TONITE.

In 1874 Tonite was introduced,an improved version of guncotton which was patented in the same year by a George French,the Faversham Factory manager.

Tonite was a mixture of guncotton and barium nitrate. These ingredients were ground together in an edge-runner mill and the mixture was formed into blocks or slabs of any desired shape or size by means of hydraulic presses.

Commercially,Tonite won prompt acceptance in the mining industry,for which it was made in the form of candle - shaped cartridges,fitted at one end with a recess to take a detonator,and covered with paraffined paper. A dense explosive,containing its own oxygen for complete combustion,it was safe in action,and for many years had the advantage over dynamite that the railways would carry it under the same conditions as gunpowder,while they would not accept dynamite.

Devices based on Tonite are still being made and marketed today (1967) by ICI and the trade name is still used.

PATRONENKSTEN 16.
100-round Trommel (drum) Magazine.
Magazine for MG08/15 Machine Gun.
The belt drum fits onto the bracket fixed on the right of the receiver below the feed-block.
The fabric belt is prevented from unwinding when not attached to the gun by folding a ratcheted handle against teeth on the outside of the carrier.
The stamped and painted warning - "FEUR! KURBELHOCK" means "LIFT HANDLE BEFORE FIRING" or "TO FIRE - (LIFT) CRANK UP" this disengages the ratchet.
Data.
Drum capacity: 100-rounds of 7.92x57mm cartridges,in fabric belt.
Weight fully loaded: 7-lbs.
Two of these drums,issued in a wooden chest,accompanied each MG08/15 gun.

THE FIRST GUNCOTTON FACTORY IN THE WORLD.
MARSH WORKS-FAVERSHAM.

Scientists were constantly seeking explosives more powerful than gunpowder,and in 1846 guncotton was introduced. It consists of purified cotton,seeped in a mixture of equal parts of nitric acid and sulphuric acid,and afterwards dried,retaining the appearance of cotton wool. John Hall and Son were quick to obtain patent rights and in October 1846 decided to build a guncotton factory-the first in the world- at the Marsh Works. Within a month they were advertising the new product,which they claimed was six times as powerful as ordinary gunpowder.

Production started shortly afterwards,but about six months later,on 14 July 1847,was summarily curtailed by a disastrous explosion,in which some 20 people lost their lives. Two buildings at the western end of the Works blew up in quick succession,and the noise was heard within two miles of Maidstone. An eye-witness account of the scene of the disaster was published in 'The Times' and reprinted in the 'Illustrated London News':

"The roofs of all the buildings within about a quarter of a mile of the explosion are completely stripped of their tiles,and the walls are much shaken. Even in the town of Faversham,fully a mile distance from the scene of the disaster,windows were broken,and the houses otherwise damaged in some instances. On the opposite side of the stream which forms the northern boundary of the Marsh Works is a field of wheat of some extent. The explosion has completely blasted this over a space of about two acres,and the ears,drooping and discoloured,present a scene of desolation in perfect character with the adjoining ruins. The willow-trees which skirt the bank of the stream referred to,and,indeed,all the trees within about 50 yards of the buildings Nos 3 and 4,are torn up by the roots,and scattered about in all directions. Those more distant are less seriously injured,but the foliage of all within a very large circle is wholly destroyed. One of the most remarkable effects of the explosion is the removal,as it appears almost bodily,of the enormous mound of earth skirting the No.4 stove. Another instance of its power was shown in the forcible ejecton from a deep well of two massive pipes,the leaden pipes of which,nearly 20 feet long,were drawn up and thrown to a very considerable distance."

Following this explosion the guncotton factory was immediately closed,and the new invention was not taken up anywhere else for nearly ten years. remaining stocks of the explosive were buried in the vicinity.

GUNPOWDER.

In the Middle Ages,the collection and manufacture of Saltpetre was a thriving industry.

Saltpetre is the popular name for either Potassium or Sodium Nitrate. It can be found occurring naturally in the ground,often attached to rocks- hence its name. (Latin Sal- salt and Greek petra- stone). It also occurs as a product of decomposing vegetable or animal matter.

It has been used world-wide,especially by the Chinese,Greeks,Romans,Egyptians and Armenians. Known to the Latins and Greeks as "Nitre" (Nitrogen was so-called as it was "Nitre forming"). Saltpetre is soluble in water and is therefore easily washed away. Saltpetre is soluble in water and is therefore easily washed away,so where it is found on the ground,it is in areas that receive little rainful such as parts of India and Spain. It seems though that little use was made of this nitre from the soil in the Middle Ages and that by far the biggest source was from products of muck,dung and compost heaps! It would collect on the floor of pigeon- houses and cow-sheds,as they were covered,but throughout Europe the use of "nitre-beds" was encouraged. For instance a pit would be dug and filled with the following:

Limestone Bitter Herbs All this to be soaked periodically with more urine.
Compost Stale Urine.
Wood-Ash.

The pit would be covered with a shed and left for two months in the summer. The nitrates,being water soluble,accumulated in the upper layers as the beds gradually dried out.

The King of Prussia,so keen to get his hands on more Saltpetre,ordered the farmers to enclose their farms in walls built of lime,mud,dung and straw. These walls would then be demolished after two years. The saltpetre would be extracted and then new similar walls would be rebuilt.

In the 16th Century,England lagged behind the Europeans in Saltpetre and therefore gunpowder production. So,for our various wars with Europe,we had to rely on imported gunpowder. Queen Elizabeth decided that it was time to start producing it in sufficient quantities at home. In those days there were thousands of dovecoted all over the countryside. They were there to provide fresh meat in the winter months though principly for the families of the Lords of the Manor and the Clergy! The pigeon droppings on the floor were rich source of saltpetre. Other covered sources were cow-sheds and cellars. Many of these large dovecotes can still be seen around the country- the biggest would house up to a thousand pigeons. (These dovecotes went into decline when the Mangold Wurzel was introduced from the continent thereby providing winter food for the cattle that were normally "killed off" each autum). The droppings were collected by the "Salpetre Men" and carted off to the nearest saltpetre factory. One was known to exist in Ashwell at Dixies Farm.

It became law that the Saltpetre Men had right of access to these dovecotes etc.,as long as they were unihabited. No one else was entitled to remove the droppings. In 1621,King James 1st appointed the Lords of the Admiralty as Commissioners for the production of Saltpetre and Gunpowder. All the gunpowder produced in the country was to be stored in the Tower of London and two-thirds of this would belong to the Crown. In 1624,another law was passed prohibiting the paving of floors in pigeon houses and cellars,as this slowed up the formation of Saltpetre. In 1626,the East India Company started extracting Saltpetre from the enormous piles of offal and rubbish on the outskirts of Calcutta.

However,the main cause of the decline of home production was at a much later date,in the last century,with the discovery of Chile Saltpetre. Though this was Sodium Nitrate it was easily converted to the Potassium salt by mixing it with Potassium Chloride. (Double Decomposition). Also in 1626 there was a Royal Proclamation for the cities of London and Westminister stating that all land-owing peasants were required to have a compost shed or "Nitriary" as it was known. A specified amount was to be given to the Crown each year. An Act was passed in 1656,prohibiting the collection of Saltpetre without the owners consent.

The presence of Saltpetre could be deteched either by tasting it or touching it 'with a hot iron rod' which causes a yellow discolouration. The latter sounds preferable ! Sometimes,in covered stables or cow-sheds,Saltpetre could be seen as a white scum collecting on old piles of dung. Occasionally.this would glow in the dark due to the additional presence of Phophorous. Sulphur had to be imported as it comes from volcanic lava. In Biblical days it was known as Brimstone. (Stone that burns.

Similar laws for the collection of Saltpetre also existed in France in the 17th Century. The Inspectors here had even wider powers as they were entitled to enter inhabited buildings and became hated for this. Known as "Saltpetriers" by the people,they had the fancy title of - Principal Officers of Artillery - and continued working until the last century.

Saltpetre could also be obtained from plants but this was very limited. The stem of the tobacco plant contains nitrates and will sparkle if thrown on to a fire. To extract the nitrates the stems should be soaked in an alkali.

These ageing piles of dung,compost,butchers scraps etc.,would be taken by the cartload to the "Saltpetre Factories" here,water would be poured over it several times,collected,and then boiled in vats leaving a residue of Saltpetre. The flies and the smell around these factories must have been awful. The product was then taken to another factory,where it was mixed with charcoal and sulphur to form gunpowder.

What did the ingredients of gunpowder do? The nitrate provided the oxygen,sulphur was ideal as it burnt at a low temperature and the carbon was an ignitable base. Originally,coal dust was used but charcoal or straw proved better. Quoting from a 17th Century paper on gunpowder gives some idea on the proportions used.

	Nitre	Sulphur	Charcoal.
1.Great Artillery.	3	1	2
2.Middle Sort Artillery	5	1	1½
3.Arquebus and Pistol	10	1	1

Transport of gunpowder was hazardous so it was often mixed at the front line of a battle. To save re-lighting from a tinder box,a cotton cord,soaked in Saltpetre and slowly burning was often worn around the neck. The ever present danger of a direct hit from the enemy or the canon barrel exploding must have meant that artillery volunteers were a rarity! At a later date,gunpowder was mixed with grease to stop it getting damp. This worked but with the result that black smoke was produced with each explosion,interfering with visibility and at the same time covering the soldiers uniform and faces with a black grime.

So much gunpowder was eventually needed that some form of mass production was required. The method used was copied from the stamping mills used in the production of olive oil,driven by water power.

When gunpowder was made,its texture was very important. If the powder was too fine,it would pack very closely,excluding the air and would not burn. On the other hand,if the grains were too coarse and lightly packed then the explosion could be too rapid and if used in a canon it would explode.

In order to get the right size grains for a particular gun,a process of "corning" was evolved. The powder was mixed with alcohol or urine (preferably the urine from heavy wine drinkers!). it was mixed into a paste,then dried and seived to the required size. It also produced irregular shaped grains which were better for igniting. Quality testing was important and was first done by firing bullets into layers of wood. Later,firing into clay was used. Mortars were assessed on the distance they were able to reach.

THE ROYAL GUN POWDER FACTORY.

Near Waltham Abbey,gunpowder has been produced since the 16th Century but in an effort to standardise production and quality it became Government controlled in 1787 and was then known as the Waltham Abbey Royal Gunpower Mills. Output here varied according to needs but when WW1 started it was thought to be the biggest gunpowder factory in Europe. Many thousands of people were employed here in the two world wars,quite a proportion coming from Hertfordshire. The site now covers 71 hectares though it used to be much bigger. The factory contains many waterways all connected with the old River Lea and is heavily forested. The trees provided the charcoal which was made on site. The big concern,as with all gunpowder factories was that of an accidental explosion,so it is interesting to reflect on the many and unusual precautions that were taken just to avoid the possibility of a "spark".

Some of the floors were covered with elephant hide and when the men entered they had to put on overboots and leather suits with no pockets - in the high risk buildings. Beards were not allowed as they too could contain a piece of grit! The electric switches controlling the mills were situated behind ramparts and electric lights were immersed in water and situated outside the windows. Only copper and wooden utensils were used. The buildings were widely spaced with trees between and high risk buildings were made of iron frames with canvas-walls. They did not want too many bricks flying around! Roofs were made of wood and a flash-board system was in operation so that in the event of an explosion water would be released on surrounding buildings. The gunpowder was put in barrels and transported by barge to the two arsenals at Woolwich and Byfleet. No-one was allowed on a footbridge when a barge was passing through underneath. In spite of all these precautions there were many accidents over the years - often fatal. It even became necessary to open a small hospital on the site.

A German bomb landed on the factory in 1943. After this,production was gradually tailed off,ceasing in 1945. However,research continued in explosives and propellants until 1991,when the factory was vacated.

EXPLOSIVE FACTORIES IN HERTFORDSHIRE.

Two little known explosives factories in Herfordshire were at Bishops Stortford (The Reliance Snap Co. - for crackers) and at Barwick Ford,near Standon.

The latter has an interesting story. It was founded in 1889 as The Smokeless Powder Company. In 1899,Herr Schultz,a german took it over and staffed it with Germans. It was known as the Schultz Gunpowder Co. In 1914,at the outbreak of ww1,they were all interned and the Government took control. A high explosive called Sabulite was made. This was used for blasting and filling hand grenades. When the warwas over,the factory was renamed The Sabulite Company,concentrating on crackers.

This factory,when in full production in WW1 was quite large. It was situated on the edge of the River Rib at the site of what is now a timber yard. For testing and storage,the woods on the other side of the river were used. So a bridge across was built. A tramway ran over this into the woods where it branched in many directions. At least,in the woods it was safer and out of sight from land and air. For the workers a pub was opened 'The Factory Arms'. This was later re-named the 'Duke of Wellington' but it closed some years ago.

In 1933,Brocks Firework Factory moved from Sutton to Hemel Hempstead. This was probably the biggest firework factory in the world,employing many people. In 1960,the factory closed and was transferred to Scotland.

THE ROYAL GUNPOWDER FACTORY

Sandurst Hospital.

Factory Hospital opened in 1894 by Lord Sanhurst. Originally injured workers had to be taken to Totenham.

This photograph was taken on December 1997,showing the sorry state of this hospital-last used as a residence,later demolished.

Sandurst Hospital Just Before Its Demolition.

Making Cordite.

To make cordite,the dry gun-cotton is taken to the nitro-glycerine house,a wholly extraordinary building,literally buried under a mound or hill,and approached by a burrow-like,brick-lined passage in the earth. The dry gun-cotton is taken to the nitro-glyverine house in boxes,and it is there saturated with nitro-glycerine,an almost colourless liquid. Should a single drop of this fall on the leaden floor,it is instantly wiped up with a damp cloth.

The saturated gun-cotton is now called "cordite dough",and it is taken direct to the kneading house. The men,have to wear curious respirators as they bend over the sticky mass,which gives forth nauseous and deadly fumes. When throroughly kneaded,the dough is sent to the incorporating-house and placed in drums,which have slow revolving screw blades; this mixing process goes on for severn hours. The component parts of cordite,by the way,are as follows: nitro-glycerine 57 parts,gun-cotton 38 parts,and five parts of mineral jelly,this latter being added three and a half hours after the dough or paste has been in the incorporating machine. Acetone is also added in quantities of 15-lb.-10-oz to every charge of 75-lb. One of the final operations takes place in the moulding-house. There one and a quarter pound of cordite paste is pressed and moulded; the mould and its contents are then placed in another machine,and,to the amazement of the onlooker,out comes 2,000ft. of what looks like brown twine,with a diameter of .0375-in. This is finished cordite,and it is wound upon a reel. For 6-inch quick-firers,cordite with a diameter of .3-in. is turned out,and as it emerges from the machine it is cut into 14-inch lengths.

An interesting operation called "ten-stranding" is carried out. Ten reels of cordite,just as they come from the machine,are fixed in a rack and are wound simultaneously on to a single reel,the object being to secure uniformity of explosiveness. Furthermore,six "ten-stranded" reels are afterwards wound upon one,and the "sixty-stranded" reel is then ready to be sent away. Munute details as to whose hands it haspassed through accompany each reel; and the end of the thread is secured with a band of webbing. Ultimately,the cordite is cut into little bits and made into bundles for the cartridge cases,but this work is not done at Waltham.

Into a pool adjoining the cordite works all water from the various nitro-glycerine houses is most carefully drained,since such water contains a certain quantity of nitro-glycerine. Every Saturday this extraordinary pond is blown up by means of a dynamite cartridge,in order to get rid of the explosive matter it contains.

The Manufacture of Cordite 1895.

Gun Cotton.

Women pick over the cotton waste,which comes from the Manchester spinning mills in hundred weight bales,and costs about £30 per ton. The stuff is picked carefully,in order that fragments of wood,rope,wire,and rag may be removed. The cotton waste is then thrown on to a powerful teasing machine,which rends and tears its fibre; after this it is cut up by another machine,and then it passes on an endless band into a drying-room heated to 180 degrees. The cotton is then weighed up into lots of one and a quarter pounds,and each lot is placed in a tin cooling box. After twenty-four hours,the lots,or charges,are ready for dipping. Each dipping pan contains 220-lb of mixed acid-three parts of sulphuric and one of nitric acid.

The operator simply throws the dry cotton into the acid and leaves it there for about five minutes,during which time each charge of one and a quarter pound will have absorbed 13½-lb of acid.

The workman now takes his implements from the cold water in which they are kept immersed,for fear that repeated contact with the acid should corrode them,and he proceeds to remove the saturated cotton from the bath or pan and places in an earthenware pot ready to receive the charge. The earthenware vessels containing the charges are then allowed to stand in shallow water for some little time.

From the earthenware vessels the cotton is shot into a centrifugal machine,whirling round at a speed of 1,200-revolutions a minute. In a very short time the cotton is comparatively dry; and the waste acid removed by the machine is allowed for by a contractor.

The next operation is the washing of the cotton in a wooden tank full of water,which is agitated by a revolving bladed wheel. When the foreman thinks this washing has gone on long enough,he tastes the cotton,and if no flavour of acid remains,it is taken out by a man who wades in in big boots. The water is wrung out and the cotton is then removed to the vat-house,where it is boiled in monstrous vats for four or five days. Each vat holds about 18-cwt of cotton.

From the vats the long-suffering cotton comes out like wet oatmeal; then comes more churning and washing,until at length the moulding process is reached,and the cotton is pressed into big cubes of 2½-lb. These cubes are veritable gun-cotton,and when pressed flat and furnished with a dry cylinder and a fulminate of mercury detonator,they are quite ready for torpedo work. The gun-cotton press-house,is furnished with what is called a protective rope mantelet,or wall of rope,such as is used in fortifications.

THE ROYAL GUNPOWDER FACTORY

The Royal Gunpowder Factory has been involved in the research and manufacture of explosives for over 300 years. Initially producing gunpowder,the site then developed to manufacture chemical-based explosives and propellants and finally experimental development of explosive materials after the Second World War.

The first dicumented references to gunpowder production on the site come from two sources. One is a contract between Ralph Hudson,a sub-tenant of the Waltham Mills,and the government,for the supply of gunpowder. The other is the first recorded death in the parish caused by an explosion within a mill. Both references date to 1665.

The early factory,based around a former fulling mill,probably situated to the south of the Island Site,quickly expanded to form the well established works depicted on the engraving by Farmer in 1735. The site continued to develop and became one of the principle suppliers of gunpowder to the Board of Ordnance.
In the second half of the eighteenth century the board became concerned about the quality,quantity and reliability of the black powder produced by these private firms. So much so that in 1759 the Government purchased the Home Works at Faverhsam,the first royal Gunpowder Factory.

Later in1787 they purchased the Waltham Abbey works. Almost immediately after,the demand for powder rose as a repercussion of the French Revolution and later the Napoleonic wars. There was major expansion and investment including the development of the Lower Island Site,a narrow strip of land to the south of the original site.

In sharp contrast,the first half of the nineteenth century,between 1802 and 1840,saw little new development. This period of relative inactivity did not last,and by the second half of the century the demand for cannon powders for larger guns and for moulded powders in greater quantities resulted in rapid changes and innovations. It was also in the latter half of the nineteenth century that tentative production of the new chemical explosive guncotton took place. Manufacture of the new liquid explosive nitroglycerine soon followed and by the last decade of the nineteenth century,cordite,a mixture of guncotton (cellulose nitrate) and nitroglycerine was in production.

Cordite was such a successful explosive,it quickly became the main service propellant and by 1900 the majority of the old gunpowder buildings on site were converted to produce cordite. Initially the South Site consisted of a guncotton factory bt nitroglycerine and cordite production areas followed shortly afterwards. Back on the North Site an acid factory and nitroglycerine facility were built in the 1890s. The wet guncotton was produced on the South Site and barged up to the Grand Magazine where it was stored. Then it was moved down the site North to South from drying to mixing and pressing,finally resting at Building H12 the cordite reel magazine.

The First and Second World wars naturally produced peaks in production and investment into the site. During the First World War the labour force rose to 5,000 its greatest number,over half were women,working shifts to ensure continuous production. A number of high explosive products were made at the Royal Gunpowder Factory even though the site was never a high explosive plant.

Picric acid was produced in the 1870s and 1890s and later around 1910 tetryl (C.E. or Composition Exploding) was produced.
Between the Wars important research was carried out on the safe and efficient production of TNT and RDX.

The site's proximity to urban areas and the continent forced its closure as a production site in 1943 in favour of the new purpose-built Ordnance sites in Scotland and the northwest of England.
The site reopened in 1945 after the war as a Government research establishment,initially set up to research into liquid fuels for rockets and other applications. A plant was also constructed to develop plastic propellants for use in rocket motors. Over the next 30 years research into propellants,plastic and rubber propellants,properties of high explosives and many other aspects of energetic and inert materials took place on North Site. By the 1960s Waltham Abbey was the sole Government Laboratory carrying out research on non-nuclear explosives of every kind.

Many of the old cordite and gunpowder laboratory buildings were used as laboratories; also some of the test beds were converted from nineteenth-century process buildings. A number of purpose-built test beds were also constructed. The site finally closed in June 1991 after 204 years of Government service.

Between 1992 and 1996 a programme of decontamination and remediation was carried out with the aim of putting the site to beneficial reuse in the public sector. The decontamination process removed the collected silts from disused canals which resulted in the discovery of many explosives related artefacts such as millstones and barges.

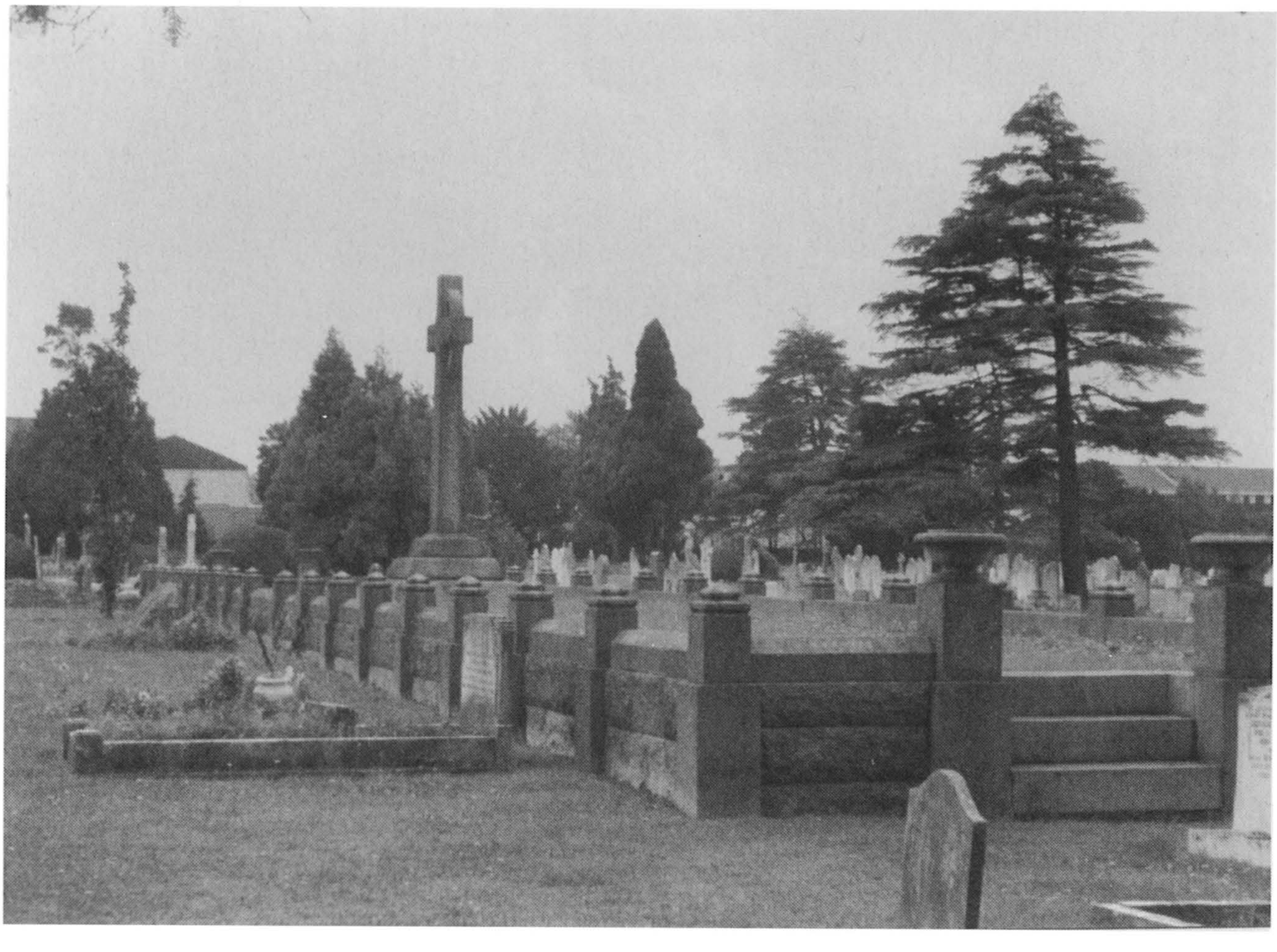
SHELL FILLING WORLD WAR ONE.

Throughout the early months of the war all the shell-filling had been carried out at Woolwich but it soon became obvious that the establishment could not cope with the vast increase in the number of shell cases. On a visit to the Arsenal some months after the outbreak of the war,Lloyd George 'found stacks of empty shells which were being slowly and tediously filled,one at a time,with ladles from cauldrons of seething fluid'. As soon as he could,he replaced the head of the Arsenal and began to set up national filling factories-one at Aintree and another at Coventry being opened in July 1915. Four more opened in August and six in September. By the end of the war there were eighteen. The number of shells filled in a week in September 1915 was 120,000. By January 1916 it had risen to 280,000,and by the middle of that year it was 1,180,000. In the year from July 1915 to June 1916,very nearly 20,000,000 shells were filled. And what was just as important,the number of heavy shells being filled grew most rapidly.

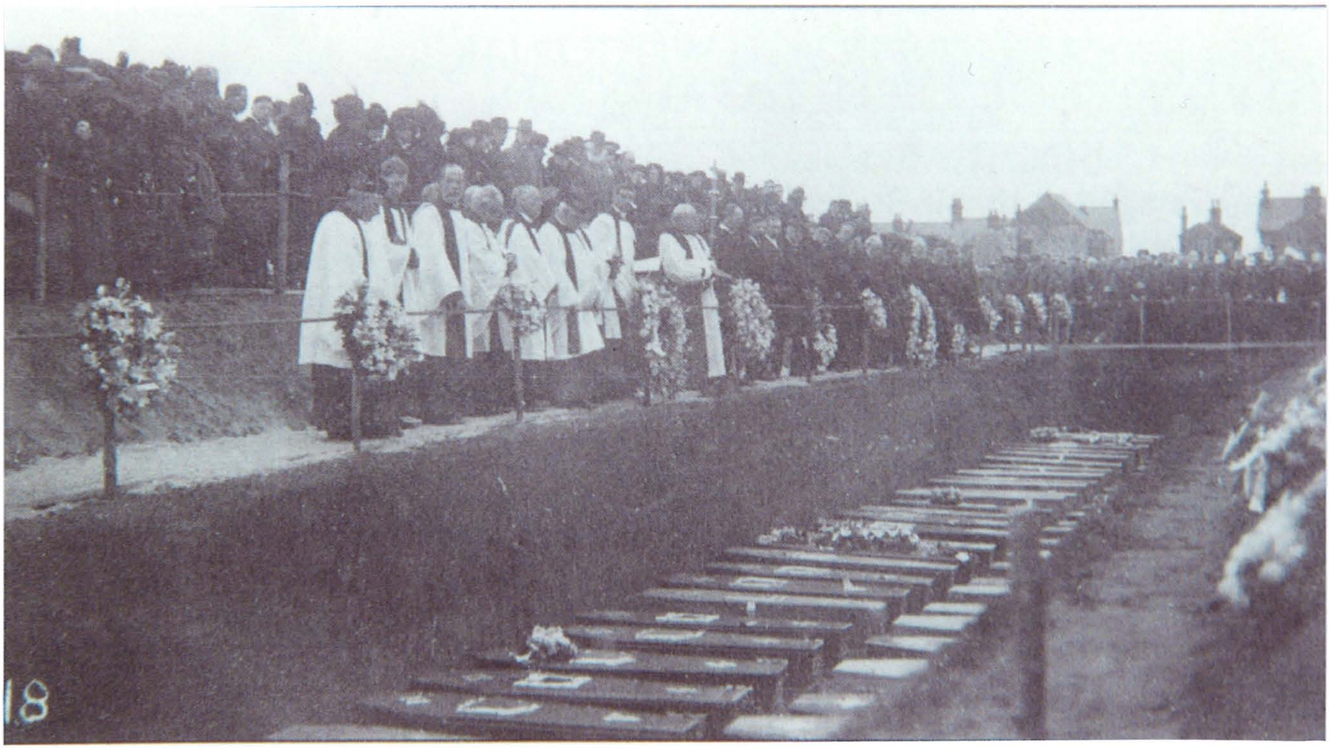
Much of the unpleasant and hazardous work was done by women and girls,and there were strict rules and regulations which had to be followed. Respirators,for example,had to be worn in some of the factories and the skin had to be protected from TNT dust by covering it with a special grease. There was a real chance of severe disfiguration,even death,from the jaundice caused by TNT poisoning. The first effect of this was to turn the skin a very bright yellow,which led to the workers in the filling factories being known as 'canaries' . 96 of them died from the disease.

THE FAVERSHAM EXPLOSION SUNDAY 2 APRIL 1916.

On Sunday 2 April 1916,in an Explosives Loading Co. Ltd Factory on the site next to the Cotton Powder Co. in Faversham. Around noon on the fateful Sunday,a workman going for his lunch noticed that some empty bags,which had contained TNT,were on fire just outside a building in which 15 tonnes of TNT and 150 tonnes of ammonium nitrate were stored. The danger was at first underestimated,because it was considered that there was nothing present which could detonate the TNT. Alas,about an hour later it blew up,causing a number of other explosions in the area. Among the 108 dead and 64 injured were many who had been helping to put out the blaze,and even some who were simply spending their lunchbreak watching the scene. 69 of the dead were buried in a communal grave which is still a dignified feature of the Faversham Borough Cemetery. It is a measure of the full horror of an explosives accident that only about half of those interred could be positively identified.



THE FAVERSHAM EXPLOSION SUNDAY 2 APRIL 1916.
THE FAVERSHAM MEMORIAL.



NITROGLYCERINE

When nitroglycerine explodes it produces a large volume of hot gases and a consequent big increase in pressure,just as gunpowder does,but the effect is on an altogether different scale. Whereas the rapid burning of gunpowder produces pressures of up to 6,000 atmospheres in a matter of milliseconds,the decomposition of nitroglycerine needs only microseconds and can give rise to pressures up to 275,000 atmospheres. This is why gunpowder is a low,and nitroglycerine a high explosive. It is the difference between being bumped into by a pedal cyclist or being knocked for six by an express train. So different is the effect that the word detonating is applied to high explosives as an alternative to the word exploding.

There is,too,a difference in usage. The steady thrust from a gunpowder explosion made it very suitable as a propellant in guns or for blasting in mines,and,when there was no alternative,it also served for demolition purposes. But nitroglycerine provided the alternative and its main role was in demolition: in peacetime,for the removal of hard rock in mining and tunnelling and excavating; in wartime,for the filling of mines,bombs and the warhead of shells and torpedoes. It could not be used by itself as a propellant in guns because the rapidity and intensity of the blast would shatter the gun barrel instead of ejecting the cannon-ball or shell.

TNT.

TNT is expensive to produce,so during WW1 the amtols were introduced. These 'stretched' the TNT by mixing with it ammonium nitrate,a much cheaper substance,which also had the advantage of providing a built-in supply of the oxygen necessary for rapid combustion. Various proportions were used,ranging from 40/60 to 80/20,the first figure denoting the amount of ammonium nitrate and the second that of TNT,and 80/20 being most widely adopted.

C.F.SCHONBEIN.

Born on 18 October 1799 at Metzingen,was the oldest of eight children.
The guncotton that he made looked very much like the cotton wool he had started with,but it fely harsher. When ignited in the open it burnt with a flash but in a confined space it exploded. It was,then,very much like gunpowder,but it was noticeably more powerful.
1 pound of this substance produces equal effects to that from 2 to 4 pounds of ordinary black powder.
It should be added that cotton so treated does not leave any residue when exploded and produces no smoke. The manufacture is not attended with the least danger and does not require costly installations. In view of these properties we cannot doubt that this explosive cotton should rapidly find a place in the pyrotechnic arts and especially in war vessels.
from a letter by the inventer.

GUNCOTTON.

Cellulose,which is the main constituent of all plant cells,is the most abundant naturally occurring organic chemical. It is found in particularly large quantities in fibrous materials such as flax,hemp,bamboo,grass and coconut fibre,but the main commercial source for many years was cotton,which was replaced to some extent by wood and straw when it became too expensive. Although cellulose is so commonplace,it has a complex arrangement of atoms in its molecule; this was elucidated in 1937 by Sir William Haworth,Professor of Chemistry at Birmingham University,whose pioneering research won him the Nobel Prize for Chemistry.

A year before Sobrero had first made nitroglycerine (NG),a German chemist,Schonbein,had treated cellulose with a mixture of hot concentrated nitric and sulphuric acids to make nitrocellulose (NC). He used cotton wool as his source of cellulose,and as he found that the nitrocellulose he made was explosive he called it guncotton. It is,however,unfair to give him all the credit for the discovery because a number of other chemists,notably Rudolf Bottger,and Jacob Berzelius,all have good claims.

NITROGLYCERINE

GLYCERINE.

The glycerine part of nitroglycerine originates from the ancient art of soap-making,which is almost two thousand years old. Originally oils and fats,such as olive oil and mutton fat,were boiled with wood ashes. Later the range of oils and fats was extended and the wood ashes were replaced by other alkalis such as quicklime,sodium hydroxide or potassium hydroxide. The soap forms as a solid,which can be filtered off; the filtrate was originally known as 'spent lye' or 'sweet water' because of its taste.

The fornular of glycerine was worked out in 1836 and it was eventually recognized as a type of alcohol; this is why,in chemistry terms,the name glycerol is preferred to glycerine.

Conversion into nitroglycerine simply involves warming the glycerol with a mixture of concentrated nitric and sulphuric acids.

NITROGLYCERINE

GUNCOTTON AND COLLODION.

Guncotton was made by prolonged treatment of cotton with hot,concentrated acids; it contained more than 13% nitrogen. By using weaker acids at a lower temperature for a shorter time it was possible to make a form of nitrocellulose containing only about 8-12 % nitrogen,which was called collodion cotton,or,simply,collodion. It had been made first at about the same time as guncotton,though the two were not clearly distinguished until later. Collodion was less explosive than guncotton and it had the important difference of being soluble in a mixture of alcohol and ether,unlike guncotton. Collodion is therefore sometimes referred to as soluble nitrocellulose,and guncotton as insoluble nitrocellulose (but that refers only to the mixture of ether and alcohol because both guncotton and collodion are soluble in acetone).

Collodion was first used in photography and in making artificial silk,celluloid.various lacquers and surface coatings,and blasting gelatine. Abel added to that list by using it in 1889 to make cordite,which at long last replaced gunpowder as a propellant and heralded the dawn of yet another era in the explosive saga-that of smokeless powders.

HIGH EXPLOSIVE.

The composition of High Explosive almost without exception is some organic substance,usually some form of carbon combined with nitrogen.
Nitrogen,one of the most inert gases known,owes its explosive value to this very inertness; it combines so very reluctantly that on the least provocation-such as shock-the compound of which it forms a part instantly breaks up into gas,giving the enormous expansion needed for explosive effect.

The characteristic of High Explosive is the extreme violence and suddenness of their detonation.
In order to make them instantly pass from a solid or liquid form to gas,they require a detonator or exploder,which applies a violent shock to them and breaks down the chemical structure of the explosive compound,and enables the flame to pass instantaneously throughout the mass of the compound. This explosive is known as detonation.

Explosives are divided into two classes:
Low Explosives.
High Explosives.
To the first group belong all propellant explosives,i.e.,all powders,such as gunpowder and smokeless powders used in firearms.
Second group belong to all explosives used in shells,torpedoes,grenades,demolition,etc.
Detonators or exploders,i.e., explosives which start explosive reactions in the explosives of group 1.

GUNPOWDER.

Saltpetre.
Nitre,potassium nitrate KNO.
White crystalline salty substance used as constituent of gunpowder,in preserving meat. salt of stone,because it occurs as an incrustation on stone.

Charcoal.
The black residue of partly burnt wood,bones,coal,etc,porous,capable of reduction to powder,and (when pure) consisting wholly of carbon..

Sulphur.
Greenish yellow non metalic inflammable element,burning with a blue flame,widely distributed free and in conbination and used in manufacture of matches,gunpowder and sulphuric acid.

MATERIALS USED IN PROPELLANTS.

Sulphuric Acid.
Containing sulphur-dense highly corrosive fluid.

Nitric Acid.
Clear colourless,pungent,highly corrosive liquid.

Glycerine.
A colourless sweet viscous liquid obtained as a by-product in the conversion of animal and vegetable oils and fats.

Acetone.
Colourless fragrant inflammable liquid,used as a solvent.

Vaseline
Proprietary name of an unctuous substance obtained from petroleum.

Cellulose.
Carbon Carbohydrate which forms chief constituent of cell walls of all plants and of textiles such as cotton and linem.

Incorporating Mill.

Consists of a long-continued trituration beneath heavy runners by which means the mass of ingredients becomes transformed from a mere mixture of three different substances into gunpowder. This is the most important process in the manufacture,and no subsequent care can possibly improve the quality of the powder.

The incorporating is effected by grinding the mixed ingredients for several hours beneath heavy runners. The bed of the mill is of iron,or of stone with iron tyres.
The runners weigh from three to four tons each,and vary in size from 3½ to 76feet in diameter,the smaller ones,creating less friction upon the bed whilst revolving round the vertical spindles,are considered the safest. Iron runners and beds were first used in Scotland in 1804.

The incorporating is one of the most dangerous processes: unavoidable accidents,arising from unknown causes,frequently destroy the sheds and machinery. A cistern contains 40 gallons of water is poised upon a support immediately over the runners; the cisterns in the various mills are connected to each other,so that upon an explosion in one mill all the cisters empty themselves automatically thus the powder under the various runners is at once rendered non-explosive. The sheds themselves are made with strong wood frames covered with light boarding or felt,so that in the case of an explosion the damage caused is comparatively trifling. the charges are placed in the mill moist,and require watering from time to time; this is done either automatically by machinery or by hand.

The charge requires to be under the runners 10 to 12 hours for best sporting powder. In the Government mills,3½ hours is considered sufficient for cannon powder and 5½ for small-arm powder; with heavier runners,making eight revolutions a minute,it is not even left so long.

The greatest danger is at the moment of starting: by Act of Parliament,60-lbs.,is the maximum charge allowed to be incorporated inone mill. The object is to prevent accidents if possible; but it is doubtful if a 100-lb., charge would not be more safe,as it would possibly prevent the two runners from coming into contact with the surface of the bed,which causes considerable friction,and is the cause to which most of the accidents are assigned.

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INCORPORATING MILL.

In this building there is a big,circular iron bed,round which revolve two enormous wheels,each weighing 4-tons.

Consists of a lon-continued trituration beneath heavy runners,by which means the mass of ingredients becomes transformed from a mere mixture of three different substances into gunpowder. This is the most important process in the manufacture,and no subsequent care can possibly improve the quality of the powder.

The incorporating is effected by grinding the mixed ingredients for several hours beneath heavy runners. The bed of the mill is of iron,or of stone with iron tyres.

The runners weigh from 3 to 4 tons each,and vary in size from 3 and a half to 7-feet in diameter.

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The charge requires to be under the runners for 3 and a half hours for cannon powder and 5 and a half for small-ars powder. The maximum charge allowed is 60-lbs.

INCORPORATING MILL.

THE ROYAL GUNPOWDER MILLS.

Gunpowder production began at waltham Abbey in the mid 1660s on the site of a late medieval fulling mill. The gunpowder mills remained in private hands until 1787,when they were purchased by the Crown. from this date,the Royal Gunpowder Mills developed into the pre-eminent powder works in Britain and one of the most important in Europe.

In the surviving structures,the earliest of which date from the Crown's acquisition of the mills,we may trace the evolution of gunpowder technology to its ultimate form in the late nineteenth century,with production on an industrial scale.
The development of new chemical explosives ran in parallel with the refinement of gunpowder making. Remains of this activity include two nitroglycerine factories,one dated 1896,the other 1940,and drying stoves,where guncotton was dried before being mixed with nitroglycerine to form cordite.

during this century Waltham Abbey was responsible for research and development of high explosives,including Tetryl,TNT and RDX.

Production at the factory ceased during the Second World War in favour of sites less accessible to German bombers. After the war it became the principle government research establishment for investigating non-nuclear explosives,often reusing existing buildings for a second,third or fourth time.

There are over 300 structures,21 listed buildings,and a profusion of waterways,surviving in a park-like lanscape of 71 hectares. More than two-thirds is a Scheduled Ancient Monument,and 34 hectares are designated as a site of Special Scientific Interest including the largest heronry in Essex.

First Smokeless Powder.

After much trial and error,Paul Vieille,a chemist and engineer at the french Government Laboratory Central des Poudres et Salpetres (Central Powder Laboratory) perfected in 1884 a method of processing nitrocellulose (nitrated wood pulp) which,after further chemical additions was thinly rolled,dried and flaked to become the world's first progressive-burning,smokeless gunpowder.
The new Poudre 'V' (named for the inventor,Paul Vieille,and later renamed Poudre 'B') offered revolutionary ballistic advantages compared to black powder,with the former producing vastly increased propulsive energy while using a fraction of "product",with neither the clouds of acrid smoke nor the troublesome fouling of the latter.

The French Minister of War in 1886,General Boulanger,was a prominent figure of great political power. As soon as he was made aware of Vieille's discovery,General Boulanger decided that France would quickly issue a modern weapon to capitalise on the vastly improved ballistics offered by the new smokeless powder. In January,1886 he therefore rashly decreed that a small-bore rifle,and cartridge,be designed and ready in three months.

Cordite.

Smokeless powders were introduced in the closing years of the 19th century. Within a very short time thereafter the classic division had occurred into the double base type such as Ballistite and Cordite,and the single base types such as the French Poudre B,with the countries concerned having made their choice,from which they were not easily,if ever,diverted in later years.

England had firmly settled on Cordite and the early patterns of the .303-inch rifle cartridge were designed for,and used,a charge of 31½-grains of Cordite Mk 1 extruded as solid cords or rods and cut to an overall length to suit the inside dimensions of the cartridge case-about 60 such strands making one charge. The official designation of this propellant was 'Cordite Mk.1,size 3 3/4; which signified that the material was Cordite Mk.* and that it had been extruded as a solid cord through a die of .0375-inch diameter. The final size of the cord was somewhat smaller due to shrinkage when the solvent was later removed during the final drying process.

The chemical composition of this material was 58% NG,37% NC and 5% Mineral Jelly,which proportions had been designed to give a propellant in which the oxygen and the fuel had been fully balanced,ie one with the highest possible energy content. This had the desired effect of keeping the required charge weights very low,but it also had the undesirable side effect of making the flame temperature very high,typically 2800 degrees C,which proved to be rather more than the barrel steels of the day could comfortably withstand. Erosion of the throat and at the commencement of the rifling was noticed in Metford rifles after as few as 500-rounds,which was quite unacceptable from both the economic and strategic points of view. The change to the deeper Enfield form of rifling some seven years later reduced this problem to more manageable proportions,but it did not really get at the root cause-the high flame temperature of the propellant.

In 1910 a new form of Cordite was introduced for small arms,designated Cordite MD (ie MoDified),in which the NG content had been reduced to 30%,the NC content increased accordingly and with the Mineral Jelly content remaining at 5%. This new material was considerably less energetic than its predecessor as the flame temperature was now a mere 2200 degrees C,thus the charge weight had to be increased to a nominal 37-grains rather than the earlier 31½-grains. Of itself this caused no immediate problems,for there was plenty of spare space in the .303 case to accommodate the extra propellant.

An unlooked-for result of this reformulation however was that the burning rate had also been significantly decreased,thus a greater surface area of propellant was needed to maintain the necessary rate of gas evolution during firing. After a series of calculations and firings,it was demonstrated that the new grain shape would have to be hollow tube rather than a solid cord and that the dimensions would need to be .050-inches outside diameter,by .020-inches inside diameter with the length being,as before,that of the cartridge case. This new propellant was named 'Cordite MDT,5-2' to signify that it was the Modified formulation,extruded as a Tube with,respectively,the outside and inside dimensions of the extrusion die being given in hundredths of an inch.

This altered grain geometry caused no worries in the propellant factories; quite the reverse in fact for the new material with its lower liquid content was much stiffer and easier to handle. It did however cause perpetual troubles in the ammunition factories where it was discovered that although there was plenty of room inside the case to accommodate either charge,the bundle of the new tubes was so much larger than the original bundle of rods,that it would no longer fit through the neck of the case during loading.
A number of options were thus available,with various factories choosing the most suitable to them; either the bundle could be pushed into the neck of the case in two or more increments,or the whole bundle could be pushed into the neck of a partly formed case and the final necking operation performed on a loaded case. Some factories fixed on one or the other of these processes and stayed with it through thick or thin,while others switched between them as circumstances dictated,but it all seemed to make little or no difference where it really counted-in the final performance of the ammunition.
This Cordite MDT proved to be such an efficient propellant for small arms that the armed services could see no overwhelming technical need to change; thus it remained in general service for over fifty years and is still being produced in some countries. In all those years there was in fact only one other variation in the small arms field, Cordite CDT,in which part,usually ½%,of the Mineral Jelly was replaced by Carbamite,a more efficient stabiliser which had the added feature of easing several of the steps during production. This CDT however officially remained an alternative to MDT rather than a successor,although in later years it was the more usual product. Cordite Mk.1 remained in limited use for many more years in a few special applications such as proof rounds,and thus may well have set a hard-to-beat record for its length of service.

The other European countries,like britain,generally remained faithful to their initial choice of propellants; Germany standardised on Ballistite and variations thereof,although in wartime they proved themselves to be masters of using whatever was to hand; France stuck resolutely to single base derivatives of Poudre B; Russia stayed with its own single base materials and Italy largely used derivatives of Cordite.

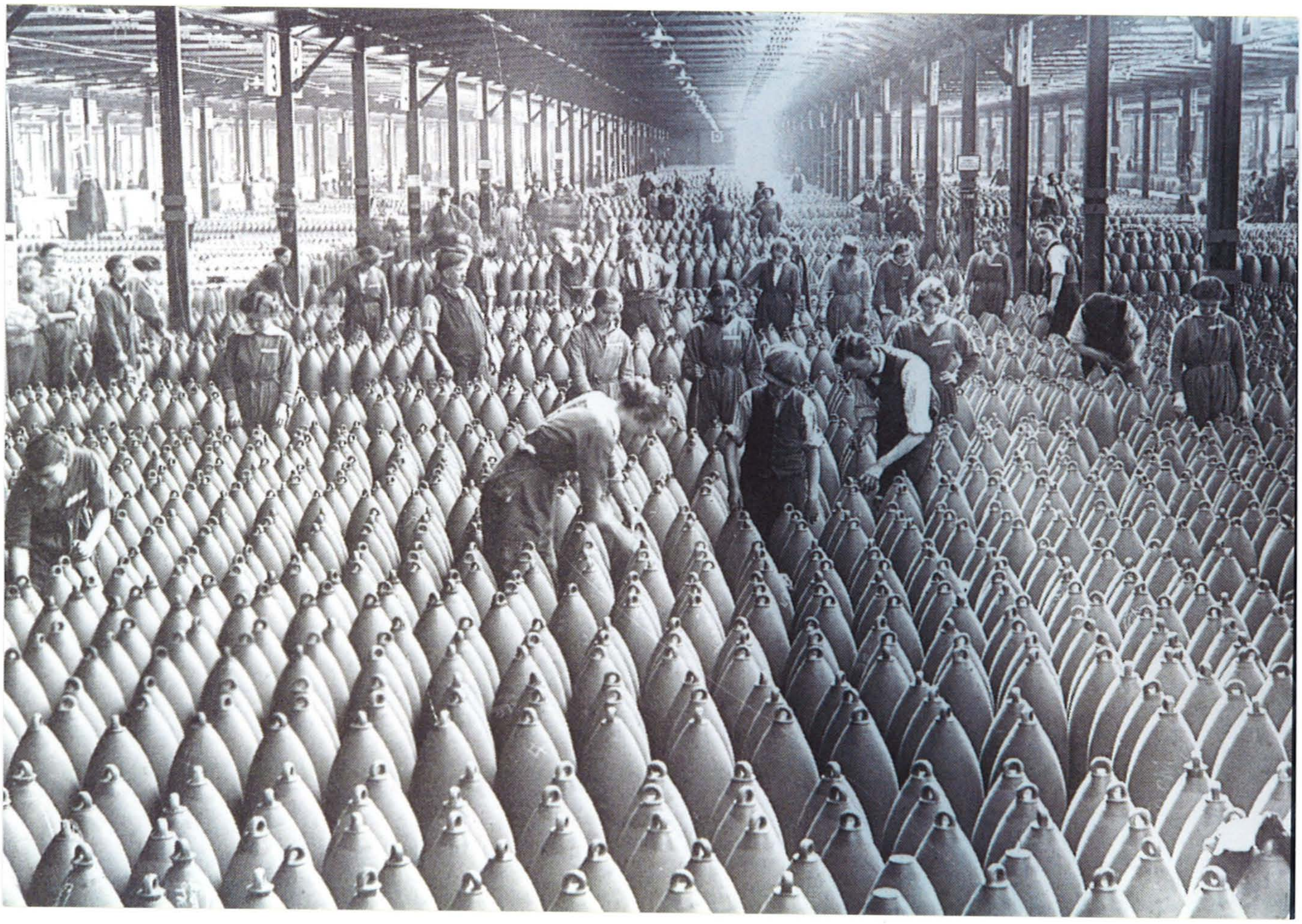
Cordite.

In 1914 there were just two grades of Cordite,Mk.1 and MD. and the total rate of production of Cordite throughout the UK was about 20 tons per week in 1914,but within one year this had risen to over 200 tons per week from just one factory.
It is an historic fact,and a matter of no small wonder and concern,that much the same conditions of unpreparedness existed again at the start of WW2 some 25 years later. Many of the developments in propellants which suddenly became apparent in that later war had their origins in the earlier war,but were never fully exploited then or during the intervening years of 'peace'.
In peace time it had been considered quite acceptable when making Cordite to add as a solvent a large quantity of acetone to the dough of nitro cellulose and nitro glycerine to speed up the gelantinisation of the NC,despite the fact that it was then necessary to stove the grains at about 50 degrees c for very long periods to get the solvent out again; small arms propellant taking three days,and cannon powders up to five weeks. In was time this delay was completely unacceptable,for not only did it slow down the rate of production,but it represented a significant hazard with several tons of propellant exposed at any given time. The alternatives were equally unattractive. The solvent could not simply be omitted,as the mixing operation then became too slow and too variable,nor could it be left inside the grains as it slowly evaporated anyway,changing the shape of the grains and their ballistics as it did so. Furthermore the solvent,like most other chemicals,was in short supply and full recovery was essential if production was to be maintained. The chemists settled down to study the whole process of gelatinisation to see if they could find ways of circumventing these and other problems.
It,for instance,known that highly nitrated nitro cellulose as used in making the existing Cordites was soluble only in acetone whereas the lower grades could be dissolved in the nore readily available solvents ether and alcohol. A new family of Cordites were thus introduced using this new solvent process and having an increased nitro glycerine content to offset the lower energy content of the lower grade nitro cellulose. Such powders were named RDB (Research Department formula B) and were very widely used,being almost completely interchangeable with Cordite Mk.1 in the larger guns.
Further research at Waltham Abbey,the original home of government powders some 150 years earlier,led to yet another family of Cordites making use of the newly developed stabiliser 'carbamite' (ethyl centralite) in place of the traditionnal mineral jelly. This material first used in Germany in World War 1,proved to be a very good stabiliser and to have the additional attractive property of greatly speeding up the incorporation of the nitro cellulose into the nitro glycerine during manufacture. This reduced the need for solvents and in turn reduced the need for the prolonged stoving which as a side-effect caused such a lot of distortion in the larger grains. Such powders were named Cordite W in honour of the place of their birth,and further work along the same lines led to yet another family of naval Cordites,the SC (Solventless Cordite) series,in which the solvent was virtually elimated by working the paste of nitro cellulose and nitro glycerine at higher temperatures and rolling pressures. This admittedly was a somewhat hazardous operation,but did away with the equally hazardous drying period of the conventional Cordites. A perfect example of 'winning on the swings but losing on the roundabouts'.
Later on during WW2 as the supplies of carbamite dwindled,another series was introduced,the WM (Waltham Modified) family in which part of the carbamite was replaced by mineral jelly,the same material which had earlier been supplanted by carbamite. Two further grades,HW and HSC,where the 'H' stood for 'Hot',were introduced to give higher energy contents for increased performance in ant-tank and ant-aircraft guns. These powders very closely resembled the original Cordite Mk.1 which had been made obsolete decades earlier. Strange things happen in wartime.

Despite such help in reducing production times,the existing government powder factories and the private contractors were quickly swamped with orders beyond the normal capacity of their plants,even had they been able to get all the new raw materials in the required quantities. New factories were erected and put into production,but these then served to aggravate the supply problems and the shortage of skilled labour. This in turn lead to severe quality control problems,and so on. It was possible in many cases to simplify a few of the production processes such as washing and purifying on the ground that the propellants were no longer required to have a shelf-life of twenty years or so-they were often fired off in a period more like twenty days,having been transported almost straight from the factory to the gun breech. This concept was a big help in many ways; but it too had problems in that the powder lots produced in this manner had to be segrated and carefully monitored to see that they were actually fired within their limited lifespan and not left in some outlying depot to become a safety hazard in years to come.
The only short term solution to this dilemma was to import propellant from overseas,but this too had its drawbacks.
Europe was,of course,closed and the only alternatives were thus from the 'Empire Countries' or from America. The countries of the then British Empire generally used the same propeellants as did the 'Mother Country',but only the larger of them had any worthwhile manufacturing capacity of their own,let alone any to spare. America's actual production was minute but her potential was enormous; the problem was that America had settled almost entirely on single base powders and hence her materials were rarely,if ever,directly interchangeable with those of England. On a weight basis the double base Cordites were more energetic than the single base types,hence a larger charge weight of the latter was needed to maintain the performance of a given gun; but this larger charge may or may not have actually fitted into the gun chamber. The situation was eased somewhat by the fact that the shorter rods of the nitro cellulose powders tended to pack more densely into a given space,but even so there were few occasions when a direct substitution was possible. The requirements of the two powders as regards primers and igniters also differed greatly.
A number of options were thus available,with one or the other being adopted at least temporarily in most cases. It was possible to import the whole system; gun,ammunition and all,but this was not very attractive as the American systems were generally outdated. In some cases an existing nitro cellulose powder could be used with only a minor compromise in performance: in other cases it was necessary to conduct long involved firing schedules to set up new range tables;in yet other cases a minor change in grain size or composition could make the necessary difference. Overall it was a very confusing time for all concerned and often the nett result was that there was scarcely enough ammunition available to stop the birds from nesting in the barrels of those guns already emplaced at the front-there were certainly no reserve stocks.

EXPLOSIVES USED DURING WW1.
CHILLWELL SHELL FILLING FACTORY.

Checking shells at the Chillwell factory. By the end of the war,the Chilwell factory had filled 19,250,000 heavy shells.



EXPLOSIVES USED DURING WW1.
WOOLWICH.
Women assembling fuzes at the Royal Arsenal Woolwich,in 1918.

EXPLOSIVES USED DURING WW1.

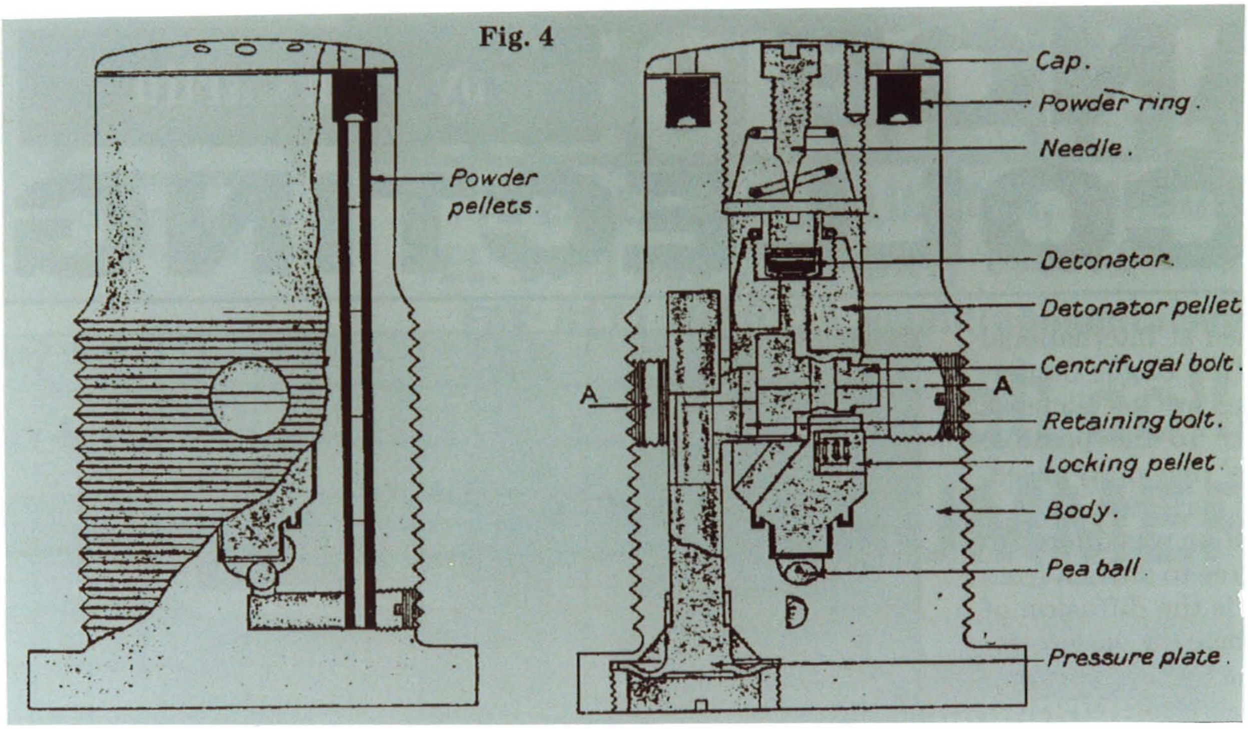
The filling factories were controlled by Lord Chetwynd,who built and supervised a large factory at Chilwell,which,within a year of its opening in January had filled almost 2,500,000 shells. He was an individualist of great ingenuity and courage. The cheapest form of Amatol,containing 80% ammonium nitrate,could not be poured into shell through the nose as a liquid,which was the normal,relatively easy way of filling shells with pure TNT or the other Amatols.

The research department at Woolwich suggested that this should be overcome by compressing the 80% Amatol into cakes for inserting into shells through a detachable base. But this meant yet another design of casing and more delay,so Chetwynd developed his own method of pressing the Amatol in through the nose.

The necessary grinding and apparent rough treatment of the explosive seemed to many to be highly dangerous. Chetwynd's response was to set himself up in a house very close to the plant,saying,'If anyone is to be blown up,I'll be the first.'

By the end of the war the chilwell factory had filled 19,250,000 heavy shells,and the boldness of all concerned ensured that the Britis Army had more than adequate supplies of ammunition for the terrific bombardments that took place in the last two years of the war.

Fig. 4


Powder pellets.
Cap.
Powder ring.
Needle.
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Detonator pellet
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A
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Locking pellet.
Body.
Pea ball.
Pressure plate.

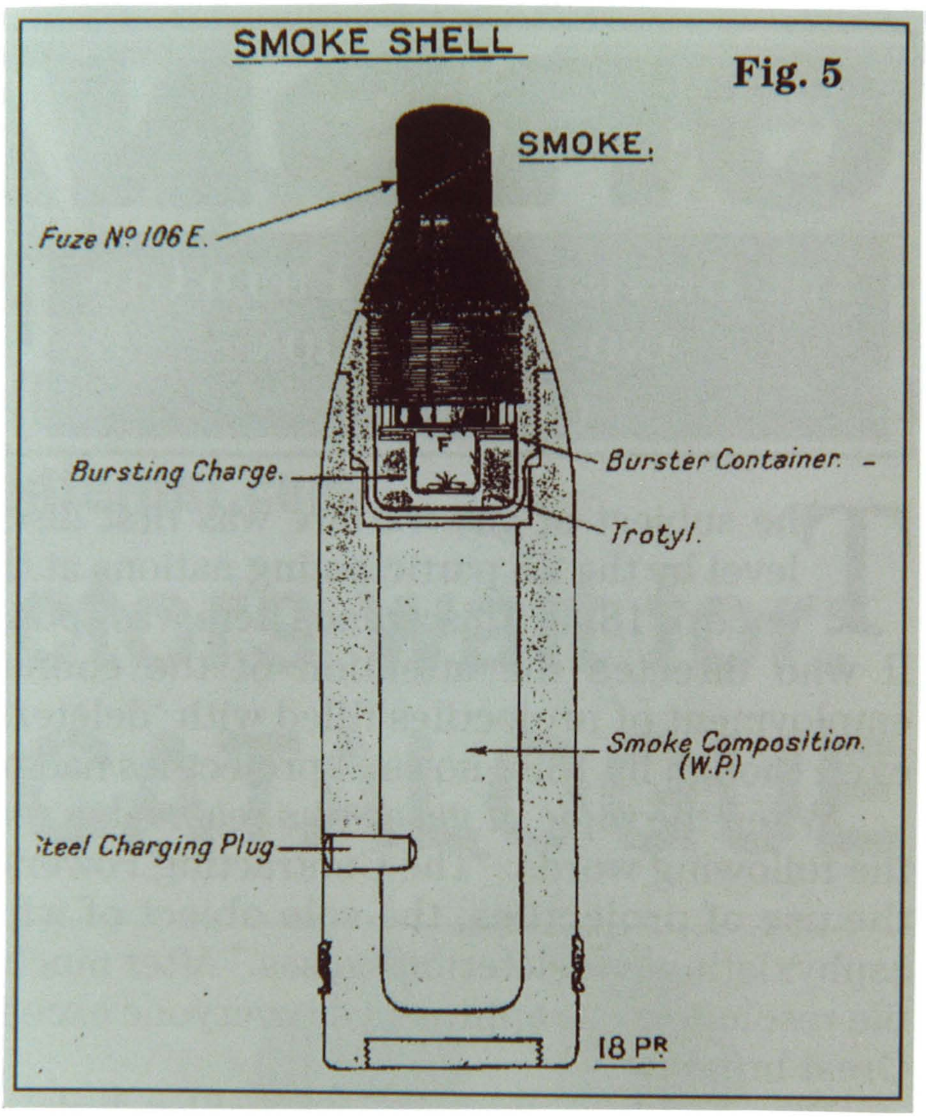
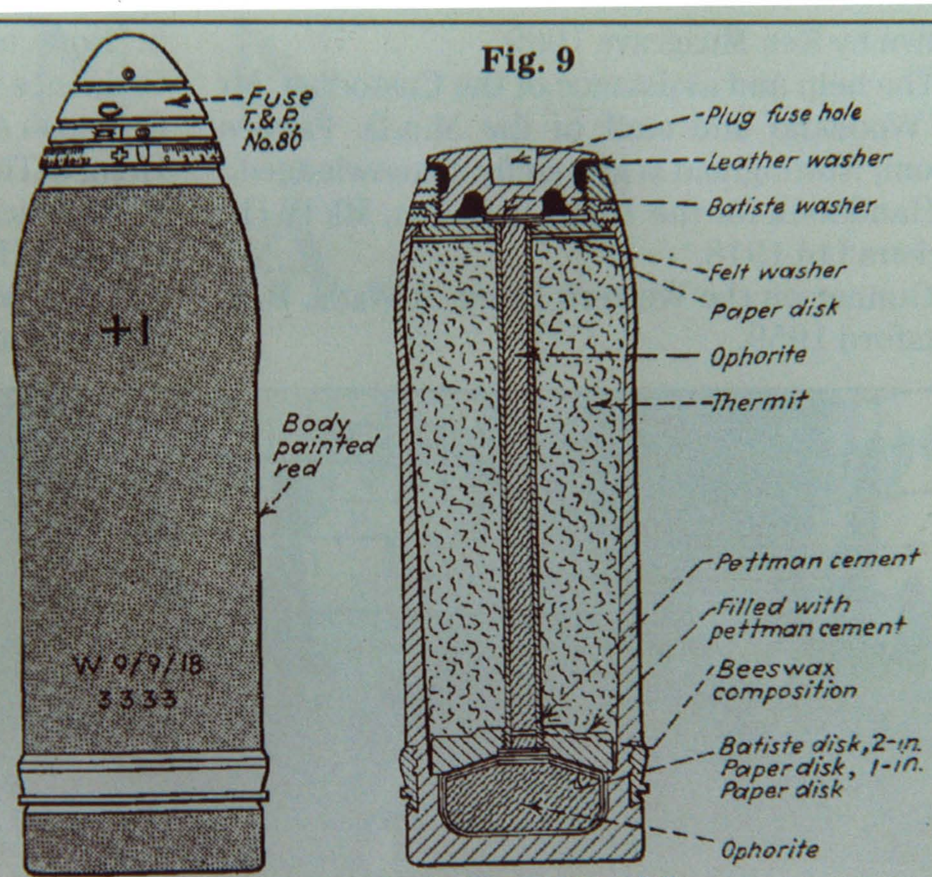
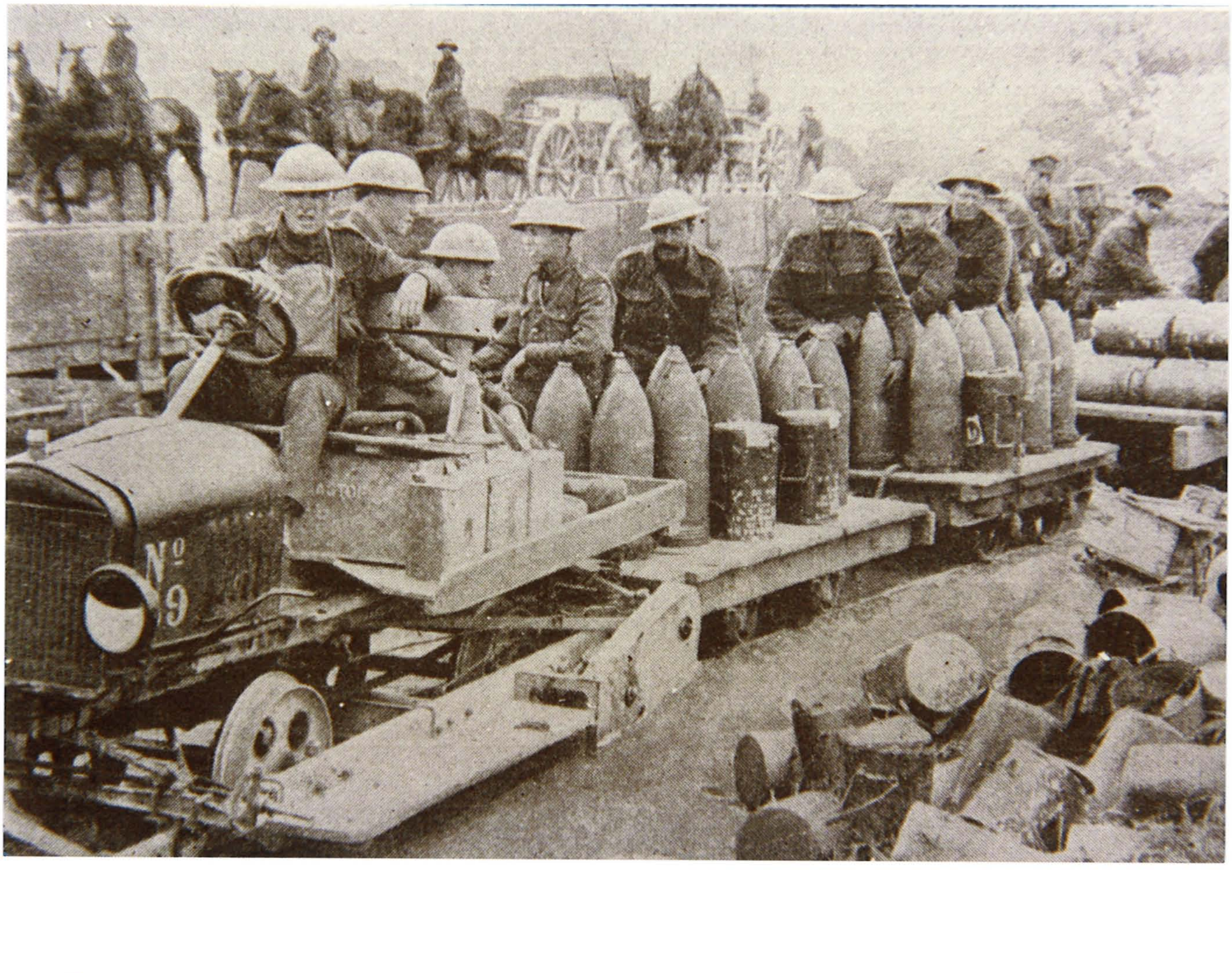

SMOKE SHELL
SMOKE.
Fuze Nº 106 E.
F
Bursting Charge.
Burster Container.
Trotyl.
Smoke Composition. (W.P.)
Steel Charging Plug
18 PR

Fig. 5

Fig. 9



18-pounder incendiary shell.



EXPLOSIVES USED DURING WW1.

The tonnage of TNT actually manufactured was made to go as far as possible by mixing it with ammonium nitrate. The mixture had been used by the French under the name of Schneiderite,but the British composition was called Amatol. It was made simply by mixing warm,granulated ammonium nitrate with molton TNT to give different grades containing 40,50 or 80% of ammonium nitrate. The Amatols were much cheaper than pure TNT because ammonium nitrate was relatively cheap,and they were only inferior in so far as they were affected by damp because ammonium nitrate is hygroscopic,and because the mixture containing 80% of the nitrate could not be obtained in a sufficiently fluid state for pouring. Amatol became the principal high explosive for filling shells,mines,depth charges and bombs. To meet these requirements the production of ammonium nitrate was stepped up from nil in 1914 to 159,114 tonnes in 1916,a total of over 341,000 tonnes being made throughout the war.

The new explosives were not accepted,however,without a struggle. This hiccup was caused,mainly,by rivalry between generals and admirals. The Navy's refusal to accept Amatol for their shells made the Army think that it was being treated as a second-class service when it was directed,by a lawyer,to use something not thought to be suitable by the Navy. A few heads had to be knocked together and in the end it'was just one of the many times throughout the war when it was necessary for people to be reminded of the truism that 'in spite of much evidence to the contary,we are all fighting on the same side'.

EXPLOSIVES USED DURING WW1.
FAVERSHAM EXPLOSION.

On Sunday 2 April 1916,in an Explosives Loading Co. Ltd factory on the site next to the Cotton Powder Co. in Faversham,around noon,a workman going for his lunch noticed that some empty bags,which had contained TNT,were on fire just outside a building in which 15 tonnes of TNT and 150 tonnes of ammonium nitrate were stored. The danger was at first underestimated,because it was considered that there was nothing present which could detonate the TNT. Alas,about an hour later it blew up,causing a number of other explosions in the area. Among the 108 dead and 64 injured were many who had been helping to put out the blaze,and even some who were simply spending their linchbreak watching the scene. 69 of the dead were buried in a communal grave which is still a dignified feature of the Faversham Borough Cemetery,only about half of those interred could be positively identified.

NITROGLYCERINE.

THE SHELL SCANDAL 1915.

When the shell scandal blew up,triggered by the headlines of The Times and the Daily Mail,and against which the government fell. On 26 May 1915 a coalition of Liberals and Conservatives replaced the old Liberal Government,with Mr Asquith still acting as Prime Minister. One of his first acts was to create a new department,the Ministry of Munitions,and to appoint Lloyd George,who had been Chancellor of the Exchequer,as its first minister. The main credit for the realization that the war could only be won if the chemists,engineers and manufactures could produce enough of the right equipment quickly must go to Lioyd George,even though his critics would say that he change his mind from the position he had adopted at the treasury. However that may be,a change of mind was what was needed,and Lloyd George set about his gigantic task in an old,mirror-panelled drawing room in 6 Whitehall Gardens,formerly the home of a well-known art dealer. He took stock with the help of two secretaries,two tables and one armchair.

Within two months he had collected a team of ninety talented and experienced men from all walks of life,including Mr Fletcher Moulton,who in the 1890s had acted as counsel for Alfred Nobel in his legal action for patent infringement against Abel. Now,as Lord Fletcher Moulton,an eminent judge,he came to head the Committee on Figh Explosives. The various teams toured the industrial areas of the country,set up new organizations and procedures,dealt with labour and trade union issues,introduced women workers,legislated to prevent any exploitation of profits,arranged for the release of key personnel from the services,extended the manufacture of machine tools,and continually upheld the morale of the new workforce by arranging royal visits and introducing good welfare and housing schemes. They even went so far as to control the sale of alcohol when it became clear that increased consumption was affecting production (so much so that the number of gallons of alcohol sold each year fell from 89 million in 1814 to 38 million in 1918).

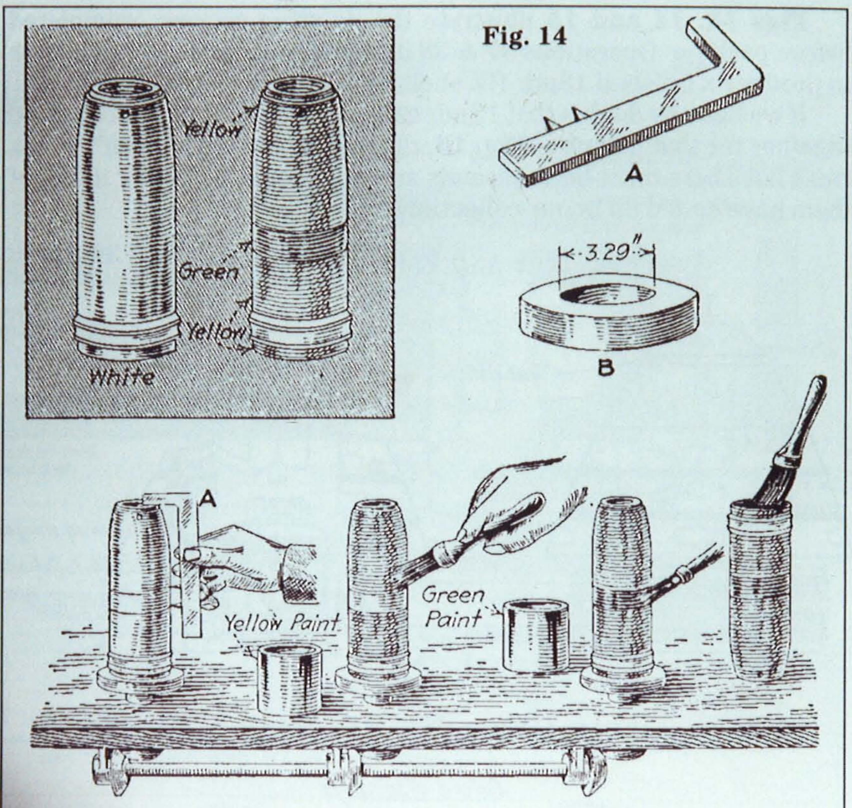
By the end of the year,the Royal Factories at Woolwick,Waltham Abbey,Enfield Lock and Farnborough,which had been transferred to the War Office in the Autumn,had been supplemented by 73 new national factories that opened all over the country. Of these,8 were for making explosives,49 for making shell casings,14 for shell-filling and 2 for making gauges. By the end of the war there were 218 factories in all.

The production of empty shell cases rose very dramatically because it only involved fairly traditional engineering processes,but it was less easy to fill them with explosives which were in distinctly short supply. At the start of the war the Royal Gunpowder Factory at Waltham Abbey was producing 68 tonnes of gunpowder and cordite each week,and there was some production in private firms. Some TNT had been made at Ardeer since 1907 but the total amount of high explosive available would have been laughable if the situation were not so serious. While the Germans were actually firing off about 2,500 tonnes of TNT every week,the total production of both TNT and Lyddite in Britain was less than 20 tonnes per week. TNT had only recently been adopted as the principle high explosive and the production of Lyddite was being run down because the War Office had let it be known that it was to be superseded.

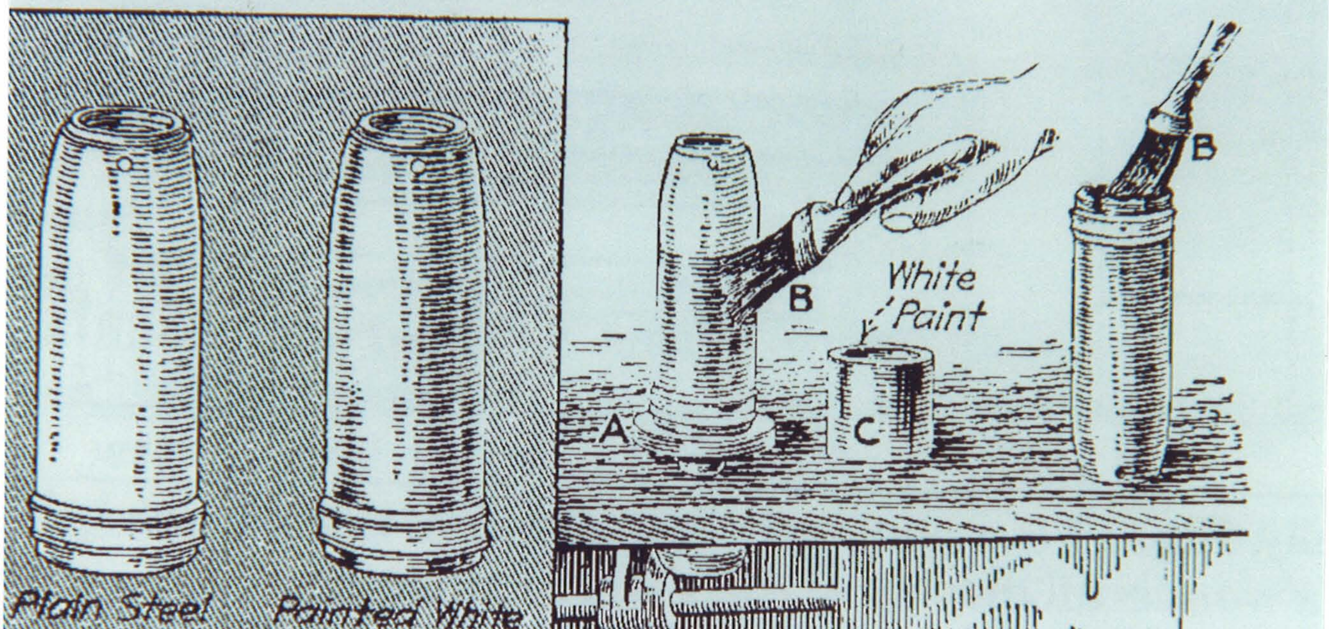
NITROGLYCERINE.

Workers who handled nitroglycerine continually were always liable to suffer from what ithey called 'NG head'. Most workers became acclimatized to it after a few weeks,but if they were away from their work for a while,they had to go through a miserable period of acclimatization once again. To avoid this,many of them used to carry a small amount of the explosive around with them,despite all the rules and regulations against it.

A cartoon showing Lloyd George leading the charge to improve the supply of munitions. (Fr
Punch, *21 April 1915)*



OPERATION 38. FINISHING COAT AND GREEN BAND



OPERATION 37. PAINTING THE PRIMING COAT

ıes Used—Motor-driven turntables A.

EXPLOSIVES USED DURING WW1

It was the German attempts to find something better than Lyddite were more successful than those in Britain.

Willbrand had made a chemical called trinitrotaluene in 1863,and this had been adopted as a shell filling in 1902. The value of what became known as TNT or Trotyl was not realized in Britain until just before WW1,even though samples of the new material had been tested in 1902 and again in 1905. It was rejected on the grounds that it lacked power and was difficult to detonate,so it was left on the shelf as just another research project.

TNT,like picric acid,is a yellow solid. On the debit side it is less powerful,harder to detonate,and more difficult to make than Lyddite,but in credit,it is cheaper,less poisonous,completely unaffected by dampness,and less dense. Moreover,it has a melting point below 100-degrees C. so that it can be melted by hot water or steam which makes shell-filling safer and easier, it is not acidic so that it does not react with metals; and the difficulty in detonating it makes it so stable that in 1910 it was exempted from the provisions of the 1875 Explosives Act not being regarded as an explosive so far as manufacture and storage were concerned.
As it is less sensitive to shock than Lyddite,it can be used (particularly with additives to desensitize it still further) as a filling for armour-piercing shells which will not explode simply on contact with an armoured surface.

The difficulty in detonating TNT was overcome bu using stronger boosters than those required by Lyddite,but the main problems of introducing TNT into the British services were those of decision making and of learning how to manufacture it as readily as the Germans could. It was made from toluene,concentrated sulphuric acid and concentrated nitric acid,and all three raw materials were more readily available in Germany than in Britain.

The Haber process for making ammonia,and hence nitric acid,originated in Germany,and,though the Contact process for making sulphic acid was originally a British discovery,it was exploited most energetically in Germany to meet the requirements of their dyestuffs industry. Toluene,like Phenol,was mainly obtained from coal-tar but it needed 600-tonnes of coal to provide 1-tonne of Toluene and the German plants were more advanced than those in Britain,again because of the requirements of the dyestuffs manufacturers. When the need for TNT was finally realized in Britain in 1913,the germans were already 11 years ahead.

EXPLOSIVES USED DURING WW1.

LYDDITE.

Picric acid,or,to give it its full chemical name,trinitrophenol,had been made on a laboratory scale in 1841 in a reaction involving phenol,concentrated sulphuric acid and concentrated nitric acid,but the British found it difficult to scale this up on to a commercial scale at the end of the century because of the backward state of their chemical industry. Initially,phenol was obtained from coal-tar but when supplies from that source could no longer meet the demand,alternative methods of making it from benzene were developed in some haste and some was imported. There were also shortages of sulphuric and nitric acids.

Despite these problems Lyddite remained the main military high explosive in Britain well into the First World War. But it was by no means ideal and it was inferior to the trinitrotoluene,TNT,adopted by Germany in 1902. It was very difficult to detonate,particularly if wet,so that it frequently misfired; whole dumps of Lyddite-filled shells were liable to blow up if hit by one hostile shell; it produced very black smoke when it exploded which made air observation on possible targets difficult; and it could not be melted by steam or hot water,which was the safest way of obtaining an explosive in its liquid form for pouring into shells. Nor was it particularly safe: in its early days it was involved in at least six accidents,including one at Woolwich Arsenal in 1903,when sixteen people were killed and fourteen injured. But it had two more important defects. First,because it was an acid it reacted with metals to form picrates and these were liable to explode when subjected to shock or friction,detonating the remaining Lyddite. To try to prevent this,all metal surfaces within a lyddite-filled shell had to be given an acid-resistant coating by being treated with copal varnish. Secondly,instead of penetrating armour-plating,which was necessary to inflict the maximum amount of damage,Lyddite-filled shells exploded on impact with the deficiency was highlighted at the Battle of Jutland in 1916,in which 155 ships were involved. Both sides claimed victory,but the British Navy,with superior gun-power,lost more ships,and twice as many men as the Germans. There have been endless arguments about the naval tactics employed by both admirals but there can be no argument about the superiority of the German shells,which were filled with desensitized TNT and not with Lyddite,and about the greater strength of the German armour-plate

The replacement of Lyddite,in Britain,by the better TNT,already under way before 1916,was accelerated by the result of the Battle of Jutland.

EXPLOSIVES USED DURING WW1.
SHELL FILLING.

Throughout the early months of the war all the shell-filling had been carried out at Woolwich but it soon became obvious that the establishment could not cope with the vast increase in the number of shell cases. On a visit to the Arsenal some months after the outbreak of the war,Lloyd George 'found stacks of empty shells which were being slowly and tediously filled,one at a time,with ladles from cauldrons of seething fluid'. As soon as he could,he replaced the head of the Arsenal and began to set up national filling factories-one at Aintree and another at Coventry being opened in July 1915. Four more opened in August and six in September. By the end of the war there were 18. The number of shells filled in a week in September 1915 was 120,ooo. By January 1916 it had risen to 280,000,and by the middle of that year it was 1,180,000. In the year from July 1915 to June 1916,very nearly 20,000,000 shells were filled. And what was just as important,the number of heavy shells being filled grew most rapidly.

Much of the unpleasant and hazardous work was done by women and girls,and there were strict rules and regulations which had to be followed. Respirators,for example,had to be worn in some of the factories and the skin had to be protected from TNT dust by covering it with a special grease. There was a real chance of severe disfiguration,even death,from the jaundice caused by TNT poisoning. The first effect of this was to turn the skin a very bright yellow,which led to the workers in the filling factories being known as 'canaries'. 96 of them died from the disease.

EXPLOSIVES

USED

DURING WW1

EXPLOSIVES USED DURING WW1

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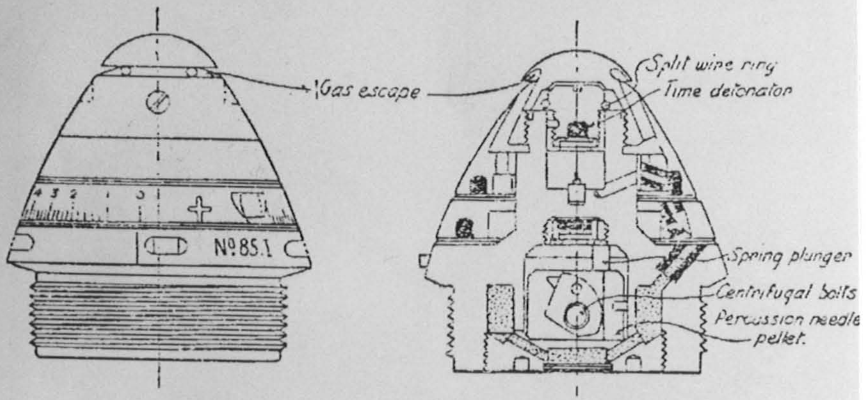
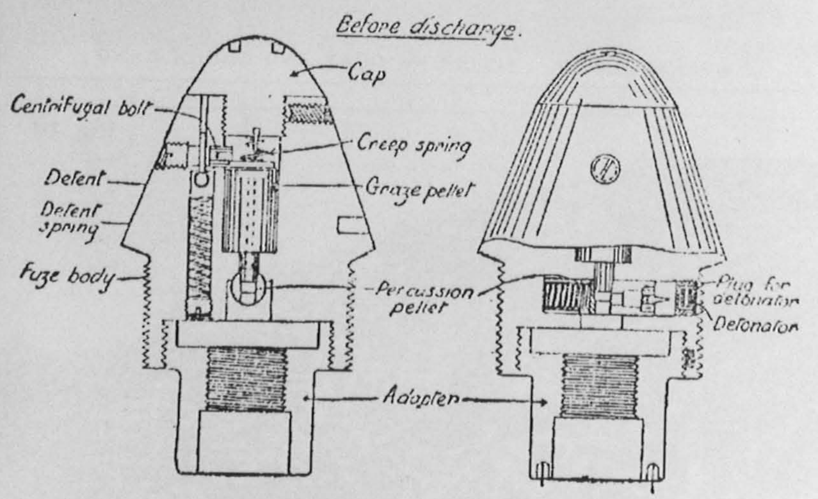
FUZE, TIME AND PERCUSSION, No. 85. **Fig. 9**



FUZE, GRAZE, No. 100, MARK I. **Fig. 10**



SHELLS, H.E., 18-PR., MARKS II AND III.

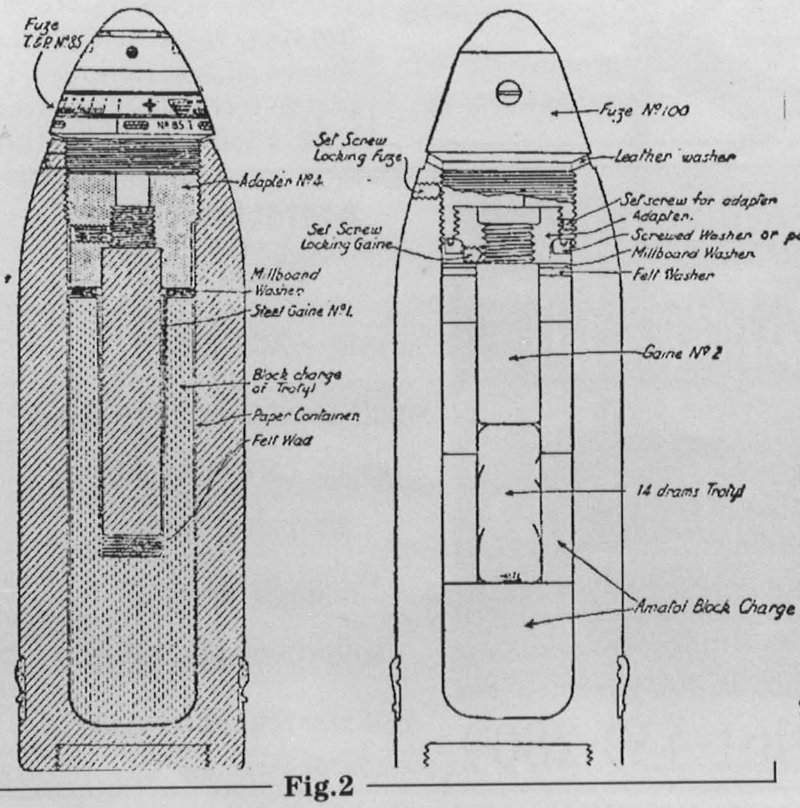


Fig.2

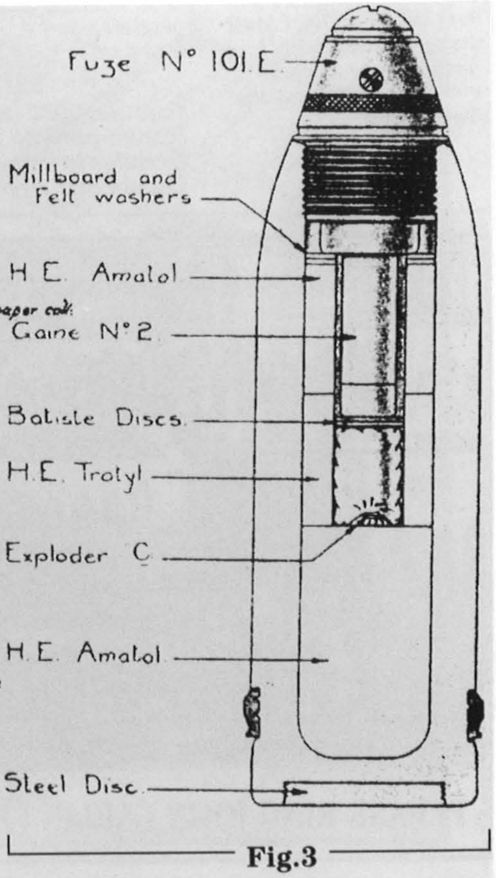


Fig.3

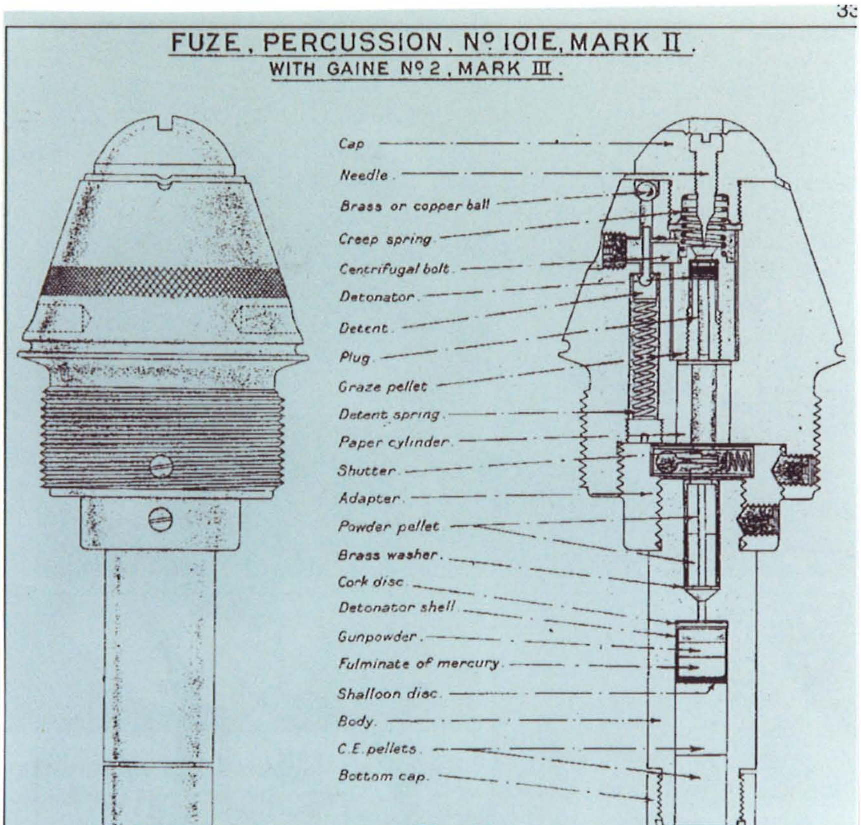

FUZE, PERCUSSION, Nº 101E, MARK II.
WITH GAINE Nº 2, MARK III.
Cap
Needle
Brass or copper ball
Creep spring
Centrifugal bolt
Detonator
Detent
Plug
Graze pellet
Detent spring
Paper cylinder
Shutter
Adapter
Powder pellet
Brass washer
Cork disc
Detonator shell
Gunpowder
Fulminate of mercury
Shalloon disc
Body
C.E. pellets
Bottom cap

Fig. 11

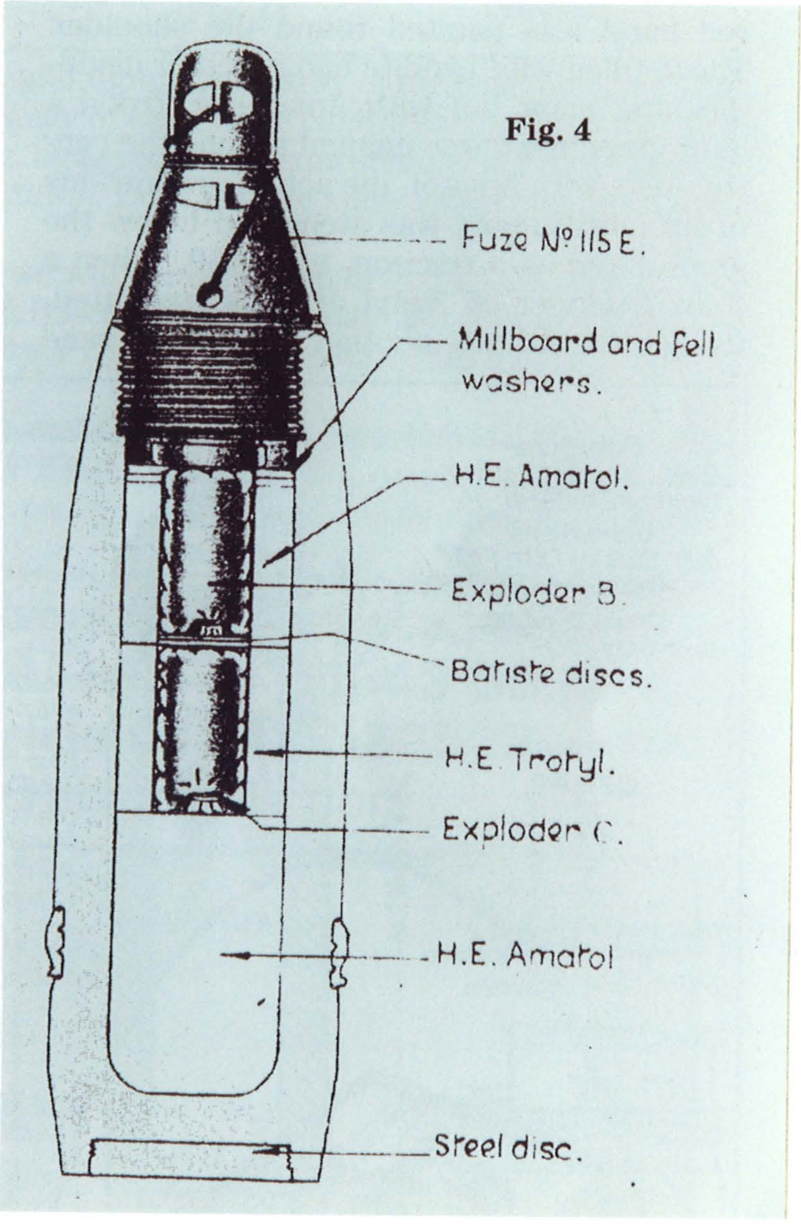

Fuze Nº 115 E.
Millboard and fell washers.
H.E. Amatol.
Exploder B.
Batiste discs.
H.E. Trotyl.
Exploder C.
H.E. Amatol
Steel disc.

Fig. 4

EXPLOSIVES.

High explosives were known about for hundreds of years,some being more stable and therefore safer to handle than others. Some examples are ammonium nitrate (1650),picric acid (1771),fulminate of mercury (1799) and trinitrotoluene (1863). Initially the latter was known as trotyl,and more commonly as TNT. Most of these explosives were used in unaltered form both long before and well after 1914. In that year,when aircraft bombs were being produced in quantity for the first time,picric acid (sometimes known as Lyddite in recognition of experimental work done at Lydd in Kent) was used as the main explosive filling in artillery shells and other projectiles,and consequently was in short supply. TNT,made from coal tar,was therefore used for early bomb fillings,but it was expensive to produce in quantity so it became necessary to mix TNT with ammonium nitrate to form a new filling,Amatol.

Fortuitously,Amatol turned out to be more disruptive,less costly and far superior to pure Lyddite or TNT. Subsequently it was used as a high explosive bomb filling from 1916 right up to the early years of the Second World War,with periodical variations in the percentages of ammonium nitrate and TNT to suit particular requirements. From the results achieved,many at the 'sharp end' considered that Amatol had more than outlived its useful life when it became apparent during the Second World War that it was considerably less effective than its German counterparts. This was clearly manifested during the 1940-41 Blitz on London and elsewhere. Static trials in late 1941 demonstrated that,weight for weight,the Luftwaffe bombs were about twice as effective against built-up areas,bridges,railways and public service installations as the general purpose (GP) types used by the Royal Air Force. Consequently,Amatol was progressively ousted by much more powerful explosives such as Cyclonite (RDX/TNT),Torpex,Amatex and Minol. By late 1943 it was realized that high-explosive power could be further enhanced by adding aluminium powder. Trials quickly demonstrated that effectiveness could be increased by as much as 40 to 100 per cent. The advent of the new explosive substances,and bomb cases to carry them,ensured that British bombs not only vied with German types,but outstripped them in power and effectiveness,both in size and range available.

Cordite.

This explosive proved,after years of use,to be satisfactory in its stability both chemically and ballistically. Its main defect is the erosion it produced,particularly in heavy ordnance,owing chiefly to the great heat it developed. To overcome this defect,a cooler propellent was worked out. This propellent,which was known as Cordite M.D. (modified cordite) contained the same three ingredients,but in different proportions.
Experience with Cordite M.D. has shown it to give rise to more erosion than certain other propellents,but it remains still one of the best rifle powders.

During WW1 certain other propellents were introduced into the British Service. Acetone,the solvent which was used in the manufacture of cordite,could not be obtained in sufficient quantity,and a modified composition known as cordite R.D.B. was introduced. This could be made with a mixture of ether and alcohol,solvents which were readily available,but the propellent was never used for small arms.

The British factories were also incapable of turning out the enormous quantities of propellent required during the war,and it became necessary to purchase supplies from America. As the American factories were not equipped for the manufacture of cordite,but for nitrocellulose powders,and as these were found to shoot satisfactorily in British guns,enormous quantities of nitrocellulose powders were introduced into the British Service.
The American rifle propellent,originally known as Dupont No.16 powder,was termed N.C.Z. in the British Service.

The Royal Small Arms Factory,Enfield Lock.

The first British Government arms works at Enfield Lock,a location affording both water transportation and water power from the lock fall,was established in 1804 largely to assemble Brown Bess flintlock muskets,the principle arm of British infantry for over 100 years. Parts,excepting stocks,were manufactured privately in London and Birmingham "by men working by hand in wretched cellars and attics," as one ordnance report put it. Standardization and what is modernly called quality control were largely lacking.

Barge Quay and Water Mill

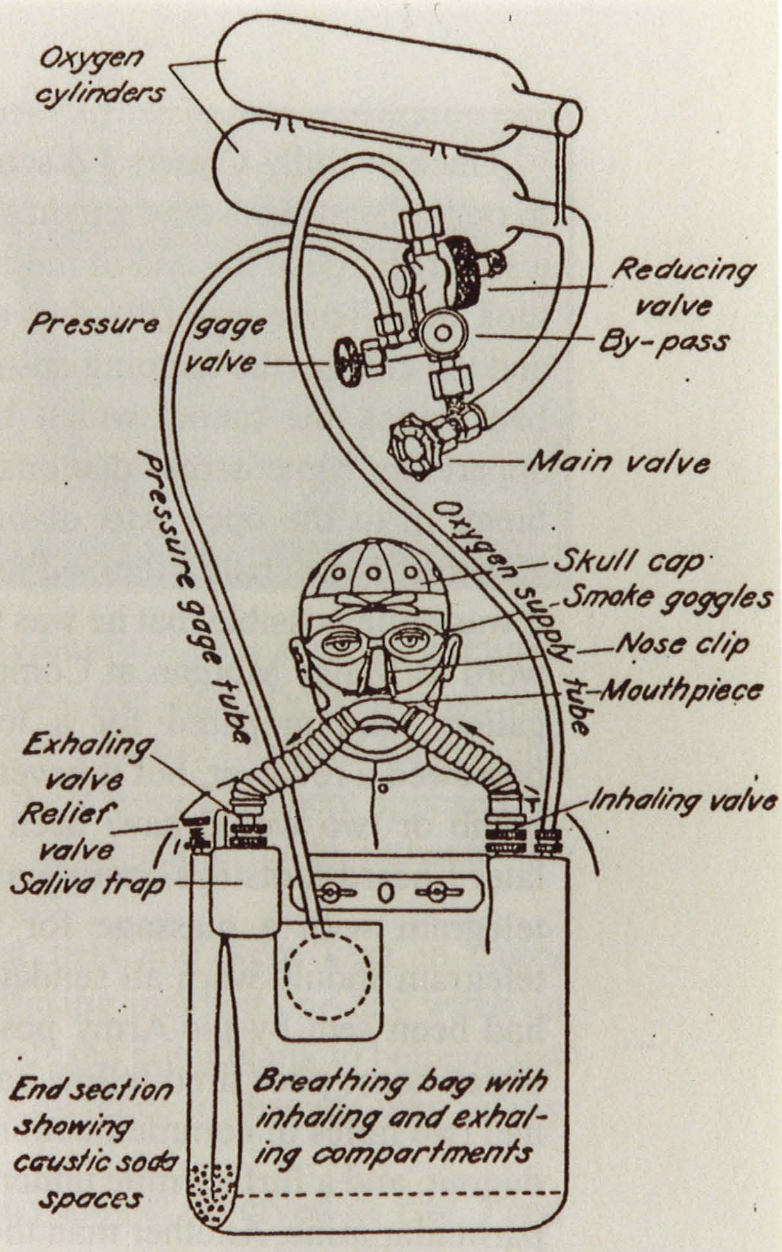


Fig. *A*. Circulating System of Fleuss, or Proto, Apparatus.

WALTHAM ABBEY ROYAL GUNPOWDER MILLS.

Gunpowder production began at waltham Abbey in the mid 1660s on the site of a late medieval fulling mill. the gunpowder mills remained in private hands until 1787,when they were purchased by the Crown. From this date,the Royal Gunpowder Mills developed into the pre-eminent powder works in Britain and one of the most important in Europe.

In the surviving structures,the earlies of which date from the Crown's acquisition of the mills,we may trace the evolution of gunpowder technology to its ultimate form in the late nineteenth century,with production on an industrial scale.

The development of new chemical explosives ran in parallel with this refinement of gunpowder making. Remains of this activity include two nitroglycerine factories,one dated 1896,the other 1940,and drying stoves,where guncotton was dried before being mixed with nitroglycerine to form cordite.

During this century Waltham Abbey was responsible for research and development of high explosives,including Tetryl,TNT and RDX.

Production at the factory ceased during the Second World War in favour of sites less accessible to German bombers.
After the war it became the principle government research establishment for investigating non-nuclear explosives,often reusing existing buildings for a second,third or fourth time. Since the site's decommissioning in 1991 the Ministry of Defence has undertaken its decontamination,so that access can be provided to this secret world.

MUNITIONS BLAST MEN HONOURED.

MARKED GRAVES FOR SIX WGO DIED IN FACTORY EXPLOSIONS.

Six men killed in massive explosions at the Waltham Abbey Royal Gunpowder Mills Factory in 1940 have finally been given marked graves-58 years on.

The remains of factory workers Albert Lawrence,John Parkes,Charles Purkis,Thomas Galvin,Francis Keene and David Lewis were put in a casket,but owing to the pressures of war,their final resting place was never marked.

But on Monday,a special memorial service at the Abbey Church,Waltham Abbey,was followed by a ceremony at the town's Sewardstone Road Cemetery during which their headstones were blessed by Canon The Rev Patrick Hobson.

The service was attended by the men's relatives and representatives from the Ministry of Defence,the Waltham Abbey Royal Gunpowder Mills and town and districr councils.

During the service the workers were remembered in prayer,as Mr Hobson led tributes to the men who he said were "just doing their duty".

Tributes were also paid to two other blast victims-Waltham Abbey's Norman Monk and Leslie Raby,from Waltham Cross-whose graves in the cemetery are already marked.

The first blast on January 18-involving some 6,000-lbs of nitro-glycerine-claimed the lives of Messrs Lawrence,Parkes and Purkis and two other men working in the circular Mixing House building which was reduced to two smouldering craters.

All died instantly. The explosion,which shattered windows of surrounding houses was heard 90 miles away in the New Forest.

The second explosion-on April 20,1940-occurred in the Paste Mixing House,which ironically was one of the buildings completely rebuilt after the first blast.

Five men-Galvin,Keene,Lewis,Monk and Raby-were killed.

It is thought the explosion happened when small lead sample bottles were knocked over,the shock igniting their volatile contents.

Campaigns by the victims' families to have the graves marked met no success as the men were civilian workers and not recognised by the War Graves Commission.

The story was told in the magazine After The Battle by Waltham Abbey historian Bryn Elliott.

The magazine offered to pay for the headstones and Monday's service was able to go ahead with the six dead men's last resting places recognised at last.

Doris Day,daughter of Charles Purkis,said: "We are overwhelmed by it all. It's good that he has finally been given recognition,we have waited a long,long time for it.

"I tried to do something over the years,but didn't get anywhere,so I'm very pleased to be here today."

Waltham Abbey Royal Gunpowder Mills Charitable Company chairman Don Spinks said: "They were very courageous men and were rightly remembered in today's ceremony. It was a fitting tribute.

"When the Gunpowder Mills site is developed there will be a 'Place of Peace in which we will work with the church,and the men will be remembered there as well."

Mr Hobson said: "It was a very moving and important service in the Abbey Church.

"Along with their families,we focused on remembering the men who died doing their duty."

Ceremony Monday 20th April 1998.

Taken from the Waltham Abbey Gazette,article written by Laura Burkin.

THE ROYAL GUNPOWDER FACTORY.

PRESS HOUSE.

"The Press House is the parting of the ways,so to speak,of the various kinds of powder,which are made from press-cake treated in different ways.

For pebble powder the press-cake which resembles thick black slate- is cut into strips and these strips are further cut into '5/8 cubes'. The rest of the cake is reduced to coarse powder by three pairs of graduated rollers.

THE ROYAL GUNPOWDER FACTORY.

PRESS HOUSE.

The glazed and granulated powder (the dust from which has been removed by another process and sent back to the incorporating mills) is now ready for moulding into prisms for the built-up charges used in big guns.
Coarse-grained powder is fed into the compartments of the wheeled trat to the right,and is then pushed under the hydraulic press,which has corresponding plungers. The hexagonal prisms emerge in batches of 64,or 13,000 per day.

The scene at Le Pelerin the day after the explosion of one of the abandoned trench mines in July 1955.

"On a stormy day,as thunder pealed over the tiny hamlet of Le Pelerin just north of Le Pelerin just north of Le Gheer,there was one great blast that made the earth tremble and shattered windows in some of the houses. As the storm cleared the people of Le Pelerin were startled to find,within a couple of hundred yards of their homes a crater about 250 feet in diameter and nearly 60 feet deep.

At 3.10 am on the 6th of June 1917 the Messines Ridge was rent by 19 huge mines with a combined explosive loading of 937,450-lb,just over 416 tons. Combined with a stupendous artillery barrage of about 2,266 guns along the 8-mile front-roughly one gun to every 6½-yards-the greatest mining attack in history totally demoralised and shattered the defence.

24 mines were actually laid. The gallery to one was lost to enemy counter mining,the other four were not required for the initial attack.

All remained sleeping-a total of 162,000-lb of explosive-until one detonated during a thunderatorm in July 1955.

We can only speculate why the mine exploded in 1955. In 1997 when the Durand Group accessed the Broadmarsh mine chamber at Vimy,the armoured firing cables,leading back almost to the surface,were found to be in excellent condition. Such cables would certainly have been used at Messines,and if any came close to the surface,the build up of static in a thunderstorm,or a lightning strike could induce sufficient current to initiate the detonators. Subsequently the Durand Group neutralised another mine charge of 6,000-lb at Vimy and a 600 (or so)-lb camouflet charge,in both cases finding the initiators and explosives in a condition probably capable of detonation.

The scene at Le Pelerin the day after the explosion of one of the abandoned trench mines in July 1955.

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.303-inch AMMUNITION BOXES.

Cartridges are packed into boxes in one of four different ways.

For use in rifles they are packed either in chargers and bandoliers,or in chargers and charger cases.

Ammunition for use in machine guns is packed in cartons,or in machine gun belts. Packing for machine guns in cartons has superseded the old method of packing in paper bundles.

In all cases small arms ammunition is packed in wooden boxes fitted with a tin lining. These boxes are usually strengthened with hardwood ends or battens,and are provided with a lid,secured either by a pin or catch,so that they can be opened quickly. They are carried by rope or web handles attached to the ends of the boxes,and the tin linings are arranged with an opening,closed by a soldered lid with a tear-off handle,the lid and the tin lining being painted black. Arrangements are made for sealing the boxes up after the ammunition has been packed into them. Boxes containing ammunition for use with rifles are stained dark brown,while machine gun ammunition is packed in boxes coloured green. The green boxes which contain carton packed ammunition are also provided with battens,one at each end,so that they can readily be distinguished by feel in the dark from boxes containing rifle ammunition.

When ammunition is packed up in bandoliers,it is first clipped up in chargers,five rounds in a charger. Then each of the five pockets of the bandolier is filled with two chargers put head and tail. The pockets are then closed up,and the bandolier which thus holds 50 rounds is folded up into a bundle. 20 of these bundles,or 1,000 rounds,are packed into each tin-lined wooden box,the lining of which is then soldered down,and the soldered joint painted black. The box is then closed and sealed.

Packing for rifles in charger cases is now seldom used. The charger case consists of a cardboard box which contains 20 rounds clipped up in four chargers. This cardboard box is closed by a buckram band fixed with shellac. 50 of these filled charger cases-or,again 1,000 rounds-are packed in the same wooden box as is used for bandolier-packed ammunition.

Ammunition in cardboard boxes for machine guns is packed head and tail either 48 or 50 rounds in a box. The boxes are then closed by paper wrappers fastened with shellac. 26 of these cardboard boxes are packed in each tin-lined wooden box,which thus holds either 1,248 or 1,300 rounds.

When ammunition is packed in machine-gun belts,each cartridge is put into the belt by hand,and the belt is then passed through a machine,which presses the cartridges firmly home in the pockets,and positions each cartridge correctly in the belt. Each belt is then examined to see that none of the pockets are split,and at the same time the cartridges are counted. each belt should hold exactly 250 rounds. The belts are then packed in 500-round tin lined boxes,each box holding two belts in separate linings.

..303-inch AMMUNITION BOXES.

It is very important from a military point of view that it should be possible to tell at a glance what ammunition is in a box,without having to read an elaborate description on the label,and,as small arm ammunition is generally stored piled in huge stacks,the top of the box is seldom visible,and it is exceptional if more than one side can be seen. To meet these conditions,small arm ammunition for British service is labelled on all four sides with labels known as "distinguishing" labels. These labels are of simple but characteristic design and embody symbols denoting the various types of ammunition.

The symbol for the mark V11 is a green grid. The labels are printed in distinctive colours,which indicate the group under which the particular ammunition falls in the Magazine Regulations. For instance,all mark v11 labels are printed green,indicating that the ammunition is in Group V1. The printing is also as large as space will allow,and in addition to the symbol gives information as to the type of ammunition contained in the box,the number of rounds,and the method of packing.

Attention is also given to the necessity of tracing the history of the ammunition during its life in the service. Every consignment of ammunition is identified by a batch number. This consists of a letter or letters denoting the manufacturer,followed by the date on which the ammunition was submitted for inspection. Thus,Government or (Royal Laboratory) manufacture submitted for inspection on Armistice Day would be called R.L. 11.11.18. The whole history of the ammunition,including its performance on proof,quality on examination,method of packing,quantity,etc., is recorded against that batch number or "make and date", and it is obviously of advantage that the ammunition while in the service should be capable of being identified with its make and date as long as possible. It is recognized that a tin lining may sometimes be taken out of its box and replaced in another box,and even bandoliers,cardboard boxes,etc., are taken out of their linings and made up into smaller packages. In order to provide for these contingencies,full particulars of the ammunition,including the make and date,are printed on a "descriptive" label. One of these is fixed on the top of the box in a recess,so that it will not rub off,and a second identical one is fixed on the closing lid of the tin lining. The same information is also printed on one pocket of every bandolier and on the paper wrapper closing each cardboard box,and the make and date is stencilled on each end of the wooden box.

In addition to the above labels,the Government group and division and explosive labels dealing with the regulations for storage and transport are fixed on one side of the box,and the box is sealed with a seal which indicates the station where the ammunition was packed.

It is customary to attach the labels with shellac varnish,as this is found to be more permanent than paste or other adhesive,and in tropical countries labels protected by shellac are not so readily attacked by white ants.

The boxes containing each batch of ammunition are numbered serially,and this serial number is stencilled on the top of the box,and the gross weight of each box is stencilled on one end.

THE .303-inch MARK V11 BRITISH CARTRIDGE

The Mark v11 cartridge has a pointed bullet weighing 174 grains with a lead core enclosed in a drawn cupro-nickle envelope. The point of the bullet is struck to a radius of about eight calibres,and in the pointed end of the envelope in front of the lead is an aluminium tip. This is required partly to bring the bullet to the correct weight for the required ballistics,and partly to balance the bullet suitably for accurate shooting. Near the rear end of the bullet there is a cannelure,which is filled with beeswax,provided partly for lubrication and partly to waterproof the joint between the bullet and case.

The bullet is secured into the case by three indents made in the case,the metal of the case being pressed into the cannelure.

The case is of solid drawn brass,and has a rim or head at the base end by which the cartridge is positioned in the gun and extracted. The cap chamber is recessed into the back of the case,and has a fixed anvil,two fire-holes being provided.

The cap composition is pressed into the cap,and a disc of varnished tinfoil is placed over it,the whole being waterproofed with a coating of shellac varnish.

The cap which is made of copper,is pressed into the case and rivetted in place,and the joint between the cap and case is varnished.

There are for this cartridge two alternative types of charge,cordite and nitrocellulose powder.

The cordite used is in the form of tubular sticks of the type and size known as M.D.T. 5.2.

The nitrocellulose powder is in the form of chopped tube,and is of the "progressive" type,that is to say,it is impregnated to a certain depth with dinitrotoluene which has the effect of slowing the rate of burning during the early stages of combustion.

In both cases a glazed board disc is provided as a wad and placed between the propellant and the bullet. The material of which the wad is made has to be carefully selected,and must be chemically neutral,since the presence of either acid or alkali is liable to effect the quality of the cordire in course of time.

.455-inch REVOLVER AMMUNITION.

This ammunition is packed in cartons,each holding 12 rounds,these cartons being in turn packed in a tin-lined wooden box. The standard package is the BOX A.S.A. H.9. holding 240 rounds,but during WW1 large quantities of revolver ammunition were packed in the rifle ammunition box (BOX A.S.A. H.1),which holds 2,160 rounds of revolver ammunition.

The characteristic symbol is a representation of a revolver chamber in green on a white ground,overprinted 11 in black.

.455-inch AUTOMATIC PISTOL AMMUNITION.

The service cartridge for use in self-loading pistols is designed for the Webley & Scott self-loading weapon of .455-inch bore. It has a solid drawn brass case of the rimless type,that is to say,it has no rim or head,and the cartridge is positioned and extracted by the extractor which fits into a circumferential groove near the base of the cartridge. The cap is identical with that of the revolver cartridge. The bullet has a nickle-plated copper envelope and a lead core,and weighs 224 grains. The normal charge is 7 grains of pistol cordite. No wad is provided.

The requirements as regards pressure,accuracy and penetration are the same as those of the .455-inch revolver cartridge,but the velocity is higher. this should be about 700-fps at a distance of 30 feet from the muzzle. The cartridge is submitted to the usual casualty proof,and must function satisfactorily in the Webley & Scott self-loading pistol. Each cartridge is weighed,hand guaged and examined,and the cartridges are packed in 7 round cartons in tin-lined wooden boxes,the normal package being the A.S.A. H.9 box,which holds 252 rounds. the characteristic symbol is a green Plimsoll mark on a white ground,overprinted 1 in black.

.303-inch Mk.V11 Cartridge.

Small arm cordite is usually loaded in the form of tubular sticks,and in this case consists of a number of tubular strands,usually about 44,grouped together into a rope,which is delivered on reels each holding from 50 to 60 lbs. of propellent. The number of strands chosen is such that the charge is formed by inserting the rope in the cartridge case,and cutting off the required quantity. The charge is controlled by regulating the length cut off for each cartridge,and the cordite should be so blended and reeled that some length within the allowable limits of 1.55-1.6 inches produces a charge which will give an average velocity between 2,340 and 2,420 feet a second,with an average pressure not exceeding 19.5 tons. Before loading,the exact charge for each reel is assessed by loading a few cartridges and measuring the velocity and pressure,and fixing the length of charge to give the required ballistics accordingly. Where there is a reason to suspect that the ballistic qualities of the reel are irregular,an assessment may be made at more frequent intervals,and a portion of a reel only used before another assessment is made.

Sometimes the cordite is unreeled and laid out on a tray,about half the cordite on a reel being laid out at a time. The cordite is placed in a hut,in the wall of which is a trumpet shaped hole,through which the cordite rope passes into the loading room. The loading mechanism consists of a horizontally reciprocating head,containing three tools,across the face of which the cartridge cases,which are fed into a rotating disc carrier,are carried in turn. The first of these tools is a case punch,which slightly opens the mouth of the case. The second tool consists of an arrangement for gripping the cordite and carrying it forward to the extent of the travel of the reciprocating head,which is adjusted so as to feed the required length of cordite at each stroke. As each length of cordite is fed into the case a rotating knife cuts it off,and the case then passes to the third tool,which is a punch which presses the cut off strands into the case. The machine is arranged so that if there is a failure in the supply of cordite,and the punch can go right into the case,the machine is automatically stopped.

As a precautionary measure the cordite is arranged to pass through a ring,to which is attached by means of an inflammable cord a string supporting a guillotine across the face of the hole in the wall. Should by chance a fire start in the cordite,this burns the cord and releases the guillotine and thus isolates the bulk of the cordite in the hut before the fire can reach it.

BOESINGHE.

A discovery in February 1992 when land was being cleared for development in the industrial park north of Ypres,was a Command Centre in a section of a communication trench east of the Yser Canal at Boesinghe.
Credit for the opening-out of the trench system,goes to a group of enthusiastic Belgians working under a special licence from the Flemish Regional Authorities,keeping ahead of the concrete pourers,attemting to locate,uncover and record such reminders of the Great War.

The communication trench was a superb example of a part-trench,part-breastwork system showing how the sappers of the time overcame the problems of drainage inherent in any sort of digging project in Flanders,and particularly alongside a canal.
The depth from ground surface to duckboard planking was about three-feet,with another two-feet of space below the planking. This latter area formed a drainage ditch,running about a foot above water-level,a level that was clearly apparent in the down sloping entrance to the dugout itself. The inverted 'A' frames and duckboards were in remarkable condition considering the time they had spent surrounded by damp earth below the surface.
A mass of telephone wiring leading into the dugout was in place,as were spare wiring drums. Spent bullets abounded and a replaced section of planking edged by scorched sections of the trench walls indicated possibly,a direct hit from an enemy shell. A fair amout of rusted iron and rifle 'skeletons' devoid of woodwork were scattered about,and a piece of the inevitable rum-jar held pride of place in the trench wall.

The sophisticated trenchlines in this area were built in 1916-17,well after the line had been consolidated following the gas attack in April 1915.

Other 'discoveries' in the area were the remains of 18 bodies,found near the site.

Only 7 of the 18 bodies were 'officially'reported and collected for re-burial,and these were visited by the scavengers between the time the remains were found and the time they were collected. Of the 7,2 were German,4 were French and one was British. The remains of the two Germans were quickly collected and taken to be buried at the Langemark German cemetery. All four Frenchmen,found buried in a shellhole about twenty-yards west of the dugout,were Zouaves of the 3rd Zouaves Regiment.

In another shellhole about 100-yards away,a British soldier was found. His remains,identifiable as British by his webbing fittings,khaki cloth (sleeve,cuff and collar,plus part of a sock and one boot),were without skull or pelvis and what small amount of bones were found indicated that he was blown to bite and,what was found of him at the time,buried in a shellhole.

He was laid to rest with six others at Cement House Cemetery,Langemarck on Monday 19th October 1998. Seven small,crude wooden boxes were lined-up in front of a narrow trench in front of seven headstones,the remains were eventually laid to rest by local War Graves Commission gardners.

Between July September of 1998,34 bodies had been found in the trading estate area. Nine were British and the rest were French and German. Seven of the British,buried as described above,will carry the 'Unknown Soldier' headstone. The remaining two were found with clues to their identity and research is underway to establish that identity before they are buried.

Unfortunately,it is becoming a nuisance in terms of paperwork and general bureaucracy for Belgian farmers,construction companies and the general puplic to report such finds. Many don't bother any more and just ignore their presence (having first pilfered cap-badges,collar-dogs,etc).

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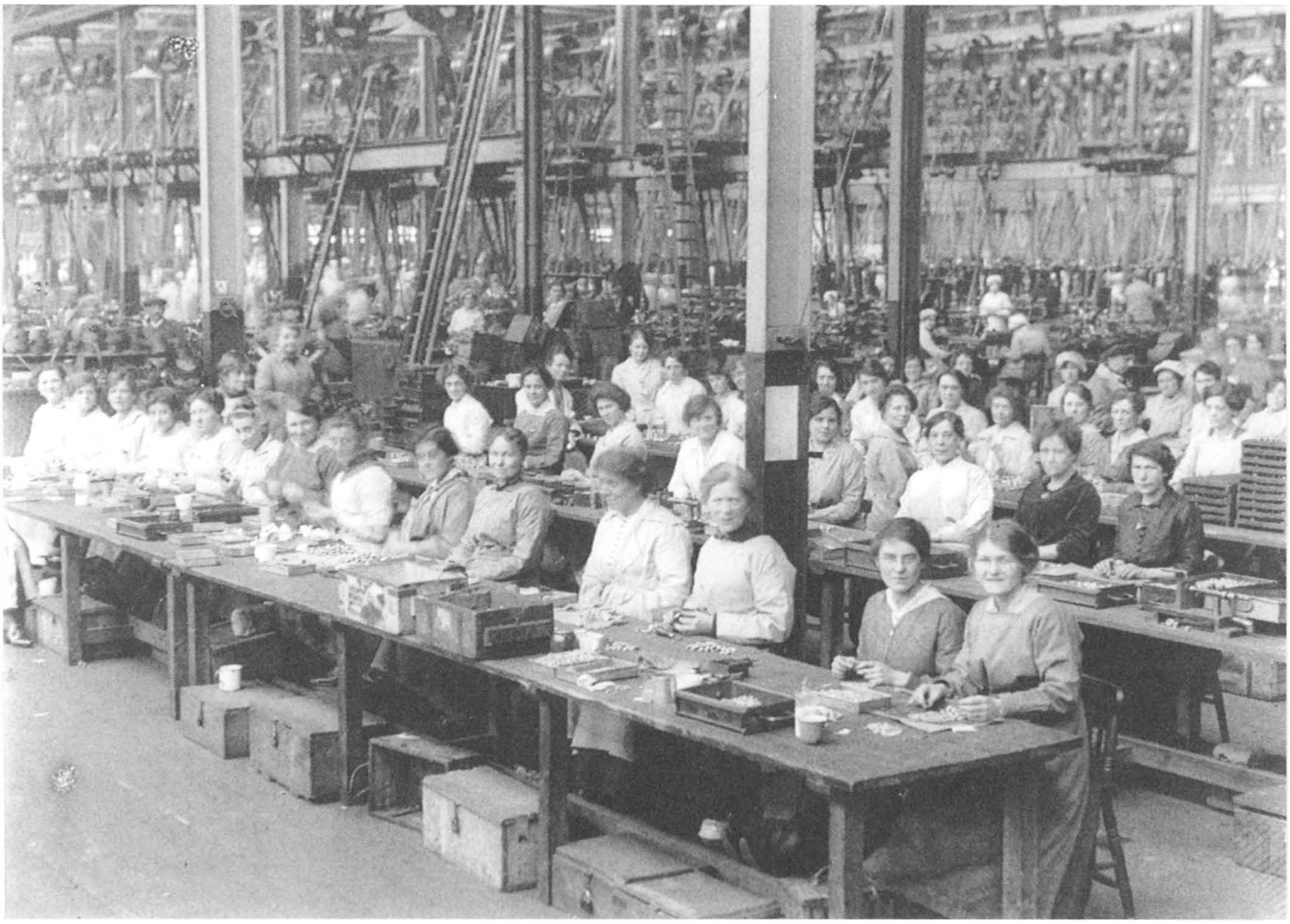

SHORT 9.45-inch MORTAR.

SHOWS ELEVATING AND CIRCULAR BASE.

<u>THE VICTORIA CROSS.</u>
Nobody pointed out until many years had passed that the 'VC guns' from which the Victoria Cross was made of were in fact Chinese,not Russian,and not have been anywhere near the Crimea. After all,one foreigner is very much like another and both the Russian and the Chinese had recently been enemies of the Queen.

The Chinese gunmetal proved so hard that the dies which Hancock's used began to crack up,so it was decided to cast the metals instead,a lucky chance which resulted in higher relief and more depth in the moulding than would have been possible with die-stamped medal.

By the spring of 1856 the Order was in hand,but there followed months of dilly-dallying on the part of Panmure and the various departments concerned,while they sorted out who would be eligible for the Admiralty and the Army,but they took a long time making up their minds.

The Queen took a lively interest in the design of the Cross. When the first drawings were submitted to her,she selected one closely modelled on an existing campaign medal,the Army Gold Cross from the Peninsular War. The Queen suggested only that it should be 'a little smaller'. She also made a significant alteration to the motto,striking out 'for the brave' and substituting 'for valour',in case anyone should come to the conclusion that only brave men in a battle were those who won the Cross.

The commission for the new medal was taken to a firm of jewellers,Hanock's of Bruton Street,who had a high reputation for silver work. From the beginning,however,it has been decided that the new decoration would be made of base metal and the first proof which the Queen received was not at all to her taste.

The Cross looks very well in form,but the metal is ugly; it is copper and not bronze and will look very heavy on a red coat with the Crimean Ribbon. Bronze is,properly speaking,gunmetal; this has a rich colour and is very hard; copper would wear very ill and would soon look an old penny. Lord Panmure should have one prepared in real bronze and the Queen is inclined to think that it ought to have a greenish varnish to protect it; the raised parts would then burnish up bright and show the design and inscription.

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GERMAN SHELLS AND FUZES.

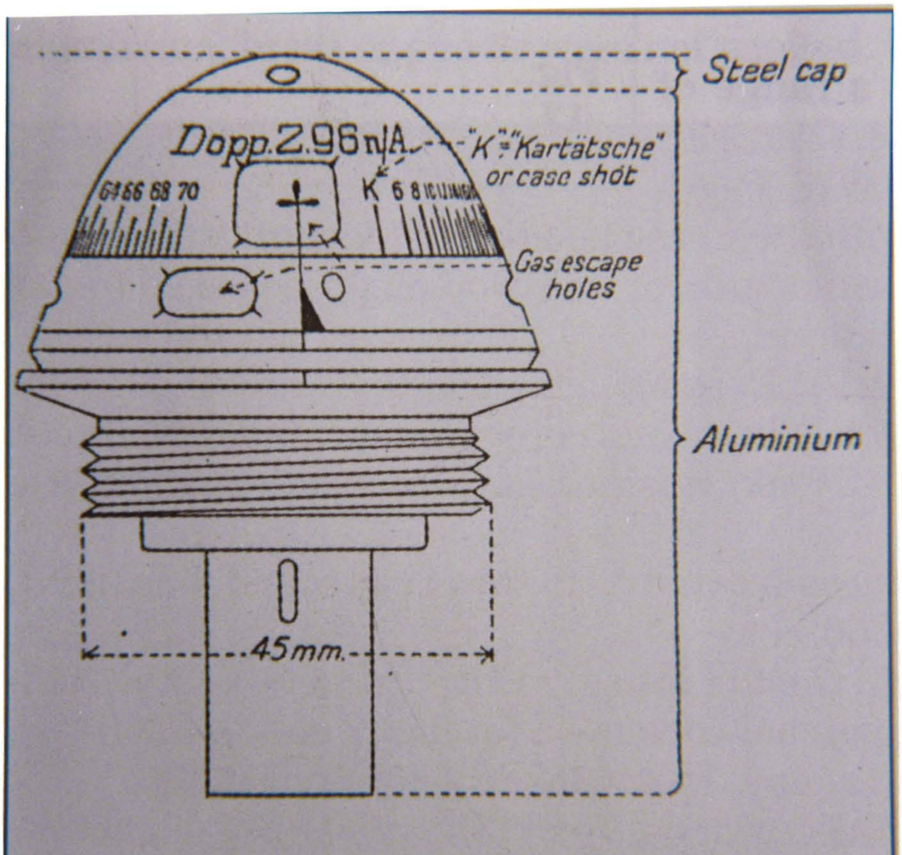


Fig.7 lg. Bd. Z. 10.

Fig. 9 Dopp. Z. 92 f. 10 cm. K.

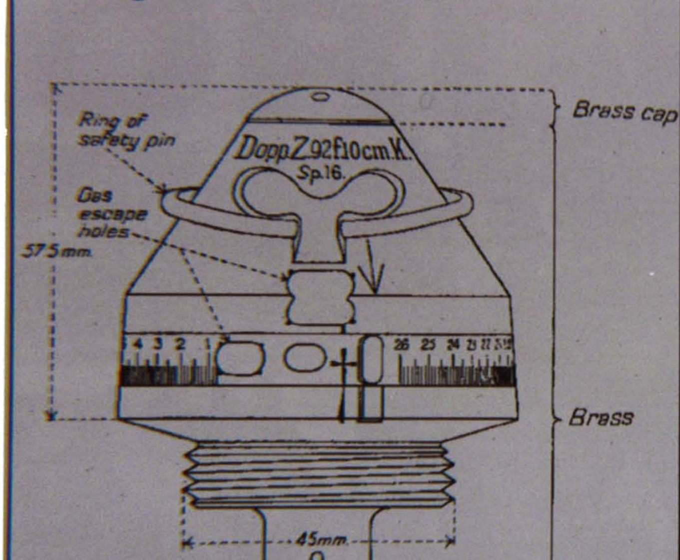
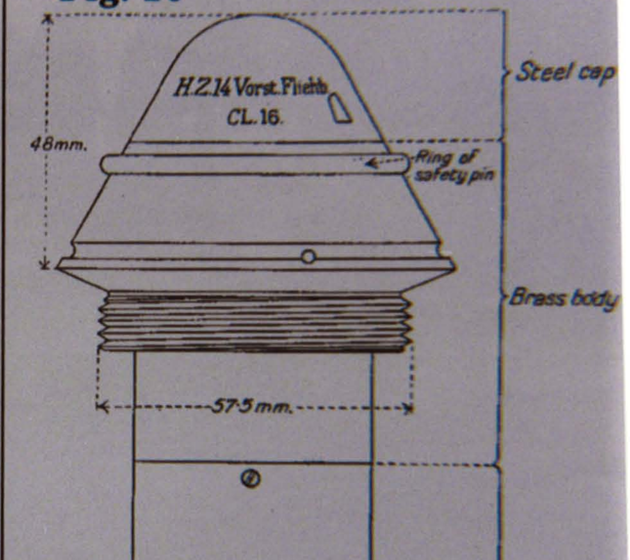


Fig. 10 H.Z.14 Vorst. Fliehb.

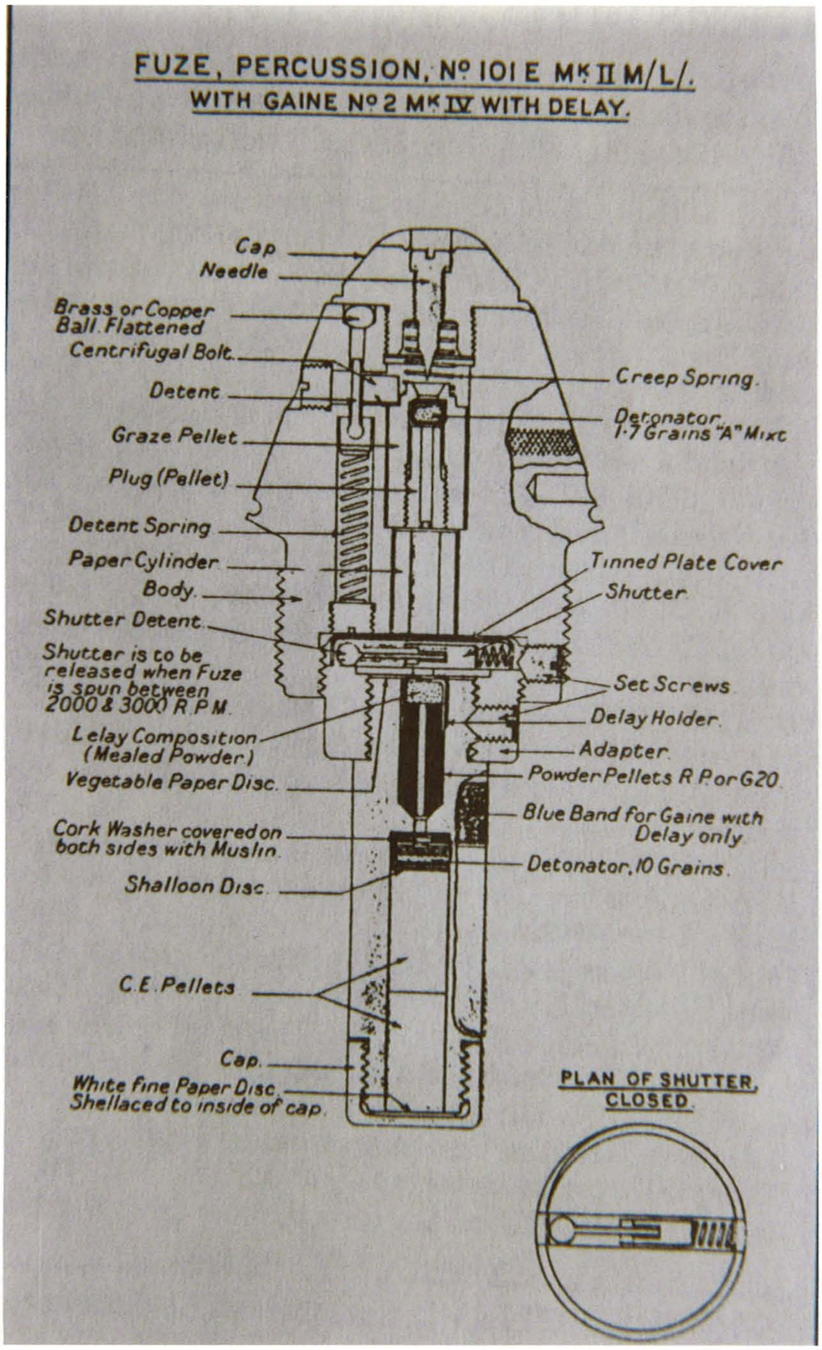


Fuzes No.100,101,102,103.

These fuzes went to 89 marks and were nose graze used with all types of HE shells from the 13-pdr to the 12-inch Railway Guns.

Graze Fuze.

A graze fuze shell differs from the direct action type in that instead of depending for its action by a blow on an actual part of the fuze,it relies in the check on impact to the forward velocity of the shell. So long as the shell stops suddenly-the shell will function.
Once fired,the detonation pellet having overcome a number of safety features such as centrifugal bolts,detents and pressure plates,floats free when the chamber of the fuze. It is prevented from striking the needle by a 'creep spring'. On impact whilst the shell loses velocity,the pellet,by reason of its inertia,overcomes the creep spring,striking the needle and causes the fuze to function.



GUN COTTON.

The cotton,in the form of the best white cotton waste,consisting of the cuttings from cotton-spinning machinery,is thoroughly cleansed from all fatty and foreign matter,and thus becomes almost pure cellulose.

It is then steeped for a short time in the strongest nitric acid,to which three parts by weight of strong sulphuric acid have been added,the use of the latter being to take up the water which results from the action of the nitric acid on the cellulose,and which,if left unabsorbed,would weaken the strength of the nitric acid,and thus prevent the proper conversion of the cotton into true gun-cotton. The cotton,now converted into gun-cotton is very thoroughly washed,wrung out,and boiled,to rid it of the free acid,which if left in,even in minute quantities,would not only be fatal to the keeping qualities of the gun-cotton,but would make it dangerous to store,owing to its liability to decomposition and spontaneous combustion. After the washing process the gun-cotton is converted into a pulp,and in this state can be moulded and pressed into any required form. When finished,it should contain from 1 to 2% of alkaline matter derived from a bath of lime water,whiting and caustic soada,into which it is placed before moulding.

WHAT IS GUNCOTTON?

Invented by Schombein in 1846.
Consists of cotton waste,purified,dried,and heated with a mixture of concentrated nitric and sulphuric acid. Washed and reduced to a pulp.
Used in the manufacture of Cordite.
Also moulded into 1-0z. slabs for Service use.
Size of wet-slab of Gun-Cotton 6x3x1.5-inch.
Wet Gun Cotton will not explode if hit by a bullet.
Wet Gun Cotton can be sawn by a wet saw.
It requires a dry primer,detonator and fuse to explode.
Dry Gun Cotton will explode if hit by a bullet.
Strength-2.5-times stronger than gunpowder unconfined.
Strength-7 to 8-times stronger than gunpowder confined.

T FRICTION PUSH TUBE MK1.
The head was of brass,square in section,with one end rounded to ensure correct loading of the tube in the breech vent and also to facilitate extraction.

Housed within the head were the detonator and friction push bar. The detonator had explosive composition contained between perforated brass discs,held together in a copper shell.
On tubes manufactured after December 1908,a pressure relief hole,0.08-inch in diameter,was bored longitudinally through the head. This was closed at the end with shellac putty and coated with Pettman's cement. The body,screwed into the head and secured with a brass pin,contained eight grains of fine grain powder,sealed at the outer end with a shellacked cork plug,shellac cement and a paper disc. A soft copper ball was retained in the body inner end by a screwed plug drilled with three flash holes.

Pushing the friction bar into the body sheared the shearing wire and forced the conical bar end through the detonator into the roughened recess,the roughened surfaces igniting the composition. The flame passed into the body,around the ball and through the three plug flash holes into the fine grain powder,which fired out through the body outer end. Pressure drove the soft copper ball back into the tapered hole to seal the tube and prevent gas leakage to the rear.

In the event of a misfire,the tube could be removed from the breech and a new one inserted with the breech closed. This would be carried out with extreme care-T-tubes or main charges or (both) could detonate during the operation.

Should the axial T-vent channel become choked with fouling from the main charge,the tapered T-tube seating would be cleared with a T-vent rimer,sufficient enough to permit the insertion of a T-friction tube. This when fired,would clear the axial T-vent of fouling.

Fired tubes woul be immersed in mineral oil as soon as possible after firing,then returned to Woolwich for repair and refilling.

T-friction tubes were issued in square tin boxes 10 to a box. Both top and bottom of the box were removable,being secured by soldered bands. This allowed 5 tubes to be withdrawn from the top and 5 from the bottom.

T-tubes manufactured before December 1908,lacking a relief hole were converted into drill tubes after firing.

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THE FIRST EXPLOSION.

Albert Lawrence,Charles Perkis and John Parkes were working in the circular No.5 Mixing House building in the nitro-glycerine section of the RGPF North Site pouring the product onto the gun-cotton when something-we shall never truly know what- went wrong. After the explosion of some 6,000-lbs of nitro,gun-cotton and mixed paste,all that was left of No.5 Mixing House was a pair of steaming craters. A shock wave reverberated across the factory,and,in spite of a high protective mound-the tried and proven feature designed to deflect the blast safely upwards-the catastrophe was not confined just to the mixing house. The blast also travelled to the east through the canal-side loading bay gap,the shock wave striking a hand-worked paste wagon being pushed by two men northward from No.20 Stove along the truck lines only 100 feet to the east. The wagon pushers,Bert Kelman and John Robinson,were lifted off the trackway,hurled to the ground and,suffering terrible injuries,both killed. It was Robinson's first day on the job.

The 8-ft long,leather-lined wagon toppled from the track and the 640-lbs of dry gun-cotton packed in 16 bags within detonated.

Although further protected by a substantial concrete wall,Building No.75 (No.14 Stove),the next danger building to the south,added its 5,200lbs of dry gun-cotton to the cacophony. The contents of this building were only 17 hours into the lengthy cooling down period and were still unstable.

Assailed from a distance of around 250-feet by the explosion of No.5 added to the subsequent blast of No.14 Stove across the canal and the eruption of the wagon load less than 50-feet away,the explosion of Building No.74A (No.18 Stove),was perhaps understandable,even though the 5,200-lbs of gun-cotton had been drying inside for 37-hours and represented the most stable explosive in the immediate area.

As some of the black,white and yellow smoke from the series of blasts cleared,other sources of fire threw further columns of acrid smoke into the sky,and Building No.76A (No.19 Stove) started to burn. In addition,a range of other factory buildings had already been wrecked by blast,four being totally destroyed and several put out of action.

The Royal Gunpowder Mills.

'...the most important site for the history of explosives in Europe. This can be stated with confidence as is was not only the place where most of the major technological breakthroughs were made but it also retains,by a very long way,the best surviving examples of structors representing each of these technologies'...

David Stocker-
Inspector of Ancient Monuments,
English Heritage.

THE ROYAL GUNPOWDER MILLS.

Explosives are recorded to have been manufactured on the 190 acre site since the Middle Ages,at a time when industrial activities,including the woollen industry,relied upon water power obtained from the River Lee. Corn milling was mentioned in the Domesday Book,and provided an additional activity when gunpowder making was reduced in times of peace.
"Nationalisation" took place in 1787 when the site was purchased by the Government and was further developed during the Napoleonic Wars between 1793-1814.
The introduction of steam in the 1850s provided the increase in power to advance the production technology of gun-cotton and nitroglycerine in 1895 and tetryl in 1910.
The site has always been a source of major employment for the town of Waltham Abbey,requiring a workforce of over 5,000 during the 1914-18 war.
As a research establishment it was responsible for the development of the "Dambusters" explosive,RDX,and late 20th century missile propellants.
In 1991,the rationalisation plans for national defence research left the site surplus to Ministry of Defence requirements.

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Scheduling and Listing.

After 6 months survey work by RCHME and the collaboration of English Heritage,the Department of National Heritage confirmed the importance of the site with the scheduling of much of the site (100 acres) and bestowing listed building designations on 21 buildings -Grade 1; 7 Grade 11* and 13 Grade 11.

POZIERES

"The powdered debris of houses and earth was spread like ash six-feet deep over the surface,as featureless as the Sahars,and level except for the shell craters which lay edge to edge like the scratchings of gigantic hens in an endless ash heap. Each fresh salvo flung up rolling clouds of the dust and rearranged the craters. Except for two fragments of German pillboxes every vestige of building above earth level eventually vanished.

Vistors shocked by the destruction of other Somme villages were unimpressed at pozieres because it had simply become an open space,marked vaguely by tree-stumps,but with no other sign that a village had been there."

THE BATTLEFIELD OF POZIERES
AS IT APPEARED IN AUGUST,1916.

POZIERES

The cross road leading to Casualty Corner. All traffic along the road to Pozieres passed through this point.

POZIERES

The trench system known as Centre Way running through the ruins of Pozieres. The view is towards the high ground and Mouquet Farm.

POZIERES

Pozieres main street on the 26th of August 1916-from the trench known as the Centre Way.

POZIERES
POZIERES CHURCH.

"We had three observation posts. The best was the church tower at Pozieres; we could see about ten kilometres behind the English lines; the airfields,the gun positions and movement of the infantry. But the English artillery hit the tower and literally in the last second,we slid down the ropes of the bells and were saved."

by Feldwebel Felix Kircher,26 Field Artillery Regiment.

POZIERES
POZIERES CHURCH AFTER 1916•

POZIERES

SOMME 1916.

POZIERES 1916.

POZIERES
GIBRALTAR.
Former German Blockhouse.

This stronpoint was called Gibraltar because the German troops defending it,the Hanoverian Fusiliers wore a regimental badge that represented the Rock of Gibraltar.

POZIERES
GIBRALTAR.
Former German Blockhouse.

POZIERES
Main street of Pozieres
looking towards the Windmill.

POZIERES
The village of Pozieres before the war
looking towards Albert.

SAILORS IN THE TRENCHES.

The Royal Marines fought their first actions of the war in dark blue uniforms,their headwear being the Brodrick cap. The Brodrick was round topped,piped with scarlet,and the cap band,which was also scarlet,was partly obscured by side flaps which were turned up. This cap was detested since it proved almost impossible to stow it in a pack without flattening it and it had been abandoned by the army some years prior to the outbreak of war. During the defence of Antwerp the RM wore khaki uniforms of the army8s 'Service dress,home service'. The only distinguishing features of their uniform at this period was the globe and laurel cap badge,in bronze,and naval web gaiters. Their equipment was of the 1908 pattern.

During the initial operations of the naval brigades they were dressed in typical sailor's fashion. The uniform proscribed being more or less that of naval landing parties. The short sailor's jacket,with white trimmed collar,and the trousers,covered at the ankle by gaiters,were blue; as was the cap. The equipment was made of blackened leather and consisted of a waistbelt with an open square buckle on each side of which were oblong,flapped,cartridge pouches. A bayonet was hung from the waistbelt and Y braces together with a bandolier and a waterbottle completed the field kit.
After their withdrawal to england,the sailors were re-clad in khaki; these uniforms were basically of the army style but with several variations.
Officer's rank was indicated on the shoulder straps in the military fashion as well on the cuffs. These latter markings were true naval insignia consisting of khaki tape rings and curls. The RNR and RNVR officers had their own distinctive 'wavey' rings.
Royal Marine officers wore army rank badges. Officers of the RN Division wore naval caps with khaki cloth covers and they were unique in the fact that they were armed with an automatic pistol which was carried in a leather holster on the belt,to the left of the buckle. Petty Officers and other non-commissioned ranks wore red naval arm badges,as did most specialists and tradesmen.

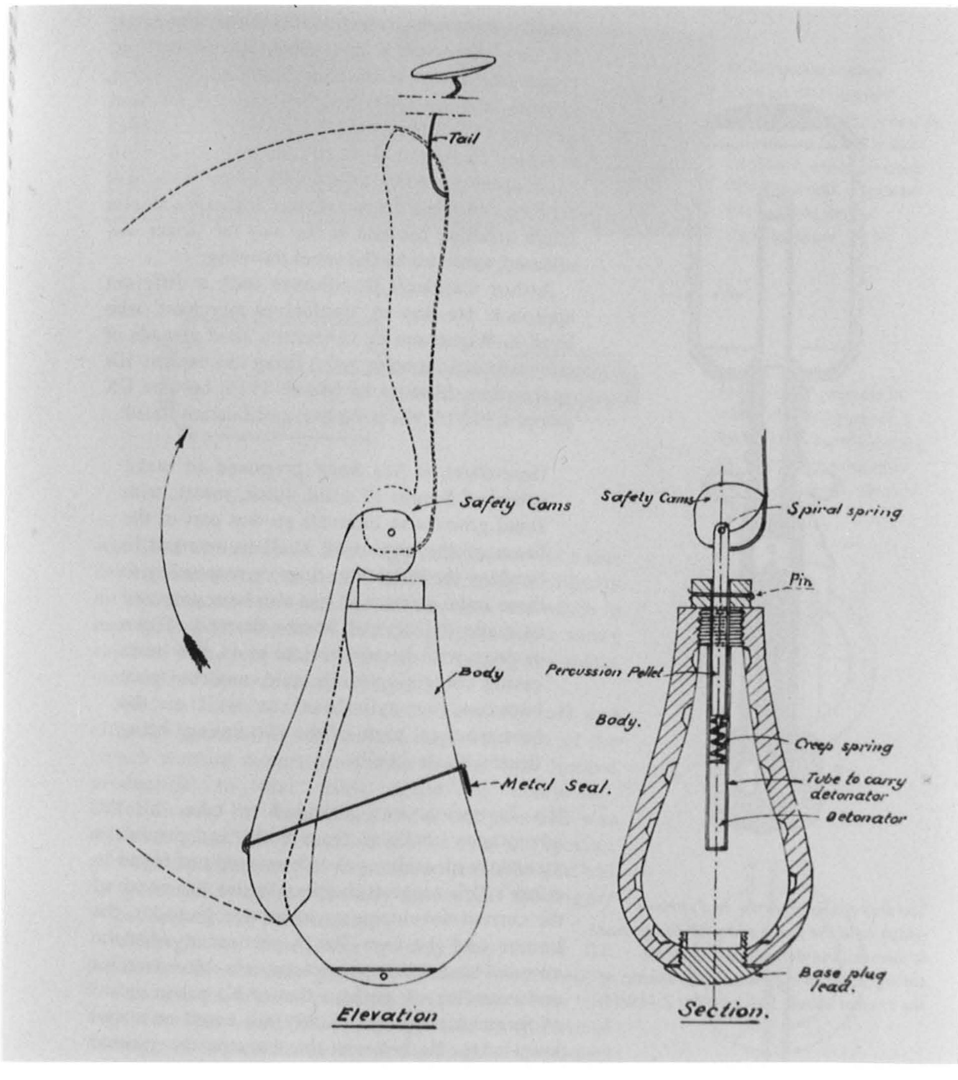
EARLY GERMAN MORTARS

WW1

THE FRENCH PERCUSSION GRENADE OF 1915.

This may have been the P MODELE 1915 (although Billant's grenade was called the P1).
It was 3.5-inches long with a maximum diameter of 2-inches and contained 1-oz of explosive.

The aluminium lever was secured to the body with a string fastened with a metal seal. An 18-inch streamer or tail with a small metal 'steadying plate' was attached to the lever and folded beneath it. The cams on the top of lever held the striker until the grenade was thrown.
When the lever flew up,the cams were freed from the grenade neck,freeing the striker. Like the Mills,the grenade was held with the lever against the palm and immediately before throwing the seal was twisted off.



The stock of the G98, showing not only the inspectors marks but the butt disc on which appeared unit identifications marks, in this case II S. B. or second 'Sea Battalion'.

measure was the substitution of the expensive and time consuming seasoned walnut stocks and hand guards with cheaper alternatives such as copper beech, and glued two piece constructions which used up pieces of wood which by themselves were too small. Interesting though small scale modifications for special purposes also included luminous sights for use in poor light, and a *"Gewehr mit Spielgelkolbern"* or rifle with periscope mirror, for firing out of a trench without showing your head.

The G98 was also widely adopted as a sniper's weapon, and its range, accuracy and power were well suited to this role. To begin with standard manufacture G98s were fitted with Goerz *Certar Kurz* telescopic sights, but very quickly a factory produced modification was under way. This modified arm was known as the *Scharfschützen Gewehr* 98 or literally Sharpshooters model 98 rifle. In essence this was a basic G98, picked from the production as a flawless and accurate example, finished to better than normal standards, and fitted with a bolt handle which bent down to a less awkward position than the usual 90 degrees to the body of the gun. A four times magnification Goerz or Zeiss telescope was mounted, slightly off set to the left so that the magazine could still be loaded using a charger. Issues were also made of special 'K' type ammunition with a steel core capable of penetrating metal shields and certain forms of cover impervious of the normal lead cored bullet.

Gewehr 98: Basic Data

Calibre: German army 7.92mm. Originally round nosed type '88' ammunition, later pointed 'S' type.
Magazine: Five round internal; later use of 20 round 'trench' magazine.
Overall length: 125 cm.
Barrel length: 74 cm.
Weight: 4kg.
Sights: *Lange* model, marked up to 2000 yards.
Production: Believed to be in excess of 5 million, 1900-1918.
Variants: Sharpshooter's model; 'star' model; also used as the basis for models of carbine including the Second World War K98k.

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Motor Raiders

Early Armoured Cars 1914-1915

Before trenches dominated warfare on the Western Front, newly armoured British cars carried out swift, relentless raids against the Germans in Flanders. DAVID FLETCHER, of the Bovington Tank Museum, reveals the buccaneering story of these first armoured cars.

The early months of the Great War are generally depicted as a David and Goliath struggle, with the tiny British Expeditionary Force pitted against a giant German opponent. All of which conveniently overlooks the massive French presence, never mind the Belgians. By the same token all historians' eyes are focused on the Marne and they tend to overlook another area, where an equally intense struggle was taking place between the Allies and the invaders.

This was the open flank of northern Belgium which existed as a result of the main German swing south on Paris. The Belgians pulled back to Antwerp, apparently secure behind its fortresses, while the French, in company with the British Expeditionary Force, covered Paris and confronted an increasing number of German armies intent upon taking it. This initial stage of the struggle took nearly three months but, throughout that time, there was a large swathe of disputed territory on the Germans' right, which was wide open for exploitation.

It proved a problem to all the combatants. Having lost Brussels the Belgian Army, under King Albert, was determined to hold Antwerp. The Germans were obliged to invest it since they had to contain such a large force which was effectively in their rear. However they were so heavily committed on the Marne and further south that they had few troops to spare to hold the rest of Flanders. The French were in the same situation. They had a force at Dunkirk but it was not very mobile and unable to react swiftly enough to German raids. German tactics were clear enough: they stayed mobile, visited towns in force and made sure everyone remembered that they had been there and then withdrew to bother somebody else. With such events taking place further south, it is not surprising that a degree of *laissez faire* crept into the situation. While the Germans more or less behaved themselves, the French forebore to respond too fiercely since it was clear that, in the end, it was the civilians who would suffer most.

The hornet that was destined to irritate this comfortable state of affairs flew in from across the English Channel. Its name was Charles Rumney Samson, Commander R.N., of the Eastchurch Squadron, Royal Naval Air

A Talbot armoured car in Ghent at the time of Churchill's visit. The Maxim gun is mounted directly on top of the driver's hood.

Service. On the morning of 27 August 1914, Samson, flying a B.E. Biplane, led his squadron into the air from Eastchurch aerodrome on the Isle of Sheppey. It was a motley flight with seven different types of aircraft. Each pilot had a couple of inflated bicycle tyres wrapped round his middle as a lifebelt and a .45 automatic pistol at his side. Each plane also carried a large Union Jack flapping from its wing struts since none of them bore any other form of national identification. Travelling independently was Samson's brother Bill with an equally odd collection of cars and lorries which formed the squadron transport. Their collective destination was Ostend.

The inspiration for this excursion lay with Winston Churchill, the First Lord of the Admiralty. Ever anxious to get in on the action he had despatched General Aston with the Royal Marine Brigade to occupy Ostend in support of the Belgians and Samson's squadron was added to the force to provide reconnaissance. Two days after they arrived General Aston asked Samson if he would carry out a motor reconnaissance to encompass the cities of Thourout and Bruges. Samson enlisted another of his brothers, Felix, who owned a large Mercedes. This was equipped with a Maxim gun and, joined by another car they set out. It was not immediately fruitful, no Germans were encountered but it sowed the germ of an idea.

On the very next day the Marines were withdrawn and Samson was ordered home with them. The force was seen as too small to achieve anything, while the ships that were supporting them were very vulnerable to U-Boat attack. Samson took his squadron down to Dunkirk and there he contrived to stay, despite signs of increasing annoyance from the Admiralty. Soon he had the support of General Bidon, the French commander in the area and within a few days the Admiralty capitulated, instructing him to provide reconnaissance for the French and also to watch out for any Zeppelins which might be raiding across the Channel. Inevitably Samson soon exceeded his brief and, with the connivance of Churchill, subsequently organised bombing raids against the Zeppelin bases at Dusseldorf and Cologne.

However our concern, in this instance, is with his activities on the ground. On 4 September he and his brother Felix, with the Mercedes and a Rolls-Royce, encountered a German car patrol near Cassel. The resulting fight was inconclusive but it convinced Samson that he could do a lot better if his cars had some armour protection. The Admiralty agreed and the company Forges at Chantiers de France of Dunkirk fitted some boiler plate, to Felix Samson's design, on the Mercedes and Rolls-Royce. At the same time he was provided with a force of 250 Royal Marines. Some of these would travel in unarmoured cars and with this mixed force Samson enjoyed a number of encounters with

One of the improved, armoured Talbots, which Samson named after an earlier action, is subjected to a rough but effective test of its armour. Notice the greater flexibility of the new Maxim mounting.

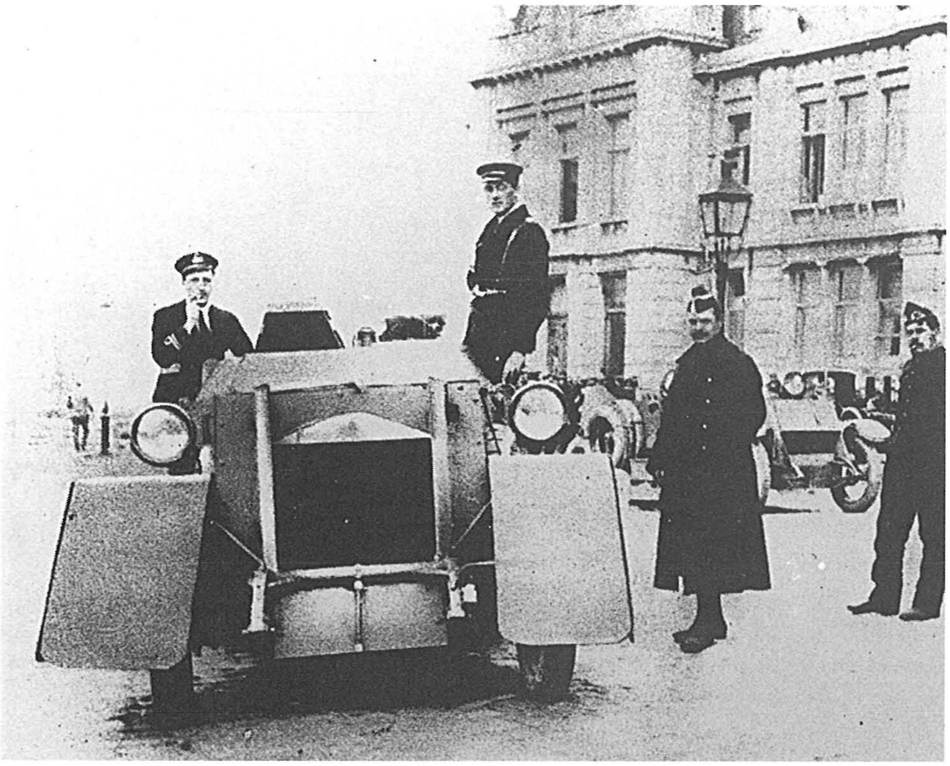
German patrols which at least served to convince the enemy that a substantial British force was operating in the area. Observing the success of these operations the Admiralty Air Department now decided to increase the size of the force. Sixty armoured cars, to a more or less standard pattern, were ordered on Rolls-Royce, Talbot and Wolseley chassis to be constructed at the Royal Naval Dockyard at Sheerness. Samson himself, meanwhile, had two ex-London bus chassis armoured at Dunkirk. They were intended as armoured personnel carriers to transport the Royal Marine riflemen, although they proved rather heavy for the job.

The cars designed by the Admiralty were not exactly what Samson would have chosen himself. They had fully armoured radiators and engines along with a sort of hood for the driver, but the body armour only extended up to the height of the dashboard which meant that the rest of the crew were dangerously exposed unless they decided to lie down under fire. Each car carried a Maxim machine gun, for which two mountings were provided.

Samson's early motor raids were typically piratical affairs. This period is described in *Britain's Sea Soldiers* by General Blumberg: '... no one except the leader, generally Commander Samson, knew the object of the expedition; no spares were carried, no food, no maps, whilst the party was lucky if the car did not break down.' A born buccaneer, Samson was having the time of his life, yet as the force grew it was obliged to become more organised. As the officer in overall command Samson had fewer opportunities to go dashing off on his own and, although some of his subordinates were short on military experience, they were men of equal character and independence.

It would be impossible to describe all the actions within the compass of one article and in any case many were inconclusive, besides being rather repetitive, so a selection must suffice. On 21 September a group of four cars under Samson, each with a six-man crew, made a reconnaissance trip via Cassel, Hazebrouck and Bethune in the direction of Arras. Near the village of Savy they were warned of the presence of German cavalry and went to investigate. It was hardly ideal country for armoured car work, the road was hemmed in by high banks which limited the field of fire but, by sending one car on ahead they managed to flush out the Uhlans who made off across country, where the cars could not follow. The following day found them near the town of Doullens when they encountered five men of the 26th (Wurtemberg) Dragoons. In the ensuring chase, with the cars going flat out, four of the enemy were killed and the fifth later gave himself up, having been wounded.

While his aircraft remained at Dunkirk, Samson established himself with the armoured cars at the dilapidated Chateau



An Admiralty Rolls-Royce, with Commander Samson's original armoured Rolls just beyond, photographed in Ostend. The officer on the left, with a cigarette, is Flight-Lieutenant Marix who bombed a Zeppelin in its shed at Dusseldorf on the previous day.

Motte au Bois at Morbecque. Here, on 20 September, he was joined by 160 of the Royal Marines. On the 23rd, during a large scale reconnaissance, Samson learned of German troops in the town of Aniche. Hitherto it had been his policy to ambush German troops outside the towns for fear of reprisals but this time he went straight in with three cars. On the corner of a small square he came under fire from a group of men in the first floor of a house at 20 yards range. In the ensuing fire fight three of the enemy were killed and the fourth wounded while Samson's driver, Sub-Lieutenant Nalder, got a bullet through his knee and two other men were wounded. After the battle they discovered that the armour on all the cars had been penetrated by German rifle fire but in return they acquired four good German horses. On the following day Samson was ordered to head quickly for the town of Orchies where French troops were under attack. Again he left most of his cars as a covering force outside the town and went in with three, plus an ambulance. Most of the French troops, rather elderly territorials, were sheltering in a house while a small detachment, some distance ahead, was trying to hold off the Germans. The arrival of the armoured cars, with their machine guns, put new heart into the French who advanced in style and drove off the Germans. Even so Samson, who now considered himself in charge of everyone, was obliged to withdraw since enemy artillery had opened up. The Germans were gradually gaining in strength.

On 1 October Samson was nearly captured in Douai. He had gone there with two armoured cars and two other vehicles and set himself up with the French General Plantey in command at the Hotel de Ville. Samson estimated that there were 2,500 troops in the town but, when word spread that they were surrounded and that German troops had closed all the exits there was something approaching a panic and the square in front of the Town Hall began to fill. Arguing that it was better to live to fight another day than be trapped among a mass of troops who were ready to surrender, Samson fought his way out but he was unable to inspire the infantry to follow.

Antwerp was still holding out and the RNAS had a detached squadron, under Major Gerrard, carrying out flying patrols. meanwhile German heavy guns were systematically demolishing the ring of forts that protected the city. On 3 October, Samson, with eleven armoured cars and 70 London buses which had just arrived from England complete with their crews, started out for the city. It was a two day trip, with an overnight stop in Bruges, and on the 4th this impressive convoy rolled into the beleaguered city. The buses were to serve as transport for a Brigade of Royal Marines comprising the Chatham and Plymouth Battalions, which had been hurried across as part of a British attempt to bolster the Belgians who, reluctantly, were planning a withdrawal. On the same day the defenders were further reinforced by the newly raised, and quite untried, Royal Naval Division, but it was all too late. For a week the Allies attempted to stem the German advance. Samson's armoured cars were sent dashing everywhere but the enemy was not to be resisted and by 9 October the defence of Antwerp ended in a virtual rout.

While all this was going on more armoured cars were arriving. Lieutenant Commander Josiah Wedgwood M.P., commanding No 4 Squadron, was operating with some success down the Scheldt valley using Lille as his base and extending through Tournai as far as Mons. The records show that he was equipped with armoured Talbots but photographic evidence from contemporary newspapers seems to indicate that he had Wolseleys. He too was thoroughly enjoying himself. 'This seems to me' he wrote 'a most admirable arm, better far than cavalry for this work'. Another section had to be despatched to Ghent to

An armoured Wolseley entering Antwerp with part of Samson's convoy.

German Sniper.

An Australian official photograph purporting to show 'An enemy sniper killed at his post by an Australian sharpshooter',Calvaire,near Bray, August 1918.