A HISTORY OF FIREWORKS

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Further Evidence
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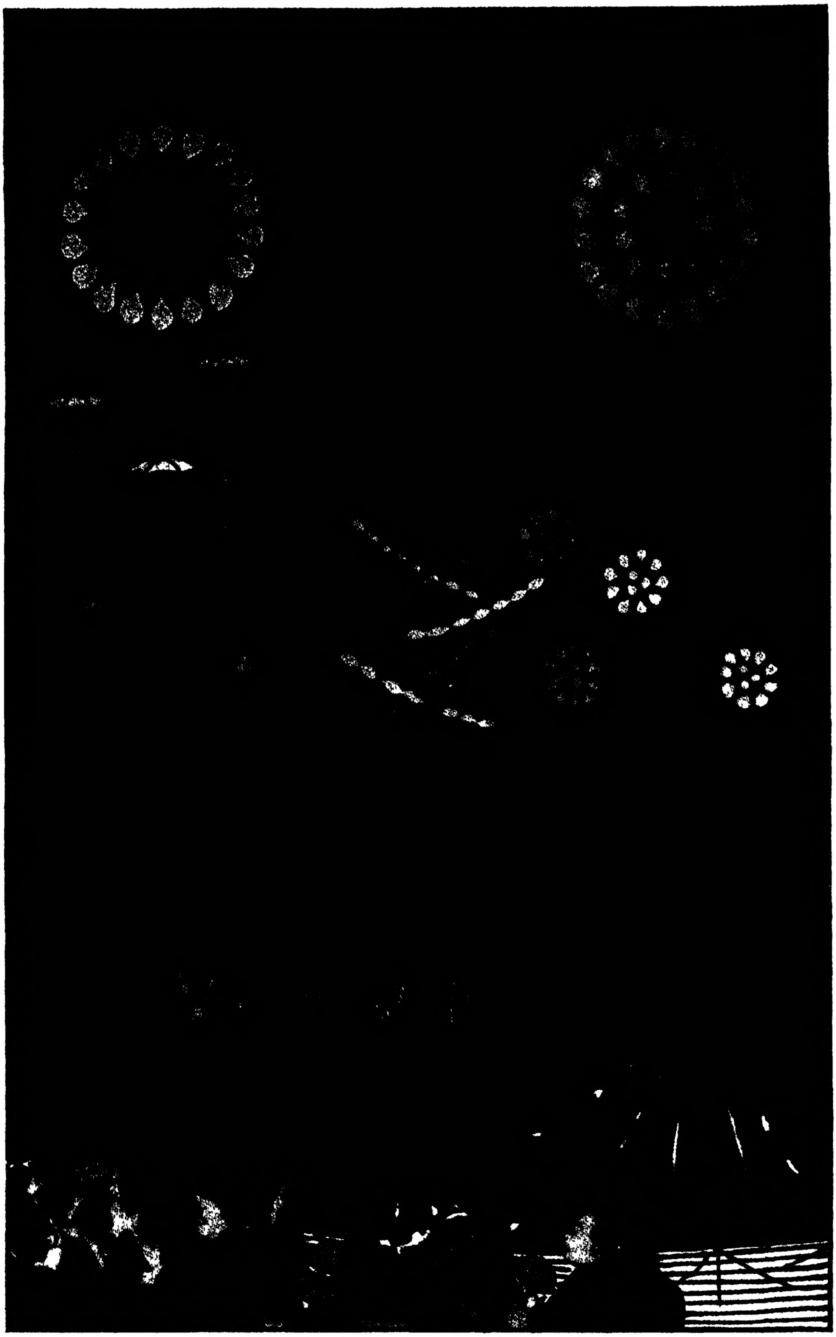
Earth to Ashes
Miss Hamblett's Ghost

OTHER WORKS

Pyrotechnics
A Case Book of Crime
Fireworks and Fêtes
A History of the 7th Battalion Herts Home Guard, 1940–44



JAPANESE AERIAL FIREWORKS

The remarkable symmetry of the patterns formed by the 'stars' is not at all exaggerated, but the artist has permitted himself considerable licence in the matter of their height.

A HISTORY OF FIREWORKS

by

ALAN ST H. BROCK A.R.I.B.A.

With Eight Plates in Colour Thirty-two in Half-tone and Line Blocks in the Text

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TO THE MEMORY OF

MY FATHER

ARTHUR BROCK

Pyrotechnist

1858–1938

PREFACE

IT is more than a quarter of a century since my first book, *Pyrotechnics: the History and Art of Firework Making*, made its appearance; it has now been out of print for several years. No one can be more aware than I of its many demerits and deficiencies, but so far as I know it presented the first, and, as I believe, until to-day the only, attempt to trace in full the history of pyrotechny. The manner in which it was received on publication and the number of inquiries that reach me, even to-day, from those who wish to obtain a copy encourage me to believe that the time has come for a second attempt to do justice to the subject.

Much has happened in the field of pyrotechny, as, indeed, elsewhere, during the last twenty-five years. During that time I have accumulated a mass of additional information on the subject, some of which has brought about a modification of certain of the views I held, and expressed, when the first book was written. Other material greatly amplifies the facts and references I was previously able to deal with. All, I hope, will be found interesting and acceptable to the many enthusiasts of the art throughout the world. For much of this information I am indebted to correspondents from places as far apart as the United States, Australia, and Malta. One would-be pyrotechnist, writing from India, expressed the hope that he might "have the priveledge to creep under your honours robe to become your faithful pupil and disciple in the glorious art." Later I learned that this gentleman's interest, in matters pyrotechnic and explosive, was so pronounced as to arouse the attention of the Indian C.I.D. I hope that the information I was able to give them was not prejudicial to my potential student.

At the time of publication of the earlier book, among many not altogether unflattering Press notices, there appeared two comments, charging me with certain omissions which I am only too pleased to repair in the current production. The first expressed surprise that anyone of my name could fill an entire volume on the subject of fireworks without once mentioning the name of their patron saint, Guy Fawkes. To be truthful, I was myself rather taken aback when I found that the complaint was deserved. The slight is unpardonable as coming from one whose family and forebears have lived for more than two hundred years on the aftermath of

Guido's misplaced political zeal. I have endeavoured to make amends in Chapter XI.

The second comment was of a more domestic nature; that I had failed to trace adequately the history of my own family, whose influence, as the reviewer pointed out, has not been without its effect on the art, and who have added a proverbial phrase to the English language: "Brock's Benefit." This omission I have also sought to repair in the present book,[1] and if it should appear to some readers that the name and its associations now make too frequent appearances, at least I have my excuse.

The illustrations of early historical displays are chiefly from contemporary prints, among the unique collection, commenced some half-century ago by my father, the late Arthur Brock, and carried on by myself, which in 1946 was accorded the very great honour of being exhibited at the Victoria and Albert Museum, South Kensington, for four or five months.

To make a satisfactory and even approximately representative selection from such a mass of material has not been easy, but I hope it will not be considered altogether unsuccessful.

A. St H. B.

Chorley Wood
August 1949

[1] A family-tree is given in Appendix III.

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Chapter I

THE ORIGIN OF PYROTECHNY

"What are fireworks like?" she [the Princess] had asked the Prince, one morning, as she was walking on the terrace.

"They are like the Aurora Borealis," said the King, ". . . only much more natural. I prefer them to stars myself, as you always know when they are going to appear. . . ."

OSCAR WILDE, *The Remarkable Rocket*

FIRE has been the most important factor in the development, even the survival, of the human race. In the early stages of man's advancement it was the possession of fire that distinguished him from the lower animals. It has made human life possible in areas of the earth where, without it, existence would be unendurable; the benefits and protection it has afforded have, by reducing wastage, been responsible, perhaps more than those of any other element, for the increase in the population of the world. Above all, fire has been the most important stimulus to the development of man's inventive capacity.

We do not know when man first achieved the art of fire-making; no tribe, or race, has yet been discovered which did not use it. At first, no doubt, ignition was obtained, and conserved, from such natural sources as the spontaneous forest fire or the volcano. The making of fire for himself must have been one of man's first inventions, although at the time it was more probably regarded as a feat of magic. The feelings of veneration and gratitude inspired by fire, as well as its association with the sun, the stars, and such awe-inspiring phenomena as meteors and eclipses, soon gave it a religious significance. There must be few, if, indeed, there be any, religions in which fire, in some form or other, does not play its part: the burnt sacrifice; ordeal by fire; the Chinese cracker; the altar candle—to mention but a few.

One of the many benefits bestowed on mankind by fire is the art of cookery, to which salt is an important adjunct. To this circumstance, it seems likely, the art of pyrotechny owes its inception. In parts of Asia, remote from the sea and possessing no mineral salt formation, saltpetre (potassium nitrate), which is found there in surface deposits, was used, and no doubt it still is, as a substitute for common salt (sodium chloride). It is not improbable that his observation of what happened when a quantity of saltpetre fell by chance into the embers of the cooking fire inspired the first experimenter in practical pyrotechny, as well as in applied chemistry.

The embers would glow and sparkle; obviously saltpetre would assist combustion, although that is perhaps rather the sense than the precise form of the primitive observer's conclusion. The possibility of using a mixture of cold embers and saltpetre as tinder would suggest itself. Later accidental ignition of a quantity of this, stored in a container, such as a length of the ubiquitous bamboo, may well have been responsible for the first display of a veritable firework, as well as the practical demonstration of the fact on which the whole art and practice of pyrotechny are based: that a mixture containing saltpetre—or, as was found later, an ingredient possessing a supply of oxygen which it readily gives up—is capable of burning without assistance from the oxygen of the atmosphere.

Sooner or later a third ingredient, sulphur, the combustible qualities of which must have been recognized from earliest times, would suggest itself. So the three ingredients of gunpowder were brought together.

When this momentous event took place we do not know; certainly it was long before the beginning of all historical record. As to where it occurred more evidence is available, some of which may be regarded as reliable; a great deal more is, to say the least, doubtful. A case can be made out for the Chinese, the Hindus, the Arabs, the Greeks, and even England. The confusion is worse confounded by reason of the proneness of translators of manuscripts on which the various theories are based to read into passages that deal with the use of incendiaries, flaming arrows, or fire pots references to the use of artillery.

Another fruitful source of misunderstanding is the widespread assumption of writers on the subject that pyrotechny began with the "invention of gunpowder." The problem of the chicken and the egg does not, however, apply here. The cold fact is that gunpowder was *not* invented.

Berthold Schwarz, the thirteenth-century Franciscan monk, of Freiburg, Germany, invented the principle of the gun: the propulsion of a missile from a vessel, or metal tube closed at one end, by the expansion of gases produced by the ignition of a quantity of firework mixture behind it. Almost any of the primitive mixtures then in use would have served his purpose, but no doubt he experimented to find the proportion most suitable to his require-

DISPLAY ON THE RIVER ARNO, FLORENCE, IN 1600

In honour of the marriage of Henry IV of France to Marie de' Medici.

[*See pp.* 40–41.]

THE "GREEN MEN" OR "WILD MEN"
Traditional figures which played their part in many early fireworks displays. (*Left*) A Danish print, probably of the early seventeenth century (*see p.* 33). (*Right*)

ments. It seems likely that not the least of his problems was the limitation of the force of the explosion, so that his gun should not be blown to pieces. It is interesting to note how, through the years, the explosive power of gunpowder has gradually increased with the strength of ordnance. In the earliest days of artillery approximately equal parts of saltpetre, sulphur, and charcoal were used; to-day the proportions average 15 : 2 : 3. Additional force is given to modern gunpowder by methods of manufacture which have been gradually evolved since the first crude mixing of the ingredients. To-day the ingredients are incorporated in a mill, under a spray of water, crushed under gun-metal rollers, and compressed into cakes, which are again crushed into grains. These are sieved and graded into various sizes, and later dried and polished in revolving drums.

While there seems little doubt that Germany was the birthplace of the gun, there is rather less certainty about the nationality of its inventor. References to him in ancient documents as *der schwarze Berthold* or *niger Bertholdus* suggest the possibility of his being a man of colour. Supporters of the belief in his Teutonic origin, however, maintain that *black* refers to the colour of his dress, quite overlooking the fact that Berthold was a Franciscan and that the habit of that order was grey—the Greyfriars.

It may well be that Berthold was, in fact, an Asiatic. In any case, there can be as little doubt that a knowledge of pyrotechnic mixtures existed in China and India for centuries before it spread to Europe, via the Arabs and the Greeks, as there can that the gun was invented in Germany. It was not until the year 1520 that the Chinese were astonished by their first sight of artillery, provided by the guns on visiting Portuguese ships at Canton, and nearly a century was to elapse before the first guns to be manufactured in that country were cast at Peking, under the superintendence of Jesuit missionaries.

A claim that gunpowder was invented in England by Friar Bacon, born at Ilchester, Somerset, in 1214, is based on the reading of certain cryptic passages in his *Epistolæ de Secretis Operibus Artis et Naturæ et de Nullitate Magiæ*. These have been widely accepted as describing the refining of saltpetre and its use in a mixture with charcoal and sulphur to produce an explosion and sparks (*tonitruum et coriscationem*). The proportions he suggests are saltpetre 7 parts, charcoal 5 parts, and sulphur 5 parts. His mixture would undoubtedly have served as a propellant, had it occurred to him that it might have been used for that purpose; there is no evidence that it did. Nowhere in his writings is there any passage that can, by any stretch of imagination, be taken as a reference to a gun. The most, therefore, that can be assumed in favour of Bacon is that he had heard of, or, it may be, had himself evolved, a pyrotechnic mixture, similar to those already in use in the East. That he makes no claim to have invented the formula suggests the former alternative.

The Greeks possessed a knowledge of pyrotechnic mixtures prior to the period of Friar Bacon's writings, as instanced by the frequent, often obscure, references to Greek Fire. Many enthusiastic accounts of the havoc wrought by this weapon are to be found in contemporary literature. Those possessing the secret of its manufacture came to regard themselves almost as invincible. That it disappeared from warfare somewhere about the end of the thirteenth century has led many to the conclusion that the secret of its composition had been lost. May it not be the fact that the appearance of artillery in the field rendered it comparatively ineffective and obsolete? The subject of Greek Fire will be further discussed in the chapter on Military Pyrotechny.

The suggestion that certain recipes in a manuscript entitled *Liber Ignium*, of Marcus Græcus, which is assumed to have been written between the years 1225 and 1300, may be taken as evidence of an early knowledge of gunpowder, as such, among the Greeks is not justified by the facts. These formulæ, five in number, certainly each have saltpetre as an ingredient, but, as in the case of Friar Bacon, there is no evidence of any knowledge of the gun or the principle underlying it. Indeed, it is more than possible that no such person as Marcus Græcus ever existed, and that the book was a collection of recipes gathered by various writers from a number of sources. There can be little doubt that the direction whence they came was the East.

Lieutenant-Colonel H. W. L. Hime, R.A., in his scholarly book *The Origin of Artillery*, published in 1915, seems to some extent at least to have fallen victim to the erroneous but popular inversion of ideas regarding gunpowder and pyrotechnic mixtures. As he points out, much of the evidence advanced for the early use of firearms by the Moslems, the Hindus, and Chinese is based on mistranslation of original manuscripts, either through want of technical knowledge on the part of the translator, or, in some few cases, by deliberate intention. References to the throwing of incendiary missiles, either by hand or by means of some mechanical contrivances resembling the catapult of the Romans, are frequently rendered as references to the use of artillery.

Quite rightly he maintains that no case is made out for the use of guns by the Eastern races before their introduction from the West. From this he argues that they possessed no knowledge of the properties of saltpetre. He points out that the Sanskrit language possessed no word for saltpetre—of which, as he admits, there always has been a plentiful supply in the valley of the Ganges—ignoring the possibility that, even if the natives were unable to distinguish saltpetre by name, they might yet be aware of its peculiar characteristics in relation to fire, as, indeed, they were.

Marco Polo gives an account of the salt industry of the city of Chang-Glu, in the province of Cathay; the salt, he says, "is white and good and is exported to various parts," but there can be no doubt that he is describing the preparation of saltpetre.

More important to the argument, Hime admits the possibility (p. 74) that in some documents there is reference to rockets, overlooking the fact that a quantity of rocket mixture ignited in a gun would be quite capable of propelling a missile. It might, indeed, have proved too strong for the guns of the earliest period.

There can be no doubt whatever that the sequence of events was as follows: the discovery of the possibilities of saltpetre as an aid to combustion, somewhere in Asia, led to the gradual development of pyrotechnic mixtures. The knowledge, in course of time, spread to Europe, where, early in the fourteenth century, the monk Berthold Schwarz invented the gun, adapting a pyrotechnic mixture to his purpose.

Two hundred years later firearms were introduced into China by the Portuguese.

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Two hundred years later firearms were introduced into China by the Portuguese.

Chapter II

PYROTECHNY IN THE EAST

> Oh, why do the myriad stars fall like rain when there is no wind to blow? They are the fireworks that have burst in the sky. Oh, what thunders are those we hear on the earth when the sky is clear? They are shouts of joy and revelry of the people gathered here.
>
> *The Story of Yone Noguchi* (told by himself, 1914)

THE early references to the use of what, it seems possible, even probable, were pyrotechnic war devices in the East, mentioned in the previous chapter, are generally vague and often ambiguous; but one is left with the conviction that the peculiar properties of saltpetre, as an aid to combustion, were recognized and employed by Asiatics some considerable time, at any rate, before any such use was made of the salt in Europe.

Incendiaries, such as blazing naphtha, fire arrows carrying burning tow, and red-hot projectiles, thrown from catapults or slings or merely dropped from the walls of beleaguered fortresses, often provide the solution of such passages, but there can be little doubt that, in some instances at least, the reference is to some device that depended for its action on the use of a pyrotechnic mixture. The Chinese employed explosive missiles, which burst during flight or on the target, as early as 1232. These were discharged from mechanical devices or dropped from the walls of forts. There seems little doubt that war rockets were used in India in very early times.

There is no definite evidence of when fireworks first began to play their part in Chinese civil life. The process was probably gradual, but the position they were eventually to occupy in the day-to-day existence of the populace was remarkable. Crackers are an outstanding feature of weddings, birth celebrations, and funerals. Minor peace celebrations, with the explosion of crackers, announce the settlement of personal quarrels, religious ceremonies, and occasions such as an eclipse of the moon and the New Year. Sir John Francis Davis, a former Governor of Hong Kong, writing in 1836, gives an account of the last-mentioned ceremony:

> . . . At the moment of midnight commences an interminable *feu de joie* of crackers strung together. Indeed the consumption of this noisy

species of firework is so enormous that the air becomes absolutely charged with nitre; and a governor of Canton once in vain endeavoured to suppress it, on the ground of the undue wastefulness of the practice, though it probably contributes to the healthiness of Chinese towns.

The final phrase of the account seems to offer possibilities for a firework advertising campaign.

Elsewhere in his book *The Chinese: a General Description of China and its Inhabitants* Governor Davis makes an interesting reference to an early example of rocket propulsion: "They also make paper figures of boats to float and move upon the water, by means of a stream of fire issuing from the stern."

His general impression of Chinese fireworks is that

they are sometimes ingenious and entertaining, rather, however, on account of the variety of moving figures which they exhibit, than the brilliancy or skill of the pyrotechny, which is inferior to our own. . . . Their rockets are bad, but blue lights they manufacture sufficiently well for the use of European ships.

He adds yet another to the number of often highly coloured accounts written by returning travellers of "the Drum," which he describes as "the best thing of its kind." The following description of this device was written by a traveller in China during the early years of the nineteenth century:

The fireworks, in some particulars, exceeded anything of the kind I had ever seen. In grandeur, magnificence, and variety they were, I own, inferior to the Chinese fireworks we had seen at Batavia, but infinitely superior in point of novelty, neatness, and ingenuity of contrivance. One piece of machinery I greatly admired: a green chest, five feet square, was hoisted up by a pulley fifty or sixty feet from the ground, the bottom of which was so contrived as then suddenly to fall out, and make way for twenty or thirty strings of lanterns, enclosed in a box, to descend from it, unfolding themselves from one another by degrees, so as at last to form a collection of full five hundred, each having a light of a beautifully coloured flame burning brightly within it. This devolution and development of lanterns was several times repeated, and at every time exhibiting a difference of colour and figure. On each side was a correspondence of smaller boxes, which opened in like manner as the other, and let down an immense network of fire, with divisions and compartments of various forms and dimensions, round and square, hexagons, octagons, etc., which shone like the brightest burnished copper, and flashed like prismatic lightnings, with every impulse of the wind. The whole concluded with a volcano, or general explosion and discharge of suns and stars, squibs, crackers, rockets, and grenades, which involved the gardens for an hour in a cloud of intolerable smoke. The diversity of colour, with which the Chinese have the secret of clothing their fire, seems one of the chief merits of their pyrotechny.

It is perhaps unnecessary to point out that the colours exhibited were not attributable to pyrotechnic agency, but to the tints of the paper of which the lanterns were made. The "intolerable smoke" requires no comment.

John Bell, who, in 1719, accompanied an embassy from the Court of Peter the Great to that of the Emperor of China, gives accounts of several displays he witnessed at Pekin. "The Drum" was one of the items he saw, but, assuming him to be correct in his estimate, it was performed on a much larger scale; he gives the diameter of the chest as twenty feet. Next day, at an audience, the Emperor asked the Ambassador for his opinion on the displays.

> On this occasion the Emperor repeated what has already been observed concerning the antiquity of illuminations composed of gunpowder, and added that although fireworks had been known in China for more than two thousand years, he himself had made many improvements upon them, and brought them to their present perfection.

The earlier statement to which Bell refers was made by a Tartar, commanding the Emperor's artillery and "by no means ignorant of his profession, particularly with respect to the various compositions of gunpowder, used in artificial fire-works." He declared that the Chinese had known the use of gunpowder for "above two thousand years in fireworks according to their records, but that its application to the purposes of war was only a late introduction." Bell adds that: "As the veracity and candour of this gentleman were well known, there was no room to doubt the truth of what he advanced on this subject."

There can be little doubt that the popular legend of the superiority of Chinese fireworks over those to be seen in Europe, which to some extent persists even to-day, was based to a great degree on the stories of such travellers, assisted, perhaps, by that general air of mystery attaching to anything connected with the East. Claude-Fortuné Ruggieri, a member of the famous family of French pyrotechnists, seems to have subscribed to the popular view in the first (1801) edition of his *Elémens de pyrotechnie* when he remarks: "The Chinese are perhaps to-day superior in this art, to the French and Italians; partly by the minuteness of the work and more by the possession of materials which we lack." However, by the time the second edition of his book appeared in 1821, he had had visual proof of the fallacy of his earlier belief:

> Some people imagine that the Chinese are still, to-day, superior to the French and Italians . . . nevertheless I have just had occasion of remarking the contrary. An agent arrived a year ago with twelve cases of Chinese fireworks . . . these were no different from what the Chinese have been making for three or four centuries; this convinced me that we in Europe are far superior to the Chinese.

It may be remarked that when that was written true colours had not yet become general in Western pyrotechny. Ruggieri gives only one colour effect in his book, a green flame produced by the tinting of a spirit flame with verdigris (copper acetate), and not therefore a legitimate pyrotechnic effect. Had the consignment of Eastern products included any firework "clothed" by even a single example of the "diversity of colour" referred to by the writer quoted above, it must have excited his interest, at least to the extent of being remarked upon. His estimate of the period during which the Chinese had been making fireworks is interesting, but hardly likely to have any factual basis.

One important contribution to Western pyrotechny was 'Chinese fire,' the formula for which was brought to Europe by returning Jesuit missionaries during the seventeenth century. The operative ingredient of the mixture, which will be dealt with in a later chapter, was powdered cast iron, or 'iron sand.' The underlying principle has since been exploited by Western makers to an extent that is quite unapproached to-day in its place of origin.

Very few books on the subject of pyrotechny are to be found in China, and they are of comparatively late dates. Two works written during the Ming Dynasty (1368–1644)—no closer estimate of the time of their appearance seems to be available—by Tüch-ling and Wan-shu, contain a few references to the subject, not of much practical value.

There are two books on Chinese military pyrotechnics written about the beginning of the seventeenth century, when, it may be remarked, contact had already been established with the Western world. The preparation for their publication in English was undertaken by my good friend the late Dr Tenney L. Davis, Emeritus Professor of Organic Chemistry, Massachusetts Institute of Technology. To him I owe a debt for permission to quote from his paper on Chao Hsüehmin's *Outline of Pyrotechnics*. This book, written about 1753, seems to be the only work on civil fireworks to appear during the long history of pyrotechny in that country.

It is apparent to the reader who happens to be possessed of any technical knowledge of the subject that the writer was recording what he had learned from practical firework-makers, and not facts arising from personal knowledge and experience of the art. He makes no mention of any ingredient that was not already in use in the West, if one excepts those varieties of charcoal obtained from raw materials not available in Europe—bamboo-knots and leaves, coconut shell, egg-plant, grasshoppers, calabash, snake-skin, melon rind, and the like. It is curious that he makes no mention of lamp-black, an ingredient which plays an important part in Eastern pyrotechny to-day.

One cannot help feeling that the effects ascribed to his charcoal variants are based on a kind of onomatopœic suggestion; grasshopper charcoal possesses the property of "flying away and running," that of coconut "produces splashing noises," and that of bamboo leaf "gives a hissing," no doubt by analogy from the sound of wind in the foliage.

His references to colour are more practical, although in general they seem to apply mostly to the tinting of smoke rather than flame. His mention of verdigris to produce a green flame is interesting, and shows that some such method was employed as that referred to above in connexion with Ruggieri. To-day, as will be seen later, copper salts are used only to give blue.

His remarks that "rockets are the eyes of fireworks, and are fired before the main display to quieten the audience," certainly conforms, to some extent at least, with present-day practice in this country, although they are not here entirely confined to that rôle. The various pieces he mentions, and the way in which they are shown, leaves one with an impression that Chinese displays of that time followed a ritual course to which the spectators were educated and reacted accordingly; even to-day there is considerable ritual connected with the letting off of fireworks in China. Crackers of differing colours are used exclusively by certain strata of the population: yellow for the aristocracy, green for the law, and red for the general public.

It is in the sphere of actual manufacture and manipulation, however, that Hsüeh-min is perhaps at his best. Can it be that his informants were pulling his leg? "The compounding," he tells us,

> must not be done in a family which is in mourning. It is especially prohibited in the house where a funeral has been held or where a man has died, for there the misfortune of accidental fire is certain to happen. In the case of mourning for some one outside the immediate family . . .

a piece of red silk-cloth may be hung in the compounding room to release the family from the prohibition of using powder.

The ashes on the charcoal must be removed before use . . . otherwise the resulting powder will usually be impeded. Probably the ashes are the ghosts of charcoal and the charcoal is afraid of them.

Women are not allowed to handle powder. If the powder is packed by women, the crackers will change into fountains and vice versa.

Certain safety measures are, one would have thought, obvious precautions. "Smoking is forbidden in the powder room" and "the testing of powder must not be carried out at any place near the powder house" are examples; but the reason given for the rule—which, by the way, is a provision of our Explosives Act of 1875—that "the room should be kept quiet and neat, and that noisy talk should be forbidden," is justified by the assertion that thereby "the soul of the powder may be soothed." The writer includes a remedial suggestion that might be worth consideration to-day. Under the heading "Moving Pieces for Banquets" he says: "Small articles such as jumping grasshoppers, wandering fish, running snakes . . . all of these being about an inch in length, are fired after a banquet. It is supposed that their smoke facilitates recovery from over-indulgence."

In Japan the art of firework-making has developed a character and a technique that are individual. The outstanding feature of Japanese displays is—or perhaps one should say was—provided by the aerial fireworks, shells which burst in the air, exhibiting designs and patterns of the most astonishing symmetry and beauty (see frontispiece). The successful functioning of these was entirely dependent on the painstaking care and exactitude with which the spherical or cylindrical cases were filled; a lengthy process that Western rates of pay render prohibitive.

In view of the antiquity ascribed to the art in China, it is surprising to read in a pamphlet, published in 1939, by the Japanese Board of Tourist Industry, that:

Regarding the introduction of fireworks to Japan, one would, on the analogy of the hundreds of things we imported from China long ago, imagine that they also came from China. But the sober fact is that we got them from some Dutchmen in 1600, or thereabouts, although it is usually stated that fireworks were known in China in remote antiquity.

According to an old record, fireworks were first brought to the port of Sakai, near Osaka. It seems, however, that the fireworks which found their way to Japan were, as might be expected, of a very simple form. That this was so is clear from a chronicle giving an account of a display at the Imperial Palace.

In 1659 a pyrotechnist named Kagiya began manufacturing fireworks at Tokyo. His descendants were still similarly employed up to the Second World War, when many other firms were engaged in the industry, notably Hirayama of Yokohama, Tamaya of Tokyo, and Ishihara of Osaka.

As early as 1703, owing to accidents arising both during manufacture and at displays, laws were passed limiting firework exhibitions to certain fixed days and regulating manufacture.

Formerly the period between May 28 and August 28 was fixed as the official fireworks season in Tokyo, with the result that displays took place nightly, to the detriment of business generally. Since 1868 August 1 has come to be recognized as the date of the great firework festival of Tokyo, the so-called "Opening of the Sumida River," when a great display of *hanabi* (flowery fire) is given from the Ryogoku Bridge and its neighbourhood.

Other firework festivals take, or took, place at Nagasaki, Osaka, Ibaraki, Mikawa, Nagano, and Echigo.

A particular variety of fireworks in which the Japanese makers excel is that for exhibition in daylight—shells which, in place of fire effects, release figures human or animal in the form of paper balloons. These are open at their lower extremities, which are weighted, and become inflated as they fall through the air. Other effects are strings of flags attached to parachutes, coloured dust-clouds, and paper streamers.

Other than the aerial fireworks already referred to, Japanese pyrotechnists have achieved nothing comparable with the work of the foremost European makers. Particularly is this so in regard to those set pieces and devices which, in the West, give variety to displays by functioning at ground-level. This is, no doubt, due to the fact that since the early seventeenth century until comparatively recent times Japan was, for a lengthy period, virtually cut off from Western influence, and during that time the art of pyrotechny was developed independently according to public taste and demand. When the influence of the West began again to be felt the native pyrotechnists did their best to introduce Western ideas into their displays. The results were, more often than not, crude and unsatisfactory.

The development of pyrotechny in India was even more restricted, and over a longer period. Although primitive firework mixtures must have been known and used by the Hindus for many centuries, it was not until almost the beginning of the present century that any advance was made, and that came only as the result of imitating Western ideas. The reasons for this state of affairs are given by Lieutenant-Colonel H. W. L. Hime, in his *Origin of Artillery*. "By the seemingly innocent institution of *caste*," he says,

> the Brahmins succeeded in tramping science in the dust. One caste was not permitted to touch this, another caste could not touch that substance; and the higher the caste, the greater the number of forbidden objects. The study of experimental science was consequently thrown back upon the lowest and poorest classes, who had neither the means, the leisure, nor the inclination to pursue it. Thus "the spirit of inquiry gradually died out," says a Hindu Professor of Chemistry, "and the name of India was all but expunged from the map of the scientific world."

In India, as in China, fireworks have, for time out of mind, played their part in religious and social ceremonies. Fireworks are discharged when the 'Anthirady' procession, having taken the ashes of the deceased for final disposal after cremation, returns to his house. Public festivals, known as Pujas, provide many opportunities for the use of fireworks, generally on somewhat indiscriminate lines. Until quite recently, when the influence of Western methods and technique began to be felt, the range of effects was very limited. As on similar occasions in China, the cracker, in differing forms known variously as *gola*, *pataka*, *vengagvedi*, and *koroo*, plays a predominant part. Additional noise is supplied by the *adirvedi*, a row of short iron pipes fixed in a plank of wood, charged with gunpowder, and fired as a volley. A form of cracker much used in India was the 'sand'- or 'dashing-cracker,' similar in principle to the 'throw-down,' formerly used in Europe. Here a minute quantity of fulminate of mercury was mixed with grit and twisted up in a piece of tissue-paper, and on being thrown against a hard surface exploded with a sharp report. In the Hindu version the fulminate was replaced by a mixture of potassium chlorate and the yellow sulphide of arsenic, often in considerable quantity. This highly sensitive and dangerous mixture, together with the primitive methods employed, was responsible for a high proportion of the enormous number of accidents among Indian firework-makers. Such mixtures had been prohibited in this country as early as 1894, and from 1902 onward steps to the same end were taken in India, but it was not until 1910, when coconut-shells filled with the mixture had become the established weapon of the native anarchist, that more drastic methods were adopted. Even as recently as January 1948 a missile of this type was thrown during the prayer meeting with which Gandhi concluded his fast.

'Chinese fire' mixture is used by Hindu pyrotechnists, often producing very striking results, burned either in paper, bamboo containers, or earthenware pots. These are known as *tubri*. A paragraph in the *Calcutta New Empire* of November 8, 1928, announces that:

> On account of Sree Sree Kali Puja festival the 3rd annual performance of the 'Janbazar Tubri Competition' will take place on the 11th instant at 7.30 P.M. Three silver medals will be awarded. Two to the first two successful competitors in 'Ordinary Tubri,' one to each, one to the best man in the 'Uran Tubri.' Competitors are required to bring three two-chatack-pots of 'Ordinary Tubri,' and ten in number in the case of 'Uran Tubri.' Admission will be free.

An alternative name for the pot variation, suggested no doubt by their shape, is *anar*, or pineapple. Another 'fountain' effect is the *puljari*. Coloured fire, when used in a container, goes by the name of *burusu*, and when employed loose is known as *chandrajota* or *mahteb*. Rockets are known as *abusavanani* or *hawai*.

While all Pujas, and particularly the Divali, the 'Feast of Light,' are marked by general communal use of fireworks and illuminations, it is the Dasserah, at the end of the rainy season, that provides the occasion for more ordered and spectacular displays.

A Siamese observance, of considerable antiquity, is the celebration of certain religious festivals by the discharge of rockets, some of which are of very large size. A traveller, writing at the end of the nineteenth century, gave their length, exclusive of the stick, as from 8 to 10 feet. The case is composed of a section of bamboo bound with string. The composition consists of coarse native powder, of which from 20 to 30 lb. is often used in one case. The stick, which is of bamboo, varying from 20 to 40 feet in length, is gaily decorated with coloured paper and tinsel and fitted with bamboo whistles. A rough scaffold is erected from which to fire the rockets, and, according to those who have witnessed such exhibitions, considerable altitudes are reached by the rockets in flight. As may be expected with such crude methods and materials, accidents are of frequent occurrence.

Chapter III

PYROTECHNY IN EUROPE: THE EARLY YEARS

. . . The king would have me present the princess . . . with some delightful ostentation, or show, or pageant, or antique, or firework.

Love's Labour's Lost, Act V, Scene 1

AN attempt to fix, even approximately, when and where in Europe pleasure fireworks, as distinct from warlike devices, first made their appearance, is a problem only slightly less difficult of solution than that presented by the East. Here, however, the evidence in respect of time is certainly less wildly vague; the end of the thirteenth century may be taken as the starting-point for the inquiry. There are, too, substantial grounds for placing the birthplace of European pyrotechny in Italy.

Classical scholars of undoubted eminence in their own field, but possessed of little technical knowledge, have cited passages from Claudian, among others, as evidence of veritable firework displays in the Roman amphitheatre. But a mention of fire in connexion with the *pegma*, or scaffolding, does not necessarily indicate that an authentic pyrotechnic set-piece, even of an early type, was displayed; nor does a reference to fiery circles and acrobats suggest anything more nearly approximating to a firework wheel than does the blazing hoop still seen in the circus tent to-day.

Early in the history of the art the titles 'feu d'artifice' and 'artificial fireworks' are called into use; 'd'artifice' and 'artificial' are clearly the operative words, and indicate effects differing from those of simple flames. It was, however, the function previously fulfilled by the latter, in stage and other spectacles, that 'artificial fires' gradually replaced, and in due course superseded altogether, to provide entertainment on their own account.

In 1540 Vanuzzio Biringuccio published his *Pyrotechnia*. The title is somewhat misleading, as the book is mainly devoted to metallurgy and kindred subjects, and touches somewhat superficially on fireworks, whether from their peacetime or military aspect. He tells us that in former times, at Sienna (his home town, although his book was published in Venice) and at Florence, it was the practice to present, on the Feast of St John or the Assumption, certain stage shows, based on a story or fable, in which figures of wood and plaster, emitting fire from their mouths and eyes, played their part, as well as 'trunks' or cylinders for the projection of fire-balls, all arranged on a lofty pedestal. It has been suggested that by his reference to 'former times' Biringuccio intended to convey that such firework effects had, by the time of writing, passed out of use. He was, of course, referring to the two occasions he mentions as examples of the early use of fireworks at celebrations which had now ceased to be observed. In fact, he mentions that similar performances were still to be seen at Rome at the election or crowning of a Pope. Biringuccio was writing as a fire-worker with practical knowledge of the subject, and there is little doubt that he was instancing the first use of pyrotechnic mixtures for display of which he knew. There is certainly no authentic evidence of any earlier example; we may therefore assume no more than that pyrotechnic mixtures were first employed by the Siennese and Florentines at some period considerably earlier than 1540.

At the time when Biringuccio was writing Italian fireworks had already, to a great extent, emerged from the status of being mere accessories and stage effects. Pyrotechnic displays were coming to be accepted in their own right as a means of entertainment on occasions of public rejoicing, as well as at religious festivals. Scenic settings, buildings, and backgrounds were still present, but, more and more, came to be regarded as subordinate to the fire effects, to enhance which they were designed and disposed. This practice, as will be seen, was to continue for many years to come, particularly in displays produced by pyrotechnists of the Italian school.

Already prints and engravings were appearing depicting and recording such displays, the forerunners of the many that, in years to come, were to commemorate the succession of great and often extravagantly costly displays fired on every occasion of public rejoicing—coronations, royal weddings and births, victory, and peace. That the number and variety of such prints seem almost disproportionate to the importance of the events they depict may well be explained by the suitability of the subject to the medium in which it was portrayed. Particularly is this observable in the numerous and remarkably effective wood-block illustrations, often of comparatively obscure events, that appeared in the weekly journals of the Victorian era. Whatever the cause, the student of pyrotechnic history has good reason to be grateful that the subject is so well and amply exemplified.

Even before Biringuccio's book made its appearance the Emperor Charles V had, in 1532, ordered the drafting of regulations for the fire-workers, as distinct from gunners, in his army. In so doing he may well have been responsible for the tradition, which was to endure for over three centuries, that the provision of fireworks for occasions of civil public rejoicing was the prerogative of the army. However that may be, the employment of fireworks for purely military purposes found many enthusiastic advocates in all countries. Even in England, where, in both its civil and military branches, the art of pyrotechny had lagged notably behind other European states, it was no later than 1543, as Stow records, that two Dutchmen, Peter Brand and Peter van Cullen, brought over by Henry VIII,

> caused to be made certain mortar pieces being at the mouth eleven inches unto nineteen inches wide, for the use whereof to be made certain hollow shot of cast-iron, to be stuffed with fire-work or wild-fire, whereof the bigger sort for the same had screwes of iron to receive a match to carry fire kindled, that the fire-work might be set on fire for to break in pieces the same hollow shot, whereof the smallest piece hitting any man would kill or spoil him.

Such newfangled contrivances, prototype of the firework shell of to-day, were evidently not approved by William Bourne, "a poor gunner," as he describes himself, whose book *Inventions or Devices* (1578) was the first work on gunnery to appear in this country. "Divers gunners," he says,

> 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 for that the force of it is so mighty and cometh with such a terror. But for their other fireworks it is rather meet to be used in the time of pleasure in the night rather than for any service.

In 1588 Cyprian Lucar appended to his translation from the Italian of the works of Niccolo Tartaglia, an early writer on artillery (1506–59), a paper of his own on the "Properties, Office and Duty of a Gunner." Following such matters as the refining of saltpetre and sulphur, the manufacture and making good of gunpowder that has lost its force, he devotes some chapters to fireworks "for triumph as well as for war."

During the first half of the sixteenth century such fireworks as were seen in this country, disregarding those stage effects of doubtful authenticity employed in the mystery plays, seem curiously enough to have been fired in daylight. These, over a considerable period, followed the lines of that recorded at the coronation of Elizabeth of York, the bride of Henry VII, in 1487. At the head of the Lord Mayor's procession which met her on the river was the "Batchelor's Barge garnished and apparelled above all others and carried a dragon spouting flames of fire into the Thames." Again, when Anne Boleyn was escorted from Greenwich to Westminster for her coronation, in 1533, the aquatic procession was preceded by a "foyste or wafter full of ordnance, in which foyste was a great red dragon continually moving and casting forth wild fire and round about were terrible monstrous wild men casting fire and making a hideous noise."

These "wild men," or "green men," as they came to be known, a title commemorated in the much-discussed inn sign, are described as preceding a procession to Chester Races on St George's Day, 1610:

> Two men in green ivy, set with work upon their outer habit, with black hair and black beards, very ugly to behold, and garlands upon their heads, with great clubs in their hands, with fireworks to scatter abroad to maintain the way for the rest of the show.

The fire-clubs referred to are described in John Bate's book *The Mysteries of Nature and Art*, published in 1635, as they are by several earlier writers abroad; he illustrates a green man on the title-page of his work (Plate II).

These figures with their foyste came to be regarded as a permanent, and no doubt important, part of the pageant whenever the Lord Mayor of London went upon the water. An entry in the City books reads:

Paid to John Kellock for the charge of the foyste and a galley and for his services with men, shot, powder, cassocks and all other necessaries	£32	10	0
Paid and given in benevolence to the fireman or green man over and above his agreement	£0	11	0

This must have been the occasion of an outstanding pyrotechnic performance on the part of the green man, or did he meet with an accident?

In an old play, *The Historie of Promos and Cassandra*, by George Whetstone, printed in 1578, the stage directions call for the entrance of "Two men apparelled like greene men at the mayor's feast, with clubbs of fyreworks."

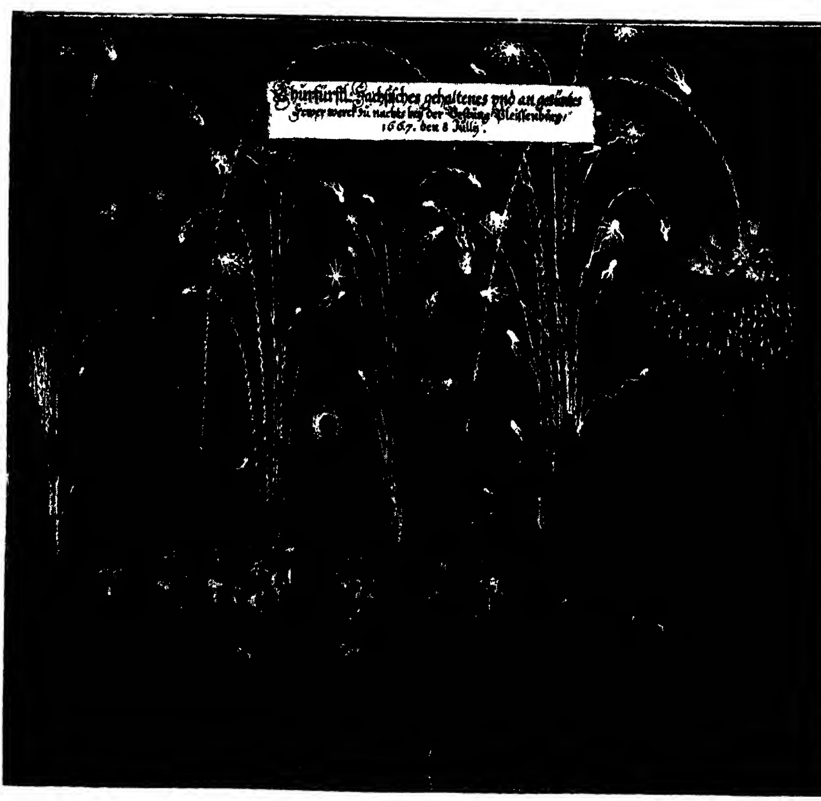
DISPLAY AT NÜRNBERG IN 1650

Fired in the St Johannis Schiesplatz, the recognized venue for such events.

DISPLAY AT NÜRNBERG IN 1678

In honour of the visit of Leopold, Emperor of Austria.

[*See p.* 42.]



DISPLAY AT PLEISSENBURG ON JULY 8, 1667

The origin of this figure is obscure, or at least the evidence is confused. It may well be that it was imported into this country by some traveller on the Continent who had witnessed those displays of the earlier sort, in which the main interest was provided by a battle between 'savages' and 'satyrs' or other monsters armed with fire-clubs. On the other hand, it seems possible that there may be some connexion between the green men and the 'savage' of heraldry. The two figures are identical, except in the matter of the fire issuing from the club of the former. It is, however, present in the case of the two performers in the firework tableau depicted in the engraving in Plate II. This is of Danish origin, as the skyline of Copenhagen confirms. I have been unable to discover the occasion or the exact date, although the initial "F" and crown suggest the reign of Frederick II (1559–88) or, as is perhaps more likely, that of Frederick III (1648–70). In either case, as the supporters of the Danish royal arms are two savages, one is here left in doubt as to the precise standing of the two performers.

As Strutt says,[1] set displays of fireworks were seldom seen in England before the reign of Elizabeth, but when her enjoyment of that form of entertainment became known there seems to have been a praiseworthy anxiety on all sides to gratify it. Her baptism of fire took place when she visited the castle of Ambrose Dudley, Earl of Warwick, Master-General of the Ordnance, in August 1572. The display was presented on the Temple Fields, where two canvas forts were erected to be alternately attacked by two hundred performers armed with "qualivers and harquebuses," and defended in turn by discharges of fireworks and twenty pieces of ordnance, brought from the Tower of London for the occasion. A contemporary account[2] relates:

> The wyld fire falling into the river Avon would for a time lye still and then again rise and fly abroad, casting forth many flashes and flames, whereat the Queen's Majesty took great pleasure till by mischance a poor man or two were much troubled, for at the last when it was appointed that the overthrowing of the fort should be, a dragon flying casting out huge flames and squibs, lighted upon the fort and so set fire, but whether by negligence or otherwise it happened that a ball fell on a house at the end of the bridge, wherein Henry Cooper dwelled and set fire to the same house, the man and wife being both in bed and asleep which burned so before they could rescued be, the house and all in it utterly perished with so much ado to save the man

[1] *Sports and Pastimes of the People of England* (1801).
[2] *The Black Book*, preserved in the Warwick Castle archives.

> and woman and beside that house another house or two adjoining were also fired—and no [small] marvail was it that so little harm was done for the fire balls and squibs cast up did fly quite over the Castle and into the midst of the town to the great peril and fear of the inhabitants of the Borough.

One can only conclude that the same Henry Cooper and his lady were sound sleepers, as well as taking little interest in pyrotechnics.

Robert Norton in his book *The Gunner*, published in 1628, gives instructions for the construction of the flying fiery dragon, which he says "is somewhat busie in the contriving, structure and composition of and he must be his Art's Master who can perform the same well." The materials were wood or whalebone, covered with paper or "Muscouvie glasse [otherwise isinglass] coloured like to a Dragon." The monster was suspended by pulleys to a stretched rope, and motion was imparted to it by one or more rockets.

More fireworks were provided for Elizabeth on the occasion of her visit to Kenilworth in July 1575, as recounted by Laneham, who was present, in Nichols' *Progresses of Queen Elizabeth*, and by Gascoigne in his *Princely Pleasures*.

There were two displays during her stay of twelve days, the first, rather surprisingly, on Sunday evening, the day following her arrival. Laneham's account reads:

> . . . After a warning shot or two, was a blaze of burning darts flying to and fro, beams of stars coruscant, streams and hail of fire sparks, lightnings of wildfire on the water; and on the land, flight and shot of thunder-bolts, all with such continuance, terror and vehemence, the heavens thundered, the waters surged and the earth shook; and for my part, hardy as I am, it made me vengeably afraid.

A graphic report, but of little technical value. Gascoigne's effort is rather more restrained: ". . . Fireworks showed upon the water, passing under the water a long space; and when all men thought they had been quenched, they would rise and mount out of the water again and burne furiously until they were utterlie consumed."

Laneham had evidently recovered his nerve by the following Thursday, when he relates, rather more calmly: "There was at night a shew of very strange and sundry fireworks compelled by cunning to fly to and fro, and to mount very high into the air upward, and also to burn unquenchable in the water beneath."

The details of display offered to the Queen by the Earl of

Hertford at Elvetham, in Hampshire, sixteen years later, seem to suggest that in the interval some progress had been made in the art. "Heralded by a peale of one hundred chambers from the Snail Mount, and a like peale from the Ship Isle," the exhibition included "a castle of fireworks of all sorts," "a globe of fireworks of all sorts, as big as a barrel," "many running rockets upon lines," to say nothing of "fire-wheels, pikes of pleasure and balles of wildfire, which burned in the water."

Already a school of pyrotechny, distinct in its display technique from that of the Italians, was coming into existence in Northern Europe—the German States, Poland, Sweden, and Denmark. In 1606 James I was introduced to fireworks of a type superior to those yet seen in England by his brother-in-law, King Christian IV of Denmark. The display was staged by the gunners of the Danish fleet at the time of its departure for home. Unfortunately, in order to catch the tide, the hour of sailing was 4 P.M., when in consequence "the beauty of the rare designs of the fire-works was not to be seen by reason of the brightness of the sun which dimmed the brightness of the same."

The fireworks, erected on a lighter, were, we are told, in the form of a cube, with a pillar at each corner, and surmounted by "a lion holding the eight capital vices in chains." Hardly, we would think, a particularly suitable design, but it "methodically, one part after another, continued burning and cracking for three-quarters of an hour," and James was no doubt suitably impressed. That this was so is suggested by the fact that he seems to have persuaded his brother-in-law to leave one of his artificers behind. At any rate, a few months later James ordered a display on his own account as a Christmas celebration: "rare fireworks contrived by a Dane, two Dutchmen and Sir Thomas Challoner."

The year 1613 saw a full-scale display on the Thames in celebration of the marriage of James's daughter Elizabeth to the Prince Palatine, the first of a long series, in that locale, which was to continue up to the peace display on June 8, 1946. In order "to avoid the bustle of boats and wherries and other perturbatious multitudes," the river was closed to traffic between Lambeth and Temple Stairs. The contemporary reports of this event are so lengthy and detailed, and agree so closely, as to suggest that they were based on a 'hand-out' circulated by the fire-workers responsible—John Nodes, Thomas Butler, John Tindale, and William Fishenden, who did their duty on the barges, while, ashore, the Master-Gunner of England, William Hammond, "did perform many and ingenious exploits with great bumbards, shooting up many artificial balls of fire."

One account, *The Manner of the Fire-Workes shewed upon the Thames*, describes the

> many artificiall concusions in Fire-Workes . . . upon the Thames performed.
>
> First, for a welcome to the beholders a peale of Ordnance like unto a terrible thunder ratled in the ayre. . . . Secondly, followed a number more of the same fashion, spredding so strangely with sparkling blazes, that the skie seemed to be filled with fire. . . . After this, in a most curious manner, an artificiall fire-worke with great wonder was seen flying in the ayre, like unto a fiery Dragon, against which another fiery vision appeared flaming like to Saint George on Horsebacke, brought in by a burning Inchanter, between which was then fought a most strange battell continuing a quarter of an howre or more; the dragon being vanquished, seemed to roar like thunder, and withall burst in pieces, and so vanished; but the champion, with his flaming horse, for a little time made a shew of a tryumphant conquest, and so ceased.
>
> After this was heard another ratling sound of Cannons, almost covering the ayre with fire and smoke, and forthwith appeared, out of a hill of earth made upon the water, a very strange fire, flaming upright like under a blazing starre. After which flew forth a number of rockets so high in the ayre, that we could not chose but approve by all reasons that Arte hath exceeded Nature, so artificially were they performed. And still as the Chambers and Culverines plaide upon the earth, the fire-workes danced in the ayre, to the great delight of his Highnes and the Princes.
>
> Out of the same mount or hill of earth flew another strange piece of artificiall fire-worke, which was in the likenes of a hunted Harte, running upon the water so swiftly, as it had been chaced by many huntsmen.
>
> After the same, issued out of the mount a number of hunting-hounds made of fire burning, pursuing the aforesaid Harte up and downe the waters, making many rebounds and turnes with much strangenes; skipping in the ayre as it had been a usual hunting upon land.
>
> These were the noble delights of Princes, and prompt were the wits of men to contrive such princely pleasures. Where Kings commands be, Art is stretcht to the true depth; as the performance of these Engineers have been approved.

A mimic sea-fight followed, so realistic, according to the report, that the God of Battle might have "been there present"; "and at last to represent the joyes of a victorie, the Castles were sacked, burned, and ruinated, and the defenders of the same forced to escape with great danger."

A critical examination of this account suggests that this display, except perhaps in the matter of showmanship and theatrical invention, shows little real advance on that witnessed by Queen Elizabeth at Warwick forty years earlier, although it may have inspired Bacon to write, in his *New Atlantis*, "We represent also ordinance and new mixtures of gun-powder, wild fires burning in the water and unquenchable, and also fire-workes of all variety." The author of a *History of Colleges in and around London*, written in 1611, claims also that there were then in the capital "many men very skilful in the art of pyrotechny and of fireworks," but it was only at this period, or even a little later, that English fire-workers began in some degree to reduce the lead established by their Continental colleagues.

This progress was no doubt in part due to the number of books dealing with the subject that now began to appear.[1] Those published in this country were generally based upon material borrowed, either frankly or furtively, from foreign works. Colonel J. R. J. Jocelyn, R.A., says[2] that the plates illustrating the *Art of Gunnery* (1648), by Nathaniel Nye, are copied *in toto* from F. Malthus' *Treatise of Artificial Fireworks* (1629), but reversed in the process. The classic *Great Art of Artillery* (1650), by Casimir Siemienowitz, Lieutenant-General of the Ordnance to the King of Poland, has perhaps provided more material for plagiarists than any other work; it was not until 1729 that a complete and authentic translation into English by George Shelvocke was published, by order of the Surveyor-General of the Ordnance, but it then still remained the outstanding work in both the military and civil branches of the subject.

The conduct of the Warwick display of 1572 was in the hands of the then Master-General of the Ordnance, that on the Thames in 1613 was directed by the Master-Gunner; the two occasions established a precedent, maintained until 1856, that the provision of fireworks for occasions of national rejoicing was the duty of the Ordnance Department. In course of time it was found necessary to appoint officers to specialize in this branch and holding the rank of Firemasters under the "Comptroller of the Fireworks as well as for war as for triumph and of all firemasters, fireworkers,

[1] See Bibliography, p. 269.
[2] *The Connexion of the Ordnance Department with National and Royal Fireworks* (Woolwich, 1906).

bombardiers, and petardiers." So came about the separation of the two branches of the Service from which the Royal Regiment of Artillery and the Royal Engineers are in common descended.

In 1672 the Laboratory was established at Woolwich "for receiving fireworks," and eleven years later a Book of Instructions was issued for the guidance of fire-workers in such matters as the preparation of unfilled cases for fireworks, so that everything should be ready "to fit and fill" when occasion for pleasure fireworks should arise.

Chapter IV

PYROTECHNY IN EUROPE: THE SEVENTEENTH CENTURY

They take pleasure to see some pageant or sight go by as at a coronation, wedding or such like solemn niceties to see an ambassador or prince received and entertained with masks, shows and fireworks.

ROBERT BURTON, *Anatomy of Melancholy* (1621)

ALREADY in the opening years of the seventeenth century the influence of two distinct schools of pyrotechny could be discerned in Europe: the Southern, dominated by the tradition and technique of the Italians, among whom the brothers Ruggieri, of Bologna, stand out prominently; and the Northern school, influenced by such masters as Clarmer, Müller, Hoch, and Miller, all of Nürnberg.

The distinction between the two systems lay rather in the methods of presentation of the display than in any particular variation in the actual fireworks employed. There can be little doubt that the fundamental cause of this divergence was religious. The Italian tradition was founded upon, and evolved from, those early observances of saints' days and religious festivals, referred to by Biringuccio, in which more or less elaborate structures were erected as settings for fireworks. The 'temple,' or 'machine,'[1] came to be regarded as an essential feature of the display. In course of time these buildings were developed and elaborated to an extraordinary degree. A classic façade, often of considerable architectural merit, was embellished with allegorical figures, flowers, lamps, gilding, and pictures, painted in transparent colours for illumination from behind. In and upon this imposing edifice the whole of the fireworks were disposed, and displayed when the time arrived for the display. Until then the pyrotechnists kept their mysteries to themselves, except perhaps for some few elaborate and impressive pieces which might be exposed to the public gaze like goods in a shop window.

[1] This, the earliest application of the word 'machine,' survives to-day among pyrotechnists, who refer to the woodwork and other accessories employed in the displays as 'machinery.'

This elaboration in countries under the influence of the Reformed Church no doubt carried with it a suggestion of the practices and influence of the Church of Rome, with the result that Northern firework-makers tended to go to the other extreme. The fireworks were brought out into the open; ranged in ordered lines, they were there for the inspection and gratification of the public in advance of their firing. Such buildings—a fort or castle or structure symbolizing the occasion—as were necessary for the performance of some particular item of the display were merely incidental and secondary to the fireworks themselves; although full advantage was always taken of such buildings or features of landscape as might adjoin or, in some cases, provide the site for the display, as is suggested in an early print of a display at Nürnberg in 1570 (Plate I). For the purpose of the display the outline of the fort has been modified by the addition of a scenic castle, on the bastion at the right of the picture.

In these circumstances it is not to be wondered at that the numerous engravings and prints which record the displays of this era reflect the characteristics of the two schools to a marked degree. Those purporting to record displays of the Southern type not infrequently depict a perspective view of an elaborate structure in the minutest detail, with no more suggestion of the actual fire-works than a few vague lines and twirls. Others, going to the other extreme, achieve a striking effect by showing all the items of the display going off together, a much more satisfying method to the student of pyrotechnic history.

The representations of the displays of the Northern school are far more factual, notably those of the many which took place on the St Johannis Schiesplatz, apparently the recognized venue for such exhibitions at Nürnberg. The fireworks are, with traditional Teutonic thoroughness, shown item by item, down to the last individual unit, as they were set out ready for the display. Often twin prints depict the full arrangement by daylight and the effect during the actual firing. The latter carry conviction that they are the results of actual observation on the part of the artist. This is noticeable, for example, in the print showing the display by Johann Müller in 1650 (Plate III): the spiral flight of the shells, as traced by the burning time-fuse turning over and over in the air, is differentiated from that of the rockets with the straight line left by the tail.

The print depicting the display given in 1600 by the Grand Duke of Tuscany on the river Arno at Florence, in honour of the marriage of Henry IV of France to Marie de' Medici (Plate I), shows clearly the degree of elaboration already attained by the 'machine' in Italy; here an artificial island, some sixty or seventy yards in length, surrounded by several smaller ones. This seems to serve as the scene of an amphibious sham fight for the entertainment of the spectators during daylight, followed by more genuinely pyrotechnic fare at night.

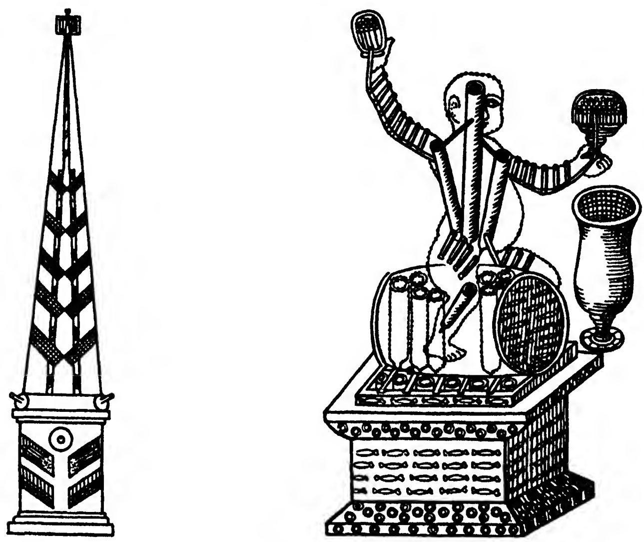
There is no doubt that of the differing types of display each was to the taste of the majority of spectators for whom it was performed. Visitors from one area to the other, however, were on occasion apt to be critical of the local effort. Diego Ufano, in his book *Tratada de Artilleria*, published at Brussels in 1612, was inclined to sneer at the "simple fireworks supported on wooden frameworks" that he saw in Flanders, comparing them unfavourably with the "magnificent spectacles" which he declares could be seen in Italy "more than fifty years before."

His book was one of the many[1] by writers of varying qualifications and knowledge of the subject that preceded the appearance in 1650 of *The Great Art of Artillery*, by Casimir Siemienowitz, which, it was said, stamped its writer as "the father of sound and intelligent pyrobolists," and from which many authors subsequently drew much of their material.

Siemienowitz's technique conformed generally to that of the Northern school of pyrotechny, although he seems to have been responsible for the introduction of certain effects which formed a compromise between the two systems. There were individual items of displays, essentially pyrotechnic in their effect, but possessing a decorative and artistic value before their ignition. Hollow papier-mâché figures germane to the occasion, or architectural features bearing appropriate inscriptions, were moulded on suitable wooden cores, and cut off in two sections when dry. Fireworks were mounted on framework so designed as to fit inside the thin paper halves, which were then joined together, concealing the contents until the time arrived for their discharge. The illustrations taken from *Kriegs Schule*, by Major Grubern, published at Nürnberg in 1705, and copied by him from Siemienowitz, show clearly the method used (see p. 42). The obelisk became a regular feature of so many displays, over many years, as almost to become a touchstone of the source of the firemaster's technique. It is seen as the centre feature of the display at Pleissenberg in 1667 (Plate IV), and in that which marked the visit of Leopold, Emperor of

[1] See Bibliography, pp. 267-270.

Austria, to Nürnberg in 1678 (Plate IV). On the latter occasion it is interesting to notice that the 'fort' has shrunk to the dimensions of a model.



THE OBELISK AND THE CUPID

Taken from *Kriegs Schule*, by Major Grubern (Nürnberg, 1705), these two illustrations show clearly the method of construction.

The types of figures introduced were more varied and suited to the occasion; although the cupid on the barrel, in the illustration, made his appearance in the display given on the Thames in June 1688 to celebrate the "Queen's upsitting" after the birth of the Old Pretender exactly as shown, except for the addition of the Prince of Wales feathers in the right hand to fit him for his part (Plate VIII).

Two obelisks were featured in this display, as they had been in that for the coronation of James II on the same site in 1685 (Plate VIII). In fact, save for the cupid, the two shows seem to have been almost identical. They, as well as the display for the coronation of Charles II, were the work of a Swedish soldier of fortune, Martin Beckman, who, until his death in 1702, held undisputed the premier position among pyrotechnists in England.

There seems to be no record, pictorial or otherwise, of the details of the display of 1660. Unfortunately Pepys was suffering from a 'hang-over'—"my head in a sad taking from the last night's drink, which I am sorry for"—and stayed at home to write up his Diary, hearing in the distance "the noise of chambers and other things of the fireworks, which are now playing upon the Thames before the King," wishing himself there, and "being sorry not to see them." So the history of pyrotechny is the poorer for what, if one may judge from his eyewitness account of the Great Fire of London, might have been an outstanding objective report of an early display. John Evelyn makes no mention of the fireworks in his account of the coronation ceremonies, so it is possible they were not of very great account.

Beckman on his return from Tangier, where he had served as Engineer under Lord Sandwich, was in 1664 appointed Firemaster, and, after another short term abroad, in 1667 he took up residence in the Tower of London, where, four years later, he personally arrested Colonel Blood with the crown under his cloak during the latter's attempt to steal the crown jewels.

It is not certain, although it seems not unlikely, that Beckman was responsible for the display fired at Stockholm in 1669, to celebrate the investiture of Charles XI of Sweden with the Order of the Garter by Charles II. At any rate, two obelisks were included, as well as a centre-piece of pillars, decorated with the royal cyphers and military colours—all, we are told in Ashmole's *The Order of the Garter*, "filled with fire." Beckman received a knighthood soon after the accession of James II, it may well be as a mark of the king's satisfaction with the coronation display.

When William of Orange arrived Beckman changed his allegiance and designed a display, fired on the Thames, in welcome (Plate IX). It will be seen that the obelisks are again in evidence. This fine engraving was published in Holland, as was another outstanding example (Plate X) recording the evidently spontaneous, if somewhat sketchily organized, celebrations staged by the British merchants of Amsterdam at the time of William's arrival in England, and the rejoicings in that city on the occasion of his coronation.

He was on active service on the Continent in command of bomb vessels engaged in "insulting the coast of France," when, in 1695, the Earl of Romney "ordered a fire-work to be made in St James's Square," to celebrate King William's capture of Namur. The show appears to have suffered by his absence, although, according to the *London Gazette*, "it was fired to the great satisfaction of all who saw it." The *pièce de résistance* was "three volleys of running fire, performed in very good order by the Foot Guards."

In 1695 Beckman had an opportunity to show what could be achieved on the St James's Square site when he staged a display to

A triumphal arch, surmounted and flanked by firework-filled figures, formed the centre-piece. Its details suggest that it may have been constructed from properties salvaged from the 1697 St James's Square display. The obelisks were there, although they do not appear in the engraving; in fact, everything was in accordance with the tradition established in this country by Beckman, even if, as seems probable from the list of items attached to the print, some definite advance is noticeable in regard to the variety of the fireworks displayed. This was certainly so in respect of the water fireworks, which included

> 1500 great and small water Rockets; 5 large water Pyramids; 4 water fountains; 13 Pumps; 21 standing Rockets, with lights all swimming on the water; 84 of Coll. Borgard's large and small Bees' swarms, half of which were set with lights to swim on the water.

It will be seen that Colonel Borgard managed an extra 'credit' for himself in the body of the programme.

A display, on an apparently smaller scale, was given for the event at Utrecht itself.

In the following year the coronation of George I, like that of his predecessor, passed without any pyrotechnic celebration; in fact, it was not until twenty-two years of the reign of George II had elapsed that London again witnessed a full-scale display.

A large display was staged at Nürnberg, in the traditional manner of the city, on January 16, 1712, to mark a visit of the Austrian Emperor, Charles VI, and five years later another was fired in Central Square round a column surmounted by a statue of the same monarch on the occasion of his inauguration as Count of Flanders. Yet a third Nürnberg display in the same year featured an equestrian figure of the Emperor and the rather fulsome motto "Victor Ubique."

In France Louis XV evidently inherited the fondness for fireworks shown by his great-grandfather and predecessor, but, as he was only five years old at the time of his succession, some years were to elapse before he was able to indulge his pyrotechnic inclinations. However, when the opportunity came, he certainly made up for lost time.

The birth of the Dauphin in 1729 was the occasion for a display at Paris, on the Seine between the Louvre and the Hôtel Bouillon. A towering island of artificial rock, topped by a rainbow bearing the figure of an angel, formed a centre-piece, surrounded by other islands and allegorical figures, while the band was accommodated in an elaborate structure which combined the main features of a state barge and bandstand. According to the caption of the print recording the event, the display was given by the orders of their Majesties "under the care of the Spanish Ambassador," possibly suggesting that the last-mentioned gentleman was accorded the honour of paying the bill.

The Dauphin's fifth birthday was celebrated with fireworks and illuminations at Meudon; evidently an intimate family affair, in which the traditional combat between a 'savage' and a dragon was staged. No doubt this, by then, already old-fashioned item was regarded as one likely to appeal to the little prince (Plate VI). He was to see many more lavish exhibitions of fireworks before his death in 1765. The marriage of his aunt, Madame la Première, Louise Elizabeth, to Dom Phillipe, Infant and Grand Admiral of Spain, in 1739, is made memorable in the history of pyrotechnics by the firing, within four days, of two displays each on a scale of unprecedented magnificence. The first of these was fired at Versailles on August 26, 1739, under the direction of pyrotechnists from Bologna, the Ruggieri brothers, who eventually became naturalized Frenchmen and founded a pyrotechnic dynasty that was to play a leading part in the development of the art in France during the century that followed.

A magnificent 'machine' with a classic façade three hundred and sixty yards in length, representing the "Palace of Hymen," was constructed on the terrace fronting the palace. Its columns, we are told, were "of red marble veined with white in imitation of that quarried at Languedoc." Before it were constructed two fountain basins in which were "illuminated rocks." These basins were evidently of a rather more permanent nature than the 'machine': they are clearly to be seen in a print recording a display on the same site thirty-one years later.

The second display, on August 29, was carried out on the Seine at the expense of the City of Paris, the bill amounting to 35,000 livres. The event is documented and illustrated with meticulous care in a massive volume dedicated to the king. The site covered over half a mile of the river between the Pont Neuf and the Pont Royal, on which was erected a classic temple in the Italian tradition. An elaborate bandstand was constructed in the centre of the river, round which water fireworks and scenic dragons played continuously. The banks on both sides of the water were illuminated with small boats, festooned with lamps.

August 24, 1741, the feast of Louis, the king's patron saint, was the occasion of a display on the Seine, carried out by the

"Artificiers du Roi," among whom appears the name of Dodemand, a pyrotechnist who was later responsible for a number of the many displays that marked French victories during the War of the Austrian Succession.

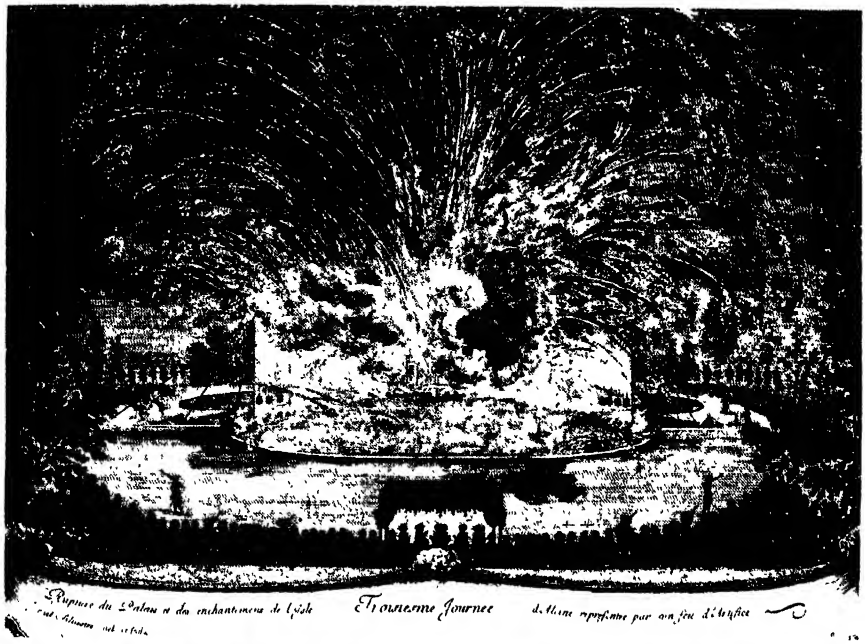
The name of Ruggieri first appears on an engraving in connexion with a display fired at Paris, in 1744, in celebration of His Majesty's restoration to health. It was this illness that was responsible for the mood of piety in which he dismissed his mistress, the Duchess of Châteauroux. A second display during the following year, inspired by a further recovery in the royal health, was the prelude to the installation of Madame Pompadour in the vacant rôle. In the interval between these clinical events a number of displays proclaimed victories in Flanders, at Tournai, Château de Gand, and Dendermonde.

Meanwhile elsewhere in Europe large-scale fireworks celebrations were becoming more and more the expected and recognized accompaniment to royal progresses or national events. In 1741 Philip V of Spain visited Frankfurt and was greeted by a grand display on the river Main. In the following year at Moscow one of the few displays to be staged in that city marked the coronation of the Empress Elizabeth Petrovna. A grand exhibition of land and water fireworks on the river Ill, before the Episcopal Palace, welcomed Louis XV to Strasbourg. A remarkably elaborate 'machine' was erected on the sea-front at Naples for a display in 1745, in honour of the marriage of the Dauphin with the Infanta Maria Theresa. Two years later, following the death of his first wife, the Dauphin married Maria Josepha of Saxony; again lavish displays of fireworks marked the occasion.

A particularly fine engraving, measuring 52 inches by 33 inches, records a display at Pillnitz, in 1747, to mark the occasion of the "double marriage between the houses of Saxe and Bavaria."

The treaty of peace signed at Aix-la-Chapelle, in 1748, was the subject in 1749 for the most widespread pyrotechnic celebrations throughout Europe ever recorded. At The Hague (see colour plate facing p. 52), a magnificent 'machine' was built for the occasion on the water. In Paris, contrary to the established custom, the exhibition took place on land, and not without incident. According to a contemporary newspaper report, "there were 40 killed and nearly 300 wounded by a dispute between the French and Italians, who, quarrelling for precedence in lighting the fires, both lighted at once and blew up the whole." Dublin had its display, on St Stephen's Green, for which was erected

PLATE V



FIREWORKS AT VERSAILLES IN 1676

The displays were staged on five successive days.
(*Above*) The destruction of the Palace of Enchantments. (*Below*) Aquatic

FIREWORKS AND ILLUMINATIONS AT MEUDON IN 1735 a magnificent dodecagon Temple of Peace 64 feet high by 32 feet wide, illuminated from within, the sides of which were adorned with figures placed in niches, representing the virtues and blessings, which are the support and ornament of Peace.

So far as London was concerned, this was to be a show unexampled and unequalled. The Royal Laboratory at Woolwich, now under civilian control in the person of Charles Frederick, Esq., Comptroller, with Captain Thomas Desaguliers as Chief Firemaster, was put to the manufacture of the fireworks "at the expense," we are told in a contemporary newspaper, "of £8000." The suggestion then was that they were "to be played off before the Duke of Newcastle's house in Lincoln's Inn Fields."

Later a site was selected in Green Park, where the 'temple,' or 'machine,' was erected, to the design of an Italian[1] brought over for the purpose, as were the Signori Gaetano, Ruggieri, and their assistant pyrotechnist, Guiseppé Sarti, of Bologna, under whose joint direction the "fire-works will be principally performed." "All the various parts of the great work," according to the order of the Board of Ordnance, were to be "performed by the direction of the Comptroller and the Firemaster. The fire and its immediate communications will be executed by the Royal Train of Artillery." A somewhat confusing allocation of duties that might be expected to lead to trouble—as, in fact, it did.

The building, the construction of which occupied the period between November 7 and April 26, was, for all its imposing appearance, composed of timber covered with canvas, whitewashed and sized.

The official programme gives the following account of its dimensions:

A Description of the Machine for the Fireworks, &c.

The Machine is 114 feet high to the Top of His Majesty's Arms, and is 410 feet long. It was invented and designed by the Chevalier Servandoni and all the framing was performed by Mr James Morris, Master Carpenter to the Office of Ordnance.

The Ornaments of this Machine are all in Relief, and it is adorned with Frets, Gilding, Lustres, Artificial Flowers, Inscriptions, Statues, Allegorical Pictures, etc. [See colour plate facing p. 52.]

A "grand overture on warlike instruments" was specially composed for the occasion by Handel, to be performed under his baton, to the accompaniment of a hundred brass cannon, fired singly and

[1] The Cavaliere Servandoni.

placed in the arcades connecting the side pavilions with the main building. This was apparently the contribution of the Royal Train of Artillery.

Among the items were included the following: "Regulated Pieces, Fixed Suns, Stars of six Points, and between each point a Ray, a large vertical Sun moved by double Fires, Cascades, Pyramids (40 feet high) of Gerbs, etc., etc." The chief device seems to have been one

> from whence Fire issues out and retires within, twelve times alternately; when without, it forms a Glory; when within it composes a Star of eight Points, and then changes to a Royal brilliant Wheel, whose Fire is thirty feet in diameter, and is moved by twelve fires.

An abstract of the rockets to be fired, printed in Chamberlain's *Survey of London*, gives a total of 10,650, made up as follows:

Honorary[1]	482
Caduces	48
Girandole	48
In flights	10,072

At seven o'clock in the evening of April 27 King George II, accompanied by the Duke of Cumberland and attended by the Dukes of Bedford, Richmond, and Montague, the Master-General of the Ordnance, made a tour of the machine, while the thronging crowds in the park listened to Handel's music. At half-past eight His Majesty, after a—it may, perhaps, be considered premature—distribution of purses of gold to those employed in the works, took his seat in the royal box, and the signal for commencing was given by the firing of a rocket.

Externally the building presented a magnificent spectacle, with its thousands of lamps and illuminated transparencies, with 'Peace' as their dominant motif. Inside, however, the atmosphere was far from tranquil. Already disputes had arisen between the English and Italian artificers over the relative merits of and dangers entailed by the use of trains of gunpowder as an alternative to quick-match for the communication of fire to the various devices. Matters came to a head when an explosion occurred in the north pavilion, which immediately burst into flames. For a time it seemed that the whole building would become involved, but at last the fire was got under control. The incident was too much for the Cavaliere Servandoni: "he drew his sword and affronted Charles Frederick Esqre." However, he was disarmed and placed under arrest.

[1] See Chapter XV for an explanation of the varying types.

Next morning he was brought before the Duke of Cumberland at the Tower, and apologized for his behaviour.

Horace Walpole's verdict on the display was not enthusiastic. "The fireworks," he says,

> by no means answered the expense, the length of preparation, and the expectation that had been raised.... The machine itself was very beautiful and was all that was worth seeing. The rockets and whatever was thrown into the air succeeded mighty well, but the wheels and all that was to compose the principal part, were pitiful and ill conducted with no change of coloured fires and shapes . . . and lighted so slowly that scarce anybody had patience to wait for the finishing.

The firing continued until midnight, but even then a considerable quantity of fireworks remained unexpended. The Duke of Richmond bought, or otherwise acquired, these, and, according to Walpole,

> took the pretence of the Duke of Modena being here to give a charming entertainment at his town house, the garden of which sloped down to the Thames, on which were lighters from whence were thrown up, after a concert of music a great number of rockets. Then from boats on every side were discharged water-rockets and fires of all kinds; and then the wheels which were ranged along the rails of the terrace were played off; and the whole concluded with the illumination of a pavilion on the top of the slope, of two pyramids[1] on either side and the whole length of the balustrade to the water.

In another letter Walpole remarks: "Whatever you hear of the Richmond fireworks, that is short of the prettiest entertainment in the world, don't believe it; I really never passed a more agreeable evening." Desaguliers was responsible for the conduct of this display, and no doubt felt some satisfaction in thus 'wiping the eye' of the foreign interlopers.

Public and Press reactions to the Green Park display were far from favourable; newspaper articles and pamphlets appeared ridiculing every aspect of the show. One of the latter, adorned by a woodcut showing the fire in progress, and being dealt with, rather inadequately, by a fire-engine of the period, bears the caption "The Grand Whim for Posterity to Laugh at." Eventually the following official statement was issued to the Press: "To destroy all groundless reports concerning the extraordinary expenses of the Fire-works in the Green Park, we are assured from good authority that the bills delivered to His Majesty's Board of Works

[1] The traditional obelisks once more, possibly a gesture on the part of Desaguliers in favour of the Northern school; no obelisks were included in the Green Park display.

amount to no more than £14,500." However, several years were to elapse before London saw any more fireworks on the grand scale.

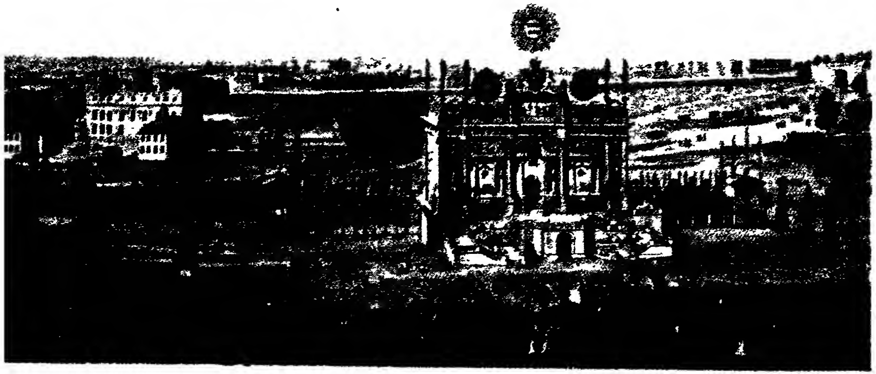
The site of the 1739 display at Versailles was again used for that given in celebration of the birth of the Duke of Burgundy, on December 30, 1751. The 'machine' was on a scale, both of size and elaboration, that has never been exceeded. Indeed, it is difficult to realize that the building depicted was of a temporary nature. The two contemporary water-colour drawings reproduced (see colour plate facing p. 81) were evidently from a set prepared by the pyrotechnist Morel Torré, whose signature they bear, to show his royal patron the various items that were to make up the display when it was in progress. These drawings have been in my family for generations, and it seems probable that they were given to John Brock when he was working with Torré at Marylebone Gardens, London, a few years later.

Following this display there seems to have been a lull in pyrotechnic activity until the opening of the Seven Years War, in 1756, gave opportunity for a continuation of the propaganda displays that had sought to raise public morale in the previous struggle. In 1756 a display was fired at Lyons to celebrate the taking of Fort St Philip. During the year 1758 a number of events were similarly acclaimed in Paris: victories "over the English in America," "over the Hessians and Hanoverians," and "over the Allies at Berghen." The engravings recording these occasions suggest that the technique had, in some degree, been modified. Quite large landscapes are depicted, in which considerable numbers of troops are seen in action, suggesting that the so-called *feu d'artifice* may, in reality, have been a sham fight re-enacting the particular engagement it commemorated.

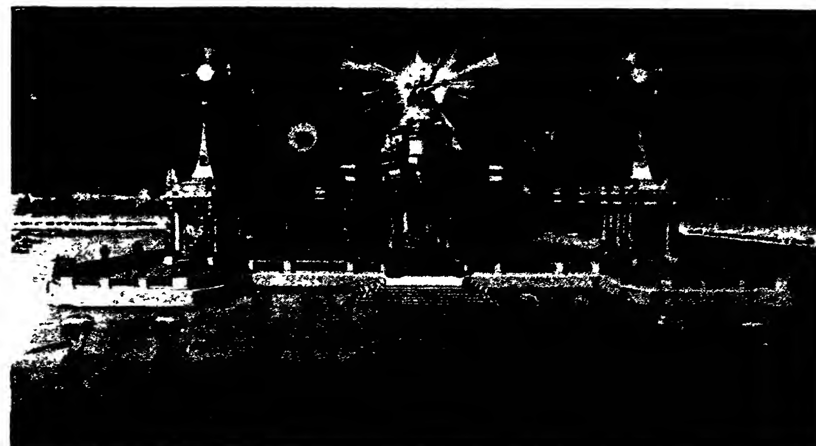
An unusual event took place in London in 1762, on June 4, when, according to Malcolm:[1]

> Our amiable Queen . . . contrived an amusement for His Majesty on his birth-night, equally calculated to surprize and please. The Queen induced her royal consort to pass several days previous to the 4th of June at St James's; and in the interval a great number of persons were employed in preparing a superb temple . . . to be illuminated with upwards of 4,000 lamps. . . . Such was the secrecy used, that the King entertained not the least suspicion of the design in progress, and consequently was astonished on returning to Buckingham House

[1] *Anecdotes of London.* He gives the year, incorrectly, as 1763, no doubt confusing the event with the peace celebrations of that year. The caption on the print is quite clear.



"Machine for the Fireworks" in Green Park, London. Its construction occupied over five months, and it was 410 feet in length and 114 feet high to the "Top of His Majesty's Arms."



The "Temple" for the display at The Hague

at ten o'clock, when the window-shutters were suddenly thrown open, at the brilliancy of the scene.

The building, which was designed by Robert Adam, gave accommodation for an orchestra "containing upwards of fifty performers led by Dr Boyce" (Plate XII).

The Peace of Paris, 1763, was celebrated in that city by a vast display on a site between the Place de Louis XV and the Palais de Bourbon. The ticket, No. 133, issued to "Madame La Duchesse D'arguillon", bears the signature of the queen, "Maria" (Plate VII). The holograph note reminding the recipient to bring her ticket with her adds a homely touch.

Some conflict of evidence exists as to the form taken by the peace celebrations in London. Malcolm[1] states definitely that "the Peace of 1763 was celebrated with uncommon splendour throughout Europe, and particularly in St James's Park, where a grand firework was exhibited." On the other hand, a writer in the *St James's Chronicle*, under the date February 18, 1764, in a letter advocating certain improvements in St James's Park evidently recalling the outcry over the 1749 display, observes: "We had no fireworks at the peace last year, that will surely obviate any argument preferred against the expense of the undertaking."

The doubt is not resolved by reference to a print, published at Paris evidently for sale during the festival there, which purports to represent the "Feu d'Artifice tiré a Londres en Rejoinssance de la Paix en 1763." In fact, it shows a view of the 1749 'machine,' reversed in the process of copying.

A very fine series of prints records the festivities, including fireworks on a magnificent scale, organized by the Crown Prince of Bavaria, Maximilian Joseph, on the occasion of a visit by the Austrian Emperor Joseph II in 1765. The manner in which they were conducted suggests that, as elsewhere, Italian artists had been imported for the purpose.

The marriage of the Dauphin, grandson of Louis XV, and later Louis XVI, to Marie Antoinette, provided the occasion for a grand display in the Place de Louis XV, Paris. The birth of the eldest child of that marriage, the Dauphin, whose brief life ended in 1789, was celebrated on January 21, 1782, by a display in the Place de Grêve, Paris. Another in 1783, before the Hôtel de Ville, for the short-lived peace between England and France, brought to an end the long series of pyrotechnic exhibitions that so frequently had delighted the populace.

[1] *Anecdotes of London*, p. 387.

The closing years of the eighteenth century in England were barren of official firework festivals, but that does not mean that the English public were starved of their due allowance of pyrotechnics. As will be seen in the following chapter, private enterprise, at the numerous pleasure gardens in London and provincial centres, was more than making up for departmental parsimony.

Among the outstanding pyrotechnic events of these years were the two displays fired at Stratford-on-Avon, on September 6 and 7, 1769, under the direction of the firework-maker Angelo, in connexion with the festival commemorating the 150th anniversary of the death of Shakespeare.[1] Rain, it is recorded, greatly interfered with the second display, as it did with the outdoor pageant, in which David Garrick was to play the leading rôle. A ticket signed by the great actor's brother, George, is reproduced (Plate VII).

Perhaps the most curious private firework party of which there is record is that referred to by Walpole in a letter to George Montague, dated May 17, 1763. ". . . I am going to dine in town and to a great ball with fireworks at Miss Chudleigh's." This was the lady who, thirteen years later, as the Duchess of Kingston, was tried by her peers for bigamy. The display took place in Hyde Park on a site across Kensington Road from the notorious lady's residence. Walpole records that "the fireworks were fine and succeeded well." One item seems curious to modern ideas: it took the form of a cenotaph for the Princess Elizabeth, a sister of the king, bearing the inscription "All honours the dead can receive."

The sequel was even more unusual, as "about one in the morning this Sarcophagus burst into crackers and guns."

[1] It was so publicized, although, in fact, Shakespeare's death had occurred in 1616.

Chapter VI

THE PLEASURE GARDENS: EIGHTEENTH AND NINETEENTH CENTURIES

I well remember my grandmother taking me through this passage to Marylebone Gardens, to see the fireworks, and thinking them prodigiously grand.

J. T. SMITH, *A Book for a Rainy Day* (1845)

IN 1654 Evelyn records that, on May 10, "My Lady Gerrard treated us at Mulberry Gardens,[1] now the onely place of refreshment about the towne for persons of the best quality to be exceedingly cheated at . . ." Pepys seems to have had a poor opinion of that same resort,[2] but to have enjoyed his visits to "Foxhall," as he called it, always with the sub-title "The Spring Garden."[3] There is more than a suggestion, however, that that appreciation of the resort was due, more often than not, to the female companions he took with him. His thrifty outlook was gratified by the thought that it was "very pleasant and cheap going thither, for a man might spend what he will, or nothing, all is one." By the commencement of the eighteenth century other and less exclusive resorts were springing up round what was then the comparatively small built-up areas of the City of London and Westminster, whose patrons began increasingly to demand something more elaborate in the way of entertainment than those simple joys that had satisfied the diarist. Some, it is true, continued to attract with medicinal spring waters, others with edible specialities—cheese-cakes, maids-of-honour cakes, and the like. Concerts, vocal and instrumental, at first billed for special occasions only, soon became a nightly feature at many resorts. Similarly, fireworks, which primarily made their appearance to mark the anniversary of some national event, became in time the chief regular item in the list of attractions offered at certain gardens during the summer season.

At the beginning of the eighteenth century, when the city merchant and trader lived at their places of business, with their staffs

[1] On the site of Buckingham Palace.
[2] May 20, 1668: "I find it a very silly place."
[3] May 28, 1667.

and apprentices close at hand, the resident population of the City of London was greater than it is now. The built-up area outside its boundaries, although very restricted in comparison with what we know to-day, was also more densely populated. The open country bounding it to the north and south across the river became the recognized playground of thousands of families for whom other sources of entertainment were few, or in many cases, to say the least, unsuitable for any patronage but that of the hardiest males. Of these, such resorts as Stoke's Amphitheatre and Hockley-in-the-Hole, both on the northern fringe of Clerkenwell, are examples. There the entertainment included sword-play, cudgel-fights, and bare-knuckle bouts between both male and female gladiators, as well as bull-baiting and dog-fighting. It was at these disreputable resorts that fireworks seem to have first played their part in commercialized entertainment.

A bill dated 1710 announces:

> At the Bear Gardens, Hockley-in-the-Hole. This is to give notice to all gentlemen gamesters, and others, that on this present Monday a match is to be fought by two dogs, one from Newgate Market against one from Hony Lane Market, at a bull, for a guinea, to be spent. Five let-goes out of hand; which goes fairest and farthest in wins all. Likewise a green bull to be baited, which was never baited before, and a bull to be turned loose, with fire-works all over him; also a mad ass to be baited. With a variety of bull-baiting and bear-baiting, and a dog to be drawn up with fireworks. To begin exactly at three of the clock.

Another sheet, offering similar entertainment, refers to "the famous Bull of fireworks, which pleased the Gentry to admiration"; yet another, under the date 1730, features "a Mad Bull dressed up with fire-works, is to be turned loose in the same place; likewise a dog dressed up with fireworks; also a bear to be turned loose. *N.B.*, a cat to be tied to the bull's tail." In the year following the rival resort advertises the attraction of "an Ass dressed up with fire-works, and a Bull dressed in like manner."

It is as a matter rather of interest than of pride that I refer to the probability that an ancestor of mine[1] was responsible for the fireworks employed in these repulsive exhibitions, from his place of business in the neighbouring Islington Road. One is glad to remember that there were other, and more reputable, outlets for the family's pyrotechnical activities close at hand in the group of

[1] John Brock, died November 5, 1720, and buried at St James's, Clerkenwell. See Appendix III.

pleasure gardens that had sprung up in the neighbourhood. The New Wells, occupying a site in what is now Rosman Street, where fireworks were advertised as early as 1740; the Sir John Oldcastle, where in 1744 fireworks were featured, including some "never exhibited before in any garden, particularly the Ship and Castle," and in 1751 "a Collection of Fire Works in the Chinese manner" subscribed for by "some gentlemen curious of seeing the New Fire Works"; the Lord Cobham's Head, where in 1744 a "curious set of fire-works by several gentlemen lovers of the curious art" were to be shown, "likewise the manner of Prince Charles's distressing the French after he passed the Rhine"; the Mulberry Gardens, where, as early as 1742, the proprietor was claiming that "the Musical Entertainment and Fireworks at this place have gain'd so general applause, that a splenetick, envious temper has lately prompted one or two neighbouring publicans to attempt the like amusements . . . ," and, in 1744, "the most curious fire-works ever seen in England" and "a rocket that weighs fifty pounds."

A resort of rather later date was the Grotto Gardens, near the New Wells, owned by a man named Jackson, who, according to J. T. Smith, was "famous for grottoes and fireworks."[1] In 1769 Jackson was featuring a combination of water and fireworks forming a "beautiful rainbow, in its proper colours, delightful to behold."

In or about 1712 the then proprietor of Hockley-in-the-Hole transferred his interest to Marylebone Gardens, or possibly divided his activities between the two resorts. It may well be that the "Horse Patrol for the City Road to and from the Gardens" was instituted as much for his own convenience as for the safety of his patrons. It appears not unlikely that his association with the two establishments was responsible for that, extending over a number of years, of the Brock family with the pyrotechnic activities of Marylebone.

Illuminations and fireworks, in celebration of the king's birthday, were staged at the Gardens as early as 1718, but it was not until 1751 that they became anything like a regular item of the entertainment. In 1753 a transparency illuminated from behind was added to the purely pyrotechnic items of cascades and showers of fire, as well as "air-balloons."[2] A display advertised for July 27, 1769, on the occasion of the benefit of Mrs Forbes, the singer, consisted

[1] *A Book for a Rainy Day.*
[2] The early name for 'shells'; see Chapter XVII. Balloons, in the modern sense, were not invented until thirty years later.

entirely of veritable firework items, and from that date onward several pyrotechnists seem to have been responsible for the shows: Rossi, 1770; Clitherow, 1772; Clanfield, 1772–73; Caillot, 1773, 1775, and 1776. A popular addition to the fireworks proper was provided by Morel Torré, whom we have already met at Versailles in 1751—a semi-theatrical, scenic display with fire effects billed as the "Forge of Vulcan." Torré, who may perhaps be regarded more as a producer than as a working pyrotechnist, was then in partnership with a Mr Thane as print-seller, and lived in Market Lane, Haymarket.[1] It was his habit to stand at the entrance with the proprietor and share the entrance money with him, no doubt settling up with the fire-workers later. For his benefit, in 1772, Torré put in, as a special attraction, "Hercules delivering Theseus from Hell," and raised the price of admission to 3*s.* 6*d.*

Dr Johnson, according to Austin Dobson,[2] used Torré for an unjust depreciation of the poet Gray, whom he called "the very Torré of poetry," who "played his corruscations so speciously that his steel dust is mistaken by many for a shower of gold."

It is recorded that the Doctor once visited the gardens on a firework night, but unfortunately a wet one, and notice was given to the handful of visitors that the fireworks were wet and the display would be cancelled. The Doctor, however, was of opinion that it was a "mere excuse to save their crackers for a more profitable company," and suggested that a threat to break the lamps would result in the show being forthcoming. Some young men standing by endeavoured, under his direction, to ignite the pieces, but unsuccessfully.

The last display advertised at Marylebone was that celebrating the king's birthday in 1776. On September 23 of that year the gardens were closed, and two years later building operations were commenced on the site.

The first resort to feature fireworks, among the many situated to the south of the Thames, was Cuper's Gardens, formerly occupying a site roughly corresponding with the approach from St John's Church in the Waterloo Road to the bridge itself. Established in 1691 by an ex-gardener of the Howard family at Arundel House across the river when that building was pulled down, its chief attraction for some years was a collection of broken statuary from the gardens of the mansion. Under its next owner, John Cuper, and the widow of his successor it rose to the position of a well-known and, later, even fashionable resort. Handel's

[1] *A Book for a Rainy Day.* [2] *Eighteenth-century Vignettes*, vol. ii.

compositions were performed there; fireworks made their appearance about 1741, and were as elaborate as any of this period. The earlier displays appear to have been conducted by "the ingenious Mr Worman," who relied to a considerable extent on transparencies and scenery; in 1749 and 1750 he reproduced in miniature the firework 'machine,' or 'temple,' used in the respective official displays in Green Park and at The Hague for the Aix-la-Chapelle peace celebrations. On June 28, 1741, it was announced that, "this night will be burnt the Gorgon's head . . . such a thing as was never known to be done in England before." Other scenic effects were a view of the city of Rhodes with a model of the Colossus, and "Neptune, issuing from a grotto below drawn by sea-horses, set fire to a pyramid or Archimedan worm [*sic*] and return to the Grotto." Clitherow was also associated with these displays, producing similar scenic effects, including a naval engagement in 1755, which was the last year of fireworks in these gardens.

Undoubtedly the best known, as it was the longest lived, of all pleasure gardens south of the river was Vauxhall. For many years it was the most fashionable, with Ranelagh as its chief competitor. In view of its later association with fireworks, it is a pity that there is no basis in fact for the legend that it was once the house of Guy Fawkes. Its early history is confused, but there can be no doubt that the "Foxhall Spring Gardens" visited by Pepys, a market garden with a side-line in refreshments, covered part of its eventual site, and received its name from the widow Jane Vaux, who acquired it from the Duchy of Cornwall London estate in 1615. John Evelyn speaks of a visit there to the ingenious Sir Samuel Morland in 1681, "to see his house and mechanics," which are said to have been the nucleus of the Vauxhall entertainments.

In 1732 the place was taken by an enterprising showman, Jonathan Tyers, who seems to have had little success until the artist Hogarth, then at the height of his fame, came to his assistance with ideas, designs, and paintings. The gardens became fashionable and successful, but it was not until 1798 that firework displays began occasionally to find their way into the bills of attractions. Not until 1813 did they become a regular feature. They continued regularly until the closing of the gardens in 1859, the final item of the programme being "Farewell for Ever" in letters of fire. In 1813 an item in the firework programme was the performance of Madame Saqui, which was to slide down an inclined rope 350 feet long from the top of a mast 60 feet high, erected on the firework platform enveloped in fireworks. So popular did this exhibition become that it was repeated here by other performers—by Longuemare in 1822, and later by Blackmore, and by a Miss Wilkinson.

The best-known pyrotechnists connected with Vauxhall were Southby, Mortram, Brock, and Hengler, the first display being by an Italian named Invetto; and in 1814, on the occasion of the Vittoria Fête, held in aid of survivors from the Peninsular War, Colonel, afterwards Sir William, Congreve, Bart., Comptroller of the Laboratory and Inspector of Military Machines, was, nominally at least, responsible for the fireworks. The Dukes of York, Clarence, Kent, Sussex, and Gloucester, together with the Princess of Wales and the Duchess of York, were present. The price of admission was one guinea.

Thackeray in *Pendennis* gives an account of a visit to Vauxhall by Pen, Captain Costigan, and Mrs and Fanny Bolton, apparently in the year 1830. It seems clear that at that time the fireworks were the main attraction of the evening.

From 1826 onward fireworks were combined with scenic displays in which actors and sometimes troops were engaged. The battle of Waterloo provided the first subject; to be repeated in 1849, when the great Duke himself came to see the show. Other presentations were Venice, "with imitation water," and the polar regions —a rather unsuitable subject, one would have thought, but perhaps the aurora borealis played its part.

Among the other numerous resorts on the Surrey side of the river there are few that did not feature fireworks from time to time. Finch's Grotto Gardens, the site of which is now occupied by the headquarters of the Metropolitan Fire Brigade in Southwark, had occasional displays of fireworks from about 1770, as did the Temple of Flora in the Westminster Bridge Road, about the same date. Clitherow advertised a display of fireworks at Jamaica House, Rotherhithe, in 1762.

A peace celebration display is announced for February 7, 1749, to "be play'd off this evening in the Field adjoining to the Tavern called Bob's Hall" (Hackney).

In 1788 the celebrated equestrian performer and circus proprietor Astley added fireworks to the usual attractions at the Royal Grove and Astley's Amphitheatre, Westminster Bridge. He advertises a

> Double Display of Fire-Works. . . . Numerous Devices prepared in the usual way from Powder, etc., which will be alternatively played off with the newly invented Philosophical Fire-Works, under the direction of Mons. Henry, the inventor and Professor of Natural Philosophy from Paris.

The "philosophical fireworks" were evidently an imitation of those exhibited at the Lyceum by Diller, which he described as "Philosophical Fireworks from Inflammable Air without smell, smoke or Detonation." These appear to have been nothing more than gas jets arranged in patterns and designs, some revolving and some stationary. Air was forced from a bladder through a sponge saturated with ether. Movement and variation were produced by turning on and off the gas from separate sets of holes. A handbill is in existence advertising a similar display at Hull, in 1804, by W. Clarke.

In the same year Astley announces a more orthodox display on the Thames immediately after "the Exhibition in Honour of His Majesty's Birth-day," and concludes:

> the Fireworks are made under the Direction of Mr Astley, by Messrs Cobonell and Son, who will let them off on the Thames this evening at different signals from Mr Astley, Sen., who will be mounted on the Gibraltar Charger, placed in a Barge, in the Front of the line of Fireworks.

Bermondsey Spa Gardens, originally relying for public resort on the virtues claimed for its chalybeate spring, owed its eventual prosperity to the enterprise of Thomas Keyse, who became proprietor in 1784. To the usual attractions of music, tea-drinking, and illuminations, Keyse, a self-taught artist, added an exhibition of pictures of still-life subjects by his own hand. It was not, however, until 1786, when fireworks were first displayed there, that it enjoyed any measure of popularity. This want of public support may have been due to its lonely situation, to overcome which disadvantage Keyse announced that "the road is lighted and watched by patroles every night at the sole expense of the proprietor." A scenic battle-piece was always the main item of the display. An advertisement, dated September 28, 1782, announced, "by special desire the Battle of the Fiery Dragons, and the line comet to come from the Rock of Gibraltar and cause the Dragons to engage." The pyrotechnists were, in turn, Rossi, Tessier, and Brock. It closed in 1805.

Ranelagh, in its heyday the most fashionable of all London pleasure gardens, began its career as a place of public entertainment in 1741, when on the suggestion of Lacy, patentee of Drury Lane Theatre, a company was formed with a capital of £36,000 to purchase the site and erect the famous Rotunda, a vast circular edifice, the promenading of which, with the consumption of light refreshments, seemed to be the sole attraction of the place for the first twenty years of its existence. On June 9, 1761, "an assembly" was announced "for the benefit of the Middlesex Hospital. . . . At ten o'clock a magnificent fire-work will be played off on the canal in the gardens." This was the first Ranelagh display: by 1766 fireworks had become a regular feature. In that year Angelo was the pyrotechnist, followed by Clitherow and Caillot in 1771, and later Tessier.

In 1792, after a period of partial eclipse, Torré was brought in to produce his "Mount Etna" and "Forge of Vulcan" spectacles, which had been such an attraction at Marylebone nearly twenty years earlier. With him came Thomas Brock to deal with the pyrotechnic portion of the display. The era of renewed prosperity that followed was not of long duration, and in 1803, in spite of regattas, shooting-matches, and balloon ascents, Ranelagh was closed. The Rotunda was demolished a year later, and the grounds were eventually embodied with those of Chelsea Hospital.

The first resort in the Chelsea area to feature fireworks was the oddly named "Jenny's Whim," which gave its name to the wooden bridge that formerly spanned the river on or near the site of the present Chelsea Bridge. The tavern and garden are said to have had the distinction of having been actually established by a firework-maker during the reign of George I.[1] Horace Walpole records having encountered at Vauxhall Lord Granby, who had arrived "very drunk from 'Jenny's Whim.'" If the pyrotechnist proprietor exhibited fireworks during the reign of George I (1714–27), as seems likely, they must have been the earliest to be fired in such surroundings.

Farther west were Cromwell's Gardens (later known as the Florida Gardens), the name of which is perpetuated in the present Cromwell Road. Here fireworks had their place in the programme in 1784. An otherwise unrecorded Italian pyrotechnist, Carlo Genovini, was, in 1762, exhibiting his skill with "stars, moving suns, a guilloche and reprises of water" from a 'machine' representing the Temple of Liberty, at the Star and Garter Tavern and Gardens, situated on a site roughly corresponding to Eaton Square, Belgravia.

Longest to survive of the West London gardens was Cremorne, which, however, did not come into existence until 1832, when the self-styled Baron de Berenger opened the Cremorne Stadium "for the cultivation of various skilled and manly exercises" on

[1] *Old and New London*, by Edward Walford.

what had been the grounds of Cremorne House. The Baron had served a term of imprisonment for complicity in the Stock Exchange hoax in which Lord Cochrane was held, quite unjustly, to have been implicated.

Manly sports, in spite of the ladies' club-room, which gentlemen could not enter "except by consent of the Ladies occupying such," seem to have been, by themselves, an insufficient attraction, and from 1836 onward the pyrotechnists Duffield and Darby were giving displays of fireworks.

Berenger died in 1845, and in the following year the undertaking was purchased by Thomas Bartlett Simpson, who spent £5000 on the addition of a theatre and banqueting hall. In 1850 twelve acres were added to the grounds by taking in the gardens of Ashburnham House, adjoining them to the west. The accepted means of transport to Cremorne was by water, the Citizen Line of steamers landing passengers on the river esplanade. The "entire fleet" of these vessels, in 1851, took part in a sham naval engagement depicting the siege of Gibraltar, with pyrotechnic effects provided by Mortram and Duffield. Two years previously Astley had staged a dramatic-cum-pyrotechnic spectacle, the "Storming of Mooltan." In spite of almost annual petition from 1857 onward against the renewal of the licence by the Chelsea Vestry, on account of the rowdy atmosphere of the place, Cremorne survived until 1877.

As London spread gradually outward, to submerge the older gardens under a tide of bricks and mortar, some, previously too far afield to enjoy any great degree of public support, took on a fresh lease of life. Among these the Yorkshire Stingo, in the Marylebone Road, facing Lisson Grove; the Bayswater Tea Gardens, later known as the Flora Gardens, where now is Lancaster Gate; and the White Conduit House, Islington, all staged firework displays from the early years of the nineteenth century up to the late thirties. With regard to the last-mentioned resort, Hone,[1] writing in 1827, draws a rather depressing picture of the place, but concludes, "fireworks 'as usual' which to say the truth are usually very good." The Mermaid Gardens, Hackney, in the *Morning Chronicle* of June 1, 1812, announces "the greatest feast for the eye ever exhibited is a superb firework by that unparalleled artist, Mr Brock, Engineer."

On Monday, August 5, 1816, were advertised "superb Fire-Works, at the Ben Jonson Tea-Gardens, Stepney, by Mr Brock,

[1] *The Everyday Book*, by William Hone, vol. ii, p. 1204.

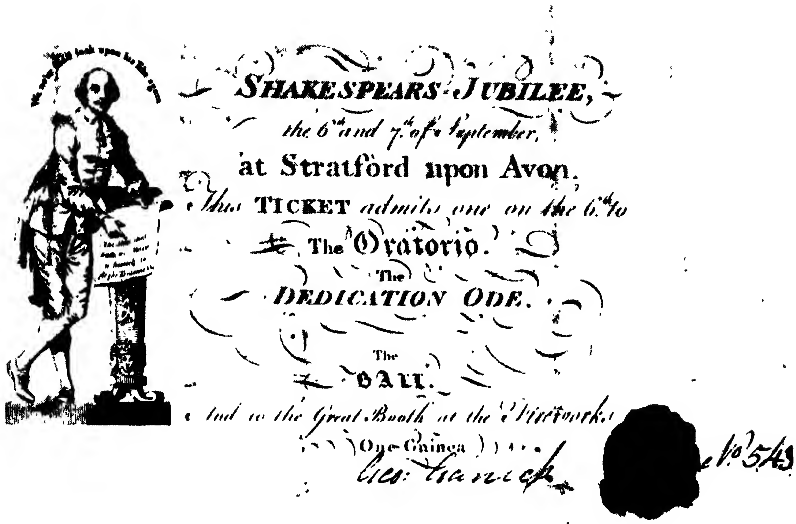
Engineer to Vauxhall, the Original Ranelagh, and Spa Gardens, Bermondsey." (Plate XIV.) A note warns the public that "the Exhibition will be so conducted as to preclude the sight of any person, but those on the ground," a rather obvious bluff when taken in conjunction with a preceding line, announcing that "some Maroons and Rockets will be fired prior to the Exhibition."

The reference to the "Original Ranelagh" was probably to absolve the pyrotechnist from any connexion with the short-lived "New Ranelagh and Vauxhall Gardens, Millbank," 1809–11, where a notice in the *Star* of August 2, 1810, announced "a grand Aquatic Exhibition of Water Fire-Works on the River and a Superb Exhibition of Fire-Works in the Gardens," by Madame Hengler.

Other short-lived resorts featuring fireworks were the "Manor House," Chelsea, 1830–48; Brunswick Gardens, Vauxhall, 1839–48; and Grosvenor Gardens, Vauxhall, where, in 1798, Signor Invetto advertised "a Magnificent Fire-Work." The Rosemary Branch, Hoxton, until the early eighteen-thirties a country inn, blossomed out as "the Islington Vauxhall," with fireworks, illuminations, pony races, equestrian acts, and a boating lake. The enterprise was brought to an end by the destruction of the buildings by fire in 1853.

The wording of the bills advertising displays during the early years of the last century is always dignified, even stately, and nicely attuned to the social atmosphere. In announcing a "Grand Pyrotechnical Exhibition, at the Swan Bowling Green, Stratford," in 1820, Mr Brock expresses himself as "grateful for the marked approbation bestowed on his last effort" and "respectfully informs the Ladies and Gentlemen of Stratford and its Vicinity that he intends to exhibit a Superb Display of Fire Works," and that "as neither labour nor expense will be spared to render the Evening's Amusement agreeable and interesting it trusts he will merit a continuance of their favors." (Plate XIV.) At Highbury House, September 8, 1823, he

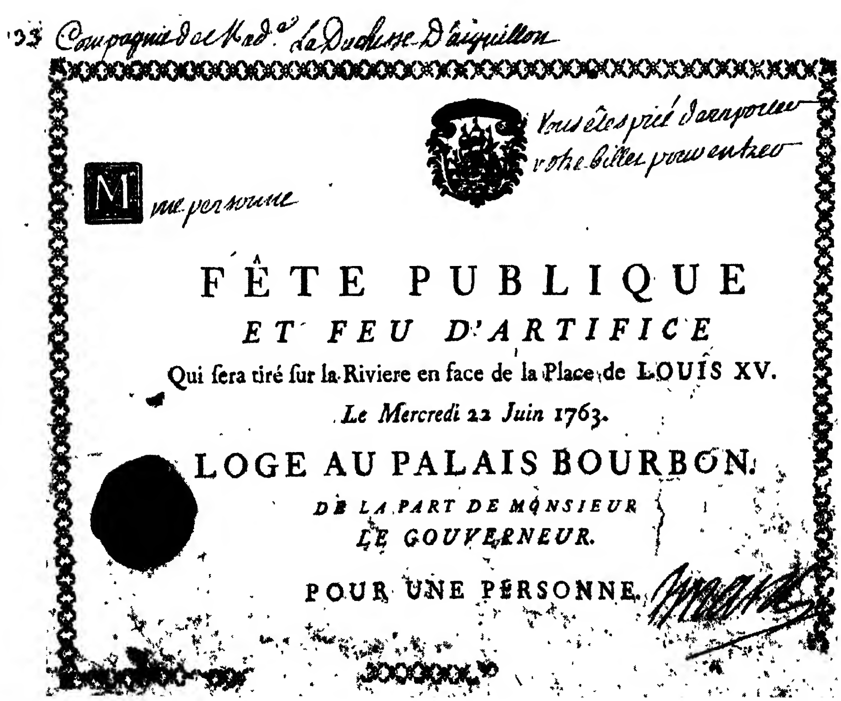
> begs to return his grateful acknowledgements to the Nobility and Gentry of Highbury, Islington and its Vicinity, and the Public in general, for the distinguished approbation his Fire Works was honored with last time; and anxious to continue the pre-eminence which a thorough knowledge of his profession has given to his Exhibitions, will, in the present, produce such a variety of New Devices and Fires as cannot fail of giving universal satisfaction, and evince to a discerning Public his superiority in the Art.



TICKET FOR BALL AND FIREWORKS

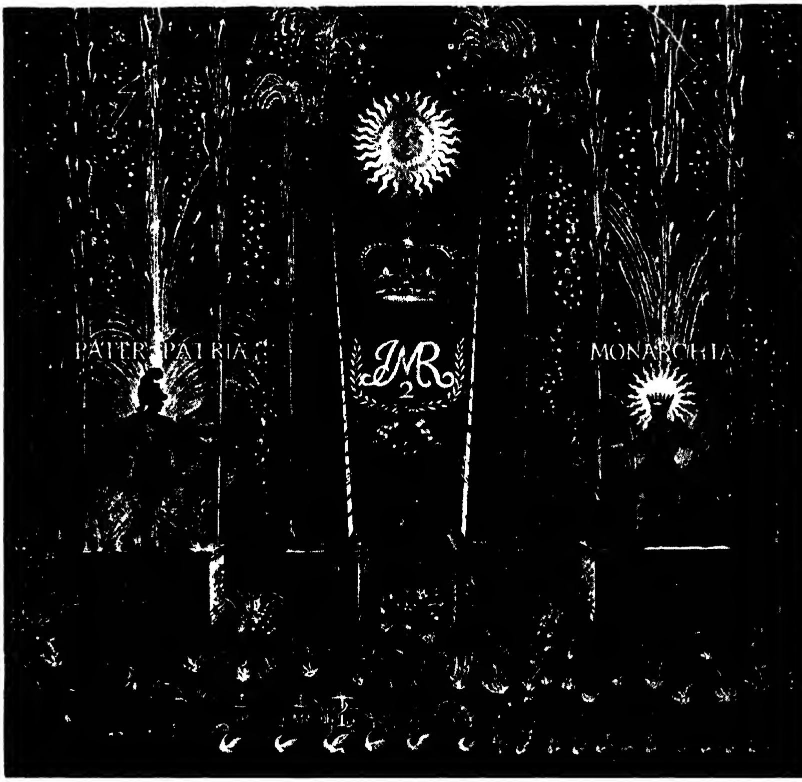
The "Shakespeare's Jubilee" commemoration at Stratford-on-Avon, in 1769. The ticket is signed by George Garrick, brother of the famous actor.

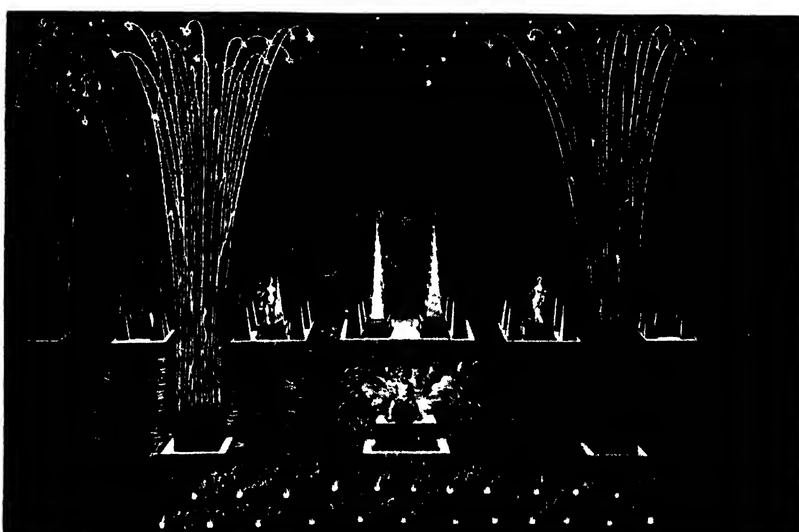
[*See p.* 54.]



TICKET OF ADMISSION TO THE FIREWORKS DISPLAY TO CELEBRATE

PLATE VIII





DISPLAYS ON THE THAMES

(*Top*) In 1685, for the coronation of James II. (*Below*) To celebrate the birth of the Prince of Wales, known to fame as the Old Pretender. Both displays were designed by Martin Beckman.

That he was not unmindful of the rising generation is suggested by the assurance: "In order that Families and Schools may be gratified with so novel a spectacle, the Business will be so regulated that its termination will not exceed Nine o'Clock." (Plate XVI.)

As London continued to spread and the old resorts where there now was insufficient space for fireworks died out, or, in many cases, reverted to the status of the public house, other and generally more ambitious undertakings came into being. Several among these were to enjoy a long and even prosperous life; of others it can be said that, at least, they continued to exist. Among the latter may be mentioned the St Helena Garden, Rotherhithe, which, emerging from the ranks of riverside inns in 1831 to advertise fireworks, musical entertainments, and dancing, continued its somewhat chequered career till as late as 1881. There were also the Anerley Gardens, opened in 1841, on the banks of the old Croydon Canal, where fireworks were the major attraction, until the loss of part of the site by the building of the London and Croydon Railroad, and eventually the incontestable competition of the unprecedented displays at the Crystal Palace, brought about their closing in 1868.

The New Globe Tavern and Pleasure Grounds, Mile End Road, which began their career about 1825, continued prosperously until the sixties, when the extensive grounds were built over. These grounds offered, in addition to rustic walks and arbours, fountains and statuary, the attraction of "Dancing on the Green Mount," an excrescence fashioned from a dump of earth accumulated during the cutting of the Regents Canal, which formed the western boundary of the gardens. There was a cricket-field, the home of the New Globe Cricket Club, which in 1835 had the distinction of defeating the fashionable Montpelier Club of Walworth. Fireworks and balloon ascents, by the famous aeronaut Coxwell, with discharges of fireworks from below the basket, were the principal attractions. It is not unlikely that William Brock was fully justified in the claim he makes, in the advertisement of his annual firework gala in 1858, that the display "for correctness, execution and brilliancy will not be surpassed by the production of any Public Garden in the Metropolis."

There were also the Eagle Tavern Gardens, in the City Road, referred to in the song containing the much-discussed line, "Pop goes the weasel." The tavern was evolved from an eighteenth-century resort, the Shepherd and Shepherdess, by an enterprising builder with a flair for public entertainment, Thomas Rouse, who, in 1824, pulled down and rebuilt the old structure, renaming it the Eagle. In the grounds were covered walks, pavilions, fountains, and statuary, as well as the 'Russian Mountain' prototype of the scenic railway of to-day, and the 'Grecian' Saloon, which was later to develop into the 'Grecian' Theatre under B. O. Conquest, the founder of the famous pantomime family of that name.

Here occurred, on July 10, 1826, the first recorded "Brock's Benefit." In the bill announcing the event:

> Mr Brock, in introducing himself to the notice of the Inhabitants of the City Road, its Vicinity, and the Public in general, and humbly soliciting their patronage and support, respectfully informs them that in consequence of the heavy loss he sustained in September last, from the unfortunate explosion in his Premises,[1] which has nearly annihilated his prospects of providing for a numerous family, Mr Rouse has, with that sympathy which characterizes the man, and does honor to his heart, generously given him the gratuitous use of his commodious Ground, to display an Exhibition of *Fire Works* for his *Benefit*, comprising a series of New and elegant Devices, which from a long life of practice and chymical knowledge of his profession, cannot fail of giving the satisfaction always attendant on his efforts which has ever, and will continue to be his study to deserve. [Plate XVI.]

Some sentence! The public were no doubt reassured to learn that "an active Police will be in attendance and every attention paid to the comfort and convenience of the Company."

It may be ungrateful to suggest that some factor, more real than apparent, lay behind Rouse's altruism; perhaps the bar receipts or the takings from the side-shows. At any rate, 'benefits' became a habit with him. In the seasons that followed there was one for the "Blind Hebrew Brethren in the East," another on behalf of "Decayed Druids and their wives and orphans," "for clothing the children of the needy," and, in 1838, a "Benefit for the Laudable Pension Society, Bethnal Green."

In the year mentioned the title of the place had been amended, to form somewhat of a mouthful: "Royal Eagle Coronation Pleasure Grounds and Grecian Saloon"; "Unrivalled Galas with Brilliant Fireworks and Illuminations by the inimitable British Artist Thomas Brock"[2] were announced for "every Monday and Wednesday during the Season." After remarking that "to attempt a description of the numerous and varied sources of entertainment at this unrivalled establishment would be in vain," the writer of

[1] See p. 169. [2] The uncle of the beneficiary mentioned above.

the advertisement attempts to do so—an imposing list, concluding, "a fairy scene, of which a due estimate can only be formed by inspection."

The North Woolwich gardens, occupying what is now the site of the Victoria public gardens, Silvertown, existed from 1851 until the early eighties, and were well known for fireworks and illuminations.

Most successful of the eighteenth-century pleasure gardens in the London area were the Surrey Zoological Gardens. The resort was founded by Edward Cross, the proprietor of the menagerie at Exeter Change, in the Strand, who had found a temporary home for his animals, when the old building was pulled down in 1829, at the royal mews occupying the site now occupied by the National Gallery. With the construction of Trafalgar Square another move became necessary, and, in 1831, Cross purchased the Manor House, Walworth, with its grounds of thirteen acres.

Until 1837 the place was conducted very much on the lines of the London Zoological Gardens, to which it appears to have been a keen rival. After that date scenic and firework shows, with the extensive lake as a foreground, became the main attractions. J. Southby, self-created 'Chevalier,' was the pyrotechnist, the panoramic setting was the work of George Danson—later working with his sons—who had provided the scenery for Astley's Amphitheatre. These displays continued year by year with, from 1843 onward, an annual change of subject, until 1853.[1] Then, after a break of one year, a topical subject was found in the "Siege of Sebastopol," followed by "Constantinople and Scutari" in 1856. After an interval of six years "Naples and Mount Vesuvius" was revived, but the competition offered by the Crystal Palace, opened at Sydenham in 1854, proved too great, and the Surrey Gardens seemed doomed.

However, in 1872 there was a courageous attempt to revive their failing fortunes by a new manager, Frederick Strange, the former owner of the Alhambra, Leicester Square. By this time the fireworks at the Crystal Palace (commenced in 1865) had set a standard for purely pyrotechnic, as opposed to scenic, display that seemed to, as, indeed, they did, defy competition, but Strange evidently thought that a show on scenic lines by the man respon-

[1] 1837–38 "Mount Vesuvius"; 1839–40 "Mount Hecla"; 1841–42 "Rome"; 1843 "Temples of Elora"; 1844 "Old London and the Great Fire"; 1845 "Edinburgh"; 1846 "Naples and Vesuvius"; 1847 "Siege of Gibraltar"; 1848 "Rome"; 1849 "Storming of Badajoz"; 1850 "Napoleon's Passage of the Alps"; 1851 "Temple of Janus"; 1852 "Mount Etna"; 1853 "Chusan."

sible for the inception and execution of the Crystal Palace displays might solve the problem. C. T. Brock agreed, with the reservation that, in deference to the wishes of the Crystal Palace Company directors, his name should not appear. The shows were accordingly billed as by Mr Charles Thomas. The subject was no doubt suggested by the pyrotechnist's activities in Turkey, where, following a visit by the Sultan to Sydenham in 1869, he had carried out a large display on the Bosphorus, established a fireworks factory at the ruler's expense, and received the appointment as pyrotechnist to the Sultan. However, "The Sultan's Summer Palace on the Bosphorus," painted by Grieve, failed to achieve its purpose, and fireworks were seen no more in the gardens. In 1877 they closed, and the site was built over.

The most outstanding and longest existing of all resorts outside London are the famous Belle Vue Gardens, Manchester, where for eighty-seven years, beginning with the "Bombardment of Algiers" in 1852 to "Clive in India" in 1939, exhibitions of the firework-scenic type were staged without a break, which must constitute a record. As was the case with many of the London resorts, Belle Vue developed from a wayside country inn, whose proprietor, Jennison, had the enterprise to add a collection of animals to the attractions of the type more usual at tea-gardens—a collection which has to-day expanded into a zoological exhibition that, of its kind, is unrivalled.

Until 1893 the scenic settings were designed and painted by Danson, which, no doubt, accounted for the fact that a number of the subjects were the same as those presented at the Surrey Gardens. Other scenic artists were Caney and Hastain. A unique feature of the Belle Vue displays was that, until 1926, the fireworks were manufactured in a small factory within the gardens. From that year fireworks have been in the hands of the Brock organization, and since the War the scenic productions have given place to a series of purely pyrotechnic displays on a scale that was never before contemplated.

Another resort which, during seventy years, has built up a reputation for fireworks displays on the grand scale is Scarborough Spa. Clifton Zoological Gardens presented displays by Gyngell as early as 1835. Rosherville Gardens, founded at Gravesend by one Rosher in 1837, although at some distance from London, could be included among its pleasure resorts, the river trip by steamboat adding to the enjoyment of a visit. Fireworks played an important part in Rosherville's attractions—which justified the claim of its advertising slogan, "The place to spend a happy day"—until the early years of the present century.

In France Torré was responsible for what might almost be called an epidemic of pleasure gardens, in and around the capital, when, in 1769, he established Torré's Vauxhall near the Porte Saint-Martin. In view of the fact that he was associated with Marylebone and Ranelagh, it seems strange that he should have selected the name of a rival resort for his Parisian venture. In so doing he added a word to the French language; 'Vauxhall' became a common noun, applied to all resorts of the kind. There was even a dance-hall known as the Winter Vauxhall.

In this connexion it is interesting to recall an even stranger application of the title, mentioned by Lord Frederic Hamilton;[1] in Russia the name for railway station is 'Vauxhall.' He recalls that in 1835 Czar Nicholas I,

> eager to show that Russia was well abreast of the times, determined to have a railway of his own, and ordered one to be built between Petrograd and Tsarskoe Selo, a distance of fourteen miles. . . . Unfortunately, with the exception of a few Court officials, no one ever wanted to go to Tsarskoe, so the line could hardly be called a commercial success. Then some one had a brilliant idea! . . . The line should be extended two miles to a place called Pavlosk, where the railway company would be given fifty acres of ground on which to construct a "Vauxhall Gardens."

The gardens became immensely popular, and the railway paid its way. As there was only one railway station in Petrograd, and practically only one reason for using it, intending passengers got into the habit of telling their coachman or cab-driver to go "to Vauxhall," with the result that, as other stations were built, all came to be known as Vauxhalls.

To return to Paris. In an attempt to break with the general usage, a resort, opened at the beginning of the nineteenth century, was named Tivoli. It was a success, and as a result a second of the same name was quickly established; to be followed by a third. A visitor to Paris, in 1815, speaking of the Tivoli in the Rue de Clichy, recalls that "the price of admission was three francs, fifteen sous, on account of the fireworks, which exceeded anything I had either witnessed or imagined. . . ."

There seems to be little doubt that the Tivoli Gardens in Copenhagen, where for many years fireworks have been one of the principal attractions, were named after one or other of the above-mentioned Parisian resorts.

[1] *The Vanished Pomps of Yesterday* (1919).

Chapter VII

THE NINETEENTH CENTURY, 1800–60

> To set the rabble on a flame,
> And keep their governors from blame,
> Disperse the news the pulpit tells,
> Confirmed with fireworks and with bells.
>
> SAMUEL BUTLER, *Hudibras*, Part III (1678)

THE event of national importance first to be celebrated in the nineteenth century was the Jubilee of George III, on October 25, 1809. The severe economic conditions existing throughout the kingdom, due to the war, together with the state of the king's health, delayed any decision on the part of authority as to what form the public rejoicings should assume, or if, indeed, they were to take place at all. Fireworks, on a national scale, were no doubt ruled out on account of the commitments of the Royal Laboratory elsewhere, as well as the fact that the king's precarious health and partial blindness would prevent him from attending, or at any rate appreciating, any such spectacle.

Eventually, somewhat late in the day, a general illumination of the capital was officially decided upon, a decision that resulted in an increase of three-halfpence a pound in the already abnormally high price of tallow candles. A purchase of 19,200 lb. by the directors of the Bank of England probably contributed in some degree to this state of affairs.

Generally the lead given by London was followed throughout the provinces, although enterprising Manchester substituted the "curious preparation called gas" for tallow candles. Some other towns marked the occasion by lighting their newly installed street gas-lamps for the first time.

On the other hand, a number of towns seemed to feel that, whatever other festivities might be included in their Jubilee celebration, a display of fireworks was the most fitting conclusion to the day's enjoyment. In all, some thirty-four were of this opinion. Manchester, not content with the novelty of gas illuminations, staged several displays. At Hull the Mayor and Corporation gave £50 for fireworks, "in order to avoid the disagreeable consequences of illuminations." At the Nore the ships of the fleet provided the pyrotechnics; a blue light was ignited at every mast-head as the evening gun was fired, and followed by flights of rockets. "A large French rocket, taken at Bathz, was thrown at nine o'clock into the air, and added much to the brilliancy of the scene." The invalid Princess Amelia, staying at Weymouth, was treated to "a most brilliant display of fireworks, on the water opposite the Palace [Royal Lodge?], at the expense of Sir John Johnstone, Bart." At Woolwich a salute of fifty guns was followed "by the discharge of an immense number of very fine rockets set up into the air by fifties."

During the day the king and queen remained at Windsor, where the celebrations included the roasting of oxen, the firing of *feux de joie* by the Volunteers, a triumphal arch and illuminations, as well as "an elegant cold colation at Mr Buckridge's." Later the royal couple went to Frogmore, where the queen, not to be deprived of pyrotechnics altogether, had arranged a fête, to which, as well as "every family in Windsor," "one hundred of the young gentlemen of Eton College" were invited. "A more striking spectacle," we are told, "was never witnessed" than that presented by the fireworks which, "reflected in the lake in a thousand directions, heightened inconceivably the splendour of the scene."

Displays took place at Edinburgh and Dublin. At Warwick—can it be that memories of the unfortunate results attending the visit of Queen Elizabeth still lingered?—both fireworks and illuminations were expressly forbidden. No display, large or small, was apparently staged in the London area; not even at the Mermaid Gardens, Hackney, where the Shoreditch Volunteers fired a *feu de joie*, and, after an "excellent dinner, marched back to their head-quarters in a very orderly, steady manner."

The anxiety felt lest His Majesty should not survive for the celebration of his Jubilee was not justified. In 1814 he was still alive, when elaborate preparations were set on foot for a fête in the London Parks intended to honour, at one time, three separate occasions: the Centenary of the House of Brunswick on the British Throne; the General Peace; and the sixteenth anniversary of the Battle of the Nile. This last commemoration was apparently added as an afterthought, to explain the date finally selected after repeated postponements. The original intention was that the affair should take place "during the stay of the Emperor of Russia, the King of Prussia and the long train of royal, princely and illustrious personages, who paid this country the honours of their visit."[1] The foreign personages came and went, but the preparations were still incomplete. Questions were asked in Parliament, but failed to elicit any satisfactory reply. The Regent's birthday, August 12, was next suggested, but at last, and rather late in the day, August 1 was decided upon.

The public notification gave the information that:

> Hyde Park, in which there will be a Grand Fair is entirely open to the people.
>
> The Green Park will also be entirely open to the people.
>
> The Mall of St James's Park, and Constitution Hill, will also be open to the people to enter by Spring Gardens, and New Street Gates.
>
> The Lawn in St James's Park, and the Birdcage Walk, will be devoted to those who have purchased tickets.

The notice concluded with the words—apparently intended to disarm possible criticism—

> Let not the people, therefore, listen to those who would poison their minds—to those who are the constant enemies of public Joy, let them be assured, that the object of the peaceful festival, is to give all ranks and orders, a grateful occasion to indulge in that full participation of happiness to which their perseverance in a most sanguinary and trying contest, crowned with unprecedented success, has so richly entitled them.

In Hyde Park, in addition to the Grand Fair, there was a mimic naval engagement on the Serpentine, lasting three hours and followed by a display of aquatic and aerial fireworks.

After a balloon ascent by a Mr Sadler, at six o'clock, the crowd assembled in Green Park had to wait until ten for the fireworks to be announced by a "loud and long discharge of artillery."

The main item of the display was "Grand Metamorphosis of the Castle into the Temple of Concord." This change, says a writer in *The Times*,

> was made with somewhat less celerity than those witnessed in our theatrical pantomimes. It resembled rather the cautious removal of a screen than the sudden leap into a new shape. When fully developed, however, it presented a spectacle which for extent of splendour, and not less for tastefulness of arrangement, deserved the admiration, and satisfied the hopes which it had inspired.

The "Temple of Concord" was an elaborate structure illuminated with coloured lamps and decorated with gilding, festoons, etc., and transparent paintings. It was designed by Smirke, the

[1] *The Times*, August 2, 1814.

FIREWORKS ON THE THAMES

To welcome William of Orange to London in November 1688.

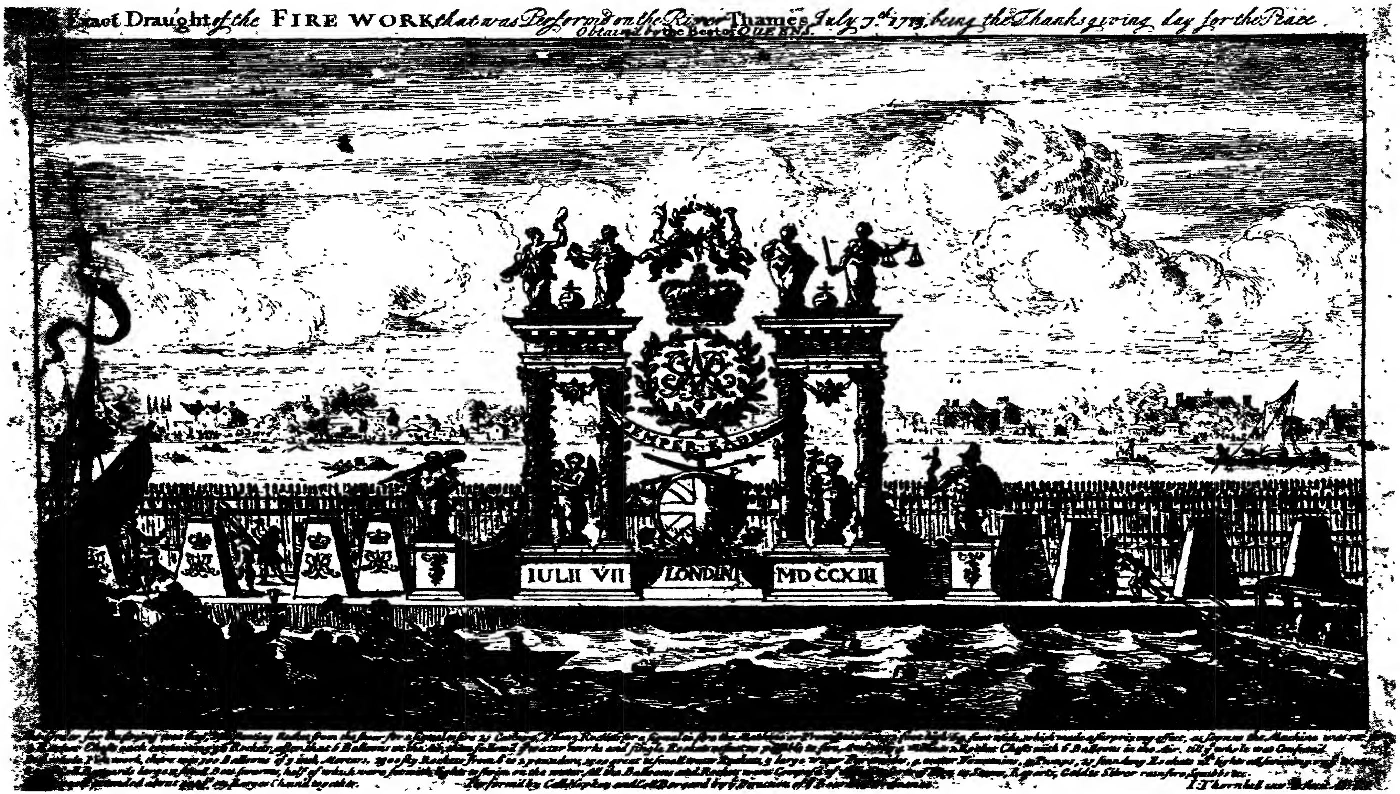
[*See p.* 43.]

PLATE X

DISPLAY AT AMSTERDAM IN 1688

Given, by the English merchants in that city, to mark the coronation of William in London

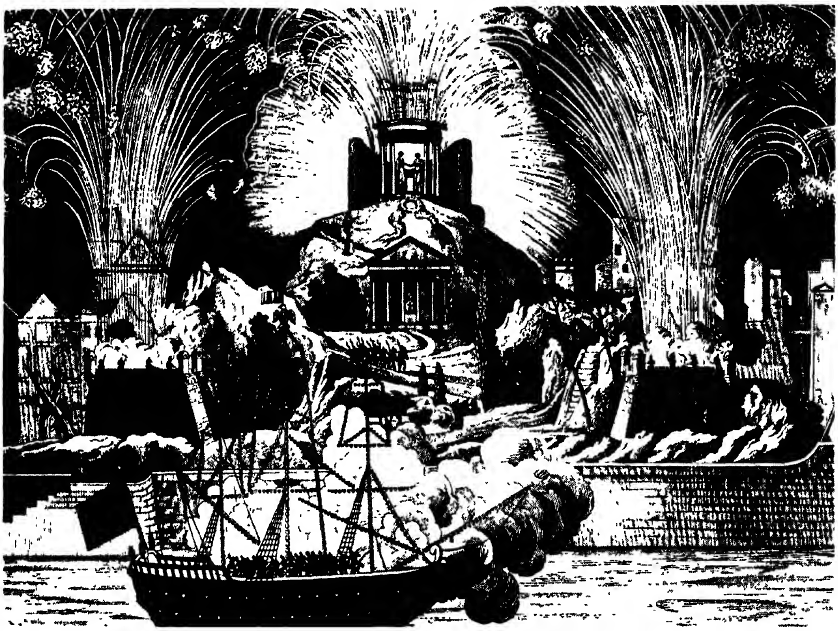
PLATE XI



PEACE DISPLAY ON THE THAMES ON JULY 7, 1713

The plate, if not the actual set-piece, was designed, and etched, by Sir James Thornhill.

[*See p.* 45.]



DISPLAY BEFORE THE HÔTEL DE VILLE, PARIS, IN 1810
On the occasion of the marriage of the Emperor Napoleon to Marie Louise.
[*See p.* 74.]

ILLUMINATION AT BUCKINGHAM PALACE ON JUNE 4, 1762
The birthday of King George III.
[*See pp.* 52–53.]

paintings being by Smirke, Stodard, Howard, Hilton, and others, and represented such subjects as "The Golden Age," and "Peace restored to Earth." When illuminated from inside it was made to revolve, so that spectators might view each side in turn. The machinery required for this refinement was provided by Messrs Maudslay and Co. (See colour plate facing p. 96.)

Charles Lamb, in a letter to William Wordsworth dated August 9, 1814, after describing the havoc wrought in the park by the crowds and booths, remarks that:

> After all the fireworks were splendent—the Rockets in clusters, in trees and all shapes, spreading about like young stars in the making, floundering about in Space (like unbroke horses) till some of Newton's calculations should fix them, but then they went out. Anyone who could see 'em and the still finer showers of gloomy rain fire that fell sulkily and angrily from 'em, and could go to bed without dreaming of the Last Day, must be as hardened an Atheist as . . .

The pyrotechnic display consisted chiefly of aerial fireworks with gerbes, roman candles, fountains, and wheels; there do not appear to have been many devices of any size. *The Times* reporter complains that "the repetition of these things, with occasional pauses, for more than two hours became tedious to all."

St James's Park, as already mentioned, was reserved for those who paid for admission, half a guinea being the charge. The trees were illuminated; not altogether successfully according to *The Times* reporter, who remarked: "If these exotic ornaments had been more numerous, the effect would have been highly graceful and pleasing; but here alone there appeared to have been a beggarly economy."

A Chinese bridge and pagoda, painted yellow lined with black, with blue roof tiles, was built across the canal and illuminated with gas-jets. A secondary display of fireworks was discharged from this structure, and, while it lasted, seems to have competed reasonably well with the "dazzling splendour" of the gas-jets. But, "near the expiration of the fireworks, the Pagoda exhibited an appearance which excited much doubt. Its upper towers [storeys?] seemed enveloped in flames, and it was soon found that it had certainly caught fire by some accident." Contemporary accounts were unanimous in blaming the fireworks for the accident, but it is much more probable that the intense heat from the thousands of primitive gas-burners was the real cause. "A lamplighter," we are told, "who was employed at the top of the building, in attempting to throw himself into the water was killed." Several others were badly burned and removed to hospital, where one subsequently died.

The pyrotechnic direction of the fête was in the hands of Colonel Congreve, who was then enjoying considerable notability on account of his war rockets, which had been employed with some degree of success in the recent war. There was, however, evidence that the skill of the professional pyrotechnist, as opposed to his Service counterpart, was beginning to be recognized officially: the firework-makers Southby and d'Ernst were engaged to introduce effects, which included the great novelty of veritable coloured fire and stars.

Meanwhile, on the Continent, our French adversaries did not have to wait for the coming of peace for firework displays. Napoleon, like his royal predecessors, set great store by the propaganda value of pyrotechnics. Fireworks and illuminations marked the emperor's progress through France and underlined his victories. In 1804 a grand display before the Hôtel de Ville, Paris, proclaimed his assumption of the title Emperor of the French. The setting represented Mount St Bernard, surmounted by an effigy of Napoleon mounted on a prancing charger. A similar display on the same site in 1810, celebrating his marriage with Marie Louise, differed by the substitution of the figures of the happy couple standing in the Temple of Hymen, for the equestrian group (Plate XII). Displays throughout France and the Empire marked the birth of the King of Rome on March 20, 1811.

It is not surprising that Napoleon included a book on fireworks, Frézier's *Traité des feux d'artifice*, in the library that accompanied him on his Eastern campaign in 1798,[1] but it is certainly strange that he selected a work published over fifty years before, when several more up-to-date treatises were available.

Napoleon's disappearance from the scene did not rob Paris of her fireworks. John Scott, in *A Visit to Paris*, gives what is for an amateur observer a notably clear account of the peace display on August 29, 1814:

> When the King reached the Tuileries a rocket was fired for the fireworks . . . to commence. They began immediately; rockets and bombs ascended in quick succession; wheels revolved, offering a variety of changes; a row of garbes, arranged on the parapet [of the bridge] threw their sparks into the Seine, and produced the exact resemblance of a cataract of fire rolling down its waves in succession; a temple in the middle of the bridge shone out with the motto "A la

[1] See *The Duke*, by Philip Guedalla (1931).

Concorde" and the expansion of a large flight of rockets and the noise of an artificial volcano completed the scene.

The bridge referred to was that named after Louis XVI, which had been the scene of displays in 1800, 1804, 1806, and was used later in 1820 and 1821. Another site frequently employed after the Revolution was the garden of the Senate, where Ruggieri[1] claims to have fired in the years 1801, 1806 (twice), and 1807.

The coronation of George IV was celebrated by a display in Hyde Park on July 19, 1821, which included aquatic fireworks, but according to a report, written at the time of Queen Victoria's coronation, "it was very insignificant and did not attract much public attention." The firework-maker Mortram, nevertheless, claimed the credit for its execution in his trade lists.

The displays for the coronation of William IV, in September 1831, appear to have been on an equally parsimonious scale. "The amount expended for fireworks and for keeping open the public theatres," we are told, "was £3034 . 18 . 7."[2] *The Times* report merely records that "the fireworks and balloons exploded and ascended at the appointed hour." The pyrotechnist was d'Ernst.

For Queen Victoria's coronation on June 28, 1838,

> fireworks were provided on the most liberal scale. They were the same in Hyde Park and in the Green Park, the former being under the direction of Lieutenant-Col. Dyneley, firemaster of the Royal Laboratory, and made by Southby, the latter under the direction of William Caffin, esq., and made by D'Ernst.[3]

These displays marked an epoch in such events, in that the central feature was not a scenic construction of canvas and plaster, but a firework set-piece on lines comparable with the 'lancework' devices of to-day, in which the design is outlined in a great number of small fireworks, or 'lances.' The fact that a display of this type does not lend itself to pictorial reproduction in daylight to the same extent as did the 'machines' of the earlier displays may account for the scarcity of engravings depicting the event. Wood-block engravers had yet to learn what a splendid subject a firework display provided for their particular art.

The design for this set-piece (Plate XIII) was said to be based on the entrance arch of Buckingham Palace—otherwise the Marble Arch, which was removed to its present site in 1851—but, if this was so, considerable imagination is required to appreciate the fact.

[1] *Elémens de pyrotechnie.* [2] *Curiosities of London* (1855), by John Timbs.
[3] *The Gentleman's Magazine*, August 1838. "Lieutenant-Col. Dyneley" should, in fact, have read "Lieutenant-General Dyneley, C.B."

The picture, in the centre, of Queen Victoria "in her Coronation Robes, on horseback, . . . wearing the stars and ribbons of the Orders of the Bath, Thistle and St Patrick," was an example of the 'transparency,' now obsolete, painted by Danson, who was the scenic artist at the Surrey Gardens, and for many years at Belie Vue Gardens, Manchester.

Southby had the happy, and no doubt commercially worthwhile, idea of staging a replica of his display at the Surrey Gardens, on two nights a week, throughout the season. As we have seen, Mr Rouse of the City Road had a similar notion, and even added a sub-title to the bills of his establishment, which now read, "Royal Eagle Coronation Pleasure Grounds and Grecian Saloon." The fireworks were not, however, by d'Ernst, as one might have expected, but by "that inimitable British Artist Thomas Brock."

From the forties of the last century onward illustrations of firework displays began to appear with increasing frequency in the weekly picture papers that had come into existence: the still flourishing *Illustrated London News*, and its shorter-lived competitors *Pictorial Times*, *Illustrated News of the World*, and the *Illustrated Times*. To some extent, perhaps, the eminent suitability of the subject to the medium in which it was reproduced was responsible for the, as might be thought, disproportionate number of such representations, but there can be no doubt of the great increase in the number of displays and the enormous advance in the popularity of fireworks. The new technique, obviating the elaborate work on the site as well as the expense which the erection of the old-fashioned 'temple' or 'machine' involved, and the introduction of real colour effects were no doubt contributory factors to this state of affairs, but equally important was the improvement in travelling facilities that made possible the interchange of visits between the royalties of Europe.

In August 1845 Queen Victoria, accompanied by the Prince Consort, set out for a month's tour on the Continent. She was greeted with firework displays at Cologne, fired from the bridge of boats, at Antwerp, and at Frankfort. A visit to Louis-Philippe in Paris was not similarly celebrated, possibly because it seems to have been unpremeditated, or for the good reason that all available fireworks had been used up at the recent display on the Seine on July 30 in celebration of the fifteenth anniversary of the July Revolution.

Louis-Philippe's birthday fêtes provided the occasion for another pyrotechnic display on the Seine in May of the following year, the last of such occasions for him, although his successor, Louis Napoleon, by no means allowed fireworks to lapse as a Parisian institution. An article, dated August 21, 1852, in the *Illustrated London News*, headed "Government by Shows," comments on the new President's penchant for fêtes and fireworks:

> The Bourbons . . . had only a few religious festivities to share with the people. Louis-Philippe, though he owed his throne to the Parisians, shared the apprehensions of his family, and preferred spending his revenue in erecting forts to giving fêtes. He got up a gorgeous and ill-advised ceremony in honour of the ashes of Napoleon, and by reviving the recollection of the Empire prepared for its restoration. Louis Napoleon, who owes his success to his quick faculty for understanding the wants and character of the French, establishes fête after fête in connexion with the life of the Emperor, or the glories of the Empire . . . By festivities, naturally attractive, the Prince President is to revive all the feelings of admiration that once prevailed throughout France for the Emperor, and on them he is to float the Empire . . . slowly but surely he is moving on to the height of power; and will have, not unwillingly, the honour of the Empire thrust upon him. He does not hurry to his object . . . he will not seize the crown and place it on his own head as did Napoleon at Milan; he is preparing the people to do this work for him and place it on his brow.
>
> A theatrical Empire in France will be a pleasant show for the rest of Europe, if the French be satisfied by the representation, and their Emperor seek popularity and power only or pyrotechnical virtues.

The particular celebration that inspired these remarks included a mimic naval engagement in the Seine; widespread and extravagantly elaborate illuminations throughout the city, in which the letter 'N' figured prominently, as well as the names of Bonaparte's victories; and electric lights made what must have been one of their earliest appearances. The firework display in the Place de la Concorde had as its principal feature "The Passage of Mount St Bernard" (Plate XVIII), bearing so very definite a resemblance to that fired in 1804, when Napoleon I proclaimed himself emperor, as to make it not unlikely that a hint was intended.

A display fired from the Arc de Triomphe, in connexion with the Grand Military Fêtes, during the same year, provides the subject for what is undoubtedly the outstanding example of art of the wood-block engraver in this particular field (Plate XVIII).

In 1853 Louis Napoleon had achieved his object, and marked the occasion with the first of the "Fêtes of the Emperor" that were to become an annual event. A visit paid by Queen Victoria and the Prince Consort to the Paris Universal Exhibition in August

1855 gave the Emperor the opportunity for an outstanding pyrotechnic demonstration, which, according to the advance notices in the Parisian Press, was "to surpass anything achieved by Louis XIV." The scene of the event was Versailles; the terraces and fountains were illuminated on a most lavish scale. The main set-piece of the firework display was a representation of Windsor Castle, and the concluding item a flight of thousands of rockets, which, if the spirited drawing by Gustave Doré (Plate XVII) is to be relied on as an accurate record, contained a considerable number of somewhat erratic performance.

The departure of the royal party from Boulogne on the following day was the occasion of another pyrotechnic compliment in the form of continuous flights of rockets from the cliffs as the royal yacht *Victoria and Albert* receded from the shore.

Within a few weeks, in both England and in France, impromptu celebrations were being staged for the fall of Sebastopol. At Balmoral the queen pressed a button to light, electrically, a large bonfire. On Woolwich Marshes 20,000 spectators witnessed a considerable expenditure of pyrotechnic stores by the officials of Woolwich Arsenal. A rather belated, although evidently better organized, display took place a month later on Blackheath. In Paris there were widespread illuminations, a *Te Deum* at Notre-Dame, and fireworks, no doubt for lack of time in which to prepare them, on a restricted scale.

These were but insignificant preludes to what was to come when, in the year 1856, peace was proclaimed between the Allies and Russia. In London four separate displays were planned. The sites chosen were Hyde Park, Green Park, Primrose Hill, and Victoria Park. They were arranged thus with the very sensible idea of splitting the crowds of sightseers into sections and thus preventing dangerous crowding to one spot. The fireworks were prepared for these displays in Woolwich Arsenal, under the direction of Mr Southby, the pyrotechnist of the Surrey Gardens, who went there for this event.

The programmes of these displays were precisely similar, with the exception of that at Primrose Hill, which consisted mainly of aerial fireworks.

Tyrrell[1] gives the following account of the display in Green Park:

> At the appointed signal there was a continuous discharge of maroons, accompanied with brilliant illuminations with white, red, green, and

[1] *History of the War with Russia*, by Henry Tyrrell (1857).

yellow fires. . . . Then, for two hours, followed every conceivable design of elegant and dazzling pyrotechnic art. Flights of rockets, a hundred at a time; revolving wheels, suns, stars, golden streamers, and fiery serpents chasing each other through the air. Gerbs, Roman candles, tourbillons, shells, and fixed pieces of the most fantastic designs and brilliant hues. The eyes were dazzled with the intensity of the light. . . . It was strange to believe that so fierce and ungovernable an element as fire could be rendered so delicately obedient to the will of man. . . . The triumph, however, of the entertainment was reserved for the close of it. This was a tremendous bombardment, during which the air was constantly filled with flights of rockets, and was intended as a representation of the last grand attack upon Sebastopol—the blowing up of the magazines and works, and general conflagration. As an introduction to this there were five fixed pieces, all of complicated construction, the centre being an enormous one which, amid all its fantastic blazing and revolving, exhibited the words "God Save the Queen." Language fails to convey a vivid idea of the deafening, roaring, crashing and grand appearance of the termination, during which the proud fortifications of Sebastopol were supposed to succumb. Then rose up into the blackness . . . rapidly one after another, six flights of rockets, comprising altogether no less than ten thousand of these beautiful and brilliant instruments. . . . It was such a spectacle as a man could not reasonably expect to witness more than once in his life.

It would appear that the writer was indulging his imagination in regard to the subjugation of the defences of Sebastopol; the official programme makes no reference whatever to any such item. But, at any rate, he seems to have been impressed by the display; a state of mind that was general, to judge from the accounts and appreciation appearing in the Press of the day.

It is worthy of note that this was the first celebration of the kind in which the displays consisted of veritable fireworks without extraneous assistance in the form of scenery, buildings, or transparencies. This may account for the fact that there was considerably less of the usual outcry against the 'waste' involved. It is curious that on occasions of this kind there are always to be found certain damp spirits who begin a clamour against the expenditure of money on fireworks which might be applied to other objects. The Aix-la-Chapelle display excited these gentlemen to a great pitch, probably on account of the elaborate nature of the preparations, which, as we have already seen, occupied over five months, thus providing them with plenty of time to develop their theme, and an object-lesson to prove their statements.

Where, however, the display consists—as on the occasion under consideration—solely of fireworks proper, a few days' preparation on the actual site is usually sufficient; the kill-joy has less time to get into his stride.

In Edinburgh a big display "by a London Artist at a cost of £600" was fired on Arthur's Seat. That in Dublin was in Phœnix Park, under the management of "Mr James Robinson, of the Polytechnic[1] Museum, Grafton Street, and the scaffolding and framework were erected under the direction of Mr Owen of her Majestie's Board of Works." Other displays were staged at Glasgow, Liverpool, Bristol, Manchester—on the Chain Pier, Brighton, by Southby—and at Lynn. At Portsmouth and Plymouth the ships were illuminated and fired flights of rockets, and there were displays and bonfires on shore. A newspaper report of the celebration at the former port makes the criticism that the show put up by the ships was considerably less effective than that achieved when the queen had reviewed the fleet there in the previous May.

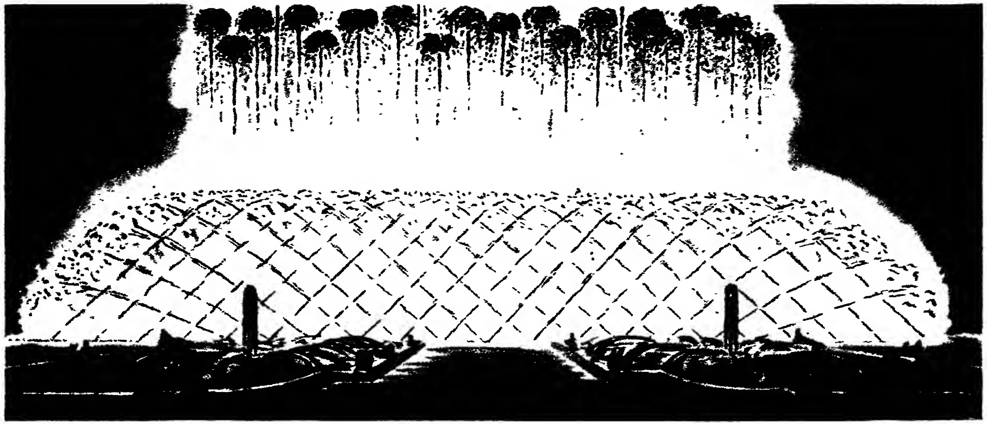
An epilogue to the London displays is contained in this paragraph:

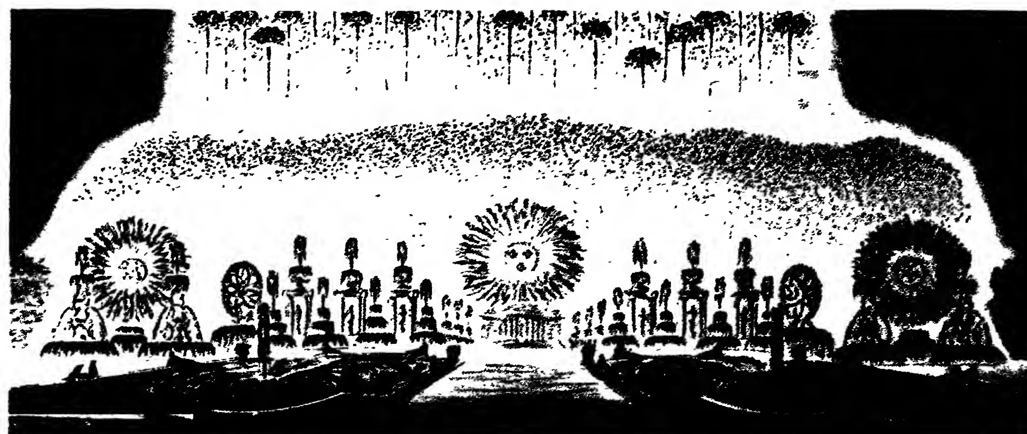
> The remnants of the fireworks exhibited in London are returning to Woolwich in waggon loads night and day. As soon as the whole has been cleared away no time is to be lost in refitting for the entertainment to be given on Woolwich Common. . . . The scale of grandeur will be equal to the exhibition in either of the London Parks. . . . The Laboratory department is then to be reduced to the ordinary peace establishment. Consequently 300 men and boys have received notice of discharge.

Paris saw another magnificent display on the Seine a month after the peace rejoicings, during the baptismal fêtes following the birth of an heir to the Empire throne, the ill-fated Prince Imperial. The main set-piece took the unusual form of a "Gothic edifice, containing a baptismal font."

In September of the year 1856 Moscow and St Petersburg were ablaze with illuminations for the coronation of Czar Alexander II. A grand firework display was staged on a site of fifty acres before the building of the Corps of Cadets at Moscow. Novel features were introduced; the firing was carried out to a background of music, provided by a band of 2000 instruments and a choir of 1000 singers,

[1] Perhaps a misprint for 'Pyrotechnic'?





FIREWORKS AT VERSAILLES, 1751

These contemporary water-colour drawings, forming part of a set of at least four, were probably submitted for royal approval when the display was contemplated by the pyrotechnist Torré, whose signature they bear.

[*See* *p.*52.]

the time to the music being marked by artillery—the guns being fired by touching a galvanic wire as easily as producing a note from a pianoforte.

After this titanic chorus a representation of the bombardment of Sinope took place, and consisted of rockets, maroons, shells, blue lights, blazing, banging, and rushing in all directions. This fancy bombardment lasted above half an hour; but long ere it ended nothing whatever could be seen but smoke.

The concluding sentence is reminiscent of Governor Davis's criticism of the display he witnessed farther East.[1]

Another royal event was celebrated with fireworks and illuminations in March 1857, the birth of an heir to King Ferdinand II, nicknamed "King Bomba," despot of the kingdom of the Two Sicilies. "The occasion of the fête was so important, and the joy of the Neapolitans thereat was considered to be so exuberant, that the authorities ordered three evenings to be given up to the festivities." A contemporary account recalls that on the same site, in March 1848, "some thousands of people . . . howled like wild beasts for their prey"—King Bomba.

The only other outstanding pyrotechnic event in Europe during that year was a display fired on the suspension bridge over the Danube on the occasion of the arrival of the Emperor of Austria at Pesth for his coronation as King of Hungary.

Calcutta was the scene of what was undoubtedly the most extensive event of the kind yet seen in India, on November 1, 1858, when illuminations and fireworks signalized the proclamation of Queen Victoria "Queen of India and Empress of Hindostan" and the extinction of the East India Company as the controlling power in India.

The rather noticeable absence of any large-scale displays in Paris during 1858 may possibly be accounted for by the emperor's preoccupation with pyrotechnics of another sort—the attempt on his life by the Italian anarchist Orsini by means of bombs loaded with fulminate of mercury, in which a hundred and sixty persons were killed or injured.

The year 1859, however, saw a revival of the emperor's pyrotechnic enthusiasm. The occasion was "the double festival of the triumphant entry into Paris [of 'the Army of Italy'] and the Emperor's birthday." Every public building was decorated by day and illuminated by night, but it would appear that the fireworks were hardly up to standard they "lasted but a short time,

[1] See p. 22.

and persons knowing in such matters do not speak very highly of them, although the concluding bouquets were certainly beautiful."

Nor were all the fireworks exhibited during the first half of the nineteenth century of professional or Service manufacture. In that period Britain, in tune to the Industrial Revolution and in common with most other civilized countries, had become science-conscious. The exclusive dilettanti of the Horace Walpole school had given place to, or been submerged by, a wider and more catholic range of inquirers. Their interest was catered for, if not always fostered, by a spate of encyclopædias and text-books of scientific—or at least pseudo-scientific—import. Among the arts and sciences that of chemistry, but recently released from the remnants of its alchemistic origin, was as popular as any. Its associated art pyrotechny then—as, in fact, it is assumed to do to-day—seemed to offer to the chemist a means whereby he could demonstrate, publicly and visually, his scientific proficiency.

Amateur pyrotechnists flourished and multiplied; some were successful, others no doubt adopted the practice, still met with, of eking out their own production with others from a more authentic source and taking full credit for the result. I do not for a moment suggest that such was the case in regard to the display at Parsonstown, Leinster, reported in the *Illustrated London News* of February 15, 1851, personally conducted by no less an expert than the President of the Royal Society, later Chancellor of Dublin University, and owner of the largest telescope in the United Kingdom, costing, it is recorded, £20,000:

FESTIVITIES AT PARSONSTOWN CASTLE

The most magnificent display of fireworks ever witnessed in Ireland was given, on Monday evening week, at Birr Castle. The Earl of Rosse had the fête prepared for the amusement of the people of the town. The fireworks were manufactured and altogether managed at the Castle, and it is said that fairer fingers than his Lordship's were busied about the greater part of them.

When seven o'clock arrived, all the guests left the Castle for the lawn, to witness the fireworks. The guests were about two hundred in number. But the multitude that assembled in the demesne exceed belief: certainly more than 20,000 persons had come together. It must have been highly gratifying to the noble projectors of the amusement, to find everything answer so exactly their intentions, and to learn, from the warm applause that occasionally burst from the crowds, that every person about them was delighted.

The slow and majestic rise of a fire-balloon commenced the display:

it gradually and steadily mounted into the air, and faded by degrees from the sight, lost in the distance. Annexed is a copy of the programme which was handed about to the guests. It is the more remarkable as having been printed by Lord Oxmantown, Lord Rosse's eldest son, now ten years of age:

1. Balloon, with fireworks, if weather permits.
2. Lights of different kinds.
3. Rockets, small and large.
4. Tourbillons, air marrons, and shells.
5. Wheelpiece, 3 mutations.
6. Tourbillons.
7. Mines of serpents and saucissons.
8. Rockets, Marrons, and shells.
9. Wheelpiece, 3 mutations.
10. Tourbillons.
11. Battery of Roman candles.
12. Mines of different kinds.
13. Lights fired by rockets.
14. Wheelpiece, 3 mutations.
15. Rockets, shells, marrons, and mines.
16. Mine fired by a rocket.
17. Wheelpiece, 3 mutations.
18. Marrons, shells, tourbillons, and rockets.
19. Wheelpiece, 5 mutations.
20. Girande.

To particularize any of these as being good, would be invidious, as they were all so superior to anything we ever before had seen; but we cannot help expressing our admiration of the rockets—their brilliancy, force, and the remarkable height they rose to, and then their burst into different-coloured lights and graceful fall were perfect. The effect of the lights on the dense mass of beings was curious, and the glare thrown on the Castle was exceedingly remarkable, seeming to equal in brilliancy the noon-day sun.

Lord Rosse himself set off all the fireworks: and it is gratifying to think that no accident occurred.

It is highly interesting to see a man of Lord Rosse's capacity blending the pleasant with the useful—amusing his friends, and, in getting up that amusement, expending so much money among his people. The fireworks would, it is said, have cost, if purchased prepared, £400. This is truly doing good.

Can it be that the reporter allowed an extra cypher to slip into his notes? £40, even to-day, would be rather a high price to pay for a similar selection. But, of course, the circumstances were admittedly exceptional.

Chapter VIII

THE NINETEENTH CENTURY, 1861–81

> I rapturously applauded the Maroon and the Balloons, the Saucissons and Asteroids, and Magnesium Lights (which *Mrs Malaprop*, near whom I had the honour of sitting, would call Sausages and Asterisks and Magnesia), the Cascades and Fountains, the Comets and the Rockets, the Batteries and the Salvoes, the Temples and the Palm Trees, and all the rest of the successful splendours achieved by Mr Brock, who seems fired by a noble sky aspiring ambition constantly to surpass himself.
>
> *Punch*, July 24, 1869

THE middle years of the nineteenth century saw a notable increase in the number of firework celebrations throughout Europe, and, indeed, in more distant parts of the world. A grand display, in which the words "All Honour to Cyrus W. Field" were prominently featured, was staged at New York, in September 1858, to mark the successful laying of the Atlantic cable between Valentia, Ireland, and Heart's Content, Newfoundland—a celebration that perhaps may be considered a little premature, in view of the fact that the life of that particular cable was approximately three months.

In March 1863 eighteen-year-old Princess Alexandra of Denmark embarked at Korsör in the royal yacht *Sleswig*, to the accompaniment of fireworks and illuminations, on her way to England for her marriage with the Prince of Wales. This event, which brought to this country, in addition to the bride's parents, the Crown Prince and Princess of Denmark and others of the Danish royal family, the Crown Prince and Princess of Prussia and the rulers of several German states, was celebrated throughout the kingdom on an unprecedented scale. In London there were no official firework displays; an elaborate gas illumination of the public and commercial buildings, sometimes eked out with flares of coloured fire, seems to have been the officially approved method of commemorating the occasion. This lead was followed in the provinces, notably at Birmingham, where, no doubt, gas-pipes and other accessories were plentiful. However, the many towns and cities that included fireworks in their celebrations provided ample opportunity for pyrotechnists to exhibit their art.

In September 1865 Queen Victoria paid a visit to Hanover and Saxe-Coburg, where at the Castle of Rosenau she was welcomed with what appears to have been a rather meagre display of fireworks. It seems probable that the journey was not unconnected with the congress of the rulers of the German states, held a few days later at Frankfort, which resulted in their confederation under the crown of Prussia. This occasion was marked by a pyrotechnic display on the banks of the Maine.

The Prince and Princess of Wales took their own fireworks with them when, in October 1864, they visited Sweden and Denmark. A display, consisting of bouquets of rockets and the outlining of the rails and paddle-boxes of the royal yacht *Osborne*, signalized their departure from Elsinore.

Meanwhile Napoleon III was continuing his policy of 'government by shows.' The Emperor's Fête had become a regular institution on the anniversary of the birthday of Bonaparte. On August 15, 1864, "The Festival of St Napoleon, as it is irreverently called, . . . happening to coincide with a great festival of the Roman Catholic Church, was celebrated with more than usual splendour."[1] In addition to the lavish illuminations throughout the city, there were two displays of fireworks, one from the Pont de Jena, the other in the Place du Trône. The King Consort of Spain was in Paris at the time, returning a visit made to Madrid by the Empress Eugénie during the previous year, and a fête at Versailles was organized in his honour—although, as was officially stated, it was necessarily of a less brilliant description than would have been observed "if the Queen, as immediate possessor of the Crown and sceptre of Spain, had honoured France with her august presence."[2] The absence of the queen was explained as being due "to the reasons of court etiquette."

This, the fifth royal firework fête to be staged at Versailles, does not, however, seem to have given the royal visitor any justifiable grounds for complaint on the score of parsimony:

> The illumination of the parterres by coloured lamps was most effective . . . and threw into bold relief the elegant proportions of the fountains and, indeed, of the park itself, which was, moreover, at times illuminated simultaneously by Bengal fires and the electric light. From the time the royal party took up their position, the din of bombs, cannons and explosions never flagged; and the clamour only ceased with the extinction of the bouquet, which was extremely beautiful.[3]

The following year, 1865, saw a revival of the *entente cordiale*,

[1] *Illustrated London News*, August 27, 1864. [2] *Ibid.* [3] *Ibid.*, September 3, 1864.

which, since its commencement in the days of the Crimean War and Queen Victoria's visit to Paris, had suffered some degree of eclipse. The British Channel Squadron paid a visit to Cherbourg in August, when, in addition to the novelty of a searchlight display by the French 'ironclad' *Magenta*, the illumination of the two fleets by coloured signal lights and by displays of rockets fired from the decks of the ships, as well as from the shore, were outstanding items in the festivities. A fortnight later the French fleet returned the visit, and a similar display was fired from the combined fleets at Spithead.

Another occasion to be celebrated with fireworks and illuminations, during the same year, was the arrival at Cologne of the King of Prussia during a tour of the Rhenish provinces. While in the city King William laid the foundation stone of the gigantic equestrian monument to his predecessor Frederick William III. The inscription included the words, "This monument is intended now and for all time to display the thanks of the Rhinelanders that through that Monarch their country . . . was restored to German freedom, German manners and German habits." It was completely destroyed during the British air-raids of the last war.

The event of most outstanding pyrotechnical importance during the year 1865, in some ways perhaps the most significant in the history of the art, was the "Grand Competition of Pyrotechnists," held at the Crystal Palace, Sydenham, on July 12, 1865. The idea of holding such a contest originated in the brain of Charles Thomas Brock, the third son of the then head of the family business, William Brock (1813–69). C. T. Brock was undoubtedly a remarkable young man. A poster, dated 1863, advertises at "the Rye House [near Hoddesdon, Herts] Mr Charles Brock's Second Annual Fête." The attractions included "a grand double fireworks display and the illumination of the grounds by thousands of parti-coloured lamps" by his father; "The Brothers Ridolini, Acrobats from the Cirque Napoléon, Paris"; as well as the "Rocky Mountain Wonders." Special trains were announced, for which, possibly the earliest of their kind, combined return railway and entrance tickets were issued. As Charles had been born in 1843, he must have reached the mature age of nineteen years at the time when he organized his first Rye House Fête. However, appearances are deceptive; his mother used to recall his appearance at that time as a tall, imposing figure of a man, with a full black beard.

The outcome of these two successful ventures evidently inspired

Charles to further efforts. The Crystal Palace, transported and re-erected at Sydenham from its original site in Hyde Park, and opened in state by Queen Victoria in 1854, was ranked not only as the greatest show-place in England, but also as "one of the wonders of the world." When, in 1855, the Emperor Napoleon visited the Palace his comment had been, "It's superb! What a place for a fête!" evidently thinking in terms of fireworks and illuminations. Charles Brock's aspirations ran on parallel lines.

He recalled the inception of what was to become an achievement unique in the field of public entertainment in an article written some years later:

> It occurred to me that of all the places of public resort suitable for the inauguration of a new era for pyrotechny, none possessed such glorious advantages as the Crystal Palace, then at the height of its popularity. Its terraces, fountains, and foliage offered unrivalled advantages for the display of grand effects. The Directors of the Crystal Palace Company, who had more than once been applied to for permission to hold displays in the grounds, feared that, inasmuch as fireworks had been recently associated solely with gardens of the Cremorne class, the Palace itself would be degraded to the same rank if consent were granted. I urged that the Exhibition of 1862[1] had afforded no opportunity for competition among firework-makers—necessarily excluded by the nature of their trade—although almost every other branch of manufactures was embraced, that such a contest might with reason and advantage be held at Sydenham, and that fireworks were really not of an immoral tendency.[2] I further agreed that in the event of the result being unfavourable, either financially or from a social point of view, no second display need take place, but if, as I felt confident, there should be a large attendance of the better classes, then other exhibitions might follow. The Directors, after many months of delay, consented to make the experiment, and the favourable result of the trial on July 12, 1865, far exceeded my most sanguine expectations.
>
> The result was an unlooked-for success, 20,000 people being present on the occasion. Three more displays took place that year upon a small scale, but always with successful results.
>
> The first display was produced jointly by my father and Mr Southby the winners of the first and second prizes, and continued to the end of that season by my father alone under my management.
>
> The success of fireworks at the Crystal Palace having become an

[1] At South Kensington.

[2] "We absolutely cannot, with the exception of the Pyrotechnic Fêtes at the Crystal Palace, find a single spot in London where respectable people may seek amusement out of doors without their sense of decency being outraged.—*All the Year Round*, October 29, 1871.

accomplished fact, I built extensive works at Nunhead, and commenced manufacturing on a scale never previously dreamt of in the trade—the vast expanse of the locale of my displays obviously necessitating extraordinary expenditure of material.

By degrees the set pieces grew from twelve feet in diameter to 300 feet. Shells for which the Crystal Palace has been renowned grew to one hundred times more than the ordinary shells of my early days, and thousands of pounds weight of material was gradually introduced to increase the effectiveness of these displays.

The Rules and Regulations for the competition issued by the company were as follows:

The Company offers three prizes—the first of £25, the second of £15, and the third of £10 to the three Competitors whose display shall be considered best by a Committee of Gentlemen appointed by the Crystal Palace Company, and free to give their decision unbiassed by interest and unprejudiced by favour. A sum of £30 will also be given to each competitor for his portion of the expenses incurred.

Each Pyrotechnist willing to compete shall furnish:

1st 25 Coloured Lights 2" in length and 2" in diameter,

5 of which shall be White
5 „ „ „ Yellow
5 „ „ „ Green
5 „ „ „ Blue
5 „ „ „ Red.

2nd 12 Rockets of ½lb. calibre.
3rd 3 Tourbillions of a size and composition at the option of the maker.
4th 12 Shells 5" in diameter.
5th One Set Piece.
6th 200 Rockets of ¼lb. calibre; 50 of which shall contain Bright Stars, 50 Tailed Stars; and 100 with Coloured Stars for Flight.

Any Rocket or Shell larger than the above stated shall be disqualified.

The Company will find and fix such poles as may be required for the pieces.

No Exhibitor to make use of his name in lancework or otherwise in the pieces.

No Transparencies will be allowed.

Each Exhibitor will be allowed five assistants but no more.

Each Exhibitor to find his own Accessories for firing his Rockets, Tourbillions etc., also five posts 8 ft. long from which to fire his lights.

The order and placing of the pieces will be determined by drawing lots.

No frameworks to be fitted before the day before the date.

No work to be fitted before the day.

The Piece must be complete in itself, and not flanked on either side by Splines, Bouquets, or Horizontal Wheels &c, but may contain any number of same on the Framework itself.

Each Exhibitor to state how many poles he will require, and their distances, and to send a programme of what he intends firing, 14 days before date.

The Crystal Palace Company expect that this Competition will be the means of reviving the interest in Fireworks, or prove a permanent benefit to Pyrotechnists in particular and a source of unbounded gratification and delight to the public in general.

Their Certificate will also be a Guarantee for Competency and tend, in an eminent degree, to promote and foster the art which requires only to be witnessed to be appreciated.

Charles T. Brock — *Pyrotechnist*

G. Grove — *Secretary*

May 23, 1865

In his account of the genesis of the Crystal Palace displays Charles omits any reference to an unhappy disagreement between his father and himself, resulting in a breach that was never healed. Following the success, financial and otherwise, of the competition and the three displays that followed, the directors were in a suitable frame of mind to listen to Charles's schemes for inaugurating, as he said, a new era in pyrotechny. As a first step in this direction he and the Secretary of the company went over to Paris to see the Emperor's Fête and, to make use of a now somewhat threadbare phrase, set the target for future Crystal Palace displays. Charles returned confident, and, on his father's behalf, entered into a contract with the company for a series of displays for the 1866 season.

William, already a sick man—he died three years later—and perhaps inclined to be conservative in his outlook, viewed the project with misgiving and refused to co-operate, with the result that Charles took over the contract. In the hope that his father might be brought to reconsider his decision, Charles billed the first displays as by William Brock, then for the remainder of the season, attempting a kind of compromise, as by Charles T. Brock, *Junior*. William, however, continued obdurate, and father and son parted never to meet again.

In order to finance what was a very considerable undertaking, Charles entered into a partnership with his wife's uncle, Robert Milner, a West India merchant, whose daughter Mary Elizabeth, in 1888, married Alfred Harmsworth, later Lord Northcliffe. In this connexion it is interesting to recall that one of the first articles published in *Answers*, Lord Northcliffe's earliest venture, was the account of a visit to the Brock factory, then at South Norwood, Surrey.

The partnership, which appears to have been of a rather informal nature, and on a year-to-year basis, continued until 1870, when, as a result of a large contract from the French Government for cartridges, followed by another for portfires, Charles found himself in a position to carry out not only the Crystal Palace displays, but others, some even larger, in all parts of the world, relying on his own resources. In 1872 he purchased the original family business from his mother, and reunited the two branches, under the style and title of C. T. Brock and Co.'s "Crystal Palace" Fireworks.

The Times of July 27, 1866, records that the first of the series of "Popular Firework Fêtes" attracted 26,694 visitors, an exceptional attendance for those days; the total number of visitors during the season of six displays was 202,949. No doubt the directors realized that they had found an attraction which was likely to add materially to their revenue for some time to come, but it is improbable that they foresaw the lengthy period of years during which the Crystal Palace displays were to remain the principal, and constant, attraction of the resort, or the enormous influence they were to have on the history of pyrotechny in general. From 1866 onward the Crystal Palace exhibition became the acknowledged standard of perfection for firework-makers throughout the world.

In July 1867 the Sultan of Turkey, then on his first visit to England, was taken by the Prince of Wales to the Crystal Palace to witness a display arranged in his honour; "probably," according to *The Times* of July 17,

> the grandest display of fireworks ever witnessed in Europe. The "Court Circular" commented . . . but while M. Ruggieri (Pyrotechnist to the Emperor of the French) can be credited with much praise, his shells, both as regards splendour of the colours and their duration, are not by any means equal to those designed by our own countryman Mr C. T. Brock.

The Sultan was so impressed that he, then and there, appointed C. T. Brock pyrotechnist to the Ottoman Court, and gave orders for the establishment of a firework factory on modern lines, at

Tophana,[1] near Constantinople, and, as a preliminary, a number of displays on the Bosphorus before the royal palace. This work was carried out by, or rather under the superintendence of, William Platt Ball, a clever young schoolmaster of considerable scientific attainments and, until then, an enthusiastic amateur pyrotechnist. His letters, written between May 1870 and August 1871, tell a story of achievement in the face of such handicaps as local lethargy, procrastination in the matter of payments, due but never forthcoming, makeshift material, and even sabotage. However, he returned with the payment called for in the contract—less depreciation—and the Star of the Order of the Medjidieh. The trump card employed to enforce a final settlement appears to have been the retention of the recipes for the firework mixture, without which the factory would have been unable to function. In fact, its period of activity seems to have been brief, as only two years later C. T. Brock himself went out to Constantinople with fireworks of his own manufacture to carry out a display for the "Feast of the Biaram" for the Sultan.

The two outstanding pyrotechnic events of the year 1868 were once again the Emperor's Fête in Paris and a display at the Crystal Palace attended by the Prince and Princess of Wales and the Duke of Edinburgh, in celebration of the latter's return from a voyage round the world in H.M.S. *Galatea*. A full-sized representation of the vessel in full sail, carried out in lines of fire, provided the subject for the main set-piece of the display, the first of a long succession of pictorial lancework set-pieces that were to become a unique feature of subsequent seasons.

In the following year the Emperor's Fêtes at Paris were on a scale of even more than the customary magnificence, as marking the centenary of the birth of Napoleon I. They were also, as it happened, the last; the outbreak of the Franco-Prussian War in 1870 diverted the attention of Napoleon III to more vital matters, but one of the earlier incidents in the campaign—the blowing up of the Bridge of Kehl, with Strasbourg Cathedral as a background—provided the material for a Crystal Palace set-piece—the first of a long series of war subjects.

Other pyrotechnic occasions during 1869 were the displays fired in Scandinavia, to celebrate the marriage of the Crown Prince of Denmark to Princess Louisa of Sweden, and a particularly elaborate show at the Crystal Palace on the occasion of the joint visit of the Khedive of Egypt and the engineer De Lesseps; the latter, fresh

[1] The Arsenal.

from his triumph, the opening of the Suez Canal, was greeted with a specially designed set-piece, in the Egyptian manner, typifying the event. (Plate XIX.)

The peace celebrations in Berlin, in 1871, took the form mainly of illuminations, with fireworks on a rather meagre scale. C. T. Brock's negotiations for a display of more suitable proportions came to nothing; possibly the contracts he had carried out for the French Government had something to do with this result. The ceremony at Turin connected with the opening of the Mont Cenis tunnel, in September of the same year, was concluded with an elaborate illumination, carried out in coloured lamps, representing the entrance to the tunnel. Here, too, the fireworks were of secondary importance. This could certainly not be said of the display at the Crystal Palace in June, staged for the visit of the Grand Duke Vladimir of Russia in company with the Prince of Wales, who by now seems to have been regarded as the official royal guide to the resort. He was, however, the central figure on the occasion of his next visit, when, in company with several members of the royal family, he attended the most ambitious display yet fired there, in celebration of his restoration to health after a serious attack of typhoid fever. A record crowd of 60,000 was present.

An innovation for the event—one, however, that was to be repeated frequently in years to come—was the illumination of the Palace grounds with thousands of coloured lamps, a specialized undertaking for which Charles employed Duffel, who for many years had been responsible for similar work at the now defunct Vauxhall Gardens. A striking addition to the aerial portion of the firework display was made possible by Charles's purchase from Woolwich Arsenal of the whole of the mortars—800 in all, from 4½ in. to 10 in. in calibre—from which the shells had been fired at the official Crimean peace celebrations.

Firework displays had by now achieved a status in society to which they had never before aspired: they had become a fashionable item of entertainment at private gatherings. For this, no doubt, the royal patronage of the Crystal Palace fireworks was responsible. During the summer of 1872 the firm carried out displays for the Duke of Bedford, the Earl of Tankerville, two for Lord Dartmouth, the Earls Darnley and Beauchamp, Lords Vane, Graves, Wenlock, and Ladies Llanover and Hicks-Beach. In addition there was the series at the Surrey Gardens already referred to.

At the end of 1871 Charles went to Russia in connexion with the proposed celebrations for the approaching marriage of the Duke of Edinburgh with the Grand Duchess Marie of Russia at St Petersburg. However, the feeling of tension, inspired by the activities of the nihilists with their predilection for explosives of another kind, decided the Russian authorities against fireworks.

On June 30, 1873, the Shah of Persia, Nasr-el-Din, came to the Palace to see the fireworks in company with members of the British royal family. So impressed was he by the show that he postponed his departure from London to enable him to see the next display, on a "popular shilling day," which he attended to mix with the crowd in plain clothes, after paying his money at the turnstile. He confided to the manager, when that gentleman, having heard rumours of his arrival, had at last run him to earth in the throng, that he had enjoyed the evening more than any other since his arrival in Europe.

The outstanding event of 1874 was the Czar's Fête, at the Crystal Palace, attended by Alexander II, the Czarina, the Prince and Princess of Wales, the Grand Duke Vladimir, and the newly married Duke and Duchess of Edinburgh, in May.

Another royal visitor that year, although of a different colour, was the King of Dahomey, whose dominions were just then the subject for a good deal of jostling among the European Powers.

An unusual pyrotechnic event, perhaps the very first in that location, was a display of considerable size fired in the harbour of Reykjavik, Iceland, from the ships of an international squadron assembled for the visit of King Christian IX of Denmark to the island.

In June 1875 Syed Burgash iben Said, Sultan of Zanzibar, visited the Palace to see the display, possibly as a reward for his recent and reluctant co-operation in the suppression of the slave trade in his dominion. He was so delighted with what he saw that he immediately ordered a display to be sent out to Zanzibar, with the necessary operators, to accord himself a fitting 'welcome home' celebration on his return, a precedent followed, years later, by Horatio Bottomley for his arrival at "The Dicker," his home in Sussex, after his release from Wormwood Scrubs.

At the Crystal Palace that season much excitement was caused by the introduction of the item "The Descent of Jove." This was the amalgamation of two features which had held their place in the programme for some years, and, it may well be, were falling a little flat: "The Descent of the Comets," two devices, each a framework shaped as their name suggests, which slid down wires from the top of the water-towers to the firework terrace during the display; and "The Demon of Fire," a figure who, suitably made up, appeared on the terrace during the display, surrounded by fire and flame. Now Jove, attired in a skin-tight suit composed of reflecting metal mirrors,[1] and striking a dramatic attitude, was to slide down from the north tower framed in fire. There was considerable discussion as to whether the tension necessary to strain the rope sufficiently tight might endanger the tower, but the idea was adopted. It is characteristic of C. T. Brock that he was the first to try out the scheme by making a trial trip. The man selected for the public exhibition was one Bill Gregory, who was billed under the more romantic title "Signor Geregorini." This concession to public partiality for foreign names was exposed when, at the first performance, the framework stuck half-way on its journey, and the staff, otherwise busily employed, allowed Bill to remain in his aerial solitude for the remainder of the display. It is recorded that his comments, intended for the ears of his colleagues on the terrace below, left no doubt in the minds of the public as to his country of origin.

It is probable that this item, coupled with the fact that the great Blondin appeared many times on his tight-rope on the terrace, surrounded by fireworks during the displays, is responsible for the oft-repeated, but entirely untrue, story of the artiste having walked on a rope stretched between the Palace towers.

The closing months of 1875 and the January and February following are notable for a series of displays fired during the Prince of Wales's tour of India, the prelude to the proclamation of Queen Victoria as Empress of India on May 1, 1876. These, the first displays on modern European lines to be seen in the peninsula, were the forerunners of many others fired by a succession of Brocks during the sixty years that followed. On this occasion the family was represented by my father, Arthur Brock, then in his eighteenth year, who went out in company with his brother-in-law, G. M. Ashby, and seven operators.

On the death of his father Charles had adopted his youngest brother, if, indeed, that is the appropriate expression to describe a compact between brothers differing in age by only fifteen years. At any rate, from that time forward Charles made himself responsible for Arthur's upbringing and education; the scene of the latter was mainly the Lycée de Saint-Omer and the Académie de Douai, Université de France, whence Arthur returned in the spring of 1874,

[1] The suit, I find, was supplied by the famous old pantomime family of Vokes.

to join the business in time to gain some practical experience at the Crystal Palace displays and to be present at the Czar's Fête. In the following year he was placed, nominally at least, in charge of the Crystal Palace displays until, in September, the party sailed for India in the s.s. *Deccan*. After being held up at Gibraltar by a damaged propeller, they arrived at Bombay only four days before the Prince's ship, H.M. Transport *Serapis*, which had been specially fitted out for the voyage. The delay left them with only twelve working days in which to prepare for the first display, on November 16.

However, they managed to be ready and to find time for a coloured fire illumination of the smaller of the famous Caves of Elephanta, and a display of rockets, when the royal visitor was entertained at a banquet in the large cave. They also managed to be present at a display, fired by native pyrotechnists, at a gathering of 12,000 children of all denominations, an experience which left them with the impression, as one of the operators remarked, that "they hadn't much to beat."

The display, in spite of the short time left for its preparation, was a great success, and on November 20th the party sailed for Ceylon, where the Prince was due to arrive on December 1 after visiting Baroda and Poona. A rather pathetic comment on the display fired at Colombo on December 7 appeared in the *Ceylon Observer*:

> A Sinhalese Aratchy himself, in the opinion of his countrymen, no mean adept in firework manufacture, came to our office this morning, and in a most despairing tone, with lengthened and sad visage, remarked "Sinhalese people make no fireworks, never no more." "Why?" we asked. "Oh," he replied, "last night splendid, all Sinhalese never make fireworks no more, when want more fireworks will send to England."

The pyrotechnic party now divided, two started the same night for Madura, where the Prince was greeted with a coloured illumination and a display of aerial fireworks, on his arrival there on December 10. The others raced ahead to Trichinopoly, where the illumination of the 300-foot-high Rock was the outstanding event of the royal visit. The following account appeared in the *Graphic* of January 15, 1876:

> All the principal points of the Rock were lighted up with lines of light . . . while the summit was ablaze with magnesium and coloured fire . . . the summit heaved forth rockets like a volcano, Niagaras of fire burst over the various terraces, while in the tank below the rock

were innumerable water fireworks . . . the lake being alive with fire devices of every hue.

At Madras some of the party had the opportunity of seeing an unusual pyrotechnic event—the illumination of the surf by firework lights, carried by innumerable Massoolah boatmen on their catamarans.

On January 1, 1876, the reunited party fired the most elaborate display yet seen in India, and on the 25th they staged a coloured fire illumination of the famous Taj Mahal at Agra. A contemporary account is not enthusiastic:

> The Taj by moonlight is said to be one of the most beautiful sights in the world; but there being no moon during the Prince's stay, the Authorities determined to illuminate the dome. . . . Any artificial illumination, however, of one of the most celebrated monuments of the world, reads to us almost like desecration, particularly when it is attended by a military band playing the "Blue Danube" waltz.

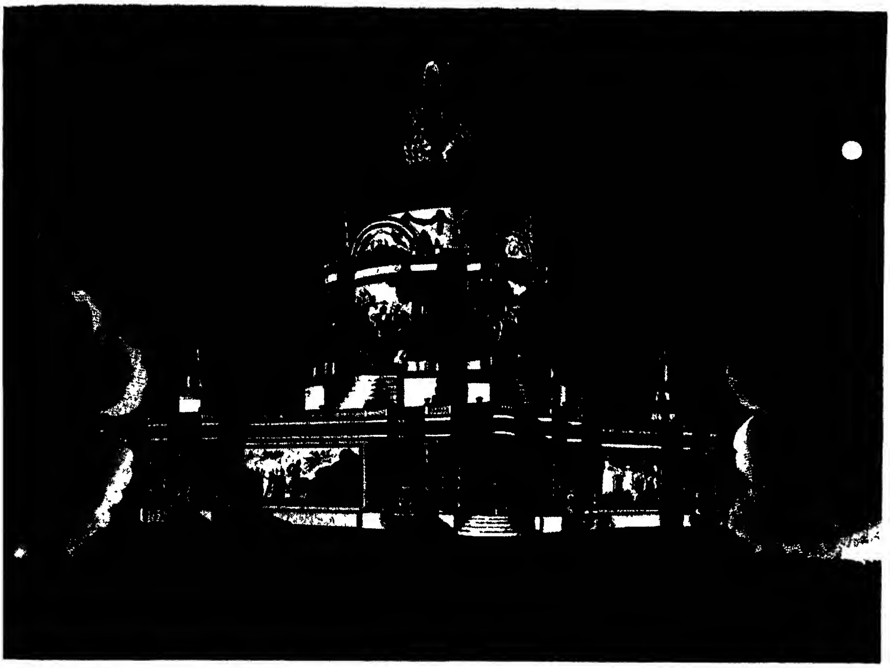
Another report is less censorious. "Brock's coloured Bengal lights last evening imparted to the glorious Mausoleum an inconceivable beauty, blending together on the white marble."

The last display of the tour was that fired at Jeypore on February 11, an event of which the Maharajah expressed his approval "in the form of a Decoration," presented to each of three members of the party—pearl and emerald pendants of considerable value.

Two of the operators remained in the East after the departure of their colleagues, to carry out a series of displays in Siam in connexion with fêtes, the particular purpose of which seems to have been forgotten.

On May 11, 1876, the Prince returned to England. In July of the same year King George I of Greece visited London, and, following the usual routine, was escorted to the Crystal Palace by the Prince and Princess of Wales to see the fireworks. A set-piece depicting the Parthenon, accompanied by the words "Long life to King George the First, King of the Hellenes," was fired in his honour.

Meanwhile preparations were afoot for a pyrotechnic invasion of the New World; C. T. Brock had signed a contract for four displays to be fired at the Philadelphia Centennial Exposition, on a scale never previously approached in the western hemisphere. These displays, one of which attracted more than a quarter of a million spectators, set a standard which, as recorded in *Frank Leslie's Illustrated Newspaper* of October 14, 1876, "far surpassed anything of the kind seen in this country," and even to-day has rarely been approached. The report concludes:



THE GRAND JUBILEE DISPLAY IN GREEN PARK, 1814

'he Castle [*below*] from which a gun has just been fired to announce the ascent of Ar Sadler's balloon, was transformed by a "Grand Metamorphosis" into the "Temple f Concord," although, according to *The Times*, "with somewhat less celerity than those witnessed in our pantomimes."

> The magnificent, and in this country, unparalleled display, ended with a simultaneous *girandole* of two thousand large rockets, which, bursting in mid-air, poured an aerial bouquet of peerless grandure, and filled the air with innumerable orbs of such dazzling splendour that the stars above paled in their presence like candles before a calcium light. The [set] pieces . . . exceeded in extent, diversity, and magnificence anything ever attempted in that line on this side of the Atlantic.

The first display was marred by an unhappy accident, the detonation of a twelve-inch shell in its mortar—in those days an occurrence of melancholy frequency which will be discussed in a later chapter[1]—by which one of the operators, Taylor, was killed. His leg was blown off above the knee, and although Arthur Brock and his next elder brother, William, who had accompanied him to America, both volunteered for the then almost untried operation of direct blood transfusion, the effort to save his life was in vain.

On November 20, 1876, Arthur and William arrived in England from the United States. On the following day they left for India, travelling overland to Marseilles, where they overtook the party of operators already on their way east to eclipse completely the pyrotechnic efforts of the preceding season. They gave two displays, fired at Calcutta and Delhi, to mark the assumption of the title of "Empress of India" by Queen Victoria, at both of which the Prince of Wales was the central figure. Charles travelled out a week or two later and was able to be present at the Delhi Durbar, the greatest assembly of Indian rulers and Princes ever to be gathered together. He always regarded it as a fortunate circumstance that a stampede of the hundreds of elephants present was caused by the firing of the imperial salute of a hundred and one salvoes of three guns each, or by the three *feux de joie* by the infantry, and not by the fireworks, as would certainly have been the case had the display preceded the review.

In 1879, as a result of what he had seen and learned of the possibilities offered by fireworks in the United States, Charles built a factory at Sheepshead Bay, in the neighbourhood of Coney Island, with the intention of establishing an entertainment resort on the lines of the English pleasure gardens, where fireworks should be the principal attraction. The project, however, never developed as it should have done, partly, no doubt, owing to the difficulty of exercising adequate supervision at such a distance from headquarters, but mainly as the result of a deliberate policy

[1] See Chapter XIV.

on the part of the two employees who had been sent out to undertake the executive and practical management of the project, who, when Charles decided to close down the factory, came forward with an offer to purchase the goodwill and plant on behalf, as it afterwards appeared, of a syndicate. One is not surprised to learn that the purchase price was never paid.

It is possible that a contributory cause of the failure of the project was Charles Brock's failing health, which was certainly not improved by the worry of a protracted legal struggle, lasting from 1875 to 1877, relating to the licence for a new factory at South Norwood. This had been opposed by the local authorities, on the grounds that the proposed factory would be "damaging to the interests of the rate-payers." In considering the details of this unprofitable struggle one is faced by two outstanding facts: one, that with practically the whole area of Surrey, and a great part of Kent, to choose from, Charles had selected what was perhaps the most unsuitable site for a fireworks factory to be found in either county; and, two, that while struggling to prevent the establishment of an industry that, for the next twenty-three years, was to be the principal asset of the locality, the inhabitants were greeting with enthusiasm a progressive project to install a service of steam trams that were to prove as dangerous as they were short-lived, and did more to depreciate local site values than any fancied threat of death and destruction from explosives.

In 1879 a special display was staged at the Crystal Palace on the occasion of a visit by the Duke of Connaught with his bride, whom, as Princess Louise Margaret of Prussia, he had married some four months earlier. They came to see the fireworks again in the following year.

An outstanding pyrotechnic event of 1880 was a display fired at Craig-y-Nos castle, the home of the Marquise de Caux, later Baroness Cederstrom, otherwise Adelina Patti the famous opera singer, to mark her retirement from the public stage.

On March 28, 1881, Charles Thomas Brock died at the age of thirty-seven, and pyrotechny lost one of its greatest exponents. He had, as he avowedly set out to do, raised the art "to a level never before dreamed of, even in the palmiest days of the eighteenth century." Possessed of a curiously impulsive temperament, fruitful of ideas, he planned on an heroic scale. Everything he undertook must be not only the best, but the biggest—or at least bigger than had been achieved before. His were the technical knowledge and the ideas; the work of putting them into practice, particularly in the later years of his career, he was inclined to leave to others. In these assistants he was fortunate; notably in the case of his youngest brother, Arthur, who, from the age of nineteen or twenty, took over the management of the great Crystal Palace displays, and succeeded him in the proprietorship of the business when only twenty-three.

It was not only in the field of public entertainment that Charles left his mark on the craft. As will be seen later,[1] it was upon the suggestions and recommendations embodied in a report written at the request of Captain, later Sir Vivian, Majendie, H.M. Inspector of Explosives, as well as a series of experiments carried out at his factory, that the provisions of the Explosives Act of 1875 were framed—a measure which established firework-making, for the first time in this country, as a properly controlled and rational industry.

[1] Chapter XII.

Chapter IX

FROM 1881 TO THE FIRST WORLD WAR

. . . there were other treats I preferred. . . . Sometimes we would be permitted to stay up to see the fireworks which accompanied "Gala Nights" at the Spa, and from the windows of The Lodge would watch the rockets proffering their golden or tinsel-starred bouquets towards the empty and uncaring heavens, the lines of their stalks, before they burst into flower, momentarily incised in gold upon the darkness.

SIR OSBERT SITWELL, *Left Hand, Right Hand* (1945)

AT his death C. T. Brock left a will which, as has been the case with many such documents, almost succeeded in defeating the very object it was designed to achieve. Under its provisions his brother Arthur inherited the business, subject to the payment of annuities to the testator's mother and wife, and, in view no doubt of Arthur's youth, he appointed his manager, W. H. Jones, as joint trustee, his intention being that his brother should have the advantage of the support, advice, and experience of one who for several years had been the trusted general manager of the firm. In consideration of this service Jones was to have an interest in the profits, in addition to his salary. This, on the face of it, would seem to have been an eminently rational arrangement, but Charles's confidence in his manager was far from being justified.

Shortly before Charles's death Jones, in partnership with a Mr Barber, had taken a lease of the Alexandra Palace, in the hope that his knowledge of firework displays would enable him, by adding their attraction to such others as were offered at that resort, to stem the tide of ill-luck under which it had been submerged since its commencement.

Designed to provide a counterpart to the Crystal Palace in North London and, similarly, constructed from the materials employed in a national exhibition—that at South Kensington in 1862—the Alexandra Palace, after repeated delays and stoppages, opened on May 24, 1873. A fortnight later it was gutted by fire. A scheme of reconstruction was at once embarked upon, and two years later a considerably modified and rather less ambitious building was opened to the public. It was not really a success, despite an attempt to establish it as a firework centre by means of a competition on September 19, 1876, carried out on lines almost exactly similar to that at the Crystal Palace. Indeed, the wording of the Rules and Regulations, the details, and prizes are identical, except that competitors were permitted to display their names in lancework. The organizing pyrotechnist was J. Hodsman, whose address—not published in the announcement—was 'Cremorne,' Love Lane, West Dublin.

The prize-winners included Harrison (a name no longer included in the list of firework firms), Pain, Wilder, Wells, and Henry Brock. The last mentioned was an elder brother of C. T. Brock, who had managed the original family business for his mother after William Brock's death, up to the time when Charles had reunited the two branches in 1872. Henry had then set up as a pyrotechnist on his own account, with a factory first at Walthamstow and later at Harold Wood, near Romford, Essex. In the year following the Alexandra Palace competition he secured a contract for a season of displays there, but they were not on a sufficiently ambitious scale to compete seriously with the Sydenham displays or to affect the fortunes of the resort. It had more than once been offered for sale by auction, and withdrawn, before Jones and Barber obtained their lease. In 1882, notwithstanding that Jones had devoted all his time to the venture, to the exclusion of the duties for which he was being paid, they were declared bankrupt.

By some obscure legal ruling C. T. Brock and Co. were brought into the statement of Jones's affairs, with the outcome that at his death, in 1883, his executors were in a position to demand a substantial sum from the firm in settlement. The result was that, at the early age of twenty-five, Arthur found himself with the sole responsibility for the management of a large and complex business and, in addition, saddled with the necessity of finding a large sum in ready money to satisfy this unlooked-for drain on its resources. The steps he took were fortunate: he approached Samuel Sharp, the head of the Chilworth Gunpowder Company, from whom the Brock family had been buying their powder since 1725, and was immediately granted a loan of the required amount. This he was able to discharge within the next two or three years.

Meanwhile, in the autumn of 1881, Arthur had travelled to Russia in connexion with fêtes, scheduled to cost a million pounds, to celebrate the coronation of Czar Alexander III, whose predecessor had been killed by a nihilist bomb in March of that year.

carried out from its resources at Adelaide in 1885, 1887, and 1888; at Sydney, and at Melbourne for an Exhibition there, in 1886, and again in 1887. These shows were directed by Henry Brock, who had rejoined the main family business. His factory at Harold Wood was placed under the management of the oldest member of the family, John, and so remained until his death in 1906, although it had been, in fact, redundant since 1901, when the Norwood factory had been given up and works, on an unprecedented scale, had been established at Sutton, Surrey.

During the summer of 1885 the King and Queen of Portugal visited the Crystal Palace, accompanied by the Prince and Princess of Wales. That the king was impressed with what he saw is indicated by his instructions to a member of his staff immediately to open negotiations for a display on a similar scale to be fired at Lisbon, in May of the following year, to celebrate the marriage of the Crown Prince to Marie Amélie, the daughter of the Dúc d'Orléans. (Plate XXIV.)

This display was fired from a fleet of hulks and rafts moored in the Tagus and was certainly the most extensive so far to be carried out in such conditions, but it was surpassed two years later by the gigantic display fired, in similar circumstances in the same surroundings, for the state visit of King Oscar II and the Queen of Sweden.

It was well that an interval separated these two exceptional pyrotechnic events, as the year 1887 provided an occasion which taxed the resources, not only of the firm responsible for them, but those of every firework-maker in the country—the Jubilee of Queen Victoria. There was considerable discussion as to the possibility of staging a firework fête in the Green Park in the tradition of similar past occasions: programmes were prepared, but the idea was eventually abandoned. The gap thus left in the list of festivities was, however, very adequately filled by a more than usually magnificent Crystal Palace display, attended by the Prince and Princess of Wales, at which, to quote the *Daily Telegraph* of the day following, "for the first time in her life, the Princess of Wales became a pyrotechnist. Her Royal Highness, through merely touching a button, put an electric current in motion which set the whole [set] piece on fire."

This year the number of visitors to the Crystal Palace in the thirty-three years since its opening at Sydenham is recorded as having reached a total of fifty million; of these it is safe to say that forty million had witnessed the famous pyrotechnic exhibitions.

Almost every city in Great Britain had its display, although some had to wait their turn until some time after the official date. Bombay, Calcutta, Adelaide, Melbourne, and Sydney all celebrated the occasion with fireworks.

Following the celebration of her Jubilee Queen Victoria made —by this time a very rare thing for her—an excursion to the Continent to visit the International Exhibition at Antwerp. There she had the opportunity to witness one of the series of displays in the Crystal Palace manner, but, it is perhaps unnecessary to add, specially modified for the occasion.

On July 6, 1889, the new Shah of Persia, then on a visit to England to be installed as Knight of the Garter, came to the Crystal Palace, in company with the Prince and Princess of Wales and other members of the royal family, to witness a display on an almost unprecedented scale, in which the Star of the Order and the royal visitor's portrait figured as set-pieces.

In the meantime pyrotechny had been making considerable progress in America, where, apart from numerous small firms whose output was chiefly absorbed by the annual "fourth of July" firework celebration, the present "Unexcelled Manufacturing Company" was already carrying out displays on a considerable scale. In addition, however, to these what may be called native activities there were others more calculated to attract the attention of British pyrotechnists: those of James Pain, who was enjoying a very notable series of successes with shows carried out on the lines of those semi-scenic, semi-pyrotechnic exhibitions which for so many years had formed the main attraction at the Surrey Gardens.

James Pain had entered the firework business in the late sixties, assisted by the advice and experience of his maternal uncle, a member of the old pyrotechnist family of Mortram. Manufacturing first on a limited scale in the Walworth Road, near the Surrey Gardens, he later established a factory in the then comparatively rural area of Brixton, and later, in 1877, when the provisions of the 1875 Explosives Act had come into force, built extensive works on up-to-date lines at Mitcham, Surrey, where they remain to-day. His enterprise in introducing the pyrotechnic-scenic shows to the American public met with such success that, to avoid the delay entailed in shipping the necessary firework effects from England, to say nothing of the heavy customs duty, a factory was established at Parkville, Long Island.

Inspired, no doubt, by the success of these exhibitions, and undeterred by the two previous unencouraging experiences in overseas branches, Arthur Brock sent his brother-in-law, George M. Ashby, to the States to investigate the possibilities of a further venture there. The latter's report on his return, dated November 1887, gives an interesting picture of the then state of the industry in North America.

The pyrotechnic tastes of the inhabitants of New York were catered for by the "Burning of Moscow," at the Fireworks Amphitheatre, Manhattan Beach, alternating with "Sebastopol" and the "Bombardment of Alexandria"; and "The Fall of Babylon," at St George's, Staten Island, under the management of Imre Kiralfy, who was later to establish the London amusement resort Earls Court, and, in 1908, organized the Franco-British Exhibition at Shepherd's Bush, London. Also on Staten Island, a resort known as "Erastina" had staged similar spectacles, but was now featuring Buffalo Bill's "Wild West."

At Atlantic City, the seaside resort of Philadelphia, the "Last Days of Pompeii" with the "Bombardment of Alexandria" were doing good business. A firework-maker from Philadelphia, named Jackson, was also giving displays at the resort. At St Louis, in the "Cable Amphitheatre," the terminus of the Cable Railway, the "Last Days of Pompeii" with the eruption of Mt Vesuvius was being shown. Chicago was without any entertainment of the kind that year owing to an embargo on fireworks following an accident during a display in 1886. However, the ban appears to have been lifted in the following year, when the "Last Days of Pompeii" was produced during the "World's Pastimes Exhibition." "The Burning of Moscow" was being shown at Louisville, Kentucky, supplemented by the engagement between the warships *Merrimac* and *Monitor*, of the Civil War, on a site occupied by the Louisville Exposition, in 1883. "Rome under Nero," ending, of course, with the burning of the city, was being produced on the Campus at Cincinnati, with the local volunteers acting as supers, their Colonel in the rôle of Nero, and "a host of prominent citizens as Senators."

At that time there appeared to be no regulations of any kind governing the manufacture and storage of fireworks in the United States. Wages were low in comparison with rates of pay in England: women workers received five dollars a week, working hours depending on the duration of daylight, there being no artificial light in any factory; skilled men earned two dollars a day. There were no manufacturers farther west than Chicago, where the

Morris Fireworks Company had a factory. No display of any kind had, up to that time, been seen in San Francisco.

In 1891 a great display was given at Amsterdam in celebration of the succession of the eleven-year-old Queen Wilhelmina to the throne of Holland, at which several Continental royalties were present. On July 11 of that year the Emperor and Empress of Germany saw a particularly lavish display at the Crystal Palace, in perfect weather conditions, with the "Battle of Trafalgar," 650 feet in length, as the main set-piece. At the conclusion of the show the Emperor asked that the pyrotechnist should be presented to him. After some complimentary remarks on the display he added that the Dutch, judging by what he had seen recently at Amsterdam, were skilful pyrotechnists. "I think if you had seen that display you would have admitted its excellence," he concluded.

"Yes, your Majesty," Arthur Brock replied. "I admit it, without question. I supplied the display."

A series of Crystal Palace displays that year provided one of the principal attractions at the Bremen International Exhibition.

The year 1892 saw the culmination of the efforts of British pyrotechnists in the United States. Brock and Pain were firing displays in competition at Manhattan Beach. Pain was continuing his successes with scenic shows in many cities of the Union, and had secured the season's contract for the Chicago World's Fair, and on October 10 Brock fired what is perhaps still the greatest display ever fired in the United States, that from Brooklyn Bridge, for the New York Columbian Celebration (Plate XXV). The most spectacular item was a "Niagara of Fire," falling into the river for the whole length of the central span. It was estimated that "the spectators from the New York, Brooklyn, and New Jersey shores numbered fully a million, while thousands more watched from the innumerable boats on the East River."

A display by the Consolidated Fireworks Company of America was fired from the same position on the following evening.

On August 23, 1892, the Shah of Persia was again entertained at the Crystal Palace, and was indirectly responsible for the inception of an item which became traditional and may well have originated the cult of so-called 'community singing.' An outstanding item of the display was a portrait (Plate XIX) of the Shah. As it commenced to burn the band, conducted by Herbert Godfrey, struck up the Persian national anthem, or, if not that, a piece considered appropriate to the occasion. The massed crowd, however, had other views; there was at the time a popular and topical music-hall song, "Have you seen the Shah?"[1] This the spectators began to sing, and went on singing. The band fell in with the popular decision and followed with the accompaniment.

The Shah was delighted; probably able to distinguish one word only of the song, he accepted the resounding chorus as a well-organized tribute to himself. Thence onward—at least, as long as popular songs continued to have singable choruses—the song of the day, suitably depicted in fireworks and accompanied by the band, remained a popular feature of the Palace displays.

During the next twenty years British pyrotechnists found ample opportunity to demonstrate their skill among the many exhibitions to be organized, on the continent of Europe as well as farther afield. Displays in the Crystal Palace tradition were staged throughout the periods of exhibition at Dresden, 1894 and 1899; Lübeck 1895; Kiel 1896; Düsseldorf 1902; Cape Town 1904; Liége 1905; Marseilles 1906; Milan 1906; Bordeaux 1907; Rio de Janeiro 1908; Valencia 1909; and Brussels 1909.

In August 1896 the legendary pre-eminence of Chinese firework-makers was once and for all time disproved by a visit to the Crystal Palace by the Chinese Viceroy, Li Hung Chang, to attend a dinner, to which he was entertained by the London committee of the Hong Kong and Shanghai Banking Corporation. He had to come to Europe to attend the coronation of the Czar of Russia, and had visited Germany, Belgium, and France on his way to this country. It is perhaps unnecessary to add that a firework display followed the dinner. The main set-piece was the façade of a Chinese temple before which Oriental jugglers performed the traditional tricks of their trade. A piece in Chinese characters—which he remarked were "especially well-formed"—wishing him long life and happiness, was fired electrically by the visitor.

The *Daily Telegraph* of August 11 commented:

> The Chinese Pagoda, which was very successful, and the bicycle race also, interested Li Hung Chang so greatly that he rose from his seat. With Mr Brock he had some conversation. He was particularly anxious to learn how the change of the colours was effected, and he repeatedly congratulated the manufacturer on his skill. He had, he said, seen firework displays in Germany, but they were not "half as good as these at the Crystal Palace." Mr Brock asked him how the latter compared with firework displays in China, and Li said they were

[1] "Have you seen the Shah,
Smoking his cigar?
Forty wives and two black eyes.
Have you seen the Shah?"

much superior in England, and he invited Mr Brock to come over and teach his countrymen in the tenth month.

According to the *Daily News* the Chinese visitors were delighted, and they could talk of nothing but the fireworks as they journeyed back to Town.

Queen Victoria's Diamond Jubilee in 1897 brought one of those harvests that provide the highlights of the pyrotechnist's career. Throughout Britain and the Empire the event was celebrated on an unprecedented scale. The number of displays fired in the United Kingdom left very few operators available for work overseas. Durban and Sydney staged full-scale displays, and Trinidad combined the celebration of the Jubilee with rejoicings for a hundred years of British rule. Elsewhere in the Empire the manpower difficulty was met very successfully by sending out complete displays with directions for amateur firing. Outstanding among these was the display dispatched to Blantyre, Nyasaland, which was carried three hundred miles from the mouth of the Zambezi by cart, canoe, and on the heads of porters by jungle path, by river, and through swamp, to be fired on the appointed day, complete with a portrait of the queen, before a huge crowd of wondering natives.

In 1898 the four hundredth anniversary of Vasco da Gama's voyage to India was commemorated by a fête at Lisbon, for which the fireworks were provided by the British pyrotechnist Pain.

A unique pyrotechnic event during 1899 was the display at Rabat, ordered by the young Sultan of Morocco, Abdul-Aziz IV, which seems to have been an expression of his determination to embrace Western ideas following the death of his dictatorial and reactionary wazir, Ahmed ben Musa. At any rate, it provided the operator who carried it out with anecdotes sufficient to last him for the remainder of his life.

What came to be known as the "Ophir Tour" of the Duke and Duchess of York, in 1901, to inaugurate the new British Commonwealth, provided several opportunities for displays throughout the Empire—in India, Australia, and South Africa.

The Crystal Palace season of 1902 was notable for two events—namley, the return of the Shah of Persia almost exactly ten years after his previous visit, and a peace festival display on July 5. Pyrotechnic activities for the coronation of King Edward VII were thrown badly out of gear by the postponement of the celebration, on account of the king's illness, from July 26 to August 9. However, the loss entailed was to a great extent recouped by a series of displays, on an unprecedented scale, in India, commencing with that in connexion with the Delhi Coronation Durbar on New Year's Day 1903, followed by others at Calcutta, Bombay, Madras, and Rangoon. These were directed by Arthur Brock's eldest son, Frank Arthur, later Commander Brock, who died on the Mole at Zeebrugge on April 23, 1918.

A month after his return from India Frank Brock set out for Budapest to conduct what must have been one of the most elaborate fêtes to be staged in Europe since the palmy days of Napoleon III. The show included a colossal aerial display from the crest of the Blochsberg mountain, and illuminations of the royal palace, the riverside boulevards, and the bridges—among which the suspension bridge, which figured in the display there in 1857, again played its part [Plate XXIV].

> As night fell over the beautiful Danube and the glorious blaze of English fire burst into the sky with a roar which shook the towering Blochsberg, the multitudes lining the river on either side swayed in the vivid light. From venerable Emperor to poorest workman, all Budapest came forth to see the beautiful city clothed in a sheen of borrowed light; they gazed in wonder, and in imagination visited the London Crystal Palace of world renown.

The newly created Prince of Wales paid a visit to the Crystal Palace, his first since 1882, when he saw a display there in company with his elder brother, the Duke of Clarence, on their return from a voyage round the world in H.M.S. *Bacchante*, a representation of which formed one of the main items of the show.

An outstanding pyrotechnic event, in August 1905, was the display fired from the assembled British warships at Spithead on the occasion of the visit of the French fleet, a manifestation of the *entente cordiale*. The fireworks, which were directed by Frank Brock, were discharged from fifty-eight ships, and in all six thousand men took part. *The Times* of August 9 commented:

> It is scarcely possible to convey by description any adequate idea of the scene presented last night by the illumination of the combined fleets and the display of fireworks by the Channel Fleet. The epithets 'magnificent,' 'brilliant,' 'imposing,' 'effective,' 'successful,' are all summed up in one word, 'unprecedented.'

In the winter of 1905–6 the Prince and Princess of Wales again travelled to India. Firework displays greeted the royal visitors at Delhi, Indore, Mysore, and Bangalore. On July 9 following there occurred what was then a unique event in pyrotechnic history, a display of daylight fireworks on the lawn of Buckingham Palace. The occasion was a children's garden party to celebrate the birthday of H.R.H. Princess Victoria, daughter of King Edward VII. Not since 1762[1] had anything of the kind been staged at the Palace; that the innovation was appreciated is indicated by its being repeated in each of the following three years. The only display of orthodox night fireworks to be given there was that I had the honour of directing for His Majesty's birthday party on December 14, 1938.

A meeting between the Amir of Afghanistan and the Viceroy of India at Agra, early in 1907, provided the occasion for an outstanding display, by which the royal visitor, who was seeing English fireworks for the first time, was greatly impressed, as was without doubt the intention.

In July 1908 the tercentenary of the founding of the city of Quebec was celebrated by a fête to which the Prince of Wales travelled out in H.M.S. *Indomitable*. The outstanding item of the festivities was the greatest display of fireworks ever to be staged on the American continent, which I directed. The firing site was at Levis, across the St Lawrence river from the city (Plate XXV). The portraits displayed included: Cartier, who, in 1535, first navigated the St Lawrence; Kings Henry IV of France and Edward VII of England; and the opposing generals, Montcalm and Wolfe, both of whom were killed in the battle of the Heights of Abraham.

The same year two Brock operators enjoyed an unusual experience when they went out to Dahomey to fire a series of displays in connexion with the Agricultural Exhibition there.

The Franco-British Exhibition at the White City, Shepherd's Bush, London, was an outstanding event in 1908. Fireworks were provided in the adjoining stadium, built for the Olympic Games, but suffered under the handicaps common to all such firing sites —the lack of wind to carry away the smoke, the interference with the view of the aerial fireworks of many of the spectators by the overhanging roofs of the stands, and the absence of any foliage or natural features.

Undoubtedly the best display connected with the Olympiad was that arranged by the American "Champagne King" Kessler at his house at Bourne End, on the Thames. This eccentric millionaire had achieved a reputation for fantastic parties: a Venetian dinner served to his guests floating in gondolas in the flooded

[1] See p. 52.

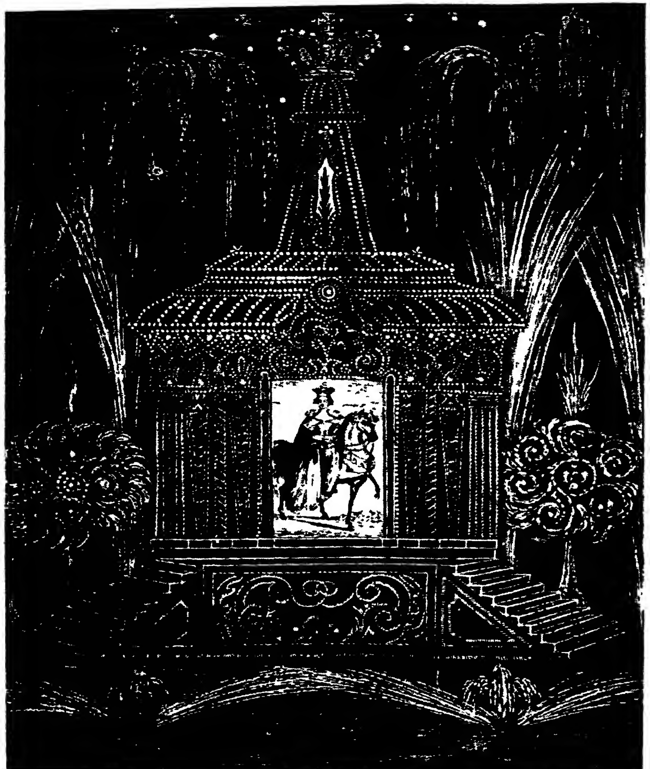
ballroom of the Savoy Hotel; an arctic dinner in real ice igloos; and others almost as odd. His idea now was to give a firework display, combined with an illumination of his grounds, in which the events of the Olympic Games were portrayed in fireworks—running, boxing, wrestling, rowing, and so on. The majority of these items were 'living fireworks'[1] in which men, dressed in asbestos suits and fitted with the suitably designed frameworks, outlined in fire, went through the appropriate evolutions. The show was an enormous success, but it was eclipsed by an unrehearsed incident at a modified repeat performance given two years later. The host and his guests had been viewing the lamp illuminations of the grounds from a launch on the river, and the boat had run alongside the marble landing-stage for the party to disembark. It had previously been arranged that the stepping ashore of the millionaire was to be the signal for a surprise illumination of the whole scene by large masses of coloured fire. This the boatman, who was in the secret, was determined not to miss, and in his anxiety omitted to hold the launch against the stage. Kessler stepped forward and the fires blazed up to illuminate a fountain of spray; a moment later the host's bearded head, with its Panama hat still in place, appeared in the widening gap between the vessel and the shore.

An innovation at the Crystal Palace during the year 1909 was a scenic presentation 'invasion,' depicting with, as it turned out, remarkably prophetic accuracy the Zeppelin raids of six years later. This spectacle was staged on the football ground, and alternated with the more orthodox displays on the Firework Terrace—that on August Bank Holiday attracting 80,000 visitors.

The Union of South Africa was celebrated in May 1910 by displays at Pretoria, Johannesburg, and Durban attended by the Duke of Connaught. In December of that year there began a series of displays lasting three months at the Allahabad Exhibition, the first undertaking of the kind to be carried out in India. These were under my direction, and drew immense and delighted crowds from the pilgrims to the Magh-mela bathing festival, which coincided with the period of the Exhibition. Hundreds of families would take up their position by the firing site on the evening of the day preceding a display and camp out there for the intervening twenty-four hours.

The presence of a pyrotechnist in India with apparently unlimited supplies aroused the interest of certain native rulers, with

[1] See Plate XXI.



QUEEN VICTORIA'S CORONATION DISPLAY

Mirror magazine

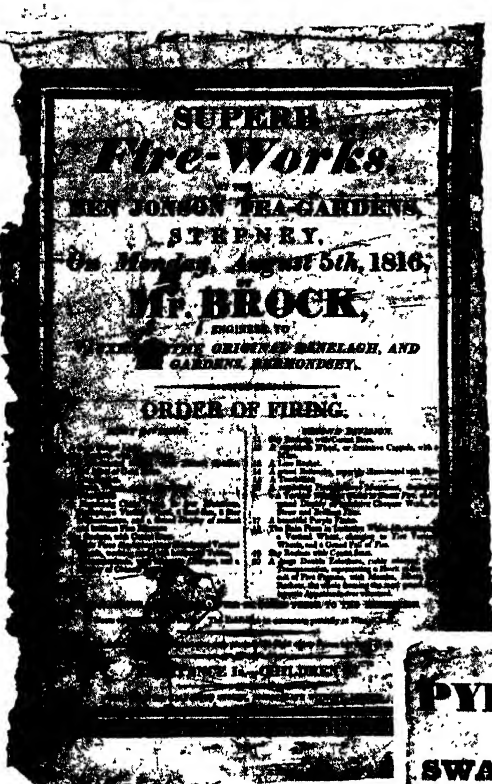
[*See p.* 75.]

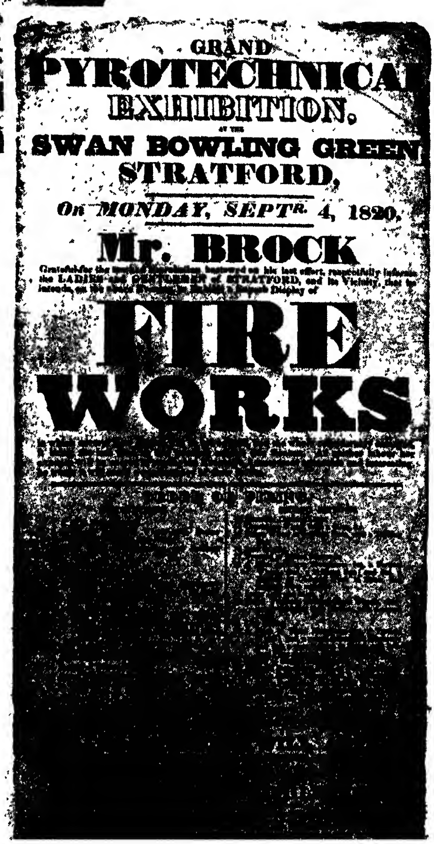
FIREWORKS AT VAUXHALL GARDENS

Illustrated London News

[*See pp.* 59 *and* 60.]

PLATE XIV





OLD FIREWORKS BILLS
[*See p.* 64.]

the result that I had the experience of carrying out additional displays for the Rajahs of Kapurthala, Bikaner, and Freedcote.

The coronation of King George V and Queen Mary on June 22, 1911, was the occasion for pyrotechnic celebrations at home and throughout the Empire. In November their Majesties set out on a Coronation Tour to India. What must have been the first full-scale firework display to be fired there greeted them at Aden on November 25. The climax of their journey was the Delhi Durbar, with what was, according to official comment, "universally regarded as the best display which has ever been given in the city," and Delhi had in its time been the scene of some notable displays. In December 1912 Frank Brock was present at a pyrotechnic demonstration of another kind in Delhi; the attempt to assassinate Lord Hardinge during his state entry as Viceroy. A bomb thrown from a building adjoining the route of the procession struck the silver howdah in which the Viceroy and Lady Hardinge were riding, and exploded with great force. Parts of the metalwork of the howdah were driven into Lord Hardinge's back; one of the attendants standing behind him was killed and his companion severely wounded. Several members of the crowd were either killed or wounded. My brother, who gave evidence at the subsequent inquiry, was able to show, from yellow stains left by the explosion on the silver, that the explosive used was a mixture of potassium chlorate and arsenic sulphide, a very sensitive compound much favoured by Indian terrorists. It was employed in a bomb thrown at Gandhi during one of his prayer meetings shortly before his murder.

The Olympic Games of 1912 in Stockholm served as an opportunity to introduce Crystal Palace displays into Scandinavia, although the neighbouring country, Denmark, had enthusiastically supported a series at Copenhagen in the previous year.

The year 1913 and the first half of 1914 seem to have suffered pyrotechnically through some premonition of what was to come, although as late as July 1 of the latter year negotiations were still in progress for a series of displays at Düsseldorf—for an exhibition that was, in fact, never held, and of which the chief protagonist was shortly afterwards arrested and imprisoned for lese-majesty towards Kaiser Wilhelm. Already firework-makers were beginning to adjust themselves and their factories to the production of wartime needs. With the outbreak of war peacetime fireworks of all descriptions were banned, but manufacturers within a very short period found their plants inadequate to deal with the demands for pyrotechnic war stores.

It is interesting to record that the last public display to be fired in the United Kingdom during 1914 was that at Scarborough Spa, by special dispensation, a week after the declaration of war. It has not been suggested, as far as I am aware, that this event had any connexion with the enemy bombardment which the town suffered a few weeks later.

Chapter X

THE TWENTIETH CENTURY, 1916–48

"What do you think of a brilliant display of fireworks?" said Mr Crummles.

"That it would be rather expensive," replied Nicholas drily.

"Eighteenpence would do it," said Mr Crummles. "You on the top of a pair of steps. . . . Farewell as a transparency behind; and nine people in the wings with a squib in each hand—all the dozen and a half going off at once—it would be very grand—awful from the front, quite awful."

CHARLES DICKENS, *Nicholas Nickleby*, Chapter XXX (1839)

AT the conclusion of the First World War, in which British firework-makers had played their part to an extent that, even allowing for the enormously increased scale of the operations, was at its commencement quite unforeseen, the readjustment to peacetime routine took place with considerably more celerity than was the case after the more recent struggle. Peace was signed in Versailles on June 28, 1919; a week later the order was given for the most extensive display of fireworks ever yet fired. The date selected was July 19, so that fifteen days only were left in which to prepare for the event. One cannot help thinking that it was a fortunate circumstance that the fashion for elaborate 'machines,' 'Temples of Concord,' and their like had expired.

On July 10 my father and I selected the site for the display in Hyde Park, a stretch of ground backing on the Serpentine, with a frontage of five hundred yards along the walk from the eastern end of the water to the Victoria Gate. The display was to include, besides portraits of the King and Queen and those of the war heroes, suitable word pieces, wheels, and other devices, the greatest concentration of aerial fireworks ever fired; shells of calibre 16 in. down to 5½ in. in salvoes of three to fifty at each discharge; rockets of 1 lb. calibre in flights of a hundred, and a final flight of 2000; Roman candles in batteries of two hundred, with fire-jets in proportion, and a cascade a thousand feet in length.

At five o'clock everything was in readiness, with four hours remaining before the official time of firing. At almost precisely that moment the rain commenced to fall, and continued. As far as is possible to do so the ground works had been waterproofed, but even so in some instances—in particular the pictorial lancework pieces—the persistent downpour gained the upper hand. Nevertheless the display was undoubtedly an enormous success, as the comments in the Press show. The *Daily Telegraph* remarked: ". . . the great bulk of the people waited patiently for nearly three hours, with water collecting in puddles at their feet. The show was worth it." The *Morning Post*:

> This vast throng . . . waited for its feast of wonder, like a patient multitude in old time awaiting miracles. Nor were they disappointed, as their roars of testimony went to show . . . a marvellous pageant of space and night and fire. In spectral Beauty Brock outdid the far-famed Brocken.

The Times: "A wonderful display. Would that one could describe it in the true pyrotechnic language. . . ." The *Daily News*:

> The effect was a complex of sensations that it only seems possible to express by the use of too many adjectives. The show was undoubtedly vastly more marvellous than anything of the kind seen in this country before. . . . It fitted as few things do, one's idea of the colossal.

The reporter of the *Warrington Guardian* confessed: "Never in my life have I seen such fiery wonders, and never since the world began had such fireworks as these been seen before." Plate XXVI is a composite picture of photographic records of the effects produced.

This, the first national firework spectacle to be staged in London since the displays that marked the ending of the Crimean War, was, it is estimated, seen by a larger number of spectators than ever previously gathered for a similar, or, indeed, any, single event. These included the king and queen, as well as other members of the royal family, for whom a platform was erected on the highest part of the roof of Buckingham Palace. Hardly a city throughout the United Kingdom was without its display, and enormous quantities of fireworks were shipped to the Dominions and Colonies. Outstanding among overseas celebrations was the official peace display on December 15 at Bombay, witnessed by the largest crowd ever assembled in the city.

On June 10, 1920, the pyrotechnic glories of the Crystal Palace, which had been in abeyance since 1911 when the resort was taken over by the organizers of the "Festival of Empire," were revived. The displays continued until the end of the 1936 season, when, on November 30, the great building was completely destroyed by fire.

It might be as well, even at this length of time after the event, to correct the report, which appeared in several newspapers of the day, that certain violent explosions heard during the conflagration were due to the ignition of the stores of fireworks in the building. In fact, they were the detonations of dynamite charges, fired at the bases of the supports of the south transept to bring it down before it should become involved and communicate the fire to the south tower. This massive structure, 284 feet in height, constructed to support a tank of 57,228 cubic feet capacity, holding 1576 tons of water, and containing in its fabric 800 tons of iron, stood in a position immediately adjoining Anerley Hill and a closely built-up area. Had it fallen the damage to property would have been very great, and loss of life could hardly have been avoided.

For seventy years the storage and preparation of the fireworks for the displays had been located in the 'engine house,' in the grounds remote from the main building, which had been built to house the pumping engines of an ingenious, but unsuccessful, 'pneumatic railway,' designed to entertain passengers as well as to convey them from the Penge entrance into the grounds to the Palace itself. Its tunnel, presumably, still lies buried and unmarked beneath the soil.

One is surprised to find, however, that on one occasion fireworks were actually manufactured in the central transept of the great building before crowds of interested spectators. This was in 1874—prior, it is to be noted, to the Explosives Act of 1875 coming into force—when "a detachment of Mr Brock's employees" exhibited their skill and workmanship. In all forty operations were demonstrated, from the rolling of small paper cases to the filling of large shells and rockets. The last-mentioned operation is now carried out in isolated buildings carefully screened from each other, and each occupied by not more than two workers. The idea of doing such work before a crowd of sightseers, all bent on a close-up view, would be to-day a pyrotechnist's nightmare, but, of course, in those days no gentleman—or lady—smoked in public. It is with relief that one learns that the demonstration ran its course without any mishap.

On July 24, 1922, the first display—in fact, I believe, the only one—to be fired in Regents Park celebrated the jubilee of the Eastern Telegraph Associated Companies. The space bounded by the Inner Circle, then forming the grounds of the Royal Botanical Society, was the scene of one of the most lavish entertainments of the kind ever held. The gardens were illuminated by 35,000 lamps and lanterns. A banquet for five hundred guests, among whom was the late Duke of Kent, was followed by dancing, variety shows, and other entertainment, both solid and liquid, for a further 2000 visitors, and a firework display worthy of the occasion.

The Wembley Exhibition was London's amusement centre during the summer of 1924. Firework displays were given in the Stadium throughout the season, by Pain, on a scale only limited by the circumscribing nature of the site and those handicaps inherent in such surroundings already referred to.

Two outstanding overseas pyrotechnic occasions of that year were displays in South Africa and Norway. The first of these was directed by Roy Brock, who has since become something of a specialist in the Dominion displays. The occasion was the centenary of the founding of the City of Durban. "The scene at the Beach on Saturday night," we are told, "was more than grand, it was Homeric. The unprecedented magnificence of the Fireworks will long stand out in the memory."[1]

The second was for the Tercentenary Celebrations of Kristiania on September 26; the occasion was marked by the reversion to the city's old name, Oslo. The display, which I directed, was fired from a line of barges, a quarter of a mile in length, moored in the fjord opposite the Castle Akershuis, between which and the seventeenth-century fleet a bombardment was exchanged during the proceedings. This is by far the most extensive display ever to be fired in Scandinavia.

The tour of the Prince of Wales, now the Duke of Windsor during 1925 was punctuated by a whole series of successful displays: at Cape Town, Durban, East London, Maritzburg, Kimberley, King William's Town, Johannesburg, and Pretoria. All were under the direction of Roy Brock.

A display of an unusual type that year was fired at the Crystal Palace for the visitors to the International Railway Conference, to celebrate the centenary of the opening of the first passenger-carrying line. Full-scale reproductions, in fire, of the original locomotive and the latest express engine puffed along the length of the Firework Terrace. The memory of George Stephenson was honoured by a fire portrait sixty feet in height.

In 1928 Johannesburg saluted its promotion from the status of town to that of city by a particularly ambitious firework display.

The wedding of Crown Prince Umberto of Italy to Princess

[1] *Natal Advertiser.*

Marie José of Belgium provided the occasion for great pyrotechnic celebrations throughout Italy in 1930. Outstanding among these was the display fired from the Janiculum Hill at Rome, which opened and concluded with traditional girandoles, each of four thousand rockets. In the following year the Prince of Wales went to the British Empire Trade Exhibition at Buenos Aires, which was very suitably marked by a display of Crystal Palace fireworks. In 1933 the largest crowds ever assembled in Finland watched with enthusiastic astonishment what must have been the first full-scale displays to be fired in that country, during 'British Week' in Helsingfors. In the same year Bulawayo celebrated similarly the fortieth anniversary of its foundation.

Then, in May 1935, there occurred one of those outstanding events which mean 'capacity business' for all pyrotechnists. This was the Silver Jubilee of King George V. Although there was no official firework display in London, the Crystal Palace supplied the deficiency with a show of suitable proportions. This was repeated later in the year when the late Duke of Kent made the last of the long series of royal visits to the resort. Somewhere in the neighbourhood of three hundred displays marked the occasion in the United Kingdom. Seventy-six were fired in various parts of Africa, eight in the West Indies, one in British Honduras, and two in British Guiana. Other unusual locations were Aden, Mauritius, and the Fiji Islands. Displays on a grand scale were fired at Bombay and Karachi, and a unique event was the Viceregal Silver Jubilee Tattoo, at which the display was witnessed, according to an official estimate, by "twenty-five thousand people, perhaps the largest crowd ever assembled in Simla."

These Empire-wide celebrations were still fresh in the public mind when, on January 20, 1936, King George V died, and Edward VIII was proclaimed king. The date of the new king's coronation was fixed, and pyrotechnists commenced their preparations for the forthcoming celebration of the event, fixed for May 1937. Then in December came the abdication; for a short time it seemed that the loss and confusion occasioned by the illness of King Edward VII on the eve of his coronation would be repeated. Fortunately the date originally fixed was confirmed, and, from the firework-makers' point of view at least, all was well. Festivities almost exactly similar to those for the Silver Jubilee were staged at the majority of places where that event had been celebrated pyrotechnically. There was, however, one notable and melancholy exception: the destruction of the Crystal Palace, on November 30, 1936, had prevented any possibility of a display that would be worthy of the occasion being staged there.

Perhaps the outstanding pyrotechnic spectacle of the festivities, of brief duration, but impressive to the point of bewilderment, was the simultaneous flight of a hundred thousand rockets of the largest size fired from the decks of the ships of the fleet during the searchlight display at the coronation review at Spithead—a sight which those who witnessed it are not likely to forget.

Following and in continuation of the national coronation festivities, in which, as Earl Marshal, he had played so strenuous a part, the Duke of Norfolk entertained his tenantry and neighbours to a magnificent aerial and aquatic firework display, combined with an extensive illumination, on the Swanbourne Lake in Arundel Castle park. An additional interest was given to the occasion in that it formed a postponed rejoicing for His Grace's marriage, which had taken place in the previous year.

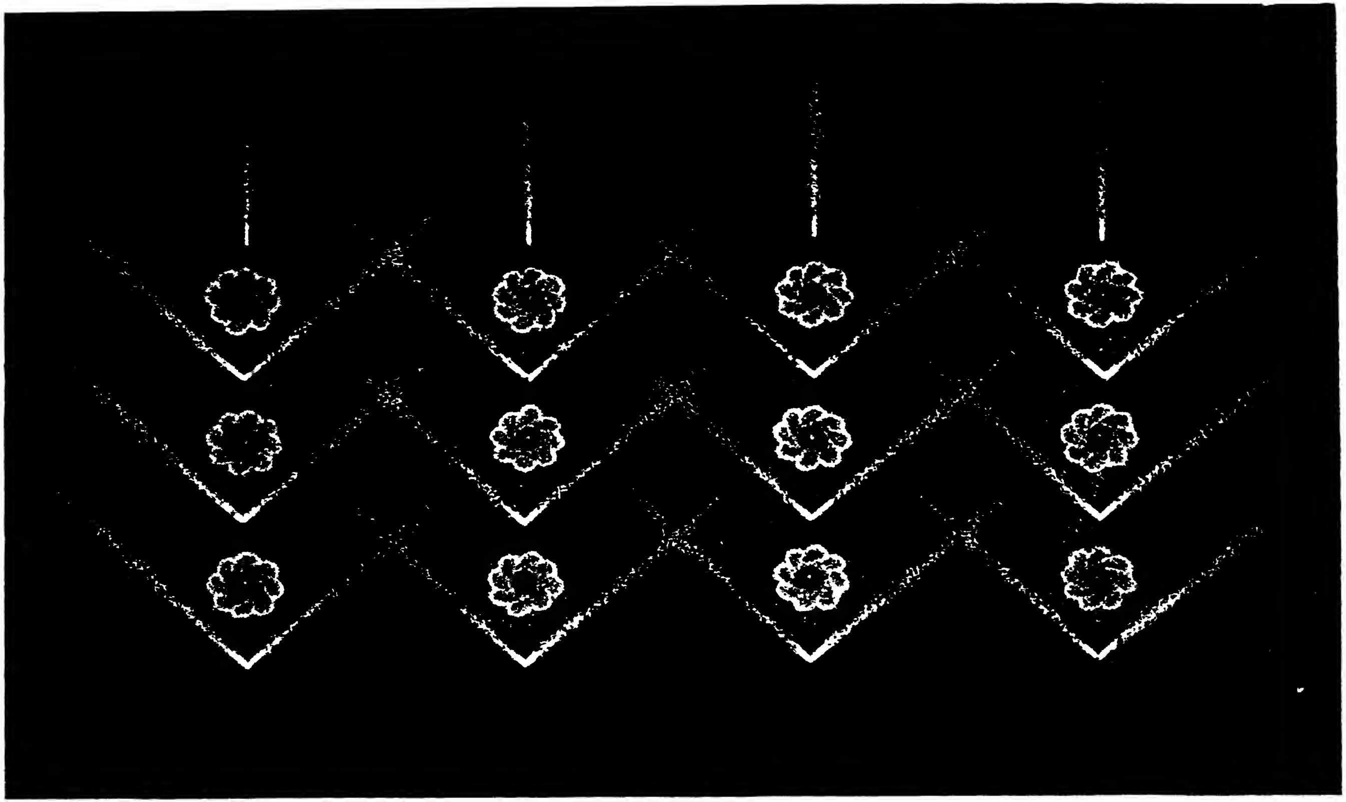
This was only one of a long series of firework festivals of which Arundel had been the scene. The fifteenth duke was a notable patron of the art, and seemed always to welcome any opportunity that might arise through some family or local event for a display on spectacular scale. The coming of age of the present peer, on May 30, 1929, was the occasion of displays not only at Arundel, but at five other of the family seats.

Another enthusiastic amateur of pyrotechny was the late Sir Jeremiah Colman, Bart., whose grounds at Gatton Park, near Reigate, provided an almost unrivalled setting for a great number of displays over a period of forty-four years, from which the charities of Surrey periodically benefited very materially.

From the mansion the park sloped down to an extensive lake, surrounded on its farther side by trees, which by its reflection greatly enhanced the effect of the fireworks, as well as giving opportunity for extensive aquatic displays.

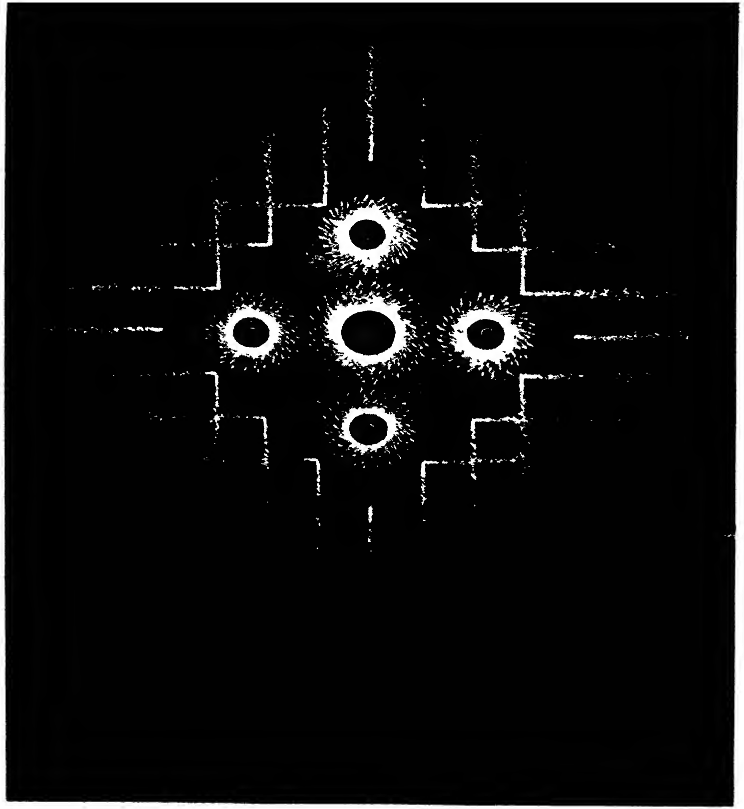
The initial display on the site marked the stay at the mansion of King George V and Queen Mary, then Duke and Duchess of York, who had come to carry out their first official engagement after their marriage in 1893—the opening of Reigate Hospital. The last display was that for His Majesty's coronation in 1911. Long experience had given Sir Jeremiah an almost professional knowledge of the composition and production of displays. It was a very great privilege to collaborate with him.

At the Exposition Internationale, at Paris, in 1937, an attempt was made—not perhaps altogether successfully—to modernize



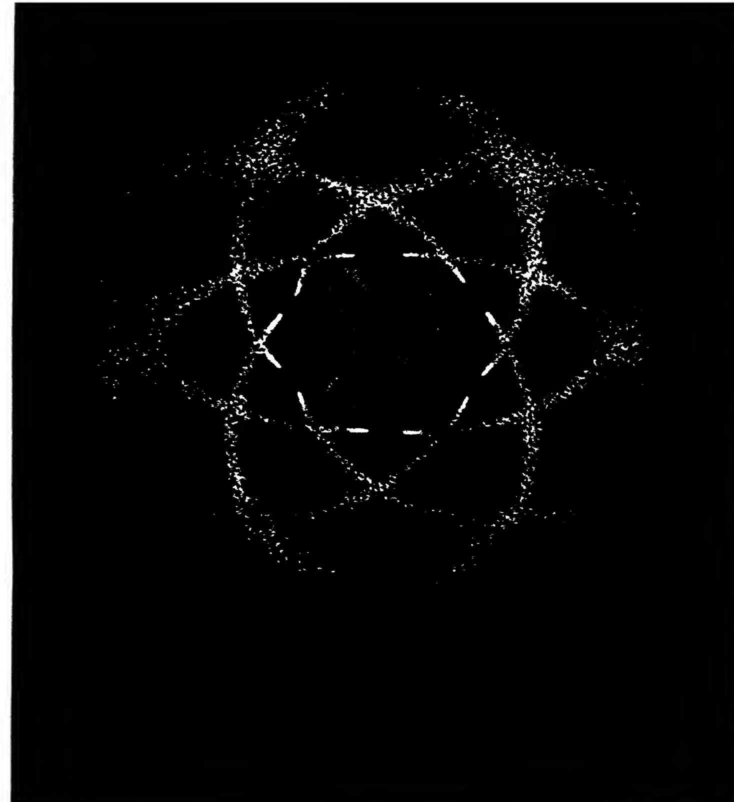
LATTICE POLES

Jets of 'brilliant' fire, forming the "Feux Croisés" of Ruggieri, decorated with coloured saxons. This and the plates facing pp. 121 and 209, possibly the most realistic drawings of firework devices in action ever made, are the work of Phil George.



THE SAXON DIAMOND

A centre of five vertical wheels surrounded by jets of 'brilliant' fire, each of which is 'bounced' so that the piece ends with a 'feu de joie.'



THE CHROMATROPE

The intersecting curves of the outer fire form the "Guilloché" of Ruggieri.

pyrotechny by combining fireworks with other effects—clouds of vapour, illuminated electrically, and coloured searchlight beams. Veritable pyrotechnic discharges from the Eiffel Tower suffered by comparison with the hard brilliancy of electric beams with which they competed. The illumination of the new Trocadéro and its fountains was an outstanding achievement of spectacular beauty.

The belated rearmament measures of 1938 turned the attention of British pyrotechnists to matters other than public entertainment; a pretaste of what was to come during the succeeding years of war.[1]

With peace came the hope that London would once again be the scene of a national firework display. Except for the great Hyde Park display on June 19, 1919, no official pyrotechnic fête had been staged in the capital of the Empire since the four simultaneous displays which marked the peace that concluded the Crimean War. In the meantime the Crystal Palace seems to have been relied upon to fill the gap, but that famous institution had ceased to exist.

Hopes, however, were realized: it was decided that a display worthy of the occasion should form the finale of the victory celebrations to be arranged for June 8, 1946. The site selected was the very same stretch of the river Thames between Lambeth and the Charing Cross Bridge which was first closed to "boats and wherries and other perturbatious multitudes" for the marriage celebrations of Princess Elizabeth and the Prince Palatine in 1613, and which since that date had been the scene of other historic displays, the last being that arranged by the Duke of Richmond in 1749 with fireworks salvaged from the Green Park display of that year.

Such a site, while restricting to some extent the scale and variety of such ground effects as set-pieces and devices, offers several very definite advantages. The water forms a barrier to the encroachment of the public on the firing point and gives opportunity for the display of aquatic items, but perhaps most important is the greatly enhanced effect produced by the reflection from its surface.

The general scheme decided upon was a composite entertainment in which pyrotechnic items were interspersed with a water display of illuminated fountains from twenty specially fitted barges, ten on each side of the river, and eight fire-boats of the National Fire Service anchored in midstream. The former were most ingeniously fitted with fire-pumps to throw a variety of jets, illuminated by R.A.F. runway projectors with lenses of coloured glass. The vessels themselves were Canadian-built wooden barges

[1] See Chapter XXI.

prepared for the invasion of Europe, as were those, thirty in number, that composed the platform from which the floating portion of the firework display was fired. During the proceedings twenty searchlights of A.A. Command projected coloured beams over the portion of the river reserved for the display.

The actual firework display, which I had the task of devising, as well as the honour of personally directing from the top of the bomb-scarred St Thomas's Hospital, included by far the most extensive discharge of aerial fireworks ever fired. Of this part of the display, the larger shells—from 8 in. to 25 in. calibre—and the rockets were fired from a bombed site fronting the river on the Surrey side between the County Hall and Charing Cross Bridge. Unfortunately, in the interval between its selection and the date of the display, a large part of this area had become covered with a mountain of brick debris, to be used in a crushing plant established there, a circumstance which rendered the firing of the rockets, in a considerable wind, a task of some difficulty.

In all seven hundred and fifty shells, of 4½, 5½, 8, 10, 12, 16, and 25 in. calibre, were discharged—from 4½ in. in salvoes of fifty to single 25 in. Rockets of 1 lb. calibre were fired in flights of two hundred, Roman candles in batteries of two hundred, and large mines in salvoes of two hundred and fifty. In all some three thousand aquatic fireworks of the largest size were employed. Special features were the two dazzling cascades of fire which spanned the entire width of the river—over 300 yards—falling into the water from a height of fifty feet. These, as well as colonnades of a hundred jewel jets, were displayed from two temporary bridges which had been erected against wartime emergencies, one opposite the Tate Gallery, the other just below the County Hall.

Their Majesties, accompanied by Princess Elizabeth and Princess Margaret, embarked in the royal barge at Cadogan Pier, Chelsea. Followed by the barge of the C.-in-C. at the Nore and escorted by craft of the River Police and the National Fire Service, the royal family arrived at the terrace of the House of Commons at ten o'clock exactly. As the party disembarked the flood-lit royal standard was broken from the flagstaff of the Victoria Tower and a royal salute of forty-one[1] maroons was fired.

The firework and water display commenced at 10.20 and continued to 11.45, watched by the royal party from the Lord Chancellor's lodgings in the Palace of Westminster. (See Plate XXVII.)

[1] By ancient custom the number of a royal salute in London only, on triumphant occasions when the King is in procession.

As we watched the show from the control position, we knew that the little vessel moored at the end of the terrace was the *Water Gipsy*, with her skipper-owner, Petty Officer Sir A. P. Herbert, M.P., late of the Royal Naval Auxiliary Patrol, aboard, and wondered what would be his reaction to our efforts from his ring-side position. His article in the *News of the World*[1] told us:

> Burn the Thames does—and bravely. In the fountains of the N.F.S. her muddy waters turn red, turn silver and gold and green . . . while Handel's Water Music is heard on the water once again.
>
> One by one 200 rockets soar with a roar from her ancient breast, sprinkling the sky with scattered stars.
>
> Now that breast is ablaze with light and carpeted with fire-foam, coming slowly down on the ebb, like floating snow, like the top of a cloud.
>
> In the snow ingenious "water-lilies" are playing—half fireworks, half fountains.
>
> The searchlights fill the sky, as they did in the old days, but this time it is British aircraft they are catching and chasing, and our hearts go up to the R.A.F.
>
> Fireworks rage gloriously up and down the river. Portraits of the King and Queen and Princess Elizabeth are brilliantly painted in flame, and tens of thousands of "Oo's" go up in wonder.
>
> We are looking forward with some trepidation to the Big Bomb, which is to go up not far from Big Ben (on the south side). It is the largest firework shell ever discharged—25 inches in diameter. It is to fill 700 feet of sky with golden rain and who knows what.
>
> Fire and water and music come together in a grand combined operation.
>
> Half a hundred magnesium shells light up the proud City that was dark so long (150,000,000 candle-power, they say: and I should think they are right).
>
> The people sing "God Save the King" and crowd away to their homes, grateful, I think, to those who designed and carried out this brilliant imaginative show—the Triumph of the Thames.
>
> As for us, old boat, the tide is against us and we shall not go home. I shall put up your riding-light now, and here for once we will lie peaceful in these troubled waters, fearing no enemy, and thankful for many things.

The royal tour to South Africa, February to April 1947, was responsible for the greatest and most numerous series of displays the Dominion had yet seen, but the royal family had already been entertained with a pyrotechnic surprise before *Vanguard* reached Cape Town. The occasion is unique. Admiral Agnew had

[1] Quoted by kind permission of the Editor.

arranged that the components of a display, specially designed to suit the circumstances in which it was to be fired, should be shipped, and for Petty Officers and ratings to attend a brief course of instruction at Hemel Hempstead before the vessel sailed. Such instruction, it is perhaps unnecessary to add, related to the assembly of the units of the display and their disposition in respect to safety, and was not inspired by any doubts as to the ability of the Navy to cope effectively with explosives, however unfamiliar.

The result was a highly successful show which brought to a conclusion the ceremony of Crossing the Line.

In all eight full-scale displays were fired under the direction of Roy Brock: at Green Point Common, Cape Town, on February 17, the day of the arrival of the royal family; at East London, March 1; Durban, March 22; Pretoria, March 31; Salisbury, April 9; Livingstone, April 11; Bulawayo, April 14; and on April 21 a specially impressive aerial display in celebration of Princess Elizabeth's twenty-first birthday. (Plate XXVII.)

Several towns, taking advantage of the presence of our staff in the Dominion to gain instruction in pyrotechnic procedure, carried out the firing of their own displays. These included those at Eshowe, Zululand; Gatooma, S. Rhodesia; Alice and Kimberley, In addition no fewer than thirty displays were fired simultaneously, in a line extending for twenty-four miles along the mines of the Rand, on April 1, watched by the royal family from the roof of the highest building in Johannesburg.

The Dominion of New Zealand has had to wait a long time for its first firework display in the Crystal Palace tradition, although a large consignment was sent out, and successfully fired by military personnel, in connexion with fifteen military searchlight tattoos at Auckland, Christchurch, and Wellington, organized by the defence authorities. However, in February 1948 the City of Dunedin celebrated its centenary with a display under the direction of Christopher Brock which, certainly in local estimation, seems to have made up for past deficiency.

Chapter XI

TRADITIONAL FIREWORK FESTIVALS

H.M.S. *Fox*, Baffin Bay, Lat. 75° N., November 5, 1857.

In order to vary our monotonous routine, we determined to celebrate the day; . . . a well-got-up procession sallied forth, marched round the ship . . . and then proceeded to burn the effigy of Guy Fawkes. Their blackened faces, extravagant costumes, flaring torches, and savage yells, frightened away all the dogs; nor was it until after the fireworks were set off and the traitor consumed that they crept back again.

CAPTAIN McCLINTOCK, R.N., LL.D., *The Fate of Franklin* (1859)

FROM earliest times fire has been the natural accessory to open-air observances and festivals. Many annual celebrations which persisted until comparatively recent times—some, indeed, still survive—had their origin in long-forgotten heathen rites. The midsummer fires that formerly blazed from many hill-tops throughout the land on St John's Eve were a survival of Druidical ceremonies. So too were those that once marked May Day and November 1. The 'tewt' hills where they once burned remain in place-names to be found in every county: Toothill Fields, Tottenham, Tattenham Corner, Totteridge, Todmorden, Totnes, and many others.

Hallow-e'en was formerly celebrated with bonfires throughout Scotland and in some parts of England, notably in Sheffield. To-day it annually provides the excuse for countless firework parties in Western Canada. Twelfth Night formerly had its bonfires, but it is possible that these may have had a more utilitarian origin—the disposal of evergreen branches used for Christmas decoration. Be that as it may, at many country towns and villages Candlemas was, perhaps after Guy Fawkes' Day, the outstanding outdoor celebration of the year. At Brough, in Westmorland, the carrying of the holly-tree was a great event. Led by the town band, a procession of torch-bearers escorted the illuminated tree through the streets.

To every branch a torch they tie,
To every torch a light apply,
At each new light send forth huzzas,
Till all the tree is in a blaze;
And then bear it flaming through the town
With minstrelsy, and rocket thrown.

A custom formerly observed throughout England was the lighting of bonfires on hill-tops, or other suitable positions, on February 3, St Blaize's Day. "Apparently for no better reason than the sound of the venerated prelate's name,"[1] Candlemas was similarly celebrated in many places. It is not without some little surprise that we read in *The Gentleman's Magazine* of the grand entertainment "for the judges, sergeants, etc." of the Temple, in 1734, which ended with "the judges, according to an ancient custom, dancing round the coal fire, singing an old French song."

Naturally when fireworks became available for use on such occasions they soon found a place in the proceedings. The addition of an effigy to add a dramatic touch to the ceremony by perishing in the flames was no doubt, in part at least, a survival handed down from the human sacrifices of the Druids.

Until the early part of the last century it was a widespread custom in Germany to welcome the arrival of spring by a fiery ceremony, which, it is suggested, had survived from pre-Roman times. A figure, representing Winter, was tied to a large wooden wheel and covered with straw, which was then lighted and sent rolling and bounding down from the crest of a hill.

Guy Fawkes, as the victim and focus of an annual firework festival, is by no means unique. Hone[2] records a similar rite celebrated annually in Paris on July 3:

> In the year 1518, a soldier coming out of a tavern, in la Rue aux Ours, where he had been gambling and losing his money and clothes . . . as he passed by an image of the Holy Virgin . . . struck it furiously with his knife; on which . . . the image bled abundantly. . . . The wretch was seized, conducted to the spot where he had committed the sacrilege, tied to a post and scourged from six o'clock in the morning till night, till his eyes dropped out; his tongue was bored with a hot iron, and his body was cast into the fire.

For some years the soldier was burned in effigy on the spot, and in course of time, and with the development of pyrotechnics, the figure was elaborated into a firework set-piece which, travelling probably on a line, was made to rise into the air. In 1744, owing to the danger of fire, the magistrates ordered that the ceremony should revert to its original form.

Effigies of Judas, filled with fireworks and suspended from the branches of trees, are burned in great numbers in Mexico during a firework festival in Holy Week. It is said that the burning of such figures was prohibited during the reign of Maximilian, a distinct

[1] Chambers's *Book of Days*, vol. i, p. 219 (1864). [2] *The Everyday Book*, vol. i.

likeness having been remarked between many of them and the Emperor, and their burning often coinciding with the news of reverses suffered by the imperial troops.

Judas is frequently the traditional effigy in the almost innumerable pyrotechnic celebrations that mark the saints' days in the Latin-America countries. He appears, too, complete with bonfires, on the first of November in the annual firework festival of the province of Algarve, in Southern Portugal, and in the Easter Eve celebrations in Seville, in which fireworks play an outstanding part.

Biringuccio, as we have seen,[1] refers to the early association of fireworks and the festivals of the Church of Rome. That association was to continue through the centuries, to reach, eventually, a very high pitch of technical attainment, particularly at Rome. There the most important firework fête was the grand display fired annually from the Castle of St Angelo during the festival of Holy Week and on the anniversary of St Peter—that is on June 29. Others, on an even larger scale, although occurring with less frequency, were those for the inaugurations of the Popes. John Evelyn has left a description of one such event he witnessed on November 23, 1644, when the newly elected Innocent X went in procession to St John de Lateran. "The night ended with fireworkes," he says, not only at St Angelo, but as well as the particular display he describes, before the house of the Spanish Ambassador, in the Piazza del Trinita:

> at least 20 other fires—workes of vast charge and rare art for their invention before divers Ambassadors, Princes and Cardinals' Palaces, especially that on the Castle of St Angelo, being a pyramid of lights.... The streets this night as light as day, full of bonfires, cannon roaring, musiq, fountaines running wine, in all excess of joy and triumph.

An English visitor to Rome in about the year 1825 gives a full account of the display as he saw it, including the Grand Girandola which open and close the display—the simultaneous flights of 4500 rockets. His description is perhaps a little exaggerated, but he was clearly impressed:

> ... an incessant and complicated display of every varied device that imagination could figure—one changing into another, and the beauty of the first effaced by that of the last. Hundreds of immense wheels turned round with such velocity that almost seemed as if demons were whirling them.... Fountains and jets of fire threw up their blazing cascades into the skies: the whole vault of heaven show with the vivid fires and seemed to receive unto itself innumerable stars and

[1] P. 29.

> suns, which shooting up into it in brightness almost insufferable, —vanished—like earth-born hopes. . . . The whole ended on a tremendous burst of fire (the girandola) that, while it lasted, almost seemed to threaten the conflagration of the world.[1]

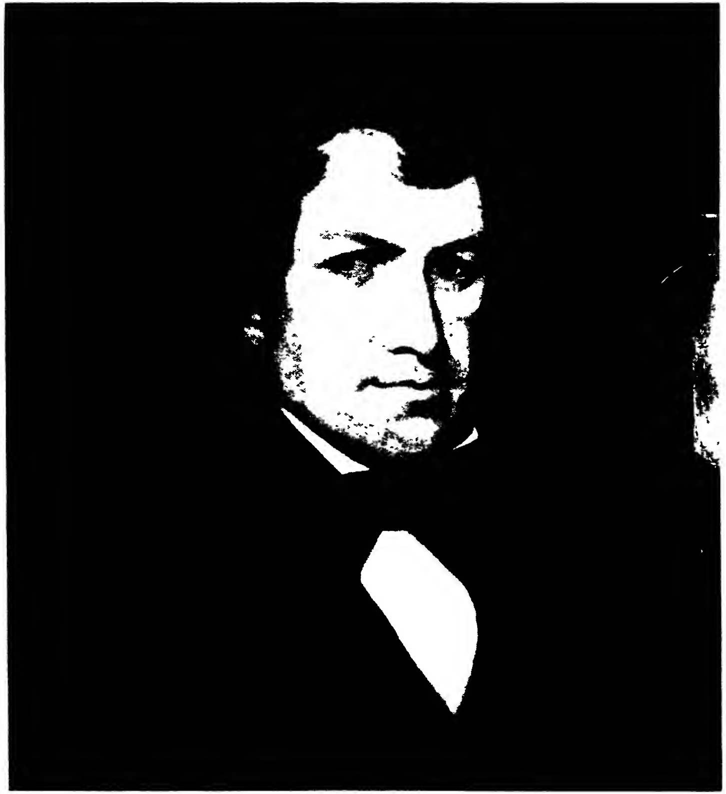
The writer adds that the cost of the displays and illuminations, on which eighty men were then employed, was 1000 crowns for two nights.

A unique pyrotechnic ceremony is the "Scappio del Carro," which takes place annually at Florence on Easter Eve; a survival from over eight centuries, it is claimed—although, for obvious reasons, not in its original form. The 'carro,' or cart, drawn by white oxen with gilded hoofs and horns, on which is a pagoda-like erection filled with fireworks, is drawn up in the square at some distance from the cathedral. From it a wire is stretched, through a window, to the high altar. At noon, after the celebration of Mass, the archbishop lights the fuse to a rocket concealed in the body of an artificial dove, which is attached to the wire. The bird flies along the wire, the fireworks on the cart are ignited, and a second rocket propels it back to its starting-point. The proper completion of the ceremony is regarded as a good omen for a fortunate year to come; any failure or hitch is believed to presage a bad harvest and other misfortunes. It was said that, in harsher times, non-success was visited on the presiding pyrotechnist by death. More recently it was the custom to withhold his fee. Pyrotechnists, however, are often ingenious people. Mr H. Preston-Thomas, who witnessed the ceremony in 1910, relates[2] that on that occasion the rocket burst prematurely when only half-way on its journey. However, the fireworks on the cart went off, apparently, according to plan. The fireworker had thoughtfully provided an electric fuse as an alternative means of ignition.

The island of Malta has long been a centre of pyrotechnic activity, almost every anniversary in the Church calendar being made an occasion for the letting off of fireworks, although, perhaps, in a less well-organized and formal manner than elsewhere. I have been told by a leading philatelist that the comparative rarity of the earlier issues of Maltese stamps is due to the eagerness with which every scrap of waste paper was collected for use by the firework-makers of the island when that most important component for their wares was difficult to come by.

Many nationalities throughout the world have their days of

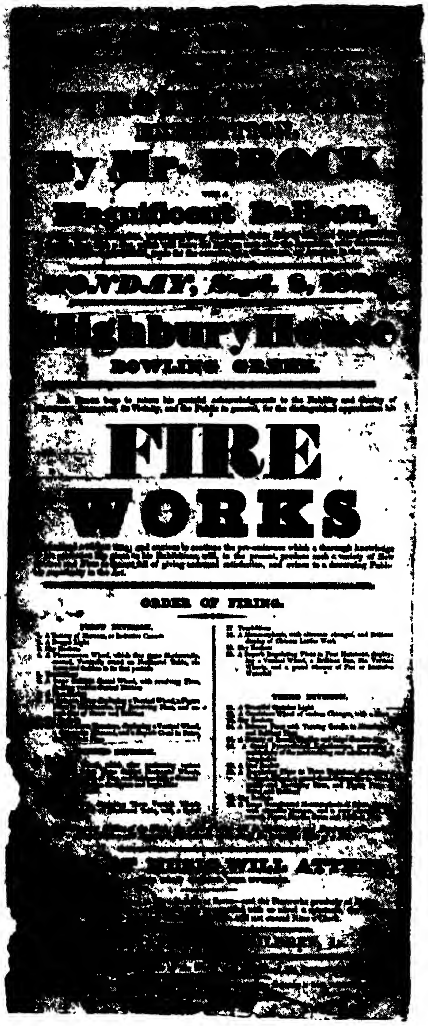
[1] C. E. Eaton, *Rome in the Nineteenth Century*, vol. iii, pp. 117–173 (1820).
[2] *The Work and Play of a Government Inspector* (1909).

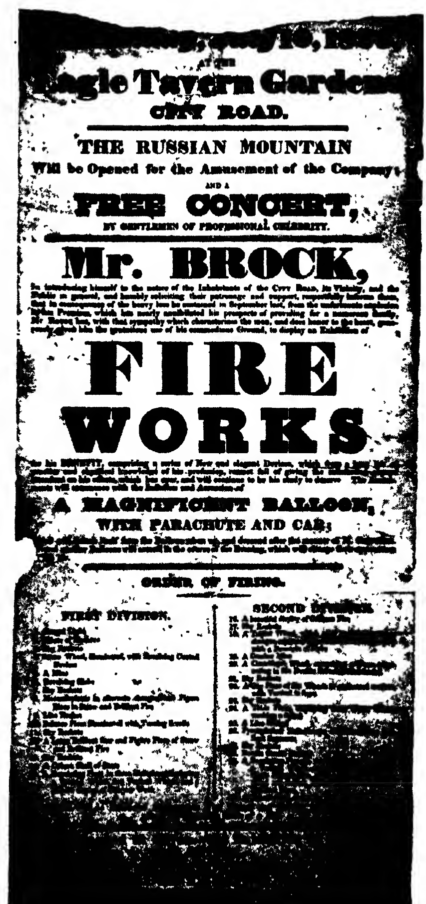


WILLIAM BROCK (1779-1849)
"Engineer to Vauxhall, the original Ranalagh, and Spa Gardens, Bermondsey."

WILLIAM BROCK, JUNIOR (1813-69)

PLATE XVI





MORE OLD FIREWORKS BILLS

That on the right advertises the first recorded "Brock's Benefit."

[*See pp.* 65–66.]

traditional pyrotechnic celebration. July 4, Independence Day, is the national firework festival of the United States, when undoubtedly a greater total quantity of explosive material is expended than in any other national celebration. This despite attempts that have been made from time to time to ban the use of fireworks, on account of the number of accidents that occur; notably the "Safe and Sane Fourth" campaign, launched during the early years of the present century, by which a state of affairs comparable to the liquor prohibition period was created. Even to-day some cities prohibit the sale of "fire-crackers" by local statute, with the result that the civic boundaries are ringed by temporary roadside firework stalls, set up to supply public demand.

Until the date of the 1914–18 war fireworks were rarely seen in the Southern States on the Fourth of July; Christmas Eve was the recognized firework night. The practice is said to have originated with the merrymaking of the plantation slaves, who were given a general holiday.

Cuba also celebrates its Independence Day with fireworks during May, and Bastille Day, July 14, provides the occasion for family, as distinct from civic or national, pyrotechnic entertainment throughout France.

Australian cities observe Guy Fawkes' Day in the English tradition, but in up-country stations Mid-winter Day is the more generally popular firework festival.

London had its annual November firework festival in the years before Guy Fawkes had achieved his eminence as the prescriptive patron of firework revels. The occasion was the Lord Mayor's Show, then a water pageant. In 1566 Sir William Draper, the Lord Mayor, travelled to Westminster in "a foyst, or barge, with ten pairs of oars and masts. The Queen's Arms flowed from the maintop, and a red cross from the foretop, long pendants were added to these, and two ancients[1] displayed on the pope [poop] or baste." The vessel carried "a master and a gunner, with squibs sufficient for the time, well painted and trimmed, with 20 pavases[2] and two half-barrels of gunpowder."

The 'family party' atmosphere which to-day characterizes the celebration of Guy Fawkes' Day was not always the rule. Chambers[3] recalls that

> in former times in London, the burning of the effigy of Guy Fawkes on the 5th of November was a most important and portentous cere-

[1] Standards or ensigns.
[2] Shields emblazoned, no doubt, with the arms of the City companies.
[3] *The Book of Days.*

mony. The bonfire in Lincolns Inn Fields was conducted on an especially magnificent scale. Two hundred cartloads of fuel would sometimes be consumed in the feeding of this single fire, while upwards of thirty 'Guys' would be suspended on gibbets and committed to the flames. Another tremendous pile was heaped up by the butchers in Clare Market. . . . The uproar, throughout the town . . . the ringing of bells . . . and the uproar which prevailed, can but faintly be imagined by an individual of the present day.

He goes on to tell how

the 'Papal Aggression' of 1850 gave a new direction to the genius of 5th of November. Instead of Guy Fawkes, a figure of Cardinal Wiseman, then recently created Archbishop of Westminster by the Pope, was solemnly burned in effigy in London.

In 1857 a similar honour was accorded to Nana Sahib, whose atrocities at Cawnpore in the previous month of July had excited such a cry of horror throughout the civilized world.

Those whose memories carry them back so far will remember when Paul Kruger, the President of the Transvaal, and Kaiser Wilhelm played a similar rôle. In 1855 the Emperor of Russia was a popular choice.

Hone,[1] writing in 1826, recalls the days when,

by ten o'clock, London was so lit up by bonfires and fireworks, that, from the suburbs it was in one red heat. Many were the overthrows of horsemen and carriages, from the discharge of hand-rockets, and the pressure of moving mobs inflamed to violence by drink, and fighting their way against each other.

This account certainly seems to suggest some justification for the attempt on the part of authority to put an end to such excesses, however greatly the firework trade might suffer thereby. One must, however, applaud the ingenuity of Messrs Barlow and Blyth in preparing the quite convincing 'proclamation' reproduced opposite, designed to counter such efforts.

The fact that Barlow was a firework-maker explains, if it does not excuse, the imposture, but one is less prepared to find a clergyman of the Church of England proclaiming similar sentiments from the pulpit. According to the *Liverpool Mail* of November 6, 1846:

The Rev. D. James, on November 5th, preached a sermon at St Simon's Church in which he remarked that Protestantism was full of light and that children should be allowed to burn their bonfires,

[1] *The Everyday Book*, vol. i.

and that rockets, squibs, blue lights and Roman Candles, should be let off on that day to commemorate the event from generation to generation. The security, as well as the permanence of their religion depends on such observances. . . .

By the King's Most Excellent Majesty.

A PROCLAMATION.

GEORGE REX.

To our Right-Trusty and Well-Beloved Cousins; JAMES BARLOW, *and* ALFRED BLYTH, *Beloved, we greet you well.*

Whereas it hath been humbly represented unto us that many of our loving Subjects have been accustomed to commemorate, and in perpetual memory to keep the Fifth day of November yearly, being the Anniversary of the discovery of the wicked, profane, malicious, and detestable conspiracy devised by atrocious men and Traitors against the life, family, and interests of His late Majesty JAMES I. of blessed memory.—And, whereas the letting off of Squibs, Crackers, Rockets, Roman Candles, and other divers kinds and sorts of Fire Works hath very essentially contributed to the pleasure of the aforesaid commemoration, which said Squibs, Crackers, Rockets, &c. are vended, retailed, and sold by many of our loving Subjects —And, whereas it hath been further most humbly represented unto us that the demand for these essential articles of gala consumption, hath of late years been gradually diminishing, to the great injury of the Vendors of the same, and to the manifest disappointment of many of our loving subjects, in whose happiness we take a lively interest: now be it known to all whom it may concern, that we, being desirous of restoring this Branch of Trade to its original state of vigour and prosperity, do, with the advice of our Privy Council, hereby appoint and constitute you the abovementioned J. B. and A. B our Royal Commissioners for soliciting, gathering, and collecting the charitable contributions of our loving and loyal subjects, in aid of this our royal and humane design ;—and we do strictly charge all our subjects aforesaid, to aid by their best exertions, as well as personal contributions, this our royal will and pleasure —Given at our Court, held this Seventeenth day of October, 1822, at our Palace of St. James's, in the Third Year of our Reign.

By His Majesty's Command,

GOD SAVE THE KING. S KIRBY.

BARLOW AND BLYTH'S 'PROCLAMATION' OF 1822

This was doubtless a voluntary effort on the part of the priest, and not comparable with the sermon preached each year in St Peter's Church, Nottingham, on the Sunday nearest to the anniversary of the Plot. In 1630 a citizen named Peter Jackson left by his will the sum of 40s. per annum for the preaching of two sermons "... for the deliverance of this land from the Armada and the Gunpowder Plot."

There are some towns where Guy Fawkes' Day is still observed on a community basis; of these Lewes, in Sussex, and Bridgwater, in Somerset, are outstanding.

At both towns, as well as elsewhere, guilds and clubs of "bonfire boys" in fancy dress and uniforms vie with one another in staging the best display. Many of the fireworks used are home-made, and include items[1] that are excluded from the lists of professional makers for sale to the general public. However, the experience of years has brought into being a satisfactory local technique for dealing with them, and accidents are less frequent than might perhaps be expected.

Throughout the long reign of George III June 4, his birthday, came to be a recognized occasion for general, as well as pyrotechnic, rejoicing. Chamberlain, writing in 1770,[2] the tenth year of the reign, gives an account of one such celebration and of an accident for which it was responsible.

> The fourth of June being his Majesty's birthday, the same was celebrated with more public demonstrations of joy than had ever been known on like occasion. The principal buildings were grandly illuminated, as were most of the private houses in the squares and streets of this metropolis; each vying with the other to express their loyalty to the sovereign, however they disliked the measures of the ministry. A terrible accident happened in the evening on Tower-hill, where were exhibited grand fire-works at the public expence. The populace repaired thither in such shoals, and crowded so fast on each other, that the rails which surrounded a well, on the bank of the ditch, at the postern, gave way, and the multitude fell together about thirty feet deep. By which accident six were taken up dead, fourteen were so hurt that they died of their wounds, and many others were most dreadfully bruised.

This unhappy event was not allowed to interfere with the observance, which continued annually for many years, although, it is probable, to somewhat less numerous spectators. The proprietors of the pleasure gardens were quick to realize that the anniversary offered a good opportunity for private enterprise and that a display specially advertised for the occasion would prove an attraction. Indeed, these commercial efforts seem to have out-

[1] "Louis Rousers" and "Bridgwater Squibs."
[2] *History and Survey of the Cities of London and Westminster.*

lasted that provided "at the public expence." Strutt, writing in 1801,[1] remarks:

> It was customary, in my memory, for the train of artillery annually to display a grand firework upon Tower-hill on the evening of his Majesty's birth-day. This spectacle has been discontinued for several years in compliance with a petition for that purpose made by the inhabitants on account of the inconveniences they sustained thereby.

An instance of such unpleasantness is recorded in *The Gentleman's Magazine*,[2] when, during the confusion caused by an accident in the crowd, a Jew robbed a sailor; he was detected and ducked. Afterwards he was pursued to a house in Duke's Place, where the inhabitants apparently attempted to defend him. The building was wrecked and its contents thrown into the street, including three children sick of the smallpox, who happily received no damage.

The day was celebrated in Edinburgh up to the year 1810, when the king's last illness brought the tradition to an end. The form of the demonstration resembled that of our "Fifth of November," with bonfire, squibs, and crackers, together with a good deal of the mob violence that formerly characterized the English festival.

The date is still commemorated in the 'Fourth of June' fête at Eton, where a firework display and the procession of boats provide the traditional climax to the day's festivities. In a note to an article on the event written, apparently, at about the time of the accession of William IV Hone[3] suggests that there was some doubt whether the observance would be continued into the new reign. In reference to the 'transparency' of the royal cipher, G.R., he comments: "So it was last time, when, in the reign of George IV they celebrated his father's birthday; whether they will be commuted to W.R. this time, or not, I am ignorant; probably they will not."

Hone's fears that the custom might be allowed to die out have not been justified. Up to the present time, except during the periods of the two World Wars and in 1901, the year that saw the death of Queen Victoria, the tradition has been continued without a break.

The annual firework festival, 'Brock's Benefit,' has become proverbial. As a phrase denoting spectacular aerial effect, in peace or war, as a simile for flights of oratorical extravagances or pictorial exuberance, it has been employed by a score of well-known

[1] *Sports and Pastimes of the People of England.*
[2] Vol. xxxiii, p. 311.
[3] *The Year Book* (1839).

writers. Commander John Irving, in *Royal Navalese: a Glossary of Forecastle and Quarterdeck Words and Phrases*, gives the wide definition: "A searchlight and/or firework display; a prolonged illumination such as a target under star shell, a big fire on shore, etc."

The fire that destroyed the Crystal Palace in 1936 brought the famous displays to an end, but 'Brock's Benefit' will remain as part of the English language. The first of the long series of these events was in 1869, when the board of directors granted C. T. Brock a benefit "as a mark of their appreciation of his unfailing efforts and outstanding achievements in the field of pyrotechny during the past five seasons." The occasion was a great success and attracted a crowd of some thirty thousand spectators. It was repeated the following year on November 9, Lord Mayor's Day —or, rather, that was the intention, but a fog, certainly the most opaque ever to be known at Sydenham, by reducing visibility to nil, necessitated a postponement till the following week.

A South London paper, under the date of November 11, 1871, records that

> Thursday was the great day of the week. . . . In the evening there was a "specially grand firework display" for the benefit of Mr C. T. Brock, pyrotechnist to the Crystal Palace. The terraces, gardens, and fountains were illuminated and the whole display was to our thinking the best of the season. We trust that Mr Brock will be benefited thereby as much as his successful efforts to please the multitudes who have witnessed his marvellous feats in pyrotechny during the past season.

In 1872 occurred the second of the only occasions on which the event had to be postponed on account of weather conditions. As a result the beneficiary was granted the option of fixing his own date for the festival, and selected the first Thursday in September. It is interesting to note that, some sixty years later, his judgment was endorsed by the meteorological authorities when they were selecting the most suitable week for the Schneider Cup competition at Spithead. Records showed that the first week in September was, on average, the finest of the whole year. However, that the rule did not always hold good is shown in a paragraph in the *Pictorial World* of August 4, 1887, relating to the Crystal Palace season:

> Good, however, as the displays have been this year, Messrs Brock are very much like children with a packet of mixed sweets; they invariably keep the best to the last, and on the occasion of their annual benefit they usually produce something startling. The date for that event this year is fixed, we believe, for September 8th when, if the

weather be propitious, the attendance is bound to be enormous; for last year, when it was a shockingly bad day, as far as wet was concerned, there were between 30,000 and 40,000 persons present.

The *Daily Telegraph* of September 6, 1889, records that the benefit of that year

> drew an enormous crowd to the Crystal Palace. It may be questioned whether Versailles in the days of the third Empire ever showed such a marvellous show of pyrotechnic variety. Sixty-three thousand, eight hundred and ninety-four persons visited the Crystal Palace, against 55,274 in 1888.

Three years later the *Sportsman* remarked: "Brock's Benefit is almost as familiar among Englishmen, and quite as well known among Londoners, as Bank Holiday itself."

The *News of the World* commented on the festival in 1892:

> To attempt to describe it would be madness. Where has there ever been the like, and where is the pen that can convey suggestion of the most meagre kind of the dazzling, fascinating effect produced upon the mind of the spectator? Truly our champion Firework-man has excelled himself! Those who have seen his finest efforts before Thursday night, have doubtless gone away, like myself, reverentially saying "Truly Brock is a giant among men and now hath he achieved even his greatest!" To them I can only say that he has produced effects more bewildering and dazzling than ever.

Of the same display the *Daily Graphic* observed: "One thing we do manage better in England than anywhere else, it is our fireworks. Brock is almost a pillar of our constitution, and his annual benefit may, in many senses, be regarded as a benefit to the public." And *Punch*:

> Unbrocken Vows. Walpurgis Brocken Night at Crystal Palace last Thursday—Grand! Celestial water-works rested awhile to make way for Terrestrial Fireworks. Todger's can do it when it likes, as all Chuzzlewittens know, and Brock can do it when he likes. Despite wind and weather, and contretemps generally, Brock has never brocken faith with the public.

The *Daily Telegraph* of September 9, 1894, records that "the fireworshippers of London joined in thousands last night in their annual celebration at the temple of pyrotechny for the benefit of the high priest."

These comments, taken at random from hundreds of similar ones, may perhaps be accepted as bearing out the sentiment expressed in the *Daily Graphic* of September 18, 1897:

The Londoner who has not at one time or another said to himself that he must really go down this year to the Crystal Palace to see the fireworks, is almost as rare as the man who is not moved at the sight of his native land. For the fireworks at the Crystal Palace in general and Brock's benefit in particular are national institutions, and Englishmen are justly proud of them.

Chapter XII

THE DEVELOPMENT OF FIREWORK MANUFACTURE

> . . . And where the white garments of Madame Somebody [Hengler] (we forget her name now), who nobly devoted her life to the manufacture of fireworks, had so often been seen fluttering in the wind, as she called up red, blue and parti-coloured light to illuminate her temple!
>
> CHARLES DICKENS, *Sketches by Boz* (1836)

AS we have seen in the preceding chapters, in England, at any rate, the provision of full-scale pyrotechnic displays was the prerogative of the military until the early years of the nineteenth century. On the Continent the names of certain firework-makers were already established at the beginning of the seventeenth century, but it would seem that their reputation was gained rather in the capacity of technician and producer than for the actual execution of the spectacles, of which the labour of manufacture, erection, and firing was, as it remained for so long, in the hands of artificers from the army.

This arrangement, encouraged by Louis XIV and his successors, was followed by our own Government in 1749, and no doubt gave rise to the complaint uttered by Lieutenant Robert Jones in the preface of his *New Treatise on Artificial Fireworks*, published in 1765—a book of some merit, displaying considerable knowledge of the subject. He says:

> I own I cannot help reflecting with some kind of chagrin that whenever we have had occasion for these sort of diversions to be exhibited in England, we have almost always had recourse to foreigners to execute them; if this has been owing to the ignorance of our own people on this subject I shall be very happy if it is in my power to correct it; if it is only owing to that prevailing fondness we entertain for everything foreign I know no remedy for that evil but time and experience.

His remarks were certainly justified. As the growing scale and popularity of the displays in the pleasure gardens clearly showed, there were already many pyrotechnists in the country, of native birth, ready to take advantage of the opportunity offered by those resorts. Until that opportunity arose they found an outlet for their wares among the members of the general public on such occasions as St John's Eve and other traditional bonfire festivals,[1] to which squibs and crackers would add interest and amusement.

In a *History of Colleges in and around London*, published in 1611, we learn that there were then living in the City many "men very skillful in the art of pyrotechny and fireworks." Pepys mentions in his *Diary*, under the date November 5, 1661, "seeing the boys in the streets flying their crackers." Again, on August 14, 1666, he tells how he, his wife, Mercer, Lady Pen, Peg, and Nan Wright celebrated a victory over the Dutch at

> Mercer's gate where the [bon-] fire and boys expected us, and her son had provided abundance of serpents and rockets; and there mighty merry . . . till about twelve at night, flinging our fireworks and burning one another and the people over the way.

The Scottish historian Lindsay records that a century earlier, in 1536, when King James V visited France for his marriage with the Princess Magdalene, "there were in the town of Paris, cunning carvers and profound necromancers, who by their art caused things to appear whilk are not, as follows: fowls flying in the air spouting fire on others . . ."

Many of the earlier, non-military, English pyrotechnists came to the country as religious refugees prior to the Edict of Nantes. With a second influx, following its revocation, came many tradesmen and craftsmen, like the Spitalfield silk-weavers, of whom a number made fireworks of the smaller kinds in the evening after their day's work. This dual activity was necessary to conceal the latter employment, for since November 15, 1666, following the Great Fire, pyrotechny had become a 'bootleg' occupation in London City. Chamberlain records[2] that an Act passed by the Common Council of the City of the date mentioned, "for the preventing and suppressing of fires," included the clause

> that no person whatever be permitted, at any time, to make, or cause to be made, any sort of fire-works, within the city or libertie thereof, except such persons only as shall be thereunto appointed by his majesty, or other lawful authority.

The immunity enjoyed by firework-makers without the liberties of the City was to continue unchallenged for some nineteen years. They, it would appear, made hay while the sun shone, finding a

[1] See Chapter XI.
[2] Chamberlain, *History and Survey of the Cities of London and Westminster.*

ready market for their wares. In addition to the annual observance of Guy Fawkes' Day, there was that of Queen Elizabeth's Day, the anniversary of her accession. This, according to the account of the proceedings in 1678, given in a tract in Lord Somers' collection, took the form of an anti-Popish demonstration. A procession, the central figure of which was an effigy of the Pope, marched from Moorgate, in the City, to Temple Bar, where,

> having entertained the thronging spectators for some time with the ingenious fireworks, a vast bonfire being prepared just over against the Inner Temple Gate, his holiness, after some compliment and reluctances, was decently toppled from his grandure into the impartial flames. . . .

Another account speaks of "the numerous platoons and volleys of squibs discharged," amid shouts that "might have been a cure for defness itself."

In 1682 the authorities professed alarm lest the celebration should lead to general rioting, and the Lord Mayor was instructed to suppress it. The City magnates, however, refused to interfere, and the show took place. In the following year a company of Horse Guards, backed by the Trained Bands of the City, were more successful, and the demonstration was prevented. It cropped up again from time to time during the reign of Queen Anne, but with the accession of George I came a greater sense of Protestant security, and the custom died out.

Meanwhile the 'Fifth of November' celebrations had been attracting the attention of the authorities; those of 1685 in particular, to judge from the date, November 6 of that year, to an Order in Council (see p. 141), which, "for the preventing of Tumultuous Disorders" and with the object of "Disappointing the Evil Designs of Persons Disaffected to the Government, who commonly make use of such occasions to turn those Meetings into Riots and Tumults," enacted that

> no Person or Persons whatsoever, do presume to make or encourage the making any Bonfires, or other Publick Fire-Works . . . without particular Permission, Leave, or Order . . . upon Pain of His Majesties Displeasure, and being Prosecuted with the utmost Severity of the Law.

Firework-makers, it cannot be doubted, were quick to see a loophole in this order. The "making of Publick Fire-Works," in the accepted meaning of the time, would refer to the letting off, not to the actual manufacture, of fireworks.

Ten years later any uncertainty about the legality of firework-making was resolved by an Act which, as was doubtless intended, made the position only too clear:

> By the 9th and 10th of William, Chap. 7, it is enacted: That if any Person shall make or cause to be made, or sell, give, or utter, or offer, or expose to sale any Squibs, Rockets, Serpents, or other Fire-works, he shall forfeit Five Pounds. And that if any Person shall permit the same to be fired from his House or Premises, or shall cast or fire, or be aiding and assisting in casting or firing the same in any public Street, House, Shop, River or Highway, he shall forfeit Twenty Shillings, or be committed to the House of Correction to hard Labour for one Month.

It certainly seems somewhat unfeeling on the part of William, who had landed in England, in a wave of anti-Romish enthusiasm, on the significant date of November 5, to be greeted with a pyrotechnic welcome in London, that he should have been, nominally at least, responsible for the suppression of the trade by an Act that was to remain in force, although perhaps more honoured in the breach than in the observance, for a hundred and fifty years.

As we have seen, during the greater part of the ensuing century the public pleasure gardens found no difficulty in obtaining ample supplies of fireworks for their entertainments, or pyrotechnists ready both to conduct the displays and to claim credit for their execution. Guy Fawkes' Day continued to be celebrated.

Nevertheless the whole business was technically illegal. From time to time the public were reminded of this fact.

A notice appeared in the Press of November 1, 1788, dated from the "Public Office, Bow Street," warning the public against firing crackers in the street, and quoting the Act "that no Person may claim Ignorance thereof." Again, in 1814, *The Times* has an account of a summons, under the Act, of a William Swift, "for exposing for sale, Squibs, Serpents, Crackers and Fireworks of other descriptions to the great danger and annoyance of the public and contrary to the Statute." The report continues:

> Mr Laws in opening the case observed, that this was a prosecution brought forward at the recommendation of the Magistrates of Union-Hall, who, however, did not by it seek to punish the defendant with severity but only to inform him and others acting like him, that the Act upon which the present indictment was founded and which so far back as the reign of William III, was passed for the protection of the public, though it had not lately been acted upon, was still in force. The defendant, it appeared, was a man of property and a respectable holder residing in Falcon Court, where he had for some time past carried

At the Court at WHITEHALL

This Sixth day of *November* 1 6 8 5.

Preſent,

The Kings moſt Excellent Majeſty.

His Royal Highneſs Prince *George*.
Lord Arch-Biſhop of *Canterbury*.
Lord Chancellor.
Lord Treaſurer.
Lord Privy Seal.
Duke of *Ormond*.
Duke of *Beaufort*.
Duke of *Queensbery*.
Lord Chamberlain.
Earl of *Huntingdon*.
Earl of *Peterborough*.
Earl of *Sunderland*.
Earl of *Craven*.
Earl of *Nottingham*.
Earl of *Perth*.
Earl of *Middleton*.
Lord Viſcount *Fauconberg*.
Lord Viſcount *Preſton*.
Lord Viſcount *Melfort*.
Lord *Dartmouth*.
Lord *Godolphin*.
Mr. Chancellour of the *Exchequer*.
Lord Chief Juſtice *Herbert*.
Mr. Chancellour of the *Dutchy*.

For the preventing Tumultuous Diſorders, which may happen hereafter upon pretence of Aſſembling, to make Bonfires, and Fire-Works, and Diſappointing the Evil Deſigns of Perſons Diſaffected to the Government, who commonly make uſe of ſuch Occaſions, to turn thoſe Meetings into Riots and Tumults: It is this Day Ordered by His Majeſty in Council, That no Perſon or Perſons whatſoever, do preſume to make or encourage the making any Bonfires, or other Publick Fire-Works, at or upon any Feſtival Day, or at any other time or times whatſoever, without particular Permiſſion, Leave, or Order Firſt had from His Majeſty, or this Board, or ſignified to them by the Right Honourable the Lord Mayor of *London*, or by the Juſtices of the Peace in their reſpective Limits, upon Pain of His Majeſties Diſpleaſure, and being Proſecuted with the utmoſt Severity of the Law; Whereof all Perſons whom it may concern, are to take notice at their Perils.

W. BRIDGEMAN.

London, Printed by the Aſſigns of *John Bill* deceas'd: And by *Henry Hills*, and *Thomas Newcomb*, Printers to the Kings moſt Excellent Majeſty, 1685.

THE ACT OF 1685 PROHIBITING THE MANUFACTURE, SALE AND FIRING OF FIREWORKS on the profession of a firework-maker. The officers of Union-Hall having heard, however, that he was in the habit of supplying boys or any person who applied indiscriminately with these dangerous commodities, they determined, if possible, to put a stop to this traffic, so dangerous to the public safety. For this purpose they sent a person, properly instructed, to purchase some; Goff, Bruce, and some other of the officers remaining near the door to detect him coming out: the purchase was made, and as the purchaser was quitting the house, the officers stopt him and forced their way in. They proceeded to search the premises, and concealed in closets and other parts, they discovered a vast quantity of fireworks of various sizes and descriptions, amounting to 19,500 and weighing upwards of 6 cwt., several of these, singly, were large enough to have spread ruin through the neighbourhood, had they by accident exploded. These the officers took away and deposited at the Office, where they still remained to the great annoyance of the Magistrates waiting the decision of this question.

During the early years of the nineteenth century a notice was left each year at every dwelling-house in the City of London. Hone[1] reproduces the form taken by the document in the parish of St Bride's:

October the 11*th*, 1825

SIR:

By Virtue of a Precept from my Lord Mayor, in order to prevent any Tumults and Riots that may happen on the Fifth of November, and the next ensuing Lord Mayor's Day, you are required to charge all your Servants and Lodgers, that they neither make, nor cause to be made, any Squibs, Serpents, Fire Balloons, or other Fireworks, nor fire, fling, nor throw them out of your House, Shop or Warehouse, or in the Streets of this City, on the Penalties contained in an Act of Parliament made in the Tenth year of the late King William.

Note. The Act was made perpetual, and is not expired, as some ignorantly suppose.

C. PUCKERIDGE, *Beadle*

TAYLOR, *Printer*, *Basinghall Street*

It may be thought that, in view of the long immunity from anything more than sporadic official action against what was, in fact, an illegal occupation, the firework-makers had little cause for complaint. Be that as it may, the effect on the industry was of the worst possible kind. There could, of course, be no official supervision, or control, over an industry which did not officially exist. As his business was carried on surreptitiously, the master pyrotechnist could hardly afford to invite the attention of the authorities by taking premises of any considerable size. Nor could he expand

[1] *The Everyday Book*.

his factory if a growing business, whether occasioned by the superiority of his products over those of his competitors, or by a general demand due to the increasing population, or his own ideas anent the connexion between elbow-room and safety, should suggest such a step. The consequence was that much of the work was given out to be made up by employees and their families in their own homes, at piecework rates. An aged workman who died only recently, after working for my family for nearly eighty years, used to recall seeing as a child the whole family at work in the home on squibs, crackers, and other small fireworks, with a fire burning in the grate and a tub containing several pounds of gunpowder in a corner of the room. The household, in some cases, would retire peacefully to bed, leaving a tray full of 'stars,' such as are used in rockets and shells, suspended to dry over a turned-down gas-bracket.

With the coming of the modern era in pyrotechny the result, as will be seen in a later chapter, of the addition of potassium chlorate to the pyrotechnist's list of ingredients was that accidents, which till then had been surprisingly few, began to occur with increasing—and, eventually, alarming—frequency. It soon became evident to authority that something must be done about it: the question was what. The old Act might have been put into effective force, but by so doing the industry would have been stamped out: an industry which found employment for a large number of work-people, and, besides giving amusement and entertainment to many, provided signal lights and rockets, the demand for which was steadily increasing.

Early in the century a compromise had been attempted, by which each manufacturer was granted a licence enabling him to store a certain limited quantity of explosives on his premises, which quantity included, besides finished stock, such fireworks as might be in process of manufacture, mixtures intended for use, and gunpowder. The specified amount, based, at the whim of the local licensing authority, on their own ideas, the number of other firework-makers in the vicinity, and the incidence of accidents in the neighbourhood, was invariably insufficient to permit of the business being carried on. Further, in the event of a maker being detected in possession of an excessive weight of stock, his conviction before the magistrates resulted in not only a fine, but a drastic cut in the amount of his licence. So a vicious circle of make-believe and frustration was established which, in reality, did nothing to improve matters.

The Gunpowder Act of 1860 was an attempt to place the manufacture and storage of explosives generally on a more satisfactory footing. It laid down regulations to be "observed with regard to the manufacture of loaded percussion caps, and the manufacture and keeping of ammunition, fireworks, fulminate of mercury, and any other preparation or composition of an explosive nature"; and made it lawful for Justices of the Peace in Quarter Sessions to license places for the manufacture and storage of such articles, and to grant licences to persons to sell fireworks. It also provided for the installation of lightning conductors in explosive magazines, a matter which up to that time had been left to the discretion of the owner.

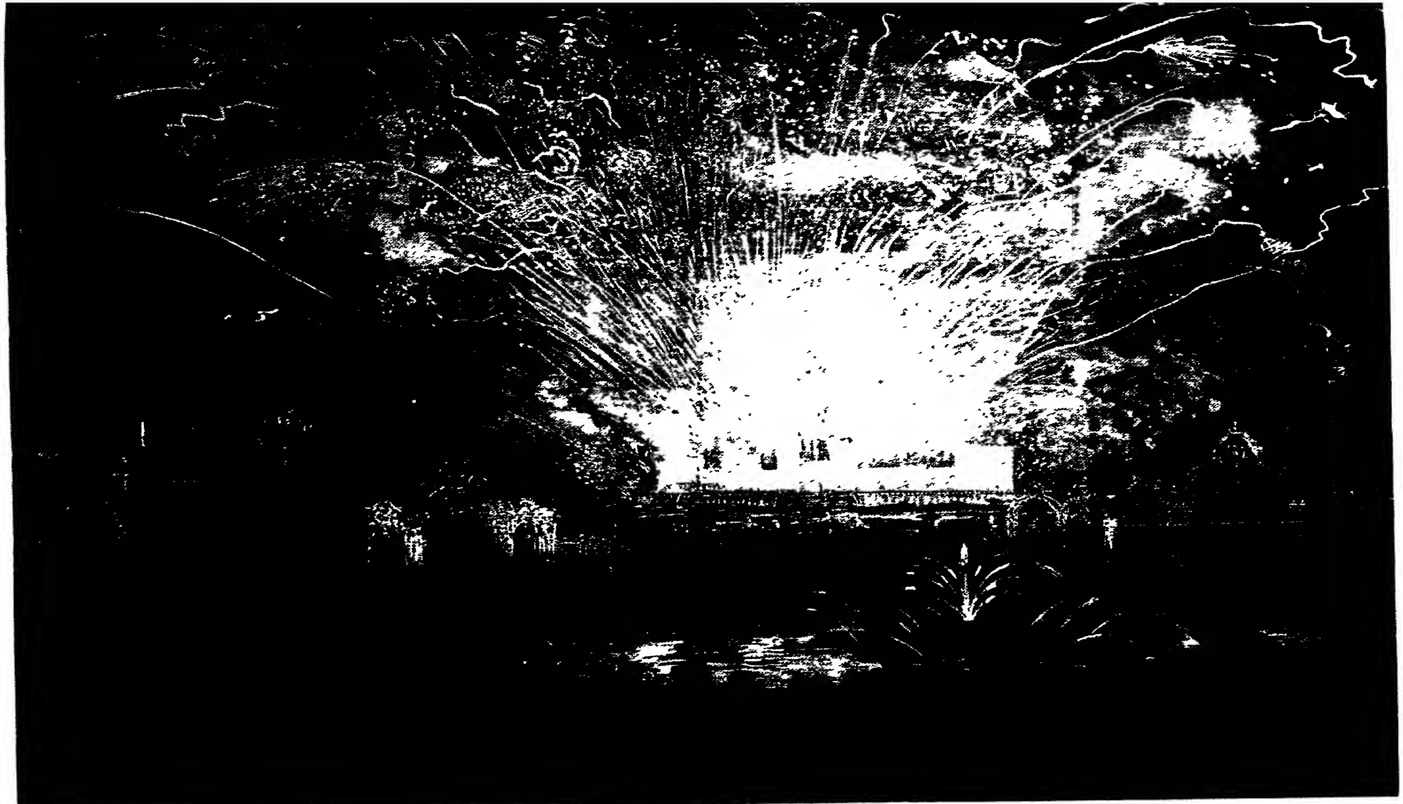
A curious inconsistency of the measure was that, while anyone was permitted to keep fifty pounds of gunpowder on his premises without licence, only ten pounds of fireworks were allowed.

This Act, although far from perfect, was a step in the right direction; it had the effect of bringing some makers out from the back streets of crowded districts to construct properly arranged factories, or, at any rate, factories planned with some regard to their use.

Four years after the passing of the Act public attention was sharply drawn to the matter by an explosion on an unprecedented scale at Erith, where several of the gunpowder manufacturers had magazines. Enormous damage was done, and many lives lost, over an area ten miles in radius. Lieutenant-Colonel Boxer, R.A., Superintendent of the Royal Laboratory, Woolwich, in his report on this explosion, drew attention to the need for a system of inspection of explosive establishments, with the result that he was himself authorized to make such inspection.

Lieutenant-Colonel Boxer was succeeded in 1871 by Captain, afterwards Colonel, Sir Vivian D. Majendie, K.C.B., who recommended the appointment of permanent Inspectors of Explosives, and pointed out the urgent need for more effective legislation. He was instructed to gather evidence on which an Act might be framed to regulate the whole of the explosives industry, regarded from the manufacturing, storage, sales, and transport aspects.

C. T. Brock, who, as well as being by far the largest manufacturer of fireworks in the kingdom, had already established a factory at Nunhead, Surrey, which embodied almost revolutionary ideas regarding both the safety of the workers and the limitation of the results of any accident that might occur, seemed the obvious man to select as adviser in matters affecting the fireworks branch of the



FIREWORKS FÊTE AT VERSAILLES

To celebrate the visit of Queen Victoria to Paris in 1855. From a drawing by Gustave Doré.

Illustrated London News

[*See p.* 78.]

THE "EMPEROR'S FETÊS," PARIS

(*Left*) Display in the Place de la Concorde, August 1852. (*Right*) Display fired from the Arc de Triomphe in 1852.

Illustrated London News

[*See p.* 77.]

explosives industry. To him Captain Majendie applied. The result was a report, dated January 11, 1872, of some three thousand words, the original draft of which is before me now.

He commences with a review of the conditions then prevailing in the trade: "There are several grades of manufacturers, from the long established Pyrotechnist, to the man who with his wife and family works in his garret. For instance, a stationer sells fireworks —he fills in his spare time making them." He mentions spontaneous combustion of certain mixtures as the cause of nearly all firework explosions, and gives a list of the ingredients he considers dangerous, together with the precautions which he suggests should be adopted when they are used. He goes on to enumerate the various types of buildings that should comprise the ideal factory; twenty-two operations are mentioned, calling for duplication of buildings in some instances. He sets out the distances by which he considers buildings should be separated in the interests of safety, and the amount of explosives they should be licensed to contain. He recommends that girls should not be employed under the age of sixteen, or boys under fourteen, and mentions a number of safety precautions that should be made compulsory. He points out that

> the excessive rates charged and the infrequent opportunities given by the Railway Companies has induced firework-makers to send their goods surreptitiously and risk a fine of £20. The Companies would really be studying their own and the public interest better by charging moderately and giving every encouragement for firework-makers honestly to declare their goods.

He adds that far greater danger is entailed by carrying explosives unknowingly than when the nature of the contents of the packages is known.

Following this report a series of experiments was arranged with a view to establishing the soundness of the suggestions it contained. These took place on April 4, 1872, with the result that, according to *The Times* of the day following: "All tended to show that the explosive, as distinct from the inflammable tendency of fireworks had been over estimated." As a result, the relative hazard of fireworks to gunpowder was reassessed as two pounds of the former to one of the latter where fireworks of the larger kind were in question. Small fireworks, or 'shop goods,' were accorded the ratio of four pounds to one of gunpowder (See page 146).

In due course practically every suggestion put forward in the report, slightly modified in certain cases, was embodied in the resulting ordinance, the Explosives Act, 1875.

EXPERIMENTS WITH FIREWORKS AT NUNHEAD,

(In a Field near Messrs. C. T. Brock & Co.'s *Firework Manufactory.)*

On Thursday, April 4th, 1872.

THE OBJECTS OF THE EXPERIMENTS ARE:—

1. To determine if the distance between Firework Sheds, as at present laid down by law, viz 20 yards, is amply sufficient to prevent an explosion in one shed communicating to other sheds situated at the statutory distance.

2 To determine the liability of Fireworks to ignite by concussion or friction.

3 To determine the liability of Fireworks to explode *en masse* if from any cause they should be accidentally ignited.

4 In the event of Fireworks exhibiting a liability to explode, to determine the area of destructive effect of such explosion.

5 To determine, with reference to the conclusions which may be arrived at as to points 3 and 4, the degree of danger which attends the transport of Fireworks by rail, barge or other public conveyance.

6 To determine at what distance from dwelling houses stores of Fireworks may be safely established.

PROGRAMME OF EXPERIMENTS.

1. Explode 30 lbs of loose Firework Composition in a Shed, another Shed being 10 yards distant Screen between.
2. Explode 30lbs. *of Composition in Fireworks* in a Shed, another Shed being 10 yards distant. Screen between
3. Ignite a Box of ½ cwt of mixed Ordinary Fireworks in open air
4 Ditto ditto ditto in contact with another Box of ditto
5. Place a Box of ½ cwt. of ditto in a bonfire.
6. No. 3 repeated, with mixed Fireworks bought over the Counter
7. No 4 ditto ditto
8 No. 5 ditto ditto
9 Hammer various sorts of Fireworks—Wood on Wood.
10 Ditto ditto Wood on Iron.
11 Ditto ditto Iron on Iron
12 Run a Railway Truck over some of the different sorts.
13 Repeat such of above as may seem necessary with "Parlour Fireworks"

V. D MAJENDIE, Captain R A,

H M's Inspector of Gunpowder Works, &c.

ANNOUNCEMENT OF THE EXPERIMENTS WITH FIREWORKS AT NUNHEAD IN 1872

Before that measure became law, however, the authorities, as well as the general public, were to receive a sharp reminder of the urgency of the matter. In October 1874 a barge laden with five tons of gunpowder, "besides a quantity of benzoline" (a cargo which suggests a certain lack of imagination on the part of whoever was responsible), was being towed along the Regents Canal by steam tug. It had reached a point near the North Gate bridge, leading to that entrance to the London Zoological Gardens, when some one aboard the barge shouted to the steersman of the tug that the former vessel was on fire. A moment later the cargo exploded. The damage to adjoining property amounted to £10,000, apart from £300-worth of glass broken in the buildings in the gardens. Certainly an incitement to action.

The result of the Act was that those makers who were in a position to do so, if they had not already taken steps in that direction, established factories on suitable sites in conformity with the rules it laid down, to the great advantage of all concerned. There was one diehard, however, who, rather than submit to what he considered interference with his liberty to run his business in his own way, retired disgruntled to the Channel Islands, where the Act did not operate. No further record of his activities seems to exist. There remained a number of small businesses and individual workers who lacked the means to re-establish themselves elsewhere, or whose trade did not warrant such a step. In order that these should not be put out of business, local authorities were empowered to grant "Small Factory" licences, under which the total quantity of manufactured fireworks, either finished or partly finished on the premises, should not exceed five hundred pounds' weight, and there should not be present more than twenty-five pounds of coloured fire, or more than a hundred pounds of any explosive other than that manufactured in the factory.

This provision, which was intended solely to obviate hardship to existing businesses, has since been interpreted as an authorization to continue indefinitely the granting of licences of this type. Yet another form of licence is that for "Toy Firework" factories; these are granted by the Secretary of State, as are licences for firework factories of the normal kind. Toy fireworks include 'snaps' for Christmas crackers, paper 'amorces' for toy pistols, and similar articles, the operative ingredient in which is a fulminate, a compound which explodes on being struck or subjected to friction. As only an infinitesimal quantity of explosive is used in each article, the total amount of explosive present in a toy-firework factory is never sufficient to constitute a danger to its surroundings, and in consequence the licence is granted under specially easy terms. I remember being told by one of the earlier makers of 'snaps' that, in the days before fulminate of silver had been replaced by fulminate of mercury and other compounds, a six-penny piece provided sufficient silver to keep his factory going with fulminate for a day. He was quite convinced that the Queen Anne sixpences, of which a number were then still in circulation, made the best fulminate, and they were always carefully collected and kept for the purpose.

A shopkeeper who retails fireworks must register his premises for the purpose. This registration, for which the modest maximum fee of a shilling is paid, is quite distinct from licensing a premises, although local authorities have, on occasion, taken the view that the terms are interchangeable, and have refused the registration of premises on the grounds of danger or unsuitability. In point of fact, the Act specifically lays down that local authorities have no power to refuse.

Fireworks may be kept on registered premises in amounts varying according to the manner in which they are stored. If they are kept on the premises, in a suitable receptacle, 50 pounds of fireworks or 100 pounds of 'shop goods' is the maximum; if in a detached building, of substantial construction and placed at a safe distance from a public thoroughfare, the amount may be 200 pounds of fireworks or 400 pounds of 'shop goods.' These two methods of storage are known as 'Mode B' and 'Mode A' respectively.

Licences for magazines for larger quantities up to 10,000 pounds, except those attached to factories which are included in the general licence of the factory, are granted by local authorities. Above that amount the licence is granted by the Secretary of State, as are factory licences. The amount of explosives which may be stored at a site is governed by a schedule of distances between it and certain 'protected works.' As an example, for 1000 pounds of gunpowder or other explosives—2000 in the case of fireworks or 4000 in the case of 'shop goods'—the distances to be preserved are: a footpath, open place of resort for the public, dock, navigable water, or mineral railway, 75 yards; for a public railway, 150 yards; dwelling-house, without the consent of the occupier, 75 yards; church, college, market, or theatre, etc., 150 yards; Government factory or magazine, without the consent of the Government department, 1320 yards; palace or house of residence of his Majesty, his heirs and successors, 2 miles. The distances, naturally, are increased in proportion to the quantity involved.

A modern fireworks factory differs very materially from the generally accepted conception of the term. The emphasis is on space rather than on architectural impressiveness or height, on dispersion rather than on concentration.

The factory is made up of three defined areas: the non-explosives section, referred to technically as the 'green area,' in which are concentrated offices, stores for chemicals, paper, etc., carpentry, engineers', paper-cutting, display woodwork, and machinery departments; sawmills and blacksmith's shop; the working area, in which are found the small, carefully isolated sheds in which the operations of mixing of ingredients and introducing them into their rolled paper containers, or 'cases,' are carried out. Here, too, are drying rooms and 'expense magazines' in which are temporarily stored partially finished fireworks, or components, awaiting further processing, and thus obviating any excess weight of explosive material in the working buildings. Farther afield, and separated by greater intervals, are the magazines, the distances, of course, being dependent on the weight for which each building is licensed, and also the packing shops.

The working buildings are constructed with a door at either end to facilitate escape in case of emergency, and are of light construction. The form most in use is a timber framing lined with composition board and covered externally with corrugated iron. No iron fittings are used, nor iron nails left exposed in the interior. The floor is covered with linoleum, which is secured by copper tacks.

The statutory distance separating working buildings is 25 yards; this is reduced to 12½ yards if an iron screen is placed between it and its neighbour in any direction. This halving of distances by the presence of a screen is general, except in the case of gunpowder magazines, for which a solid mound of earth surrounding it to the height of the eaves is demanded.

The quantity of explosive material, as well as the number of workpeople in each working building, is dependent on the nature of the work being done. For instance, when small fireworks are being 'finished'—that is, being covered with their fancy paper covering—there may be six persons present and a hundred pounds of fireworks; where 'cases' are being filled four workers may be present, with ten pounds of firework mixture and a total of fifty pounds of wholly or partly finished fireworks; where large rockets are being charged by hydraulic power one man only may be present. In the packing shops, where finished fireworks are assembled and packed for dispatch from the factory, twelve persons may work together, with a stock of 10,000 pounds.

All workers in the explosive area are required to wear special non-inflammable clothing, without pockets, and to put on, when entering their place of work, 'magazine boots,' or overshoes, constructed without nails, to minimize the chances of accidental ignition of any explosive mixture that may have fallen on the floor.

The actual processes employed in manufacture, and the mixtures, or 'compositions,' used, will be discussed later when the varying types of fireworks are considered.[1]

There can be no question of the great benefits conferred on the firework industry, and no less on the public in general, by the Explosives Act of 1875 and by the various Orders in Council by which it has, from time to time, been amended. The measure transformed the trade from a surreptitious, furtive occupation of questionable legality into a properly organized and administered industry; translated it from the back streets of congested districts into properly equipped and constructed factories in suitable localities, where what was a highly hazardous occupation has become as safe as almost any—certainly as safe as those in any way comparable to it—in the country.[2] I am sure that all firework manufacturers will agree with me that the smooth, effective, and generally satisfactory way in which the Act has operated is in a great degree due to the manner of its administration by H.M. Inspectors of Explosives. They, on the other hand, will, I believe, admit that in general they can rely on the goodwill and co-operation of the trade in matters both of practice and administration.

[1] Chapters XV–XVIII.

[2] Up to 1941 the insurance rate for explosives workers in the Hemel Hempstead factory was 12*s*. 9*d*. per cent. of wages, or rather less than one quarter of that then paid in the London building trade. It should perhaps be noted that when the factory was taken over for the duration of the War the rate, based on experience, gradually rose to 58*s*. per cent.

Chapter XIII

THE DEVELOPMENT OF FIREWORK MIXTURES

My art's bold science grasps the lightning's powers,
Bids fearful Fire and Thunder rule the sky,
And steals for Beauty realms and wondrous hours
Of new existence, feasting mortal eye
With evanescent sights born but to die.

W. P. BALL, *Poems from Turkey* (1872)

IN the earlier chapters I have endeavoured, I hope not too tediously, to trace the history of fireworks as a spectacle. Apart from the scenic constructions and non-pyrotechnic aids with which the earlier displays were embroidered, they consisted, fundamentally, of the arrangement and reduplication of a more or less limited range of firework units. The same is, of course, true to-day when displays, in general, consist entirely of fireworks, but the variety of units and effects available to the pyrotechnist are infinitely greater.

Each unit, from the earliest and most crude up to the most beautiful and dazzling creation of the present day, has the common characteristic that it consists of a container, or 'case,' filled with a pyrotechnic mixture, or 'composition.' The process of tracing the development of the firework composition is not a lengthy one, for the very good reason that, from the time of the earliest mixtures of which we have definite knowledge up to the end of the eighteenth century, real development is negligible.

A firework composition possesses the characteristic that it is capable of burning in a confined space—that is to say, independently of the oxygen of the atmosphere. It must contain one ingredient having a supply of oxygen which it gives up readily and one or more others to act as fuel for combustion. As we have already seen, the oxygen-supplying ingredient, which played its part in the earliest mixtures, and, indeed, inspired their making, was saltpetre (potassium nitrate). It continued the sole performer of that rôle until the introduction of potassium chlorate into pyrotechny some few years after its first preparation by the French chemist Berthollet in 1786.

Firework compositions to-day, with, perhaps, one or two exceptions, may be divided into two types: those designed to produce force and sparks, and those producing flame. There can be no doubt that, with the ingredients saltpetre and charcoal—to which, in course of time, sulphur was added—the earlier efforts in pyrotechny were of the first-mentioned type. So at first, as was only natural, attention tended to be focused on spark- and force-producing compositions. There was no known method of imparting true colours to flame, and there was little difference to the eye between a flame produced by a pyrotechnic mixture and one resulting from the combustion of pitch, petroleum, or even of a piece of resinous wood. Sparks, on the other hand, might be varied in form and degree of brightness, if not in colour. Moreover, the force that drove a rocket into the air, and threw up a jet of sparks into a fountain of fire, might be employed to impart motion to wheels and other devices. Spark compositions and their development became, and for centuries remained, the main consideration of the firework-maker.

The two types of compositions differ not only in the results they produce as they burn, but in the manner in which they are employed. The effect of flame compositions is visual and, apart from their use sometimes for illumination, quite local. For that reason combustion must be as complete as possible and the actual point of combustion visible to the spectator. If they are employed in a case—sometimes they are burned unenclosed in compressed pellets or in powder form—the container is so constructed that it is consumed at the same rate as its contents. Force and spark compositions, on the other hand, achieve their effect by partial combustion. They contain a surplus of one ingredient which is thrown out of the case in the form of sparks, unconsumed but glowing, which may complete their combustion on coming into contact with the oxygen of the atmosphere. The case is of sufficient thickness and strength to remain unburned and to withstand the internal pressure set up by the combustion.

Early pyrotechnists sought constantly to increase the variety of their fires by adding to the number of spark-forming ingredients, which they employed in conjunction with the basic constituents—saltpetre, sulphur, and charcoal.

John Bate,[1] writing in 1635 and admittedly quoting from other writers, employed "yron scales," no doubt in an attempt to achieve an effect similar to the sparks he saw flying from a blacksmith's anvil. He may have been successful, but only to a limited extent.

[1] *The Mysteries of Nature and Art.*

Later writers made use of 'sea-coal' dust, sawdust of various kinds, brass and copper filings, and even ground pottery. It is unlikely that the differences in the appearance of the sparks so obtained were sufficient to warrant the trouble entailed, but, at any rate, some limited degree of variety was added to the pyrotechnists' work.

There is a lingering suggestion of the recipes and methods of the old alchemists about the formulæ of Bate and his contemporaries. To the three components of gunpowder, and some few ingredients that are in use to-day—antimony (sulphide), orpiment (sulphide of arsenic), pitch, gum resin, and linseed oil—they added a number of substances of an inflammable nature, presumably to guarantee combustion: oil of petre (crude petroleum); oil of tile or benedict (evidently a mineral oil of some kind); oil of spike (lavender); turpentine and aqua vitæ (spirits of wine). Such strange additions as ink, onion juice, and the drainings of a dunghill could hardly seem to have served any useful purpose whatever.

No doubt the inflammable liquids were necessary to ensure the ignition of the majority of the very limited range of flame compositions then used.

Bate gives instructions for the preparation of a liquid, apparently designed for this purpose, which he calls "Aqua Ardens":

> Take old red wine, put it into a glasse vessell, and put into it of orpiment one pound, quicke sulphur, halfe a pound, quicke lime a quarter of a pound; mingle them very well, and afterwards distill them in a rosewater still; a cloth being wet in this water will burne like a candle and will not be quenched with water.

It is difficult to see what he obtained by this process differing from spirits of wine. The quicklime would serve to dehydrate the wine, but it seems unlikely that any part of the orpiment or sulphur would be taken over in the distillation.

One writer of this period stands out as seeming to rely on practical experience rather than on the work of others—Hanzelet,[1] if only because he limits his flame compositions for 'stars' to two —"the only two which are well approved." There may be some slight exaggeration in his description of "how to make fire-balls so white that one can scarcely look at them without being dazzled," but he was far in advance of his time in suggesting the use of verdigris (acetate of copper) for giving a green tint to flame.

In 1650 there was published Casimir Siemienowitz's *Great Art of*

[1] *La Pyrotechnie*, by Jean Appier, alias Hanzelet (Pont-à-Mousson, 1630). He had already, in 1620, written *Recueil de plusieurs machines militaires* . . .

Artillery, already referred to,[1] but its influence, until Shelvocke's English translation became available in 1729, was far less than it deserved, except in the matter of the illustrations, which were freely pirated by a number of writers.

About a century later Frézier[2] and Jones[3] made some additions to the ingredients of pyrotechny, the most notable innovations being the use of iron filings (not to be confused with the iron scales of Bate), steel filings, and pulverized cast iron. Beyond these, and the spark-producing agents already mentioned, the other additions are of small importance, the most notable being lapis calaminaris, the mineral carbonate of zinc, which, however, was not used as are metal salts to-day—that is, for the production of colour.

Jones's book, written some years after that of Frézier, shows little advance from the latter as far as pyrotechnic results are concerned. He has, however, almost entirely eliminated the alchemistic tendency which still pervaded many of Frézier's compositions.

For the use of powdered cast iron, known as 'iron sand,' a most notable step forward in the art, which led to the introduction of iron and steel filings, we are indebted to the Chinese and to Jesuit missionaries, who were responsible for bringing the secret to Europe. The method of its manufacture is described in an article in the *Universal Magazine* of 1764:

> Old broken or useless pots serve generally for making this sand; they are broken into pieces of the breadth of the hand, after which, being made red-hot in the fire of a forge, they are thrown in that condition into a trough filled with fresh water where they are left to cool. Thus calcined, the rust falls off in scales, and they are easily reduced into sand, being first broken into parcels of a finger's breadth. The anvil and hammer used for this purpose must be also of cast-iron, because steel flats the grains of sand. It is necessary that the angles of those grains should be sharp, as it is the angles that form the flowers.

The compositions in which iron sand, and later those containing iron filings, were used came to be known as 'Chinese fire'; those in which steel filings were used, as 'Rayonet,' 'Straw,' and 'Brilliant' fires. The last-mentioned term survived until the introduction of aluminium into pyrotechny reduced that brilliancy, by comparison, to a glimmer.

There is the knowledge and experience of several generations

[1] See p. 41.

[2] *Traité des feux d'artifice* (Paris, 1741; second edition, 1747).

[3] *A New Treatise on Artificial Fireworks* (London, 1765; second edition (now by Captain Jones) 1776).

of pyrotechnists in the works of Claude-Fortuné Ruggieri.[1] He is the first writer to make use of metal salts in the production of coloured flame—apart, that is, from the isolated use by Hanzelet of verdigris. He also introduced sal-ammoniac (ammonium chloride), which, by volatilizing the metal, greatly assisted colour production. This was a great step forward, although the use of that salt has now been discontinued on account of its hygroscopic nature. Its purpose is now achieved, as will be seen later, by potassium chlorate or perchlorate.

Ruggieri's account of the invention of this composition is interesting. He recalls that he was told by a returned traveller from Russia of a set-piece representing a palm-tree, "the colour of which rivalled nature." This piece he set out to imitate, and did so—at any rate, to his own satisfaction. The method he describes would undoubtedly give a good colour effect, although the means of firing was clumsy. The palm-tree was constructed of sheet iron, on which the composition was distributed and ignited by a spirit flame. He remarks that he does not know if his method was as that adopted in Russia, but claims "merit if not of discovering a new fire at least to have imitated, or rather to have rediscovered it." My own view is that Ruggieri does himself less than justice. It is more than likely that the account that inspired his experiment was yet another of those travellers' tales of the wonders of Eastern pyrotechny, and that what his informant saw was a transparency or illumination.

He concludes his account by remarking that he puts the facts on record with the object of

> thus preventing writers from attributing it to the Chinese, the Medes, or Arabs, as is the custom in Europe, and above all in France, where more than elsewhere there is a mania for enriching foreigners with our merits and to rob ourselves of the birthrights of genius.

Between the two French editions of Ruggieri's *Elémens* two manuals of firework-making appeared: T. Angelo's *Art of Making Fireworks*,[2] and *L'art de faire à peu de frais les feux d'artifice*, by L.-E. Audot.[3] The first of these, notwithstanding that the name of its author was well known in pyrotechny, is a disappointing production, a great deal of its contents having been, quite obviously, pirated from Lieutenant Jones. Much of it is sheer nonsense; one passage verges on the incomprehensible. In this he says:

[1] *Elémens de pyrotechnie* (Paris, 1801 and 1821); *Die Pyrotechnie nach der Vorschriften von Claude Ruggieri und Thomas Morel* (Leipzig, 1807); *Pyrotechnie militaire* (Paris, 1812).
[2] London, *c.* 1816.
[3] Paris, 1818.

"The set colours of fire produced by sparks are divided into four sorts—viz., black, white, grey and red." The solitary addition he makes to the material already published elsewhere is a description of what he calls "Waterloo Crackers," in which "Fulminating Silver" is employed. These are the 'snaps' used to-day in Christmas crackers to supply their 'bangs,' although fifty years were to elapse before the late Tom Brown—for many years experimental chemist to my firm—hit upon the idea of their construction and sold it to the late Tom Smith.

I have not been able to see a copy of Audot's book, and rely for what knowledge I have of its contents on details published by Professor Tenney L. Davis.[1] This is a much more advanced work; the use of metals, generally but not always in metallic form, is now definitely assigned to the production of colour effects. It may be that some of the tints produced by his compositions might have been more correctly described, as Frézier described his more primitive efforts—greenish (*verdâtre*), yellowish, reddish, and russet—but, at any rate, Audot's writing gives one far more confidence in his practical acquaintance with his subject than does that of his contemporary Angelo.

The modern era of pyrotechny began with the introduction of potassium chlorate, or, as it was then called, oxymuriate or hyperoxymuriate of potash. It is curious that so long a period should have elapsed between its first being prepared by Berthollet in 1786 and its adoption into the range of the firework-maker's materials. It may be that the explanation is to be found in a comment by Samuel Parkes in a book on chemistry written in 1811:[2] "The shocking death of two individuals in October 1788, and the burns others have suffered by it, render it feared by chemists in general."

He continues that, notwithstanding this accident, "the French have since actually employed in one of their campaigns gunpowder made with oxymuriate of potash instead of saltpetre," and adds that a Scots clergyman[3] had taken out a patent for the use of a powder containing chlorate of potash to be fired by percussion. This patent, granted in 1807, was the first for the percussion system in firearms.

G. W. Mortimer[4] makes no reference to potassium chlorate, but as certain of his material seems to have been inspired by Angelo, this is perhaps not altogether surprising. The first formula in

[1] *The Chemistry of Powder and Explosives* (New York, 1943).
[2] *Rudiments of Chemistry.* [3] Alexander John Forsyth.
[4] *A Manual of Pyrotechny* (London, 1824).

which the salt is included to appear in print occurs in an article by James Cutbush[1] in the *American Journal of Science* for 1823: "Remarks on the Composition and Properties of the Chinese Fire; and on the so-called Brilliant Fires." He says:

> Besides the admixture of several saline substances, which communicate particular colours to flame, we know that the most brilliant red is given to flame by nitrate of strontian, a preparation of which is used for theatrical purposes in France, is made as follows: take forty parts of dry nitrate of strontian, thirteen parts of finely powdered sulphur, five parts of chlorate or hyperoximurate of potash, and four parts of sulphuret of antimony, and mix them intimately in a mortar, observing at the same time to pulverize the chlorate of potash separately.

This composition must have been a very striking advance on any previous colour mixture, although by modern standards extremely dangerous in its preparation, even if the writer's suggestion of pulverizing the chlorate separately were followed.

One has the impression, however, that the significance of the innovation was rather lost on Cutbush. The formula is 'thrown away,' as it were, in the text; all his other recipes are set out in tabular form. Nor does he seem to have speculated upon the possibility that other metal salts might repay the trouble of experiment. Even in a posthumous book[2] which appeared two years later he hardly seems to have taken the novelty seriously, but only as affording "a variety of amusing experiments. . . . Although it has neither been used for fireworks on an extensive scale, nor does it enter into any of the compositions usually made for exhibition, yet its effect is not the less amusing."

What probably occurred was that those pyrotechnists who had already taken advantage of this outstanding addition to their range of materials treated its use as a closely guarded trade secret. The same no doubt would apply to its employment in military arsenals.

In 1836 a Belgian lieutenant of artillery, Hippert by name, published a translation of a work by Captain Moritz Meyer of the Prussian Artillery on the application of chemistry to artifices of war. A chapter is devoted to coloured fire, and in it he gives several formulæ containing potassium chlorate. He makes no reference to any degree of novelty for the ingredient, so we may

[1] Then Acting Professor of Chemistry and Mineralogy, U.S. Military Academy (West Point).

[2] *A System of Pyrotechny, comprehending the Theory and Practice, with the Application of Chemistry* (Philadelphia, 1825).

conclude that by 1836 its characteristics were fairly well known. Meyer concludes his remarks on coloured composition by saying that the English at that time made use of coloured rockets for signalling at sea, and had succeeded in producing ten different shades, "which are quite sufficient for the purpose of signalling particular pieces of information." This mention of ten distinguishable tints, however, is somewhat optimistic. During the 1914–18 war it was found that to avoid any chance of a mistake in code signals only three colours could be used for long-distance signalling: red, green, and white.

It is also curious that Meyer makes a mistake over the first composition he mentions. He describes a light composition of chlorate of potash and sugar, which, he says, burns with a red light. In fact, however, the light so produced is a bluish white, similar to the so-called 'blue light,' which is a signal at sea.

The directions he gives for the preparation of other colours are as follows:

> A powder which burns with a green flame is obtained by the addition of nitrate of baryta to chlorate of potash, nitrate of copper, acetate of copper. A white flame is made by the addition of sulphide of antimony, sulphide of arsenic, camphor. Red by the mixture of lampblack, coal, bone ash, mineral oxide of iron, nitrate of strontia, pumice stone, mica, oxide of cobalt. Blue with ivory, bismuth, aluminium, zinc, copper sulphate purified of its sea-water [*sic*]. Yellow by amber, carbonate of soda, sulphate of soda, cinnabar. It is necessary in order to make the colours come out well to animate the combustion by adding chlorate of potash.

These formulæ, if somewhat incoherent, and clearly showing a want of experimental verification, indicate a real advance in pyrotechnic chemistry.

Meyer also describes, as does Cutbush, the use of salts to tint an alcohol flame, which is merely an elaboration of Ruggieri's palm-tree, and of little interest at the present time.

A bill, dated July 27, 1827, for a benefit at the New Royal Pavilion Theatre, contains a paragraph which suggests that my great-grandfather, William Brock, was, at any rate, abreast of the times: "The above devices will be superbly adorned with a variety of colours, the result of chymical research, amongst which will be produced (a recent discovery of Mr Brock's) an Emerald Green Flame."

With potassium chlorate firmly established as an ingredient, the art progressed rapidly in the matter of colour. By the year 1845

Ruggieri[1] was able to publish a pamphlet which included formulæ for a number of colour compositions to be used in several types of firework. Among these, however, there is one notable exception, blue. This omission was somewhat unsatisfactorily filled, as it was for some years to come, by the use of the so-called 'blue light' mixture of saltpetre, sulphur, and antimony sulphide, or similar compositions, giving what was in fact a white flame with a slightly bluish tint, or, alternatively, following earlier practice, by a pure sulphur flame. However, eventually it was found that copper salts when burned in the presence of chlorine—liberated by the combustion of chlorate—would produce, not green, as in the old verdigris mixtures, but blue. The colour was further enriched by the addition of calomel (mercury subchloride). Green was henceforward produced by the use of salts of barium.

In the twenty years that followed the publication of Meyer's book a considerable number of works, dealing with various aspects of the art, and of varying merit, made their appearance. Outstanding among these are the two editions of a book by F. M. Chertier.[2] He devotes much space to the subject of colour, and displays a practical knowledge of his subject that was far ahead of that of his contemporaries. By modern standards his range of materials was limited, but Chertier stands a very prominent figure in the literature of pyrotechny. Salts and materials which in his time were unobtainable or the price of which was prohibitive, have now become available on a commercial scale. His most notable achievement was the preparation known as 'Chertier's Copper,' which produced a blue flame of great depth and brilliancy; "a double salt of chlorate of copper and ammonia." It was prepared by a somewhat tedious process: solutions of barium nitrate and copper sulphate were mixed in carefully adjusted proportions, evaporated, treated with liquid ammonia, and dried. The salt, although giving excellent results, is too unstable for modern conditions and has become obsolete.

Tessier, in the introduction to his treatise on coloured fires, published in 1859,[3] while paying tribute to Chertier's work, regrets that he possessed only "quite superficial notions of chemistry." On the other hand, the late R. M. Butt, whose knowledge of the scientific aspects of firework-making was unique, summed up Tessier's book by saying that it contained "too much chemical theory and too little pyrotechnic practice." There you

[1] *Handbüchlein der Lustfeuerwerkerei* (Leipzig).
[2] *Nouvelles recherches sur les feux d'artifice* (Paris, 1843 and 1854).
[3] *Chimie pyrotechnique, ou traité pratique des feux colorés* (Paris).

have two points of view. No practical pyrotechnist will seek to belittle the debt which his art owes to chemistry. On the other hand, he will strenuously resist the view, so widely held, that every chemist is *ipso facto* a competent pyrotechnist. Chertier may, as Tessier suggests, have possessed but superficial notions of chemistry, but in spite of—it would, perhaps, be an exaggeration to say because of—his chemical ignorance he produced a work which, from the point of view of the practical pyrotechnist, is, for its time, a masterpiece.

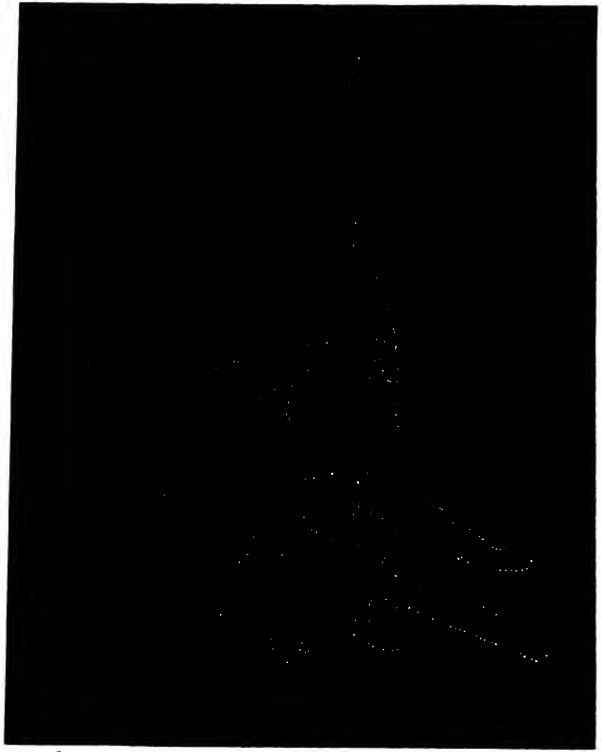
His researches were conducted by practical experiment unbiased by theoretical considerations; he had one end in view—pyrotechnic effect—and by exhaustive trials of the materials obtainable he succeeded in advancing the art to a stage quite unforeseen a few years previously. It is true that many of his formulæ are not in use in this country to-day, but solely on account of the risk entailed in using sulphur or sulphur compounds in conjunction with chlorates. There can be no doubt that his writings and research work laid the foundation of modern pyrotechnic practice.

Chertier, however, appears to have been an amateur in the art, not a professional; his methods in general were perhaps more suitable to the private laboratory than to manufacture on a commercial scale. I do not think it can be questioned that the man who exercised the greatest influence on the development of pyrotechny (at any rate in this country), in both its technical and executive aspects, during its transition from an individual occupation to an industry was C. T. Brock. Writing in 1878, he says:

> It was at this period—about 1864—when I, whose earliest recollections had been associated with fireworks, felt that great things were even then to be achieved in pyrotechny. I believed that great improvements could be made in the manufacture of fireworks; that if sound chemical knowledge were brought to bear upon the subject, some scientific system might be devised to replace the existing clumsy guesswork determination of the proportions forming the recipes. It was my good fortune to succeed in placing the matter of the combinations of pyrotechnic chemicals on a scientific basis.

The influence exerted by his successor, Arthur Brock, was certainly no less important, and covered a period of fifty-four years.

As will be seen in the following chapter, the introduction of chlorate and sulphur colour compositions, while bringing to the art a new interest that might be compared to the effect of Technicolor in the cinema, was responsible for a spate of accidents in



THE SHAH OF PERSIA

A fire portrait, sixty feet in height, fired at the Crystal Palace on August 23, 1892.

[*See p.* 107.]

THE MAIN SET-PIECE OF THE CRYSTAL PALACE DISPLAY IN 1869

Fired to celebrate the visit of the Khedive of Egypt and De Lesseps, engineer of the Suez Canal.

Illustrated London News

[*See p.* 92.]

PLATE XX

CHARLES THOMAS BROCK (1843–81)
The originator of the Crystal Palace displays.

WING-COMMANDER FRANK ARTHUR BROCK,
R.N.A.S. (1884–1918)
Killed on the Mole at Zeebrugge,
St George's Day, April 23.

manufacture, which, in this country, ceased only when such admixtures were prohibited by law.

This perhaps somewhat belated step was taken under the Explosives Act by Order in Council No. 15, dated April 30, 1894. The result on the trade was far less disturbing than might have been anticipated. When once the theory underlying the production of colour had become well established—that is to say, the volatilization of a metal salt in a hotly burning flame—it was a matter of less difficulty to eliminate sulphur, which was present as a burnable, by the substitution of other fuels. Powdered shellac was at first used almost exclusively, but other gums and resins have since been found to answer the purpose. The gradual development of commercial chemistry has made available an increasingly wide variety of ingredients, some of which have made possible the elimination, in certain cases, of chlorate.

In addition, many manufacturers, anticipating such legislation, had been for some time previously, in their own interest, seeking substitutes for such compositions, and although it has been claimed that colours were obtained by the use of chlorate and sulphur which have not been equalled by subsequent formulæ, yet most have not only been equalled but improved upon; the small minority, if, indeed, there are any, that have not are surely a small price to pay for the safety and sense of security the manufacturers have gained.

The report, already referred to, from C. T. Brock to Sir Vivian Majendie[1] indicates that he was well aware of the necessity for special precautions in matters of chlorate and colour compositions, and had already, in 1872, taken steps in that direction, as the following quotations will show:

> Any coloured stars made with sulphur [and chlorate] are dangerous, a little friction will fire them. My stars for shells and rockets are *all* made from shellac in place of sulphur. Any shellac star free from sulphur, sulphides, or any other of the above-named zinc, lead, or magnesium compounds, I consider safe from the danger of spontaneous combustion and to require a great amount of friction to ignite.
>
> What follows should be commonly known (it generally is) by all firework-makers. The following are Dangerous Compounds, being more or less liable to go off by friction or percussion, and also being liable to spontaneous combustion, especially in large masses and when newly made, when dried after being damp, or when warmed by sunshine or the warmth of a room. Mixtures containing Orpiment or

[1] See p. 145.

> Realgar and a Chlorate, or antimony [sulphide] and a Chlorate. Mixtures containing Sulphur and a Chlorate. Black oxide of Copper or Sulphide of Copper (and probably all Sulphides and Sulphites) with chlorate should be avoided. Purple fires which generally contain one of the above compounds of Copper have a specially bad name for going off spontaneously.

He admitted that it was a matter of great difficulty to eliminate mixtures containing sulphur and chlorate entirely, but suggests that special precautions should be taken in dealing with them.

As will be seen in the appended bibliography,[1] between the date of the publication of Chertier's book and the close of the century many works on pyrotechny made their appearance. Among the work of French writers the *Traité pratique complet des feux d'artifice* of Amédée Denisse is outstanding. The English works of value during this period were: *The Manual of Pyrotechny*, by "Practicus" (*c.* 1870);[2] Browne's *Practical Firework-making for Amateurs* (1880); and *The Pyrotechnist's Treasury*, by Kentish[3] in 1878.

Hutstein and Websky's *Lustfeuerwerkkunst*, published at Leipzig in 1873; a book published under a similar title by Oscar Frey about 1885; and *A Theoretical and Practical Treatise of Civil Pyrotechny*, by Antoni, published at Trieste in 1893; together with some works on military pyrotechny published both in Europe and the United States, are also of some importance.

Some of the military works are of considerable value, but are chiefly directed to the study of rockets and signals; some, however, are in the same category as *The Artillerist's Manual and British Soldier's Compendium*, by Captain F. A. Griffiths, R.A., published in 1859. The section dealing with fireworks in this work might almost be taken as an attempt to be humorous on the subject. The author quotes in all seriousness formulæ dating from the days of Bate and Babington, and knows so little of his subject that he gives instructions for making the same firework under different names with the impression that they are distinct units, the information being obviously pillaged from earlier writers.

During the nineteenth century there was in general a tendency towards simplification in firework composition; what may be regarded as the alchemistic survivals gradually disappeared. Even

[1] See p. 267.

[2] I have good reason for believing that the pseudonym covered the identity of Charles Thomas Brock. Alternatively, he may have been responsible only for revising and editing the second edition.

[3] Thomas Kentish was a schoolmaster, and, like Southby, employed in Woolwich Arsenal during the preparations for the Crimean peace displays. He was a close friend of C. T. Brock.

so, Kentish's colour compositions, as late as 1878, often contain as many as eight ingredients; to-day colour formulæ with more than four are the exception rather than the rule.

Modern chemical manufacturing processes have not only placed a wider range of materials in the hands of the pyrotechnist, often enabling him to substitute a single ingredient where formerly two or more would have been employed, but have also enabled him to obtain his materials in the form best suited to his purpose. Even as late as the middle of the last century to the firework-maker the preliminary preparation of his ingredients, such as grinding, and often purification, was a very necessary part of the work; in some cases it was found that by melting two of the ingredients together and allowing the mass to cool they could be ground with greater ease. Chertier went so far as to melt shellac and common salt together, grind them, and afterwards remove the salt by dissolving it in water.

The use of metals, formerly employed in their metallic form and chiefly in a spark-producing capacity,[1] with the exception of steel and iron filings, has now been discontinued. For this the introduction of the metals magnesium and aluminium have been responsible. The former was first prepared on a commercial scale about 1860, and within a few years had added a brilliancy to European pyrotechny hitherto undreamed of. In America, however, probably on account of its comparative costliness, magnesium seems to have been less extensively used. Henry B. Faber, Dean of the Pyrotechnic Schools, Ordnance Department of the U.S. Army, writing in 1919, makes no reference to the metal whatever,[2] an George W. Weingart[3] says that the metal "after being unused by the pyrotechnist for 40 years had again entered the picture." Later he mentions that about "60 years ago the price was $75.00 a pound," and explains that "later it was found that aluminium was in every way better, . . ." thereby suggesting that during the period of its exclusion in the United States the possibilities of magnesium had hardly been sufficiently explored.

While admittedly, for some purposes, aluminium makes a satisfactory substitute for magnesium, there are a number of unique and striking effects which the latter metal is alone capable of producing. In any case, the demand for magnesium in other spheres —alloys for aircraft construction and other engineering purposes—

[1] Copper, brass, and zinc.
[2] *Military Fireworks* (3 vols.; Washington Government Printing Offices).
[3] *Pyrotechnics* (second edition; Brooklyn, N.Y., 1947).

has resulted in a very great reduction in the matter of its cost, and in this respect the metals are now on an equal footing.

In 1888 aluminium, which had before hardly been known in its metallic form—a few small specimens exhibited in science museums as a rare metal made up all that existed—became a commercial proposition, owing to the Hall process. Although the possibilities of the new ingredient were quickly realized, its use in pyrotechny did not become general until some years later. Its appearance at the Crystal Palace in 1894 may be regarded as almost revolutionary; its advent opened a new era in the art.

Both these metals are used in a twofold capacity—as spark-producing ingredients, in the same way as are steel and iron filings, and, in addition, in the production of flame. Both burn with a brilliancy which would certainly have excited the envious admiration of Hanzelet, who, it will be remembered, in 1630 suggested a composition he claimed was too dazzling to be looked at. Both have been introduced into colour compositions to achieve an effulgence otherwise unapproached. Magnesium, as the operative constituent in a simple composition, gives a greenish-white illumination of amazing brilliancy.

The compositions employed in the various types of fireworks, and the methods employed introducing them into their appropriate containers, will be dealt with in a following chapter. Appendix II gives a list of the materials and salts now generally in use among pyrotechnists.

Chapter XIV

FIREWORK ACCIDENTS

"... and what with being blowed out of winder, case-filling at the firework business, I'm ugly enough to be made a show on!"

CHARLES DICKENS, *Bleak House*, Chapter XXVI (1853)

FIREWORK accidents may be divided into two classes: those occurring during the preparations for or during the firing of public displays, and those arising in the course of manufacture. Those in the former class may occur through official lack of control over the crowds assembled to see the display, or through some mishap or error of judgment on the part of the pyrotechnist or his assistants.

The fireworkers can hardly be held responsible for the catastrophe at Tower Hill in 1770, related at p. 132, or for the terrible disaster which marred the display on the Seine in celebration of the marriage of the Dauphin in 1770, when "the passages being stopped up occasioned such a crowd that the people seized with panic, trampled one upon another till they lay in heaps: a scaffold erected over the river also broke down, and hundreds were drowned: near 1000 persons lost their lives."[1]

"The Kings Ingenier," Major Martin Beckman, may or may not have been to blame for the accident to himself when superintending the display for the coronation of Charles II; no details of the mishap are available. There is little doubt, however, that the German quack-doctor Karls Bernoju had only himself to thank when he met his death at Ratisbon in 1673, as graphically depicted in a contemporary print (Plate XXIX). The caption explains that, covered with fireworks and carrying *twenty pounds of gunpowder*, he essayed to slide down a rope, fifty fathoms in length, stretched from the top of a tower to the ground. He fell from a height of several fathoms and was killed. The account concludes with the not that such feats are now forbidden.

The affair which darkened the Paris peace celebrations of 1749 may be ascribed to the Latin temperament. "There were 40 killed," we read, "and nearly 300 wounded by a dispute between

[1] *The Tablet of Memory* (London, 1818).

the French and Italians, [the pyrotechnists] who quarrelling for precedence in lighting the fires, both lighted at once and blew up the whole."[1]

London came off better on that occasion. The explosion which caused the fire in the north wing of the 'machine' proved the point, maintained by the Woolwich fire-workers, that quick-match was safer than the trains of corned powder advocated by Ruggieri and Sarti, but the mishap did not involve any member of the public. There were some accidents, however. Horace Walpole records that "very little mischief was done, and but two persons killed." Another casualty was a young lady in one of the galleries who was struck by a falling rocket "and would have been destroyed if some persons had not had the presence of mind to strip her cloathes off immediately to her stays and petticoat."

The cause of the accident by which the balloonist Madame Blanchard met her death at the Tivoli Gardens, Paris, on July 6, 1819, seems to have been a matter for doubt, according to contemporary reports:

> The fête at Tivoli . . . was marked by a dreadful catastrophe. Among the amusements which had been announced was the ascension of Madame Blanchard in an illuminated balloon, ornamented with fireworks. . . . At the signal given, the balloon rose slowly, in order that no part of the fire-works should touch the trees, though this could not altogether be prevented. . . . Madame Blanchard then set fire to the fire-works, which produced the intended effect; but it was observed that some of the fiery matter took a direction towards the balloon, and the fire communicated to its base. Immediately the most dreadful fright seized all the spectators, there being no doubt of the deplorable fate of the aeronaut.

Another account makes two suggestions as to the cause of the disaster; that when the fireworks touched the trees some of them might have been disarranged,

> thus a Roman candle, for instance, instead of going off horizontally . . . might have taken a direction towards the balloon and set fire to it. On the other hand, it is supposed that the unfortunate aeronaut . . . had not closed the valve, that the gas thus escaped, and on Madame Blanchard setting light to the fireworks the gas also took fire.

The report concludes: "It is certain that every precaution had been taken previous to the ascension, and that none of those who assisted in the preparation have to reproach themselves either with

[1] Horace Walpole.

incapacity or want of foresight." A comforting assurance which hardly seems to have been borne out by the facts!

Balloon ascents with fireworks by the aeronauts Green and Coxwell later became a regular attraction at Vauxhall, Cremorne, and elsewhere. I have been unable to find that any accident is recorded.

Accidents arising from the amateur use of fireworks on such occasions as Guy Fawkes' Day are seldom of a serious nature. They may even be considered as part of the fun, a view evidently taken by Samuel Pepys when he refers to "burning one another and the people over the way."

One wishes that the diarist John Evelyn could have found time, or space, to amplify the laconic entry for July 23, 1699: "The city of Moscow burnt by the throwing of squibs."

Accidents during manufacture may be disposed of in two periods —that before and that subsequent to 1830, the approximate date of the introduction of potassium chlorate. Indeed, a similar classification might well be applied to accidents at firework displays, many of which were due to the premature explosions of shells containing chlorate and sulphur compositions. Most of the manufacturing accidents in the earlier period seem to have been due to the conditions under which the work was carried out: open fires, before which finished, or partly finished, work was quite unconcernedly dried; unshielded candles on the work-benches; and disregard of the most elementary precautions through pure heedlessness of danger.

No details exist of the accident that caused the death of my ancestor John Brock at his house in Islington Road, Clerkenwell, on November 5, 1720. The date, however, is significant; the explosion may have arisen through relaxation of precautions during a last-minute rush of business, or, as I prefer to picture it, through the carelessness of a customer. That the mishap was of a severe nature is suggested by the fact that his daughter, Mary, was also so severely injured that she died twenty-two days later and was buried in the same grave at St James's, Clerkenwell.

Two years later we learn of the death of Mr Goodsheaf,[1] of White's Alley in Chancery Lane:

> As he was making some fireworks, the Gunpowder took fire and blew him up, by which means the House was fired and that adjoining somewhat damaged. More Mischief had been done, but that there was timely help. The Man is so hurt that his life is despaired of.

[1] Another account gives the name as 'Goodship.'

It is unlikely that the nine decades that followed were entirely free of accidents of the kind, but if they did occur they do not appear to have been considered of sufficient interest to be worth reporting. In the early days of the nineteenth century the Press contains many reports of such events. In 1810 we read:

> On Monday, a dreadful accident happened at Bath to Mrs Invetto, a firework-maker, and a young man her assistant. They were preparing sky-rockets, etc., for the Jubilee, when, by some means, an explosion took place of a considerable quantity of powder, some say upwards of two hundred barrels, which blew the house, and another adjoining, to atoms. The unfortunate woman was miserably burnt and bruised; and no hopes are entertained of her recovery. The poor fellow also lies in a shocking state at the Casualty Hospital at Bath.

The means by which the ignition was caused is not stated.

There seems to have been no doubt as to the cause of the accident which destroyed the factory of Benjamin Clitherow, in Fleet Street Hill, Bethnal Green, four years later, but one is certainly surprised to learn that the pyrotechnist was so far ahead of his time as to be employing a steam engine "for the purpose of making fireworks." Three persons were dreadfully burned, and much glass was broken in the neighbourhood.

In the same year, 1814, is recorded the first of a series of explosions that punctuated the business career of Mortram at the premises he then occupied in the Westminster Bridge Road. The cause on this occasion was clear—spontaneous ignition during the mixing of composition Little damage was done, but three persons were severely burned. Mortram moved to Mead Place, and here in August 1818 a second accident occurred, caused, we are told, "by a spark elicited from the tool used by one of the men at work in the shed." Two separate explosions completely destroyed the premises. "The houses in the neighbourhood were shaken, and thousands of persons ran with terror in their looks to ascertain the cause of the shock." A horrible aspect of the affair was the sufferings of a monkey, who could be seen by the onlookers, chained on the roof.

By 1821 Mortram had returned to the Westminster Road, and here was the victim of what can only be described as the idiocy of an employee.

> It appears that one of the boys employed in making composition stars for rockets had placed a number of them on the fender before the fire to dry, and had set fire to one on the hob, which falling in amongst the others, the whole exploded, by which a little girl was much hurt

in the back, and so frightened that she ran to the window of the first floor, but was prevented jumping out. The boy escaped up the area with his jacket on fire. The neighbours were now much alarmed, fearing that the fire might spread to more combustible matter in the house, and so on to the extensive workshops of Madame Hengler, the celebrated pyrotechnic to his Majesty; but through the activity of the workmen, who ran into the adjoining house with buckets of water, further damage was happily prevented, or the consequences might have been dreadful. An accident of a shocking nature, it will be recollected, occurred about three years since in the same person's repository, when two men were killed by the explosion.

Going back to 1814 after that digression, we find that the preparation for the official displays of that year were not without their troubles. One of the sheds at Woolwich Arsenal in which the fireworks were being made blew up, killing four men.

The year 1815 was marked by two serious explosions. In July, according to the *Tablet of Memory*, "several houses were destroyed and 14 persons lost their lives, by an explosion of gunpowder at the house of a manufacturer of fireworks at John Street, Spitalfields." In a second, at Wilkes Street, also at Spitalfields, the house of a firework-maker named Lushalan and the two adjoining premises were destroyed and five persons were killed.

In 1824 then occurred what might be called an official explosion, when the factory employed for the manufacture of Sir William Congreve's war rockets at West Ham blew up, causing the deaths of two men. The cause was ignition by a spark struck while a man was nailing up a case of rockets.

The next event of the kind I have to record was the second of its nature in the Brock family. It is reported in *Bell's Weekly Messenger* of September 4, 1825:

Yesterday morning, about half-past eight o'clock, Whitechapel Road, and the numerous streets that abound there, were thrown into the greatest state of agitation, by the inhabitants experiencing a most tremendous shock, as if caused by a volcano or an earthquake. The houses for a considerable distance were deserted by their inhabitants, and men, women, and children were seen running about in all directions, under the impression that the world was at an end. It was soon ascertained that their alarm was produced by the explosion of the factory of Mr Brock, the artist in fireworks at No. 11, Baker's Row, Whitechapel Road, nearly opposite the London Hospital.

The following particulars relative to this direful disaster have reached us: Mr Brock has resided for the last five years in Baker's Row, and at the back of his dwelling-house is his repository for fireworks, where they are manufactured. This building is about 50 feet by 20 feet, and contains three magazines, which are lined with lead, and would be perfectly secure from fire, should it occur, on any of the adjoining premises. In these receptacles were deposited all the powder, composition, and, in fact, all the combustible matter, and Mr B. was remarkable for the method he had taken to prevent any accident occurring on his premises. A few weeks since he had taken two boys out of the poor-house to instruct in the art of firework making, and he kept them chiefly employed in filling and ramming the cases of the sky-rockets, serpents, squibs, etc. . . .

Yesterday morning, at the time above stated, Mr Brock and his men left the factory to go to breakfast, leaving the two boys engaged at the work-board, ramming the sky-rockets. They had scarcely sat down to their meal when they, as well as the inhabitants around them for some distance, heard a sort of rumbling noise as if of some distant thunder, and the next moment a tremendous and deafening explosion followed, and the air was illumined with lights of various descriptions, and accompanied by continued reports. The concussion thus occasioned was so great that the inmates in the different houses were shaken from their seats, many of whom were sitting at their breakfast, and the tables and tea-things were upset and broken to pieces. The window frames were all forced out, and the brickbats and materials were flying about in every direction. The roofs of Mr Brock's manufactory, and the factory of Mr M'Devitt adjoining, were blown to a considerable height, and the falling materials did considerable mischief. After the agitation was somewhat subsided, an inquiry into the cause of the accident took place, when it appeared from the statement of the two boys (who were blown a considerable height and were much injured) that they were at work ramming the rockets, when the ramrod struck against the funnel, and the friction caused a spark, which flew into the bowl of gunpowder that stood near them; this soon exploded, and ran like a train to all the other fireworks in the factory, and at length communicated to the magazines, which caused the disaster. Mr Brock, however, declares that it could not have arisen in that way, as the nipple of the funnel was copper, therefore a friction would not cause a spark. One poor woman, sister to the beadle, who lives next door to Mr Brock, was so dreadfully injured by the broken glass that she lies in the London Hospital, without hopes of recovery. Ten houses were seriously damaged, and over sixty had their windows broken from top to bottom.

The first accident recorded during the 'chlorate-sulphur' period was very clearly the result of spontaneous combustion and, there can be little room for doubt, caused by that particular mixture. The Cockerill family of pyrotechnists, consisting of the parents, four sons, and a daughter, were in bed and asleep early one Sunday morning at their home in Paradise Row, Lower Road, Islington, in 1838, when one of the sons, who slept alone on the ground floor, heard an explosion in the workshop. Before he could do more than give the alarm the whole house was a mass of fire. In all four persons lost their lives.

There is no mystery as to the cause of an explosion at 6 Edward Street, Bethnal Green, in 1839: "A spark from a piece of wood placed on the fire ignited a quantity of gunpowder, exceeding two pounds weight, which was lying loose upon the table, and from thence communicated to a larger quantity in a barrel." The report concludes with the comment: "The most miserable negligence was displayed by the persons engaged in the fabrication of the fireworks, as just previous to the accident one of the individuals was making a squib by the fire with a lighted pipe in his mouth." The pyrotechnist's name is not recorded.

This affair was one of the great number that arose through the practice, followed by the majority of established manufacturers, of giving out materials to workers to be made up into fireworks of the smaller kinds in their own homes at piece-work rates. Most of the accidents were brought about by similar causes; the compositions employed were not of a sensitive nature or liable to spontaneous ignition, and, as the quantities involved were generally small, the ensuing damage was, on the whole, not extensive.

The formulæ for the new colour compositions were, on the other hand, treated as trade secrets, which each manufacturer carefully guarded, compounding and making them up into fireworks in the privacy of his own factory or workshop. Unfortunately a considerable period was to elapse before the dangerous nature of such compositions came to be recognized, or, at any rate, before adequate precautions were adopted. The danger to life and property was increased by the fact that the mixing and manipulation of these compositions was carried out in close proximity to the manufacturer's stock of fireworks, often amounting to quantities of explosives capable of causing damage over a considerable area.

As might have been foreseen, in the twenty years preceding the Gunpowder Act of 1860, and, to a somewhat lesser extent, between the date of that measure and the more imaginative Explosives Act of 1875, the destruction of firework factories recurred with monotonous and melancholy regularity. Nor, indeed, was the number of accidents reduced to reasonable proportions until, in 1895, chlorate and sulphur compositions were altogether forbidden.

"At twelve o'clock [midnight] in the morning of Monday February 28, 1842, the factory of the veteran pyrotechnist d'Ernst, in Prince's Street, Lambeth, was," in the words of the report in *Cleave's Penny Gazette*, "levelled to the earth, and in their place an immense mass of ruins only is to be seen." Two loud reports were followed by "a noise resembling the discharge of artillery in rapid succession. . . . To such a height did they [the flames] ascend, as to render the mass of ruins visible to those passing over the metropolitan bridges." D'Ernst, his sister, Mrs Hampshire, and another, who were living on the premises were killed. The time of its occurrence, as in the case of the explosion which caused the deaths in the Cockerill family four years earlier, leaves little doubt as to its cause —spontaneous ignition. The woodcut (Plate XXVIII) accompanying the account quoted bears a curiously striking resemblance to the final scene of that popular item among "Pollock's Juvenile Dramas" —"The Miller and his Men."

Spontaneous ignition was again quite clearly the cause of the explosion which destroyed the factory and stock of Drewell[1] at 6 Hatfield Place, Lambeth, in 1846; no one was on the premises at the time of the occurrence.

Darby, who for several years advertised himself as "Successor to d'Ernst," seems to have been particularly unfortunate. In 1857 his factory at 98 Regent Street, Lambeth Walk, was destroyed. The upper part of the four-storied house was used as bedrooms, with the stock below; the whole of the premises and stock were destroyed, the occupants of the bedrooms, who were cut off, being rescued by the aid of ladders. On this occasion the gunpowder appears to have been stored in a magazine away from the house. The report adds that the same premises had suffered in a similar manner on one or two previous occasions. Three years later yet another explosion there caused the death of three persons, and again in 1873 an even more disastrous catastrophe resulted in the loss of no fewer than eight lives. And yet when the Explosives Act came into force Darby removed his works to the Channel Islands, rather than submit to its provisions!

The explosion at the factory of Madame Coton ("Successor to Madame Hengler") in 1858 is depicted with such obvious accuracy, as well as such technical correctness, that one feels convinced that the artist actually witnessed the scene. (Plate XXVIII.) Here, again, there is no doubt as to the cause of the accident—spontaneous ignition. A boy named Bray "was in what is termed 'the coloured-fire

[1] The account gives the name, in error, as 'Drewett.'

department.' . . . Of a sudden he called out, 'Oh, the red fire is a-light,' and immediately rushed out of the building."

The whole factory, which stood at the corner of the Westminster (now Westminster Bridge) Road and Charles Street, was soon involved, and rockets flying across the thoroughfare set fire to the factory of Gibson ("Successor to Cannon"); both were completely destroyed. Three persons were killed, including Madame Coton, whose real name, it appeared at the inquest, was Bennett. Her husband was at Cremorne Gardens at the time of the disaster. In all three hundred persons were more or less severely injured. "A highly influential meeting" of local rate-payers the same evening passed a resolution that a memorial should be presented to the Government, praying that stringent measures should be adopted "to prevent the manufacture of fireworks in or near the public streets."

Firework-making was not the only industry which was causing alarm. In Birmingham the manufacture of percussion-caps was claiming a regular and increasing toll of victims. In 1852 a man was blown literally to pieces while preparing fulminate of mercury. In July 1859 two men and a woman were the victims of an explosion in a cap factory. Two months later at another works eighteen persons were killed outright, and three more died soon afterwards.

The Gunpowder Act of 1860, it is not surprising to find, made a serious attempt to deal with the percussion-cap industry, not, however, by any means successfully. In 1862 nine workers, between the ages of ten and thirty-five, were killed and thirty injured by an explosion of fulminate at a Birmingham works, and in 1870 eight deaths and injuries to twenty-eight others resulted from an explosion at Kynoch's factory. Less than a month had elapsed before a terrible disaster at Ludlow's works caused the deaths of no fewer than fifty-one workers.

The Act of 1875 did not come into force a moment too soon. The beneficial results for which it was responsible were quickly felt. They would have been greater, and even more immediate, had chlorate and sulphur mixtures been then forbidden. During the period of seventeen years that elapsed between the passing of the Act and their prohibition twenty-eight accidents, resulting in eleven deaths, were attributed to the use of such mixtures.

Almost the last of such incidents occurred in August 1893 at Brock's works, then at South Norwood, Surrey, in which one man was killed. He was emptying a small quantity of crimson stars on to a canvas tray from an earthenware jar; the slight friction so caused was sufficient to cause ignition, with the result that the whole contents of the building were ignited. One man was so badly burned that he died later. The victim, it is interesting to record, was the brother of Dave Nourse, who also worked in the factory at the time, and later was sent out on the firm's behalf to South Africa, where he settled down to achieve fame on the cricket field. The fact that the composition involved represented the only chlorate-sulphur formula in use in the factory renders the happening even more distressing.

Quite apart from any question as to the admixture of ingredients, the benefit obtained from what may be called the strategic provisions of the Act were demonstrated by an accident which occurred at a Mitcham factory in 1885. The initial cause of the mishap was simple: a workman was nailing a piece of curved wood to a tourbillion,[1] and the nail, instead of entering a section of clay as it should, penetrated the composition and fired it. The remainder of the building's contents was ignited and, the function of tourbillions being motive, took flight. One entered an expense magazine containing 3000 lb. of unfinished fireworks. Among these were a quantity of rockets, which in their turn caught fire and flew off in all directions. Ten other buildings and an open-air drying-rack were fired and destroyed completely; three more buildings and three racks were partly demolished. The total quantity of explosive material involved was probably greater than in any one of the accidents already mentioned, and yet the human casualties amounted to only two persons slightly injured—a striking proof of the efficacy of the precautions instituted by the Explosives Act.

In the period between 1875 and the date of the prohibition of chlorate and sulphur compositions there was a great falling off both in the number of accidents during manufacture and in the number of casualties to workpeople. Only in one instance were more than two persons killed by one accident. Since that date the average number of manufacturing mishaps amounts to about 4·6 per annum.[2] The number of persons killed averages rather less than one a year, or one in every five accidents, and the number of injured five in every seven accidents. These figures are for normal peacetime years. In wartime, owing to the relaxation of precautions and, in a greater degree, the use of formulæ origin-

[1] See p. 187.
[2] These include all ignitions occurring during manufacture, whether or not personal damage results.

ating outside the industry, casualties have shown a very marked increase.[1]

These figures compare most favourably with those of other countries. In India and the East generally the mental approach to the question of safety to the workers, or to the general public, is so different, accidents are so bewildering in their frequency, and their effects are often so widespread that no purpose is served in attempting a comparison. Such disasters as that which occurred at Vizagapatam, Madras, in April 1936, when thirty-nine persons were killed in a firework-factory explosion, are typical. In March of the same year twenty-three Chinese were killed and sixty-seven injured, including women and small children, while making crackers on Taipa Island, near Macao. In 1937 thirty women employees were burned to death and fifty others were reported missing in a fire which destroyed a Chinese fireworks factory, following a terrific explosion, at Manila.

The explosion of an illegal mixture (potassium chlorate and sulphide of arsenic) in an unlicensed factory was responsible for the deaths of sixteen people, and injuries to many more, at Worli, a suburb of Bombay, in April 1935. How little the lesson of this disaster was heeded is shown by the fact that it was repeated, in almost exactly similar circumstances, in the same neighbourhood only six months later, when nine deaths, including those of four children, are recorded.

It is strange that in Italy, the birthplace of European pyrotechny, the dangers entailed in manufacture seem to have been less appreciated, or, at any rate, less regarded, than elsewhere on the Continent. In 1885 ten workers were killed and twice that number injured by an explosion in a factory at Civitavecchia. During the year 1901 eighteen persons were killed in three accidents; in 1903, twenty-one in four; in 1907, twenty-three persons met their death in five such occurrences; while in Palermo, Sicily, no fewer than forty-four were killed and eighty-one injured in a single disaster. Twenty persons met their deaths and over a hundred were injured at Capurso, near Milan, in August 1926 when a lighted candle was dropped among some fireworks stored in readiness for the celebration of a saint's day at Castelfranco. Twenty-seven were killed in similar circumstances at Catania, Sicily, three years later.

In Portugal and Spain such occurrences as those referred to above are of comparable frequency. In France there has been a steady decline both in the number of accidents and, perhaps more

[1] See footnote at p. 150.

markedly, in the proportionate number of casualties. In 1889 by an explosion in a room where red phosphorus and potassium chlorate were being used as ingredients seven girls were killed out of eighteen who were together present. Fifteen years later a contemporary account records that

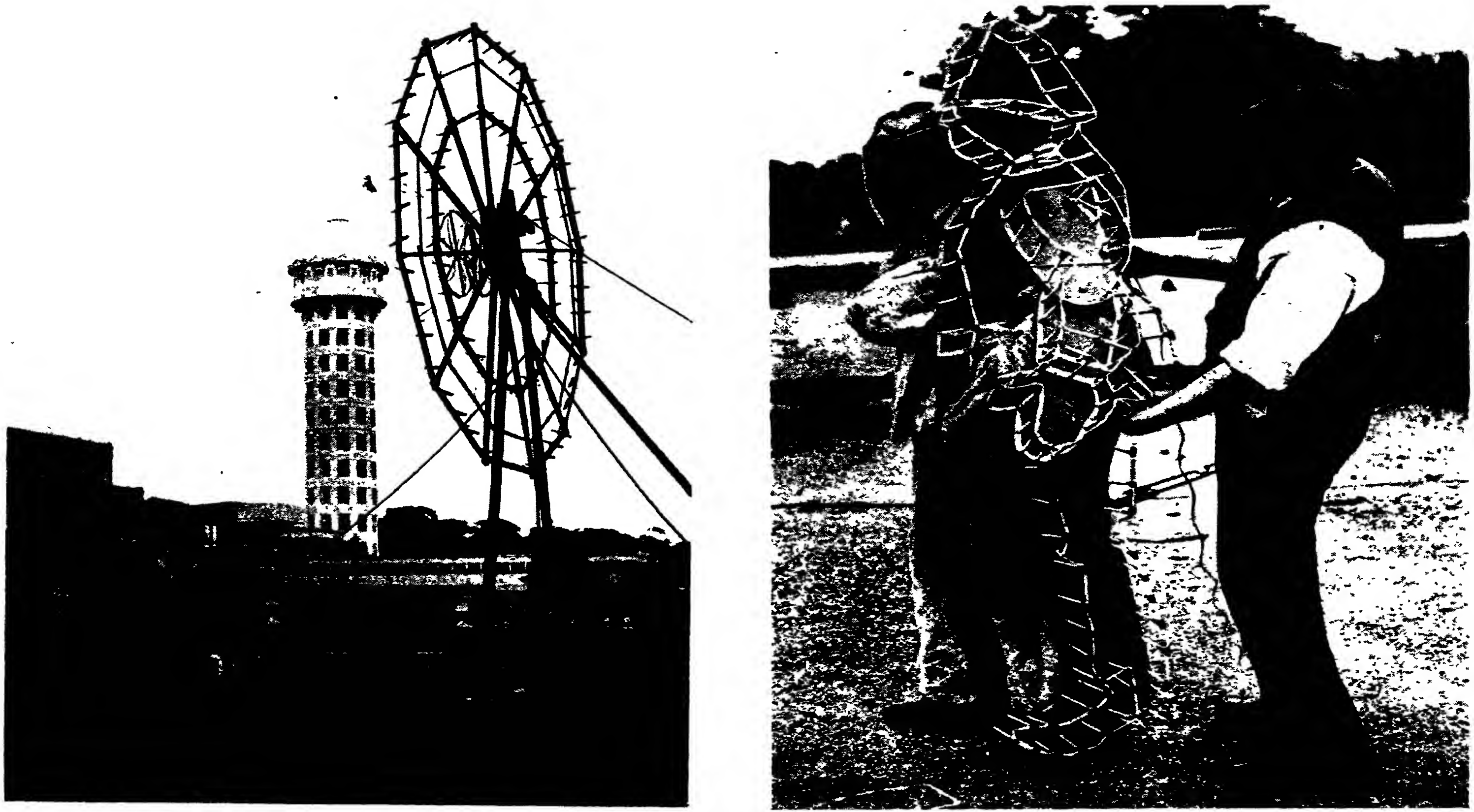
> a violent explosion occurred yesterday in the Ruggieri Firework Factory at St Ouen. The noise was terrific. . . . Thanks, however, to the system of isolation employed, only one small hut was blown down, and the three men who were working in it escaped with slight burns on their hands and faces.

In 1905 one man only was killed, although, according to a newspaper report, damage to the estimated value of £20,000 was caused in an explosion at Rouen.

Again, in 1925, when a series of explosions and a fire partially destroyed the Ruggieri factory at Saint-Denis, and adjacent dwelling-houses were badly damaged, no human casualties whatever resulted.

In Germany, too, accidents during manufacture have been comparatively few, and in such as have occurred the loss of life, except during wartime, has been remarkably low. Hochst, near Frankfurt, was the scene of a terrible explosion, in which pyrotechnic munitions were involved, in 1915; the number of victims has never been made public. At the same place, nine years later, an explosion which caused great structural damage and fires which necessitated the attendance of sixty-five engines resulted in the death of two men only. Again, in 1924, four girls were killed at the Geka factory at Offenbach, where in 1918 a disastrous explosion of pyrotechnic stores caused a heavy loss of life.

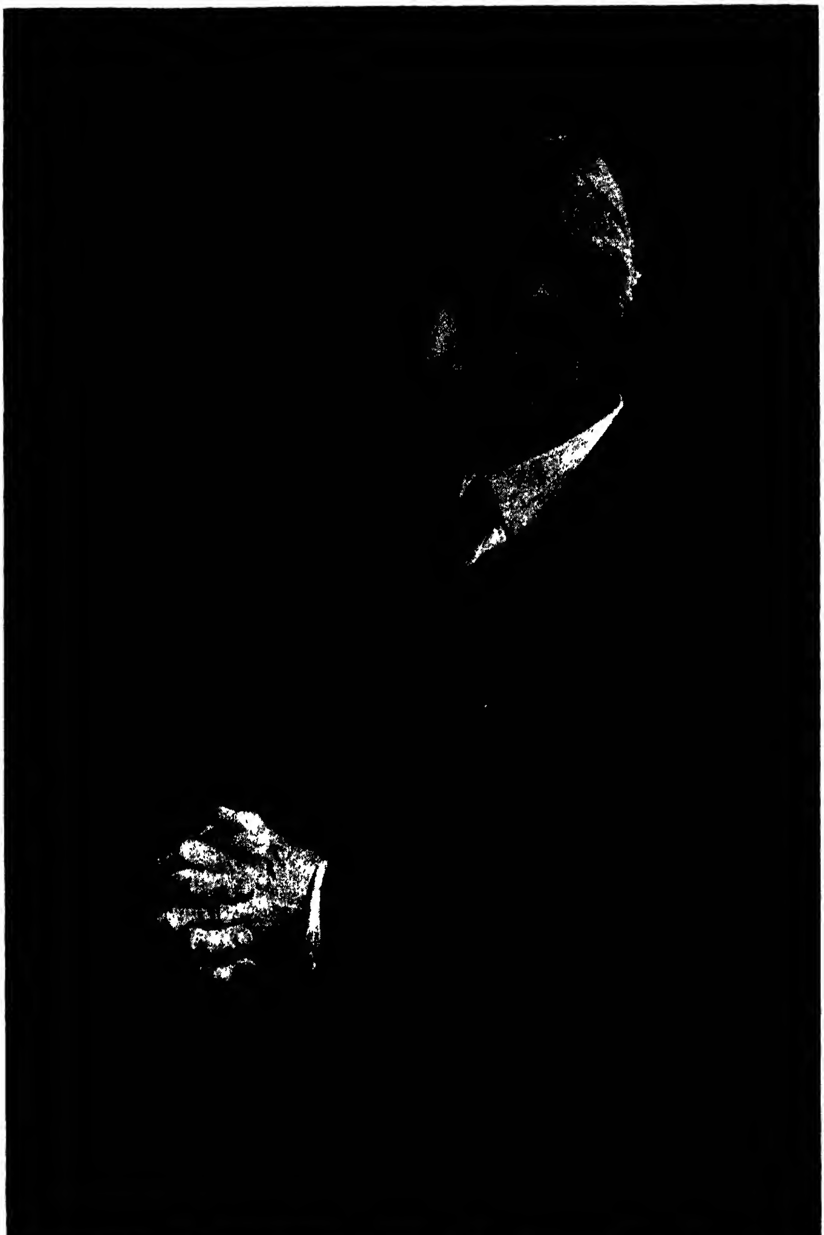
In the Western Hemisphere the toll of deaths has surpassed anything recorded in Europe, not even excluding Italy. In Latin America accidents have been almost too frequent, and fatalities too numerous, to list, while in the United States the number of such events seems, at any rate for a considerable period, to have increased as the industry expanded. In 1882 fourteen persons were killed and no fewer than seventy injured at Chester, Pennsylvania, by one explosion. From 1891 to 1894 eight accidents in the United States were reported, resulting in a total of twenty-three deaths and injury to more than fifty persons. In 1894, at New Haven, Connecticut, damage to the extent of 125,000 dollars was done, and at Dallas a considerable part of the city was destroyed, according to newspaper accounts at the time.



DISPLAY PREPARATIONS AT THE CRYSTAL PALACE

(*Left*) Raising a 'fixed piece' into position. (*Right*) Dressing a 'living firework.'

PLATE XXII



ARTHUR BROCK (1858-1938)
From a portrait by W. O. Hutchison, R.S.A., painted in 1931 to commemorate the subject's fifty years as head of the family business.

In 1901 fifteen employees were killed by an explosion in a factory at Paterson, New Jersey. The year 1904 produced an appalling list of tragedies. At Priceburg, Pennsylvania, in April, seven women workers were killed and many others injured; the factory blew up when a girl "threw a squib into a closed stove for a joke." Her reckless stupidity is hard to credit, but the want of imagination exhibited by the management in having such a means of heating in a room occupied by at least twelve workers, and situated on an upper floor, is unbelievable. In May six persons were killed and six injured at Camden, New Jersey. The accident was caused by a man taking potassium chlorate from a barrel with a scoop on which was some sulphur. The casualties amounted to a fifth of the total number of employees. On the same day twelve workers were killed, two reported missing, and twelve injured, out of a total of thirty engaged on overtime work, in a factory at Findlay, Ohio. The cause of the accident was unknown. In June a Press report stated that two girls only were accounted for, out of twenty-two, employed in packing fireworks, on the third floor of a firework factory at Philadelphia. Finally, in August, a man was killed while working alone in the mixing shed of the factory responsible for the supply of fireworks for the Manhattan Beach displays.

During the following years accidents occurred with monotonous regularity, if with less frequency. In 1925 very heavy material damage was caused by explosions at Hanover, Massachusetts, and at Franklin Park, a suburb of Chicago. The comparatively few human casualties suggest that more consideration was being given to the safety of the workers. In the following year two men were fatally injured in another explosion at the second factory mentioned above, and six men were killed and twenty-four injured in an unlicensed factory at Providence, Rhode Island. Three deaths resulted from an accident at Allentown, Pennsylvania. The fact that there was no loss of life in an explosion at North Bergen, New Jersey, which "shattered windows within a three-mile radius," did not affect the official decision to empower the police to close down the factory, together with two others in the neighbourhood.

A terrible disaster is recorded at Devon, Pennsylvania, in April 1930. A contemporary report stated:

> At least fifteen persons were killed, more than a score of others are dying and hundreds are suffering from burns and bruises. The initial explosion was heard for 80 miles around the countryside . . . the con-

> cussion was so great that it derailed and partly wrecked a passing train and rained down a cloud of flaming debris which fired several houses in the town a quarter of a mile away. Half a dozen minor explosions quickly followed.

The report suggests that the cause was spontaneous ignition in a magazine in which pyrotechnic shells were stored.

The examples quoted do not, of course, present anything like a complete list of such events, but only a selection from such as I have been able to collect from newspaper reports. Previous to the First World War the value of the annual report of H.M. Inspectors of Explosives was very greatly enhanced by the inclusion of notes and comments on such occurrences overseas. Since that time, presumably in the interests of economy, this practice has been discontinued. Is it too much to hope that, among the present welter of official publications, sufficient paper may yet be found to restore this most important and instructive document to its original form?

Quite apart from the alarming number of accidents arising during manufacture, authorities in the United States were increasingly concerned, during the early years of the century, by the ever-growing number of mishaps, entailing loss of life and personal injury, not to mention material damage, caused by the use of fireworks by the general public during Independence Day celebrations. According to statistics compiled by the American Medical Association, in the thirteen years between 1903 and 1915, 1862 persons were killed and 42,089 injured while using fireworks on the Fourth of July. In 1910 a national society for the prevention of accidents inaugurated what was known as the "Safe and Sane Fourth" movement.

The result was soon apparent: the deaths in 1909 were recorded as 215; in 1910, 131; in 1911, 57; and in 1912, 41. Injuries during the period dropped from 5002 to 947.

Influenced by the agitation, most of the principal cities of the United States instituted some form of legislation governing the use of fireworks. In many cases total prohibition of fireworks was ordered, with the result that a state of affairs arose comparable to the results of the Eighteenth Amendment. The sale of fireworks was transferred to 'bootleg' dealers, who did business, with impunity, on the fringe of city boundaries.

It seems to an impartial outside observer that, in too many communities, the possibility of a middle course between what amounted to unrestrained carnage and total prohibition might be followed: that the more dangerous, and unnecessarily dangerous, fireworks might be eliminated and still leave a sufficient variety for a worthy celebration of the national firework festival. A Bill which foreshadowed this outlook was introduced into the Michigan Legislature in April 1925. It restricted the sale of fire-crackers more than two inches in length and more than half an inch in diameter, crackers containing dynamite or picric acid, skyrockets, and Roman candles with more than ten balls (stars).

There was yet another productive source of pyrotechnic accidents at public displays, one which for a time constituted—and, indeed, in some countries does so even to-day—a very real menace to onlookers, as well as to surrounding property. This damage arises from the detonation of a shell, in the mortar from which it is fired,[1] by the 'lifting charge.' By this detonation the stars with which the shell is filled explode *en masse*, instead of being scattered to burn in the air, as they are intended to do, when the shell has reached the top of its trajectory. By this detonation the mortar may be shattered into fragments (or, to use that ill-applied and quite erroneous description so much in vogue during the War, 'shrapnel'[2]), which may cause great damage to surrounding persons or property.

This detonation in such accidents is initiated by the explosion of the lifting charge—the designed function of which is to blow the shell into the air—in the same manner in which the cap of a cartridge explodes the propelling charge. Naturally this misfortune is more liable to take place when the composition of the stars contained in the shell is of a sensitive nature. In this country the number of such occurrences was greatly reduced with the prohibition of chlorate and sulphur colour-composition, but they still happened occasionally. In September 1896 my father, the late Arthur Brock, carried out a series of experiments at Shoeburyness, at the request of Sir Vivian Majendie, to ascertain the cause. It is on record that explosives experts, who had had no previous opportunity of observing explosions so caused, were amazed at the terrific force exerted by the detonation of even a shell of 5½ in. diameter containing coloured stars.

It was found that detonation was most likely to occur when badly made stars—and for that reason inclined to be crumbly and

[1] See Chapter XVII.

[2] The Shrapnel shell, first used by the British Army in 1808 and so named after its inventor, Lieutenant-General Henry Shrapnel, R.A., is designed to throw forward a quantity of spherical bullets in flight; its light body does not 'fragment,' as do high-explosive shells. It was little used in the late war.

friable—were used. The salts most liable to cause detonation, when present in compositions, were copper arsenite and sodium oxalate. Other salts frequently produced only partial detonation of the mass of stars, a considerable portion of which were thrown out burning normally. One important fact was established: that by diluting the contents of a shell with a proportion of non-chlorate stars the risk of detonation is very materially reduced. The Brock firm have since adopted this course with all shells over 5½ in. calibre, with most happy results.[1] The effect of the coloured stars is very little diminished, and the others provide a pleasing secondary effect of golden rain after the former have burned out.

Another result of these experiments was the rule requiring all mortars to be buried in the ground to within two inches of the muzzle, a precaution which has had the effect of limiting the effect of such incidents as have occurred since. So also has the improved grade of steel now employed in the construction of mortars. The extra strength and toughness permit the use of a comparatively thin barrel, which rips open as the result of a detonation without fragmentation.

The most terrible disaster arising from this cause was that at Madison Square, New York, on November 4, 1902. Ten thousand spectators had gathered in the square to witness a display of aerial fireworks in celebration of the election to Congress of William R. Hearst, the proprietor of the *New York Journal*. The display included shells from three inches to nine inches in diameter. The mortars for their discharge were arranged in three groups of twenty each, and standing, unsupported in any way, on the asphalt. A shell in the first group to be fired detonated, blowing the mortar into fragments and, as reports seem to indicate, causing a sympathetic detonation in at least some of the others in the group. The terrific concussion upset the mortars of the other groups, with the result that the shells, ignited by fire from the first explosion, were discharged point blank at the densely packed crowd. Fifteen persons were killed and eighty seriously injured. Had the mortars been buried, and the spectators kept at a reasonable distance, it is quite possible that all casualties might have been avoided. (Plate XXIX.)

[1] The stars used for the purpose are known as 'lampblack.' A suitable formula is:

Saltpetre	9	parts
Sulphur	1½	„
Fine charcoal	4½	„
Lampblack	2	„
Black antimony	1	„
Dextrin	2	„

Chapter XV

SIMPLE FIREWORKS: FORCE AND SPARKS

How she cried O, O, O, as the rocket soared into the air, and showered them in azure, and emerald, and vermilion! As these wonders blazed and disappeared before her, the little girl thrilled and trembled with delight....

W. M. THACKERAY, *Pendennis* (1848)

SO far in this book fireworks have been discussed mainly in the mass, but even the most imposing display is composed of a sequence of items, and depends for its success, as well as for its spectacular value, on their individual performance. Such items may comprise simple fireworks, each one complete in itself, fired singly or in succession or in groups, or compound fireworks, which are built up from a number of simple fireworks, arranged to fire in unison, to form a set-piece, wheel, or device.

Simple fireworks, as are firework compositions, may be divided into two main classes: those producing force and sparks and those producing flame. There are, in addition, a few units which, on account of their unique performance, can only be regarded as freaks. Of the two types the first, notwithstanding that natural flame must antedate pyrotechnic mixtures, preceded the second by many years, possibly centuries.

It is difficult to decide which firework has the greater claim to antiquity—the fountain, whether or not in its specialized form of rocket, or the cracker. The latter in its simplest form—not to be confused with the 'jumping cracker,' which is one of the freaks referred to above—consisting of a quantity of a primitive composition confined in some sort of container, must, probably more by accident than design, have made a very early appearance, but a fountain effect, arising from some such incident as that described in the first chapter, may well have preceded it. We shall never know.

Pre-eminent among fireworks of the fountain type is the rocket. It seems to date from the embryonic period of pyrotechny in the East, and appears in the earliest printed works on the art to be published in Europe. Biringuccio describes them, and John Babington in his book gives illustrations of rocket-charging tools and describes the manufacture of rockets, on lines approximating to those of the present day. Only in the proportions of the ingredients is any considerable difference to be noted. The illustration showing the various phases in the making of a rocket in 1751[1] agrees almost exactly with methods in use to-day (Plate XXX).

The word 'rocket' appears to be Italian in origin, and to be based on the similarity in appearance of a rocket on its stick to the round piece of wood used in the Middle Ages to cover the point of a lance in mimic combat, and known as a 'rockette,' a diminutive of the Italian for 'distaff.'

The means by which motion is imparted to a rocket, even in these days of jet-propulsion and so-called 'rocket projectiles,' is not generally understood. The 'tail' which is seen streaming behind a rocket in flight is no more closely associated with its motion than is the exhaust gas from a motor-car. Movement results from internal pressure in the body of the rocket. If one imagines a hollow cylinder filled with gas under pressure it is obvious that that pressure would be exerted equally against both ends, and the cylinder would remain stationary. Now, if one end were removed and by some means the pressure was kept up, it is clear that the force continuously exerted on the closed end would tend to push the cylinder in the direction away from the open end. That is the principle on which the rocket operates. If, in fact, the missile does receive any additional forward impulse from the impinging of the escaping gases on the atmosphere, it is not unlikely that the resistance offered by the atmosphere to the forward movement of the rocket cancels it out.

It will be seen, therefore, that a rocket will—or, perhaps, one should say would—function in a vacuum or above the earth's atmosphere. It is this fact which, for some years prior to the late war, led many hopeful inventors to the belief that rocket propulsion might provide the solution to the problem of the so-called 'space ship.' It may yet do so; but most certainly not with power provided by rockets of the pyrotechnic type. A comparison between the result achieved by a rocket and the composition expended on its flight will make this plain.

A rocket of 2 lb. calibre—that is to say, approximately $2\frac{1}{16}$ in. in diameter—has a charge of 12·5 oz. of composition, and rises to a height of approximately two thousand feet in six seconds. The power developed is not continuous, however. In the first second of flight a maximum impulse of 62 lb. is developed; there-

[1] Diderot et D'Alembert, *Encyclopédie* (Paris, 1751–72).

after the power diminishes rapidly. For a time it serves to retard deceleration, but towards the end of the flight the burning composition does little more than to provide the visual effect of the tail. Anything approaching sustained flight, over even a limited distance, is out of the question.

A display rocket consists of two parts (apart from the stick, which balances it and directs its flight): the propelling unit, or 'body,' and the 'cap,' or 'pot,' which contains the garniture of 'stars' which provide the climax of its aerial effect. The body consists of a cylindrical case of stout paper, pasted and rolled on a former.

In order that the maximum internal pressure may be developed as quickly as possible, a conical cavity is formed in the composition with which the body is filled, thus exposing a greatly increased surface to ignition. The pressure is increased, and to some extent conserved, by reducing the size of the outlet by which the resulting gases escape. This is achieved by constricting the case, while still wet, by pressure with a cord. The waist, so formed, is known as the 'choke.' Small rockets, as well as other kinds of fireworks, are choked by means of a diaphragm of compressed dry, ground clay in which a hole of suitable size is formed.[1] The process of charging, or filling the case, is as follows: the case is placed on a spindle—a strong gun-metal base with a nipple of a size to fit the choke exactly and having above a tapering metal extension conforming to the dimensions of the cavity. The composition is poured in in small quantities measured in a scoop, each scoopful being consolidated by blows with a wooden mallet on a wooden 'drift' bored to receive the spindle. Before the first scoop of composition is introduced the rocket is 'set down'—that is, several blows are given on a suitably shaped drift to consolidate the paper at the choke and give it accurate shape. Next a scoop of ground dry clay is poured in and charged firm as a protection to the paper of the choke. The charging is then proceeded with. Varying drifts are used in order that the hole may correspond approximately with the diameter of the tapering spindle as the composition rises in the case.

A short portion of the case above the spindle is charged solid; this is referred to as the 'heading,' and is usually about one and a half times the bore in depth. A diaphragm of clay is formed above the heading, in which is a central hole.

The ingredients of the composition employed as the propellent

[1] In the U.S.A. the clay choke is frequently employed for rockets of the larger sizes.

charge in rockets have remained the same since the first was made. They are those of gunpowder, saltpetre, sulphur, and charcoal, but not in the same proportions, nor are they subjected to the same process of incorporation. Some early writers employed crushed, or, as we should say, 'mealed,' gunpowder grains, diluted with powdered charcoal or other material.

Babington (1635) suggests the following proportions:

1 oz.–4 oz. rockets, 1 lb. of mealed powder to 2 oz. charcoal.
4 oz.–10 oz. rockets, 1 lb. of mealed powder to 2½ oz. charcoal.
10 oz.–1 lb. rockets, 1 lb. of mealed powder to 3 oz. charcoal.

John Bate's compositions are rather erratically arranged; in some cases he adds the saltpetre, charcoal, and sulphur, and a further addition is "yron scales," presumably to increase the effect of the tail, for which purpose later pyrotechnists employed iron filings.

The proportions (in parts by weight) of the three ingredients to-day vary considerably with the calibre, as in the following table:

Calibre	Saltpetre	Sulphur	Charcoal
6 lb.	13	2	8
2 lb.	13	2	7½
1 lb.	13	2	7¼
½ lb.	13	2	7
4 oz.	13	2	6½
2 oz.	13	2	6
1 oz.	13	2	5

In display rockets the charcoal content is made up of approximately equal parts of fine and coarsely ground charcoal in order to enhance the effect of the tail.

I should make clear that the classification of the various sizes of rockets by a system of pounds and ounces does not refer to their actual weights, but to the weight of a ball of lead of a size to fit the mould in which the rocket case is contained while in process of charging, to prevent its being spilt by the force of the blows. To-day only rockets of the larger sizes are charged in moulds, but the classification remains despite sporadic attempts on the part of writers to introduce what, not altogether without justification, they considered a more rational system.

Perinet d'Orval (1740–45) published a system, based on the internal diameter in 'lignes,' or twelfths of an inch.[1] A name was given to each size: the 'Petit Partement,' 8 lignes diameter; 'Partement,' 10 lignes; 'La Marquise,' 12 lignes; 'Double Marquise,' 14 lignes. Rockets of larger sizes were designated 'Les Fusées de trois douzaines,' 16 lignes; 'de quatre douzaines,' 18 lignes; 'de cinq douzaines,' 21 lignes. The quantities refer to the varying capacities of the rockets' caps and the number of 'vetilles' or 'lardons' (squibs and serpents) they would contain. From this distinction it seems probable that the four sizes first mentioned were what, in this country, were then known as 'honorary' rockets—that is to say, they carried no cap and produced no visible effect other than the actual upward flight of the body.[2] His larger sizes he designates simply as of two, three, or four pouces. It can hardly be claimed that d'Orval's system, or, indeed, that of Frézier (1747), who attempted a similar classification, did much to clarify the issue.

T. Angelo (*c.* 1816), in a muddle as usual, attempts to provide a general rule for the dimensions of rockets: "Taking the diameter of the orifice its height should be equal to 6 diameters and 2 thirds; the choke 1 diameter and 1 third, this model will serve for every rocket from 4 oz. to 6 lb." There seems to be some doubt in his mind as to the precise meaning of the word 'choke.'

The dimensions of the various calibres of rockets to-day are as follows:

Calibre	External Diameter	Internal Diameter	Length of Body
6 lb.	$2\frac{5}{8}$ in.	$1\frac{13}{16}$ in.	20 in.
2 lb.	$2\frac{1}{16}$ in.	$1\frac{1}{2}$ in.	13 in.
1 lb.	$1\frac{5}{8}$ in.	$1\frac{1}{8}$ in.	$10\frac{1}{2}$ in.
8 oz.	$1\frac{3}{8}$ in.	$\frac{15}{16}$ in.	$8\frac{5}{8}$ in.
4 oz.	$1\frac{1}{8}$ in.	$\frac{3}{4}$ in.	$6\frac{3}{8}$ in.
2 oz.	$\frac{15}{16}$ in.	$\frac{5}{8}$ in.	$5\frac{1}{4}$ in.
1 oz.	$\frac{3}{4}$ in.	$\frac{1}{2}$ in.	$4\frac{1}{2}$ in.

Within recent years the charging of rockets by means of hydraulic power has been introduced with considerable success, but it is not altogether certain that, either in the time saved or in the quality of the product, the innovation is justified.

[1] The French inch, or pouce, was 1·1656 English inches; the ligne 0·0971 in.
[2] Only toy rockets of the smallest size are of this description to-day.

When a rocket reaches the top of its trajectory the fire of the burning 'heading' passes through the hole in the clay diaphragm above it into the cap, igniting the garniture and a small 'blowing charge' which bursts the cap and throws out its contents.

Some earlier pyrotechnists, as an alternative to the clay diaphragm, turned over and malleted down the top of the case to form the partition, through which one or more holes were pierced by means of an awl. Others, including the writer of an article which appeared in the *Gallery of Nature and Art* as late as 1817, advocated the use of chewed paper, a method which, one would think, must have depended for success on the dental equipment of the charger.

Formerly the clay diaphragm was charged in solid and the hole was bored afterwards. In modern practice the hole is formed during consolidation by using a drift provided with a projecting dowel.

The cap assumes a variety of forms according to the nature of the contents, the most usual being that of a truncated cone or a cylinder. The garniture may consist of 'stars' in varying forms or other special effects. If the former, their composition is usually a flame mixture, which, together with the manner of their construction, will be dealt with in a later chapter.

Before the introduction of colour composition the number of effects available to the pyrotechnist for use as garniture was very limited. The 'lardons' and 'vetilles' of d'Orval and a very few primitive flame-producing stars constituted the entire range. Variety was achieved, to a limited extent, by the contrasting effects of the 'honorary' and the now obsolete 'caduceus' rocket. The latter, as its name implies, left a double helical trail of sparks as it rose into the air. This was achieved by fixing two rockets to a single stick at angles slightly opposed to each other. The effect was good, but behind the brilliancy of a modern display would probably pass unnoticed.

Lardons, or serpents, produced the effect of the modern squib, a jet of sparks ending in a report, but with the slight difference in construction that the noise was increased by extra compression of the 'bounce'—that is to say, the gunpowder which provided the explosion. This was done by choking the case between the spark-producing composition and the powder.

In addition to their aerial function, rockets were employed to provide motion to those dragons, and similar figures, which played so prominent a part in early displays. A rocket body was attached to an open cylindrical case, through which a line was passed and tightly stretched between two supports. The 'line rocket' was employed, either concealed in a theatrical figure, or, as shown in many of the early plates of displays, to provide the high light of the performance, when a distinguished visitor might be asked to light one and so send it along its line to ignite one of the more important items.[1] Line rockets are often used in displays, at the present time, to provide the simultaneous ignition at several points of set-pieces covering a large area.

A modified form of rocket, the 'turning case,' has been long employed to give movement to wheels and other rotating devices. As the length of the time of burning is of more importance than the force exerted, which can be adjusted by the multiplication of units, turning cases are charged without the central cavity provided in a rocket. The composition used is a mixture of mealed gunpowder and steel filings.

There are two other fireworks belonging to this class whose function is to revolve, but in both cases as self-contained units: the 'saxon' and the 'tourbillion.' The former is designed to rotate about a nail passing through a hole bored in the centre of its length and driven into a support. Motion is provided by fire from two holes bored near the end at right angles to the axis. Each end, as well as the central position, is charged with clay. In a cheaper form the hole for the nail is situated at one end and the fire-hole at the other. As a unit for a compound device, the saxon may have a small case charged with colour composition attached to its side to provide a more striking effect.

The tourbillion is a development of the saxon; instead of the central hole and nail, a piece of curved wood is secured to the case, forming a pivot on which it may revolve when lying on a flat surface, and two additional holes are bored on the under side of the case, so arranged as to light when the case has sufficiently rapid revolution and project it into the air.

A modification, formerly applied to both fireworks, was the use of a wooden central portion, in place of the clayed section, suitably shaped to enter for a short distance into the cases forming the two halves of the unit.

Jones describes tourbillions as made to-day, also saxons under the older name of 'Chinese flyer.' In addition, he describes what

[1] *Cf.* Middleton and Decker's *Roaring Girl*, v, 1: "A justice used that rogue like a firework to run upon a line 'twixt him and me." Also Kirke's *Seven Champions of Christendom* (1638): "Have you any squibs, any green men in your shows; any whizzies on lines, Jack Pudding upon the rope or resin fireworks?"

he calls "table rockets," which resemble two double saxons fitted to a centre, which has a projecting cone upon which the piece revolves. He says that

> table rockets are designed merely to show the truth of driving and the judgment of a fireworker, they having no other effect when fired than spinning round in the same place where they begin till they are burnt out, and showing nothing more than a horizontal circle of fire.

It is, perhaps, understandable that this particular firework has long been obsolete. Later he adds that "these rockets may be made to rise like tourbillions by making the cases shorter and boring holes in the under side of each case at equal distances: this being done, they are called 'double tourbillions.'"

The origin of the name 'saxon' is obscure; 'tourbillion' is a corruption of the French *tourbillon*—whirlwind. Ruggieri applies the term to a compound device, and designates what we know as tourbillions as 'fusées de table,' or 'artichauts,' the name by which they are known in France at the present time. A programme of fireworks at Marylebone Gardens for the benefit of the singer Forbes, in 1769, contributes the original version 'tourballoons.'

Frézier shows the tourbillion manufactured as at present, which he calls "tourbillon de feu" or "soleil montant," but the nearest device he shows to a saxon is similar to Jones's table rocket, made to revolve on a spindle and having several holes bored down the side of each case, presumably to produce more effect. These he designates "tourniquets" or "soleils tournants."

He also illustrates cases mounted on a centre similar to that of a double saxon. This he calls "bâton à feu," and explains that one case lights after the other is burned out. He makes it clear that the device is intended to revolve, but how this is achieved by fire issuing radially, as is made clear in the print, is not apparent.

The compositions used in tourbillions vary with their size; from a simple mixture of saltpetre, sulphur, and charcoal in proportion 14 : 5 : 3 to that used in those of the largest type as used in displays:

Mealed gunpowder	7
Saltpetre	8
Sulphur	2
Charcoal	2
Iron filings	6

A typical saxon composition is:

Mealed gunpowder	3
Saltpetre	2
Sulphur	1
Steel filings	1

A class of firework rivalling the rocket in antiquity is that which includes the various types throwing out jets or fountains of fire. These are used not only in their individual capacity, but as units in the construction of a large proportion of the compound devices which make up the ground items of displays.

Foremost in this group is the gerbe (so named from the French *gerbe*—a wheatsheaf), or, as it is often called, the 'Chinese tree,' in acknowledgment of the Eastern origin of the composition employed in it. Prior to the introduction of Chinese fire[1] fountain effects were provided by 'ground rockets'; these were merely rocket bodies, modified by reducing the force of the composition by the addition of a larger proportion of charcoal.

The next step was a composition of mealed gunpowder and 'iron sand,' prepared by the method brought from China. It was not long, however, before the laborious process involved was rendered unnecessary by the discovery that iron filings or borings would give an equally striking result—one of the most beautiful and individually characteristic in pyrotechny.

The early makers choked the cases for all fountains in the same way as rockets. To-day a clay diaphragm with a central hole is universal. The time of the introduction of the clay choke is difficult to fix exactly. Jones (1765), although using clay in the heading of rockets, still choked all cases, but Mortimer (1824) uses only clay, and Ruggieri (1821), while sometimes employing clay, appears to think choking preferable. Mortimer gives instructions for charging the clay solid and boring the central hole; Ruggieri, however, uses a nipple like a much shortened rocket spindle, in which he agrees with the modern practice. Gerbes and other fountain cases are charged with mallet and drift similarly to rockets, but as there is no central cavity, the drift is solid. A typical gerbe composition is:

Saltpetre	10
Mealed gunpowder	2
Sulphur	2
Charcoal	2
Iron filings	7

[1] See p. 23.

Gerbes are employed both in static and in revolving devices, to which they provide both motive power and embellishment. The three big fire-wheels, two of 30 ft. diameter and one of 50 ft., which for many years, and in different dresses, formed a prominent feature of the Crystal Palace displays, were turned by gerbes of 2-lb. calibre attached to the end of the spokes.

A fountain unit which plays a purely static rôle, as its name suggests, is the 'fixed,' or, as known in the trade, 'fixt,' case. It is charged with a composition producing a somewhat more brilliant effect than the gerbe, but perhaps rather less striking, and formerly known as 'brilliant fire.' This usually consists of sixteen parts mealed gunpowder with from five to eight parts steel filings, according to size.

A difficulty which presented itself to early users of metal filings was the rapid deterioration of such mixtures due to the rapid rusting of the particles, with the result that the effect was quite spoiled. For this reason it was the custom to charge the cases at the last possible moment before firing the display. Even as late as 1876 the gerbes employed in the series of displays in India referred to in Chapter VIII were charged immediately before each show. This difficulty has now been surmounted by treating the iron before use. Various methods are satisfactorily employed for the purpose: coating the filings with linseed oil, marine glue, or other substance, which is then carbonized in a cauldron over a fire.

An interesting firework of the fountain type is the 'flower pot,' which produces a very striking effect, but one that can be properly observed only at close quarters, and is therefore not used in displays. Its composition, formerly known as 'spur-fire,' or 'carnation fire,' from the form taken by the coruscations it produced, is almost certainly of Eastern origin. It consists of the mixture saltpetre 12, sulphur 5, lampblack 3, orpiment 2. Jones suggested using flower pots indoors as what he called a "saloon firework." His addition of the aromatic 'gum benjamin,' or gum benzoin, was presumably an attempt to mitigate the effect of the smoke.

Most early writers devoted considerable space to water fireworks, many of which were simple modifications of the types already described above. A gerbe, fountain, or other firework is fitted with a float, such as a block of wood or papier-mâché bowl, and functions floating on the surface of the water, the effect being greatly enhanced by the reflection. Similar effects are in use to-day, as is the form of water rocket known as the 'skimmer.'

This is in effect a stickless rocket with the cap (which is empty and provides buoyancy) set at an angle to the axis of the body. When fired the skimmer, as its name implies, skims over the water in an erratic course, with occasional dives under the surface. It requires a considerable area of water for its safe display. These are known by French pyrotechnists as *genouillères*, from their shape.

Ruggieri and Frézier describe what they call "plongeons." These are gerbes charged in the ordinary way, except that before each scoop of composition a small quantity of mealed powder is added. This produces a jerky burning, the recoil of each puff of powder driving the gerbe beneath the surface of the water; the jet of fire, of course, is sufficient to prevent water entering the case while so submerged. These, and other writers, give elaborate details for the construction of a variety of devices, complex in execution but dull in performance, which would almost appear to have been included with the idea of filling space. One item which is often included gives directions for firing rockets under water. Jones's effort in this direction is as follows:

> TO FIRE SKY ROCKETS UNDER WATER
>
> You must have stands made as usual, only the rails must be placed flat, instead of edgeways, and have holes in them for the rocket sticks to go through; for if they were hung upon hooks, the motion of the water would throw them off; the stands being made, if the pond is deep enough, sink them at the sides so deep that when the rockets are in their heads may just appear above the surface of the water; to the mouth of each rocket fix a leader, which put through the hole with the stick; then a little above the water must be a board, supported by the stand, and placed along one side of the rockets; then the ends of the leaders are turned up through holes made in this board, exactly opposite the rockets. By this means you may fire them singly, or all at once. Rockets may be fired by this method, in the middle of a pond, by a Neptune, a swan, a water-wheel, or anything else you chuse.

It will be noted that, with all this elaboration, the rockets themselves are above the surface of the water and only the sticks submerged.

The history of the 'Roman candle' presents a most interesting study. The evidence available points to the fact that this very interesting and attractive firework—at any rate in anything approaching its present form—originated in this country. The name most certainly did so.

The first mention of any unit resembling it is found in Babington's book. He describes what he calls "a trunck of fire which shall cast forth divers fire balls." It is one of a class, apparently in favour at this time, intended to be carried on staffs, and known collectively as 'fire lances,' or 'clubs.' What he describes, although very large by comparison, being four inches in diameter, and throwing up only two balls or stars, would seem to be the prototype of the Roman candle.

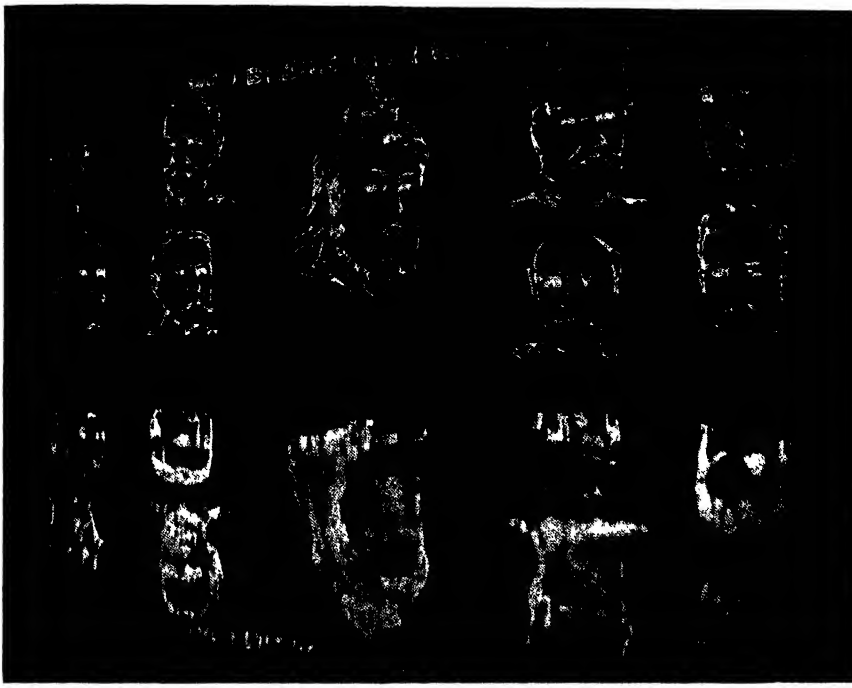
Bate describes a somewhat similar lance, with the difference that 'petards' or single crackers are substituted for stars. This was in 1635. Over a hundred years later Frézier describes an almost exactly similar firework under the heading "Artifices Portatifs," which name he adopts in place of the old French name *lance à feu*, in order to avoid confusion with the lance as known to-day—the small firework employed to form the outline of set-pieces—which was just coming into use. This is the only mention he makes of anything even remotely resembling a Roman candle, and, as he refers to several other foreign writers, a justifiable inference seems to be that neither he nor they had any knowledge of such a firework. Had he known of such a popular item he would certainly have mentioned it.

Yet in the descriptions subjoined to the engravings depicting the London peace displays of 1697 and 1713 the items "Pumps" and "Pumps with Starrs" appear. No details of these particular fireworks are given, but Jones's directions for making what he calls the "fire pump" makes it quite clear that Roman candles, substantially in their present form, are referred to.

When, however, the elder Ruggieri came over to this country in 1749 to conduct the Aix-la-Chapelle peace display in Green Park, in conjunction with Sarti, no firework of this nature appears in the programme of the display. Here were two pyrotechnists who can be considered to represent the best skill of France and Italy; in fact, it was, as his descendant wrote in 1802, the arrival of the Ruggieri brothers in Paris from Bologna that marked the beginning of the golden age of French pyrotechny. Yet the 'pump' does not appear in this great display planned and executed by them, although for years it had been a popular item in displays in this country. The obvious reason for this omission is that they did not know of it.

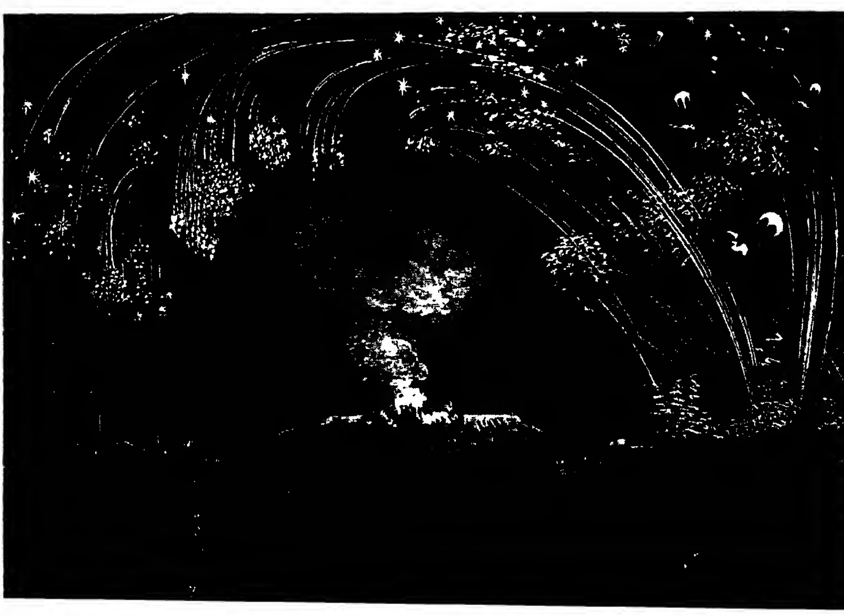
The first use of the present title for the firework I have encountered appears in the programme of the Forbes benefit display at Marylebone Gardens in 1769, already referred to: "Two Pyramids of Roman Candles" are promised. Item 28 of a Caillot programme at Ranelagh, dated June 6, 1791, reads: "A Grand display of

PLATE XXIII



A CRYSTAL PALACE SET-PIECE

At the time of the South African War: Queen Victoria with her Generals. Size: 200 feet by 60 feet. [*See p.* 225.]



FIREWORKS ON WOOLWICH MARSHES

In September 1855, to celebrate the fall of Sebastopol. Advantage was taken of the occasion to exhibit "Captain Boxer's newly invented parachute rockets."

PLATE XXIV

IMPERIAL FESTIVAL AT BUDAPEST IN 1903
[*See p.* 110.]

DISPLAY ON THE TAGUS, LISBON, ON MAY 27, 1886

Roman Candles." The first use of the name in France is to be found in Ruggieri's book (1801), "chandelle romaine."

How the adjective 'Roman' came to be attached to this particular firework is obscure, but my guess, for what it is worth, is that it was inspired by the carnival in Rome which preceded Lent, when merrymakers thronged the streets, each carrying a candle, which he endeavoured to keep alight, while extinguishing those of his neighbours—a continuous lighting and putting out of the flames.

The principle on which the Roman candle is constructed is as follows: the case is loaded with a series of repetitions of the following—Roman-candle fuse, 'dark fire,' star, 'blowing charge.' These are repeated as many times as the case will hold, and function thus: the fuse burns with a fountain effect, and, upon being exhausted, lights the dark fire, which lights the star. This in its turn fires the blowing charge beneath it, which propels the star from the case. The blowing charge also ignites the next layer of fuse, and the effect is repeated down the case. Each time the dark fire comes into action the Roman candle appears momentarily to have gone out, and to be rekindled when a star is thrown up.

In filling the case different-sized scoops are used for the blowing charge, which is of fine-grain powder, the smaller scoops being used at the lower portion of the case. This is done so that the stars may rise to approximately the same height; the charge at the bottom, acting through a greater distance, is naturally more effective, and less is required.

Earlier pyrotechnists, as a means of regulating the height of the stars' flight, made the stars of differing sizes; this practice, under modern manufacturing conditions, would be impracticable, and has been abandoned.

Roman-candle fuse is composed of sulphur, charcoal, and saltpetre in the proportion of 4, 8, 15. The dark fire is of mealed powder, with a small admixture of charcoal; to-day this is often omitted in the interests of simplification.

The Roman candle of the present time is made with an almost endless variety of stars, but those in use when the name was first introduced were of very simple character. The compositions used by Jones and Ruggieri would give a flame-coloured star with a tail of sparks, similar to that used in a type of Roman candle which we now call the Italian streamer. It seems possible that when the new colour compositions came to be used in these fireworks the name was transferred to those types in which the novelties appeared, and Italian streamer was applied to the earlier type.

Another firework, which was probably developed from the Roman candle, is the coloured gerbe, or jewelled fountain. Granules of colour composition are incorporated in a fountain mixture before charging, and are thrown up to mingle with fountain fire. The effect is pretty, but it is doubtful if it justifies the risk entailed in charging an intimate combination of sulphur and chlorate compositions.

Of the smaller fireworks of this division the squib, golden rain, and others are too well known to need description. The squib and its variations have a choked case; the golden rain and similar fireworks are left with an open bore.

Chapter XVI

SIMPLE FIREWORKS: FLAME COLOUR AND 'FREAK' UNITS

. . . Flames o' fire . . . sometimes plue and sometimes red.

Henry V, Act iii, scene 6

THE development of flame-producing units was even slower than that of those of the force-and-spark class. The early firework-makers, indeed, seem to have been blind to the possibility that any real development might be achieved. Flame to them was the natural accompaniment of fire; its colour and form were characteristic. If flame was wanted in a spectacle or display there were a number of readily inflammable materials ready to hand to provide it. As late as the end of the seventeenth century the more legitimate pyrotechnic items of displays were still eked out by the interpolation of fire-pots, flares, and torches, of tar pitch, resin, and oil, burned either singly or in rows, or even as units of crude devices. These last usually took the form of a mast fitted with a series of diminishing circular platforms, round the edges of which the flame units were disposed.

Later, with the introduction of the 'machine' or 'temple,' variety was assured by the use of flambeaux along the summit of the architectural elevation, and candle-lit lamps, sometimes enhanced by coloured glass shades and lustres. Later again came the transparency, depicting some allegorical subject and illuminated from behind by lamps and candles. All, no doubt, impressive in their way, but definitely not pyrotechny.

However, such adventitious aids held their ground, in default of pyrotechnic units that could compete with them. Neither was any more definite progress accomplished in the air: the use of flame effects in garniture was, for a long period, almost unknown. John Bate's star composition of "salt petre one pound and gunpowder and brimstone of each half a pound" made into a paste, shaped into "little balles," and rolled in "drie gunpowder dust" was quite capable of functioning satisfactorily as a pyrotechnic mixture. His suggestion of "oil of peter" (rock oil) as solvent in the paste may be interpreted as an extra assurance of inflammability.

So also may be regarded such liquid additions as spirits of wine, turpentine, and brandy. Any solid material readily ignitable of itself—sulphur, camphor, resin, various gums, amber—was also welcome to the list of the early fire-workers' materials. Bate's formula, and others similar, no doubt, did result in some limited appearance of variety, but the almost invariable inclusion of gunpowder, either in grain or mealed, and of charcoal almost as frequently, could only have resulted in fires in which spark effects were still definitely noticeable, even when they did not predominate.

It is true that antimony, in its 'black' metallic form, and orpiment (the trisulphide of arsenic) were already in use in the earlier years, but their true function in flame composition was not yet appreciated.

At Marylebone Gardens, in August 1772, on the occasion of "Mr Hook's[1] Annual Festival," the main feature of the firework display was a representation of "Cox's Museum"[2] and a "Magnificent Temple" outlined by "upwards of 10,000 cases of different fires all . . . lighted at the same time." The introduction of what looks very like commercial advertising into the displays is notable, but even more interesting is the suggestion of a new technique in the manner of treating architectural representations. The number of cases advertised is quite obviously an exaggeration, but there seems no doubt that it was sufficient to show the buildings in outline—a definite step in the direction of modern lancework.

As will be seen in the following chapter, the lance of to-day approximates to the size of a cigarette; the cases mentioned above would probably be of far greater dimensions—nine or ten inches in length and half an inch or more in diameter. They would—or, at any rate, most of them—however, be filled with a flame composition, as are modern lances. The mixture would be something approaching what came later to be known as 'Bengal fire,' consisting of saltpetre eight parts, sulphur and antimony sulphide one, and so called because, at that time, the only overseas source of saltpetre was Bengal. This mixture, and its variants, remained practically the only true flame composition until the commencement of the era of colour.

The introduction of potassium chlorate into flame compositions had a revolutionary effect on pyrotechny, but it did not result in

[1] James Hook, father of Theodore Hook, organist, musical director, producer, and writer to the gardens (1769–73).

[2] An exhibition of mechanical models, formed by James Cox, jeweller, located in Spring Gardens. The collection was dispersed by lottery in 1774.

any major changes in the form of the individual fireworks in which they were employed. Red, green, and yellow replaced the bluish white of Bengal fire, but in thin paper cylindrical cases of the same type, designed to burn away with the fire. Rockets and shells functioned as in the past, but a new value and interest was added to their garniture by a variegation of tints and fires. Stationary and moving devices were still formed and actuated by gerbes, fixed and turning cases, but coloured additions relieved their monotone of sparks. Moreover, it was not long before the pictorial lancework set-piece completely eclipsed, and eventually replaced, the transparency.

The small heaps of so-called 'coloured fire,' formerly burned in iron pans on the stage to emphasize the fall of the curtain on the more dramatic situations, now justified the description. Such usage has been superseded by electrical equipment, but 'flares' of loose coloured fire composition are still employed for landscape illumination during big modern displays, and very beautiful effects are achieved by such means.

The stars composing the garniture of rockets and shells, and those used in Roman candles, often consist of pellets of compressed composition without case or covering of any kind. These are known as 'pumped stars'; the composition employed in their manufacture contains an agglutinative substance, such as shellac, gum, dextrin, or starch, which fulfils the double purpose of supplying fuel to the flame and of giving the star sufficient hardness to withstand the shock of the opening charge in rockets and shells, or of the blowing charge in the case of the Roman candle. Before the process of compression the composition is damped with spirit in the case of shellac, otherwise with water. The moisture is subsequently evaporated out in a drying-room.

Another form is the 'pinched,' or 'pill-box,' star. This consists of a quantity of composition pinched into a short, thin cylindrical case, through which, and projecting slightly at either end, is threaded a piece of raw match.[1] The function of the match is to facilitate lighting; pumped stars of a composition that is not readily inflammable are primed with a paste of mealed gunpowder to the same end.

It will, no doubt, be realized that, as the whole surface of a pumped star is immediately inflamed, whereas the pinched star ignites at its ends, the time of burning of the former is considerably shorter than that of the latter. The difference is sometimes in-

[1] See p. 215.

creased by the extra length of pinched stars over that of pumped, which are usually of a length roughly corresponding to their diameter. Pinched stars are generally more suitable for use in shells, where the shock of opening is greater.

A method of star-making formerly much in use produced what were known as 'cut stars.' The dampened composition is spread out evenly in a shallow tray, pressed down, and scored in squares corresponding with the depth of the layer. After drying, the cake of composition is readily broken into cubes. The rough surfaces left by the fracture are considered to ensure easy lighting, but Angelo's advocacy of stars of this type for Roman candles must surely have led to irregular performance on the part of individuals. His other suggestion of flat stars with holes through their centre would, one would have thought, hardly repay the obvious difficulties of their preparation. Yet another suggestion of his is even more ridiculous: the graduation of the size of the stars in a Roman candle to accord with its position in the case, instead of following the otherwise universal usage of varying the blowing charges.

Stars designed to produce special effects may be separately charged in cases of varying proportions, or may be 'married stars,'

STAR COMPOSITIONS

	Yellow ('Amber'[1])			Red			Green			Blue			White ('Bright'[1])		
Potassium chlorate	5	4	5½	12	7½	11	6		3	2		5			6
Potassium perchlorate											6				
Saltpetre													16	22	
Barium chlorate								16	5	4					
Barium carbonate							6								¼
Sodium oxalate	1½	2	1½												
Strontium carbonate				2	2¾	7½									
Copper sulphide										1½	3⅜	4			
Calomel					½					2	2 2/8	4			
Antimony regulus														4	
Antimony sulphide													4		
Sulphur													4	7	
Meal gunpowder													1½	4	
Charcoal					¾	1		1½						1	½
Shellac	1	1	1½	2	1	1	2	1	1	½					½
Dextrin		½									1				
Stearin			½							½		1			

[1] These are the trade names.

made up of two units with contrasting effects. The number of formulæ in use is very great indeed; each colour has its own range of mixings, varying with the particular star or firework in which it is to be employed. It is perhaps unnecessary to add that every pyrotechnist has his own modifications of what are, to all intents and purposes, the same formulæ. In England, where, as we have seen, admixtures of chlorates and sulphur are forbidden, the list is sufficiently lengthy, but in countries where such compositions are used the total is vastly extended. It would obviously be impossible to give here anything approaching a comprehensive selection of every type of formula, but the examples set out above may be taken as typical.

The following formulæ are a representative, if limited, selection from the wide range of compositions used in lights, lances, and colour cases which play their parts in displays, sometimes as individual units, but more often as parts of set-pieces and devices:

	Yellow			Red			Green			Blue			White		
Saltpetre													14	8	8
Potassium chlorate	8	5			16	1		10			8				
Potassium perchlorate				6			½			6		16			
Barium chlorate	2						5½	10	12						
Barium nitrate								8			7				
Sodium oxalate	1½	2													
Sodium carbonate				1¼	6										
Strontium nitrate						8									
Copper sulphide										3⅝					
Copper arsenite											6	5			
Calomel								2	3		1	3			
Antimony regulus													4		
Antimony sulphide															3
Meal gunpowder													1¼	4	
Sulphur													4	4	2
Charcoal					1	½				2¾					
Shellac	2	1			4	1		4	2		1½				
Stearin	½	¼								1		1½			
Lactose				¾											
Pitch							½								

Since the introduction of the metals magnesium and aluminium into pyrotechny many beautiful effects of great brilliancy have been made possible. Below are a number of star formulæ in which these metals play an essential part:

	Red	Green	White	White	Illuminations	Green	Yellow	Red	Yellow
Magnesium					10	3	1½	2½	1
Aluminium	8	10	8	1	8¾				
Potassium chlorate						2¼		6	4
Potassium perchlorate				2			4		
Barium chlorate		9							
Barium nitrate					70	3¼			
Barium carbonate		5							
Strontium sulphate								3	
Strontium oxalate							2		
Strontium nitrate	16								
Strontium carbonate	3								
Sodium oxalate									2
Saltpetre			19						
Meal gunpowder	2								
Charcoal			1¼						
Sulphur			1¼						
Shellac								1	1
Gum				*					
Rosin					7½		1½		

* Dampened with gum water.

A number of other aluminium and magnesium formulæ are employed in illuminating lights, and in 'shower cases.' The latter provide one of the most striking display effects in pyrotechny, a cascade of dazzlingly brilliant fire, so aptly described in the Press, on the occasion of its first appearance at the Crystal Palace, as the "Weird White Waterfall." The following are typical examples:

	Lights					Showers		
Aluminium		2¾		2		6[1]	1¾	1¼
Magnesium	2		2		½		¼	¼
Potassium chlorate	1¾	6	6		6	6	6	
Barium carbonate				3				
Barium nitrate	6	5						4
Barium chlorate								2
Strontium carbonate							1	
Strontium oxalate					1			
Strontium sulphate			3					
Gum	1½	½						
Shellac			1	⅛	1		1	

[1] Three parts fine powder and three parts 'flitters' in the form of thin scales.

Flame cases, generally, are loaded with their compositions by one of two methods; the larger sizes are charged in a similar way to fountain units, except that a lighter mallet is employed and less force required, and, as no clay choke has to be formed, it is more convenient to proceed from the clay base upward to the open mouth of the case. Smaller cases, such as lances, as well as the numerous variety of 'back-garden' fireworks, are filled, or 'stemmed,' by what is known as the 'funnel-and-wire' method. The copper funnel (formerly known as a 'tun-dish') has an outlet, in the form of a short cylindrical spout, of a size to fit the interior of the case. The wire, of brass and of slightly less diameter than the outlet, is of suitable length and fitted with a wooden knob for the hand. The end of the funnel, which is filled with composition, is inserted in the upright case. The wire is then drawn up, thus freeing a small quantity of the composition, which runs down into the case, the lowering of the wire pushing it into position. In order to render the downward movement more effective the wire is often notched, but it is doubtful if this actually increases the efficiency. This action is rapidly repeated until the case is filled. This method, although simple, is very effective, and in the hands of a practised worker is exceedingly quick.

The 'pump' with which the stars named from it are processed consists of a short brass tube with an internal diameter corresponding to that of the star and about twice its length. Into this fits a brass plunger provided with a knob for the hand, and having a small metal stud at the side. The tube has a slot cut partially down the side to receive this stud.

The method of using the pump is as follows. The plunger is drawn up so that the stud rests on the top of the tube. The tool is pressed into a heap of prepared composition, which action has the effect of compressing the composition in the tube. The plunger is then turned so that the stud engages with the slot, so that it may slide down and expel the star from the tube. A practised worker with this perhaps primitive-sounding instrument can reach an astonishingly high rate of output; in fact, may exceed the production of elaborate mechanical equipment.

Here seems as good a place as any in this book to consider the behaviour of certain individual fireworks which can only be described as freaks; their performance is either peculiar to themselves or at variance with that of those in the class to which, by the nature of their compositions, they should belong.

Foremost among such examples, both in point of seniority and in its behaviour, is the jumping cracker. This would seem to have been a completely English creation. For many years writers abroad ignored its existence. Later we find it employed as a garniture in shells, and attached to a rocket so that it gave out a series of reports as the parent firework rose into the air. Ruggieri gives instructions for making them under the name 'péteroles,' remarking that "these are the most common which are known in England." Even to-day Weingart describes[1] their construction below the heading "English Crackers," with the sub-title "Grass-hoppers."

On the other hand, as early as 1635 Bate seems to assume a general knowledge of this firework, particularly among the juvenile population. Under the somewhat misleading paragraph heading "How to make Crackers" he says: "It is well knowne that every boy can make these, therefore I think it will be but labour lost, to bestow time to describe their making."

He also describes a kind of kite which he designates a "Fire Drake," to the tail of which he fastens "divers crackers," which are shown in the illustration to be exactly like those of the present day. Babington illustrates a cracker fixed to the top of a rocket, and so should be awarded the credit for this innovation many years before it was adopted on the Continent. As we have seen, Pepys' *Diary* has the entry "Seeing the boys in the streets flying their crackers . . ." for November 5, 1661.

The only practical difference between the cracker of 1635 and that of to-day is in the difference of methods of manufacture, the early practice being to fold the gunpowder in the paper, the modern to roll a paper case and fill it by a funnel and wire, afterwards flattening it through a roller mill, and so crushing the grains of powder. I feel I may, like Bate, safely assume that the reader is well acquainted with both the appearance and behaviour of the jumping cracker, but just why it functions as it does is, no doubt, a matter for speculation. It seems that, while the crushed powder burns comparatively slowly through the straight, partially filled portions of the case, the compression and constriction caused by the bends bring about an explosion at each; but it should be remarked that this behaviour is in direct contrast to what happens in somewhat similar circumstances elsewhere, and may be regarded as unique. "Crackers," says Mortimer,[2]

> when well made and of sufficient strength are productive of much mirth, and when of considerable magnitude, furnish excellent means of dispersing a crowd; at the same time they are so perfectly harmless

[1] *Pyrotechnics* (1947). [2] *A Manual of Pyrotechny* (1824).

that no evil consequences may be expected to follow the amusement they afford.

Another small firework the behaviour of which is individual to itself is the 'pin-wheel,' also generally known as the 'catherine wheel,' although, at one time, the latter name was also applied to the larger, compound wheels seen in displays. A list of items in a display, fired "for the benefit of a reduced citizen," at Lord Cobham's Head[1] in 1744, includes "Katherine Wheels," but to-day the term is restricted in its application. In France this firework is called 'pastille.' It does not appear to be of any considerable antiquity. Chertier remarks that "one finds in no book instructions for making pastilles," and mentions a particular type invented by himself, which he calls the 'dahlia,' as being originated in 1836. He seems to have overlooked—possibly, and justifiably, perhaps, as beneath his notice—Mortimer's somewhat sketchy instructions for making "Pin or Catherine Wheels" published in 1824. The latter makes no suggestion of their being anything of a novelty, and yet Ruggieri, undoubtedly the leading pyrotechnist of his day, fails to mention them in 1821.

As readers will remember, this little firework consists of a long, thin case wound in a spiral round a central, circular block, which is pierced by a hole to receive the pin on which the firework revolves. Why it does so presents a problem. As we have seen, a rocket receives its impulse from the internal pressure in the case; the jet of sparks is thrown out from a fountain case by similar reaction, but in both instances the pressure is maintained by the case remaining intact. The case of a pin-wheel, however, burns away with the composition, so the question of internal pressure does not arise. The composition may vary between what is virtually a force-and-spark mixture (meal gunpowder 16, saltpetre 1¾, charcoal 1) to one that is more of the nature of a flame composition. As the factor of internal pressure does not enter into the matter, one would assume that the motion is imparted by the reaction of the flame, and such sparks as are present, on the air. In fact, this must be so; but neither the degree of fierceness of burning nor the extent of the fire seems to have any observable effect on the speed with which the firework revolves. Again, the speed increases noticeably as the case burns away—that is to say, as the distance of the fire from the centre lessens and the leverage becomes less.

Mortimer's interest was aroused by the problem, although his remarks on the subject do little to assist in its solution:

[1] See p. 57.

> The force by which this wheel revolves is very remarkable, as it unites in itself those two adverse forces which have been the subject of so much mathematical controversy, namely, the centrifugal and centripetal: it may appear like trifling with science to observe these forces in this simple production, but that they do exist in it is not less evident: for from the revolutions of the ignited particles of the composition the former is produced, and from the nature and well known properties of the evolute curve, *coeteris paribus*, the latter is produced. The Evolute and Involute Curves are possessed with many remarkable properties, which it would be no difficult task to unfold, but as it could be of no practical use to the Pyrotechnist, we shall leave it to such of our Mathematical readers as are able to appreciate the pleasure which such investigations afford.

A curious firework of unique form, which, as far as I am aware, has now become obsolete, was the 'five-pointed star'—the 'étoile fixé,' of Ruggieri, and mentioned by Cutbush as "Italian Rose," or fixed star. It is described by Jones (1765), but not by Frézier (1741 and 1747).

The first of its unusual features is that it consisted of a stout, unexpendable case, of the type generally employed with force-and-spark compositions, charged with a flame composition: meal gunpowder 4, saltpetre 16, sulphur 4, antimony sulphide 2.[1] Another one was that it was fired in a horizontal position with the end of the case pointing towards the spectators. Also it was designed to emit five simultaneous jets of fire, radiating from the case near its end, in the form of a star. After the case was charged the opening was sealed with plaster of paris—probably clay would have served the purpose equally well—below this five radiating holes were bored through the wall of the case, and through these, after ignition, five jets of flame emerged.

It is difficult to believe that this unit was often completely successful in action, so many factors militating against perfection; but no doubt it was valuable as providing another to the very limited range of effects available before the era of colour. Its chief use was to fill in blank spaces in compound devices—as, for instance, the middle of a sun composed of a number of fountain cases radiating from a centre, in which the commencement of the fires of the jets would be separated by a distance equal to twice the length of the cases.

Yet another pyrotechnic curiosity is the unit which provides the noise in the always popular 'whistling rocket.' This effect is

[1] Ruggieri's formula.

not mechanical, as is often supposed; it is produced by the actual burning of the composition. Nevertheless the Siamese have made use of mechanical whistles attached to the rocket or the stick and actuated by the rush of air during the firework's upward flight, and a set of engravings recording a display at Augsburg, in 1666, certainly suggests the use of a similar contrivance, in connexion with tourbillions.

In the modern whistling rocket pyrotechnic whistling units replace the more orthodox garniture in the cap, to be released at the top of the trajectory. The 'whistlers' consist of small, stout cases charged with potassium picrate, prepared from picric acid (tri-nitro-phenol) and potassium carbonate, to which is added either saltpetre or asphaltum. Other compositions have been found to produce a similar effect. One such is a mixture of potassium chlorate and gallic acid, in the proportion 3 : 1; others which were used during the late war are still on the secret list.

Chapter XVII

SIMPLE FIREWORKS: SHELLS AND MINES

Then shell on shell ascends heav'n's vaulted dome,
Paling the dim forgotten stars. E'en there,
Amidst their loud-storm'd and invaded home
The meteor-flash and rolling thunder dare
Calm heaven. . . .

W. P. BALL, *Poems from Turkey* (1872)

UNLIKE the rocket, which, as we have seen, provides its own motive power, the shell is propelled into the air from a mortar—in effect a short-barrelled, muzzle-loading cannon—by the force of a 'lifting charge' of gunpowder. The two are often confused in the minds of spectators at displays; in fact, there seems to be a widespread impression that the two terms are synonymous or, at any rate, interchangeable. They can easily be distinguished by the following points of difference: the flight of the shell is preceded by the report of the lifting charge, that of the rocket is accompanied by the hiss of its burning composition; the rocket traces its path by the clearly defined tail, whereas the shell travels silently while the slight glow of its burning time-fuse can be seen as it turns over and over in its ascent. The report of the opening charge of the shell is much greater than that caused by the opening of the rocket's cap, and most noticeable is the difference in the extent of the effect of the respective garnitures: a small shell contains more stars than even the largest rocket is able to lift into the air.

The name originally applied to this firework was 'balloon' or 'air balloon,' a fact which has led modern writers, who have seen 'balloons' mentioned in advertisements of early displays, to suppose that an actual balloon ascension was referred to. J. T. Smith,[1] referring to an advertisement in the *Public Advertiser* of 1753, which mentions "grand air-balloons" to be included in the displays at the Marylebone Gardens, adds a note to the effect that these were perhaps the first balloons in England.[2]

[1] *A Book for a Rainy Day*, by John Thomas Smith (London; second edition, 1845).
[2] In this connexion it is interesting to note Ruggieri's claim that his father was the first to release a balloon carrying fireworks, in 1786.

Babington (1635) gives instructions for the making of a rather primitive shell, and although he generally gives the impression of being more advanced than his contemporary, Bate, in this instance he seems to fall behind him.

He describes a hollow sphere of canvas—hardly more than a bag—part of which is filled with a slow-burning composition, the remainder with stars and grain powder; the canvas is pierced to expose the slow composition. This doubtful projectile is fired from a mortar provided with a touch-hole. These are his directions:

> Load your mortar piece with one ounce of corne powder, putting after a wadd and tampion, and put on your ball with the vent towards the mouth of your piece: so elevating your piece to the zenith, you may proceed to the firing of it, which must be after this manner: provide two matches ready lighted, having one in each hand, and first fire your ball with one hand and presently give fire to your piece with the other, alwaies holding your head under the horizontall line of your piece, for fear the blast annoy you: this having done you shall see your ball mount very high with a fair taile of fire, and when at its highest, shall break forth into a goodly showre of starres.

This somewhat unconvincing account almost makes one wonder if the worthy gunner had in fact fired a shell such as he describes, and, if so, whether he was not more than "annoyed" at the result. He gives the lifting charge as exactly one ounce, but makes no mention of the size of the shell or mortar. It seems probable that he had never seen a shell of this nature, and was giving his idea of it without practical experience; this is the more curious, as, generally speaking, his book is advanced for the period, and usually seems to indicate personal experience of the matters under discussion.

John Bate, although less fluent, gives greater indication of practical knowledge of the matter. His "balloone" is rather oblong in section, and is made by rolling canvas on a former, using eight or nine turns. The ends are choked in the same way as a rocket case, one on to a "little cane rammed full of a slow composition." The shell is placed in the mortar, with the fuse downward above a lifting charge of loose gunpowder. The explosion of this charge ignites the primitive time-fuse provided by the "little cane." He suggests the very sensible precaution of having a second time-fuse at the touch-hole of the mortar, and concludes his instructions for firing by saying, "And while that burneth, retreat out of harm's way." Altogether a more practical and convincing description.

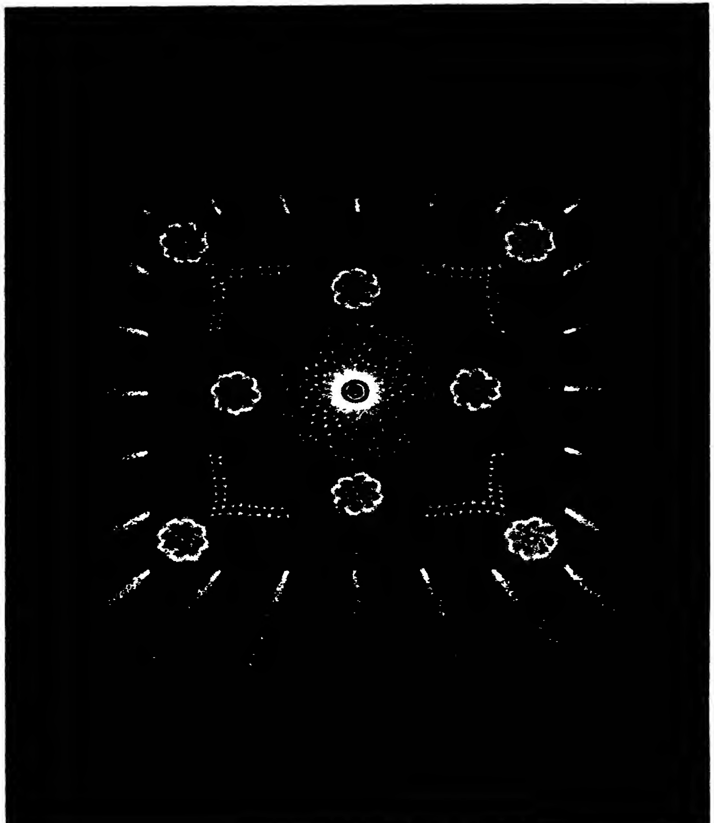
Frézier (1747) prefaces his chapter on shells with the following very sound general remarks:

> The name of 'ballon' is given to a firework which is thrown into the air like artillery bombs for war, so that they are often given the same name as bomb.
>
> The difference between this firework and a bomb is not only that the former is to amuse and the latter to destroy, and that the one is made of iron, and the other of wood, linen, or cardboard, but principally because the latter is made to burst and throw out its garniture at the point of the highest elevation, while the war bombs do so at the moment of their fall to the earth; also the war bombs are thrown towards the horizon, while the firework bombs are thrown vertically or nearly so.
>
> The fireworks differ also from the war bombs in shape, the former being not always spherical, as the latter are.
>
> We must therefore understand by the name of ballon a firework of which the effect and principal beauty is that while going up in the air it only shews a small stream of fire, which multiplies itself suddenly into a great number of others at the moment of its highest elevation, which causes a pleasant surprise.
>
> As this firework does not lift itself, but is thrown by impulsion in the same way as a bomb, it can, like the latter, only be fired from a mortar.

He describes two shapes of shell, the spherical and cylindrical, with a hemispherical end, which shape, he says, is more convenient where the contents are long in form, such as rockets and fountain cases. He attributes the introduction of this shape to Siemienowitz, who, he says, made the cases of wood. He himself, however, adopts the modern method of construction with papier mâché, as he does with the fuse, which he calls the port-fire. The lifting charge, however, is placed in the mortar separately from the shell and ignited at a touch-hole, in which, as will be seen, he differs from modern practice.

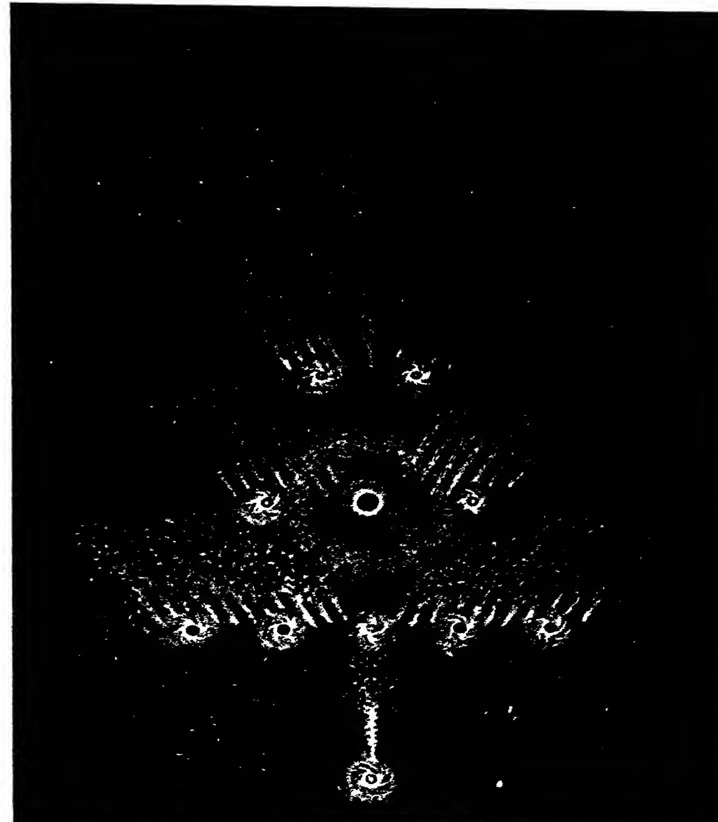
His list of garnitures is interesting as showing the practice of the day:

> The first is the one which gives the effect of a waterfall or head of hair ["chevlure"]. This is made of thin, narrow tubes, or, if possible, of thin canes, cut to the length of the shell, and filled with a slow-burning composition made of three parts of priming powder, two of charcoal, and one of sulphur, damped with a little petroleum, and capped with a paste made of powder crushed in distilled water or spirit and afterwards dried. All these are put in the tube, around the one which is used for the passage of the port-fire.
>
> When it is full the loaded port-fire is introduced, and pushed so far



THE CARPET PIECE

A design in lancework, with saxons and a central vertical wheel,



THE TREE PIECE

Composed of gerbes of 'Chinese fire,' with saxons and wheel, with a continuous discharge of coloured stars from Roman that it reaches the frame, and when it is touching the lid, this lid must be glued by the rough ends to that of the tube, and the shell is finished.

As it is rather heavy, it is advisable to adopt means for its resisting the shock of the lifting charge of powder which drives it out of the mortar, by strengthening it with a covering of linen strips, which should be stuck on to the shell by means of a paste, composed of two-thirds of flour paste and one-third of glue.

Unless this is done it often happens that the shell bursts before it rises in the air.

The second consists of serpents, the third of "saucissons volans," similar to the "fiz-gig" of Bate, the chokes between the composition and the bang being varied in position so as to produce a succession of reports. The vacant spaces left between the cases may be filled with stars.

The fourth is of stars arranged in beds of grain powder, the interstices being filled with a mixture of mealed powder and charcoal. The fifth is of "light balls," and for the sixth he describes "the manner of making figures and various shapes in fire appear in the air." These shapes are made on a wire frame covered with composition, and are consequently limited in size to the internal diameter of the shell, then less than eight inches. It seems improbable that they could be distinguished satisfactorily at the height of a shell's trajectory, besides which the difficulties involved, as he himself explains, are very great—a fact which no doubt explains why this idea is now obsolete.

Under the heading "Double and Triple Balloons," this writer describes the method of placing a shell of smaller size inside a larger. The bursting of the first shell lights the short time-fuse of the contained shell, which falls some distance and bursts. This technique is followed to-day: the larger calibres in use make possible the inclusion of several secondary, and even tertiary, shells.

Jones (1765) divides shell into four kinds—namely, "illuminated balloons" filled with stars; "balloons of serpents"; "balloons of reports, marrons and crackers"; and "compound balloons." The last description is misleading, as the balloon is not compound, but the contents are varied—as, for example, the contents of one specified: "ten crackers of six reports, twenty golden rains, sixteen two-ounce cases charged half-inch with star composition and bounced,[1] two ounces each of brilliant, blue, coloured tailed, large string and rolled stars." It is hard to believe that this writer had ever seen a shell so filled actually fired; the result, one imagines,

[1] Ending with a report.

would have been mere confusion. The star compositions of that date were quite rudimentary, the colours more imaginary than real, and when seen from a distance practically indistinguishable.

One interesting detail in Jones's work is the classification of sizes. The smallest shell mentioned by him is the "Coehorn Balloon"; he does not give the size, but it is 4⅗ in. He also refers to 8-in. and 10-in. calibres, the first time any writer has spoken of so large a shell.

Angelo (1816) confines himself to those of the "Cohorn"[1] size. His effects are limited: balloons illuminated containing 1 oz. "drove or rolled stars," "Balloons of Serpents," "Balloons of Crackers and Serpents," "4 reports and as many crackers of six bounces as will fill the case." His "Compound Cohorn Balloon" is rather less elaborate than that of Jones and contains ten blue stars and "rolled stars," as many as will complete the balloon with crackers and serpents.

Ruggieri (1812) is the first writer to combine the lifting charge and the projectile in one interacting unit, a development comparable to the introduction of the quick-firing gun. By so doing he not only anticipated the almost universal modern practice, but was more than a century ahead of some of his compatriots, who still keep the two separate. It is possible, however, that this apparent conservatism is, in fact, intended as a measure of safety. It permits the placing of a thick felt disc—known as a 'sabot'—between the lifting charge and the shell, as a precaution against the detonation of the latter by the explosion of the former. This danger exists only where chlorate and sulphur colours are still employed.

Ruggieri gives a table of sizes of shells in use at the time of writing—3, 4, 6, 9, and 12 pouces, each being slightly larger than the corresponding number of inches—and adds a note to the effect that he was the only pyrotechnist who had so far made a bomb of the largest calibre mentioned. He explains that the measurement applies to the internal diameter of the mortar and that the shell is one-fifth less in measurement. This would make his sizes correspond very nearly with our own. It is curious that he fails to mention the material from which his shell cases are constructed, merely describing it as a "kind of hollow ball," but the illustration, showing two halves of a case, suggests that he employed wood. Otherwise his methods follow, quite closely, those of the present time.

[1] Although Jones's spelling is the more correct, Angelo's was, later, the more general.

The modern shell consists of a papier-mâché case, generally spherical in form, though occasionally cylindrical. The two halves of a spherical shell are prepared in a hollow mould, a method that ensures uniformity of the exterior dimensions. As much could not be claimed for the earlier system of pasting successive layers of paper over a wooden ball, until sufficient thickness was obtained, and, after drying, cutting the two halvés apart. Before joining the two portions of the case a hole is punched in one of them to receive the time-fuse. This consists of a stout paper case charged with a composition (mealed gunpowder 4, saltpetre 2, sulphur 1) which must be very well consolidated to resist the shock of the lifting charge; otherwise the premature explosion of the shell in the mortar may ensue.

The lifting charge is contained in a cone, made of paper for the smaller types of shell, or flannel for those of larger calibre, attached to the lower side of the shell as it stands in its mortar. This charge is connected to the time-fuse by two pieces of quick-match which run round the perimeter of the shell case in two grooves, formed to receive them during moulding. The time-fuse is also provided with a 'lighter' of quick-match, of sufficient length to project some distance from the muzzle of the mortar when the shell is in position.

When the lighter is ignited, it flashes down to fire the time-fuse and the upper ends of the two pieces of quick-match communicating with the lifting charge. This last explodes, propelling the shell into the air. At the top of the trajectory the time-fuse burns through to ignite the bursting charge, which opens the shell and ignites and distributes its garniture.

To-day the variety of effects from shells are of almost infinite diversity. Apart from the variety achieved by differences in the colour, form, and contrasting combinations of simple or compound stars, striking, and often surprising, results are produced by the use of secondary shells and other types of fireworks, specially constructed for the purpose, actuated by time-fuses, so that a succession of effects is produced after that of the initial opening has subsided.

In the famous Crystal Palace displays shells of 4½-, 5½-, 8-, and 10-in. calibre were fired in salvoes of from twenty-five to ten, and an outstanding item was a display of single shells, of 8-, 10-, 12-, and 16-in. calibre. (It may not be out of place here to mention the 'nouns of assembly' applying to the various types of aerial fireworks: shells are fired in 'salvoes,' rockets in 'flights,' Roman candles in 'batteries.')

The largest mortar yet constructed fires a shell 25 in. in diameter, and weighs, when loaded, over two hundredweight. The occasions on which a projectile of this size can be used are necessarily few. Its last appearance was in the London peace display on June 8, 1946.

A variation of the shell, known as the 'comet,' consists of a spherical case, 3–3½ in. in diameter, fitted with a much-enlarged time-fuse of brilliant fire, which leaves a spectacular tail during the comet's flight. These are usually fired from either side of the firing ground in rapid succession, producing an aerial arch, and opening just after having passed each other. Another is the aerial maroon, with which many Londoners are familiar through its former use as the signal for the two-minute silence on Armistice Day, and as the official air-raid warning in the First World War. In peacetime it has become, by long-established custom, the recognized signal for the commencement of a display. It is, in effect, a small shell containing only a bursting charge of explosive, which functions with a flash and a loud report. Its case is formed from a short rolled-paper cylinder—the length being equal to the diameter—with wooden ends. In order to provide extra strength, and compression, the cylinder is wound with cord and afterwards dipped in glue, and when completed resembles a ball of thick string. Lifting charge and time-fuse are arranged as with a shell.

Before its comparatively recent adaptation as an aerial firework, the maroon—that is to say, a firework designed purely for the production of noise and reinforced by string winding—had been in use for many years. The obvious French derivation of the name, originally 'marron'—suggested no doubt by the bursting of a roasting chestnut—confirms its origin in that country. Frézier, as well as many later writers, shows a cube-shaped case, string wound, for use on the ground.

Ruggieri adopts the present form, and is the first to refer to the aerial maroon—"marron d'air." He does not, however, claim—rather unusually for him—to have invented it. He tells us that

> before the Revolution, the administrators of the King's Garden caused to be made in the maze, which still exists there, a meridian with a burning-glass which, every day that the sun appeared, fired a kind of bomb which exploded the lifting charge [chasse] of a marron in its mortar, the explosion of the marron in the air being heard for a great distance.

He also mentions what may well be the first use of aerial maroons as a commencing signal, "to announce the opening of fêtes at the

Tivoli since the police have forbidden the use of 'boîtes' [small cannon, known in England as 'chambers'] which have formerly caused accidents in this pleasure resort."

A class of firework much in evidence in the displays of earlier times shared with the shell the common characteristic of depending for their individual performance on the initial action of a propelling charge in a mortar, or its counterpart[1]; these were known generally as "pots-à-feu."

Babington includes in his list of fireworks:

> Another which I call Jack in a Box. The order of making this is after this manner: provide a box of plate, of what largeness you please—then putting in a quantity of corn powder or powder dust (in the bottom of the box) you shall fill it with fisgigs or serpents, leaving a case in the middle for a cane to go through to the bottom, which cane must be filled with a slow receipt, in which you shall put a quantity of champhire but no oyles, in regard of the narrow passage it has to burn without any other vent.

He then describes the fitting of a cardboard top having a central hole, through which the 'cane' passes, and concludes:

> Light your cane, which will appear like a candle, and after a pretty distance of time, you shall heare a sudden noyse and see all those fisgigs flying some one way, some another. This toy has given great content to the spectators.

Except for the substitution of a fountain-case for his "cane," and a rolled-paper container for his "box of plate," Babington's description might apply to those of the 'jack-in-the-box'[2] or 'mine of serpents' sold in the shops to-day. A counterpart is provided in modern displays by the 'mine,' usually fired either in salvoes or in rapid succession from steel mortars. These, as their technical name, 'bags,' implies, are cylindrical bags of garniture—squibs, crackers, or stars of various kinds—of a diameter corresponding with that of the mortar, each having its lifting charge and quick-match lighter, similar to that of a shell.

To this general class also belonged the 'trunck of fire' of Babington and the 'artifice portatif' of Frézier, which, as we have seen, in this country developed into the 'fire-pump,' prototype of the Roman candle. In France the development followed another line to 'pots-à-feu,' 'pots d'aignette,' and 'pots des brins'; by

[1] "Feux d'air par force d'impulsion" (Ruggieri).

[2] In the 'devil among the tailors,' a refinement of the 'jack,' the case is surrounded by Roman candles.

Frézier's time the 'trunck,' with but minor alterations, had become the 'trompe d'artifice.'

Frézier's 'pot-à-aigrette' differed little from Babington's 'jack-in the-box'; his 'pot-à-feu ordinaire' consisted of a rolled-paper mortar, ignited through a touch-hole in its base, projecting a single firework, which roughly fitted its bore. The projectile might take the form of a 'serpent' or 'serpenteau,' a large squib with the noise of its bang emphasized by a choke between the main composition and the 'bounce,' or a 'saussison,' a simple squib with its case reinforced by string binding. A row of such pots arranged to fire simultaneously he designates "brins de pots-à-feu." 'Pots des brins' remained a regular feature in displays for many years.

Jones adopts a similar terminology, but his 'pot d'aigrette' has assumed the form of the modern 'jack' by the substitution of a Roman candle for a fountain. These he advocates firing in groups.

Ruggieri classifies all fireworks of this sort as 'pots-à-feu'; their garnitures are 'serpenteau,' 'lardons,' and 'veteilles,'[1] according to increasing size—or, rather, as it appears, thickness of case. The lifting charge for 'pots,' consisting of a flat packet of gunpowder with the edge of the containing paper gathered round a piece of quick-match, he calls "champignon," obviously from the resemblance in shape to a mushroom. One gathers from the small amount of space he allocates to the discussion of fireworks of this type that he does not attach much importance to them.

Mortimer lumps all variations of the kind under the collective heading "Pots des Brins," which he describes as "large paper cylinders filled with powder, Stars, Sparks, Rain, Snakes, Serpents, Crackers, etc.," explaining that "they are generally exhibited in numbers, fixed on a plank of some kind," and concluding with the remark: "From their affording so great a variety of fires, [they] produce a most pleasing exhibition."

[1] Frézier uses the term 'fougues' for the largest size.

Chapter XVIII

COMPOUND FIREWORKS

And Catherine wheels, and crowns, and names
Of great men whizzing in blue flames;
  Lights, like the smiles of hope;
And radiant, fiery palaces
Showing the tops of all the trees,
  And Blackmore on the rope!

The London Magazine (1824)

IN this category are included those wheels and other devices, of comparatively modest size, known in the trade as 'fitted goods,' which are sold complete and ready for firing at private celebrations, as well as the more elaborate and spectacular pieces, moving, stationary, and pictorial, that are assembled and 'fitted up' on the sites of the displays in which they play so important a part; those, as Mortimer remarks, "resulting from the combination of the single or the more simple kind." All depend for their success on the orderly ignition, simultaneous or in succession, of the units of which they are composed. The means by which this is accomplished is provided by quick-match.

Quick-match 'leaders' consist of cotton-wick, of the kind employed in the manufacture of candles, impregnated with gunpowder and threaded in paper tubes. The wick is run slowly through a pan containing paste composed of gunpowder and starch, gum, or dextrin. As it emerges the soaked wick is wound on to a light wood frame, six feet by three feet, and pivoted at its centre. It is then dusted with mealed gunpowder and dried. When dry it is cut from the frame in lengths of six feet and threaded into thin paper tubes, or 'pipes,' which have an internal diameter sufficient to allow an air-space round the impregnated wick.

Before piping it is known in the trade as 'raw match'; in that state it burns quite slowly, and is employed in short pieces as 'priming' to ensure the ignition of compositions which may be otherwise difficult to light. Fire flashes from one end to the other of a length of quick-match almost instantaneously.

The cases forming a device are tied in position on cleats provided on the assembled wooden framework and are then 'led up.'

Each case has a 'cap' formed of a few turns of paper extending beyond its lighting end to receive the quick-match 'leader'; into this the match is inserted; it is then gathered in and tied. This is continued round the piece, each case having match entering and leaving the cap, and in some cases a further length connecting one series with another. The leading-up of set-pieces is work requiring skill and knowledge which is gained only by experience. An amateur at a first attempt might possibly be successful in lighting all the cases on a piece, but he would be very unlikely to produce that instant and symmetrical ignition which denotes the skilled pyrotechnist. It is an axiom of leading-up that every case shall have a 'double chance.'

In certain instances where it is necessary for cases to burn in succession—such as on small wheels where quick-burning turning cases are employed—continuity is ensured by the use of 'open-ended' units. In these the clay diaphragm, usually found at the base, is absent and an extra cap is provided at that end. By connecting cases in series by quick-match, each, as it burns out, lights its successor.

Although the idea of communicating fire by means of impregnated wick seems to have been in use from the early years of the seventeenth century, the advantage to be gained by enclosing it in pipes was not recognized until nearly two hundred years later. As early as 1640[1] Malthus describes the preparation of what he calls "estoupille" by the impregnation of cotton-wick with a paste of powdered gunpowder with pure water, and warns his reader against the use of such liquids as brandy, white wine, vinegar, and urine advocated by "les ignorants."

Bate, despite his admission that he had gained his information from Malthus, among others, can make no better suggestion for making what he calls "stouple" than "cotton weeke" dipped in "aqua vitae [brandy] wherein camphire hath been dissolved." This would produce a match dependent on the oxygen of the atmosphere for combustion and slow burning, unless it was his intention to use it wet, in which case the burning of the spirit might quicken the effect. It would, however, be quite out of the question to construct a piece of any elaboration with such materials.

Babington, it appears, knew nothing of such new-fangled methods. His method of communicating fire from one unit to another was to place them as close together as possible and connect

[1] The second edition of his work; I have not seen the 1629 edition.

"NIAGARA OF FIRE" FROM BROOKLYN BRIDGE, OCTOBER 10, 1892
A feature of New York's Columbian Celebrations.
[*See p.* 107.]

DISPLAY CELEBRATING THE TERCENTENARY OF THE FOUNDING OF

PEACE DISPLAY IN HYDE PARK, JULY 19, 1919

Some of the aerial items reflected in the waters of the Serpentine.

[*See pp.* 115–116.]

FIREWORKS IN SOUTH AFRICA

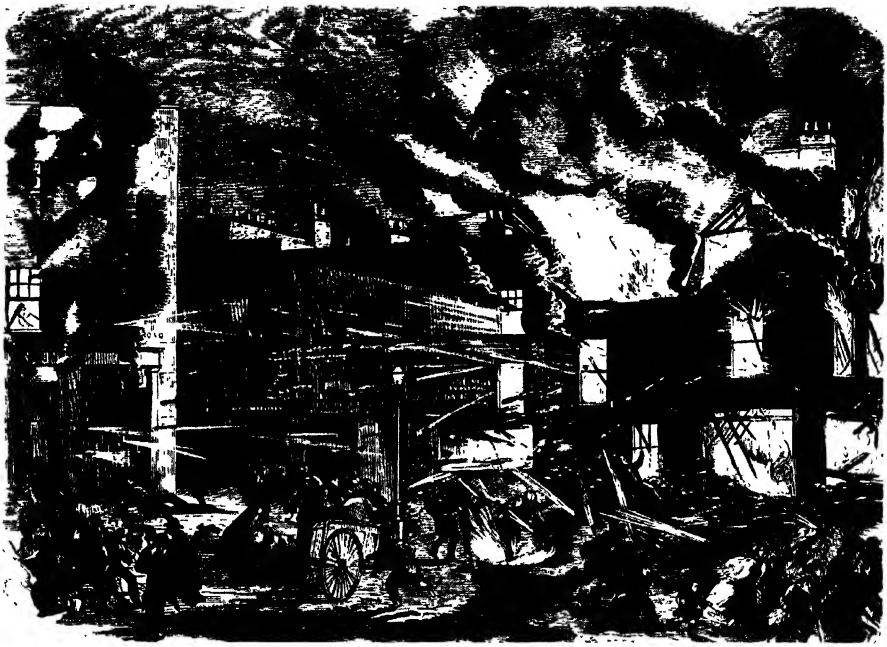
Part of the display fired at Cape Town during the royal visit of 1947, to mark the twenty-first birthday of Princess Elizabeth. H.M.S. *Vanguard* is seen in the foreground.

[*See p.* 124.]

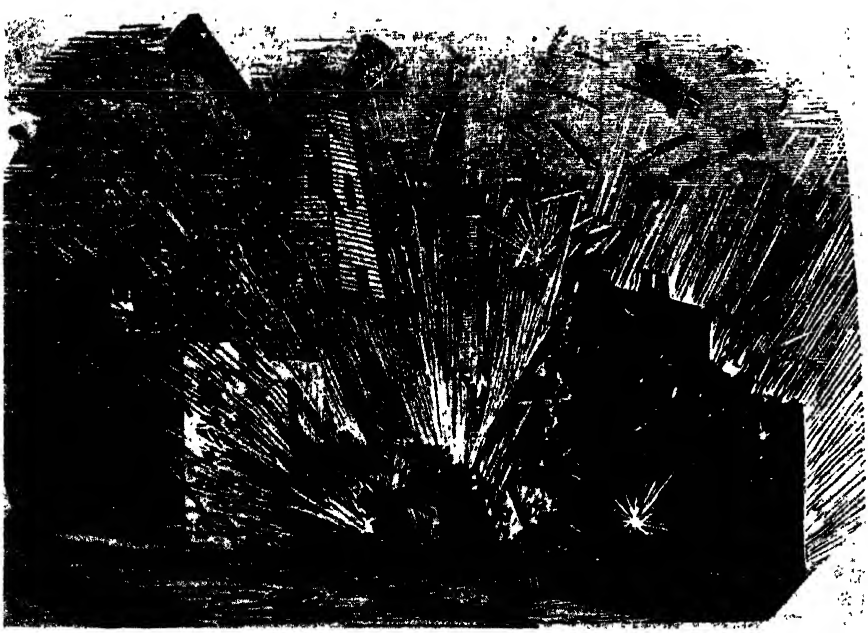
ROCKETS OVER THE THAMES

During the great national Peace Display on June 8, 1946.

PLATE XXVIII



EXPLOSION AT MADAME COTON'S FACTORY
In Westminster Bridge Road, 1858.
Illustrated London News
[*See p.* 172.]



EXPLOSION AT D'ERNST'S FACTORY
In Lambeth, 1842.

them by wrapping their respective ends in a tube of paper in which he placed a quantity of crushed gunpowder, a method that was, no doubt, effective, but of limited application.

Frézier's method approximates to that of Malthus; he uses the name "étoupille." Also he gives instructions for making "mèches a feu"—smouldering slow match, the purpose of which was to keep a means of lighting ready at hand when flint and steel was the only alternative. The materials are unusual—crushed dried mushroom and saltpetre. It may be that the former ingredient achieved some resemblance to lycopodium.

It is obvious from the disagreement between the Woolwich experts and the visiting Italians, at the Green Park display in 1749, over the use of trains of 'corned powder' for lighting the devices, instead of match, that the Royal Laboratory was already using it in some form.

Strutt[1] says definitely that he was informed by "a very skillful firework-maker, belonging to the train of artillery," who was present, that quick-match could have been used.

Ruggieri's "étoupille, commonly called mèche de communication," shows a great advance on former practice by the addition of gum to the gunpowder and water paste. What was far more important, however, was his introduction of piped match. He describes what was to all intents the quick-match of to-day, the only point of difference being that it was in short lengths, corresponding to the width of the paper from which the pipes were rolled. These he calls "conduits."

It is strange that he seems hardly to have realized the possibilities of the innovation; there are few references to the use of 'conduits' in his book. It may be that he preferred to follow earlier methods where possible, and that by threading raw match through holes pierced through the rather over-elaborate woodwork, or 'machinery,' of the period, or laying it in covered grooves worked in the surfaces, he achieved his purpose equally well. Time was then perhaps of less account than to-day.

Only three years after the appearance of the third edition of Ruggieri's book, Mortimer, whose information was not usually distinguished for its up-to-date character, describes match-making in all essentials as carried out at the present time.

Malthus has no suggestions to make in regard to devices or wheels. His suggestion for "L'ordre de disposition pour construire un feu de joye [display]" are contained in a few pages

[1] *Sports and Pastimes of the People of England.*

devoted to vague descriptions of scenic effects. Babington has several bright ideas, but it is more than possible that some of them he had never tried out. Most of these are based on the motive power of the rocket: he describes horizontal and vertical wheels which appear to be the same piece fired either horizontally or vertically. In neither case is there any further visual effect than that of the fire from the rockets tied to the periphery. His illustration shows no fewer than sixteen rockets to fire singly in succession, which would, by modern standards, make a rather lengthy and monotonous piece. He also describes ground wheels, which consist of two wheels fitted to an axle, with a smaller wheel placed centrally between them. The centre wheel has rocket cases fitted to it, causing the whole arrangement to revolve and run along the ground. As an alternative he suggests substituting cases secured to the axle without a central wheel, so arranged that, one being burned out, the second burns in the opposite direction and reverses the direction of the wheels.

He also describes what he calls "fixed wheels," an arrangement of fountain cases radiating from a centre, later (and, in fact, to-day) known as a 'fixed sun.' By way of variation he suggests various effects, such as "a fixed wheel which shall give divers reports," and another "which shall cast forth divers fisgigs, and likewise as many reports or breakers." He also describes a wheel "which shall cast forth many rockets into the ayre." This is evidently the prototype of a piece known later as the rocket wheel, popular for some time, but little used at the present, the objection to it being that there is no control over the direction in which the rockets fly from it. The wheel revolved horizontally and projected a series of rockets into the air as it did so.

Bate has less to say on this particular development of the art, but his heading "How to make Gironells or Fire Wheels" is interesting from another aspect. The word 'gironell' is certainly a corruption of 'girandole,' a term to which almost every writer on pyrotechny during the ensuing centuries seems to have attached a different meaning. Malthus refers to 'girindolles.' His confused, and somewhat meagre, description suggests something similar to Babington's rocket wheel, with the addition of 'pots-à-feu.' Frézier says, with apparent justification, that "the word Girandole signifies many things in our language." He explains that the word comes from the Italian *girare*, 'to turn,' and that in pyrotechny it "signifies all sorts of fire turning on its centre," but later restricts its meaning to wheels turning horizontally.

The elder Ruggieri and Sarti, assuming that they were responsible for the wording of the 1749 Green Park display programme, used the word in the sense of a large flight of rockets, a meaning for long applied to those which formed the *pièce de résistance* of the Castle St Angelo displays at Rome. Ruggieri the younger, in his book, reverts to the earlier significance, a horizontal wheel, but with vertical jets of fire and without rockets. He adds to the confusion by explaining that the name comes from the resemblance of the piece to "chandeliers of several branches called girandoles." He introduces an entirely new word for the rocket flight, the 'girande,' remarking that it is better known to the vulgar as 'the boquet.'

Neither Frézier's book nor that of d'Orval shows evidence of any notable advance in the form of compound fireworks. The fixed sun, some rudimentary revolving devices, some not very convincing attempts to improve the action of sky-rockets, and a considerable number of intricate and often impracticable-appearing aquatic devices make up the entire range. It is probable that these writers were behind the times, or, at any rate, that they fell far short of Ruggieri and Sarti in achievement. The Aix-la-Chapelle peace display included several elaborate pieces which, even allowing for the customary exaggeration in the programme, must have required considerable skill and knowledge in construction. These were mostly what were called 'regulated' or 'regulating pieces,' generally described as of so many 'mutations' or changes. They were so constructed that, after being first lit, they went through a series of alterations of form and movement without further attention.

Unfortunately the hiatus in pyrotechnic writings between the date of publication of Frézier's last edition in 1747 and the appearance of Ruggieri's first, in 1801, leaves us practically without information of the process of development in the art, and that during an epoch when real progress was being made. It is true that during the period the two editions of Jones's book had appeared, but his first edition takes us no further than did Frézier and d'Orval, from whom, no doubt, he gathered much of his material. The second contains little more additional information than that he had been promoted Captain in the meantime. Nor do the many engravings recording the triumphs of the French pyrotechnists help us, concentrating as they do on the scenic and architectural aspects of the 'machines' and 'temples.'

It is clear from Ruggieri's book that considerable development had taken place in the interval. How much of the technique he describes accorded with the general practice among firework-makers, and how much was personal to himself, it is, of course, impossible to say. My own opinion is that his family were always in advance of their contemporaries, and that as long as there were lavish patrons of their art and skill, such as Kings Louis XV and XVI, they kept their knowledge and methods to themselves as family trade secrets. Then came the Revolution; a barren period for French pyrotechnists followed, until the rise of the Emperor Napoleon brought back what must have seemed like the 'good old days.'

Meanwhile the prospect must have appeared bleak in the extreme to Ruggieri. His book, which for the first time made public the family technique, was, no doubt, a means of raising the wind during a critical period.

How much the family surpassed the work of their contemporaries is indicated in the following passages:

> It was in the month of July 1743 that my father and my uncles Ruggieri exhibited for the first time at the Théâtre de la Comédie Italienne and before the King the passage of fire from a moving to a fixed piece.
>
> This ingenious contrivance at first astonished the scientists of the day, who said when it was explained to them that nothing could be more simple and that any one could have done it at once.

He then explains the method of construction, which is to lead from the open end of one of the turning cases through the hollow centre of the axle to the lighter of the fixed piece situated behind it. To-day a similar result can be achieved by less elaborate means—a time-fuse, or, even more simply and quite as effectively from the spectators' point of view, by a second lighting. The modern spectator is more interested in the effect produced than in the manner in which it is achieved.

Ruggieri divides his compound fireworks into groups:

1. Feux fixés.
2. Feux tournant verticalement.
3. Feux tournant horizontalement ou tournant sur pivot.
4. Pièces composées et tournant sur pivot.
5. Découpes [cut-outs] et transparens [transparencies].

Of these the cut-out and the transparency are, as we have seen, obsolete to-day. Most of the other arrangements he describes are to be seen in modern displays. His stationary devices include 'glorys' and 'fixed suns'; the former consisting of a simple arrangement of fountain cases radiating from the centre, the latter of concentric circles of cases so arranged. In this country the names became reversed. His 'fixed sun' was known as a 'glory' until larger and more elaborate circular fixed pieces were accorded names more in keeping with their individual designs—'sunflower,' 'feather fixed piece,' and so on (Plate XXI). His 'glory' now goes by the name 'fixed sun,' and is fired most frequently as a component part of a more elaborate design.

His 'fans,' 'goose feet' ('pates d'oie') and names that explain themselves, are represented by our 'boquets' (generally of Roman candles) and the 'Prince of Wales's Feathers' of three gerbes. Ruggieri applies the term 'boquet' to an arrangement of fountain cases playing upward in tiers, somewhat similar to what is called a 'tree piece' to-day. To a particular form of this device he gives the title 'palmier,' taking care that it shall not be confused with his own pet invention, the palm-tree in coloured fire, referred to in an earlier chapter.

He deals separately with two arrangements of fire which, to-day, are frequently employed together in the same device. In fact, they may be said to embody the basic principles underlying the design of the great majority of pyrotechnic devices. He classifies as 'mosaiques' geometrical designs formed by arranging fountain cases on frameworks so that their combined fire forms a symmetrical pattern. The blank spaces were filled up by the use of saxons and the now obsolete five-pointed star.

The simplest device of this type now in use is the 'lattice pole.' Several are fired in a row, so spaced that the jets form a lattice of fire. This title Ruggieri gives to devices of another class which he calls "feux croisés"; in it the arrangement of the cases is such that the jet from each is crossed by the fire of one or more others. A very effective device of this kind, the 'lattice diamond,' is still in use to-day.

His device, the 'cascade' needs no explanation. He says that Chinese fire is the best composition for such a piece; this remained true up to the introduction of aluminium into pyrotechny, when the "Weird White Waterfall," two hundred feet in length and eighty feet high, became a feature of the Crystal Palace displays. Whatever fire is employed, the effectiveness of the cascade is governed only by its size.

The heading "Décorations en Feu de Couleur" introduces 'lancework' almost exactly as carried out to-day, in regard to construction, although its possibilities were far from being realized.

The continuing use of transparencies and cut-outs—the latter being designs in profile silhouetted by fire placed behind them—is evidence of this fact. Ruggieri's use of lancework was confined to the outlining of architectural designs, lingering survivals of the 'temples' of the past. They were merely, as he says, "decorations in coloured fire," the colour existing mainly in the imagination of the executant. His lance compositions, nine in number, could have produced but barely distinguishable effects.

He also describes a method of outlining by means of what he calls "cordes de couleur," which he says is "still, but rarely, employed." The cords were of wick prepared in a manner similar to that for match, but with a slow-burning composition consisting mainly of sulphur with small additions of saltpetre, antimony, and gum. Attached to wire outlines, they were lighted simultaneously along their whole length. Frézier makes a brief, and somewhat vague, reference to this method.

The greatest factor in the development of lancework to its present level of achievement was undoubtedly the increasingly ambitious and successful standard set by the pictorial set-pieces of the Crystal Palace displays. During more than sixty seasons a technique was evolved and an installation built up which was capable of dealing with almost any subject possessing sufficient pyrogenic appeal and dramatic interest. The permanent gantry, employed to support the highest portion of the set-piece, as well as the cascade, was capable of raising a section two hundred feet in length and seventy feet in height. When the subject demanded it, the overall length could be—as, in fact, it often was—extended to six hundred and fifty feet.

A favourite subject, and one lending itself particularly well to pyrotechnic production, is the sea-battle. Almost every historic naval engagement of sufficient size to warrant its adoption has provided the subject for a fire picture. Among the battles produced have been: "Bombardment of Alexandria," in 1882; "Siege of Gibraltar," in 1883; "Battle of Trafalgar," in 1884; during 1885 two pictures representing the use of the new 'ironclads' of the period, and based on the naval manœuvres of that year, entitled the "Attack on Dover," and the "Battle of Bantry Bay"; the following year another imaginary picture depicting an attack by torpedo-boats on the latest battleship *Colossus*. The "Bombardment of Sebastopol" was represented in 1887, followed by the "Jubilee Naval Review at Spithead." In 1888 the "Defeat of the Spanish Armada" was depicted; in 1890 "Trafalgar," followed, in 1891, by the engagement between the *Chesapeake* and the *Shannon*, together with a portrait of Admiral Sir Provo Wallis (who was present, at the astonishing age of a hundred), and another portrait from an early painting showing him at the time of the engagement, when, as a midshipman, the command of the English vessel devolved upon him owing to the casualties among the senior officers. Later in that year the "Battle of the Nile" was represented; 1893 saw the "Bombardment of Canton"; 1894 the "Battle of the First of June" and the "Battle of the Yalu." The "Battle of Manila Bay" was produced in 1898, and on the centenary date the "Battle of the Nile." In 1889 H.M.S. *Implacable* was shown in action on the day on which she was commissioned. This was followed, in 1900, by the "Bombardment of the Taku Forts," and, in 1901, the immortal sea-fight between the "*Revenge* and the Fifty-three." In 1904 the Russo-Japanese war gave subjects in the various attacks on Port Arthur, the Battle of Tsu-Shima, and the Battle of the Sea of Japan in the year following. The "Battle of Trafalgar" was renewed that season, and in 1908 another imaginary picture portraying modern naval warfare was produced, followed, in 1909, by an imaginary encounter between the first Dreadnought and other craft.

Following the First World War the battle of Jutland and the attack on Zeebrugge provided obvious choices of subject, and a representation of a Zeppelin raid on London was an outstanding success.

In the years before the possibilities for the representation of dramatic incidents had been fully explored the static fire pictures of famous buildings were frequently displayed: the cathedrals of Strasbourg, Salisbury, and Worcester; the Arc de Triomphe, serving as a foreground to a repetition of the aerial items of the Emperor's Fêtes at Paris; and, what seems a curious choice, a representation of the Crystal Palace itself, on a scale of about a quarter full size. In 1892 architectural interest and movement were combined in the portrayal of an incident in a Delhi Durbar; the procession of elephants past the Jamma Musjid mosque. A working counterpart of the then projected Tower Bridge was an obvious, if not very exciting, selection.

Since 1879, the date of the first portrait in fire, the number of royal, exalted, and famous personages who have seen—and in many cases personally fired—their own portraits is enormous. In 1887 the resources of lancework were greatly extended by the invention of the 'transformation piece.' This, on ignition, exhibits a design in fire of varying colours, such as a bouquet or emblematic floral device, and, after burning for some time, changes to a portrait or other suitable subject in white fire. This effect is achieved by embodying the lines of the second design in those of the first and 'sticking' them with long lances, all of which are so filled that they finish with white fire after the short lances which make up the redundant portions of the first design have burned out. The concealment of the outline of the second picture is assisted by the camouflage effect of the original colours. As will be readily imagined, the execution of such a piece requires very careful design and exact execution.

The first transformation portrait to be so shown was that of Lord Beaconsfield, the floral design being of primroses, and the occasion Primrose Day. This was most successful, and later in the year an enormous transformation picture, 200 feet long and 180 feet high, was fired at the Jubilee display, an emblematic design of roses, thistles, and shamrocks changing to portraits of Queen Victoria and members of the royal family. On this occasion there was a somewhat disconcerting hitch, fortunately of but brief duration. When the drawings for the piece were being prepared It was seen that the eyes of the subjects, situated at the same level and regularly spaced, would be difficult to conceal effectively in the floral outlines and so would 'give the show away.' Accordingly those features were executed on boarding counterbalanced and turned up behind the main framework, where they would burn, unseen, until the transformation, when they were to be pulled down into position. The duty of adjusting the right eye of the central portrait fell to one 'Sailor' Sam Cook, a picturesque character who had served in the Crimean War, and, as a result of his experiences there, had become almost stone deaf. Owing to this disability he gathered quite a wrong idea of what he was expected to do. In the past he had often pulled a rope to supply animation to a 'mechanical piece,' and assumed that this was just such another experience. The transformation took place, the five pairs of eyes assumed their correct positions, and then Queen Victoria winked. Sam continued to sway lustily on his rope, replying to all shouted persuasions to desist, "I am pulling, ain't I?"

A very successful transformation piece was a puzzle picture, in which a jungle scene changed to groups of wild animals. Another, "The Seasons," first produced in 1889 and revived from time to time, showed a rural scene which changed gradually from spring to summer, from summer to autumn, and finally to winter. Natural

ROCKET PRACTICE ON WOOLWICH MARSHES, 1841

The group on the left includes Queen Victoria and the Duke of Wellington, with spyglass, and possibly the Prince Consort. The tube from which the rocket has just been fired is seen in the foreground; the projectile is nearing the flagstaff to the right.

catastrophes, such as the eruption of Mount Vesuvius with the destruction of Pompeii, the avalanche, and a forest fire, provided striking subjects. Shipwrecks, amid waves which actually surged, and gallant rescues by lifeboats, in which the rowers could be seen toiling at their oars, were excellent material until the introduction of power-driven rescue craft took the human element from the scene.

Such incidents as the harpooning of whales in the Arctic and "Jack and the Beanstalk"—a favourite in the annual children's displays—derived added interest from the introduction of live performers, following the invention of 'living fireworks' in 1888.

The performers are clad in overalls of asbestos cloth, and on the side nearest to the spectators wear light wood frameworks on which the outline is 'lanced' to depict the particular characters to be portrayed (Plate XXI). The first subject dealt with was the boxing match, which has enjoyed continuous popularity up to the present day, and is possibly the most successful. Blondin on the tight-rope, inspired by the appearance of that great artist on the terrace on several occasions, surrounded by fires; a house on fire successfully dealt with by living firemen with hoses from which issued jets of fire; performing elephants and seals, and a Spanish bull-fight—in which incidents, it is perhaps unnecessary to mention, only the humans were, in fact, living. The animals were of a type of device known as 'mechanical.' These generally depict their subject in profile, cut out in light woodwork and outlined in lancework. Movement is provided either by mechanical attachment to the wheels on which they may move, or by means of actuating cords.

The smaller mechanical pieces form a history of locomotion during the period of the Crystal Palace displays. Bicycles, motor-cars, aeroplanes, costers' barrows, hansom cabs, fire-engines, scooters, have all been represented, either on their own merits or as accessories to living fireworks. In 1895 "The Village Blacksmith" was enacted, with horse, blacksmith, assistant, horse's owner, forge, bellows, anvil, and all necessary 'properties.' In the following year a piece was exhibited showing various members of the building trades at work on a partially constructed building, a subject which one cannot help feeling would arouse considerable interest to-day. In 1906 the then popular song "I wouldn't leave my Little Wooden Hut for You" was the theme of what was described in the programme as a "Living Firework Drama."

Automobile, motor-cycle, and greyhound races have provided much excitement, particularly when the apparent certain winner meets with a dramatic and fiery mishap. Interest in the Derby, with a field of six runners, was greatly increased by the behaviour of Tom Webster's immortal "Tishy," the horse with the erratic forelegs. Another Derby Day incident was the "Road to the Races," in which an imperturbable 'living' policeman controlled a procession of vehicles of all types, some of them directed by live, and lively, drivers.

The steps in the preparation of a lancework set-piece are as follows: A drawing of the subject is prepared in plain outline, from which all unnecessary detail and any shading must be excluded. This is ruled out in squares, each of which corresponds to one foot in the set piece. Light wood frames, measuring usually five feet by ten and divided by light battens into squares of one foot, are laid out on the drawing-floor. By following the lines of the corresponding squares the design is reproduced on the floor at its full scale. The outline is then followed by strips of thin wood or rattan cane nailed to the battens of the framework. The lines thus indicated are then 'pegged': small wire nails, pointed at both ends, are driven in at intervals of about four inches. The lances are glued and pushed on to the pegs so that they stand vertically from the framework. The frames are 'led-up' with quick-match, secured by pins driven into the priming at the top of the composition.[1] The match is then pierced with a small awl above the priming, and secured and protected by a strip of paper pasted over it and round the case of the lance. The piece is then assembled at the firing site, the individual frames are connected together, and the whole is hoisted into position, ready for firing.

It will be seen that, apart from the preparation of the framework, including the necessary cleaning-off of the residue from the previous firing and re-pegging, the preparation of a set-piece for each occasion entails seven separate operations on every lance. As many of the large Crystal Palace set-pieces required 35,000 lances for their execution, a total of 245,000 operations was involved, with 2450 six-foot lengths of quick-match, or rather more than two and three-quarter miles.

Ruggieri's division of revolving fireworks into vertical, horizontal, and composite ('composé') is perhaps somewhat arbitrary. It appears that, in his day, the use of flame-lances and colour cases —in conjunction with the spark effects inherent in moving devices

[1] Ruggieri attached the match, as do some modern pyrotechnists, by wire passing the composition at the top of the lance.

—was sufficiently rare to place devices in which it occurred in a class by themselves. To-day there are few examples in which the combination does not occur. Nevertheless his more ambitious efforts, although they seem to have been carried out on a considerably smaller scale than would be looked for by a crowd of modern spectators, embody most of the principles of present-day firework design. Some of the smaller pieces mentioned by him, and even earlier by Frézier and Jones, have survived in their original form up to the present time: the 'triangle wheel,' consisting of three spokes radiating from a centre, with turning cases mounted tangentially at their ends and forming an equilateral triangle; the 'double triangle' of six cases; the 'caprice' of three tiers, each of three spokes turning on a vertical spindle; and the 'furiloni' wheel, consisting of two tiers. In all these devices the cases burn in succession; in the two last mentioned the direction of the jet changes with each successive ignition, at an upward or downward angle or horizontal.

The spelling of 'furiloni,' the origin of which I have been unable to discover, varies in old programmes, advertisements, and books; furolona, forlona, forlone, and even trouana are found, and berlino may, as seems probable, be intended to indicate the same device. The 'enconstant wheel,' which appears in an advertisement of 1761, is doubtless a reference to a caprice. Ruggieri classes as caprices any horizontally rotating device in which jets play at varying angles. He illustrates as a 'caprice simple' a single tier of six cases, firing at varying angles successively, with a vertical fountain in the centre.

Jones describes a furiloni wheel having twenty-five cases. His method of leading would, however, not be so effective as the modern type of three tiers of three cases with a case placed vertically at the top. The cases are led-up in the following order: one case horizontal, one upward, one downward, one horizontal, two cases, up and down together, followed by four, one in each direction and one vertical—ten cases in all. For a compact piece this is one of the most effective made; a row of them fired together and working in unison makes a very effective item in a display.

Ruggieri's simple caprice survives to-day in one or other of the forms of the horizontal wheel. His central vertical fountain case may be replaced by a mine or a mine surrounded by Roman candles, the mine being lighted when the last case is exploded. When Roman candles are present they are ignited with the lighting of the last turning case but one.

Triangle wheels and small vertical wheels, named according to the number of their turning cases—'three-case,' 'four-case,' etc.—are much used, as also are saxons, as decorations for the larger fixed and turning devices of the present day. Simple geometrical designs in coloured lancework are similarly employed. A revolving spiral, as the centre of a large vertical wheel device, is particularly effective, as also is a conical helix turning on a vertical axis—the 'spirale' of Ruggieri and the 'spirali' of Jones.

Perhaps the most striking effect in moving fire is achieved by the intersection of jets and lines of lancework on two similar devices turning in opposite directions on the same axis. This effect is the basis of the 'guilloché,' an elaborate piece which Ruggieri places in his third class. It consisted of six wheels placed one behind the other in pairs of graduated size; the smallest two—which fired first—had six cases, the next eight, and the largest forty-eight, and was twenty feet in diameter. This device, one is surprised to read, was first fired at Versailles in 1729 by Ruggieri's father. One modern development of this basic idea is the 'chromatrope' (see colour plate facing p. 121), consisting of counter-revolving jets and bars of coloured lancework, a particularly striking and attractive piece.

Even more astonishing than the above-mentioned instance is Ruggieri's assertion that on the same occasion was fired a mechanical piece which even to-day is always well received if it does not, as he claims, occupy the premier place in pyrotechny. This was the 'salamandre,' the pursuit of a butterfly by a serpent. The mechanism consists of an endless chain of wooden links running in and out between eight sprocket wheels arranged in octagon formation. About half the length of the chain is made out and lanced to represent the snake, and a lancework butterfly is situated in the centre of the other half. The area of movement is enclosed in a frame of gerbes, which are lighted when the chase has been in progress for some time. Motive power is provided by pulling on a cord which has been previously wound round a pulley on one of the wheels.

Space is not available for a description of even a selection of the devices and pieces to be seen in modern display, but the illustrations will perhaps give some idea of the pitch which has been attained.

Chapter XIX

MILITARY PYROTECHNY TO 1900

And that it was great pity, so it was,
This villanous salt-petre should be digg'd
Out of the bowels of the harmless earth,
Which many a good tall fellow had destroy'd
So cowardly; . . .

Henry IV, Part I, Act i, scene 3

WHATEVER conclusion one may reach after assessing the conflicting evidence available towards the solution of the much-debated problem of the place of origin of artillery, there can be little doubt that the first use of pyrotechnic mixtures for warlike purposes occurred in the East. In an article appearing in the *American Journal of Chemical Education*,[1] Drs Tenney L. Davis[2] and James R. Ware,[3] two early native works on the subject of Chinese military fire weapons are examined, for the first time, in the light of modern technical knowledge. This paper, from which I had Dr Davis's kind permission to quote, deals with "Têng T'an Pi Chiu," by Wang Ming-hao, written towards the end of the sixteenth century, and "Wu Pei Chih," by Mao Yüan-i, written about 1621. Of these, the second contains most of the material and illustrations included in the first, as well as a considerable amount of additional matter. The "Wu Pei Chih," in 1869, formed the basis of a paper, read by W. F. Mayers before the Royal Asiatic Society of Shanghai, on the history of gunpowder and firearms in China. It would seem that, as with many writers both before and since, Mayers' lack of practical knowledge on the subject of pyrotechnics led him to undervalue certain evidence provided by the document in the matter of firework mixtures, and to overlook the fact that, until the principle of the gun was established, what is known as gunpowder was just another pyrotechnic composition.

Unfortunately "Wu Pei Chih" does not attempt to fix the dates for the invention of the devices it enumerates, but Professors Davis

[1] Vol. xxiv (November 1947), p. 522.
[2] Emeritus Professor of Organic Chemistry, Massachusetts Institute of Technology, author of *The Chemistry of Powder and Explosives* (New York, 1943).
[3] Associate Professor of Chinese, Harvard University.

and Ware preface their examination of the text with a chronological list of possible pyrotechnic innovations collected from other sources. A reference to fireworks at a very early period would, so it seems to me, require very careful verification before acceptance. The authority for the statement that "Emperor Yang of Sui dynasty introduced fireworks, probably firecrackers, 603–617 [A.D.]," is not mentioned. Fang I-chih (*c.* 1630) is cited as the authority for the statement that during the Tang dynasty, 618–906, recreational fireworks were already known in China. The period of nearly three hundred years leaves the student a wide choice in his selection of a date for the introduction of pyrotechnic mixtures, either for peace or war, but there can be no question that by the eleventh century saltpetre was well established as an ingredient in incendiary mixtures. The authors quote two recipes for incendiary mixtures from a work by Tsêng Kung-liang (1044), in both of which the three ingredients of gunpowder appear, together with a host of other materials of an inflammable nature; one contains fourteen components, the other sixteen, notable among which are orpiment, lead oxide, shellac, resin, beeswax, pitch, and four types of oil—'clear,' 'small,' 'heavy,' and '*t'ung*.' It would, indeed, seem probable that such mixtures would burn readily in the open even if the saltpetre, sulphur, and charcoal were omitted. The fact that the uses to which it was suggested they should be put—as incendiary headings for whip (slung) or bow arrows, or wrapped in paper or contained in hollow vessels as a missile for use with catapults—makes it appear probable that as late as 1044, at least, the Chinese knew nothing of any pyrotechnic method of projecting such missiles.

"Wu Pei Chih" gives two formulæ, for mixtures to be similarly employed, which are much less complicated and approximate reasonably closely the proportion of saltpetre, sulphur, and charcoal in modern gunpowder, with almost negligible additions of white arsenic and camphor. Similar devices are described by the contemporary European writers Hanzelet and d'Orval, but the use of a firework case, charged with composition and complete with time-fuse, for use as an attachment to an arrow is a definite step forward in military pyrotechny. The composition consisted of saltpetre, sulphur, and charcoal, with the addition of mercury sulphide (cinnabar), and was designed to throw out a fountain of sparks, or globules, of unconsumed matter. Its use was also suggested in connexion with a spear for hand-to-hand fighting, where it might well have proved more effective.

It is interesting to note that when used on arrows these cases were so affixed as to throw the fire forward in the direction of the target, and not so that they might assist the flight of the missile. However, this improvement is shown later in the book, although, in the absence of any dates except that of publication, it is impossible to guess what interval separated the two inventions.

The book includes formulæ for toxic and coloured smokes as well as incendiary and explosive mixtures—devices similar to the 'artifices portatifs' and 'fire trunks' of European writers, designed to throw out fire, poison gas, or projectiles, or a combination of the same—boxes, baskets, and tubes adapted to discharge flights of iron arrows, the flight of which was assisted and sustained by attached rockets, and guns of more or less complex performance and design.

An overall consideration of its scope and contents leads one to the conclusion that at the date of its appearance Chinese military pyrotechny—from the point of view, at least, of lethal effect—was well in advance of what had been achieved in the West. In one department only do the European artificers seem to have had the advantage—that of rocket-making. In 1540 Biringuccio had already advanced further in this branch of the art.

Perhaps the outstanding surprise contained in the book, from the point of view of the practical pyrotechnist, is the discovery that Chinese firework-makers had already solved the problem of 'coating'[1] the iron ingredient in their 'Chinese fire' by roasting it in *t'ung*, or croton oil, a detail which the Jesuit missionary d'Incarville seems to have overlooked, or disregarded, when he brought the composition to Europe. A little more attention to detail on his part would have saved generations of Western pyrotechnists much trouble.

Among the contrivances contained in "Wu Pei Chih" is one designed to project a succession of incendiary pellets in the same way, and by a similar system of construction, as stars are thrown from a Roman candle. According to the *Dictionnaire mobilier français*, a similar weapon was in use among the Arabs during the fifteenth century, with bullets replacing the pellets. The latter may have been a more lethal development of the former after its importation overland from China, or, as I think more probable, it was an attempted compromise between the comparatively novel weapons brought into being by Schwarz's invention of the gun and the now obsolete, or at least obsolescent, Greek fire.

[1] See p. 190.

Much has been written on the subject of Greek fire; a great deal of thought has been expended in attempting the solution of a problem which exists chiefly in the minds of the inquirers. The late Lieutenant-Colonel H. W. L. Hime[1] was perhaps better qualified than were the majority of investigators, but even he seems to have overlooked the possibility that the explanation of the supposed mystery might be comparatively simple. The issue has become clouded by a number of assumptions for which no basis of fact can be said definitely to have existed. In the first place, there can be little doubt that contemporary accounts of the use of the weapon were greatly exaggerated; those by writers on the side which employed it were influenced by feelings of understandable exultation in its invincible efficiency; those on the opposing side by a desire to excuse defeat. The secret of the formula is supposed to have become mysteriously lost, whereas, of course, there was in fact no general recipe; each artificer responsible for its preparation had his own, which he would keep in his head as a valuable trade secret and on which his employment depended. The operative ingredients were pitch and saltpetre, with additional burnables according to fancy. With the invention of artillery, and the practical demonstration of its superiority, the old weapon became obsolete and the manner of its preparation, now valueless, was forgotten.

I was convinced of the real nature of Greek fire by a chance demonstration of something evidently very similar during trials of smoke-producing composition in 1914. The particular mixture was: saltpetre 6, sulphur 1, powdered pitch 3½, powdered glue ½, and plumbago ½. This was contained in a steel mortar 3 ft. 6 in. in length and 5½ in. internal diameter. The method of filling, which may probably have had some influence on the manner of burning, was as follows: after mixing, the mass of composition was rendered plastic by heat, taken in handfuls, moulded into balls each of which was dropped into the mortar in turn, and pressed down to fit the bore. When ignited at the muzzle, the composition burned for a time with a certain degree of violence, followed by a momentary pause. This was followed by what can be best described as a 'cough,' and a burning, viscous mass of partly consumed composition was blown out to a distance of upward of a hundred yards. This action was repeated with surprising regularity down the whole length of the composition.

Lieutenant-Colonel Hime sets out four characteristics of the

[1] *The Origin of Artillery* (1915).

original fire which the chance demonstration described seems, to me at any rate, to fulfil.

(*a*) "It was a wet fire." By that he assumes that its action was necessarily connected in some way with water or the sea. As a matter of history, it was used at sea with great success on many occasions, but may not a "wet fire" be a way of saying "a molten, viscous mass of fire"? The masses would float, and, although some might become extinguished, some would certainly burn on the surface of the water. An adjustment of the ingredients would make chance a certainty in this respect.

(*b*) "Its composition was such as could be kept secret in Constantinople." Here he suggests that the ingredients were of a kind readily available, and not brought from afar. Saltpetre would be in use as an alternative to common salt; the others would also be at hand.

(*c*) "It burned with much noise and smoke." Allowing for the fact that the sound of artillery had not then been heard in war, the noise produced would be impressive. The latter condition is certainly fulfilled.

(*d*) "It was necessarily connected in some way with syphons." As Hime himself points out, the words for syphon and tube were interchangeable terms, and some accounts describe definitely a metal tube, mounted in the bows of a ship, as the recognized method of discharge.

There can be no doubt that some contrivance on the lines I have suggested supplies the answer to the vexed question. Before the days of gunnery, when the longest range for a missile was that attained by an arrow from a bow or arbalest, even a hundred yards was a commanding distance from which to harass one's enemy with burning masses of adhesive fire.

With the coming of artillery and the gradual development of pyrotechny on independent lines there grew up a spirit of rivalry between the two bodies of practitioners in the use of saltpetre mixtures. As we have seen, the "poor gunner" William Bourne[1] thought little of the attempts of "divers gunners and other men" to adapt fireworks to the uses of war. Many early writers, and, indeed, some of a later era up to and including Ruggieri, devoted considerable space to descriptions of military pyrotechnic devices. At the outset these were intended for the destruction or discomfiture of the enemy; later it was recognized that pyrotechny might play a more useful rôle in assisting the troops on the side employing

[1] See p. 31.

them. Through the centuries emphasis has swayed between these two functions. Rockets are said to have been used as projectiles during the siege of Orleans as early as 1429. Count Jean Dunois, the "Bastard of Orleans," employed them in the campaign which drove the English from Northern France in 1449. In 1540 Biringuccio advocated their use, in print. Eighty years later Hanzelet devotes a considerable portion of his space to the pyrotechny of war—in fact, the emphasis seems to be on the military rather than the recreational aspect of his subject. His offensive weapons include fire-arrows, equipped either with incendiary or explosive charges; shells and grenades of various kinds; "burning shot"; "palottes," primitive incendiary devices for burning the sails of ships; shots to burn on water; and a number of "ruses de guerre," such as fire-barrels. He also suggests compositions for the asphyxiation of the enemy containing aconite leaves and the seed and leaves of henbane. On the defensive side his contribution is a brightly burning light ball for purposes of illumination.

Taken as a whole, Hanzelet's suggestions are not particularly convincing, but that of a rocket carrying an explosive grenade deserves attention. Siemienowitz[1] (1650) speaks of war rockets up to 100 lb.—whether the reference is to weight or calibre is not clear—and gives elaborate instructions for their construction. It is on record that, in 1688, trials were conducted at Berlin with rockets up to 120 lb., carrying an explosive charge weighing 16 lb. The composition was nine parts saltpetre, four parts sulphur, and three parts charcoal. The case is stated to have been of wood covered with linen.

Hyder Ali made considerable use of rockets against our troops in India; he is said to have had a corps of 1200 "rocketers" in 1766, while later on his son, Tippoo Sahib, employed as many as 5000. Captain Moritz Meyer (1836) ascribes to experience of these weapons the efforts made in England to bring them to perfection. He describes the Indian rocket as

> an iron envelope about 8 inches long and 1½ inches in diameter, with sharp points at the top. The stick of bamboo 8 or 10 feet long, but sometimes consisting of an iron rod. They were hand-thrown by the rocketers, and did much damage to the cavalry.

It is possible that the success of the Indian rockets was also responsible for a revival of the interest in pyrotechnic weapons throughout Europe, where for some time past it had languished.

[1] *The Great Art of Artillery.*

No doubt Meyer is referring particularly to the work of William Congreve, whose name is so closely associated with the development of the war rocket in Europe, but, in point of fact, experiments had been carried out over a number of years by Lieutenant-General T. Desaguliers, Colonel Commandant of the Royal Laboratory, Woolwich, whom we have previously met as Captain Desaguliers, when, as Chief Firemaster, he was in charge of the English contingent at the Green Park peace display of 1749. These experiments, which do not appear to have been particularly fruitful of results,[1] came to an end with Desaguliers' death in 1780. Congreve was then only eight years old, but as his father succeeded to the office of the Colonel Commandant and lived adjacent to the Laboratory, it is likely that he was already familiar with the work and ways of the establishment.

Congreve commenced his experiments in the second or third year of the nineteenth century. His object was to produce a large rocket, with an incendiary or explosive charge, ranging up to 3500 yards, and by 1804 he had been so far successful that he was able to put forward a plan for the destruction of the French flotilla at Boulogne by flights of incendiary rockets, fired from boats fitted with frames from which they were to rise at an angle of 55 degrees.

The enthusiasm of the Prince Regent, and a successful demonstration before Pitt and his Ministers at Woolwich, brought about the acceptance of the scheme. An expedition sailed in 1805, but, owing to severe weather conditions, it was found impossible to fire a single round. In October 1806 another attempt was made, and although Congreve, who was present on both occasions, seems to have been gratified by the results achieved, the prime object—the destruction of the French fleet—was far from being attained. The town of Boulogne, where the majority of the rockets were deflected by the wind, was set on fire. That this was not intentional is shown in Congreve's own account:[2]

> In about half an hour, about two hundred rockets were discharged; the dismay and astonishment of the enemy were complete—not a shot was returned—and in less than ten minutes after the first discharge, the town was discovered to be on fire.

In 1807 Congreve personally directed the firing of his rockets at the siege of Copenhagen, when they seem to have been effective,

[1] Desaguliers was the first to propound the true theory of the principles governing the flight of rockets.

[2] Treatises on rockets, 1807, 1814, 1827.

and, again, under Admiral Gambier at Basque Roads. He was also present in H.M.S. *Ætna* when they were employed in the Walcheren Expedition. In 1813 the Field Rocket Brigade was formed under the command of Captain Bogue of the Horse Artillery, and served —the only British unit to be present—with the Allies at Leipzig. The commanding officer was killed, but so successful were the rockets that Congreve was awarded the Orders of St Anne of Russia and the Sword of Sweden. Rockets were gaining a reputation for destructive power; protests even were made against their use in civilized war.

Meyer, writing in 1833, but, it would appear, from information collected some years previously, gives Congreve's rockets little credit for efficiency, but admits that they "attracted great attention and were regarded as formidable." He asserts that at the siege of Flessingen "the rockets acted so badly that the English themselves said that they did more harm to the battery than the besieged town." He goes on to say that, as a result of finding an "unburnt specimen" in the town after the bombardment of Copenhagen, trials were commenced by a Danish officer, Captain Schuhmacher. How an unburned rocket could reach the town is not clear; possibly he means from a reconstruction of collected fragments.

Colonel Augustin, of the Austrian Army, who had seen the English rocket batteries in action and trials of Congreve rockets in London, visited Copenhagen in 1814, where, by arrangement between the two Powers, he was instructed by Schuhmacher in his method of rocket construction. As a result the Austrian Government shortly afterwards established a rocket factory at Wienerisch-Neustadt.

By the end of the first quarter of the nineteenth century all the leading Powers in Europe were manufacturing war rockets. Factories for their manufacture had been established at Warsaw, Turin, Toulon, and Metz. In 1831 a series of trials was made by the Swiss military authorities of 6-lb. rockets fired from a 6-ft. tube, when a range of from 1800 to 1900 yards was obtained, and three hits out of five were registered at 1100 yards. The size of the target is not mentioned.

Although the generic term 'Congreve rocket' remained current for approximately half a century, the form of the weapon varied considerably during that period; its evolution was gradual. The first rockets differed little from their anonymous predecessors. Congreve's first improvement was the introduction of an iron case. In its final form, designed to attain greater accuracy in flight, it

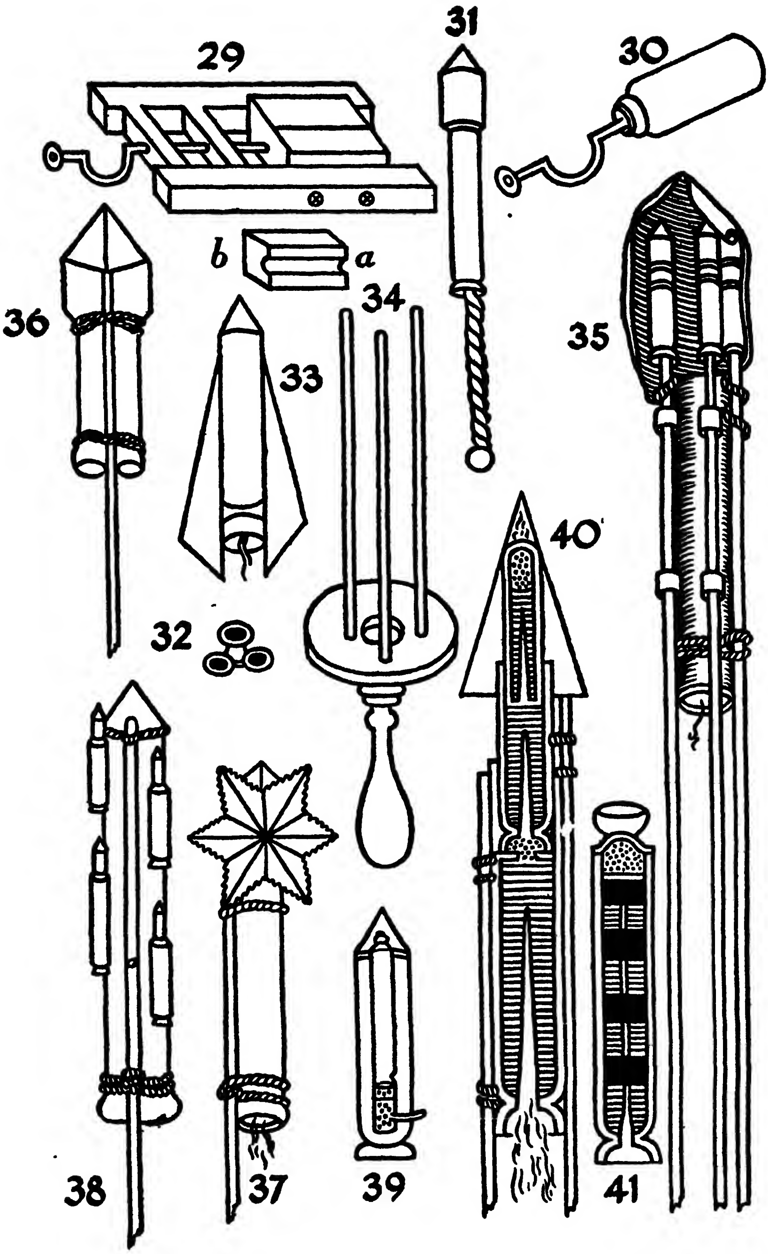


PLATE III FROM FRÉZIER'S "TRAITÉ DES FEUX D'ARTIFICE" PARIS, 1747)
This shows clearly several ideas which have inspired a succession of later 'inventors.'

(*See pp.* 238, 242 *and* 247)

had a stick placed centrally on the axis of the case, round which the fire issued from nine holes in a metal diaphragm forming the choke. In the interval Congreve had worked upon other ideas, most of which had, in fact, been suggested by earlier pyrotechnists; the substitution of a weight and chain, or cord, for the stick, which had been suggested by Frézier.[1] In 1826 he patented a method of fixing two or more rockets together so that the heading of one ignited the next and so ensured a longer total flight; this method was, however, also anticipated in Frézier's book,[2] as had been his idea for the elimination of the stick by the use of fins, or wings, attached to a rocket's body.[3]

Ruggieri seems also to have overlooked this 'prior user' by Frézier, and others, when, in the 1821 edition of his book, he attacks Congreve in these words:

> When I wrote this work [in 1801] France was at peace with England; I did not believe that three or four years later, the English officer Congreve, would attribute to himself as his personal discovery, a kind of rocket which he had imitated from my book, as I have since been assured he did by one of his compatriots in London.

The particular idea here referred to was the use of a conical head to a rocket to facilitate penetration of the target.

While the relative accuracies of rockets and smooth-bore solid-shot ordnance showed no very great difference, any advantage in this respect that could be claimed for the latter was, in the view of many, fully offset by the greater mobility, as well as the greater moral effect, of the former. Congreve's claim that "rockets were ammunition without ordnance, the soul of artillery without its body," was to some extent justified by his comparison between the weight of a twelve-pounder gun, eighteen hundredweight, and the tube employed to discharge a rocket of like calibre, twenty pounds. With the introduction of rifling into artillery (*c.* 1845), however, the rocket began to lose ground, with the result that much work and ingenuity were expended on the problem of imparting a rotary motion to a rocket in flight, and so not only ensure greater accuracy, but at the same time render the stick unnecessary.

As early as 1815 promising experiments had been carried out in America to this end, spin being imparted to the case by holes bored through it, in to the composition at an angle to its axis. There was, however, the disadvantage that the internal pressure was more rapidly reduced and part of the forward impulse lost.

[1] Fig. 31, Plate III. [2] Fig. 40, Plate III. [3] Fig. 33, Plate III.

In 1844 Hale, an Englishman, patented a rocket constructed on similar lines, but with the holes nearly tangential.

In 1835 Macintosh patented a method of rotating the tube from which the rocket was fired so as to give an initial rotary movement before the flight commenced. In the following year Fitzmaurice patented the idea of causing rotation by a screw-shaped head, and Court a method by which the fire impinged on surfaces inclined to the axis of the rocket. Both of the last-mentioned methods laboured under the defect that the means of imparting the spin offered definite resistance to the rocket's forward movements. Then came the invention of the Hale rocket proper, which was to be the standard missile not only in the British service, but in most other countries. The twenty-four- and nine-pounder rockets were of similar construction—a steel body, corrugated to prevent any risk of the composition twisting away from the case, with a cast-iron head plugged with wood. A metal tailpiece gave the rocket its rotary motion. This had three vents, each of which was half surrounded by a short semi-cylindrical flange, so that at the moment of leaving the rocket each jet was enclosed on one side. The rotation was clockwise, and it is interesting to learn that the missile travelled noticeably farther in a wind blowing from right to left. The range, at an elevation of 15 degrees, varied between 1550 and 2200 yards for the twenty-four-pounder, and between 1300 and 2200 for the nine-pounder. By the year 1872 war-rockets were beginning to be withdrawn, and after an interim period, when they were employed solely in savage warfare, finally disappeared from service towards the end of the last century.

Apart from the rocket, pyrotechnic war stores changed and developed remarkably little during the seventeenth, eighteenth, and nineteenth centuries. Incendiary mixtures, whether used in connexion with projectiles or placed in position and ignited by hand for demolition purposes, altered hardly at all throughout that period; to the basic ingredients saltpetre and sulphur, with or without mealed gunpowder and antimony sulphide, were added a range of inflammable material such as resin, pitch, tallow, beeswax, linseed oil, and turpentine. The actual proportions are of little interest to the inquirer, and, in fact, would seem to have affected the result but slightly.

Illumination compositions also remained comparatively static until the advent of magnesium. A light mixture of saltpetre 7, sulphur 3½, orpiment 1, which was still in use, differs only slightly in its proportion from the "fire balls" described by Hanzelet two hundred and sixty years earlier. A primitive type of 'Ground Light Balls,' of calibres 4⅖ in. to 10 in., still included among British military stores until the seventies of the last century, containing a composition of saltpetre, sulphur, resin, and linseed oil, certainly would seem to have given justification for the comment in the official *Notes on Ammunition* of the period (1873): "The composition is not a very good one but it is hard to extinguish, water having no effect on it. A few shovelfulls of earth will hide its light." "They are used," we are told, "at night to discover working parties, etc., of the enemy, and might, failing carcasses, be used in their place."

Carcasses were for many years the recognized incendiary projectile. The earliest form was a cylindrical bag or container of canvas coated with pitch and bound with hoops of strap iron. The name, according to Chambers's *Cyclopædia* of 1741, was suggested by likeness of these bands to the ribs of a corpse. Later they assumed a spherical form, but their composition remained substantially the same; the official filling until they became obsolete, towards the end of the last century, was the familiar mixture of saltpetre, sulphur, rosin, antimony sulphide, turpentine, and tallow.

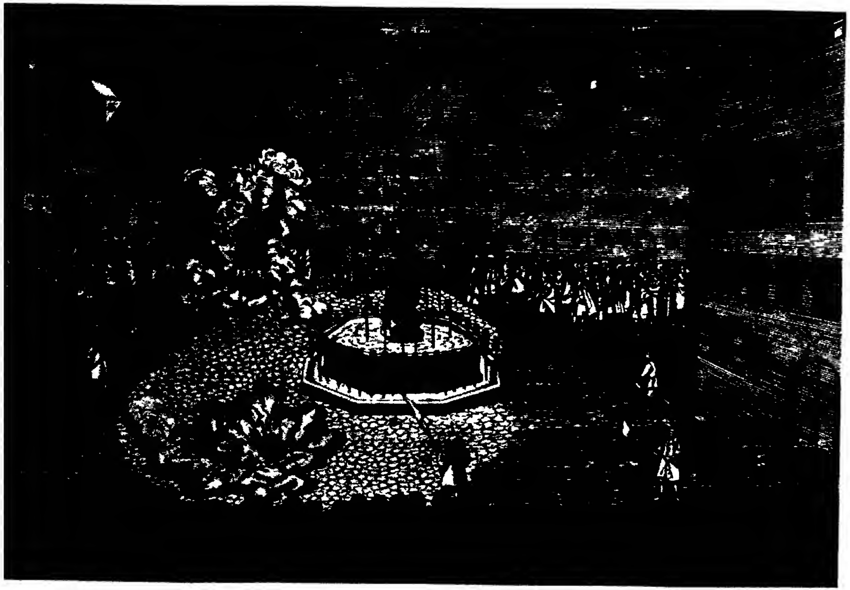
The use of smoke as a means either of screening one's own operations, or of neutralizing enemy action, is as old as warfare itself. In the days before gunpowder and other pyrotechnic mixtures it was provided by the burning of grass and other natural material; later the need for any special means for its production does not seem to have arisen, in view of the liberal, and fortuitous, supply which invariably overlay the scene of operations. The smoke from those incendiary projectiles which reached their target might be relied on to cause additional embarrassment to the enemy.

Read's Weekly Journal of October 25, 1760, in an account of a review in Hyde Park, mentions, as the concluding item of the manœuvres, that "pieces of a new construction, of a globular form, were set on fire, which occasioned such a smoke as to render all persons within a considerable distance entirely invisible, and thereby the better in time of action to secure a retreat."

There is a defeatist ring in the use of the word 'retreat,' instead of 'advance,' but it seems quite clear that a military novelty was being exhibited.

Smoke balls, from 4⅖-in. up to 13-in. calibre, were still included in the range of British military devices until 1873, and it seems likely that the original composition had remained unaltered: L.G.

.ATE XXIX

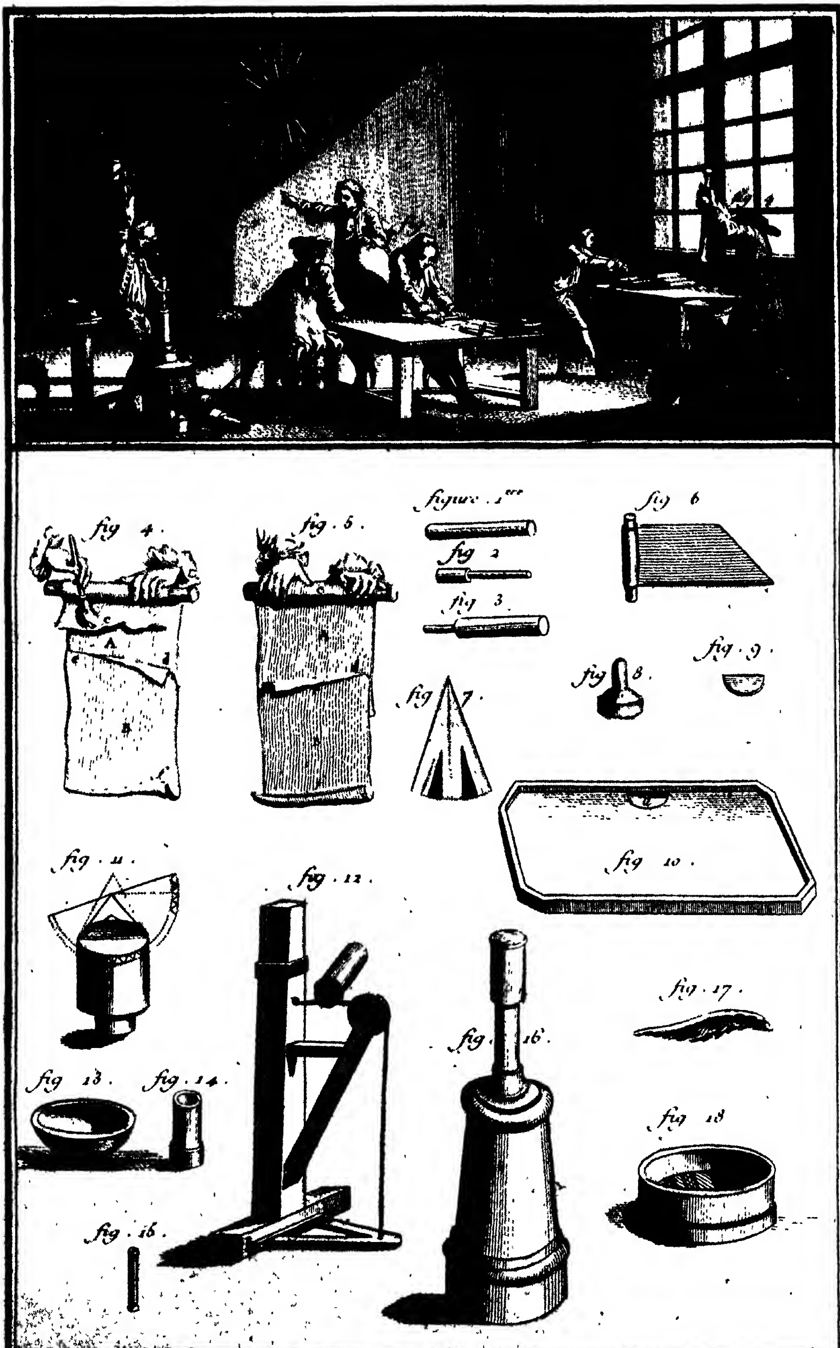


AN ADVERTISING STUNT OF 1673
In which the quack doctor Karls Bernoyn met his death.

[*See p.* 165.]

FIREWORKS DISASTER IN MADISON SQUARE GARDENS
On November 4, 1902, in which fifteen persons were killed and eighty seriously injured through the detonation of a shell in its mortar.
Shurey's Illustrated

[*See p.* 180.]



FIREWORKS APPARATUS AND MANUFACTURE IN THE EIGHTEENTH CENTURY

This plate from Diderot's encyclopædia, published between 1751 and 1772, shows methods and practice approximating to those of to-day.

[*See p.* 182.]

(large grain) gunpowder, saltpetre, coal-dust, pitch, and tallow. The comment in *Notes on Ammunition* of the time is not enthusiastic about them:

> These balls appear to be useless as projectiles, they are intended (1) to put in enemy's mines, (2) to conceal operations from the enemy, (3) for signals in the Arctic Regions; they burn from one to eight minutes. It is very doubtful whether smoke balls have ever been fired [in war?].

Most important among the very few inventions to be applied to military pyrotechny during the later nineteenth century was the parachute light, which embodied a principle the far-reaching results of which could not have been even vaguely glimpsed at the time. The idea of suspending an illuminating unit from a parachute seems to have originated in Denmark in the year 1820, just twenty-three years after the French aeronaut Garnerin had made his first parachute descent from a balloon. A year later a similar device appeared in Austria. In both the parachute and light were lifted into the air packed in the cap of a rocket. Within a few years 'asteroid rockets' constructed on this principle were frequently seen in the displays at Vauxhall Gardens and elsewhere. Captain (later Colonel) Boxer, R.A., of the Royal Laboratory, Woolwich, with whose name other pyrotechnic developments were afterwards associated, perfected a shell which performed the same function. As these were gradually increased from the original calibre of 5½ in. up to 13 in., the size of the light was very much greater than even the largest rocket would lift. Boxer celebrated the fall of Sebastopol with a display of his new creation on Woolwich Marshes in September 1855 (Plate XXIII).

Another invention which was to play an important part in warfare in the years to come originated as a civil signalling device. This was the Very pistol, patented in June 1878 and adopted in the service ten years later. It was a short-barrelled pistol of 1-in. bore (a model with a bore of 1½ in. was introduced during the 1914–18 war) firing a cartridge similar to that used in sporting guns, with a pyrotechnic star substituted for the charge of shot—in effect, a single-star Roman candle fired by percussion. The name of the inventor, who was of French nationality, is sometimes spelled 'Verey,' and it would be interesting to know whether he is a lineal descendant of the William de Verey who defeated the troops of the King of Bohemia before Metz in 1324 by the use of cannons, "serpentines et collverines," mounted in a barge.

From 1850 onward a number of patents, inventions, and often re-inventions of old ideas were put forward in connexion with pyrotechnic devices, for signalling and other purposes, the majority of which have since been forgotten. In this connexion it is interesting to turn to a volume of *Abridgements of Specifications relating to Fire-arms and Other Weapons*, published by the Patent Office in 1859. The preface contains the following remarks:

> It is worthy of notice that a very large proportion of the so-called inventions of the present day are, in fact, old contrivances, sometimes modified and adapted to modern requirements, but very often identical with what has been tried and abandoned as useless long ago. From the year 1617 down to the end of the year 1852, not more than about 300 patents were granted for inventions relating to fire-arms. When the war with Russia broke out the Patent Office was inundated with applications for Letters Patent for similar inventions, and about 600 have since been actually granted. Of these it may be safely said that five-sixths of the applications related to old contrivances which have been patented over and over again.

Many of these inventions recall a story of the Duke of Wellington, who was examining a steam rocket invented and patented by a Jacob Perkins in 1824. This device consisted of an iron body, with a stick like that of a rocket, partially filled with water and fitted with a fusible metal plug at the base. The body was heated over a lamp, and when the plug melted the generated steam escaped, driving the projectile forward. The absurdity of the idea seems too obvious to need discussion. The Duke carefully examined it, and, after asking many questions, remarked: "If this had been invented first and gunpowder afterwards, what a capital improvement gunpowder would have been."

Chapter XX

ESSENTIAL FIREWORKS

Or—for I have some mechanic skill—
To make a grasshopper with wings of steel
And launch myself by quick succeeding fires,
Saltpetre-fed, to the stars' pastures blue!

EDMOND ROSTAND, *Cyrano de Bergerac*, Scene 11 (1898)

THE development of pyrotechnic appliances for other than recreational purposes was far more marked during the nineteenth century in the sphere of civil, as distinct from military, activity. In the period between the Crimean and South African wars military pyrotechny underwent a period of unenterprising tranquillity, dictated either by a basic lack of confidence in pyrotechnic devices—as one can easily imagine might be engendered by such primitive efforts as those described in the last chapter—or by pure inertia. Whatever the cause, many very valuable inventions had not only proved their worth, but had been improved and elaborated over long periods before being adopted into the services. The South African War no doubt did something to bring about a change in this state of affairs, but it required the impact of the First World War, with its totally unforeseen factors and implications, to bring about a complete change of outlook. The consequences of the Second World War, on account of the enormous complexity of the struggle and the vast scope of the problems involved, was even more marked, but, whatever the ultimate outcome, it can hardly be disputed that the modern applications of pyrotechny in the services owe more to civil and commercial inspiration than to internal effort. For this reason it will be both convenient and expedient to consider the evolution of pyrotechnic ideas and devices in the sphere of civil usefulness during the last hundred years or so before completing a review of their military counterparts.

In no one field have fireworks played a more important part than at sea, whether as a means of signalling or of saving life. The line-carrying rocket, in its varying forms, has been the means of saving more than twenty thousand lives. The history of the quest for some efficient means of establishing communication between a wrecked vessel and the shore begins in 1791 when Sergeant John Bell, of the Royal Artillery, was awarded fifty guineas for the method he demonstrated on the Thames before a committee of the Society of Arts. A lead-filled cast-iron shot attached to a line was fired from a mortar mounted on a vessel two hundred and fifty yards from the shore. The missile covered a distance of four hundred yards and buried itself eighteen inches in the ground. Sergeant Bell then pulled himself and a friend ashore on a raft formed from a seaman's chest lashed to four casks. In addition to the premium awarded by the Society of Arts, he was commissioned as Lieutenant.

The next suggestion, put forward by a Captain Dansey, to carry a line ashore by means of a kite met with little practical success. Then, on December 24, 1807, the frigate *Anson* was driven ashore on the Loe Bar, three miles from Helston, Cornwall, with the result that the entire ship's company were drowned within sight of those on shore not more than sixty yards distant. The disaster was witnessed by a cabinet-maker, Henry Trengrouse, who set himself to the task of devising some means of communication for use in similar circumstances. As a result, it is said, of witnessing a firework display on Helston Green in celebration of the king's birthday, he put forward the suggestion of using rockets for the purpose.

Unfortunately for Trengrouse, a previous disaster[1] had already inspired another experimenter to similar efforts. Captain G. W. Manby, R.N., did little more than elaborate the ideas of Lieutenant Bell by fitting the shot with four smoke cases or lights, placed in holes bored for the purpose, by which the flight of the projectile might be traced, by day or by night.

Trengrouse's method was to send a line from a vessel to the shore, or vice versa, by means of a rocket fired from the barrel of a musket. His aim was to have the apparatus carried on all vessels, packed in a case, containing gun-rockets, lines, and breeches-buoy.

A comparison of the two systems is very much in Trengrouse's favour, if only on the score of the difference in weight between a musket of a few pounds and a mortar weighing hundreds. Nevertheless Manby was awarded the Gold Medal of the Society of Arts in 1808; forty-five mortar stations were established round the coast by the Government within the next six years, and he received a grant of £2000. It was not until 1818, after he had spent £3000

[1] The wreck of H.M. Gun-brig *Snipe* off Yarmouth, February 18, 1807.

of his own money, that Trengrouse was able to stage a demonstration before the Royal Humane Society on the Serpentine in Hyde Park. This the Duke of Kent was to have attended, but was prevented owing to the birth of his daughter, Princess (later Queen) Victoria. As a result of this demonstration twenty sets of apparatus were ordered, and he was awarded £50 by the Government and their large Silver Medal and thirty guineas by the Society of Arts—surely a poor reward for an invention which, had its possibilities been properly assessed, would have revolutionized sea-rescue?

One is not altogether surprised to find that Ruggieri (1821) puts forward a claim to the idea, on behalf of his father, for "la fusée de secours" which "mon père a imaginé," and which "all captains of ships would be wise to provide themselves with." His description of the device is, however, vague in the extreme.

The Manby Shot remained the official life-saving apparatus for thirty-five years, although the rocket principle was revived in 1826 by a Mr John Dennett, of Newport, Isle of Wight, and four stations were established on the island for the use of rockets of his pattern. It was not until 1855, when a rocket of greater range was invented by Colonel Boxer, R.A., of the Royal Laboratory, that the rocket as a line-carrier came into its own. The Boxer rocket consisted of two rocket cases joined head to tail, and so arranged that when the first case had burned out it was blown off, and the second gave renewed impetus. This idea had been illustrated by Frézier over a hundred years before, but, re-invented, it remained the standard equipment of the coastguard rocket stations until recently, when the Schermuly twelve-pound rocket came into use.

The Schermuly apparatus as used to-day has been evolved from the original pattern designed by the late William Schermuly (1887–1925), for the express purpose of carrying a line from ship to shore. The aim of the inventor, a blue-water mariner of the old school, was to provide a compact, self-contained unit which might be operated effectively from the deck of a ship; his ambition was to see the day when every ship should be compelled to carry a means of establishing communication with the shore. By a tragic coincidence he died nineteen days after the coming into force of an amendment to the Merchant Shipping Act making it compulsory for all but the smallest British ships to carry an efficient line-throwing apparatus.

Schermuly's struggle for recognition bears a striking resemblance to that of Trengrouse ninety years before. His ideals and methods

—quite unconsciously, I believe, on his part—were basically similar to those of the earlier genius, but the ultimate achievement of William Schermuly and his successors stands alone.

The original pattern first shown to the public at the Diamond Jubilee Exhibition of 1897 received the award of a Gold Medal, but owing to indifference on the part of shipowners and officials alike no steps were taken towards the practical use of the idea for several years. Few seemed to be able to appreciate that the scheme tirelessly advocated by Schermuly was not so much the carrying of a line between two points, but the direction in which it should be carried. A stranded vessel generally lies on a lee shore, driven there by the wind. That wind will materially assist the flight of a rocket fired towards the shore, which in itself offers a much easier target than does a wreck, possibly bows on and half submerged in the surf, to a rocket fired into the teeth of a gale.

In 1920 the efficiency of the apparatus was enormously increased, and the manner of its operation simplified, by replacing the paper-cased rocket, fired from a trough, by a smaller steel-cased rocket fired from, and ignited in, the barrel of a pistol by a blank cartridge. Not only does this arrangement allow the firer a greater opportunity for accuracy in sighting, by the elimination of the time-lag between ignition and the commencement of the rocket's flight—a matter of some seconds in the original pattern—but a considerably greater range is attained, owing to the fact that, by the impulse of the cartridge, the rocket is already in flight by the time it reaches its maximum force.

As an early development of the line-carrying rocket, it is interesting to note that Congreve, in association with Lieutenant J. M. Colquhoun, took out a patent for the use of the rocket as a harpoon in whale-fishing, which must surely have shown marked advantages over the methods of the time. It is strange, particularly in view of the rapid adoption of the harpoon gun in modern times, that the idea did not make more headway.

During the second half of the last century much originality of thought, if rather less technical knowledge, was expended in the invention of pyrotechnical signals and safety devices for use at sea and elsewhere. One such resulted from the first railway murder, that of Mr Thomas Briggs by the German Franz Müller, on the North London Railway in July 1864. The demand for some means by which a passenger might make known his plight if attacked in a compartment was widespread, and in February 1866 Le Keux and Wishart patented the idea of a Roman candle, or other pyrotechnic signal, which projected through the roof of a compartment to be ignited in case of emergency by the passenger, using the striking composition with which the back of every ticket was to be coated.

Even more absurd were the patents covering the idea of a truncheon which a constable could use alternatively as a Roman candle, or vice versa. The first patent was granted in 1887; a second embodying precisely the same 'invention' was taken out by a different individual in 1893.

There was a patent which might well have been of considerable value at the time, but which was never exploited—the automatic firing of red or green lights from port or starboard sides of the bridge when the helm was put over to avoid collision. Several pyrotechnic and mechanical methods for the automatic firing of lights attached to lifebuoys when the latter were thrown overboard were patented, but the final solution of this most valuable idea was eventually provided by the Holmes' apparatus, which is still in general use. Its action depends on the spontaneous ignition of calcium phosphide in contact with water.

Many old ideas cropped up with almost monotonous regularity: the three-winged rocket; the rocket rotated by tangential holes; and a bare-faced attempt to re-exploit Hale's principle of a stickless rocket in a paragraph reading: ". . . kept on its proper course by a disc inserted in the base or by projections or indentations in the case."

The need for a signal light embodying its own means of ignition was recognized early in the century. The first solution of the problem was provided by Robson (*c.* 1840). Ignition was effected by breaking a glass globule containing sulphuric acid so that it came in contact with a small cake of potassium chlorate, which at once caught fire. The method, though cumbersome, was in use for some forty-seven years, when, in 1887, Arthur Brock patented the 'friction light' now in general use, although, as far as I am aware, no royalty has ever been paid by the Government, or any other body, for its employment or infringement. A wooden plug, which is kept ready for use in the handle of the light, has its end coated with composition similar to that on a safety match-box. The lighting end of the light is coated with a potassium chlorate mixture, which readily ignites on being lightly struck with the composition of the plug.

It is strange that, even before the coming of wireless communication rendered them, to a great extent, unnecessary, no international system of pyrotechnic signals was ever established. In 1889 F. Crundall endeavoured to get a standard distress signal recognized by shipping companies and Governments throughout the world. This consisted of a Roman candle surrounded at its mouth by four lights which burnt simultaneously with it, and when demonstrated before Board of Trade and other officials was distinguishable across the Channel at Dover. It was, however, never universally adopted. Nevertheless two pyrotechnic signals are more or less generally recognized in all waters throughout the world—the red hand-light for distress and the blue light as the demand for a pilot.

The lifeboats of all British ships are compelled to carry a small watertight magazine containing a supply of friction-ignited red hand-lights. Another distress signal is a combination of Roman candle and light, similar to, but of less complicated pattern than, the Crundall signal. Yet another, the "Five Star Red," which came into being during the Second World War, and is still much used, provides one of the most outstanding effects in pyrotechny: a succession of five deep crimson stars of quite unprecedented brilliancy make a signal which is visible at a very great distance. A steel case permits the stars being driven up to a very considerable height.

Wireless has rendered practically obsolete the elaborate, not to say picturesque, system of identification formerly used by vessels of all nations to make themselves known when passing Lloyd's stations at night and on similar occasions. Each line had its characteristic pyrotechnic display, consisting of Roman candles, rockets, hand- and Coston lights. The last-mentioned are cases charged with fire of various colours in layers, so that any required combination of colour may be burned in succession from one unit. These were more frequently in use by foreign shipping. A glance at the *Universal Guide*, setting out the signals employed, makes one realize that their passing has taken something from the colour of night-life at sea. The following are a few examples taken at random: the Zud-Amerika Lyn of Amsterdam employed a white light at stern, green at bridge, and blue at bow; the White Star Line a green light at bow and green at stern; W. Johnston and Co. a green light, followed by a Roman candle throwing three red and three blue stars, followed by a white light; the Aberdeen, a red light, followed by a Roman candle throwing red, white, and blue stars three times successively, shown from aft; J. L. Burnham and Co. a blue light changing to white, then to red, followed by a red star; a vessel of the Cunard Line when off the coast of Ireland fired a blue light followed by two golden star-rockets; the Ulster Steamship Co., Ltd, three lights, yellow, blue, and red above one another, followed by two Roman candles fired together, each throwing two yellow, two blue, and two red stars. As suffixes to the identification signal, a red light indicated "All's well," a green signified "Wish to communicate." Eldérs and Fyffe's banana-boats employed a code of their own, designed to advise the quantity and condition of their cargoes; the number of bunches carried, 'ripe,' 'green,' or 'ripe and turning.'

It might be thought that the cessation of this practice would bring disaster to the non-recreational branch of the firework industry, and that the results of the introduction of wireless communication might be equally calamitous in other fields, but, in fact, the demand on the industry for what are perhaps best described as 'essential pyrotechnic articles' has never been greater than it is to-day. Some are supplied in continuation of long-established demand; those signals, lights, and rockets carried by all ships for use in cases of emergency; the special aerial maroons employed to summon lifeboat-men and firemen for duty; railway lights, long-burning red units, provided with spikes for holding them upright in the permanent way, used by the guard of a train which has broken down as a signal to warn trains approaching on the same track. In the United States motor-trucks are compelled by law to carry lights of this type in case of a breakdown involving the availability of the lighting system. In wine-growing districts of France a fund, to which all owners of vineyards must subscribe, administered by the Département de l'Agriculture provides for the maintenance and service of stations from which rockets are fired for the defence of the vintage against hailstorms. The rockets carry up detonating charges which have the effect of precipitating the moisture of the clouds in the form of rain, so averting heavy falls of hail which might cause very heavy damage to the crop.

'Fuze-lighters' and 'chieza sticks' are forms of port fire designed to meet the requirements of the particular class of mine in which they are used. The 'miners' squib' combines the functions of time-fuse and igniter in quarries and gas-free mines where black-powder blasting operations are possible. The seemingly anti-quated, but nevertheless efficient, contrivance consists of a thin tube of paper, half of which is twisted into a tight spiral and dipped in molten sulphur; the remainder is filled with fine-grain gun-powder. It is inserted in the mouth of the hole containing a blasting charge and lighted. The twisted portion burns slowly, giving the shot-firer time to retire. When the flame reaches the powder-filled portion a jet of fire is projected down to ignite the blasting charge. Many thousands of this simple device are used annually in British mines and quarries.

Smoke-producing cases have been for a long time employed for testing drains. Other smokes are used for the destruction of vermin and, a comparatively recent development, as vehicles for insecticides.

Other innovations, devised to meet particular needs, include 'engine starters' designed, as their name implies, to provide heat for the starting of Diesel engines; also small units to serve a like purpose in the operation of vulcanizing tyre patches.

The existing state of affairs in agriculture is reflected in the great and rapidly increasing demand for bird scarers. These embody a simple slow fuse to which are attached a number of single-burst crackers, arranged to fire at intervals. As the fuse burns at an even speed the explosions may be set to fire regularly at predetermined times without further attention.

The uses of firework effects of all kinds, as well as explosives of spectacular rather than disruptive intent, in connexion with the training of military and civil formations, and the fire brigade, in stage and film productions are too numerous and varied to allow any attempt to describe them in detail. A special application of a pyrotechnic composition in the field of chemical engineering is the use of Thermit for welding iron and steel. It consists of a mixture of three parts aluminium to ten parts iron oxide. It burns at a temperature of 25,000 degrees C., giving up seven parts of molten steel. By enclosing the two sections at the proposed junction in a suitable mould they are firmly fused together. For special welds small quantities of nickel, steel, and manganese are added.

As regards that highly topical subject rocket propulsion, the interest of the firework industry is, so far as I am aware, confined solely to the supplying of small units, designed to provide necessarily brief periods of power to model aeroplanes. The fact that certain features associated with the flight of a rocket seem to render it particularly suitable for flight outside the atmosphere of the earth, and the possibility thereby suggested of interplanetary flight, was certainly responsible for the widespread interest in rockets which arose during the period of the present century preceding the Second World War. Those features are that, as it carries in itself the oxygen necessary for combustion, and as its motion is derived entirely from internal pressure, it is capable of functioning quite independently of the air. Indeed, without the resistance of the atmosphere, its flight would be more rapid and its action more efficient. In theory, therefore, the rocket seemed to provide a solution to the problem of the navigation of space. But there is frequently a considerable gap between theory and practice. H. G. Wells, in his romance *The First Men in the Moon*, envisaged the perfect means of achieving interplanetary flight—a substance, "Cavorite," which was opaque to the force of gravity. The discovery of such a material presents a problem, perhaps somewhat more difficult of solution, but at least comparable to that of discovering a fuel possessing the qualities and characteristics demanded by a 'space ship.' A vertical velocity of seven miles per second would be required to neutralize the earth's attraction and make possible a voyage into outer space.

There are, however, more practical, if less romantic, applications of rocket and jet propulsion than trips to the moon, as we have seen both during and since the late war. The names of three men are closely associated with original inquiry into the science of rocket propulsion: Professor R. H. Goddard, of Clark University, Mass.[1]; R. Esnault-Pelterie,[2] of France; and Professor Herman Oberth,[3] a Roumanian who worked in Germany and is said to have been mainly responsible for the development of Hitler's war weapons V1 and V2—an outstanding achievement, whatever may be one's views on the manner in which the results were employed.

On one point, at least, these three scientists seem to be agreed: that the pyrotechnic rocket, in anything approximating to its existing form or content, might be disregarded in their quest. The figures quoted earlier[4] support Goddard's finding that the efficiency of a pyrotechnic rocket is low; he states it as somewhere in the neighbourhood of 5 per cent. It can be increased only by increasing the strength of the case, or combustion chamber, in a proportion that rises more and more sharply as the efficiency increases.

Dr Herbert Chatley, in a paper on "Rocket Theory,"[5] stated that one pound of a combustible mixture which is capable of being wholly converted into gas could, in ideal conditions, lift itself to a height of 260 miles, or to a position at which any trace of the earth's atmosphere is practically non-existent. The operative word, however, is *itself*:

[1] *A Method of reaching Extreme Altitudes* (1919).
[2] *L'exploration par fusées de la très haute atmosphère* (1928).
[3] *Wege zur Raumschiffahrt* (1929).
[4] See pp. 182-183. [5] Read before the Society of Engineers, May 2, 1932.

> The proportion of propellant to empty weight of rocket with the available propellants must be of the order of 50 or so for long-distance flight between two points on the earth, several hundred for a flight to the moon, and possibly one thousand for a flight to Mars.

The performance of the fuel depends, in increasing proportion, on the strength and, it follows, the weight of the container. To this last must be added the weight of the crew, stores, and mechanical devices necessary to control combustion, landing speed, etc., for both the outward and return journeys. It is not without a sense of relief that at least one pyrotechnist realizes that the solution of this apparently impenetrable problem has passed from the realm of his particular art, or science, into that of physics and engineering. Indeed, he might be excused for suggesting that some name other than that of the time-honoured 'rocket' should be applied to these new devices, either existing or prospective; 'rojectile' or 'reactrocraft' might serve.

The sincere, penetrating, and masterly researches of the highly qualified workers already mentioned was unfortunately paralleled, particularly during the early thirties, by the antics of a number—far too great—of cranks and publicity-seekers possessing little or no qualification for the task they claimed to have set themselves. Some were no doubt sincere, others were mere charlatans, and not a few might safely be classed as mentally unstable. The first requirement was some sort of machine with which the 'inventor' might be photographed. The resulting picture, accompanied by a statement of the designer's intention to send, or to travel in, the contrivance to the moon, was readily accorded space in the Press. After that, as a rule, nothing more was heard of him or his project, unless it might be a brief announcement that the flight had been postponed owing to a technical hitch. More rarely there was a fairly serious accident.

In 1928 Von Opel attracted a certain amount of attention to himself by impelling first a bicycle, next a car, and finally a small aeroplane by attaching a number of commercial rocket bodies to them. On the road the car was said to have reached a speed of 62 m.p.h. in two seconds. No doubt it would have attained a higher speed if the rockets had burned longer and more effectively. When the performance was repeated, with the car running on rails, Von Opel's place was taken by a cat. After reaching an estimated speed of 160 m.p.h. the vehicle came off the rails and the cat was killed. The aeroplane crashed. The experiments took the matter of rocket propulsion no single step further than had been reached by Babington three hundred years before.

There was Zucker, a German, who, in 1934, came to England with a scheme for establishing rocket postal services between outlying islands and the mainland. By what was possibly a coincidence Mr Thomas Ramsay, in the House of Commons on June 4 (a firework anniversary, but November 5 might have been more suitable), asked Sir Kingsley Wood, the Postmaster-General, if "in view of the use of mail rockets on the continent of Europe,[1] he had considered the possibility of their use in this country, especially in the case of islands where it is difficult to land the mails by ordinary methods when the sea is rough?" The reply was "Not yet; but I shall be prepared to consider their use, if such a method is found to be practicable."

Herr Zucker's rocket was typical of its kind, but unfortunately contained no propellant. "The German authorities," it was explained, "would not allow the fuel to be exported." Some trial shots were made using two-pound commercial rocket bodies, and, encouraged by the results obtained, the inventor had a larger steel case filled with the same composition under hydraulic pressure, thereby completely upsetting the balance of things. A composition suitable for use in hand-charged rockets is too fast-burning for use in a larger case under hydraulic pressure of several tons.

At a demonstration in the Western Isles in July of the same year, when an attempt was made to fire a rocket from Scarp to Harris, the projectile exploded violently, but not, to some at least, unexpectedly. There could be traced no evidence whatever of any originality of thought—even of any practical pyrotechnical experience—throughout the affair. (Plate XXXII.)

Later in the same year experiments were carried out to test the possibility of sending mail ashore from the mailboat while navigating the difficult shoal-infested lower reaches of the river Hooghly, and so effect a saving, in some deliveries, of several days. Successful results were achieved, but, so far as I am aware, no 'inventor' has put forward any claim in respect of them.

The introduction of the cordite rocket for war purposes will be dealt with in the ensuing chapter. It marks a great step forward in the development of the pyrotechnic rocket. The charge is not detonated, as is the case when cordite is employed as the propellant in guns and small arms, but burns in the same manner as do the contents of rockets of the old type. One particular appli-

[1] In fact there were none.

cation of this unit, developed during hostilities, which will undoubtedly find a place in civil aviation is the rocket-assisted take-off. Cordite rockets, mounted in metal tubes under the wing roots of a plane and fired electrically from the cockpit, gave increased acceleration when taking-off in a confined space—such as the flight-deck of a carrier—or with a heavy load, and reduced the take-off run by as much as 60 per cent. One can visualize a similar contrivance being used to power temporarily, for the run-in and landing, a glider which has been towed over its objective by a plane, which continues on its way after casting it off. It would fulfil the same function as that of an auxiliary engine in relation to a sailing vessel.

There is undoubtedly still much scope for further exploitation of pyrotechnic mixtures, methods, and devices in the sphere of civil, as distinct from warlike or purely recreational, uses, but progress will not be achieved by raking over the ideas and relics of past ages and dishing them up as new inventions. Nor does it serve any good purpose to select the moon as one's objective while one two-thousandth part of the distance, in vertical flight, is as yet unreached.

Chapter XXI

MILITARY PYROTECHNY FROM 1900

The front of heaven was full of fiery shapes. . . .
The heavens were all on fire, the earth did tremble. . . .

Henry IV, Part I, Act iii, scene 1

BY the end of the nineteenth century pyrotechnic weapons had practically disappeared from the list of British munitions of war. The Very pistol, a few rockets and lights, all employed for signalling purposes, and star shells, of doubtful efficiency, for illumination, were the only pyrotechnic stores still in use.

The war rockets had disappeared, following their last extensive appearance in the form of the 'ground volley,' during the Zulu War of 1879. Field-Marshal Lord Wolseley, who became Commander-in-Chief in 1895, had little confidence in the weapon. In his *Soldier's Pocket-book for Field Service* he says: "In a thick bush country like Burma or Ashanti, rockets are likely to be as demoralizing to your own men as to the enemy, owing to the eccentricity of their flight when they strike trees." Even when there were no trees to interfere with their flight, rockets could not compete with the accuracy achieved by the rifle barrel. Breach-loading, quick-firing, and automatic methods in ordnance had eliminated any other advantages once claimed for the rocket, just as the field telegraph, telephone, and heliograph had superseded pyrotechnic methods of signalling, save in cases of emergency.

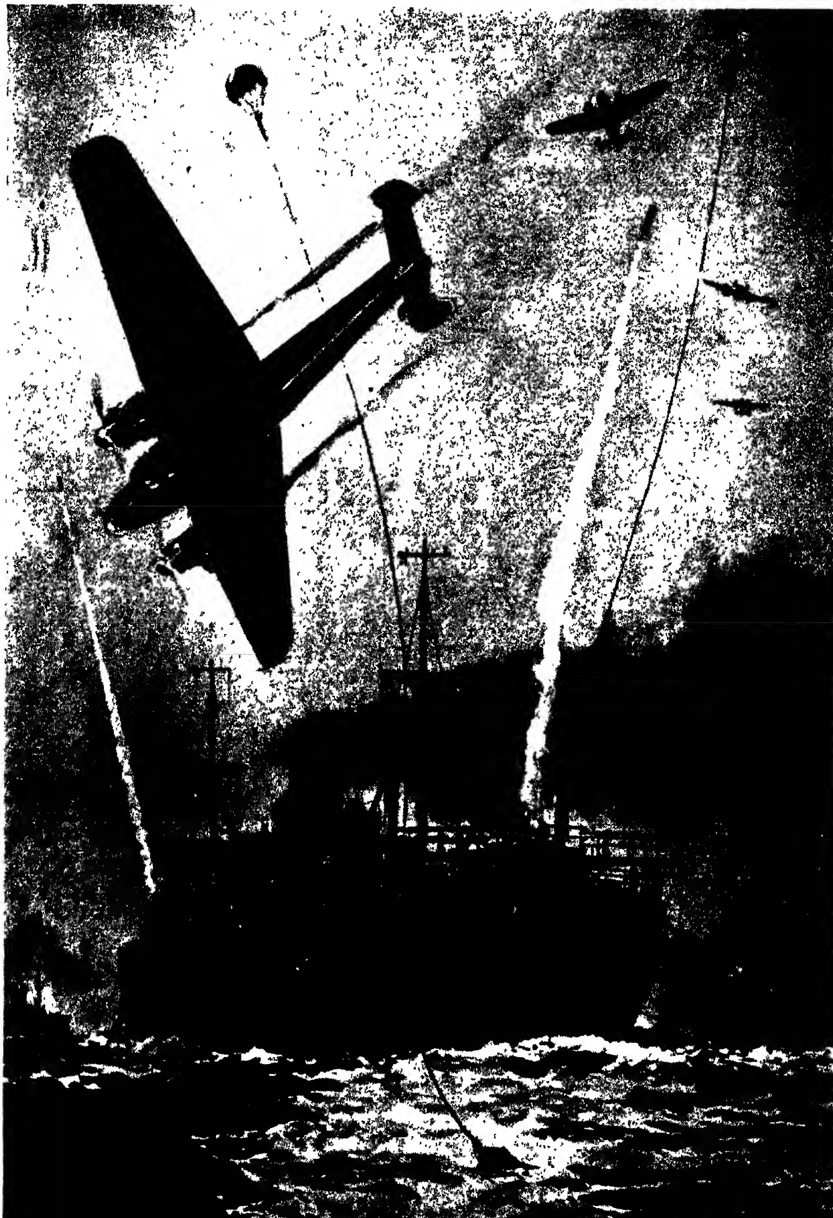
The South African War was fought practically without fireworks stores; the First World War commenced, pyrotechnically speaking, in an atmosphere of speculation approaching bewilderment. The rapid development of aerial warfare was, of course, foreseen, but the part that pyrotechny was to play, in either its offensive or defensive aspects, was yet to be determined by practical experience. As had been the case at the time of the Crimean War, the invention of war devices became almost a popular pastime. Much of this output was nonsensical; some contained the germs of ideas which were capable of development into something useful; a few, in comparison to the mass, were of the greatest possible value. These last were generally the work of those possessed of technical knowledge of the particular subject, or, as the war progressed, the product of practical experience of, and personal contact with, the problem involved. In the last-mentioned category may be included the majority of devices which the quite unforeseen requirements of static trench-warfare conditions imposed as that phase of the struggle developed.

In this connexion the Very pistol was of great service. At the outbreak of war it was confined to the purpose for which it had been adopted into the service in 1888—that of signalling with single stars of varying colour. Other uses for the pistol were soon suggested, the most important of which was the projection of illuminating stars over enemy trenches and formations. The original calibre of 1 in. was increased to 1½ in., and later the barrel was lengthened to give longer range, and a wooden stock added to counteract the increased recoil so caused. The stars were of two patterns, both containing aluminium as the illuminant; the 'dark ignition,' which lit up on reaching its objective, and a rather complicated 'star' which, on reaching the top of its trajectory, opened to throw out a light suspended from a parachute. Both stars attained a pitch of brilliancy never before approached by similar means.

The pyrotechnic adaptation of the rifle grenade consisted of a tinned iron container, fulfilling the function of a rocket cap, attached to an iron rod of a size to fit the barrel of a service rifle. Rod and container were blown from the barrel by a blank cartridge, the shock of discharge operating a time-fuse which ignited and ejected the contents at the greatest altitude. The garniture consisted of stars of various types or a series of lights suspended from a parachute and arranged in a code of colours for recognition purposes.

Smoke, both for concealment and signalling, was soon called for. In the former category the 'type S' smoke case held its own for a considerable portion of the war period. It consisted of a tinned iron canister, with a securely fastened lid having a central hole for the passage of the smoke. Each case carried its individual means of friction ignition. The composition used in the British version was a mixture of saltpetre, sulphur, pitch, borax, powdered glue, and plumbago. In the second class a number of coloured smoke compositions were perfected, in which the tint was provided by certain volatile organic dyes. These were employed in place of light-giving stars for daylight signalling.

PLATE XXXI



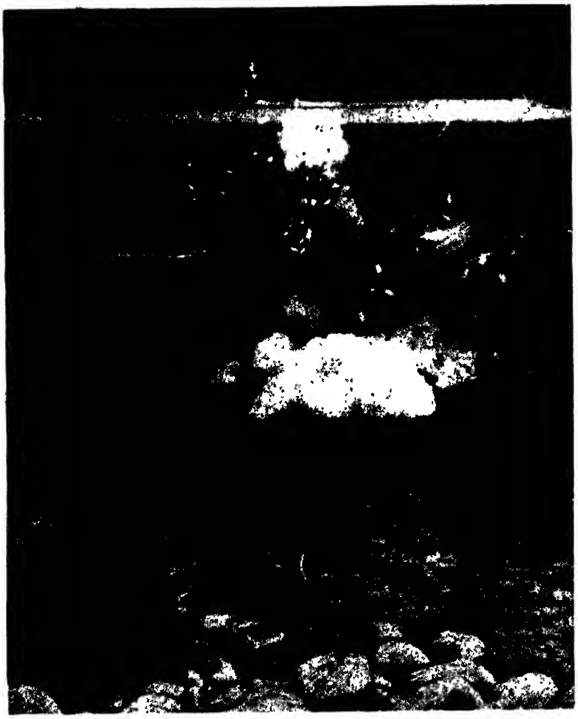
P.A.C. ROCKET BARRAGE

Protecting a convoy from low-flying enemy aircraft.

By permission of the Schermuly Pistol Rocket Apparatus, Ltd

[See p. 262]

PLATE XXXII

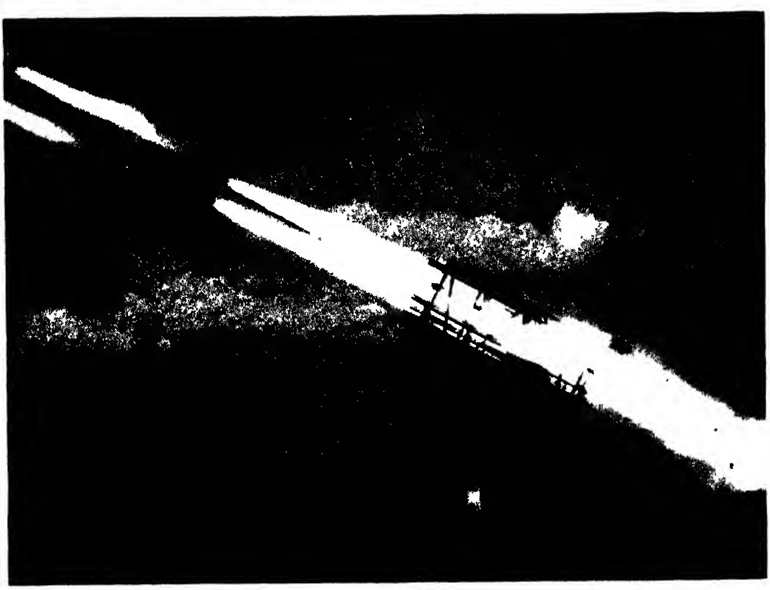


THE BURSTING OF HERR ZUCKER'S ROCKET DURING AN ATTEMPT TO CARRY MAIL FROM SCARP TO HARRIS, IN THE WESTERN ISLES OF SCOTLAND

Letters can be seen flying in all directions.

[*See p.* 253.]

Photo Graphic Photo Union



MULTIPLE ROCKET PROJECTOR

As used for the anti-aircraft rocket barrage during the War.

[*See p.* 263.]

Imperial War Museum photograph. Crown copyright

Among other purely pyrotechnic devices employed in ground warfare were many variations of signal and position lights and rockets, often designed for some special operation and discarded when their term of usefulness was ended. There were numerous ruses, such as mock gun-flashes and shell-bursts, devised for the purpose of misleading enemy observers.

In the air an entirely new field was opened to the pyrotechnist, although what was achieved during the period 1914–18 was, in fact, merely a foretaste of what was to be required in the more recent struggle. The importance of some means by which a pilot might establish his identity was quickly realized. The ubiquitous Very pistol was replaced by the 3·45-in. dropping tube. This device was fixed to the side of the plane's fuselage, and through it were dropped cases having a metal strip on either side wired to an electric fuse. As the case left the tube contact was made and the fuse ignited, and after a few seconds' delay the signal ignited and opened. A further development was the firing of illuminating flares by the same means—either free-falling or, as in a later type, six long-burning magnesium lights in a mechanical holder, attached to a parachute, which caused them to spring out like the spokes of a wheel. Another recognition signal was the 'wing-tip flare,' one of which was mounted at the extremity of each wing, to be fired electrically from the cockpit. This method was also employed for illuminating lights which were burned in reflectors attached to the underside of the wings. Landing-lights and smoke cases to show the direction of the wind were also introduced.

On the offensive side of air warfare the possibilities of aluminium compositions as incendiaries was quickly realized; the heat it was possible to generate by means of such mixtures was comparable to that of thermite.

There was another aspect of aerial warfare which, at the outbreak of hostilities, gave not only the appropriate authorities, but the man in the street, grounds for serious thought, not to say apprehension: the possibility of large-scale bombing raids over this country by German Zeppelins. Our means of defence against such a menace were slender: anti-aircraft gunnery was in its infancy—one might almost say in its pre-natal stage—and the newly formed Royal Flying Corps, owing to its commitments with the Expeditionary Force, was not in a position to allocate planes for home defence. It was even uncertain how effective gunfire would be against lighter-than-air craft assuming hits were obtained —a possibility rather than a probability, at that stage—or how much of its 400,000 cubic feet of gas, contained in separate ballonets, a Zeppelin could afford to lose before it lost buoyancy.

Fortunately, although the reason was not known until some years later, Britain was granted a respite; it was not until January 9, 1915, that the Kaiser signed the order for air raids "expressly restricted to military shipyards, arsenals, and, in general, military establishments." London itself was not to be bombed, a reservation which does not appear to have carried much weight. Another factor tending to delay in the opening of the campaign was the accidental loss, through a number of causes, of no fewer than four airships, out of a total of twenty-one available, during August 1914.

The first air raid by airship on this country took place on January 19, 1915, and in the meantime Britain had opened an anti-Zeppelin campaign, getting in the first blow by attacking the potential raider in its hangar. On October 8 Flight-Lieutenant R. S. L. Marix, R.N.A.S., bombed and destroyed a Zeppelin in its hangar at Düsseldorf. On November 21, 1914, a brilliant success was achieved by Squadron-Commander Briggs, Flight-Lieutenant Babington, and Flight-Lieutenant Sippe, all of the R.N.A.S., by flying 250 miles over enemy territory, in the primitive aircraft of the period, to bomb the Zeppelin hangars at Friedrichshafen. The flight was based on Belfort, where the late Wing-Commander F. A. Brock accompanied them to superintend personally the installation of the special incendiary and explosive bombs which he had designed for the occasion.

On the return of the party to England they reported to the then First Lord of the Admiralty, Mr Winston Churchill, and Brock seized the opportunity to request that he might be transferred from the Royal Artillery, in which he was then serving, to the R.N.A.S. So began a career of usefulness, perhaps unparalleled in the field of military pyrotechny, which ended with his death in the raid on Zeebrugge on St George's Day, April 23, 1918. In his account of the action[1] the late Admiral of the Fleet, Lord Keyes, refers to "Brock the gallant optimist, whose inventions had been so invaluable to us," and in his report on the operation to the Admiralty and Commander-in-Chief: "Regret also that Wing-Commander Brock, who was responsible for the production of smoke, without which the operation could not have been successful, is missing and believed to have been killed on the Mole." Elsewhere in the book he says:

[1] *Naval Memoirs, 1916–18* (London, 1935). Quoted by kind permission of Messrs Eyre and Spottiswoode, Ltd.

The value of Brock's contribution to the undertaking was simply incalculable, in addition to fitting out the vessels with smoke-making apparatus, he designed special smoke floats to be anchored in special positions; he also designed immense flame throwers for the *Vindictive*; parachute flares for aircraft to drop; flare rockets for surface vessels to fire, and special light buoys to mark the route. Brock's one plea, which I would have preferred to refuse—as his genius for inventions was so valuable—was that he should be allowed to take part in the attack. He told me he was particularly anxious to get on the Mole, in order to try and find out the German method of sound ranging, so I reluctantly consented to his going in the *Vindictive*. Brock also suggested that he should provide a detachment for working the fixed and portable flame throwers, smoke apparatus, phosphorus grenades, etc., and for firing rockets from the *Vindictive* whilst alongside, to illuminate the entrance and show up the lighthouse on the end of the Mole as a guide to the blockships. This detachment was known as the "Pyrotechnic Party" and consisted of 34 men from the Admiralty Experimental Station at Stratford,[1] and, Brock told me, were all volunteers for a hazardous service. Lieutenant Graham Hewett, R.N.V.R., was to command them, and Lieutenant A. L. Eastlake, R.E.—flame thrower expert—was attached to the party.

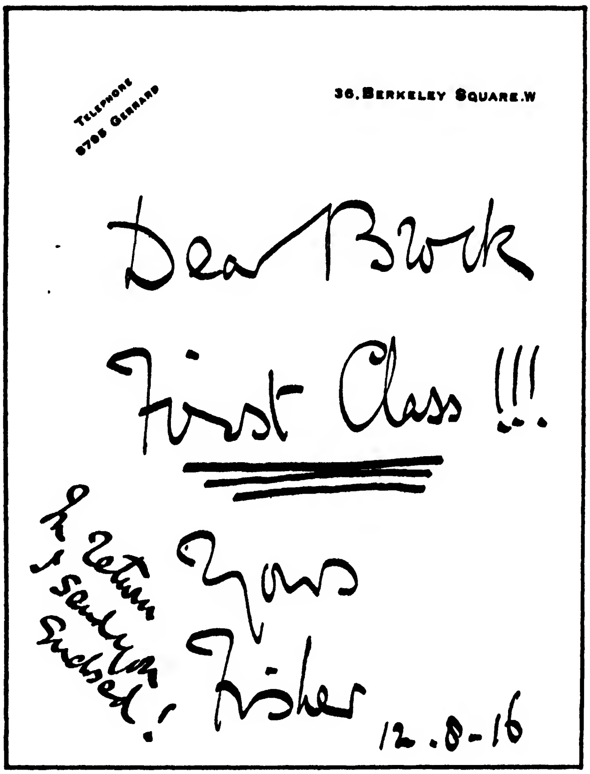
Admiral of the Fleet Lord Fisher, with and for whom Brock worked, was bitterly opposed to the Zeebrugge adventure. In his book *Memories*[2] he speaks of "my dear friend Brock, of imperishable memory and Victoria Cross bravery, wickedly massacred at Zeebrugge," evidently unaware that, as Lord Keyes makes clear, Brock was present at the action by his own particular request. A characteristic letter from Lord Fisher to my brother is reproduced (p. 260).

Soon after joining the R.N.A.S. Brock was working on measures to combat the enemy's intensified U-boat campaign, and to this end devised the million-candle-power 'Dover flare' with which the cross-Channel barrage was illuminated, and described by Lord Keyes as "wonderfully efficient." "The submarine menace in the Straits of Dover," he says, "was defeated . . . by a combination of the deep minefield, Brock's flares, and the dense patrol."

Another contribution he made to the anti-submarine measures was the 'E' smoke float, for ships of the Merchant Navy, enabling a vessel to evade submarine attack by laying its own smoke screen; probably one of the most ingenious purely pyrotechnic devices ever designed. At first sight it may not appear difficult to design a box, or float, which on being ignited and thrown overboard will

[1] Established and commanded by Commander Brock. [2] London, 1919.

emit a smoke cloud, but, in practice, several factors have to be taken into consideration. The apparatus was to be used by men whom, by nature of their employment, it was impossible to train individually; therefore its ignition must be simple and at the same time certain and quick in action, and carried on the float itself; a chamber had to be provided in which to accumulate the smoke


Telephone
9705 Gerrard
36, Berkeley Square. W

Dear Brock

First Class!!!

Yours

Fisher

12.8-16

LORD FISHER'S LETTER TO WING-COMMANDER F. A. BROCK

generated, which chamber had of necessity to have holes through which the smoke could issue. As the float had to be dropped after ignition from the deck of the vessel into the sea, and would consequently be submerged for a short time, these holes must be in some way sealed until the float rose to the surface. The pyrotechnic compositions which produce the greatest volume of smoke were found to take some considerable time to attain their maximum of production, and separate units had to be included which would develop almost instantaneously a big mass of smoke, pending the generation of the main supply. In addition, the whole must be so constructed as to remain efficient when stored on the deck of a merchant vessel in all weathers and conditions. Two hundred thousand of these floats were issued during the war.

Perhaps Brock's greatest contribution to the war effort was his work against the Zeppelin menace. The first success in the air to which he contributed was the brilliant exploit of Flight-Sub-Lieutenant R. A. J. Warneford, V.C., R.N.A.S., on June 7, 1915, in bringing down the L.Z.37 in flames with a specially constructed bomb, for the design of which he was, at any rate in part, responsible. Later came the Brock bullet, which, as the evidence given before the Commission on Awards to Inventors clearly showed, was responsible for the destruction of a number of enemy airships, and contributed in a great degree to the collapse of the Zeppelin campaign. Altogether twelve, out of a total of seventeen dirigibles destroyed in the air,[1] were brought down in flames by machine-gun fire with bullets of this type. The distinctive feature of the Brock bullet was that after leaving the barrel it became so sensitive that it would ignite and explode on impact with the thin fabric of a Zeppelin's outer skin.

Of Brock a technical naval correspondent to the *Navy* magazine wrote:

> From H_2O to WO_2 they knew all about it, or thought they did until the wayward genius of the Commander, who never pretended to be a chemist, taught them that there were permutations and combinations to the *n*th degree that they had never dared to think of.
>
> Wing-Commander Brock's great secret was originality. To the accepted formula he would add just a touch of the unexpected. The chemists would say it can't be done, or it wouldn't work. Sometimes it did not, but often it did, very nearly. And Brock's pioneer brain touched it a bit more—and lo! the impossible and the unexpected had arrived.

During the more recent struggle the most important developments in pyrotechnic munitions of war were, as can well be imagined, in connexion with aerial warfare. A number of devices contributed greatly to the success of the massive night bombing raids of the Royal Air Force over Germany. There were the large flares, four and a half inches in diameter, and of an almost fantastic degree of brilliancy, which hung suspended from parachutes to indicate and illuminate the area of attack; the target-indicator bombs, used by the Pathfinder Force, to mark off the target area on the ground by igniting on impact and burning with changing

[1] In all, apart from eight otherwise lost, twenty-one German airships were destroyed.

colour effects, even under water. Each group dropped included a few containing an explosive charge of T.N.T. to discourage interference by the enemy. There was also the photo-flash, a big—very big—brother to the flashlight of the Press photographers, which ignited below the plane from which it was dropped and made possible many of the wonderful aerial operational photographs reproduced during hostilities.

Many a hard-hit straggler, returning from a raid and forced to land at the first available air-strip, has owed his safety to being able to fire the 'colours of the day' as a means of establishing his identity and so avoiding the mistaken attentions of the defences. These were fired from the standard Very pistol or, in some single-seater aircraft, from a built-in 'signal discharger,' constructed on the lines of a revolver and loaded before the plane's take-off.

The use of the cordite rocket to assist a plane's take-off has been mentioned in the previous chapter. Another application of cordite, in a modified form, is the Mechanite power cartridge, of which many millions have been used by the Royal Air Force, during and since the war, for starting aero engines, and also as an alternative means of lowering the undercarriage of a plane in the event of failure of the hydraulic equipment. The engine-starter unit, roughly the size of a twelve-bore sporting cartridge, generates gas which is led directly into a cylinder of the engine through a valve, and operates on the piston in the same way as the normal charge and so dispenses with much of the mechanism associated with many starting devices. The possibilities opened up by this concentrated and instantly available power unit, the rate of burning of which can be adjusted to the particular purpose, are obviously very wide indeed.

Cordite provided the motive force of the 'non-rotating projectile' (N.R.P.), more generally known as the rocket bomb, used with such effect by our Typhoons against ground targets. It consisted of a long, narrow body to which was attached a war-head charged with 14 lb. of high explosive. Six were carried on rails under the wings of the aircraft, to be discharged as and when required by the pilot. As at the time of its release the rocket had already a forward velocity equal to that of the diving plane, to which was added not only the speed imparted by its propellant, but the force of gravity as well, the speed at which the projectile reached its target must have been well over 1000 miles an hour.

One could wish that Congreve had been present to see the vindication of his ideas on floating rocket batteries as exemplified in the specially fitted out Landing Craft Tank (Rocket) which did service on the coast of Sicily, and again against the Normandy beaches. This method of directing massed fire-power to coastal targets from a craft at sea was developed by Colonel H. F. Langley. It was authoritatively stated that a single discharge from one vessel was roughly equal to that of thirty cruisers mounting twelve 6-in. guns. So great was the back-rush of fire developed from each 'flight' that the captain of the vessel—the only man of the ship's company above decks—was housed in a fireproof structure on the bridge from which to direct the fire.

Most Londoners will remember the impressive effect of the massed anti-aircraft rocket barrage that was a regular feature of air-raid nights (Plate XXXII). Another highly effective anti-aircraft device was the 'P.A.C.' rocket, developed by Schermuly. A 6-lb. rocket, fired from a vertical projector, carried up to a height of several hundred feet a length of strong steel wire, which was held suspended in the air by a parachute, released at the top of the rocket's trajectory. A number fired together produced what was, in effect, an emergency balloon barrage, and served as a deterrent to low-level attacks on airfields and merchant convoys (see Plate XXXI).

The Germans made extensive use of rocket-driven projectiles in the field for some considerable time before the appearance of the so-called 'rockets' V1 and V2. These were of two main types: those of which the direction was controlled by three wings, or fins, attached to the body containing the propellant, and spring-loaded so that they sprang out into the flying position after emerging from the firing tube; and a type which maintained direction by spinning. The war-heads of German rockets were charged with high-explosive, gas-producing, smoke-producing, or incendiary mixtures. The maximum range varied from 2000 up to 6000 yards. Fired from a specially constructed mobile stand, they could be discharged at the rate of six rounds in ten seconds. It is interesting to note that the German gas-warning signal was a whistling firework unit, fired from a Very pistol.

An ingenious application of the rocket principle, although, like the V1 and V2 weapons, hardly falling within the scope of pyrotechnics, was the liquid-fuel unit employed by the German Air Force in fighter planes specially designed for the interception of bomber attacks. A very lightly built plane fitted with 'rocket' units was towed up to a great height, where it cruised by gliding for some time. When the pilot sighted a hostile formation, he switched on one or more power units to carry out a diving attack at very high speed. A modification of this system would seem to have possibilities in relation to the auxiliary powering of gliders for commercial purposes.

Another most valuable device, but perhaps even more remotely connected with pyrotechny, is the Graviner fire-extinguisher for use in aeroplane engines. This consisted of a metal cylinder, mounted in a suitable position in the plane, filled with methyl bromide and pressurized with nitrogen. The sealed outlet was piped to vulnerable points on the engine. Flame or impact automatically closed an electric circuit firing a small explosive charge in the cylinder, which perforated the seal and permitted the escape of the methyl bromide to do its work in extinguishing any outbreak of fire.

Among the more typically pyrotechnic stores were many signals of the Roman candle type, in which the orthodox rolled-paper case was replaced by a steel tube, thus permitting a heavier 'blowing charge' to be employed and the stars to be driven up to a greater height. Air-sea-rescue dinghies carried signals throwing two red stars; the recognized lifeboat signal discharged five red stars; five-star white signals were employed in Admiralty convoy work; and a ten-star multi-coloured signal was used by the airborne forces as a rallying signal, etc. All were fitted with a spring-loaded ignition device. The lethal functions of the 2-in. infantry mortar were varied by the introduction of a number of signalling projectiles, some releasing coloured stars, and others employed for illuminating purposes. Coloured smokes were also used for a number of purposes, most frequently in air-sea work.

The wide variety of incendiary devices which made their appearance throughout the period of hostilities ranged from small phosphorous 'leaves,' dispersed wet from aircraft, to a great number of contrivances for sabotage work in occupied territory. Many, particularly in the earlier days, were based on aluminium compositions—thermite and the like; later came an almost infinite assortment of mixtures and combinations of phosphorous waxes and hydrocarbons, more or less suited to the particular circumstances in which they were intended to be employed.

A great number of units, designed to represent with some degree of accuracy, but with rather less than their actual potency, the action of the versions supplied by enemy agency, were employed for training purposes, A.R.P., battle inoculation, etc., and vast quantities of 'thunder flashes,' single-burst crackers ignited by friction, were consumed on training exercises as signals and for the provision of 'noises off.'

An innovation, appearing for the first time in warfare—unless a claim can be established for the inclusion of the old-fashioned sulphur candle in the same category—is the cloud dispersal of D.D.T. and other similar insecticides by means of a pyrotechnic heating mixture. This device will no doubt find a place in peace-time; in fact, a number of patents have been filed, covering special mixtures and methods of arriving at what is, after all, the production of smoke for a particular purpose. The earliest known use of a comparable expedient must surely be the use of clouds of noxious smoke by the native Indians of Brazil, as a no doubt effective weapon against their Spanish invaders. This was achieved by sprinkling red peppers on pans of glowing charcoal.

Another use of pyrotechnic mixtures in wartime that will surely find a place in domestic life, particularly should the present-day difficulties relative to fuel and power persist, is the self-heating food tin, by which a hot meal could be obtained at all times, even under the most unpropitious conditions. Some of these containers depended for their functioning on chemical action—such as the production of heat by the reaction of water in unslaked lime—but others, certainly no less successful, were purely pyrotechnic in action, a firework unit burning down through a metal tube built axially into the can.

And so I come to the end of my story of fireworks through the ages. As I write these concluding words I am conscious that those of my readers who claim to possess a practical knowledge of the subject—in particular those whose contact with the art of pyrotechny was established during one or other of the two world wars—will be able to point to sins of omission and, perhaps, of over-emphasis. In my defence I can only say that it is not easy, for one whose interest in a subject is both technical and personal, to select from the facts and material gathered during thirty or forty years of study those items most likely to interest the majority of readers. To my fellow pyrotechnists, both at home and abroad—particularly the former—and to firework enthusiasts, of all ages, everywhere I tender my warm and respectful salutations. May I express the hope that no reader who has reached this stage in my book will echo the words of Sir Toby Belch in *Twelfth Night*: "Marry, hang thee, Brock!"

Appendix I

BIBLIOGRAPHY

Manuscripts

Artificial Fireworks: 3 vols., in manuscript, with illustrations; on the title-page of each the words "To Major Congreve this volume is humbly dedicated by his most obedient devoted servant John Maskell" (1785). (Author's collection.)

Feuerwerksbuch (1432). (MS. 362 in the University Library of Freiburg i.B.)

Latin manuscript, with enumeration of materials for all fires (*c.* 1438). (No. 197 in the Royal Library, Munich.)

Recueil de l'artifice contenant celle de guere et de joye appartenant a M. La Jierofflée, Sargent au Corps Royal (1766).

Treatise of the Ruses of War, the Capturing of Towns and the Defence of Passes, according to the Instructions of Alexander, Son of Philip (1225). (In the Leyden Library. Contains no mention of saltpetre.)

Printed Sources

Abridgments of the Specifications relating to Firearms, etc. (H.M. Patent Office.) (London, 1859.)

Anderson, Robert: (Title missing). Deals with the making of rockets. (London, 1696.)

Angelo, T.: *The Art of Making Fireworks made Plain and Easy* (London, *c.* 1816.)

Anonymous: *Buchsenmeisterei von Geschoss, Buchsenpulver, Salpeter und Feuerwerk* (Strasbourg, 1529).

—— *The Gallery of Nature and Art. Pyrotechny or the Art of Constructing Fireworks* (London, 1817).

—— *A Profitable and Necessary Book of Observations for all those that are burned with the Flame of Gunpowder, etc.* (London, 1591).

—— *Die Pyrotechnie nach der Vorschriften von Claude Ruggieri und Thomas Mórel* (Leipzig, 1807).

—— *The Rise and Progress of the British Explosives Industry* (London, 1909).

—— *Der Wohlerfahrne Salpetersieder und Feuerwerker* (Frankfort, 1755).

Antoni, Domenico: *Trattato teorico—practico de pirotecnia civile* (Trieste, 1893).

Appier, Jean (alias Hanzelet): *La Pyrotechnie* (Pont-à-Mousson, 1630).

—— *Recueil de plusiers machines militaires . . .* (Pont-à-Mousson, 1620).

AUDOT, L.-E.: *L'art de faire à peu de frais les feux d'artifice* (Paris, 1818 and 1825).
BABINGTON, JOHN: *Pyrotechnia* (London, 1635).
BATE, JOHN: *The Mysteries of Nature and Art. The Second Book teaching most plainly and withall most exactly the Composing of all Manner of Fireworks for Tryumph and Recreation* (London, 1635).
BERMEJO, D'ANTONIO: *Manual de pirotécnia militar* (Madrid, 1845).
BERTHELOT, MARCELIN: "Les compositions incendiaires dans l'antiquité et au moyen âge. Le feu grégois et les origines de la poudre à canon," in *Revue des Deux Mondes* (Paris, 1891).
BIRINGUCCIO, VANUCCIO: *De la pirotechnia* (Venice, 1540).
BOURNE, WILLIAM: *Inventions and Devices* (1578).
BROCK, A. ST H.: *Pyrotechnics: the Art and History of Firework-making* (London, 1922).
BROWNE, DR W. H.: *Firework Accidents* (Hull, 1884).
—— *Practical Firework-making for Amateurs* (London, 1880).
BRUHL, —: *The Art of making Fireworks* (1844).
BUJARD, ALFONS: *Die Feuerwerkerei* (Berlin, 1912).
CHAPNIS, —: *Considérations sur l'art des feux d'artifice, Autriche* (Paris, 1830).
CHERTIER, F. M.: *Nouvelles recherches sur les feux d'artifice* (Paris, 1854).
Corona e palma militare di arteglieria, Capitano Alessandro Capo Branio Vincentiano (Venice, N.D., *c.* 1540).
CUTBUSH, PROFESSOR JAMES: "Chinese Fire," in the *American Journal of Science*, vol. vii (Philadelphia, 1823).
—— "On the Properties and Composition of Greek Fire," in the *American Journal of Science*, vol. v (Philadelphia, 1822).
—— *A System of Pyrotechny* (Philadelphia, 1825).
DAVIS, DR TENNEY L.: *The Chemistry of Powder and Explosives* (New York, 1943).
DENISSE, AMÉDÉE: *Traité pratique complet des feux d'artifice* (Paris, 1882).
DESORTIAUX, E.: *La poudre, les corps explosifs et la pyrotechnie. Traduction des ouvrages des docteurs Upmann et Meyer* (Paris, 1876).
DIGGS, LEONARD: *Stratistico* (1579).
DU-HALDE, JEAN-BAPTISTE: *Description géographique historique, chronologique et physique de l'empire de la Chine et de la Tartarie chinoise* (Paris, 1735).
DUSSAUCE, G.: *A Practical Treatise on the Fabrication of Matches, Guncotton, Coloured Fires and Fulminating Powders* (Philadelphia, 1864).
ELDRED, W.: *The Gunners Glasse* (*c.* 1620).
FABER, HENRY B.: *Military Fireworks* (Washington, 1919).
FREY, OSCAR: *Die Feuerwerkkunst* (Erfurt, 1885).
FRÉZIER, —: *Traité des feux d'artifice* (Paris, 1741 and 1747).
GUTTMAN, OSCAR: *The Manufacture of Explosives* (London, 1895).
HIME, LIEUTENANT-COLONEL H. W. L., R.A.: *The Origin of Artillery* (London, 1915).
HUTSTEIN and WEBSKY: *Lustfeuerwerkkunst* (Leipzig, 1873).

JOCELYN, COLONEL J. R. J., R.A.: *The Connexion of the Ordnance Department with National and Royal Fireworks* (Woolwich, 1906).

JONES, LIEUTENANT ROBERT: *A New Treatise on Artificial Fireworks* (London, 1765 and 1776).

KENTISH, THOMAS: *The Pyrotechnist's Treasury* (London, 1878).

LALANNE, L.: *Recherches sur le feu grégois et la poudre* (Paris, 1845).

—— "Greek Fire and Gunpowder," in *Blackwood's Magazine*, 1846.

LAMARRE, A.: *Nouveau manuel de l'artificier, ou traité pratique pour la fabrication des feux de couleurs, etc.* (Paris, 1878).

LUCAR, CYPRIAN: *Lucar Appendix, collected to shew the Properties, Office and Dutie of a Gunner, and to teach him to make and refine Artificial Saltpeeter to sublime for Gunpowder, etc.* (Annexed to a translation of Tartagalia's book.) (London, 1588.)

MAGNUS, ALBERTUS: *De mirabilibus mundi* (Argentorati (Strasbourg), 1607).

MALTHUS, F. (FRANÇOIS DE MALTHE): *Treatise of Artificial Fireworks* (Paris, 1629).

MEYER, CAPITAINE MORITZ (translated into French by Lieutenant Hippert, 1836): *Pyrotechnie raisonnée* (Bruxelles, 1836).

MOREL, THOMAS: *Traité de pyrotechnie* (Paris, *c.* 1812).

MORTIMER, G. W.: *A Manual of Pyrotechny* (London, 1824).

—— *Pyrotechny or Recreative Fireworks* (Paris (in English), 1852).

NORTON, ROBERT: *The Gunner* (London, 1628).

—— *The Gunner's Dialogue* (London, 1643).

NYE, NATHANIEL: *The Art of Gunnery* (Worcester, 1648).

PERETSDORF, J. RAVICHIO DE: *Traité de pyrotechnie militaire, contenant tous les artifices de guerre en usage en Autriche* (Strasbourg, 1824).

PERINET-D'ORVAL: *Essai sur les feux d'artifice* (Paris, 1740 and 1745).

"PRACTICUS": *The Manual of Pyrotechny* (London, *c.* 1870).

—— *Pyrotechny, or the Art of making Fireworks* (London, 1865).

REINAUD, JOSEPH-TOUSSAINT, and FAVÉ, GÉNÉRAL ILDEPHONSE: *Controverse à propos du feu grégois. Réponse aux objections de L. Lalanne* (Paris, 1847).

—— *Histoire de l'artillerie. 1ère partie: Du feu grégois, des feux de guerre et des origines de la poudre à canon* (Paris, 1845).

RICHARDSON and WATTS: *Chemical Technology* (London, 1865).

RUGGIERI, CLAUDE-FORTUNÉ: *Elémens de pyrotechnie* (Paris, 1801 and 1821).

—— *Pyrotechnie militaire* (Paris, 1812).

SCOFFERN, JOHN: *Weapons of War* (London, 1854).

SIEMIENOWITZ, CASIMIR: *The Great Art of Artillery.* (Translated into English by George Shelvocke in 1729 by order of the Surveyor-General of the Ordnance.) (Amsterdam, 1650.)

SINCERI, —: *Saltpetersieder und Feuerwerker* (Frankfort, 1710).

TESSIER, PAUL: *Chimie pyrotechnique, ou traité pratique des feux colorés* (Paris, 1859).

UFANO, DIEGO: *Tratada de Artilleria* (Brussels, 1612).

VERGNAUD, A. D. and P.: *1ère partie: Pyrotechnie militaire. 2ième partie: Pyrotechnie civile* (Paris, 1865).

WEBSKY, MARTIN: *Schule der Lustfeuerwerkerei* (Breslau, 1850).

WEINGART, GEORGE W.: *Dictionary and Manual of Pyrotechny* (New Orleans, 1930).

—— *Pyrotechnics* (Brooklyn, 1947).

WELMAN, HENRY J.: *Fireworks and how to make them* (New York, N.D., *c.* 1900).

WHITEHORNE, PETER: *How to make Saltpetre, Gunpowder, etc.* (London, 1573).

WHITTEMORE, MAJOR JAMES M., and HEATH, LIEUTENANT F.: *Ammunition, Fuses, Primers, Military Pyrotechny, etc.* (Washington, 1878).

WINTER, —: *De pulvere pyrio* (Hafnia (Copenhagen), 1698).

WROTH, WARWICK, F.S.A.: *The London Pleasure Gardens of the Eighteenth Century* (London, 1896).

ENCYCLOPÆDIAS, PERIODICALS, ETC.

Boy's Own Volume: "Papers on Pyrotechny," by "Practicus" (1865).

Brewster's Cyclopædia: article by MacCullock.

Chambers's Cyclopædia (1753).

Chambers's Encyclopædia: article by A. St H. Brock.

DAVIS, DR TENNEY L., and CHAO YUN-TS'UNG: "Chao Hsuch-Min's Outline of Pyrotechnics," in *American Academy of Arts and Sciences* (1943), vol. lxxv, No. 4, pp. 95–107.

DAVIS, DR TENNEY L., *Chymia: The Early Use of Potassium Chlorate in Pyrotechny* (Philadelphia, 1948).

DAVIS, DR TENNEY L., and WARE, DR JAMES R.: "Early Chinese Military Pyrotechnics," in *American Journal of Chemical Education* (1947), vol. xxiv, p. 522.

The Edinburgh Encyclopædia (1824).

Encyclopædia Britannica (fourteenth edition): article by A. St H. Brock (1929).

Encyclopédie (Diderot et D'Alembert) (Paris, 1751–72).

English Encyclopædia (1802).

Every Boy's Book (1856).

Harmsworth Universal Encyclopædia: article by A. St H. Brock (1921).

The Techno-Chemical Receipt Book: article by Brannt and Wahl (1886).

THORPE, J. F., and WHITELEY, M. A.: *Dictionary of Applied Chemistry* (1941).

Appendix II

CHEMICALS AND INGREDIENTS USED IN PYROTECHNIC PRODUCTION

Acaroid resin
Aluminium
Ammonium salts
Anthracene
Antimony and its salts
Arsenic
Asphaltum

Barium salts
Beta naphthol
Borax
Bronze powder

Calcium salts
Calomel
Charcoal
Clay
Copper salts

Dextrine

Emery dust

Flour (maize)
Fluorescein

Glue
Graphite
Gum arabic
Gum, red
Gum, white
Gunpowder

Hammerscale
Hexachlorethane

Iron powder
Ivory nut powder

Kaolin
Kieselguhr

Lactose
Lampblack
Lead salts
Linseed oil
Litharge
Lutin

Magnesium
Maize starch
Manganese salts
Methylated spirits
Mica

Naphthalene

Organic dyes

Paraffin wax
Phosphorus, yellow and amorphous
Picric acid
Pitch
Potassium salts

Resin

Shellac
Silicon
Sodium salts
Stearine
Steel dust
Strontium salts
Sulphur

Titanium salts

Wood meal

Zinc oxide

Appendix III

THE BROCK FAMILY TREE

The names of the pyrotechnists are given in heavy type.

John Brock *m.* Eleanor
(of Islington Road; *d.* Nov. 5; buried at St James's, Clerkenwell)

John *m.* Martha
(*b.* Nov. 25, 1700) | (*d.* 1750; buried at St James's, Clerkenwell)

Mary
(*d.* Nov. 27, 1720; buried at St James's, Clerkenwell)

Paul *m.* Mary
(of Allen Street, Clerkenwell)

John *m.* Mary Lovett
(Master paviour (*b.* 1728) of Theobald's Road, Holborn) | (aged eighteen, of Holborn; *m.* at St George's, Queen Square, 1746)

James *m.* Mary
(*b.* 1727)

Elizabeth
(*b.* 1725; baptized at St John's, Clerkenwell)

Elizabeth
(*b.* 1726; baptized at St James's, Clerkenwell)

Martha
(*b.* 1729; baptized at St James's, Clerkenwell)

Martha
(*b.* 1750)

Sarah
(*b.* 1752)

Abraham
(*b.* 1753; *d.* 1754)

(All baptized at St James's, Clerkenwell)

John *m.* (1) Mary Willan, of Eynsford, Kent (1776)
(2) Lidea Benham, at St Giles-in-the-Field (1778)
(*b.* 1750; *d.* at Camden Town, 1803)

William *m.* Elizabeth Powell (widow),
(*b.* 1752) | of St Pancras (*m.* at St George's, Queen Square (1774); *d.* Mile End Old Town, 1786)

Thomas *m.* Mary
(*b.* 1756; *d.* 1819; of Red Lion Street, Spitalfields) | (*m.* at the Charlotte Chapel, St Pancras, 1788)

John
(*d.* 1817)

Mary
(baptized at Islington, 1780)

S

William *m.* Elizabeth (*b.* 1779; *d.* 1849) — **Thomas** (*b.* 1797) — Two sons and six daughters [1]

William *m.* Mary Anne Isabella Miller (*b.* 1813; *d.* 1869) (*m.* 1838; *d.* 1899) — **Henry** (*b.* 1826) — Two sons and four daughters [2]

John Robert (*b.* 1841; *d.* 1906; *m.* Sarah Murgatroyd, 1874—1*s.*, 2*d.*) — **Henry** (*b.* 1841; *d.* 1901; *m.* Florence Cooper, 1873—1*s.*, 3*d.*) — **Charles Thomas** (*b.* 1843; *d.* 1881; *m.* Rhoda Garland, 1865—no issue) — **William Andrew** (*b.* 1855; *d.* 1887) — **Arthur** *m.* Anne St Hill Dewdney, of Ugborough, Devon (*b.* 1858; *d.* 1938) (*b.* 1859; *d.* 1949, *m.* 1883) — Three sons and three daughters [3]

Cmdr. Frank Arthur, R.N. (*b.* 1884; killed at Zeebrugge, St George's Day, 1918) — **Alan St Hill** (*b.* 1886) — **Bernard** (*b.* 1888) — **Harold Vernon** (*b.* 1891; *d.* 1947) — **Christopher Dewdney** (*b.* 1892) — **Roland Benjamin (Roy)** (*b.* 1897) — Three daughters [4]

[1] Benjamin (*b.* 1781) and John (*b.* 1783) and Harriet (*b.* 1784), Mary (*b.* 1786), Sophia (*b.* 1788), Elizabeth (*b.* 1790), Elizabeth (*b.* 1792), and Sarah (*b.* 1795).

[2] Thomas (*b.* 1815) and John (no date in family Bible) and Elizabeth, Ann, Elizabeth (no dates in family Bible), and Emma (*b.* 1828; *d.* 1865).

[3] William (*b.* 1839; *d.* in infancy), Alfred (artist; *b.* 1845; *d.* 1874; *m.* Anne Morley, 1861 (1*s.*, 1*d.*)), and Samuel (dentist; *m.* Louisa Tabor, 1874 (4*s.*, 1*d.*)), and Isabella (*b.* 1849; *d.* 1917; *m.* Daniel Thurston, M.D., 1885 (1*s.*, 1*d.*)), Alice (*b.* 1853; *d.* 1854), and Mary Ann (*b.* 1854; *d.* 1917; *m.* George Ashby, 1874 (2*s.*, 1*d.*)).

[4] Gwenlian May (*b.* 1890), Sylvia Muriel (*b.* 1895), and Margaret Eleanor (*b.* 1901).

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