MOD FORM 583

WASC 1792

On Her Majesty's Service

The Engineer and the Petard

A talk to be given by E G Whitbread, 9Mar81, Bush Hill Park Methodist Church.

When Albert Wilson asked me to talk to you about my working life my first thought was that there is little I can say that is of interest. I have spent most of my working life on explosives; making them, inventing new ones, administering the law relating to them,and in the last few years trying to drag dangerous goods legislation (including explosives) into the 1980s. To mimic the old saw about eating cream buns and other desirable pursuits: everything about explosives is illegal, dangerous or boring. Eventually I made up my title (which does derive from what I have been doing) and trust that I canfind enough that is not too legitimate or safe to be boring to put into an account of what is still a somewhat mysterious material and which has provided me with an occupation for some 43 years.

First,perhaps, I should say something about my origins. Both sides of my family were peasant smallholders from way back. About 100 years ago my paternal grandfather, being a younger son and therefornot in line to take over the family holding, walked from Bedfordshire to the brickworks about two miles outside the village of Gamlingay in Cambridgeshire where he could, as a strong young man, earn good money "running" bricks from the kiln to the stack. He married a local girl, took up smallholding and my father was born in a cottage on Gamlingay Heath in 1887. My father in his turn went back to Tingreth in Bedfordshire for his bride but set up home in Gamlingay which is how I came to be born in that place in 1920.

The 1920s were bad years for farmers, eventually my father was driven from his holding by drought and misfortune and at about the end of the decade came to Edmonton to try his luck in the big smoke.

I find family history fascinating. In the spring of 1939, my father,having risen to such affluence that he could afford a car, brought his parents up from the country for a holiday. Two things stick in my mind: The first is that this was the first occasion that my grandmother had travelled outside the village since the first World War; the secondis that I was given the job of taking the grandparents about and my grandfather wanted to see Winchmore Hill. I thought this odd but took him. He gazed at the expanse of speculative housing that we all know, and said quietly "When I was a young man, every haymaking time I would walk from Gamlingay to Winchmore Hill for a week or ten days work, haymaking." I was astonished. "Walk?". "Yes, it took two or three days each way and I slept rough on the way".

The family were always ambitious; Sons (and daughters) were expected to do better than their parents. I wanted to be a surgeon but there was simply no money for this, which is just as well because I have always been more at ease with things rather than people. In the event I settled for chemistry being fascinated by my reading of the work of the pioneering chemists, Perkin, Mond, Leblanc and the like.

My initial education had been patchy but eventually I found myself in Latymer's School where eventually I passed the old style GCE examination at a level which gave me exemption from the London matriculation and forthwith needed a job. Careers help for youngsters in 1937 was rudimentary. In the fifth form we had a number of talks (rather like the one I am giving now) from time expired professional people but virtually no concrete advice on the nuts and bolts of developing a career. The nearest I got to this was a personal interview with a very earnest gentleman who assured me that there was absolutely no future in science whatever and I would do much better to become a clerk in an office in town. Needless to say I ignored this and without knowing what I was letting myself in for, acting solely on the basis of the pay offerred, I applied for and got a job as a temporary junior laboratory assistant at the Royal Gunpowder Factory at the princely sum of 29/8 per week. This was indeed high pay, the going rate for a lab assistant in those days was one guinea and 17/6 was not unknown.

Perhaps it will help if I sketch out at this stage my entire career in outline, filling in the detail later. As I said, my first job was that of a laboratory assistant in the laboratories of what was then the Royal Gunpowder Factory in Waltham Abbey. For seven years I was involved in laboratory work to do with the production of military propellants and high explosives. In 1945 the factory was closed and the site used to build an explosives research establishment.

I was taken over with the fixtures and fittings; but there now followed a total of twenty five happy years in scientific research which is, in my opinion, the most satisfying job there is and equalled by none other. By 1963 I had become Superintendent of Explosives Research at Waltham, a post which I occupied for the next seven years. This happy period came to an end in 1970. At the beginning of that year the post of HM Chief Inspector of Explosives (in the Home Office) became vacant, I applied and, somewhat to my surprise, was appointed to this venerable and somewhat awe-inspiring vocation. I have been asked more than once why I had even applied for the job, my reasons were complex and I will touch on them later.

I was HMCIE for six years. In 1974, feeling not at all like Moses, I led the Explosives Inspectorate out of the Home Office into the Department of Employment as a preliminary to its incorporatio into the than embryonic Health and Safety Executive which was to be formed as a consequence of the passage of the Health and Safety at Work Act, 1974. I will not dwell on the Executive but the situation was very different from what had obtained in the Home Office and demanded a restructuring of the group in my charge. In 1976 I left the Inspectorate as such (I continued to hold a warrant as an Inspector) and took charge of a policy group. For the last four years I have had the entirely thankless task (which, to be fair,was adequately paid) of trying to get agreement on proposals for the overhaul of much of the legislation to do with dangerous goods generally and of which the law on explosives forms only a part.

Let us return to the powder mills in 1937. This was all that I, as a boy of 17 had ever dreamed a big chemical plant to be. I was delighted to see processes I had only read about actually carried out on a multi-ton scale; I was fascinated by the vast complex hierarchy embracing a multi-discipline structure of tradesmen of all kinds, progess workers, chemists and engineers; and by the many different characters one met. And, of course, we were all working on that most esoteric of materials, explosive!

I have described the office of HMCIE as venerable, and going back to Vivian Majendie in the early 1870s indeed it is, but compared to the powder mills in Waltham Abbey the Inspectorate is a veritable newcomer. The origins of the mills are obscure but Malcolm McLaren, a former colleague and now the kingpin of the information service in the establishment, has found mention of a contract for the supply of saltpetre and sulphur dated 1561. It is possible that the powder for the gunpowder plot was made there. McLaren has also noted that at the relevant time Father Henry Garnett, the Superior of the English Jesuits was living under the assumed name of Mr.Meaze at White Webbs where the conspirators were frequent visitors.

The mills were nationalised in 1787, the first Master being a Major Congreave. His son also had a distinguished career in the artillery and also became, in due course, Master of the Waltham Abbey mills; but in his case he is better known as the inventor of the military rocket and of the peculiar clock which has instead of a pendulum a metal ball running back and forth on a grooved track. In the course of my career I have had much contact with American colleagues both military and civil; you may know that in the second verse of their national anthem there is a phrase "...the rockets red glare ,bombs bursting in air..." referring to an incident in the war between our two countries which started in 1812; I have had not a little fun with my American friends pointing out that these rockets were filled a Waltham Abbey.

I referred to the hierarchy inthe factory. This was of a kind which less than half a century later seems to be of another world. The top man was called the "Superintendent" or "the Super" and as the districts largest employeroccupied a position with a resemblance to a country squire. A large mansion was provided for his accomodation and as a reminder of even more remote and spacious days this had a considerable accomodation for servants and there was provision for his carriages and horseflesh.

Below the Super stood a structure, almost germanic in its rigidity, of manager, works chemists, shift chemists, formen, assisltant formenand charge hands.

Behaviour was strictly controlled by two inter-locking sets of rules, one for general discipline and the other for safety. Both were enforced with a resolution that today would produce strikes on the instant. Understanddably, oneof the most heinous crimes was to introduce on ones person matches or lighters. This prohibition extended to cover all smoking material and there was only one punishment: instant dismissal. The ban actually covered

a whole range of items eg cough sweets and during the war (under the emergency legislation prosecutions were mounted for an offence with a month in prison on conviction. All this was calculated to strike terror into the mind of a boy and even now I never carry matches in my pocket so fixed did the habit become.

It will be appreciated that following world war one the factory had gone through a very dull period until re-armament starting in the early thirties. The factory was essentially chemical, run by chemists and for at least two hundred years of it's long history had been associated with the leading scientific thought in the country. In the expansion of the 1930s (into which I had by chance stepped) the very far sighted policy was adopted of building a home team of chemists by recruiting boys (in those days females never penetrated the factory proper) at Matriculation level on a condition of employment that they worked in their own time for a degree. To encourage us further we were allowed 3 hours off per week. One snag was that the nearest polytechnic offering a suitable course was the old Northern Polytechnic in Islington and a degree course meant four nights per week; so our three hours became divided into four in order to leave that much early on those nights to make the dash to Holloway Road. Travel by bus was not usually possible on our pay; the bicycle was the order of the day. I lived in Edmonton and on those four class days would cycle 8½ miles to work, do a days work (less 45 minutes) cycle 15 or so miles to the Poly, do 3 hours classes finishing at 9-30 and cycle nearly 8 miles home again. In later years I had many a private smile whilst listening to applicants for jobs saying how difficult it had been to get a degree at university.

Came the end of the war and the factory was clearly finished as such. In the late forties no need was seen, even in a future war, for the provision of explosives on the scale that had been necessary in the past and in any event Waltham was badly sited for future large scale production having become part of the London sprawl. You may know that for many years the centre of military scientific research had been in Woolwich Arsenal, during the 39-45 war much of this had been dispersed as a precaution against air attack and after the war it was decided not to bring it back. Different aspects went to different places and the decision was made to site the explosives research establishment on the historic factory site at Waltham Abbey.

It occurs to me that I have been rattling on about explosives without in any way saying what these are. The simplest definition is that it is a chemical or mixture of chemicals which when it "explodes" produces heat, light, noise and a tremendous expansion. The classic explosive and indeed the only practical explosive for some 5 or 6 hundred years is gunpowder and the word is still synonymous in most people's minds with "explosives".

One of the games historians play is to seek the nationality of the inventor of gunpowder. It is claimed for the chinese and the Indians; the Greeks claim it for Mark the Greek the presumed inventor of Greek fire, the Germans claim it for Berthold Swartz and we, of course claim it for Roger Bacon.

The truth is that in all probability no one invented gunpowder; like Topsy it just growed. There is no evidence that the Chinese had it before the Portuguese sailed a ship armed with cannon there in the 14th century. They invented the fire cracker of course. This originally was a length of bamboo thrown on the fire when the cells between the knots exploded one after the othe and it is easy to see how gunpowder, once they had learned its secret, would improve the device.

The most likely origin, in my opinion, of gunpowder is in the middle-east. There one finds a history of the native surface petroleum being used as a weapo of war: if you were besieged you poured boiling oil over your adversaries, if you set fire to it first it was more effective. One day someone put some saltpetre brought on the caravan routes from India in the mixture and we were well on the way to gunpowder. What he had done was to include the oxygen necessary for the combustion of the fuel into the mixture so that it would now burn in the absence of air. This meant that it could burn very fast since the rate was no longer controlled by the rate air could get at the brew.

Energy was released quickly and an explosion resulted.

The obvious first use for this material was in assaults on castles. Your military engineer would fill a bucket with the stuff with a string, soaked in saltpetre solution and dried, sticking out of the top and, seizing his opportunity, would rush up to the gate and hang it on the outside light the string and retire, as they say, immediately. Of course if things didn't go quite to plan it might explode early and the army would need a new engineer as well as a new bucket. These devices were called petards, a word which means "to break wind" and the Bard, ever watchful for a pun, has Hamlet say, after having killed Polonius,

"Let it work;
For 'tis sport to have the engineer
Hoist with his own petard.

The next invention clearly was the gun and these soon proliferated in a variety of shapes and sizes

It has been said that the noisy, stinking remote weapon was unchivalrous and meant that every Jack was now as powerful as his mounted master. It is certain that the arrival of gunpowder probably heralded the greatest change in the affairs of man in history due to technology (even including atomic energy) but the effect was quite the reverse of making Jack equal to his master. Before the gun, to raise an army all you need do was collect enough men each with his own rough weapon, cutting or clubbing, which he kept at home; came with gunpowder the need for factories, difficult imports of sulphur and (usually) saltpetre. These things were only achieved by nations and armies became much more the prerogative of kings.

The next really big step came in the 19th century when the chemist succeeded in combining the fuel and oxygen in a single molecule; or rather a variety of single molecules and many modern explosives (but by no means all) are of this type. If the addition of an oxidizer to a fuel speeds the combustion by eliminating the process by which air diffuses to the fuel the combination of oxygen and fuel in one molecule speeds the process further and the organic explosives are a whole order more powerful than gunpowder.

Almost at the outset of my time in research I was given the job of setting up a research group concerned with the sensitiveness of explosives. This may be crudely but explicitly defined as seeing how far they could be provoked before they answered back. Three points: one, there are in fact two parameters, sensitiveness which is the tendency of the explosive to go off when you do NOT want it to and sensitivity which is it's reluctance to do so when you do. Quite apart from the mathematics the physico-chemical processes are different. Two, it is easy to make powerful explosives but difficult to make safe ones and particularly so if you want to combine a high sensitivity (reliability) with a low sensitiveness (safety). Three, the foregoing means that sensitization, as a topic, is commercially and militarily valuable so there is little that I can say about the results. However some of the techniques used to obtain data yield unusual, even beautiful results and I can illustrate this part of my talk by means of some film I made many years ago.

The study is really one of reaction kinetics, ie the way in which the rate of the various chemical reactions are controlled. The problem is the extreme speed at which events occur and the violence of the result. Right at the outset it was seen that high speed photography would provide a powerful tool.

In the early days, around 1946-56, commercially made cameras were very difficult to acquire, very expensive and far too slow. We therefore had to build our own. It was not until 1956 that I was able to buy an American camera for a sum so large that it still frightens me today and it is with this machine that the film you will see was made.

It can take a sequence of photographs at a rate of up to 4 million a second at an aperture of f14.5 with an exposure of $\frac{3}{8}$ the frame interval, ie less than 1/10 of a millionth of a second for the highest rate. In 1956 the problems of using such a machine were such as to need a lecture for this topic alone but in the end the results came in freely and made it worth while.

(Film or films inserted here)

In 1970 I became HMCIE in the Home Office. The Explosives Branch (now divided and part of the Health and Safety Executive) had about 100 years of history. It had its origins in the extremely unsatisfactory state of the gunpowder industry in the middle of the 19th century, and specifically in the Regent's Park explosion, coupled with the fact that organic eplosives, of which nitroglycerine is the obvious example, were beginning to appear on the scene. These problems were met by the intrduction of the 1875 Explosives Act. This is an excellent piece of Victorian drafting and shows tremendous foresight and attention to detail.

It starts by defining an explosive, and the definition is so good that with very little modification it now forms part of the United Nations definition. One aspect of this legislation which stands out very forcibly to the modern eye is the almost draconian powers given to HM Inspectors: "A Government Inspector shall have power to make such examination and inquiry as may be necessary to ascertain whether this Act is complied with, and for that purpose:- he may enter, inspect, and examine any factory, magazine, or store of any explosive, and every part thereof, at all times by day and night .....". "The occupier of every such factory, magazine, store and registered premises, his agents and servants, shall furnish the means required by the inspector as necessary for every such entry, inspection, examination, and inquiry". Even further, an Inspector can, on his own Warrant, if he thinks that an offence against the Act likely to endanger life is being committed; eg. the keeping of unsafe, possibly illegally manufactured, explosive, enter any premises at any time, and if needs be by force, and as well on Sunday as on other days, the said place and every part thereof.

The reference to Sunday is interesting. Captain Vivian Majendie, apart from being the virtual author of the 1875 Act and the first Inspector was also very active in the religious life of St Paul's Cathedral and has a memorial plaque in the crypt. He doubtless felt the need of a little extra authority on a day in which I am sure he would have much preferred to be singing psalms.

In the early years of the present century, it began to be apparent that yet another class of chemical in fact exhibited some of the characteristics of explosives,viz. petroleum. Just as prior to 1875 there had been a number of minor Acts controlling gunpowder, so prior to 1928there existed a body of legislation on petroleum which was brought together in the 1928 Petroleum (Consolidation)Act, the Home Office finding ready to hand in the E xplosives Inspectorate the necessary expertise. The position today is vastly more complex, there are a great many chemicals which are manufactured, moved by rail or road,stored, handled and used all of which can be hazardous not only to those directly concerned but also to the public nearby.

A very significant part of the policy work undertaken by the Inspectorate and their colleagues in the Home Office consisted of international discussions notionally aimed at a standardisation of safety requirements in the interests of trade. This international work falls under three heads: First there are the bilateral or multi-lateral agreements where two or three countries agree on a specific procedure. The Common Market work in Brussels is a particular example of this. The next major division arises from an old agreement known as CIM which is an agreement for the standardisation of railway practice and is administered by a European organisation centered on Berne in Switzerland. Early in this century the members of CIM brought out an international agreement on the carriage of dangerous goods by rail in Europe known as RID; with the advent of Road as a serious competitor to Rail there developed, also from the central office in Berne a committee om the transport of dangerous goods by road which produced an agreement known as ADR. The third division is the work undertaken by the United Nations Organisation on the transport of dangerous goods. The parent body is the Economic and Social Council which is at Ambassador level and meets in New York. This body has four subsidiaries which would be more efficient if they did not overlap. The first is the senior technical body, the Committee of Experts on the Transport of Dangerous Goods, which is supposed to cover all modes of transport, and has two subsidiaries: the Group of Experts on Explosives and the Group of Rapporteurs, the last dealing with all dangerous goods which are not explosives. All three meet in the old League of Nations building in Geneva. Duplication arises because not content with this the UN has also set up the Inter-Governmental Maritime Consultative Organisation for the sea mode and which meets in London, the International Civil Aviation Organisation for the air which is based in Montreal and has taken over joint meetings of RID/ADR which now meet in Geneva.

With our entry into the Common Market the work has multiplied. The members all subscribe to CIM,RID and ADR not to mention the United Nations bodies noted, but this does not prevent them from taking up positions at the different bodies which are mutually in conflict. Another aspect of these international discussions is the naked politics which appear at the conference table. It is by no means unknown for a country to put forward safety regulations which in fact favour its trade in a somewhat unilateral fashion, discussion then becomes rather difficult.

I cannot say that I enjoyed international work of this kind. It is entirely different from the often less polite but much more plainspoken scientific meetings to which I had been accustomed. I think, however, that I was accepted since I held the chair of the UN explosives group from 1973 to 1978, giving it up on my election

to the Chair of the parent Committee of Experts in that year.

Such then, has been my working life. I stress "working" since every man has at least two lives: the occupation by which he earns his bread and his family. I do not think that, with hindsight, I could have ordered it better. I had, in the early years, my share of the pleasure that derives from research and if the last few years, spent in dull law, have not been such fun they have been just as rewarding in other ways.