debentures, all issued.

The Company's business lies chiefly in the United Kingdom and the countries overseas.

In 1871 Alfred Nobel, the inventor of dynamite, was invited to
come to Glasgow, and formed the British Dynamite Company, Limited, with a capital of £24,000.

By the end of 1876 the Company, having for four years paid a dividend of 10 per cent. per annum, and having accumulated a reserve fund of £67,000, was reconstructed under its present name of Nobel's Explosives Company, Limited, with a capital of £240,000, and the directors decided to restrict dividends to 5 per cent. until the goodwill account created by the reconstruction was extinguished. This was done in five years, and then the profits, after considerable depreciation had been written off the works, were applied to the payment of dividends ranging from 12½ to 20 per cent.

In 1886 the Nobel-Dynamite Trust Company, Limited, was formed, and that Company offered the Shareholders of Nobel's Explosives Company £25 of its Share Capital for every share of £10 held by them in the Glasgow Company.

In addition to writing down their works to a very considerable extent, Nobel's Explosives Company, Limited, accumulated reserves which were capitalized on the reconstruction of the Company under the same name in 1900, bringing the capital of the Company to £800,000, at which it now stands, in addition to which Debentures to the value of £500,000 have been issued.

That the foregoing results were achieved in the face of competition, frequently of the very keenest, affords sufficient evidence of the activity shown in the development of the Company.

The extension of the commercial organization, the erection of magazines, and other arrangements necessary to comply with the regulations for the transport and storage of explosives at home and abroad, the creation of a fleet of steamers for carrying the commodities coastwise, are but solitary instances of the efforts required. But above all there was the necessity for extending the factories to keep pace with the ever-growing demand consequent on the progress of mining and public works all the world over. In order to keep abreast of the times the achievements of science have had to be carefully watched,
and wherever possible adapted to the manufacture and introduced into the works.

Factories

(1) Ardeer Factory, Stevenston, Ayrshire

Works Manager: C. O. Lundholm, J.P., F.I.C.

Area of Factory, in acres, 837.
Number of Buildings where explosives are handled . 689
" " of a non-danger description . 315

In addition to the above Factory Buildings there are built within the Company's ground Dwelling Houses for Works Manager, Assistant Works Manager, and other officials, and also for a number of the Company's employés.

Steam Plant:

Large Steam Boilers, 37.

H.P. of Steam or other Engines:
Reciprocating (steam) of all kinds . . 3,470
Turbine (exhaust steam) . . . . 430

Internal Combustion Engines . . . 300

Total . . 4,200

H.P. of Air-compressing Plant:
Driven by Steam Engines included in above statement, 450.

Electric Plant:

Generators:
Capacity of Generators driven by Reciprocating Engines
in Kilowatts per hour . . . . . . 610
Capacity of Generator driven by Exhaust Steam Turbine 310

Total . . 920
MOTORS:
Number of Motors, 150.
H.P. of Motors, \(780 = \text{K.W. 582}\).

WATER PUMPS:
Two sets capable of delivering 2,000,000 gallons per day.
Filtered water delivered from neighbouring Water Works, 600,000 gallons per day.

COAL used per annum: 73,000 tons.

LOCOMOTIVES: 4.
Railway and Tramway Lines, 28\(\frac{1}{2}\) miles.

1 Steam Fire Engine.

FOREMEN AND WORKERS: 2,300.

OFFICIALS:
Head Office, 69.
Factory Office and Drawing Office, 27.
Chemists, 35.

PENSION FUND for Technical Staff.

AMBULANCE ROOM with two Wards and Operation Room.

PRODUCTS:
Collodion Cotton.
Explosives (Blasting): Blasting Gelatine, No. 1; Gelatine Dynamite; Gelignite; Dynamite, Nos. 1, 2, and 3; Nobel Carbonite, and other Safety Explosives.

Gunpowders: Empire (Sporting Bulk); Ballistite (Sporting); N. S. Smokeless (Sporting); Ballistite (Military); Cordite; Nitrocellulose Powders.

Nitric Acid; Nitre Cake; Lead Nitrate; Dynamite Glycerine; Sulphuric Acid (Oleum); Nitrocellulose in its various forms, such as for Blasting Gelatine, Collodion, and Smokeless Powder making; Guncotton for Cordite, Abel's Guncotton, and compressed Guncotton for Torpedoes, Shells, Military Engineer-
ing, etc.; Picric Acid, Nitro-hydrocarbons, Nitro-benzols, Nitrotoluols, Nitro-naphthalenes, etc.

**Medals:** Gold Medal, Paris Exhibition, 1876; Gold Medal, International Inventions Exhibition, London, 1885; Gold, Silver, and other Medals have been awarded for the Nobel Blasting Explosives at many other Exhibitions.

Alfred Nobel himself selected the site near Stevenston in Ayrshire, between Saltcoats and Irvine, facing the Isle of Arran, and there erected Explosives Works, which, according to present notions, were of the most diminutive type, when one sees to-day the enormous factory covering 837 acres, with 6.3 miles of main line railway and 22 miles of tramway on its own ground, with its pier and loading stage in the river Garnock. It hardly seems credible that this factory can have sprung from such small beginnings, when a few carts supplied it with all the raw material required, and a few cases at a time were manufactured and carried by men and women to the beach, and then taken through the surf to be loaded into boats in the most primitive manner.

From 1872 till 1879 dynamite was the only explosive manufactured there for sale. At an early date the nitric acid required for the manufacture was made in the factory itself, but the sulphuric acid and the refined glycerine were purchased. Kieselguhr (infusorial earth) was first imported from Germany, but afterwards deposits were found in Scotland near Aberdeen.

In 1875 Nobel had invented blasting gelatine—nitro-glycerine gelatinized and converted into a stiff dough by the addition of about 8 per cent. of nitrocellulose,—but it was not till four years afterwards that the Nobel Company could place this new explosive on the market. It was soon followed by its modifications known as gelatine dynamite and gelignite, wherein the colossal force of blasting gelatine is tempered by the addition of potassium nitrate and wood meal. In the meantime the Continental Nobel factories were making and selling these explosives, but in this country the progress was slow, owing to the regulations
imposed by the Home Office. For the new explosive different tests had to be devised from those applicable to dynamite. The heat test had to be modified in the details of its application, and various physical tests were introduced. It took several years of insistent and assiduous work to successfully produce gelatine explosives, and it went so far that Nobel's Company stopped manufacture until some modification was made in the test enabling them to comply with it; hence the delay in their introduction in this country. The patents for dynamite expired in 1881; those for blasting gelatine in 1889. It was therefore at Ardeer that in this country the pioneer work was done in connection with the manufacture of nitro-glycerine and blasting explosives.

In 1889 Nobel discovered that by increasing the percentage of nitrocellulose incorporated with the nitro-glycerine, blasting gelatine lost its shattering properties, and he ultimately devised a propellent of smokeless powder consisting of 50 per cent. nitro-glycerine, and 50 per cent. of a nitrocellulose similar to that used in the manufacture of blasting gelatine.

It was at Ardeer, as far as this country is concerned, that the manufacture of soluble nitrocellulose suitable for the manufacture of gelatine compounds was first satisfactorily made, and the company applied it to the manufacture of the smokeless powder which Nobel had called Ballistite. The British Government, however, adopted a powder in which guncotton, the insoluble kind of nitrocellulose, was used, it being incorporated with nitro-glycerine with the assistance of acetone as a solvent. The Company brought an action against the Government under the Nobel patents, but were unsuccessful, it being held that Nobel had restricted himself to the use of soluble nitrocellulose, and that the use of the insoluble with the assistance of the solvent was not an infringement.

Consequent on the introduction of Cordite, which was the name given to this smokeless powder by the British Government, large smokeless-powder works were erected at Ardeer, and in conjunction therewith extensive works for the production of guncotton. Shortly
afterwards machinery for the compression of guncotton was erected. The extension of the business had already before this necessitated the erection of glycerine refineries, now greatly expanded. Sulphuric acid works on a large scale were started in January, 1902, on the contact system.

Ballistite, the first nitro-glycerine smokeless powder invented by Nobel, is in this country chiefly used for sporting purposes. Its intrinsic value and power may be judged from the fact that the charge of Ballistite consists of only 26 grains as against 33 grains required in the case of other smokeless sporting powders. It is made by the mixture of soluble guncotton with nitro-glycerine, and after gelatinization the paste is passed between heated cylinders and rolled into flat sheets like paper. Acetone is then added, the rolling repeated, when smooth finished sheets 0.065 of an inch thick, and looking like oil-silk, emerge.

Over 1,000 yards of this explosive fabric is produced daily at Ardeer. The sheets are stoved, sifted and graphited by revolution in a copper bowl. Thus is produced Ballistite, which is sold all over the world, or filled into cartridges at Nobel's Explosives Company's Factory at Waltham Abbey.

This sporting powder has just gained the Grand Prix and the Grande Poule d'Essai at Monte Carlo.

Ballistite has, moreover, had great success in the United States, where it is equally popular for both game and trap shooting.

Another sporting propellent is Empire Powder—a bulk powder made from nitrocellulose. It consists of 80 per cent. guncotton combined with certain quantities of potassium nitrate, and starch. It is not gelatinized, but by grinding and sieving becomes granular. It is the smokeless equivalent of ordinary black powder for sportsmen who prefer to fill their own cartridges.

Carbonite was taken up as a safety explosive; this is a nitroglycerine explosive in which the requisite lower temperature of the explosion gases is produced by an excess of wood meal.

D D
It may be mentioned that on the introduction of Lyddite by the British Government, picric acid works were erected at Ardeer.

With regard to by-products, the scrap lead is employed to utilize the weak regained nitric acid for the manufacture of lead nitrate.

(2) West Quarter and Redding Moor

Works Manager: George Smith, F.R.S.E., F.I.C., F.C.S.
Area of Factory: 1.5½ acres.
Number of Buildings where explosives are handled: 126.
Number of Buildings of a non-danger description: 38.
Workers: 354.
Officials: Factory Office and Drawing Office, 10; Chemists, 6.
Pension Fund for Technical Staff.

Surgery: There is a fully equipped surgery, with operating table, where accidents can be dealt with by the medical officer or the ambulance staff; a large proportion of the male workers are qualified ambulance men, and throughout the departments, both at West Quarter and Regent, there are First Aid Boxes and Emergency Books for instantaneous use and reference; and in addition, a qualified nurse, who also acts as Matron to the girls, is always on duty during working hours.

Products: Fulminate of Mercury, Detonators, Electric Detonator Fuses.

It was Alfred Nobel who first recognized the importance of initial detonation. He first used the impact of black powder loaded in a tube to fire nitro-glycerine, and then devised a special igniter containing fulminate of mercury, ultimately adopting a large percussion cap called a detonator. Shortly after the erection of Ardeer he selected a site near Polmont, about half-way between Glasgow and Edinburgh, and there started small works for the manufacture of detonators, purchasing the fulminate of mercury. When the works became more
important, and the quantity of detonators required increased, fulminate of mercury works were established close to the detonator works at Redding Moor. Gradually these works were extended. The manufacture of fulminate of mercury amounts to half a ton per day. As soon as electric blasting was introduced, a special department for the manufacture of electric detonator fuses was added to the West Quarter factory, and that department has, with the growing use of electric blasting in coal mines, made considerable strides.

(3) Clayton Bridge

This electric fuse and detonator factory is now practically abandoned, only the magazines being in use.

(4) Regent Factory, Linlithgow

Works Manager: George Smith, F.R.S.E., F.I.C., F.C.S.
Area of Factory: 2½ acres.
Number of Buildings where explosives are handled: 4.
Number of Buildings of a non-danger description: 14.
Workers: 132.
Officials: Factory Office and Drawing Office, 2; Chemists, 3.
Products: Electric Fuse Wire, Safety-Fuse.

The Safety-Fuse Works at Linlithgow, which is about seven miles from West Quarter, are of recent construction, and contain machinery of the very latest type.

(5) Perranporth

Works Manager: Joseph Turner.

Perranporth Factory is 163 acres in extent. It was originally built in 1889 to supply De Beers with dynamite, but as it cost more to build than was calculated, it was offered to Nobels.
In conformity with the laws of the Duchy of Cornwall, a small tin mine is kept going. The tin obtained does not add much to the revenue.

For the last year the factory, which is situated in Cornwall, near Truro, on the coast, has not been used for making explosives, but is kept as a reserve factory. It is equipped to start at short notice for making blasting explosives, but has no nitrocellulose or sulphuric acid departments.

(6) Waltham Abbey, Essex

General Manager; W. Wotherspoon.
Head Office: Kingsway House, Kingsway, London, W.C.
Number of Buildings: 17.
Number of Engines: One 2 H.P., one 28 H.P., one 100 Volts Dynamo.
Number of Machines used in manufacture: 50.
Tramway Lines: 500 yards, 24 inches gauge tramway; 1 bogie.
Commercial and Administrative Staff: 14.
Manufacturing Staff: 58.
Products manufactured: Sporting Shot-gun Cartridges.
Prime Materials used: Empty Paper Shot-gun Shells, Felt Wadding, etc., and Lead Shot.
Manufacture for home and foreign consumption. Agency arrangements are for the most part the same as those which apply to Nobel's, Glasgow.

Owing to the development in the Ammunition Department, it was deemed advisable to remove the Loading Establishment from Ardeer to Waltham, where a factory, equipped with up-to-date machinery, has been erected, and will shortly be in a position considerably to increase the output.
The Company also own the following works:

(7) **BIRMINGHAM METAL AND MUNITIONS COMPANY, LIMITED, ADDERLEY PARK AND STREETLY.**

(8) **F. JOYCE AND COMPANY, LIMITED, WALTHAM.**

(9) **SWANSEA SAFETY-FUSE COMPANY, LIMITED, SWANSEA.**

*(For details of these works, see under the respective headings.)*

**JAMES PAIN AND SONS**

**MESSRS. JAMES PAIN AND SONS**, Firework manufacturers and Pyrotechnists to H.M. the King (sole appointment), have factories at Mitcham, Surrey, and Long Island, New York. The Mitcham Factory employs in actual firework production two to three hundred hands, about an equal number of male and female; one hundred hands are also employed off the Works in non-explosive branches relating to fireworks. Illumination and decoration hands are not enumerated, because they are employed at a separate place. The output of this firm is very considerable. The chief branches are:

(a) Public Displays at home and abroad for National and public rejoicings and events, with Set Pieces in Fireworks Illustrative thereof.

(b) Signals for use of Armies and Navies of England and foreign countries, Life-Line Rockets, Cannons, and apparatus.

(c) Distress Signals for Mercantile Marine, life-saving, and Railway companies, Military and Camp Signals, and those for Tropical and Arctic Expeditions.

(d) Ordinary Fireworks for private consumption and export trade, Signals for Fishing Fleets and smoke tests.

The Pain family can trace their history as firework manufacturers
definitely back to 1700. The grandfather of the present "Sons," who died in 1870, was one of the chiefs employed by the Government for the displays for the Peace Rejoicings in Hyde Park in 1814, and the Coronation Displays for H. M. Queen Victoria's Coronation in 1838. Mr. James Pain Senior defeated, in 1876, the celebrated Ruggieri (who died in the eighties) in a series of public competitions in London. He was also employed by the Government under General Boxer in the displays in 1856 after the Crimean War. The firm have given their displays in all corners of the earth, viz.:

**Europe.**—France, Italy, Belgium, Germany, Holland, Austria, Hungary, Roumania, Turkey, Spain, Portugal, Sweden, Norway.

**Asia.**—Calcutta, Ceylon, Bombay, Siam, Aden, Japan.


**America.**—United States, Canada, Mexico, Cuba, Brazil, Jamaica, Argentine Chile.

**Australia.**—New South Wales, Brisbane, Victoria, Hobart, Adelaide.

**New Zealand.**

They have received thirty Grand Prix Gold Medals and Diplomas of Honour in various Exhibitions, including Paris, Chicago, Liège, and St. Louis.

**THE PATENT ELECTRIC SHOT-FIRING COMPANY, NEWBOLD, NEAR CHESTERFIELD**

Manufacture of Electric Detonators and Fuses. Licensed in 1893.

**M. RILEY AND SONS, OSSETT, NEAR WAKEFIELD**

Manufacture of Fireworks. Licensed in 1876.
THE ROBURITE EXPLOSIVES COMPANY, LIMITED, LONDON

Head Office: 103, Cannon Street, London, E.C.

Capital: £125,000.

Factory: Gathurst, near Wigan, Lancashire.

Personnel: 1 qualified Chemist.

Office staff in London, 3.
Office staff at factory, 7.
Male workers, including foremen, 49.
Female workers, 29.

Products manufactured: Explosives, Ammonium Nitrate, Chlor-Naphthalene.

Capacity of output: 3 tons of Blasting Cartridges per day, but quantity could be easily increased, if necessary, by a double shift.


Explosives manufactured for home, colonial, and foreign consumption.

The Factory occupies about 40 acres in all, and is divided into two sections separated by a valley through which flow a river and the Leeds and Liverpool Canal. The valley is bridged by a steel lattice girder Bridge 500 feet long, in spans of 100 feet.

The smaller (Chemical) section, of about 7 acres, is used for the manufacture and preparation (drying and grinding) of the Chemicals used in the manufacture of Explosives, as well as by the Factory Offices, Laboratory, Stores, Printing Room, Cartridge-Case-making Rooms, Carpenters' Shop, Main Boiler House, Mechanics' Shop, Smithy, etc.

The larger (Explosives) section of about 33 acres is licensed
and used only for the manufacture and storage of Explosives, as well as for fitting up electric detonators.

On the Chemical section there are 13 buildings, some of them of large dimensions. On the Explosives section there are 24 separate buildings, including work-rooms and magazines.

**Boilers** (Chemical section): 2 Lancashire boilers.
(Explosives section): 2 Vertical boilers.

In both cases the steam is used both for power and for heating purposes, the steam having to be carried for considerable distances for heating.

**Engines** (Chemical section): 5 of an aggregate of 26 H.P.
(Explosives section): 1 Engine in use, with a spare one, each 15 H.P.

**Electric Plant** for both power and lighting purposes. One 50 amp. Dynamo and one 220 amp. A further generating set, 440 amp., about to be added. Voltage in each case 110. The current is generated on the Chemical section and conveyed to the Explosives section, where most of the current is used. At present motors aggregating 10 H.P. are in use for driving Cartridge-filling machines and ventilating plant, but in the near future all the power used on the Explosives section will be electrical, and will aggregate 40 H.P.

**Pumps** are used for water supply and for lifting Ammonium Nitrate liquor.

**Tramways**: All the separate buildings of the Factory, as well as the Siding on the Lancashire and Yorkshire Railway, are connected by tram lines, equipped with the necessary covered and open trucks.

**Specialities Manufactured**: Safety explosives of the Sprengel class including those containing aluminium. Practically all explosive is made into Blasting Cartridges.

**Distinctions Obtained**: Gold Medals, London, 1890, Kimberley, 1892.

The explosive Roburite was the first of an entirely new class of explosives to be manufactured in the United Kingdom. The patent
rights were acquired from the inventor, Dr. Carl Roth, by the Roburite Explosives Company, Limited, in 1887, when the company was formed. Manufacture was started early in 1888, and has been carried on ever since. The Factory is exceptionally well situated, being close to the important Wigan Coalfield, and on the Leeds and Liverpool Canal and the Lancashire and Yorkshire Railway. In addition to Roburite the company manufacture Amvis and Negro Powder. All three explosives have passed the official test established in 1897 for inclusion in the Permitted List of Explosives which may legally be used in fiery and dusty coal-mines. Besides the safety of these explosives in the presence of fire-damp and coal-dust, they are safe to handle and will not freeze. As an example of their safety when burned, a few years ago the Mixing-House at the Factory was burnt down. At the time of the fire 1,200 lb. of finished Roburite was in the building, and this burned quietly away without explosion.

SCHULTZE GUNPOWDER COMPANY, LIMITED, LONDON

Head Office: 28, Gresham Street, London, E.C.
Capital: £323,400.
Factories: Eyeworth, Lyndhurst, Redbridge, Totton, 1, York Place, Westminster.
Personnel: 3 Chemists.
   6 manufacturing, commercial, and administrative employés.
   127 male workers.
   1 female worker.
Products manufactured: Schultze Sporting Gunpowders.
Prime Materials used: Wood-pulp, nitric and sulphuric acids, barium nitrate, vaseline, acetone, and alcohol.
Waste Products obtained: Glauber’s salts.
Powders are manufactured for home and foreign consumption.
NUMBER OF MANUFACTURING BUILDINGS: non-danger, 20; danger, 18;
magazines, 14; offices and stores, 15; stables, 5.
7 boilers, N.H.P., 325.
7 steam engines, 160 B.H.P.
1 oil engine, 72 B.H.P.
Electric light plant of 20 K.W. capacity.
1 air compressor.
6 water and 1 vacuum pump.

SPECIALITIES MANUFACTURED OR INVENTED: Schultze Ordinary and
Schultze Cube Gunpowders.

DISTINCTIONS OBTAINED: At the following Exhibitions the highest
awards were obtained: International Inventions Exhibition, 1885;
Chicago, 1893; California, 1894; Antwerp, 1894; Milan, 1894;
Atlanta, 1895; Brussels, 1897; Franco-British, London, 1908.

ORIGINAL RESEARCH WORK by the late Mr. Griffith on internal pressures
and the stringing of shot.

The Schultze gunpowder, which is made by the Schultze Gun-
powder Company, is one of the oldest and best-known Smokeless
Sporting Powders, and the outcome of the experience gained by many
years' manufacture on a very large scale.

In about 1866 Colonel Schultze produced a nitrated wood fibre,
which promised to be more pliable and more easily regulated in its
burning than guncotton. This was introduced into England, and in
1868 the Schultze Company was formed. From that time to this
Schultze gunpowder has been produced in increasing quantities. It is
known and used all over the world, and has found imitators both in
England and abroad.

Schultze gunpowder has passed through various modifications.
It was first made in a small cubical grain formed by cutting the actual
fibre transversely, and then breaking this veneer into cubes.

Later, an improvement was introduced, and the wood fibre was
crushed to a fine degree, and then reformed into small irregular grains.
Further progress was made by breaking down the fibre through the action of chemicals under high temperature, an extremely pure nitro-compound being thus produced.

In it was found possible to render the grains of the powder practically waterproof and less affected by the atmospheric influence of moisture and dryness, and the last addition to the process was that of hardening the grains by means of a solvent of the nitro-lignin, so as to do away with the dust that was often formed from the rubbing of the grains during transit.

Minor modifications have been made to meet alterations in guns and cartridges, but this company has adhered to the use of wood fibre in preference to cotton as the basis of smokeless powder, as, in their opinion, such a powder is less sensitive to variations of loading, and gives more satisfactory results under different climatic conditions.

The specific gravity of the powder has always been regulated so that by bulk it occupies the same measure as the best black powder, and weighs just one half less than black.

The latest development of Schultze Shot-gun Powders recently placed on the market by the Schultze Gunpowder Company, Limited, is called "Schultze Cube" powder, from the cubical shape of the grains.

This powder is made from the same base as the older Schultze powder, but while the quantity of oxygen-bearing salts and restrainers has been reduced to a minimum, the nitro-lignin is gelatinized by solvents, and the resulting jelly is thoroughly incorporated with the other ingredients until it is a stiff homogeneous mass, which is divided up into small grains of cubical shape. The grains are then submitted to a process by which they are made porous. By the new process the weight of a charge has been reduced from 42 grains to 30 grains.

THE SEDGWICK GUNPOWDER COMPANY, LIMITED, KENDAL

Manufacture of Gunpowder. Licensed in 1876.
H. SHAW AND SONS, ROWLEY HILL, NEAR HUDDERSFIELD

Manufacture of Fireworks. Licensed in 1876.

STEELITE EXPLOSIVES, LIMITED, PENRHYNDENDRAETH, NEAR PORTMADOC

Manufacture of "Steelite" Explosives. License dated 1876, but Company formed in 1908.

SWANSEA SAFETY-FUSE COMPANY, LIMITED

Head Office: 220, Winchester House, Old Broad Street, London, E.C.
This Company is almost entirely owned by Nobel's Explosives Company, Limited, of Glasgow.


Size of Factory: About 3½ acres.
Number of Buildings: 46.
Fire Brigade: Composed of Male Workers.
Number of Officials: 3.
Number of Workpeople: 23 male, 120 female.
Number of Boilers: 1.
Number of Engines: 2 (26 H.P.).
Number of Electric Motors: 4 (50 H.P.).
Products Manufactured: Safety-Fuse for Blasting.
Medals: 1 (Melbourne, 1888—First Award).

THE UNITY SAFETY-FUSE COMPANY, SCORRIER

Head Office: Scorrier, Cornwall.
PRIVATE ESTABLISHMENTS

Products manufactured: Safety-Fuse for Blasting and Submarine works.
Prime Materials used: Yarns, Powder, Tar, Pitch and Gutta-percha.
The goods are manufactured for home and foreign consumption.
Number of Buildings at the Factory: 33.
  2 Engines and 2 Boilers, 14 H.P.

The Unity Safety-Fuse Company's works were established in 1846, some fifteen years after the invention of Safety-Fuse by a Cornishman, whose discovery was hailed with much delight by the miners of his native county. The works from the commencement have been under the control of Shareholders and Managers in the Cornish mines, with mining engineers, who, by their technical acquaintance with the requirements of the trade, have been successful in producing Safety-Fuse of excellent quality.

The original method of spinning by hand and with primitive appliances has been completely superseded by delicate and costly machinery, which enables the output to be of considerable magnitude, and with a minimum of irregularities.

This Company manufactures some score or more types of fuse.

VICKERS, SONS AND MAXIM, LIMITED

Founded in the later years of the eighteenth century by the grandfather of two of the present managing directors, Mr. T. E. Vickers, C.B., and Mr. Albert Vickers, and the great-grandfather of the other managing director, Mr. Douglas Vickers, this Company is able to-day, in the several works owned, to construct the hull, machinery, armour, guns, gun-mountings, projectiles, and explosive compounds, and the many auxiliaries, which constitute probably the greatest triumph of mechanical ingenuity—the modern battleship.
Mr. George Naylor, the founder of the firm, began in a small way, but soon gained a wide reputation for his iron-making. In 1829 his son-in-law, Mr. Edward Vickers, became a partner, and in the following year a branch was formed in New York with the object of sharing in the rapidly developing trade of the United States, but this was discontinued later.

In 1856 Mr. Edward Vickers relinquished the control of the business to his eldest son, Mr. T. E. Vickers, now the Chairman of the Company, who was joined later by his brother, Mr. Albert Vickers.

Among the recent developments of the Company, ordnance and armour plate manufacture were commenced in 1888, and the Naval Construction and Armament Works at Barrow-in-Furness, and the Maxim-Nordenfelt Gun and Ammunition Works at Erith, Birmingham, and other places, were acquired in 1897.

The ordnance works at Sheffield have an area of 50 acres, and give employment to 5,000 men. The establishment embraces not only steel-producing furnaces with a capacity of 2,000 tons per week, but plant for the production of 10,000 tons of armour per annum, and 360 guns of various calibres. The machine shops utilized for ordnance alone have a total area of 350,000 square feet. The Sheffield Works are also engaged in the manufacture of projectiles.

The Barrow Works are mainly employed in the manufacture of gun-mountings, two of the erecting shops having a length of over 1,000 feet, while the total area of the shops for this work alone is 300,000 square feet. The shops are contiguous to the fitting-out basin, and warships of all types, including their machinery, are constructed in this establishment. During the past ten years, the vessels built represent a total displacement of 223,464 tons, while the total horse-power of the warship machinery constructed in the same period is nearly 500,000 I.H.P. The approximate value of the ships exceeds £20,000,000 sterling.

The Company's works at Erith, at which quick-firing guns and their ammunition are manufactured, have an area of 18½ acres, and
PRIVATE ESTABLISHMENTS

comprise three factories in close proximity to each other. There are 2,000 machine tools at these works, and about 4,000 men are employed.

At Birmingham a great variety of light ordnance work is carried out, including fuses, cartridge cases for pompom guns, tin canisters for shrapnel shell, brass central tubes for shrapnel shell, case shot, solid brass cartridge cases for all sizes of guns up to 5-inch bore, etc.

The Company have a cartridge factory at Dartford, which is specially laid out for this class of work, in accordance with the requirements of the Home Office. This means that there is a large area studded with small buildings, in each of which only two or three workers are engaged in loading, assembling, priming, etc. There are, of course, a number of powder magazines, each properly safeguarded. Additional to the isolated huts, or danger buildings, there are fairly extensive shops for examining and gauging the completed ammunition prior to packing, also for painting same with the special marks which indicate its kind, whether shrapnel, solid, etc.

Explosive compounds, projectiles, guns and armour, are tested at a big gun range at Eskmeads, on the Cumberland coast, where a crane of 80 tons capacity, running on an overhead gantry, lifts the loads from the railway wagons to the gun-mounting, armour-framing, etc. There are also ranges at Eynsford and Swanley in Kent, for testing lighter guns.

W. H. WAKEFIELD AND COMPANY, LIMITED

GATEBECK GUNPOWDER MILLS, NEAR KENDAL

This Company was started at Sedgwick, in Westmorland, in the year 1764, by John Wakefield, great-great-grandfather of the present owners, and continued in a small way there until 1852, when the bulk of the works were transferred to Gatebeck, where they now exist.

In 1882 the Lowwood Gunpowder Company, Limited, near
Ulverston, was absorbed into this firm, which became a limited Company in June, 1903.

Blasting black powder has been practically the only manufacture during the whole period, and the saltpetre manufactory is the earliest in England, having been erected in 1864.

JOSEPH WELLS, LONDON

Office and Factory: Albert Firework Factory, Honor Oak Park, London, S.E.

Personnel: Administrative Employés at Factory, 5.
Male workers (inside), varies from 15 to 30.
Female workers (inside), varies from 2 to 6.
Male workers (outside), 4.
Female workers (outside), varies to 10.
Travellers, 10.

Products manufactured: Fireworks for sale, 5th November, and for Displays in all parts of the world. Ships' signals, including Rockets, Blue and Coloured Lights, etc. Smoke Rockets for Drain testing, etc.

Prime materials used: Ordinary Pyrotechnic materials.
Goods are manufactured for Home and Foreign consumption.
Agents in New Zealand, America, Sierra Leone, Egypt, S. Africa, Australia, India, etc.

Magazine at Gravesend for import and export.

Number of buildings: Danger buildings for the manufacture of Explosives, 13.
Danger buildings for storage, 5.
Non-danger buildings, 10.

Distinctions obtained: Various Gold Medals and other Prizes.

Established in the year 1839, and carried on from that time at different addresses until the present day. Established at Honor Oak Park, S.E., in the year 1875.
The first importer of Aluminium torches into London, and one of the first to import Chinese crackers.


Contractor for Limelights, Decorations, Illuminations, Manager of Fêtes and all amusements. Fire Effects for Pantomimes, Plays, and Music Halls.

Men and goods sent to all parts of the world.

W. AND J. WILDER, BIRMINGHAM

HEAD OFFICE: 29, Great Francis Street, Birmingham.
FACTORIES: Greet and Knowle, Warwickshire.
NUMBER OF WORKERS: Male, 20; female, 30.
CAPACITY OF WORKS: About 50 tons are sold yearly.
PRIME MATERIALS USED: Ordinary Pyrotechnic Materials.
GOODS are manufactured for home consumption.
NUMBER OF BUILDINGS: 50 Sheds and Magazines.
DISTINCTIONS OBTAINED: Awarded First Prize in the Firework Competition at Alexandra Palace, London.
The firm was established in 1834.
LIST OF MANUFACTURERS OF PICRIC ACID

Bradford Dyers Association, Ltd. (The Low Moor Chemical Co., Ltd.), Low Moor, near Bradford.
S. Breaks and Son, Ltd., Bradford.
R. Graesser, Ruabon.
Chas. Lowe and Co., Reddish, near Stockport.
Read, Holliday and Sons, Ltd., Huddersfield.
Sharp and Mallett, Copley, Halifax.
The White Lee Chemical Co. (Hy. Ellison), Cleckheaton.
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