

FIREWORKS

Principles and Practice

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Preface

For many years Weingart's "Pyrotechnics" has been regarded as the amateur firework enthusiast's Bible, and it was news of the re-print of this work in 1968 which prompted the writer to suggest a revision of it. As it happened the suggestion came too late with the result that a new work has evolved.

From the beginning the writer was anxious to share the task of writing this work, and accords grateful thanks to the other three contributors:- Dr. Shimizu, who very willingly translated part of his book "Hanabi" from the original Japanese. The script of chapter 19 is more or less as he translated it, and a great credit to him. To the best of our knowledge this is the only treatise on Japanese firework manufacture in the English language.

Ronald Hall, one of my long-standing firework friends who has long experience as a chemist in the explosives and firework industries. Has also been responsible for the introduction of polymerizing resins into commercial firework manufacture and is especially interested in forensic aspects of explosives.

Last but not least my thanks go to my teaching colleague and friend Roy Butler; an able firework maker who has given even more of his time to write a precis of the available historical records, adding also more up-to-date material.

Turning to the general preparation of the book, I would like to express grateful thanks to Peter Smout Esq., M.A., Senior Master at Kimbolton School who has so kindly read through the script and made many helpful suggestions.

Helpful comments have also been made by Peter Watson Esq., B. Sc. Senior Chemistry Master at Kimbolton School, Dr. Herbert Ellern, the author of Military and Civilian Pyrotechnics, and Mr. J. Barkley and Mr. J. Wommack, two other American friends. My wife, Kathleen Lancaster, Dip. Arts, Dip. Ed., has kindly assisted with drawings and diagrams along with P. R. Lambert, a member of the School Sixth Form.

In particular also my grateful thanks go to Edwin Bailey who kindly used his printer's expertise to convert many of the drawings into a suitable form for printing.

Several commercial firms have been kind enough to supply technical information. These were Imperial Chemical Industries, Albright and Wilson Ltd., Frederick Allen & Sons Ltd., Anchor Chemical Co. Ltd., F. W. Berk & Co., Ltd., Columbian International Ltd., Du Pont de Nemours & Co., K. W. Chemicals Ltd., W. S. Lloyd Ltd., Magnesium Elektron Ltd., Chas. Page & Co. Ltd., L. R. B. Pearce Ltd., A. F. Suter & Co. Ltd. and Bush Beach, Segner Bayley. I would like to express my gratitude to all those people who helped me along the firework road in those early days when help was required to cross the threshold which separates amateur and professional firework manufacture. In particular I would mention the Greenhalgh Family of Standard Fireworks Ltd., Huddersfield, along with W. Stott Esq. and J. Seymour Esq. who also live in Huddersfield, my native town. Kindly friends abroad include Lünig of Stuttgart; Nico of Trittau, Hamburg; Moog of Wuppertal; Hamberger of Oberried and the Barfod Family of the Tivoli Gardens in Denmark.

Lastly, and in more recent times, gratitude is due to Pains-Wessex Ltd. to whom I have been Firework Consultant since 1963 and to John Decker F.C.A. and David A.S. Little for their help and friendship.

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Introduction

It is illegal to manufacture fireworks in most countries unless a license has been obtained from the government. This is absolutely right, for nowhere else does the old saying that “a little knowledge is a dangerous thing” apply more than here, perhaps with disastrous effects. Accidents occasionally happen in the most experienced hands and old and hardened manufacturers shudder at some of the experiments of the uninitiated.

Why then write a book about fireworks?

There is a need for an up-to-date description of *general* firework practice. Firework manufacture may be a mixture of chemistry and cooking, but it is nevertheless an important branch of pyrotechnics. All the books in existence lack either accurate detailed information or publish information which may be incorrect, dangerous or useless commercially. Naturally this has been deliberate because firework manufacture has been in the hands of private families and is still more or less entirely tied up with money and competition. This is a pity, but like so many commercial enterprises, considerable sums of money are invested in plants or research and returns are naturally expected. Indeed, the writer has done little more than skim over the surface, quite deliberately; nevertheless all the compositions are typical of those in use in Europe and are as reasonably safe as such things can be. Clearly the intention of this book has been to attempt to show that much of the available printed information is dangerous.

Over the last few decades the attitudes of the manufacturers have changed. In the past each one regarded his compositions as a great secret, the “boss” himself frequently doing the mixing and giving the chemicals false names to fool the industrial spies. All this has more or less gone. Chemical suppliers became fewer and larger, selling the same materials to everyone; gunpowder manufacture is virtually a monopoly, and fireworkers in some countries change their employment from one company to another.

Most good firework makers share the same basic formulations; only the finer points and the techniques are more or less secret and naturally these are details which do not reach publication. In any case half the

battle of firework manufacture is experience, namely the constant observation of the burning characteristics and performance of fireworks, and consequently the experience of knowing what adjustments to make and what to look for.

In the opinion of the writer, the argument that explosive information should not be published, does not hold water. Determined people can get a good deal of information, for there is plenty of it in print, and after all, legal and other restrictions make it very difficult for anyone to start manufacture.

The writers naturally would be greatly disturbed to feel that this book has caused anyone to damage people or property but such risks have to be taken at all levels of life. Fireworks are dangerous but so are domestic electricity supplies, oil burning heaters, pans of boiling fat, gasoline pumps, gas supplies, children's bicycles on roads. the possibilities are endless.

From time to time attempts are made to ban the sale of fireworks to the public. Recent voting in Great Britain indicated that the majority of the voters were against such a move, and quite rightly so. After all people have to act responsibly and should be free to exercise their responsibility in this direction. Britain, in common with most European countries, has rigid legislation and inspection of firework manufacture and an agreement amongst manufacturers that flash crackers and certain dangerous fireworks should not be sold to the general public. The result is that a fairly wide range of fireworks can be purchased in the shops at certain times of the year, and display fireworks can be organized by people with specialized experience. The U.S.A. could do well to benefit from our experience, for it would appear that a country priding itself on its freedom can nevertheless allow some bureaucratic fire marshal or other excited group to bring in legislation to outlaw fireworks in individual states. The result appears to be that it encourages people to buy fireworks over the border in a more permissive state and fire them illegally. Restrict the dangerous explosive items by all means, but "safe and sane" as the Americans put it, covers *very* much more than sparklers.

The Germans say in effect that once a person has smelt blackpowder, he will be with it for the rest of his life. There is undoubtedly some truth in this, for real fireworkers all over the world love to get together and talk about the fascination of this, their mutual interest. It is to be hoped that it will always be possible to strike a happy balance between the enthusiast and the legislation.

In recent years while pyrotechnics have been striding ahead, the art of firework manufacture appears to be relatively static and oldfashioned. Nevertheless this should not be a matter exciting too great a concern, for the firework maker can only display his art on those grand and comparatively rare occasions when large sums of money are spent on a single display. The burst of an 8" golden octopus, crossette shell or a Japanese chrysanthemum will still thrill people for many years to come, in spite of the fact that the composition may be primitive. Public taste will not have the opportunity to become bored by those fireworks which really display the firework maker's art.

Contents

Chapter 1	The History of Fireworks	1
2	Firework Materials	25
3	General Pyrotechnic Principles	53
4	Mixing and Charging	63
5	Containers	75
6	Stars	85
7	Colored Fires, Bengals, Lances, Portfires, Torches...	97
8	Roman Candles, Comets, Mines	109
9	Noisemakers	119
10	Rockets	125
11	Drivers, Saxons, Tourbillions	135
12	Shells	143
13	Gerbs, Fountains, Rains, Squibs, Cones	159
14	Pinwheels and Crackers	167
15	Indoor Fireworks	173
16	Fuses, Quickmatch	181
17	Smoke	187
18	Exhibition Fireworks	193
19	The Manufacturing Processes of Firework Composition	205
References	269
Index	271

Chapter 1

The History of Fireworks

R. E. A. Butler

Firework manufacture has a long history, but the development of the pyrotechnic art has been remarkably slow. The Chinese may have made fireworks of sorts over a thousand years ago; displays have been fired at public and private celebrations for five hundred years, and their popularity, now throughout the world, seems undiminished. Nevertheless, basically firework displays have changed little over several centuries, and rockets, shells and Roman candles, in various forms, remain the main display components. Certainly colors have been improved, and the range of colors extended, shells are more spectacular, rockets are propelled higher, the use of new materials has brought some new effects, and set pieces and the style of displays have been changed, but the essential ingredients of the firework exhibition do not alter. The fireworker still strives to excite and delight with a combination of color and noise. He creates patterns of beauty and brilliance using natural materials and employing a knowledge of chemical reaction, together with the benefits of experience, and often much patience, dedication and intuition. The beginning of the pyrotechnic art was heralded by the invention of gunpowder, and this dark mixture is still the firework maker's principal material. Thus, in this capacity as a bringer of pleasure and beauty, gunpowder makes some amends for its evil reputation as a source of death and destruction.

It is probable that the first gunpowder was formed when, quite by chance, charcoal, saltpeter and sulphur were brought together. The result of this accident would be obvious if the mixture was exposed to some means of ignition, and the potential use of this new explosive material would soon become apparent. Traditionally the Chinese are credited with the discovery at a time well before historical records. Certainly the evidence suggests that gunpowder originated in the East,

with China or India being the likely source, although the Arabs and Greeks have certain claims. Moreover, coded writings by the English friar, Roger Bacon, in the thirteenth century, are generally accepted as a description of a gunpowder mixture for the production of an explosion. The invention of the gun, which probably represented the greatest step forward in the application of gunpowder, was almost certainly made in Germany, at Freiburg, by a Franciscan monk called Berthold Schwarz, although the inventor could well have had Asiatic origins. It was over two centuries later that the first artillery was seen in China, and that was on Portuguese ships in 1520.

However, the Chinese had employed pyrotechnic mixtures long before this date. Ancient manuscripts describe explosive bombs, which were fired from giant catapults, and burst on landing or in the air. Similar missiles were merely dropped on the enemy from fortress walls. Firecrackers were used in early times, just as they are now, to scare away evil spirits from wedding and birth celebrations, and from funerals, and they were also much in evidence at various religious festivals. These crackers were often made by packing gunpowder into bamboo cases or rolled paper tubes, so laying the foundations of modern firework making.

An encyclopaedia by Fang I Chih in about 1630 included a mention of 'fire trees and silver trees' used in the Tang dynasty (7th to 10th centuries) in which gunpowder was thought by the author to have been used. These fireworks may have been forerunners of those used in big displays which were frequently put on in China in the seventeenth and eighteenth centuries, and which were described in various writings by travellers returning to Europe. Apparently the development of Chinese fireworks proceeded very slowly, and in 1821 Claude-Fortune Ruggieri, the French pyrotechnist, remarked that his information was that the 'Chinese fireworks 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'.

In India too progress appears to have been slow, for war rockets were in use at a very early time. Here, as in China, fireworks of sorts were frequently seen at celebrations and public festivities, and fifteenth and sixteenth century writings, such as the Marathi poem of Saint Ekanatha, describe displays, and mention rockets and fireworks producing garlands of flowers, a moonlight effect and hissing noises. By the eighteenth century displays were being organized on a lavish scale.

The first English display in India was in 1790 near Lucknow, and was said to have taken six months to prepare.

In Europe pyrotechnics for military purposes saw an early peak of achievement in the form of Greek fire. Highly combustible material, including sulphur, resin, camphor and pitch, was blown by a bellows device out of copper or iron tubes, or even handpumps, and was almost inextinguishable. Old manuscripts suggest several ways of attempting to combat the fire, especially the application of wine, vinegar, sand and even urine. For four hundred years the Greeks guarded the secret of their devastating weapon, and used it with spectacular effect on land and sea; but by the tenth century the Saracens had learned the formula, and used it against the Crusaders. By the fourteenth century gunpowder had made its appearance in European warfare, and made the short-ranged Greek fire powerless against far-flung missiles.

In the wake of gunpowder came the arrival of firework mixtures, both of them appearing in Europe, probably as a result of information on their manufacture being brought from the East. Italy seems to have been the first area in Europe to make fireworks, as opposed to military pyrotechnics, and to put on displays. It is clear that before 1500 fireworks were employed extensively at religious festivals and public events, and frequent displays were becoming popular entertainments. Florence was probably the center of an expanding manufacturing industry, as demand for the new spectacle increased. Before this period fireworks had been used as scenic effects at theatrical productions. In fact, fiery torches and the like had been added embellishments in the amphitheatres of classical Roman times. Now the fireworks became the main concern, although elaborate scenic sets and buildings were to form backgrounds to displays for many years to come.

Firework displays were seldom seen in England before the end of the sixteenth century. Shakespeare refers to 'fireworks' on several occasions in his plays, suggesting that the term was in general usage in England at that time. Other literature of the period often mentions the 'green man' whose function was to walk at the head of processions carrying 'fire clubs' and scattering 'fireworks' (in this case probably meaning sparks) to clear the way. The origin of this character and his title are a mystery, but we are told that he was usually made up to appear very ugly, and he certainly survived well into the next century.

The earliest record of a firework display in England was in 1572, when a large show was put on at Warwick Castle to mark the visit of Queen Elizabeth I. The Queen is said to have enjoyed the spectacle

Index

A

Accroides, 36
Adhesives, 72, 216, 249
Alloprene, 34, 60
Aluminium, 25, 57, 120
Ammonium salts, 28, 58, 189
Anthracene, 28, 188, 242
Antimony, 28
Arabic, gum, 37, 250
Arsenic salts, 29
Asphalt, 30, 121

B

Bacon, Roger, 2
Barium salts, 30
Bengal lights, 100
Bengal matches, 174
Beta-naphthol, 31
Bickford, 181
Binders, 216, 249
Blue lights, 103
Boric acid, 31, 57
Brock, 5, 7, 9, 13, 14, 16
Burning speeds, 54, 70
Bursting charges, 144, 209

C

Calcium salts, 32

Calomel, 44, 60
Carbon black, 32
Castor oil, 33
Charcoal, 33
Chlorate/sulphur, 14, 55, 90
Chlorinated rubber, 34, 60
Choking, 80
Clay, 34
Colophony, 39
Color changes, 98
Colored lights, 99, 212
Coloring agents, 61, 215
Comets, 113
Comet shells, 154
Cones, 82, 164
Copal, gum, 37
Copper salts, 34
Corvic, 46
Crackers, 169
Cryolite, 35
Crystal Palace, 9
Cutters, 77
Cylinder shells, 148

D

Delays, 61
Devil among the Tailors, 117
Dextrin, 35, 250
Drifts, 67
Drivers, 135

Dyestuffs, 35, 187, 243

E

Explosives acts, 14

Explosive sound, 119, 231

F

Fern paper, 173

Filling machines, 69

Fire pellets, 174

Fire pictures, 174, 197, 246

Flares, 105, 229

Flash composition, 119, 232

Flash paper, 174

Flitter, 26

Flour (wheat), 36

Flow agents, 32

Flower pot, 160

Flying pigeon, 141

Flying squibs, 163

Formers, 77

Fountains, 159, 174, 201

Friction, 54

Funnel and wire, 67

Fuses, 146, 183, 247

G

Gallic acid, 36

Gang rammers, 111

Gerb 159,

Glitter effect, 29, 89

Glue, 36, 188

Gold streamer, 221

Graphite, 36

Green man, 3

Gunpowder, 39, 207

H

Hand charging, 66

Hexachlorobenzene, 41, 60

Hexachloroethane, 41, 188, 238

Hexamine, 42, 174

Hummers, 123

I

Igelith, 46

Igniter cord, 182

Indoor fireworks, 173

Iron, 42

L

Lactose, 50, 187

Lampblack, 32

Lances, 101, 217

Linseed oil, 42

Lithium salts, 43

Loading pressures, 73

M

Magnesium, 43, 57

Match, 184

Matches, 174

Matching, 195

Mines, 115
Mixing, 63, 206
Mortars, 147
Molds, 70, 75, 93

N

Naphthalene, 44, 188, 242

O

Orpiment, 29

P

Pains, 9, 17
Paper, 73
Paper-powder pasted, 245
Parachutes, 155
Paraffin oil, 45
Paris green, 34
Parlon, 34
Paste, 76
Phlegmatizers, 56
Phosphorus, 45, 61, 205
Picric acid/picrates, 47, 97, 120,
234
Pine resin, 39
Pinwheels, 167
Pitch, 45, 188
Poka, 208, 257, 266
Portfires, 103
Potassium salts, 46
Powder scoops, 67
Presses, 69

Prime, 73
Propellants, 129
PVC, 45, 60

Q

Quickmatch, 184

R

Rains, 162
Realgar, 29, 233, 241
Red gum, 36
Repeating shells, 152
Rockets, 125, 196
Roman Candles, 109, 194
Round shells, 145

S

Safety fuse, 181
Saran, 46, 60
Saxons, 136
Schwartz, Berthold, 2
Scoops, 65
Sensitivity, 54
Shakespeare, 3
Shellac, 38, 250
Shell fuse, 146, 183
Shells, 143
Shock, 54
Sieves, 53, 63
Silicon, 47
Silver stars, 90, 92, 224
Smoke, 175, 187, 237

Snakes, 175
 Snow Cone, 177
 Sodium salts, 48
 Spark composition, 225
 Starch, 48, 249
 Starlights, 103
 Stars, 85, 249
 Stars, cut, 90, 251
 Stars, pill box, 91
 Stars, pressed, 93
 Stars, pumped, 86
 Stars, round, 94, 218, 252
 Stearin, 49
 Stibnite, 29
 Strontium salts, 49
 Sucrose, 50, 187
 Sulphur, 14, 50, 55, 240

T

Table bombs, 180
 Theater fires, 180
 Thiourea, 51, 187, 190
 Titanium, 51, 57
 Torches, 104
 Tourbillions, 139
 Tubes, 77

U

U.S.Legislators, 11

V

Vestolith, 46

W

Warimono, 208, 257
 Water, in mixtures, 57, 59
 Waterfall, 106, 223
 Wells, 9, 18
 Wheels, 135, 201
 Whistles, 120, 234
 Wilder, 9

Y

Yacca, Gum, 36

Z

Zinc, 51, 60, 238

