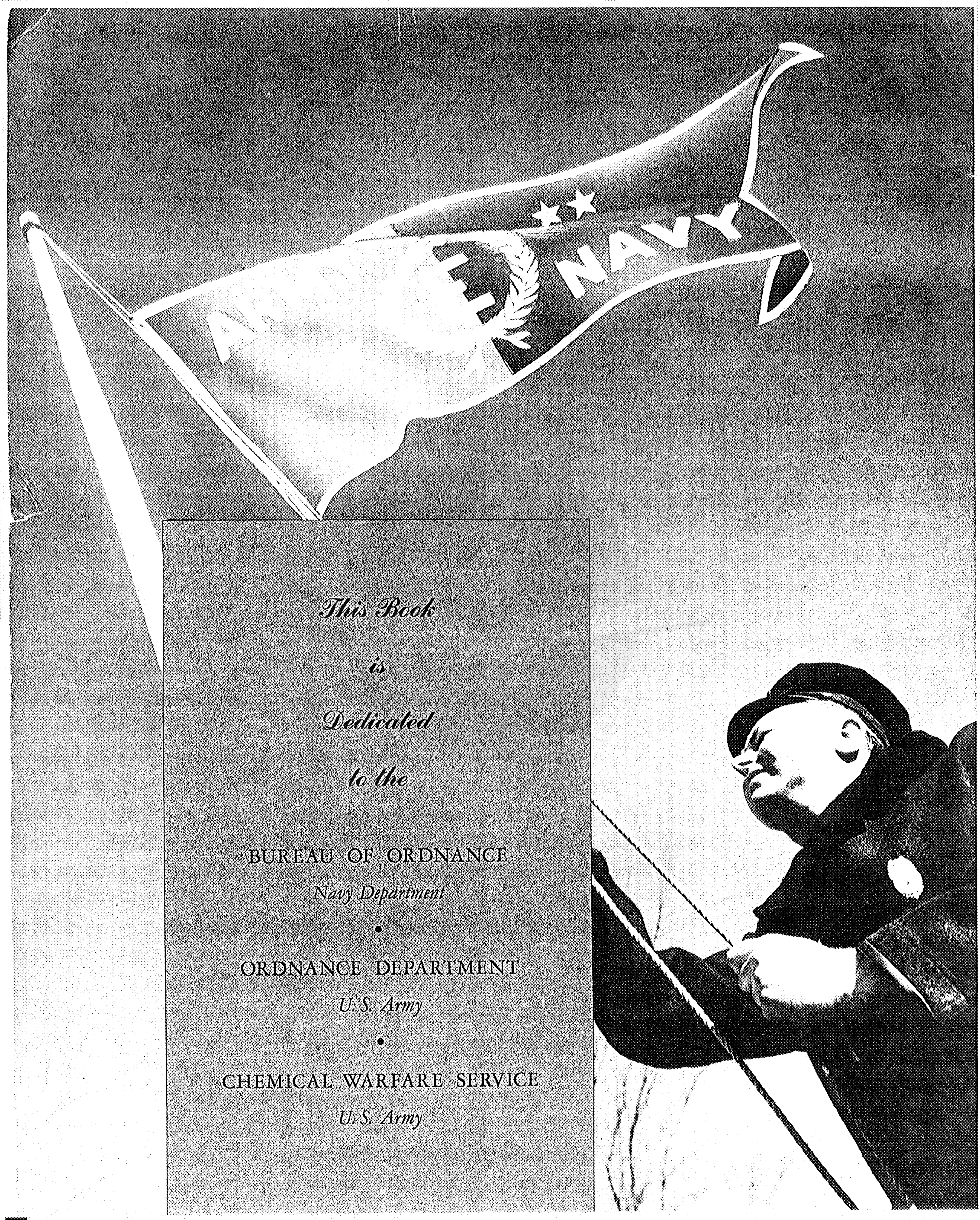
NATIONAL FIREWORKS *Review*

PUBLISHED IN THE INTEREST OF THE NATIONAL WAR EFFORT BY NATIONAL FIREWORKS, INC.



This Book

is

Dedicated

to the

BUREAU OF ORDNANCE

Navy Department

•

ORDNANCE DEPARTMENT

U. S. Army

•

CHEMICAL WARFARE SERVICE

U. S. Army

NATIONAL FIREWORKS, Inc.

National's part in the war effort is a well-established record of which every member of the National organization can be proud. We have gone "all out" to do everything, in every way possible, to speed the day of Victory. We have utilized to the fullest extent every facility we could muster—men, money, and machines.

Long before the United States entered the war, we saw the handwriting on the wall and set out to form a team of men that would be capable of doing the "impossible" almost as quickly as the "merely difficult." We scoured the country for men of outstanding ability, tops in their respective fields, and brought them together here at National—a team that is not afraid to tackle *any* problem.

We used every dollar we had, and borrowed what we didn't have, to meet emergencies where money was required to eliminate delay and speed vital production.

To do required jobs, we got the best machines made for the purpose. When machines couldn't be had, we used Yankee ingenuity and did the jobs anyway.

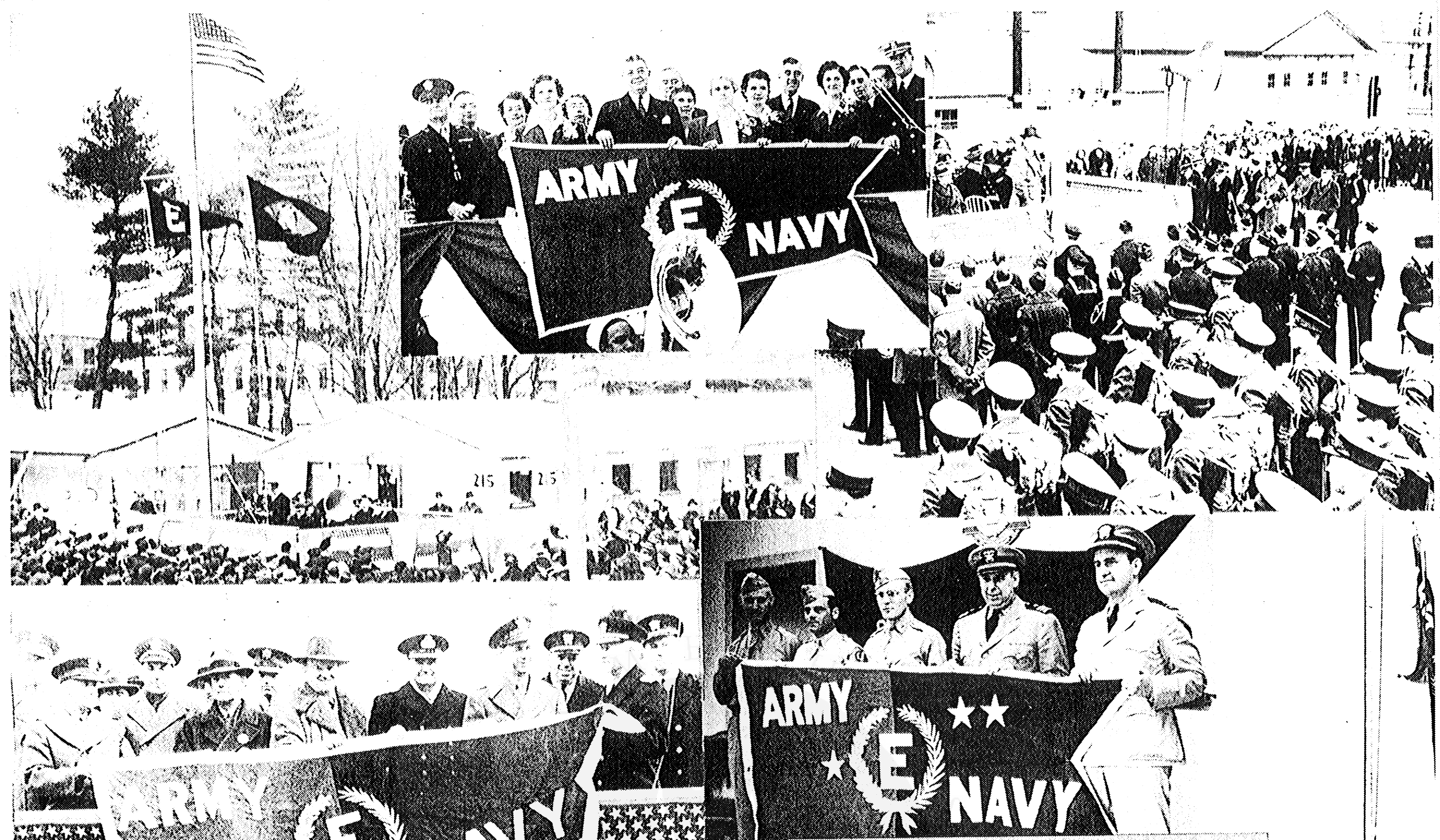
Every man and woman in the National organization has done his or her part, and the results have been good. Navy "E's" and Army-Navy "E's" have come from appreciative and splendidly cooperative Army and Navy bureaus. We have been, and are, producing the goods—*enough and on time*—of the quality necessary to do the best possible job

But, there is another great problem that National must face in order fully to serve its people and its country. That is the job of postwar accomplishment. We must continue to give employment to our presently employed men and women, and provide jobs for our people returning from the battlefronts.

Unless we, and other companies like National—the thousands now engaged in total war activity — plan with practical purpose for quick conversion to peacetime operation, our country will face a chaotic situation second only in danger to war.

National is already working and planning for the peacetime world to come. We are confident that we can lick this problem as successfully as we have licked so many others, and march forward together into the brighter, better World of Tomorrow.

Executive Vice-President



PRODUCTION HONORS

Main Plant

WEST HANOVER, MASSACHUSETTS

Navy "E"	January 12, 1942
Navy "E" Burgee with Anchor	May 1, 1942
Army-Navy "E" with Star	December 18, 1942
Army-Navy "E" with Two Stars	March 10, 1943
Army-Navy "E" with Three Stars	August 17, 1943
Army-Navy "E" with Four Stars	December 31, 1943

CORDOVA, TENNESSEE PLANT

Army-Navy "E"	December 8, 1942
Army-Navy "E" with Star	June 30, 1943
Army-Navy "E" with Two Stars	December 13, 1943

ELKTON, MARYLAND PLANT

Army-Navy "E"	March 18, 1943
Army-Navy "E" with Star	August 21, 1943

BRISTOL, VIRGINIA PLANT

Army-Navy "E"	October 23, 1943

AMERICAN FIREWORKS CO.

Randolph, Mass.

Army-Navy "E"	October 9, 1943

CHILLICOTHE PLANT

Army-Navy "E"	January 22, 1944

NATIONAL FIREWORKS Review

PUBLISHED IN THE INTEREST OF NATIONAL WAR EFFORT BY NATIONAL FIREWORKS, INC.

E. WILLARD FLINT, Editor of National Fireworks Review and the National News, the Employees' Magazine of National Fireworks, Inc.

This first number of the National Fireworks Review is in no sense a yearbook or history of National Fireworks, Inc. It is being published, not at the end of the war effort to summarize achievements—nor at the beginning to pre-view our abilities—but rather as an unfinished record of performance which may, or may not, be added to in the future.

This Review, for the most part, takes the form of a magazine published in the interest of the national war effort and to record in an informal way a number of subjects related to our activities as "loaders and fillers" of ammunition for the armed forces.

Many things which might have been said have been left unsaid. For excellent reasons we cannot even allude to certain phases of our contribution to the war effort. But, we have tried to succeed in making what we can tell at this time interesting to professional and layman alike.

Credits and Thanks

The Editor desires to express appreciation to Dr. Tenny L. Davis, Dr. C. G. Storm, Dr. Joseph Ackerman, Jr., Colonel Walter H. Lillard, Major C. P. T. Kaffke, Mr. W. Melvin Clark, Mr. David Black, Mr. Clark B. Allen, Mr. Earl Willson, and Mr. A. A. Borland of National Fireworks, Inc., for their helpful collaboration.

• • •

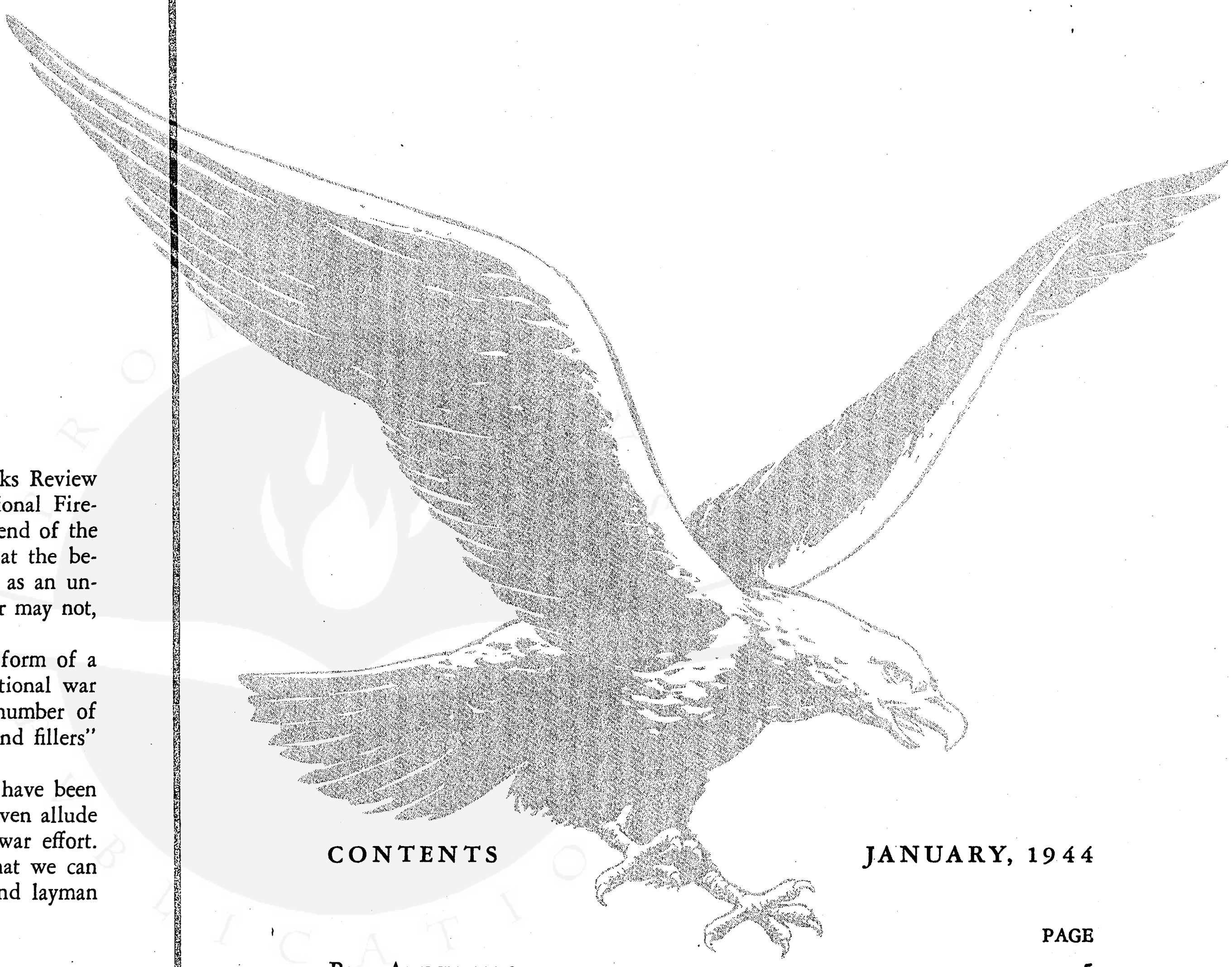
Typography and layout has been done under the supervision of Mr. Hugh Donnell, Vice-President and Art Director of Tracy, Kent & Co., Inc., of New York City.

• • •

A large part of the photography was done by the well-known industrial photographer, Robert Yarnall Richie of New York. On pages 6 and 7, Official U. S. Navy photographs have been used. Other photographers whose work is included are Louis Fabian Bachrach of Boston, H. Armstrong Roberts of Philadelphia, Acme Photos of New York, Cassaday's Studio, Frederic Lewis and Lawrence C. House, Edmund Kent and Wiggin Merrill of National Fireworks, Inc.

• • •

Printing is by the Optak Process by Edward Stern & Company, Inc., of Philadelphia and New York City.



CONTENTS JANUARY, 1944

	PAGE
RED AMMUNITION	5
THE OERLIKON	6
CULTURAL RELATIONSHIPS OF EXPLOSIVES	11
THE EFFICIENCY OF EXPLOSIVES	19
TRAINING MANPOWER FOR MUNITIONS	22
MANUFACTURE OF MAGNESIUM POWDER	26
SHELL LOADING AND BEECH HILL	28
EARLY INCENDIARIES	32
BOOK REVIEW	35
A RECORD OF PERFORMANCE	40
LABOR RELATIONS	47

RED AMMUNITION

IN BLUE PACIFIC SKIES

A Report on a South Pacific Incident Released by the Navy Department

IN the summer of 1942 the Navy requested National Fireworks, Inc., to develop a special piece of ammunition for use in anti-aircraft guns and adapted particularly for the Pacific Area. After months of work in our Research Laboratory a shell was developed which we thought would bring the results that the Navy required in the South Pacific. A trial run of this piece was completed and shipped to the Navy who turned it over to Captain Thomas Leigh Gatch. We have now received a report from the Navy Department as to the efficiency of this piece of ammunition.

In describing a particular action in the South Pacific in which the battleship under his command downed 32 Japanese planes, Captain Gatch said that the anti-aircraft guns worked continuously for more than 25 minutes of intense firing and with only one failure that was caused by water splashing into the barrel from a near miss from a bomb. The guns on his ship, spouting steel at the rate of 4,000 rounds per minute, put up a volume of fire that spelt suicide for any dive bomber that attempted to go through it. The battle took place on the morning of October 26, 1942, as the ship was steaming along in position to protect an American carrier force seeking three Japanese carriers moving from the north toward the Solomons. Many of this ship's crew were entering a combat zone for the first time and her officers included many newly-commissioned reservists.

Over the ship's public address system Captain Gatch asked the men if they were ready for action. From every part of the mighty battleship the answer came blaring back through the speaker on the bridge: "Aye, aye, Sir!" The first attack launched by 20 enemy dive bombers lasted eight minutes. The Jap planes ran into a wall of flaming steel set up by the ship's anti-aircraft guns. Every one of the 20 dive bombers was destroyed. The ship was using special ammunition developed and loaded by National Fireworks at West Hanover, Mass., and, as the whipping fire from the guns caught one speeding target after another, the Jap planes seemed to explode and disintegrate at the end of the streams of fire which looked like crimson bursts from huge Roman candles.

Half an hour later the Japs came on again to assault the battleship and an aircraft carrier she was escorting. 40 torpedo planes and dive bombers roared down in waves about a minute and a half apart. "Our ship was cutting circles and figure eights and other maneuvers without names," related the skipper. "I was more afraid of ramming the carrier than of the attacking planes." The withering barrage of fire from the guns on the ship downed or turned back all but one of the Japs. This one, a torpedo plane, its wings clipped by shells, was jarred out of its line of flight and released its torpedo well in the air. For a moment it seemed that the torpedo would drop on the ship but it passed over into the sea on the opposite side of the stern.

The third and final attack of the day, arriving on the wings of 24 dive bombers and torpedo planes, followed about an hour later and lasted eleven minutes. Now for the first time the battleship received a hit. One of the dive bombers, penetrating the curtain of anti-aircraft fire, screamed down upon the ship. Captain Gatch, as he stood on the bridge's exposed catwalk, saw its bomb released not 100 feet above the bow. "I hoped it would strike the turret and not the deck," he said, "for it was a good sized bomb — probably a 500 pounder — and it might blow a hole in the deck and hurt the men below; and it certainly would kill many in the gun crews on the deck itself." While the bomb fortunately did land on the turret, it proved not so lucky for the skipper himself. A fragment of the bomb tore into his neck severing an artery. Another ripped the muscles of his shoulder. He was knocked unconscious against the conning tower. His ship came through, however, and the crew joyfully counted up their score for the day — 32 enemy aircraft blasted in fewer than that number of minutes of fighting.

Photograph by Ollie Atkins

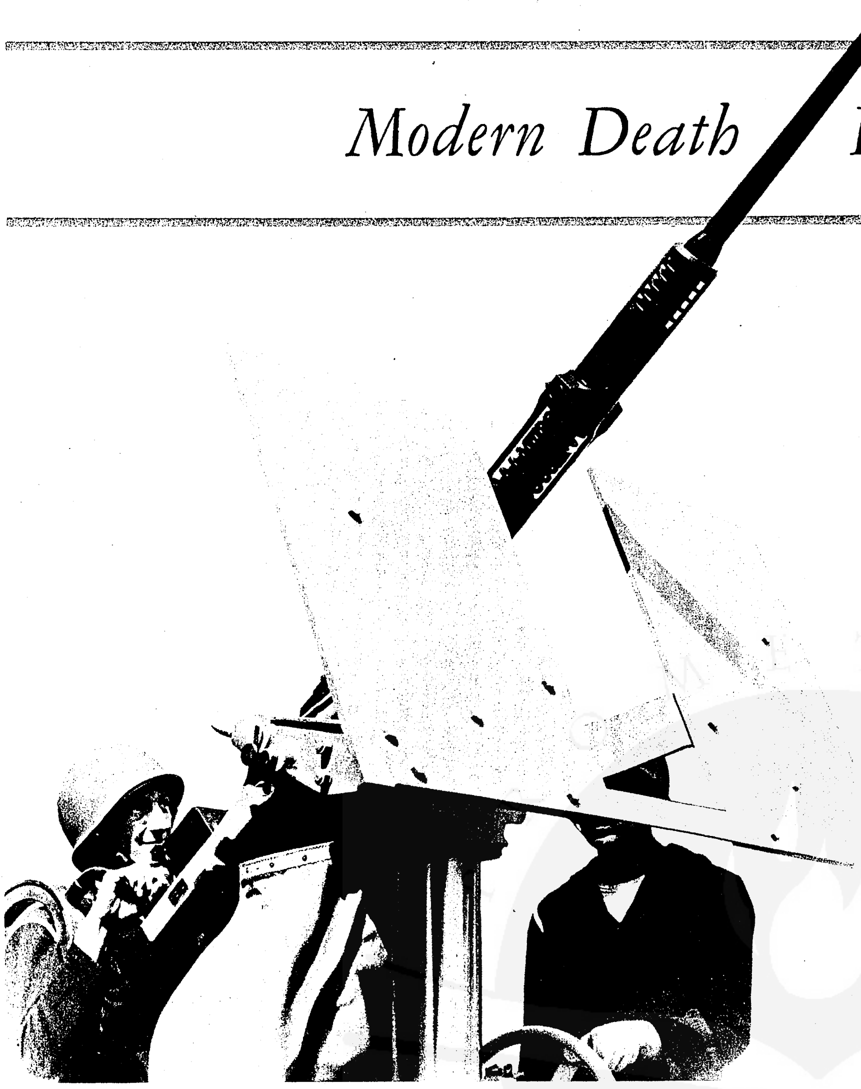
By permission Saturday Evening Post: Copyright 1943, Curtis Publishing Company

CAPTAIN* THOMAS L. GATCH, U.S.N., of Annapolis, Maryland, was awarded the Navy Cross for this action by Admiral William F. Halsey, Jr., U.S.N., Commander, South Pacific Area and South Pacific Force.

**Now Rear Admiral.*

THE OERLIKON

Modern Death Ray of the Skies



EARLY in the war the Nazi propaganda machine darkly hinted in vaguely-phrased stories that they were holding in reserve a devastating mystery weapon, usually alluded to by them as a "death-ray."

But after Dunkirk, when Nazi dive bombers preyed upon Britain's vital sea lanes of supply, there began to appear on the decks of the harried merchantmen and British Navy convoying craft an A-A gun which demonstrated its right to the title of the "modern death-ray of the skies." Not the veiled threat of a superman's death-ray — but an actual death-ray of flying destruction streaming skyward with ample striking power to effectually sweep the Nazi aircraft from the skies.

The 20 MM Oerlikon gun met the test of Britain's most critical period of sea warfare so effectively that dive bombing tactics over ships carrying this protection were almost wholly abandoned by the Nazi. Today, many merchant-marine ships of both Britain and the United States are equipped with these guns and carry their specially-trained crews to operate them. The British and United States navies mount these death-rays of the skies along the hulls of aircraft carriers, clustered along the superstructures of battleships and cruisers, and amidship on destroyers and sub-chasers. These guns are the answer to dive bombing and all other forms of air attack. They are the genuine, real-life death-rays of this war.

The Oerlikon 20 MM gun is of European design, originating at the Oerlikon Machine Works, Ltd., at Oerlikon, Switzerland. Both the British and United States navies have adapted the distinctive Oerlikon features to their own techniques of manufacture.

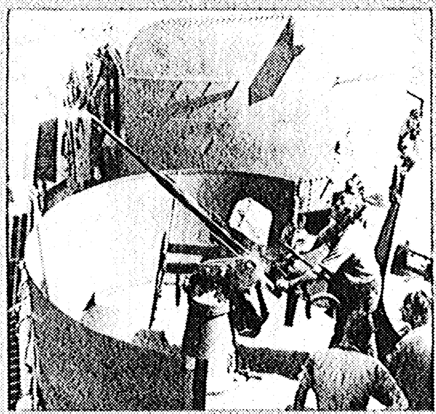
This gun develops a rate of fire of approximately 400 shots per minute. In rapid fire a full magazine of 60 rounds of ammunition is discharged from the gun in 9 seconds. A new magazine can be snapped in place immediately without interrupting the action of the gun. The effective range of this gun is over 5,000 feet, roughly one mile.

The gunner, rapid-firing this gun, with the shoulder-brackets against his body, and both hands held on the firing mechanism, swings the barrel of the gun with his body as he aims through the sighting apparatus and follows the course of his fire by the tracer. He has the sensation of playing a hose of powerful impulses — a continuous stream of projectiles—far different from the sensation of machine-gun operation.

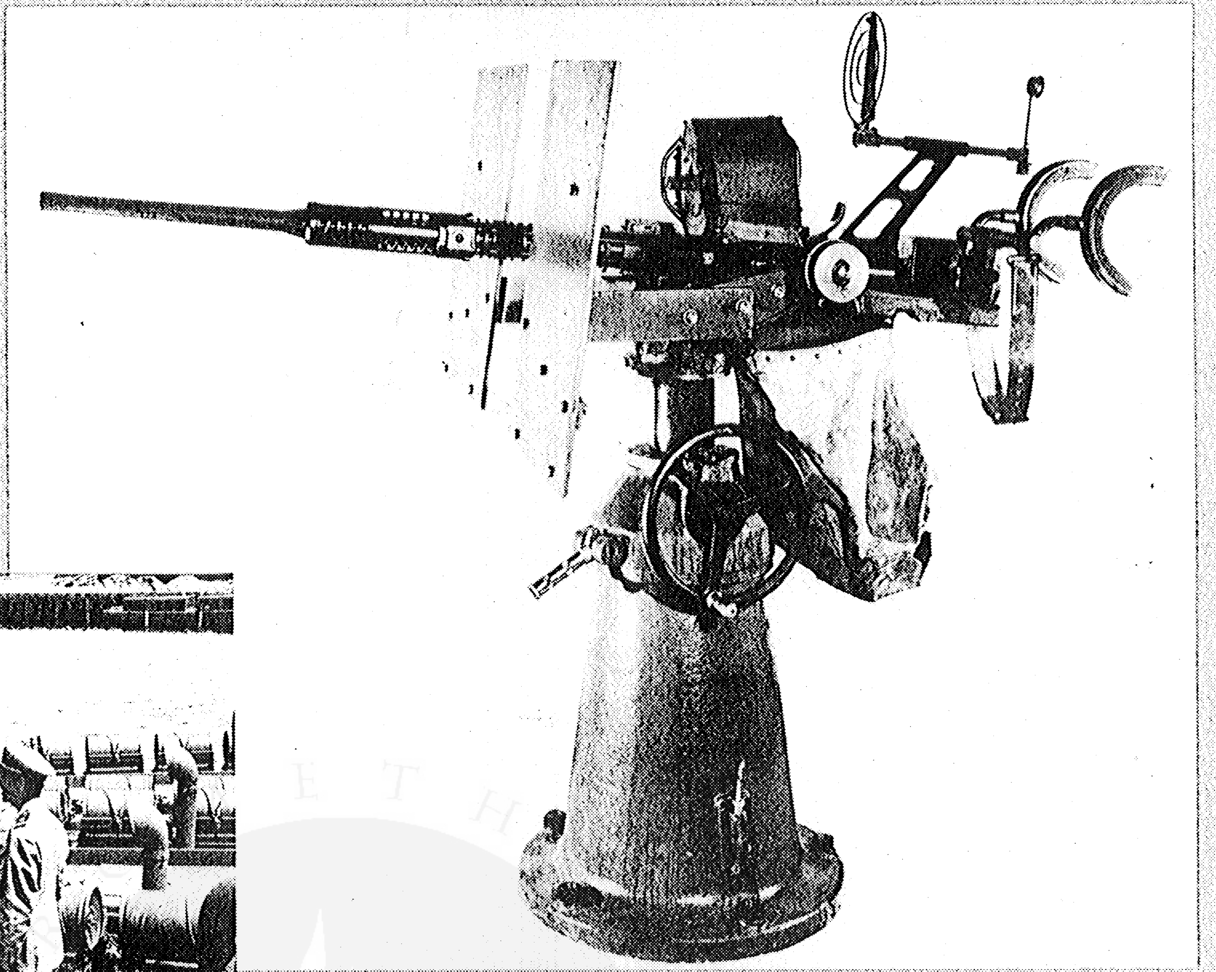
A cluster of special ammunition for this gun, recorded in the Navy news release printed on the foregoing page, would indicate that the end is not yet in sight of the capabilities of this gun in anti-aircraft warfare, or the development of still greater effectiveness in the ammunition which it uses . . . the death-rays with which it stabs the skies.

U. S. Navy Photograph

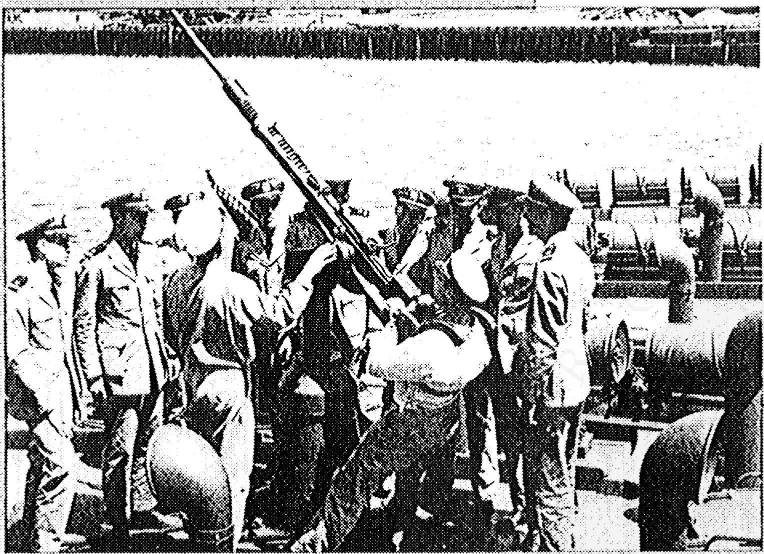
FINDING A SKY TARGET



Practice Shooting of 20 MM Oerlikon Gun

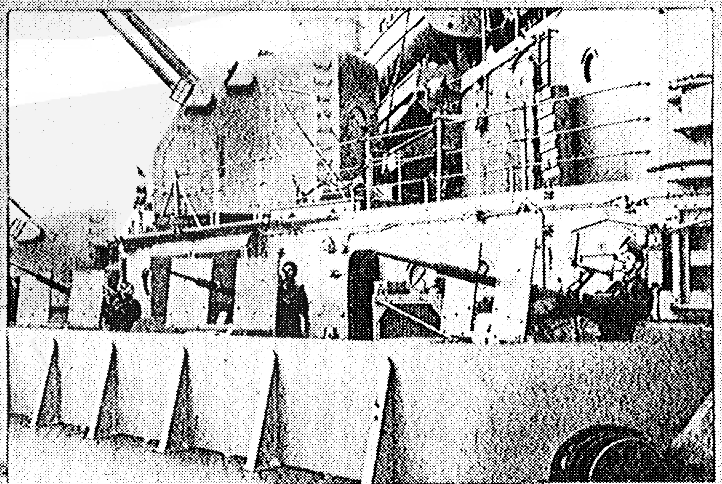


The Oerlikon 20 MM Gun



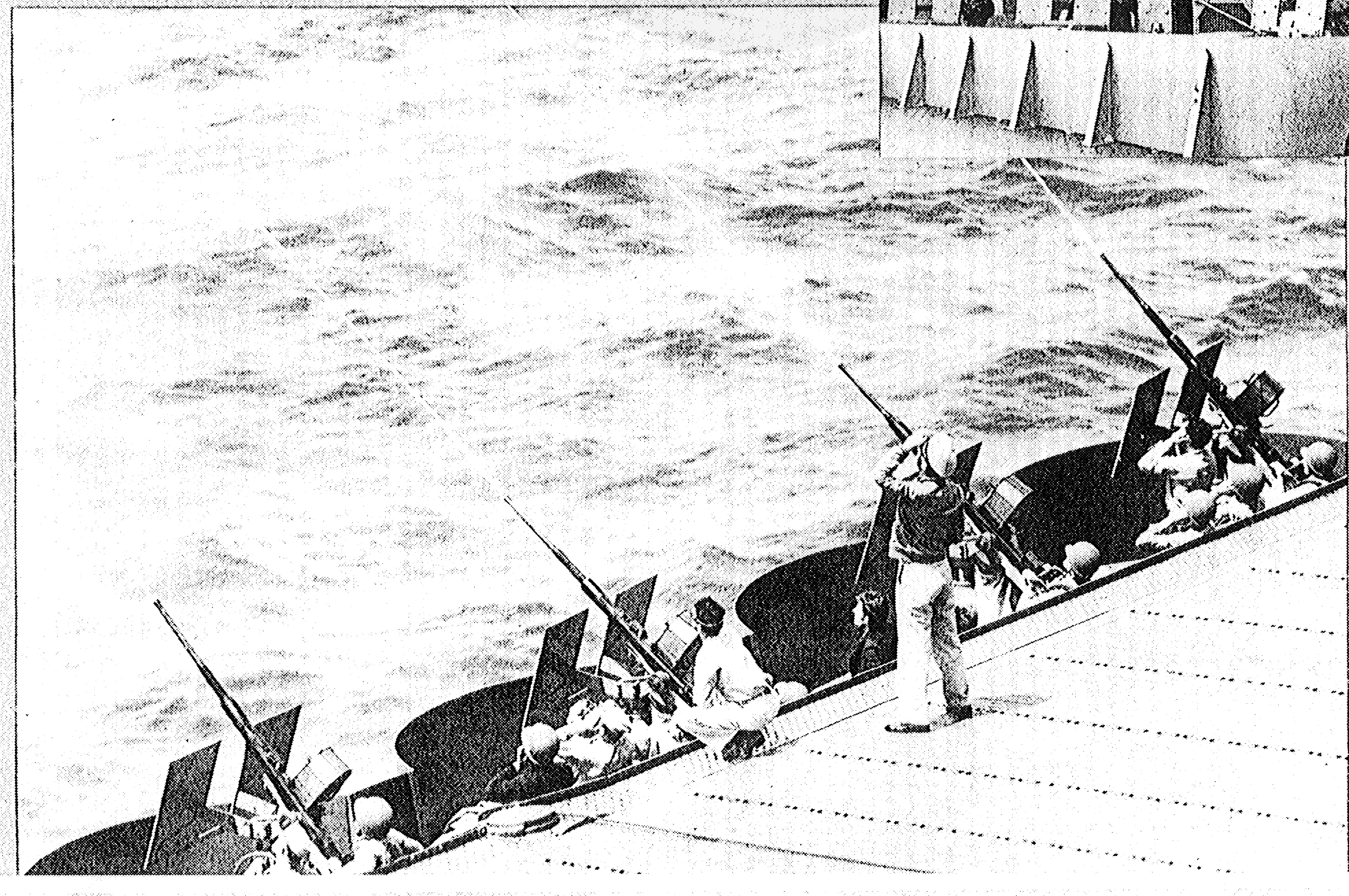
Navy Instruction Group

Battleship Anti-aircraft Installation



20 MM Guns on U. S. Navy Carrier

Official U. S. Navy Photographs



NATIONAL FIREWORKS, Inc., *West Hanover, Massachusetts*

CONFIDENTIAL REPORT OF "THAT GOOD RED AMMUNITION"

by CLARK B. ALLEN, Plant Manager, Plant No. 1

The new special type of 20 MM ammunition which figured in the foregoing account of a battle in the South Pacific was a special production problem for which the National Fireworks organization, by experience and resourcefulness, was peculiarly well-fitted to solve. Not only could it draw upon the production resources developed in this war—but it could reach back into its experience in military pyrotechnics during World War I, even to the point of placing this part of the project in the hands of some of the same individuals.

While the confidential nature of the Company's operations precludes telling more than a skeleton story of this project, it may be of interest to note some of the steps taken in producing this important contribution to the Navy's war matériel.

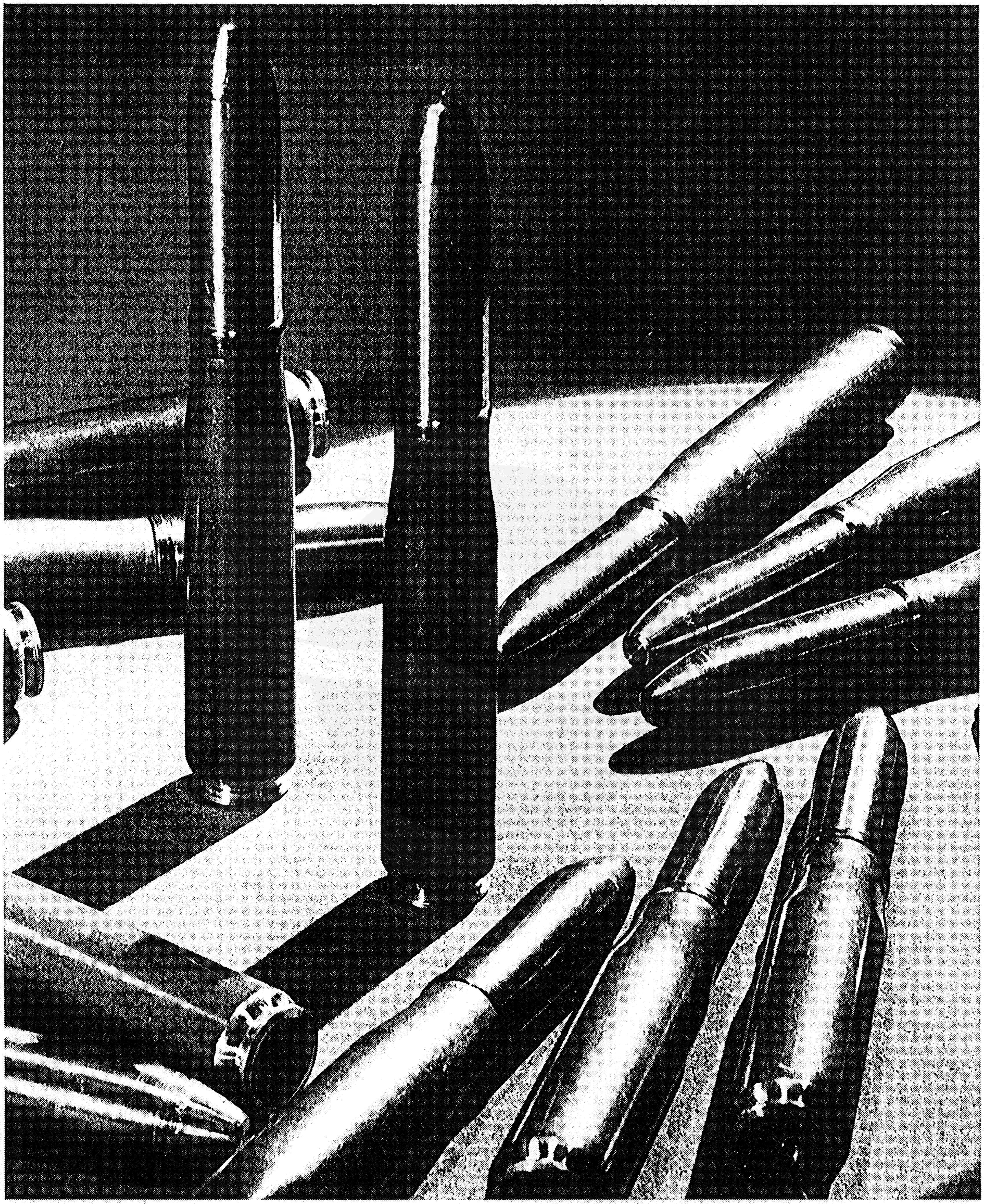
The major burden of pyrotechnical research fell upon Warren Thrasher whose long familiarity with this line of work, both during the last war and in commercial fireworks, qualified him to direct the experimental stages of the project. A period of several weeks of experimental procedure followed. Rounds of ammunition containing new mixtures of many variants were made, tested on the range, and proved over and over until the desired result was approved by the Navy. A trial order for use in actual battle test by the Pacific Fleet was received, with urgency written across its face.

New machinery was designed by John Alexander, Chief Engineer; change-overs in equipment were made in unbelievable time, and the special assembly lines were set up for operation. The task of getting production out in record time was entrusted to Hugh Wolfert, Supervisor of all 20 MM projects at Main Plant, No. 1, who selected from the plant personnel a hand-picked force of trustworthy and highly-skilled operators for this project. All records of production for experimental ammunition were broken by this especially-created assembly line.

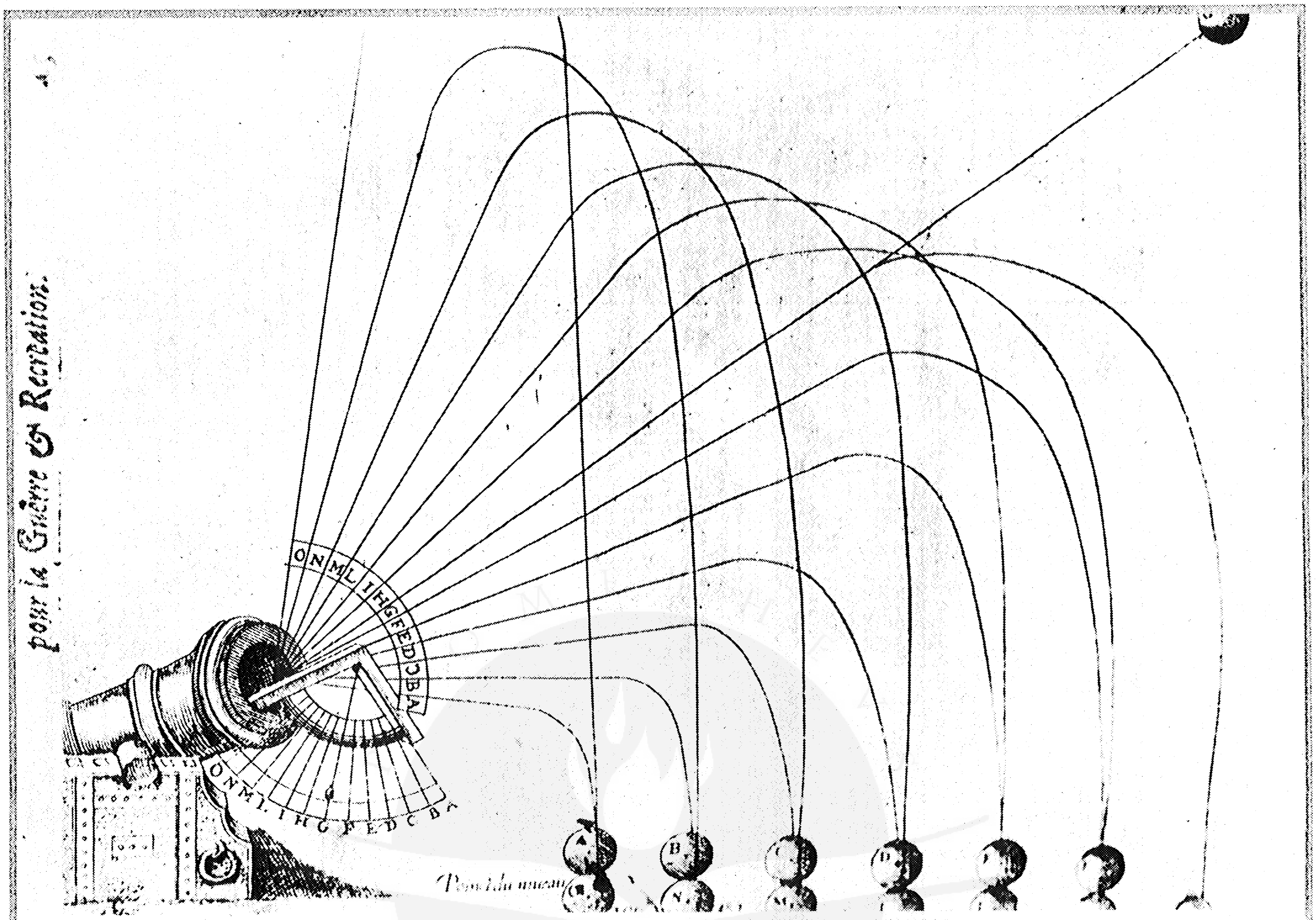
To insure that the final results of our research work should be exactly represented in each and every round of this ammunition Thomas N. Aikens, Chief Inspector of all National products, personally supervised the inspection of this record run.

That the painstaking research, engineering, production and inspection effort put into this special project have been rewarded by the performance of this ammunition in battle is eloquently demonstrated in the story of Captain Gatch's exploit.

Note: The description of this ammunition as "that good red ammunition" refers to the fact that the projectiles were painted red as a means of identification and has no other connotation.

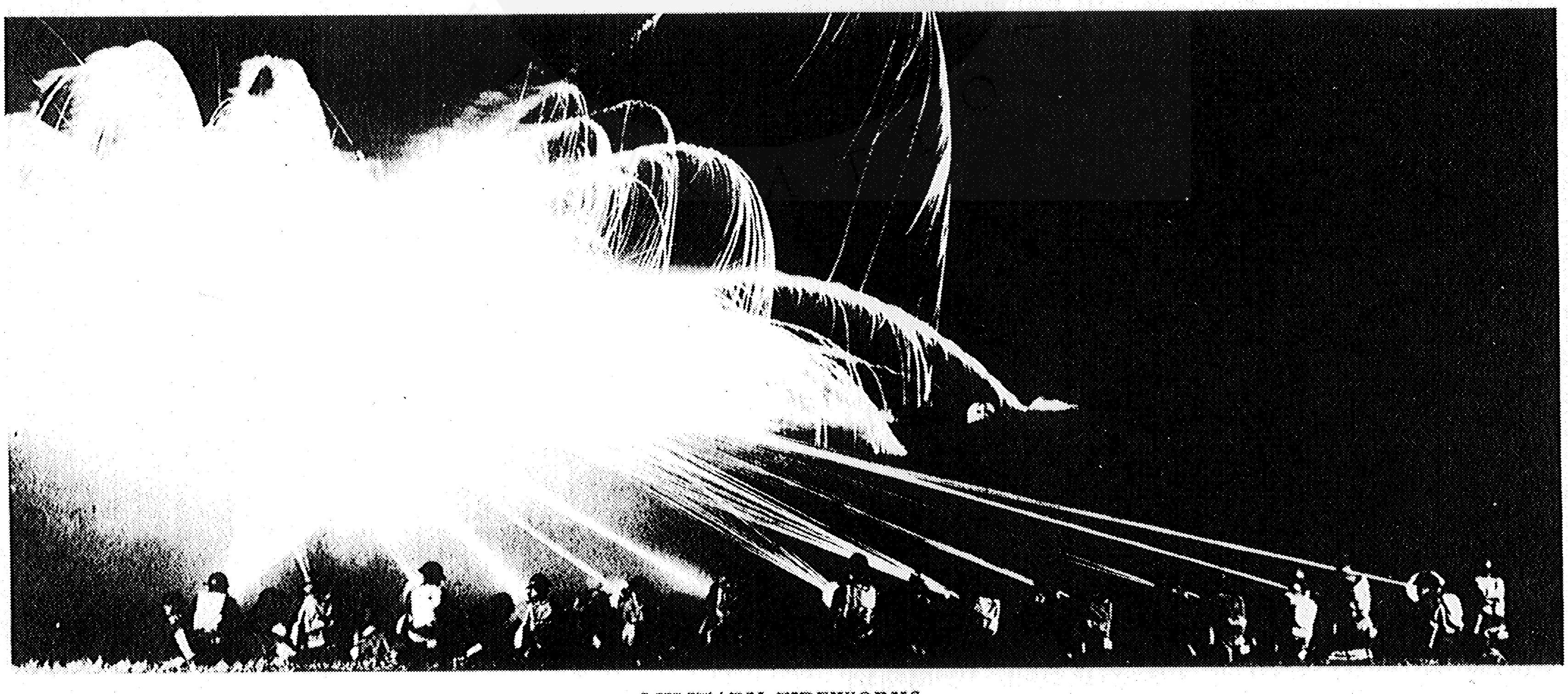


20 MM ROUNDS



BALLISTICS IN THE EARLY SEVENTEENTH CENTURY

Reproduced from "La Pyrotechnie" by Hanzelet Lorrain (Jean Appier), Pont à Mousson, 1630.



MILITARY FIREWORKS

Modern Tracer Bullets and Phosphorus Shells

CULTURAL RELATIONSHIPS OF EXPLOSIVES

Their Usefulness Begins and Ends—in Peace

by TENNEY L. DAVIS

EXPLOSIVES are to be listed among the chemical substances which have been of great service to man. They have been potent factors in promoting the growth of civilization and the spread of culture. Although enormous quantities are being used at present for the destructive purposes of war, yet it is probably true in the long run that military explosives represent not more than 5% of all of the explosives which are produced. Ninety-five percent is used for beneficial and creative civil purposes of peace—to dig canals, to gain access to minerals under the earth, to open the way for engineering accomplishments of all kinds. Truly, explosives are substances of good repute and of good associations.

It is interesting to note that the discovery of America, the discovery of printing, and the discovery of gunpowder occurred at about the same time in history. And very difficult indeed it is to assess the comparative values of these discoveries and to decide in one's own mind which of them has been the most important or has done the greatest good. By the "discovery of gunpowder," we mean the discovery that useful mechanical work can be done by the combination of chemicals, saltpeter, sulphur, and charcoal, out of which black powder is made. This mechanical work, to cite only one example, has given us coal and iron ore, and has been directly responsible for bringing on the present age of steel and, with it, such things as great ocean steamships, rapid communication, the automobile, the airplane, and the radio. It has made possible the rapid and wide diffusion of knowledge consequent upon the discovery of printing, and it has made possible the use and development of the new wealth, the new foods, the new drugs, and the new lands of the Americas.

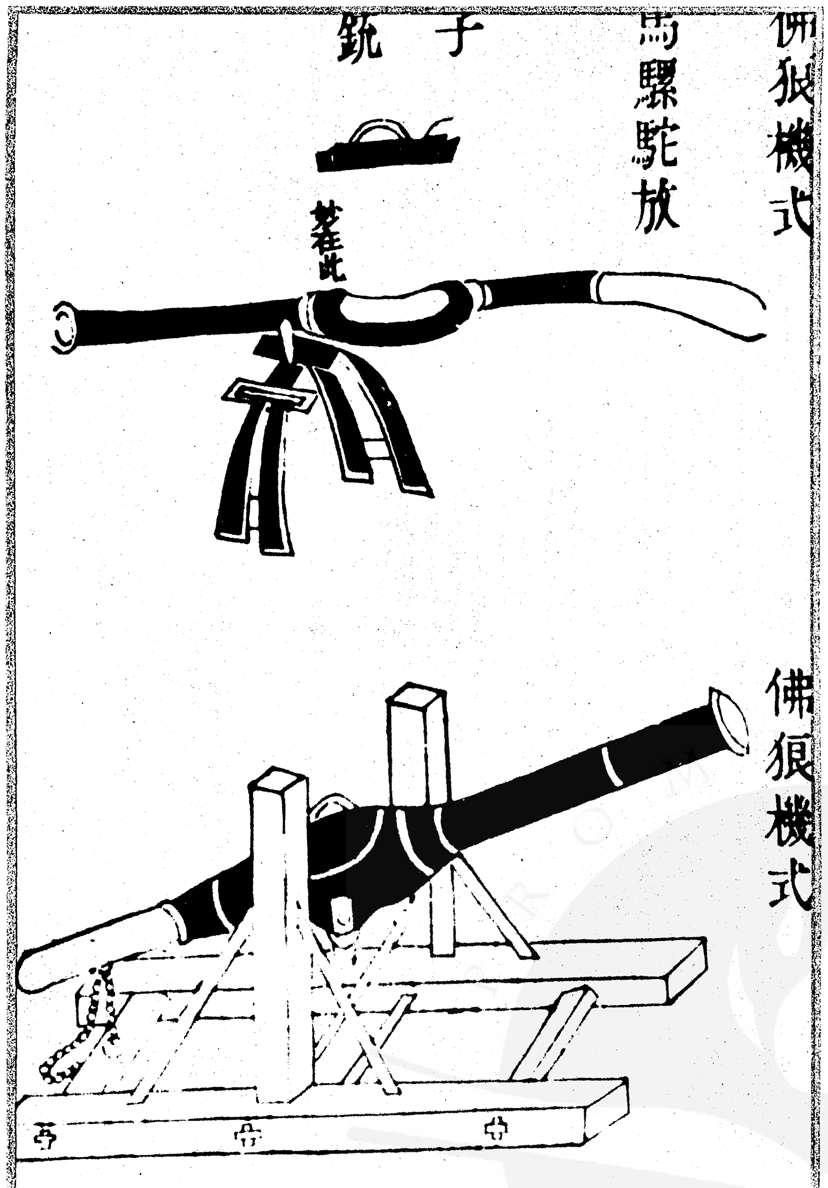
Roger Bacon, about 1250, was probably the first in Latin Europe to set down a description of black gunpowder and to foresee the possibilities of its use. He considered the material so important that he concealed its exact composition in an anagram and in a little problem in algebra by which the solution of the anagram could be checked. Thus, he disclosed the composition only to the most studious and most intelligent of his readers. The treatise "On the Marvelous Power of Art and of Nature and on the Nullity of Magic," which is ascribed to Roger Bacon and which contains the famous black powder anagram, closes with the words—"Whoever will rewrite this will have a key which opens and no man shuts, and when he will shut, no man opens." Although guns did not come into use until about 1350, it is evident that Roger Bacon foresaw that useful—and irreversible—mechanical work could be accomplished by means of his powder. And since his time explosives have shut the door upon much that is evil and opened the door permanently to much that is good.

Antiquity of Fireworks

Fireworks are older than explosives, and fireworks—pyrotechnics or the arts of fire—were used for pleasure and entertainment, and for magic, as in the exorcising of demons, long before they were used for purposes of war.

Some unknown scientist of an early time discovered that combustible material burned much more brightly and vigorously if saltpeter was

TENNEY L. DAVIS, PH.D., Director of Research and Development, National Fireworks, Inc., has been working with explosives since 1917. First Lieutenant, Ordnance Department, U. S. Army, 1917-1919; member of Chemistry Department, Massachusetts Institute of Technology, until retirement as Emeritus Professor of Organic Chemistry in June, 1942.



BREECH-LOADING CANNON. Reproduced from a late sixteenth century Chinese text* in the Library of Congress, by permission of the Chief, Division of Orientalia.

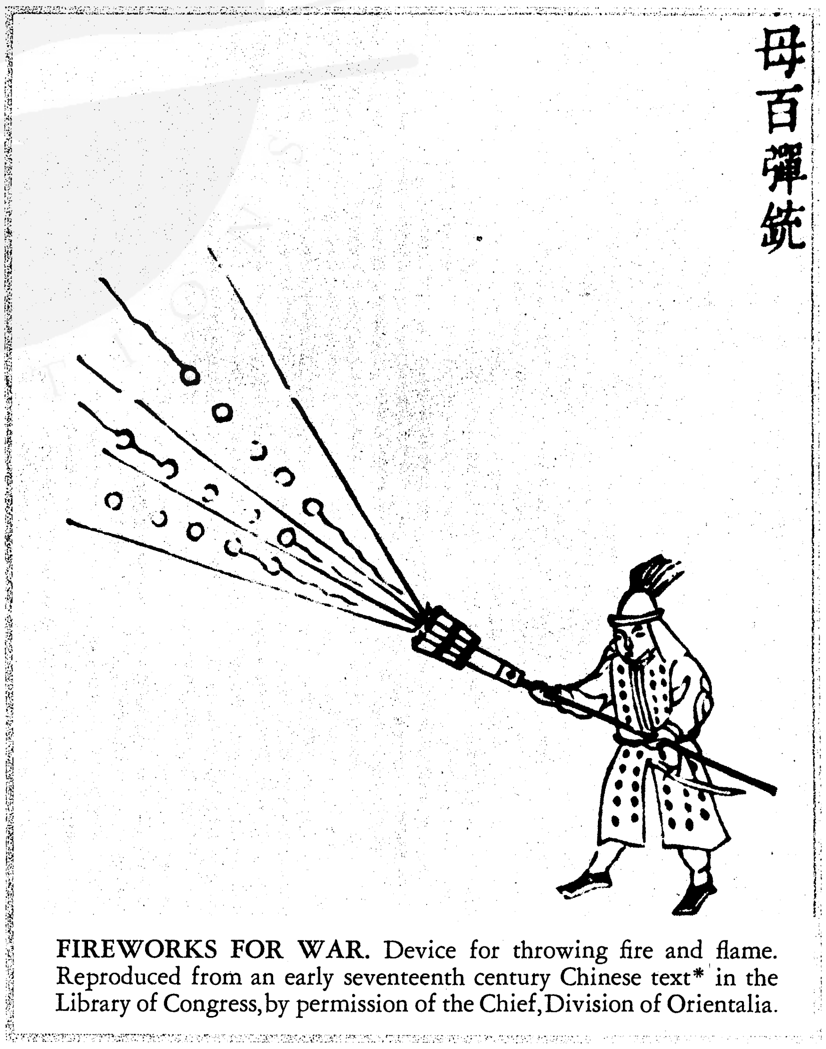
added to it. Saltpeter (potassium nitrate) was found as an effluorescence in various arid places on the surface of the earth. It was the final product from the putrefaction of nitrogenous animal and vegetable materials. It had interesting properties. It was readily soluble in water and crystallized in handsome geometrical forms. It was a good preservative for meat. It had a pleasant and cooling taste, and actually lowered the temperature of water in which it was dissolved. The Emperor Nero is reported to have used it for cooling his wine. It was an article of commerce at an early date.

By using saltpeter with different combustible materials different visual effects were produced. Sound and motion also resulted according to the method by which the combustible material was utilized or packaged. An intimate mixture of finely-powdered saltpeter, sulphur, and charcoal burned with a single, quick flash, and it is this mixture which later found use as gunpowder. Other compositions burned for a longer time with a bright light, with a smoke, or with the throwing about of glowing or of scintillating sparks; and still others were designed which would burn when thrown through the air and could not be extinguished by water or by sand. Crackers, rockets, gerbs, and wheels were all known at an early date, and all were charged with compositions which contained saltpeter and were in fact black powder or modified black powder. The earliest printed books on fireworks describe the same devices as those which are used today. For three centuries at least no important improvements have been made in the mechanical construction of the pieces; the improvements have been in the use of new chemicals. Potassium chlorate is a more vigorous oxidizing agent than potassium nitrate. Its use, beginning early in the nineteenth century, gave brighter flames and sharper explosions. Certain safe high explosives have been made from this material, but it has never been slowed down sufficiently to make a satisfactory propellant powder. Barium salts for green, and strontium salts for red, soon came into use for the production of more interesting colors. Toward the end of the century magnesium was used for intensely brilliant lights, and, soon after, the cheaper and more stable aluminum for "electric" effects.

The early history of fireworks is obscure. Pyrotechnic devices were apparently invented in China where they were developed to a fairly high state, and from China a knowledge of them evidently found its way to Byzantium over the trade routes. There is evidence which indicates that Chinese and European fireworks later developed independently but along parallel lines. The Chinese had breech-loading cannon at the beginning of the seventeenth century, perhaps earlier. As early as the Sung dynasty they used rocket-propelled arrows for purposes of war.

Greek Fire – Early Incendiaries – Firecrackers

The earliest known document on the subject of fireworks and explosives is probably the "Book of Fires for Burning the Enemy" which was written by Marcus Graecus in the eighth century. This describes various mixtures containing saltpeter for use in crackers and rockets and in the Greek fire which made the Byzantines so successful for several centuries in their warfare against the Moslems. The latter fire was ejected from tubes attached to the prows of ships or from small hand siphons, or the combustible material was fastened to heavy stones and thrown with the projectiles from ballistic machines. It was of course enormously effective against wooden ships and against personnel.



FIREWORKS FOR WAR. Device for throwing fire and flame. Reproduced from an early seventeenth century Chinese text* in the Library of Congress, by permission of the Chief, Division of Orientalia.

*The two Chinese texts from which pictures are here reproduced are being studied by Chao Yün-ts'ung and Tenney L. Davis who expect later to publish translations from them with pictures of many early Chinese pyrotechnic devices.

"Greek fire," wrote Marcus Graecus, "is made as follows: Take sulphur, tartar, sarcocolla, pitch, melted saltpeter, petroleum oil, and oil of gum, boil all these together, impregnate tow with the mixture, and the material is ready to be set on fire. This fire cannot be extinguished by urine, or by vinegar, or by sand."

The same writer describes another mixture which resembles black powder more closely, and tells how it is used in firecrackers and rockets. He even specifies grapevine and willow charcoal which, with alder charcoal, are still the preferred charcoals for making fuze powders and other grades for special purposes.—

"Take one pound of pure sulphur, two pounds of grapevine or willow charcoal, and six pounds of saltpeter. Grind these three substances in a marble mortar in such manner as to reduce them to a most subtle powder. After that, the powder in desired quantity is put into an envelope for flying (a rocket) or for making thunder (a cracker). Note that the envelope for flying ought to be thin and long and well-filled with the above-described powder tightly packed, while the envelope for making thunder ought to be short and thick, only half filled with powder, and tightly tied up at both ends with an iron wire. Note that a small hole ought to be made in each envelope for the introduction of the match. The match ought to be thin at both ends, thick in the middle, and filled with the above-described powder. The envelope intended to fly in the air has as many thicknesses (ply) as one pleases; that for making thunder, however, has a great many."

Firecrackers appear to have been used as toys by European youngsters before the composition with which they were filled was yet known to European scholars. Roger Bacon judged that they would be useful in war because of their frightfulness. He wrote:

"Certain inventions disturb the hearing to such a degree that, if they are set off suddenly at night with sufficient skill, neither city nor army can endure them. No clap of thunder could compare with such noises. Certain of these strike such terror to the sight that the coruscations of the clouds disturb it incomparably less. . . . We have an example of this in that toy of children which is made in many parts of the world, namely an instrument as large as the human thumb. From the force of the salt called saltpeter so horrible a sound is produced at the bursting of so small a thing, namely a small piece of parchment, that we perceive it exceeds the roar of sharp thunder, and the flash exceeds the greatest brilliancy of the lightning accompanying the thunder."

Composition of Black Powder

Roger Bacon's gunpowder formula called for six parts of saltpeter, five of young willow charcoal, and five of sulphur, and did not correspond by any means to the most powerful combination of the three ingredients. After the invention of guns, numerous studies were made to determine the most advantageous proportions of the components. Since the time of Queen Elizabeth it has been accepted that the best ballistic effects are secured from black powder made according to the 6:1:1 formula, that is, saltpeter 75%, charcoal 12.5%, and sulphur 12.5%, or according to the formula, saltpeter 75%, charcoal 15%, and sulphur 10%, or between the two or thereabouts. For four or five centuries no significant improvements have been made in black powder except in the methods of its manufacture, in the shape of the grains, etc. For ballistic use it has been largely superseded by smokeless powder, the result of advances in chemistry, but it still remains the best material there is for communicating fire or for producing a quick hot flame for the ignition of smokeless powder.

Importance of Nitrogen

The property of saltpeter which qualifies it so well for use in gunpowder is its property of supporting combustion, its property of giving up its oxygen readily to substances which have a great tendency to react with that element. Other nitrates possess this same property as does also nitric acid itself, a happy balance of readiness to give over the oxygen with a tendency toward retention of the oxygen sufficient to make them stable. There are other substances, such as potassium chlorate and permanganate, which contain oxygen enough but give it up so readily that their usefulness is limited. The oxides of nitrogen, and their compounds and derivatives, appear to be uniquely suited to the needs of the explosives worker.

When black powder burns, the nitrogen of the nitrate forms nitrogen gas, the oxygen combines with the charcoal and the sulphur to form compounds of which some are gaseous and some, into the composition of which the potassium enters, are solid. The hot gases, largely nitrogen and carbon monoxide and dioxide, produce the expansive effect of the explosion; the solids, largely potassium carbonate, sulfate, and sulfide, produce the smoke and contribute nothing to the

FIREWORKS FOR FUN

Some Important Events in the History of Explosives

The following outline lists some of the most important events in the history of explosives, and serves to show something of the sequence of discoveries which have brought the art to its present state.

1786 Berthollet discovered potassium chlorate.

1788 Disastrous chlorate explosion.

1800 Edward Howard described mercury fulminate in a paper before the Royal Society.

- **1805** Rev. A. J. Forsyth—detonator lock.
- **1814** Shaw of Philadelphia—steel fulminate cap.
- **1841** Prussian needle gun.
- **1861** First successful center-fire ammunition.

1833 Braconnot described xyloidine.

1838 Pelouze studied xyloidine further; prepared nitrated paper (nitrocellulose).

1846 Schönbein described nitration of sugar, experimented with other organic substances, prepared guncotton but did not describe his method. Acknowledged independent discovery by Böttger with whom he collaborated to exploit guncotton for use in artillery.

- **1847** Maynard discovered collodion—soluble in mixture of ether and alcohol.
- **1870** J. W. and I. S. Hyatt—celluloid.
- **1884** Chardonnet's first patent—artificial silk.

1847 Sobrero discovered nitroglycerin.

1863 Immanuel Nobel and his sons, Alfred and Emil, commenced manufacture of nitroglycerin at Heleneborg, near Stockholm. Emil was killed by explosion September 3, 1864.

- **1865** Nobel Company commenced manufacture in Germany, near Hamburg.
- **1865** Explosion of sample of nitroglycerin at Wyoming Hotel, New York City.
- **1868** Mowbray commenced using nitroglycerin in work on Hoosac tunnel (July, 1868).
- **1871** Mowbray's magazine exploded without detonating frozen nitroglycerin in tins. Mowbray's book, 1872; 3rd ed., 1874.

1864 Captain Schultze (Prussian) devised first successful smokeless powder.

1864 Alfred Nobel—improvements in manufacture of nitroglycerin and in method of exploding it.

1875 Manufacture of guncotton officially forbidden in Austria because of the dangerous character of the substance.

1867 Abel—"Researches on Guncotton," Trans. Roy. Soc.

- **1931** Olsen—pulping before boiling.
- **1933** Olsen—quick stabilization of nitrocellulose.
- **1936–1940** Olsen—ball grain powder.

1867 Ohlsson and Norrbin—ammonium nitrate explosives.

1867 Nobel—dynamite and the fulminate cap.

1868 Brown (Abel's assistant) discovered that dry guncotton could be detonated by fulminate and that wet guncotton could be detonated by dry (the principle of the booster).

1869 Nobel invented dynamite with an active base "straight dynamite."

1870 Siege of Paris.

- **1878** Berthelot, President of the Commission des Poudres et Salpêtres.
- **1882–1883** Mémorial des Poudres et Salpêtres, Volume I.

1871 Sprengel explosives containing one or more liquid components.

1875 Nobel invented blasting gelatin and gelatin dynamite.

1877 Permissible explosives—for use in gaseous and dusty coal mines.

1882 E. C. powder manufactured in England.

1884 Vieille invented poudre B, the first colloided smokeless powder.

1885 Turpin patented and France adopted the use of picric acid in high explosive shells.

1885 Great Britain commenced use of picric acid in shells.

1888 Nobel invented ballistite.

1889 Nobel invented ballistite without volatile solvent.

1889 British committee invented cordite.

1891 Munroe in U. S. invented indurite.

1891–1895 Mendeleef studied nitrocellulose, discovered pyrocellulose.

1898 Linde—oxyliquite (liquid oxygen explosive).

1900 Naval Powder Factory commenced manufacture of smokeless powder at Indian Head, Maryland.

1904 Trinitrotoluene used in shells.

1907 Smokeless Powder factory built at Picatinny Arsenal, Dover, New Jersey.

force of the explosion. When black powder burns, about 56% of its weight is converted into useless smoke. Compounds such as ammonium nitrate, cellulose nitrate (nitrocellulose), and glyceryl trinitrate (nitroglycerin) contain only elements which yield gaseous oxides; they produce no smoke, and are more powerful explosives in consequence.

Combined nitrogen, then, is absolutely essential for the production of explosives. The development of new explosive substances, the production of ammonia and nitric acid for their manufacture, and the actual making of them from combined nitrogen and other materials—all these are problems for chemistry.

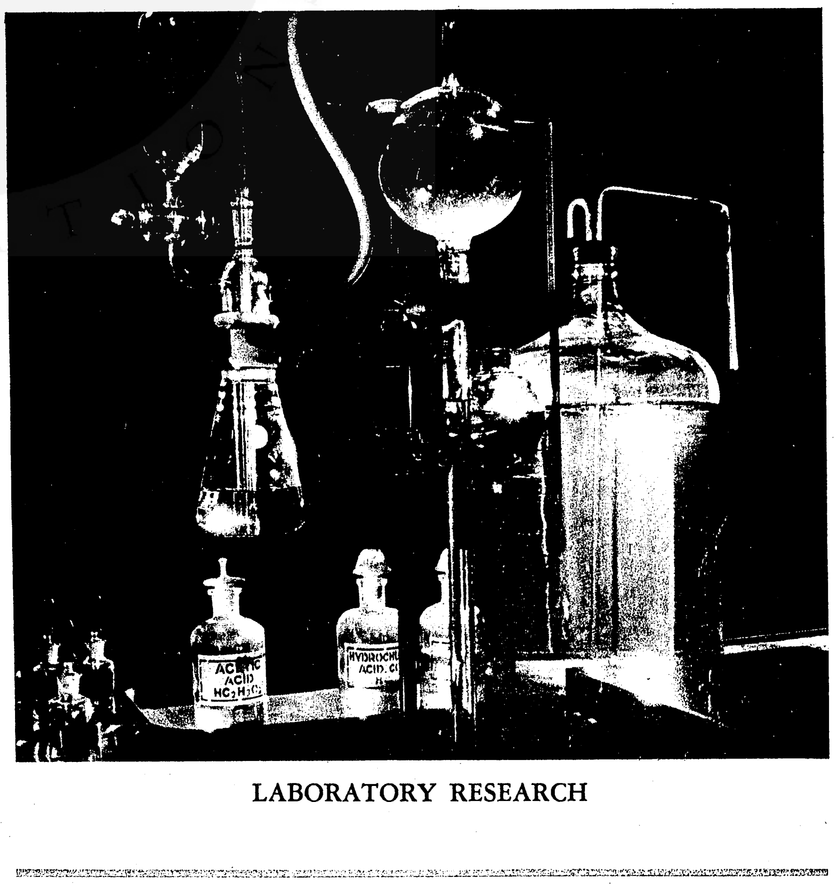
Chemistry in Warfare

There appear to be three principal varieties of warfare,

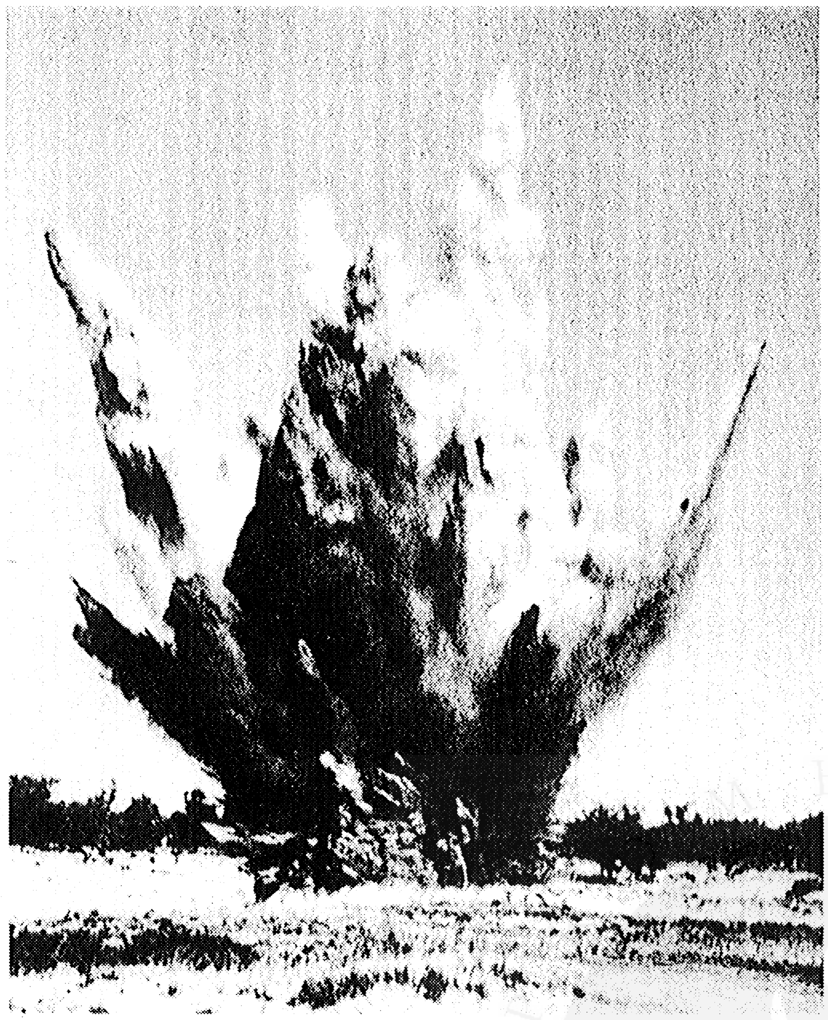
1. Physical
2. Chemical, and
3. Psychological.

In the first, we attack the enemy with physical instruments, tooth and claw, tomahawk, mace and pike, dagger and bayonet, bullet and fragments of metal from a shell or bomb. This is the commonest method of waging war. And it is an ancient one, appearing early in the evolutionary process. Cats and tigers are beautifully equipped by nature with instruments of physical warfare. In the second, we attack the enemy with chemical agents, smoke which gets in his eyes, tear gas, sneeze gas, mustard and phosgene. This method of warfare is very much more ancient in the evolutionary process than any of the others. The feeble and slow-moving skunk is equipped to practice it, and the primitive and unsubstantial jelly fish which yet is able to sting. In the third method, we work our will upon the enemy through the use of propaganda and other psychological devices which cause him by his own acts to do the things we wish. This is the most recent, the most subtle, and the most powerful of the several methods.

Explosives in warfare are devices which apply matter physically in a manner to do physical injury to the person or to the property of the enemy. Chemical warfare is outside the interest of the present



LABORATORY RESEARCH



CLEARING FARMLAND

discussion. When we speak in this article of the importance of chemistry in warfare, we wish to be understood as referring to the physical warfare in which explosives are effective.

Herman Boerhaave, Professor of Chemistry at Leiden, was acquainted more than two centuries ago with certain combinations of chemicals, such as nitric acid and oil of cloves, which were capable of reacting with explosive violence. Black powder was the only explosive known to him which was suitable for use in war. Yet he was so fully convinced of the importance of chemistry for war that he wrote the following extraordinary and thoroughly modern observation upon it.

"It were indeed to be wish'd that our art has been less ingenious, in contriving means destructive to mankind; we mean those instruments of war, which were unknown to the ancients, and have made such havoc among the moderns. But as men have always been bent on seeking each other's destruction by continual wars; and as force, when brought against us, can only be repelled by force; the chief support of war, must, after money, be now sought in chemistry."

If this were true in Boerhaave's time, how much truer it is today when we are able by chemical processes to convert the inert but endlessly accessible nitrogen of the atmosphere into the combined or fixed nitrogen of ammonia and nitric acid. These substances are necessary for the production of explosives, and they are utterly necessary too for fertilizers and the growth of plants. Man's newly-acquired ability to synthesize them from the air has given him a new status in the universe. He is now no longer dependent upon the unsolicited bounty of nature for his food. He can demand his food and can cause the unfertile soil to yield it to him. And we note, in passing, that that chemistry which is most fundamental for war is also truly fundamental for peace, for the very sustenance of life itself.

Definition and Classification of Explosives

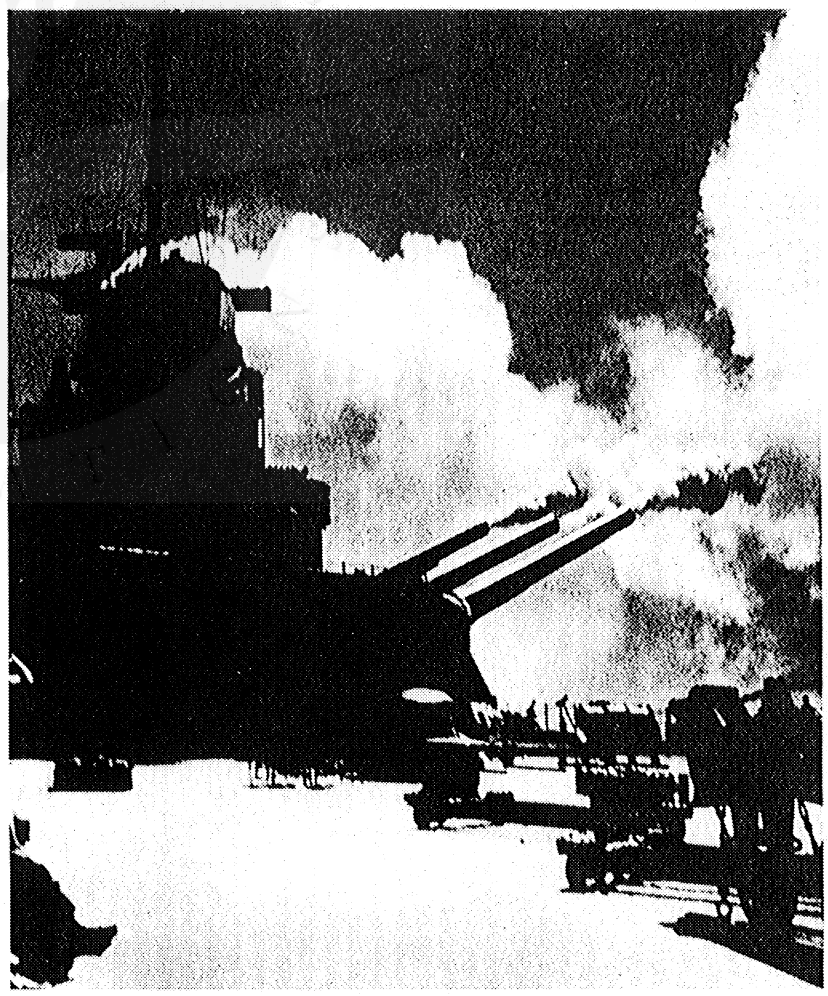
An explosive is defined as a material, either a single substance or a mixture of substances, which is capable of producing an explosion by its own energy.

The various materials which conform to this definition may be classified according to their modes of behavior, according to the manner in which they release their energy, according to the stimuli which induce them to produce explosions. There are thus three classes of explosives:

1. Propellants or low explosives function by burning rapidly; they produce hot gas and the expansion of the gas produces an explosion. Examples are black powder and smokeless powder.

2. Primary explosives or initiators explode or detonate when they are heated or subjected to shock. They do not burn. They explode, whether they are confined or not. The substances themselves, when they explode, tear themselves apart, and produce a considerable local shock, which is capable of initiating the explosion of the so-called high explosives. The most important primary explosives are mercury fulminate and lead azide.

3. High explosives differ widely among themselves in their combustibility, sensitivity to shock, friction, etc., but are characterized by their ability to be exploded by the shock of the explosion of a suitable initiator. Examples are dynamite, trinitrotoluene, tetryl, picric acid, nitrocellulose, nitroglycerin, ammonium nitrate, ammonium picrate, and nitroguanidine. Nitroglycerin burns easily and is exploded easily by shock. Nitroguanidine does not burn at all. Ammonium picrate, properly loaded in a shell will withstand impact against heavy armor plate without exploding.



NAVAL FIREPOWER

Behavior of Typical Explosives

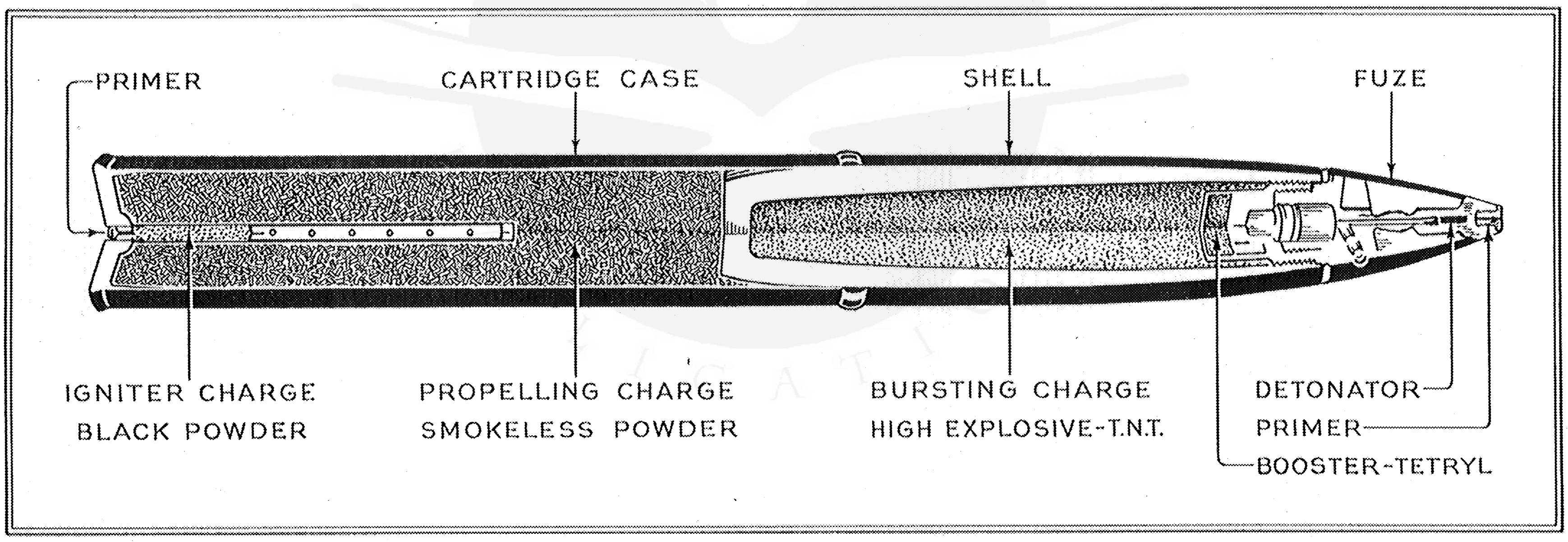
Primary explosives occur in two places in the complete round of H. E. ammunition, in the primer cap at the base of the cartridge case, and in the fuze at the nose of the shell. The purpose of the primer cap is to produce fire when the trigger strikes it. The cap contains a mixture of mercury fulminate, potassium chlorate, and antimony sulfide. The fulminate in the first instance produces fire which ignites the antimony sulfide and this burns at the expense of the oxygen of the chlorate to produce a flame which sets fire to the black powder in the primer or igniter. The large flame from the black powder sets fire to the smokeless powder which constitutes the propelling charge.

If the fuze is a combination fuze designed to explode the shell either upon impact with the target or at a certain predetermined time after it has left the muzzle of the gun, then it contains a primer cap which is fired by means of an inertia-operated device at the moment that the projectile starts its flight. The fire from this lights a train of black powder, the length of which has been adjusted by turning the time train rings, and from the end of this passes to the detonator, loaded with fulminate or azide, which explodes the shell. If the time train rings have been set to burn to a dead end without bringing fire to the detonator, then the shell explodes only after it strikes the target. In this case an inertia-operated device fires a primer cap from which the fire passes directly to the detonator.

The high explosive with which the shell is loaded is one, obviously, which is insensitive enough to tolerate the shock of being fired from the gun. Trinitrotoluene (TNT) is generally preferred for this purpose. It is manufactured by treating toluene (a coal tar hydrocarbon) with mixed nitric and sulfuric acids. It melts at 81.5° C., below the boiling point of water, and is cast in the shell or loaded by pouring. After the TNT has cooled in the shell, a cavity for the booster is bored out in the middle of the front end of the charge, next to the detonator. This is filled with the booster explosive, usually tetryl, more sensitive and more brisant than TNT, which serves the double purpose of securing a better detonation of the principal charge and of making it possible to build satisfactory ammunition which contains smaller and hence safer quantities of fulminate or azide.

To one who is not familiar with explosives, the smokeless powder of the propelling charge is perhaps the most mysterious and impressive component of the ammunition. It is a dense colloided powder, having the appearance and about the toughness of horn. In the open it burns slowly. In the confined space of the chamber of the gun, where the heat of its burning serves to accelerate the rate, it burns rapidly, but none the less progressively, and in such manner that it pushes the projectile, and continues to push it, harder and harder, until the moment that the projectile leaves the muzzle of the gun.

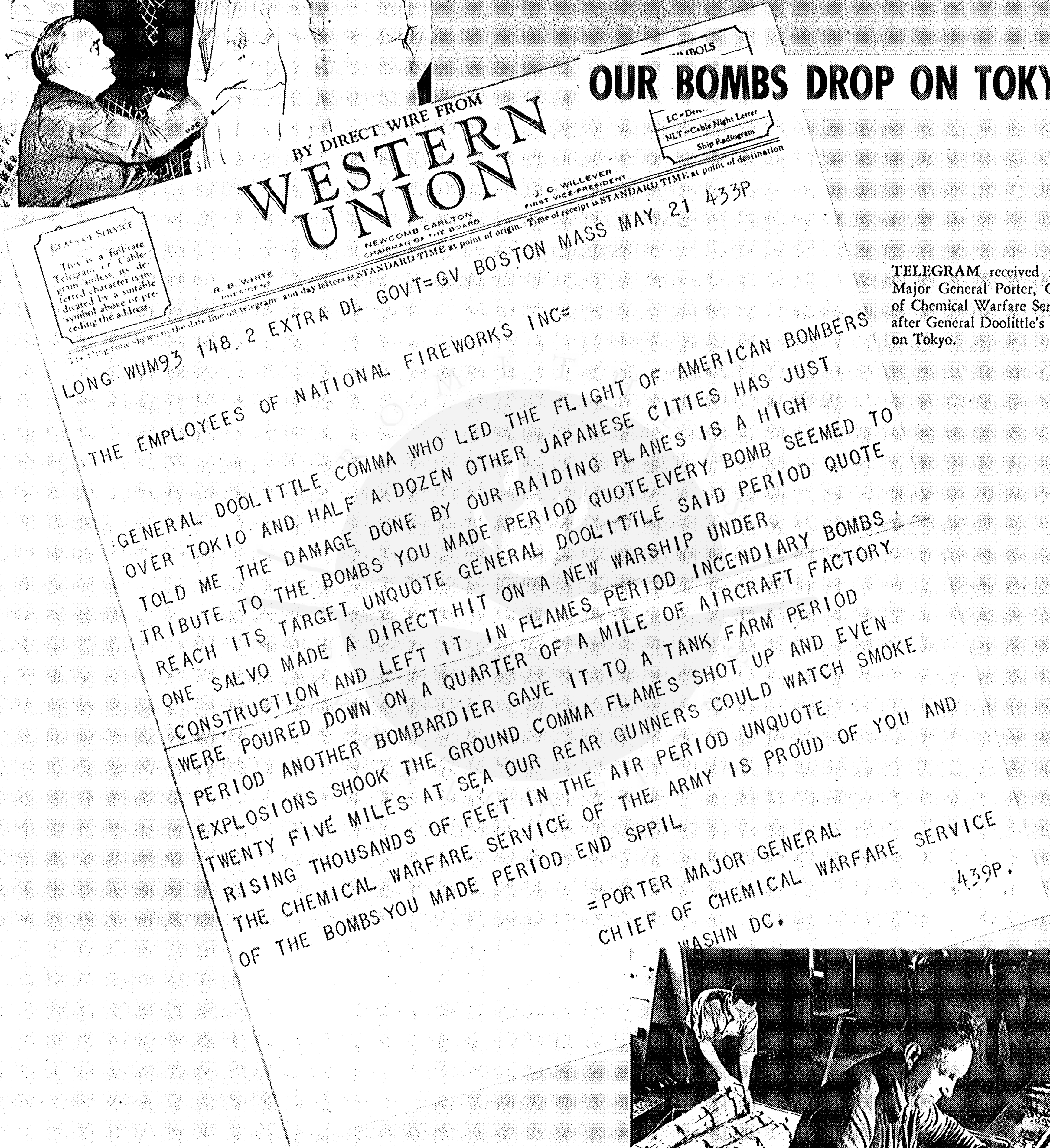
U. S. military powder is a nitrocellulose powder in the form of short cylindrical grains having seven longitudinal perforations. The short grains make it possible to blend many small lots of powder into a large lot which is ballistically uniform. British cordite contains both nitrocellulose and nitroglycerin, and exists in the form of single-perforated amber-colored, flexible sticks or cords. It is hotter and more erosive in the gun than straight nitrocellulose powder, but it is also more powerful. When pushed by either of these powders, a 75mm anti-aircraft shell starts on its flight with a velocity considerably greater than half a mile per second.



DIAGRAMMATIC REPRESENTATION of a complete round of high explosives ammunition, showing the relationships of the various parts.

PRESIDENT ROOSEVELT pins Congressional Medal of Honor on Brig.-Gen. James Doolittle. In background are: Lt.-Gen. Henry H. Arnold, Mrs. Doolittle and Gen. George C. Marshall.

OUR BOMBS DROP ON TOKYO!



BY DIRECT WIRE FROM
WESTERN UNION

LONG WUM93 148 2 EXTRA DL GOVT=GV BOSTON MASS MAY 21 433P

THE EMPLOYEES OF NATIONAL FIREWORKS INC=

GENERAL DOOLITTLE COMMA WHO LED THE FLIGHT OF AMERICAN BOMBERS OVER TOKIO AND HALF A DOZEN OTHER JAPANESE CITIES HAS JUST TOLD ME THE DAMAGE DONE BY OUR RAIDING PLANES IS A HIGH TRIBUTE TO THE BOMBS YOU MADE PERIOD QUOTE EVERY BOMB SEEMED TO REACH ITS TARGET UNQUOTE GENERAL DOOLITTLE SAID PERIOD QUOTE ONE SALVO MADE A DIRECT HIT ON A NEW WARSHIP UNDER CONSTRUCTION AND LEFT IT IN FLAMES PERIOD INCENDIARY BOMBS WERE POURED DOWN ON A QUARTER OF A MILE OF AIRCRAFT FACTORY PERIOD ANOTHER BOMBARDIER GAVE IT TO A TANK FARM PERIOD EXPLOSIONS SHOOK THE GROUND COMMA FLAMES SHOT UP AND EVEN TWENTY FIVE MILES AT SEA OUR REAR GUNNERS COULD WATCH SMOKE RISING THOUSANDS OF FEET IN THE AIR PERIOD UNQUOTE THE CHEMICAL WARFARE SERVICE OF THE ARMY IS PROUD OF YOU AND OF THE BOMBS YOU MADE PERIOD END SPPIL

=PORTER MAJOR GENERAL
CHIEF OF CHEMICAL WARFARE SERVICE
WASHN DC.

439P.

TELEGRAM received from Major General Porter, Chief of Chemical Warfare Service, after General Doolittle's Raid on Tokyo.

BUNDLING INCENDIARY BOMBS at National Fireworks, Inc.

THE EFFICIENCY OF EXPLOSIVES

Large Energy Losses as a Factor in Cost

by C. G. STORM

THE efficiency of an explosive may be defined as the percentage of its total available energy actually expended in doing the work for which the explosive is used. It is, therefore, necessary to know the manner in which the useful energy of a given explosive is exerted in performing its work.

For our purpose it is convenient to divide explosives into three general classes: (1) propellants, (2) disruptive or blasting explosives, and (3) initiating explosives or detonators. The useful energy of a propellant is expended in setting in motion a projectile; that of a disruptive explosive in fragmenting or dislodging some material which is to be destroyed or moved; that of a detonator in setting up a disturbance of such intensity as to bring about the release of the chemical energy stored up in another explosive with which it is in close contact, thereby causing it to detonate or explode.

The total energy of an explosive may be expressed as the total amount of heat, in calories, evolved when a unit weight is exploded, or it may also be expressed in terms of mechanical energy (foot-pounds) by multiplying the number of calories by the factor 3.085. The total energy of fuels or other combustibles is expressed in exactly the same manner, as calories evolved when a unit weight of the substance burns in oxygen (or air), which makes it possible to compare the available energies of explosives and ordinary fuels. Contrary to popular ideas, explosives are far from being economical and efficient sources of energy, when compared with ordinary combustibles used for generating heat. Thus, whereas petroleum evolves 12,000 calories per gram, coal 8,000, and wood about 4,000, nitroglycerin liberates only 1470 calories per gram, guncotton 1100, picric acid 810, and mercury fulminate only 410. It must be remembered, however, that the function of an explosive is to perform work by the conversion of its heat energy into mechanical energy in an exceedingly short space of time, whereas fuels evolve their heat energy slowly.

It is of interest to compare two liquid substances, one an explosive, nitroglycerin, the other a combustible, benzene (a liquid similar in physical properties to gasoline).

1 gram of nitroglycerin on being detonated evolves about 1470 calories.

1 gram of benzene on being burned evolves about 9470 calories.

However, the benzene, like other combustibles, cannot burn without being supplied with oxygen to support its combustion, while nitroglycerin contains its own oxygen and will explode out of contact with air or oxygen.

It is, therefore, only fair to include with the benzene the necessary proportion of oxygen (4.36 parts of oxygen to 1 part by weight of benzene). The comparison is then:

1 gram of nitroglycerin — 1470 calories.

1 gram of mixture of benzene and oxygen — 2330 calories.

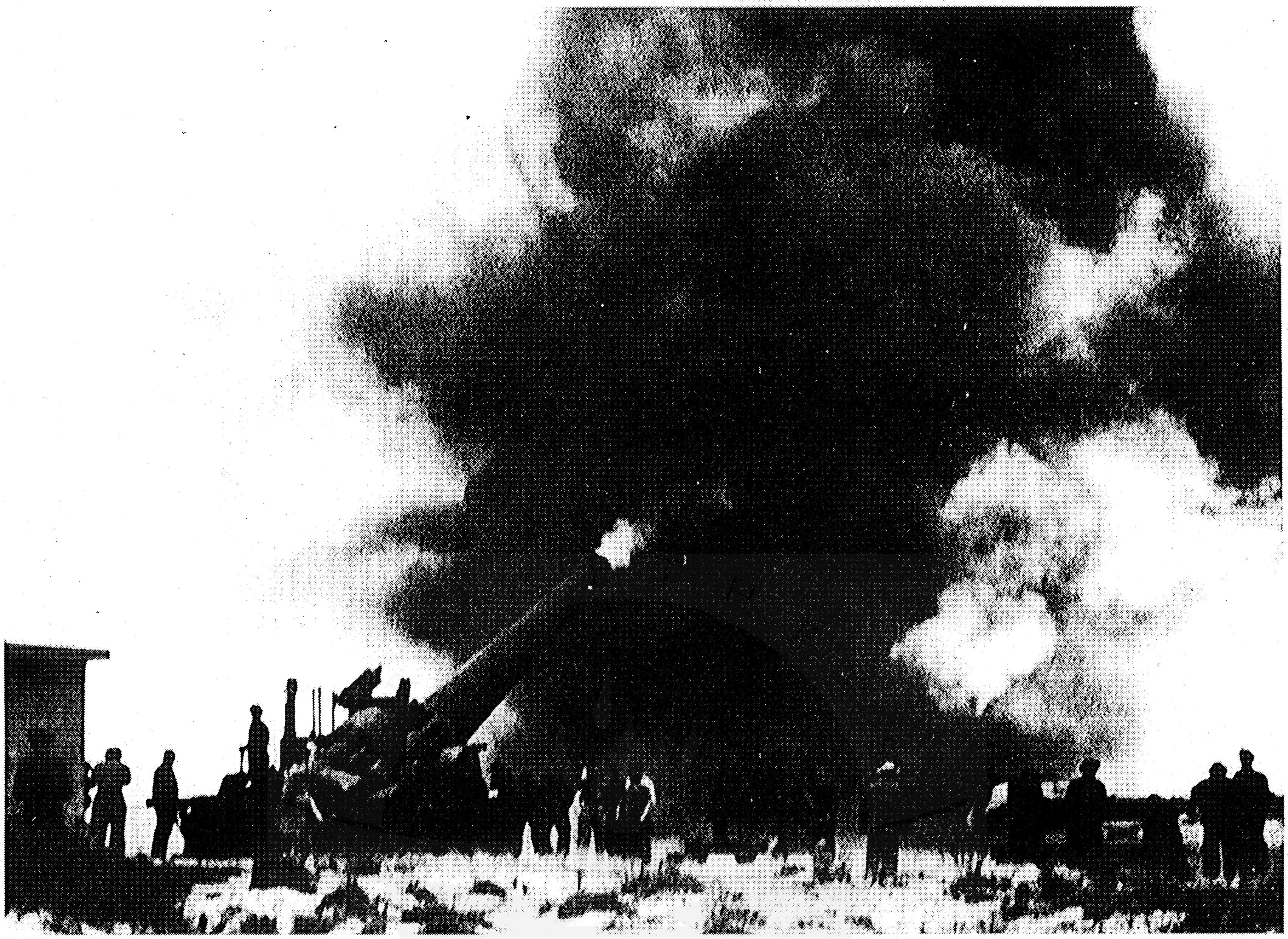
Since oxygen in its normal state is a gas, it is proper to make the comparison in terms of equal volumes, instead of equal weights, whereupon the picture becomes still more radically altered:

1 cubic centimeter of nitroglycerin—2350 calories.

1 cubic centimeter of benzene and oxygen (gas)—4.4 calories.

If, on the other hand, the oxygen mixed with the benzene were liquid oxygen, that is ordinary oxygen of the air converted to the liquid state at high pressure and very low temperature, then the mixture would be actually a high explosive, capable of detonating with the evolution of much energy. Weight for weight, such a mixture possesses about 1.6 times as much energy as nitroglycerin (see above), but volume for volume this superiority of the liquid oxygen-benzene mixture disappears, because of the fact that both liquid benzene and liquid oxygen are appreciably lighter than nitroglycerin, and hence the mixture occupies more space for a given weight.

C. G. STORM, PH.D., Technical Director, National Fireworks, Inc. Beginning in 1901 Explosives Chemist, Navy Powder Works and U. S. Bureau of Mines. Directing Chemist, Aetna Explosives Co. 1915-1917; Major and Lt. Col., Ordnance Department, U. S. Army, 1917-1919; Research Chemist, Trojan Powder Co., 1919; Chief Explosives Chemical Engineer, Office of the Chief of Ordnance, War Department, 1919-1942.



UNCLE SAM'S BIG GUNS ROAR INTO ACTION

In general, it may be said that mixtures of combustible liquids or solids with liquid oxygen are very powerful explosives but are unsuited for military use, for example in airplane bombs, because of the fact that the liquid oxygen has such a high rate of evaporation that it cannot be sealed up within a bomb, and if a bomb loaded with such a mixture is vented it loses the liquid oxygen so rapidly that the bomb becomes inert before it can be dropped.

It is apparent from the foregoing discussion that the great distinction between explosives and combustibles is that the former possess a greater *concentration* of energy, and release their energy much more rapidly than do combustibles.

In the case of an explosive used for blasting or for fragmenting a high explosive shell or bomb, it is not possible to calculate what percentage of its total energy is expended in doing useful work.

In mining, it is desired to break down rocks or other material from place, in the form of fragments of suitable size, the size depending on the use to which the material is to be put. Thus, for coal, a minimum proportion of fine material is desired; for hard ores which subsequently must be crushed for treatment, large lumps are not wanted. In quarrying building stone, fragmentation is to be avoided as much as possible, large blocks being desired.

In the case of explosives used as bursting charges for shells, it is generally desired that the shell be disrupted into many fragments of such size and projected at such velocity as to have the maximum destructive effect against personnel, aircraft, or other target. In the case of larger shells a maximum blast effect, rather than fragmentation, is desired.

It is, therefore, apparent that disruptive or blasting explosives have many widely differing applications and must produce a large variety of results. There must therefore be many different types, each possessing its own distinct properties. An explosive suitable for use as a bursting charge for high explosive shells would be entirely unfit for quarrying building stone or mining coal. The principal factor which determines the suitability of an explosive for a given purpose is its brisance, a factor depending on energy concentration or density of the explosive, and on its rate of detonation.

The actual efficiency of an explosive used for mining or quarrying or for fragmenting a shell might be calculated with some degree of approximation if means were available for determining the energy required to break the rock or the shell into fragments of a given size, but such a calculation would be of questionable accuracy. One authority has estimated that nitroglycerin on detonation exerts a total pressure of 210,000 lbs. per square inch and that only 14% of its total energy is employed in doing useful work such as shattering or displacing rock, the remainder being lost as heat, sound, etc.

Similarly, in the case of a detonator used for producing the detonation of a larger charge of another explosive, it is impossible to estimate what part of the total energy of the detonator is exerted in setting up an explosive wave in the main charge, and what part is expended in bursting its container and doing useless work.

With propellants, however, the problem is much more simple. A charge of smokeless powder in a gun possesses a total energy which may be expressed in terms of the total number of calories evolved on explosion. The purpose of this powder charge is to propel a projectile from the gun at a prescribed velocity. The problem is, therefore, to determine what portion of the original potential energy of the powder charge has been transferred to the projectile in the form of kinetic energy at the instant that it leaves the muzzle.

In an article published in 1913 by C. Cranz,* an attempt was made to calculate the energy balance in the case of the powder charge for an infantry rifle.

The powder charge (weighing 3.2 grams) had a calculated total energy content of 2762 calories (about 860 cal. per g.), or, expressed in mechanical terms, 8459 foot-pounds, i.e., energy sufficient to raise 8459 pounds a height of one foot.

Cranz's calculations showed the following approximate distribution of this total energy content of the powder charge as it performed its mission of propelling the bullet from the rifle:

Muzzle energy of bullet due to its forward movement	905	calories
Muzzle energy of bullet due to its rotation	4	"
Recoil energy imparted to rifle	3	"
Absorption of heat by barrel	620	"
Energy expelled from muzzle in the form of hot gases, sound, etc.	1230	"
Total	2762	"

The above summary shows that only about one-third of the total potential energy of the powder charge was actually expended in imparting forward velocity to the bullet. In this illustration, the 905 calories representing muzzle energy may be expressed as about 2,700 foot-pounds. It is interesting to compare this with the calculated value of about 92,600,000 foot-pounds for the muzzle energy of a 2000 pound projectile as it is propelled out of the muzzle of a 16-inch gun at a velocity of 1800 feet per second by a smokeless powder charge of more than 800 pounds. The time required for the projectile to attain this muzzle energy (i.e., to travel the length of the barrel—over 60 feet), is about one one-hundredth of a second. But the accuracy-life of the 16-inch gun is only about 100 rounds, or about 1 second of actual work. The powder for these 100 rounds would cost probably $30,000. On the other hand, a 100-horse-power steam engine would require about 45 hours to do the same number of foot-pounds of work, at a fuel cost of probably less than $20.

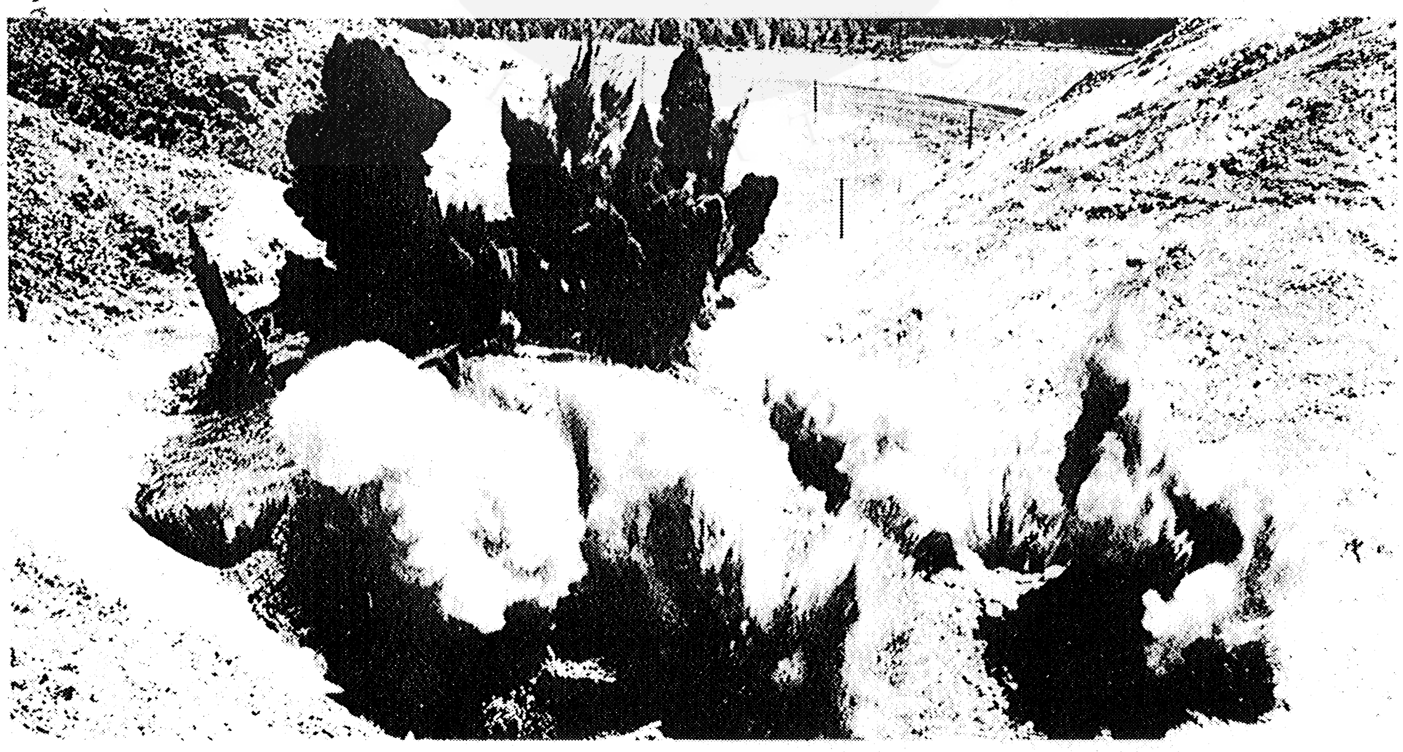
Let us consider the energy of the projectile when it reaches its target, rather than its energy when it leaves the muzzle of the gun. In the case of the infantry rifle referred to above, at a range of about 1200 yards, the energy of the bullet has fallen to only about 10% of the original energy at the muzzle of the rifle. In other words, the energy expended by the bullet in striking a target at a range of 1200 yards is less than 3.5% of the total energy contained in the smokeless powder charge.

In the case of larger weapons, the efficiency of the projectile is much greater.

Cranz (see above) calculated that the projectile from a 12-inch naval gun, weighing 980 pounds, leaving the muzzle with a velocity of 2700 feet per second, has a muzzle energy of 110,000,000 foot-pounds. If the gun is elevated at an angle of 40 degrees, the shell will reach a maximum height of about 7 miles and have a range of 20 miles. On reaching the end of its flight after 95 seconds, it will have a remaining velocity of 1300 feet per second and its striking energy will amount to about 20% of its original muzzle energy.

It is apparent from the foregoing discussion that propellant explosives are relatively poor sources of energy, even when the projectiles which they drive out of the gun actually strike the target at which they are aimed. As a matter of fact, only a small percentage of fired projectiles hit the target, the great majority striking the ground at points where they do no damage. If we consider also that a large percentage of bombs of all sizes dropped from airplanes miss the targets for which they are intended and merely make plenty of noise and tear big holes in the ground or make big splashes in the ocean, we can readily realize that war is exceedingly wasteful of the vast amount of potential energy contained in the explosives actually consumed in battle.

*C. Cranz, Zeit. fur Elektrochem. *19*, 731-8 (1913).



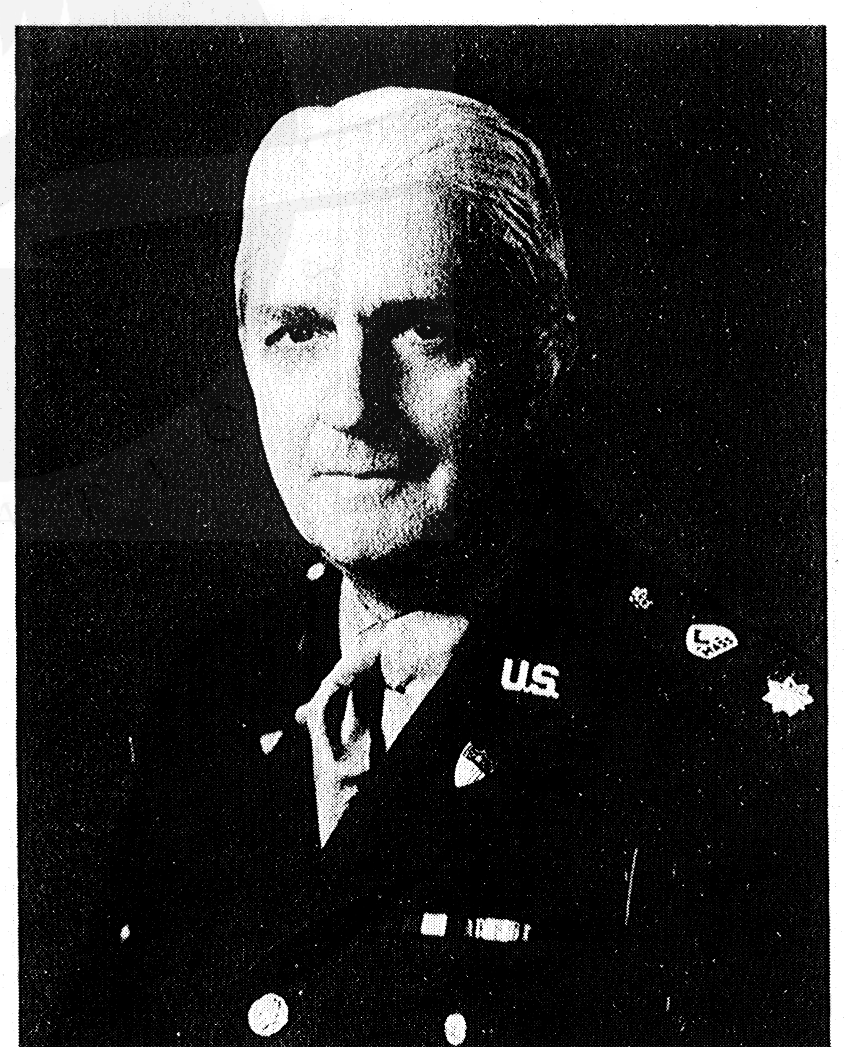
A BLAST OF 13 TONS OF TNT GOING UP TO SHATTER THE ROCK OF A NEW QUARRY

TRAINING MANPOWER FOR MUNITIONS

The School of Munitions Technology

The imperative need for training manpower applies to the production elements as well as to the fighting forces. With this principle in mind, Mr. E. V. Babbitt, Executive Vice-President of National Fireworks, Inc., began to plan for a School of Munitions early in 1942—a rare example of foresight which resulted in the first school of its kind in America. It was his thought to develop a progressive training program which would bring into the battle of production the maximum power of his whole organization of ammunition loaders, then numbering some seven thousand workers in five plants and about to expand into an army of twenty thousand working in thirteen plants.

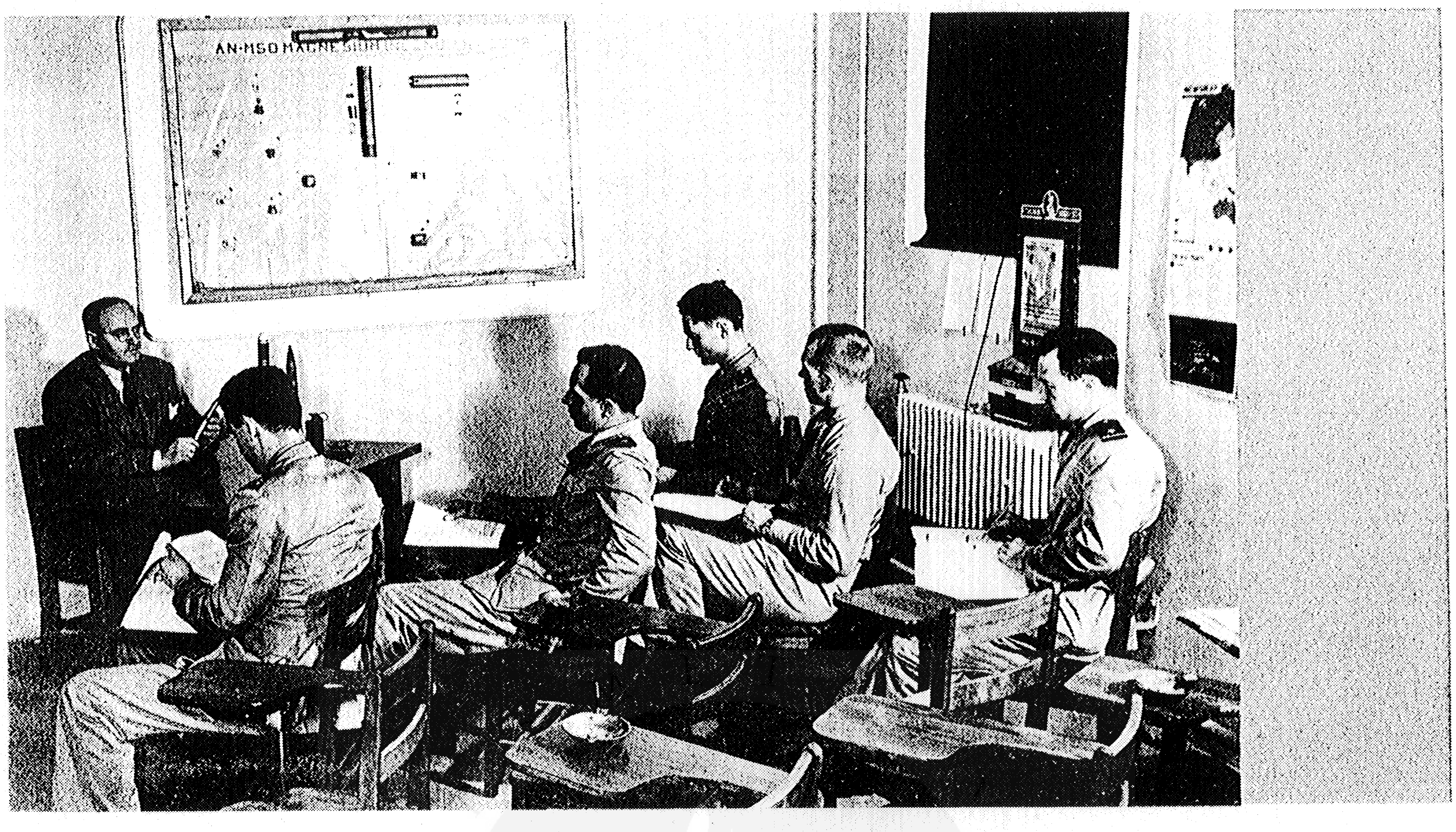
His first step was to secure a director with a background of experience in civilian education and army personnel training. Walter H. Lillard was appointed director in February, 1942, and a board of trustees was organized to assist in developing the principles of training. In addition to Mr. Babbitt and Colonel Lillard, the board includes C. W. Wannen, Vice-President and General Manager, General Daniel Needham, General Counsel of the Corporation; David Black, General Plants Manager; and Tenney L. Davis, Ph.D., Director of Research. Under the guidance of this board, a comprehensive program was launched in March, 1942, which soon began to gain momentum and power.



LT. COL. WALTER H. LILLARD, A. G. Res.,
Director of the School of Munitions.

Vestibule Training

In the School of Munitions the first opportunity to train a new employee comes during the so-called vestibule period which follows immediately the various employment arrangements. Many of the workers are about to join the assembly lines where the various kinds of shells, bombs and grenades are loaded. Lessons to these recruits are centered in accuracy, thoroughness, safety and speed. Others have assignments in such departments as Traffic, Maintenance, or Administration where they do not often come into close contact with the actual munitions. But all of them are made to understand at the outset that their assignment is a very essential one and that they will share in the fight for democracy during every hour of their service.



NAVY OFFICERS assigned to duty in Advance Bases study ammunition under Lt. Col. Charles G. Frost, Eng. Ret.

Next comes instruction about safety and eternal vigilance—a respect for the hazards of loading munitions, but no fear of the job. Thus the rumors the employees so often hear outside the plant are killed at the start. The new recruits are shown the different types of munitions which the Company assembles. Company rules are explained. Safety precautions and anti-sabotage are stressed. The disloyalty of the Monday morning absentee is made very clear. After this vestibule training is completed the new employee is ready for the lines.

Visual

Through the use of a portable 16 MM sound projector, the School maintains constant contact with the workers and proceeds with a regular program of moving pictures. In order to reach all three of the shifts, this part of the training goes into action twenty-four times each week. The most popular pictures are those which take the audience into the combat zone where they can actually see the deadly effect their ammunition has against the enemy.

Training the Supervisors

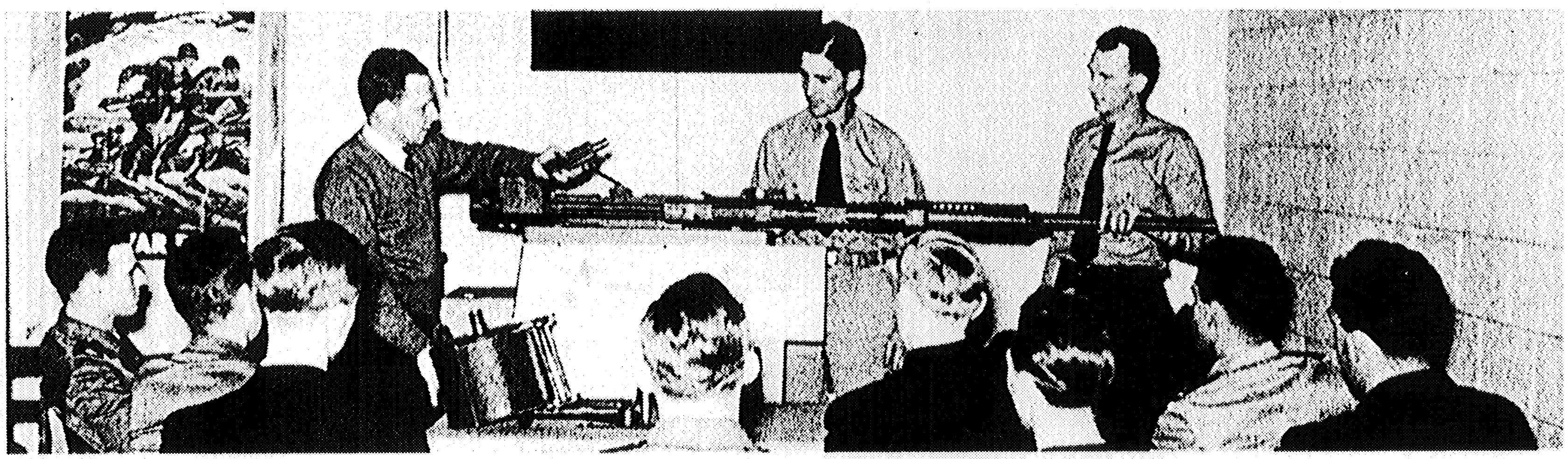
During the first months of loading ammunition in many of our American plants each foreman took over a small sector of the production front, was given a meager amount of information from his superintendent, and then had to develop his production team by a system of trial and error. There was a trading of ideas back and forth, coming from the usual surge of Yankee resourcefulness; and somehow or other production got under way. Here was the obvious beginning point in the development of the School of Munitions at National Fireworks.

All of the group leaders who had any kind of supervisory assignment were organized in classes, averaging about twenty, and began attending weekly meetings where they could have presented to them ways and means of improving their efficiency. Some of these meetings were devoted to lectures followed by question periods; others were conferences in which a foreman with a good idea concerning some phase of his work could share it with the others. For lecturers there were experts available in the organization who were successful in presenting their own subjects to these groups.

War Training Courses for Employees

One of the best features of the whole program reaches all grades of the organization—assembly line workers, foremen, and administrative officers. This has been developed in the form of evening classes during two periods: the first period extended from October, 1942, through May, 1943; the second period began in October, 1943, and will extend through May, 1944.

During the first period the program here was sponsored by the United States Office of Education under the general heading of *Engineering, Science,* and *Management War Training Courses.* The faculty consisted of instructors from Northeastern University and from our own staff. Classes in the following subjects were conducted:



CLASS INSTRUCTION in 20 MM Oerlikon Anti-aircraft Gun, under Instructor Paul Stiga.

Cost Accounting
Engineering Drawing
Explosives and Ballistics
Foreman Training
General Chemistry
General Mathematics
Methods Engineering
Office Machines
Production Planning and Control
Secretarial Skills

The enrollment list contained 191 students. As transportation became more difficult during the winter months attendance fell off, but 83 succeeded in completing the work and qualifying for certificates. The most successful classes in holding attendance were Explosives and Ballistics, General Chemistry, and Foreman Training.

Training for Post-War Assignments

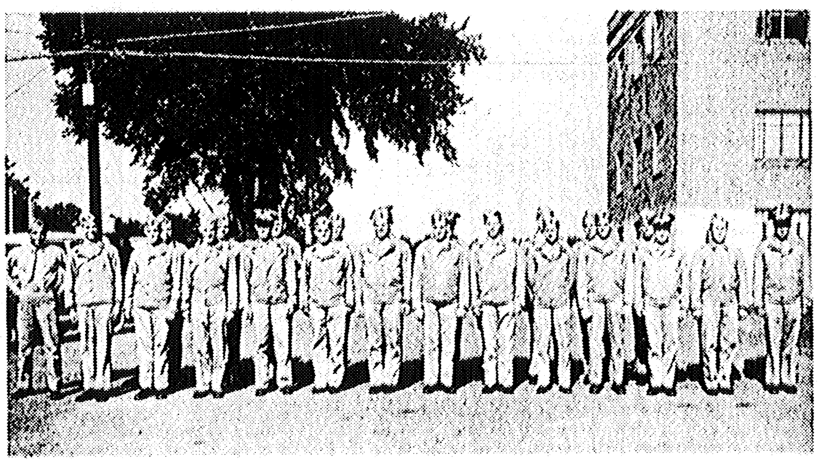
The second period of evening courses at the School began in early October of this year after our management had agreed to subsidize an educational plan which would build up the assets of our employees at present and also prepare them for post-war opportunities. In setting up this very generous plan the management here was looking beyond the war horizon with queer vision and constructive problems. Loading shells is very definitely a war assignment. When peace comes our production soldiers like the members of the armed forces will be demobilized and available for new jobs. That is why our School of Munitions was authorized to set up a generous program of study.

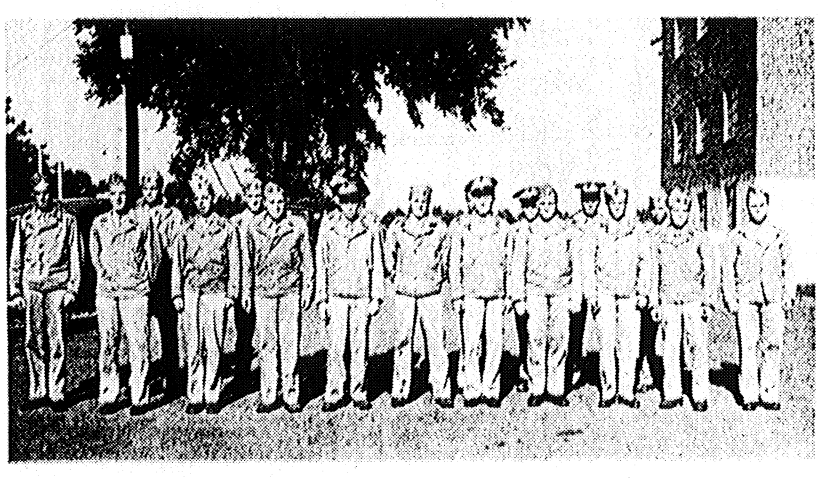
Some of these courses are being conducted by the College of Business Administration, Boston University, and the other courses are under our own instructors as during the first period. There are 177 students enrolled. The curriculum includes the following courses:

Auto Mechanics
Auto Maintenance
Business Fundamentals
Explosives
Round-Table Studies on Post-War Conditions
Sales Presentation and Business Correspondence
Spanish
Stenography
Typing

The School as an Aid to the Armed Forces

At the time of the School's founding in February, 1942, it was planned to develop from the National Fireworks executive personnel a faculty of munitions experts whose experience might be placed at the service of the Armed Forces. In August, only six months after





U. S. MARINES attend the School in two platoons in order to become better acquainted with their ammunition.

the establishment of training courses for plant supervisors and workers, the program was expanded to begin the schooling of Navy officers in Ordnance.

First to be trained was a group of ten Navy officers who were preparing to go on duty in similar Ordnance plants as inspectors. They were given three weeks of intensive training, which combined actual close-up observation of loading with lectures and conferences by the heads of departments and their lieutenants.

Next to report for duty here, in September, was a group of sixteen young women who had been selected by the Chemical Warfare Service of the Army to be trained as inspectors in various plants which are making incendiary bombs and grenades. This class was given three weeks of careful training with the supervision of the resident C.W.S. officers under Major Chenery Salmon. The third class to report consisted of four Navy officers, who were trained, like the first group, for duty as Ordnance plant inspectors. This group studied during the last week of October and the first week of November. In December came the fourth class numbering twenty-seven young women to be trained as inspectors in the Chemical Warfare Service projects.

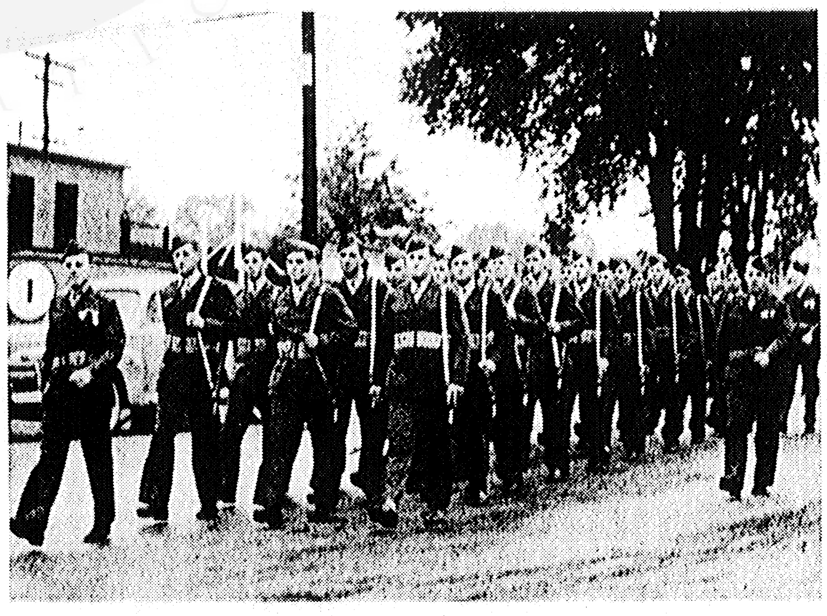
Having established a reputation of merit in training inspectors, the School was contacted in January by the Personnel Section of the Navy Ordnance branch and asked to train officers for duty in the Advance Bases about to be established on the shores of the Seven Seas. Instruction began at once and has continued regularly from January, 1943, to the present time.

The actual time allotted for their training at the School of Munitions is two weeks, as there are other Schools which they are scheduled to attend before and after. Naturally the administrative and teaching personnel of the School feel that this is a real privilege, and they have entered into the training program with enthusiasm. The first class of five officers reported for two weeks of intensive study beginning on January 4th, and they soon demonstrated the fact that they had been carefully selected for the responsible mission ahead. They were very keen about the opportunities offered by the School faculty to become well informed concerning the loading, inspection, storage and handling of various kinds of Navy munitions, such as the 20 MM, the 2 Pounder, 40 MM, the 50 Caliber, Incendiary Bombs, Grenades, and Military Pyrotechnics. Fuze Mechanics and Demolition are also regular parts of the curriculum. Twenty-three classes totalling one hundred and eighty-three officers have taken this training up to November, 1943.

The Marine Corps has been served by the School through a course of lectures and demonstrations arranged for the battalion stationed at the Naval Air Base at South Weymouth, Massachusetts. When it was learned that these soldiers of the sea were on duty so near the School, and that they were eager to learn more about their ammunition before going overseas, the facilities of the School were made available at once on a time schedule arranged by their commanding officer. Most interesting to the Marines are the 20 MM Round and the Oerlikon cannon. Classes of twenty-five Marines come to the School once a week for eleven weeks. One hundred and four certificates for completion of the course have been issued to Marines from this base.

CLASS 23, U. S. Navy Officers.

NAVY enlisted men's class at School.



STUDENT MARINES help dedicate the Honor Roll.

MANUFACTURE OF MAGNESIUM POWDER

At the West Hanover Plant of National Fireworks, Inc.

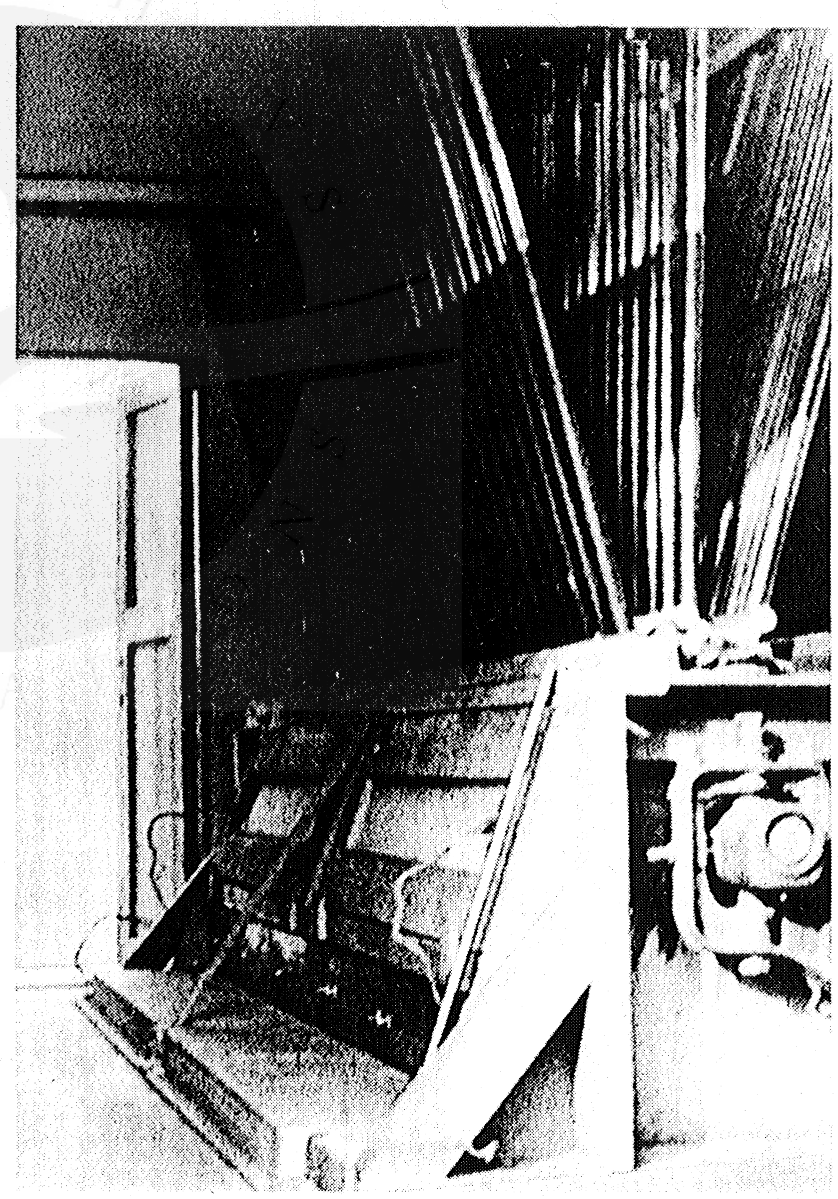
by WILLIAM MELVIN CLARK

SEVERAL months before our entry into the War, when the need arose for magnesium powder for use in tracer bullets, flares, etc., National Fireworks stood ready to undertake the manufacture. We had what amounted to a prior knowledge of the art, or a prior acquaintance at least, for we had manufactured powdered aluminum during the first World War. For that purpose filing machines had been designed, and machines in which bars of aluminum were hammered until the metal was reduced to powder. The latter method was found to be inapplicable to magnesium, but the filing machines were satisfactory—and machines are now being used for filing magnesium which operate in the same general manner as the machines of twenty-five years ago designed for use with aluminum.

The filing machines consist of horizontally-rotating cylinders covered with coarse files bent to conform to the surface and fastened on with screws. These are turned by a constant speed motor at a rate which may be adjusted by means of gears according to the sharpness of the files. The magnesium is received in the form of cylindrical bars, 1.3″ in diameter. A strong frame above the file mill holds three rows of pipes, radially disposed with respect to the horizontal cylinder, in such manner that the ends of the magnesium bars inserted in these pipes rest against the files and are held in place by their own weight and by any additional weights which may be inserted in the pipes on top of them. The files thus remove shavings from the ends of the rods, cutting them across the grain of the metal.

The magnesium rods which are received at the plant have been made from ingots by extruding at a temperature of about 750-800°F. Pure magnesium melts at 1204°F. (651°C.). The temperature at which the bar stock is extruded is considerably below the melting point of magnesium and evidently, also, below the temperature of recrystallization (annealing temperature) of the metal. The bar stock has the qualities of a metal which has been cold-worked. The crystals appear to be oriented in the direction of the length of the bar, and this property, as might be expected, is reflected in the properties of the shavings which are filed from the end of the bar.

The magnesium filings fall into drawers which are copper lined and electrically grounded. Indeed, from this point on, all of the machines which handle the magnesium powder are electrically grounded, and every precaution is taken both to prevent the flying about of magnesium dust and to prevent the accumulation of static electricity by which the magnesium might be ignited. The drawers or bins underneath the file mills and the receptacles into which the magnesium falls



FILE MILL. Note the drawers, with handles, bottom center of the picture. Above them, electrically grounded covers made of canvas and wire screening for ventilation. At the top, weights standing in the pipes, which hold the magnesium bars against the file.

from the screens and hammer mills are enclosed by canvas in order that dust from them may not circulate in the room. The file mills have been studied for the purpose of determining the best speed of rotation, the best weights to place upon the magnesium bars, the best temperatures of operation, and so forth. At the present time, each file mill produces about 300 pounds of magnesium filings in a 24-hour day.

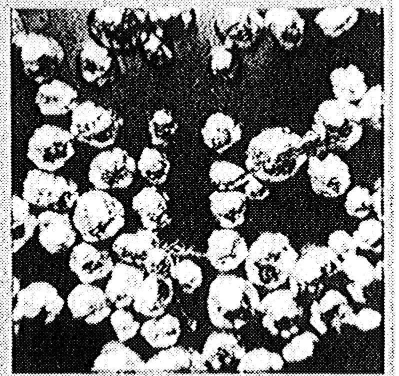
The material from the files is screened through a 4-mesh screen which removes slugs, bar ends, and very coarse slivers. It then goes to the hammer mills. These are Fitzpatrick mills, chosen because of their size and safety of design, and have been equipped by this Company with water jackets and air regulators, with aquastats to control chamber temperatures, and with devices for controlling the rate of flow of the air and for shutting off the machines in case of excessive temperature rise. The chips or filings are fed into the hammer mills from elevated hoppers at a rate of about one pound per minute, and thence, after being pounded, they pass through a slotted screen into containers from which they are emptied again into the hoppers which supply the hammer mills. After two passages through the hammer mills, the magnesium powder is screened and separated into the various grades which are blended for the production of the finished lots. Coarse material which does not pass through the screens, is returned for two more passages through the hammer mills, then screened again, and so on. It has been found that eight times through the hammer mill gives the maximum production of fine powder.

The chips, filings, or shavings which come directly from the file mills are the fluffiest of any and have the lowest apparent density. Hammering of the material makes it more dense. It is therefore necessary to determine the apparent density of each batch of material from the screens, and then to calculate the proportions in which the several batches must be blended to produce material which conforms to the Army or Navy specifications for granulation and density. The product is shipped in 100-pound lots in hermetically sealed metal drums from which all dampness is rigorously excluded.

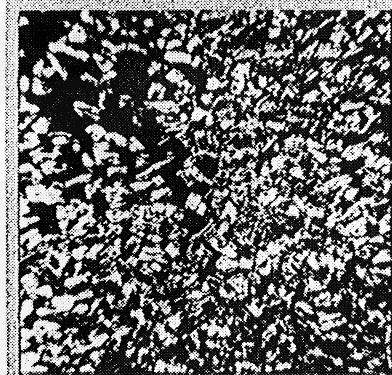
SHAVINGS produced by new sharp files. These do not break up in the hammer-mills as well as the shavings produced by duller files.

SHAVINGS produced by old, dull, somewhat worn files. Note the segmentation which causes these shavings to break in pieces very readily.

PEANUT-SHAPED PARTICLES of magnesium, the edges pounded down and rounded by the action of the hammer-mill.

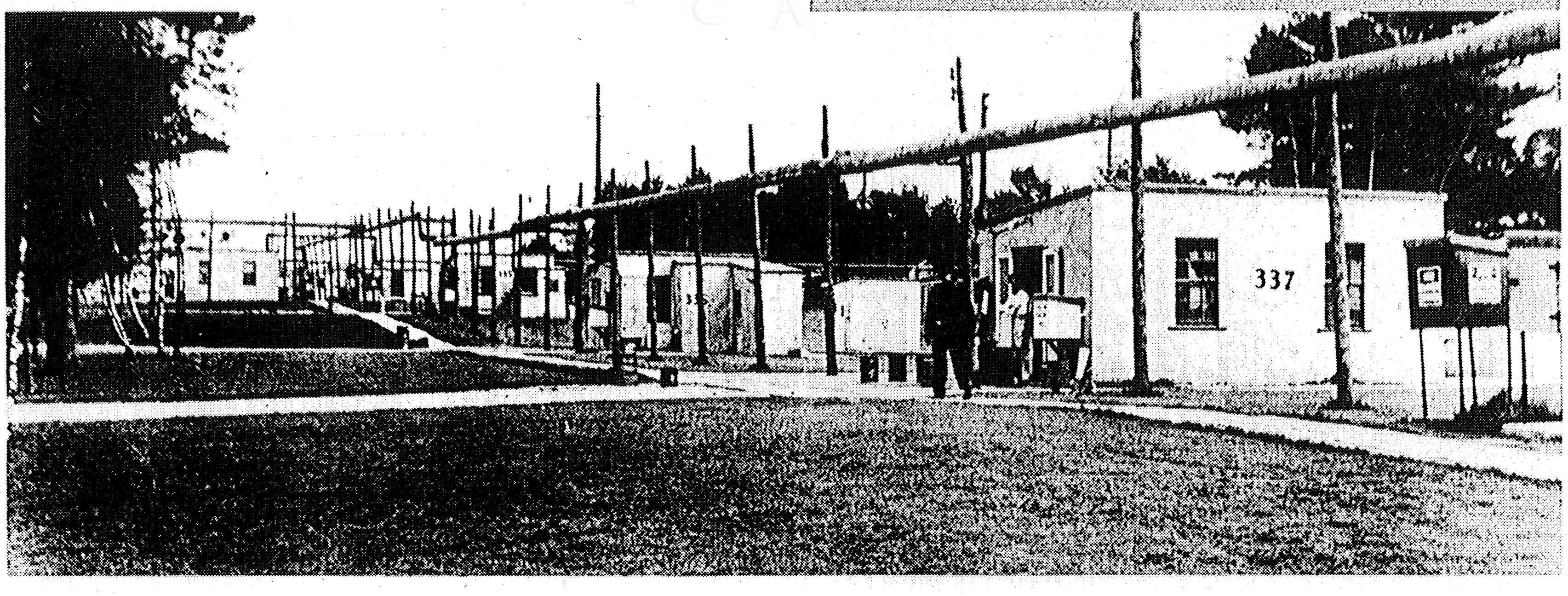


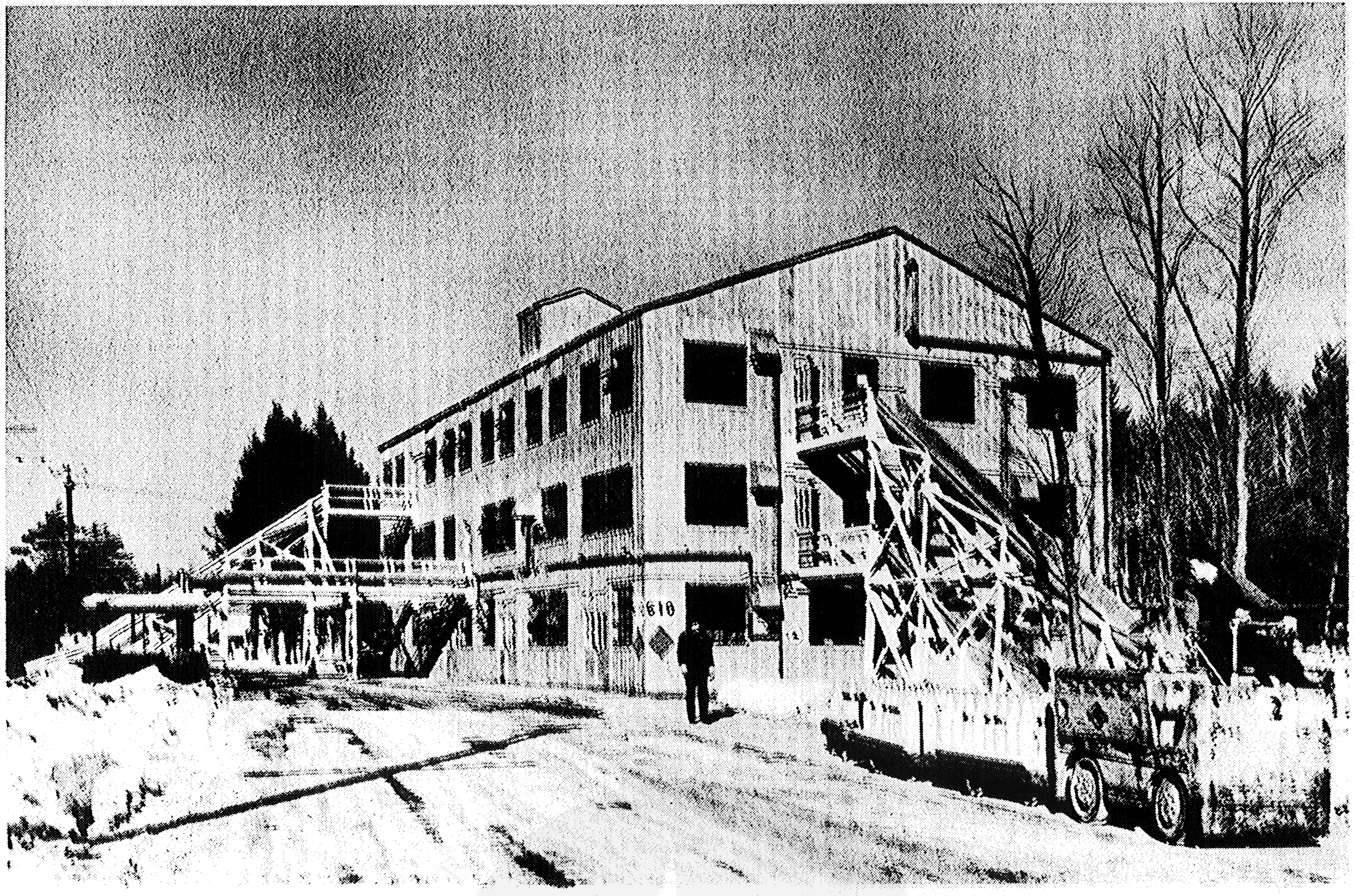
BALL-SHAPED PARTICLES of magnesium, the result of too much hammering.



FINISHED MAGNESIUM POWDER, 48 to 100 mesh.

A portion of the magnesium grinding plant at West Hanover.





MAIN BUILDING in shell loading group, where amatol, a widely used explosive, is mixed and poured. Extraordinary safety precautions are taken here. Note chutes for quick evacuation of building in case of emergency.

SHELL LOADING and BEECH HILL

A Modern Munitions Plant Built-to-Order for This War

by MAJOR C. P. T. KAFFKE

THE modern shell loading and assembly plant, known within the National Fireworks organization as "Shell Loading and Beech Hill," was built-to-order for this war.

In August, 1940, representatives of the British Government suggested that National Fireworks would be the logical organization to design, build and operate a high explosives plant for them. This proposal was based on the experience and record of the company during World War I in loading small arms ammunition, and, since then, the production of various types of pyrotechnic loadings for the U. S. Army.

The decision to build such a plant was reached after several meetings with the British representatives, at which the type of shells to be loaded and the approximate daily schedule of production was determined. In these discussions it was proposed that this new plant should embody, in a moderate scale, the most modern features of design and operation known to British and American military technicians. It was to be built-to-order for this war, and to be put into effective operation at the earliest moment.

The problem of acquiring a suitable site for a project of this nature for immediate use was solved by the availability of a six-hundred-acre tract of flat and rolling land within a mile of the original National Fireworks plant. As soon as the decision to convert this site was reached a hectic period of negotiation, surveying, and title search began, in order to co-ordinate the individual parcels held by a large number of owners. While this survey was being conducted, the size and design of the buildings and the general layout of the plant were being worked out on paper, and the equipment specifications written. Since the largest part of the equipment and fixtures of a high explosives plant are not commercially available in ready-to-use form, the engineering detail involved was accomplished at high tension.

As soon as practicable the field-work on the site was begun and carried on at fever pitch. The terrain consisted of the widest variety of contour and cover — plains, hills, gullies, meadows, woodland and swampland. The business of co-ordinating paper plans and actual locations required days of exacting foot-work and observation. The ideal layout on paper had been attained—but its translation into practical sites entailed many shifts in plan. The mysterious underground meanderings of the swampland were found to interfere seriously with many pre-arranged foundations. Soundings often showed chosen spots to be veritable bottomless pits, and every compromise in re-location would throw out carefully worked out zones and present numberless new problems for re-thinking. Meanwhile the work of clearing, draining, and road-building was extended all over the tract with armies of men and machines seemingly overlapping one another.

Ground for the plant buildings was broken on November 1, 1940—and on March 1, 1941, the first shell was poured—four months to construct and implement a plant layout of more than half-a-hundred buildings. Maximum production was achieved three weeks later—the result of painstaking personnel organization and planning which had been carried on simultaneously with the construction period.

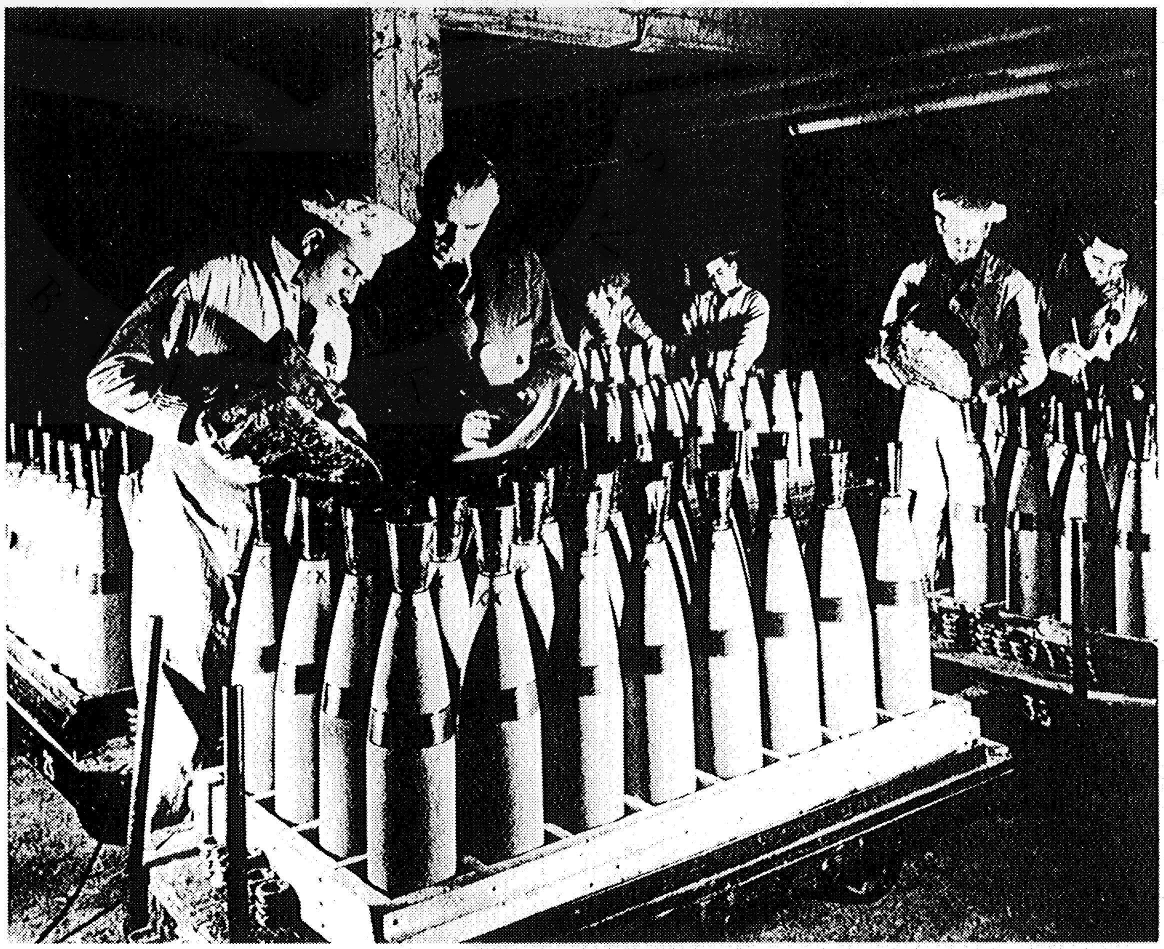
The first shells poured were for the British Government, and were sent to Africa. Some of these were used in the first siege of Tobruk during which the British African Army reduced the strong enemy defenses and took the city from the Italians. Shells of the second type loaded here found their way both to Russia and to Africa and were used with devastating effect against enemy personnel and tanks.

Somewhat later, when the swiftly-changing pace of modern warfare brought into use by the Nazis' more heavily-armored tanks, this type of munition lost its usefulness and was discontinued.

A third type of ammunition for use against high-flying aircraft went into production here, following this change in materiel. It is interesting to note that the plant layout specifically designed at the outset for the loading of large-calibre shells could be so readily adapted to a totally different type of loading. Many of the construc-

MELTING TNT, a yellowish powder, used in making amatol. Workers wear coveralls and paper caps for protection against TNT dust.

PRE-HEATING AMMONIUM NITRATE before blending with TNT.



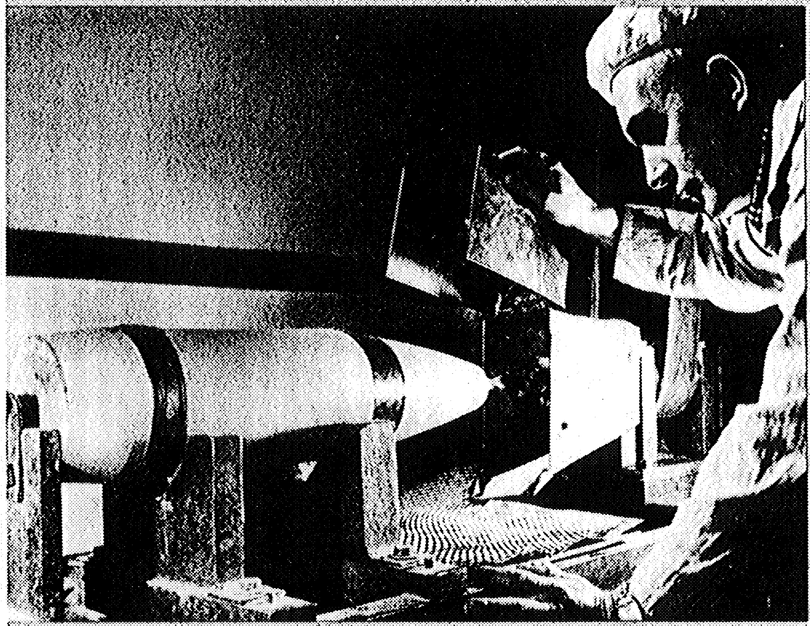
TNT TOPPING. Conical pouring cups provide the necessary excess to make up for shrinkage when the TNT cools.

tional features of the plant proved to be so functionally basic for high explosive handling that it could serve the new purposes as ideally as those for which it was originally designed.

This type of anti-aircraft loading uses a sensitive point-detonating fuze that is capable of functioning on contact with a 9-oz. millboard, but is "bore-safe" inasmuch as it will not function until it develops rotational speed. Because only a very small percentage of anti-aircraft projectiles actually hit a plane, and therefore create an appreciable battle-hazard to friendly personnel as they return to earth, these projectiles are fitted with self-destroying elements. These elements also serve as a tracer which shows the direction of flight and assists the gunner in finding his target. In addition to the loading of the projectile, tracer, primer, and fuze, it is necessary to weigh and bundle the cordite which is used as a propellant. The safety factors which were embodied in the original plant are equally necessary for these later operations, and the areas for the storage of large quantities of high explosives and finished products located remotely from the manufacturing buildings have proved of great advantage.

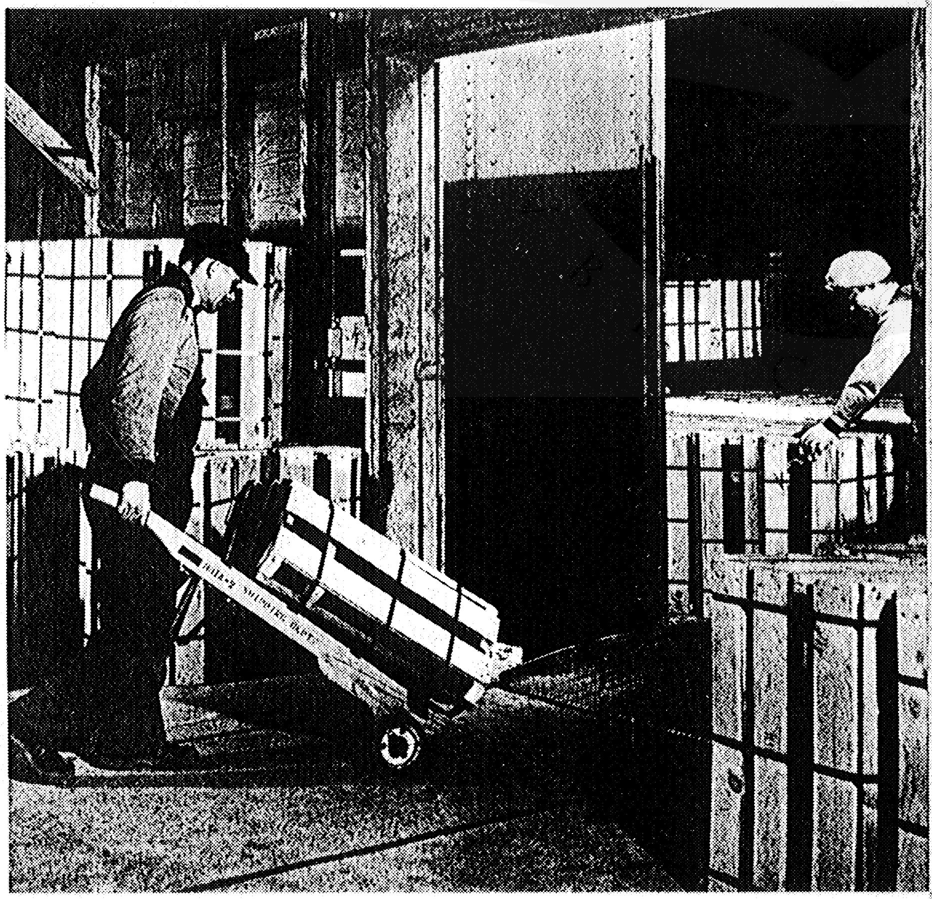
This ammunition is fired at a great number of rounds per minute when in use, and is assembled as a complete round. The assembly buildings are large enough to permit an assembly routine in which the components going into the complete round may enter one end of the building in proper sequence, and the completely-finished and packed round emerges from the other end, ready to be placed in freight cars or aboard ships.

After the war, when military secrets of today may be cited in terms of millions of pounds of high explosives used and tons of shells handled, the production record of this modern munitions plant, "built-to-order" for this war, may make interesting reading for the public, as well as for ordnance and explosives experts.

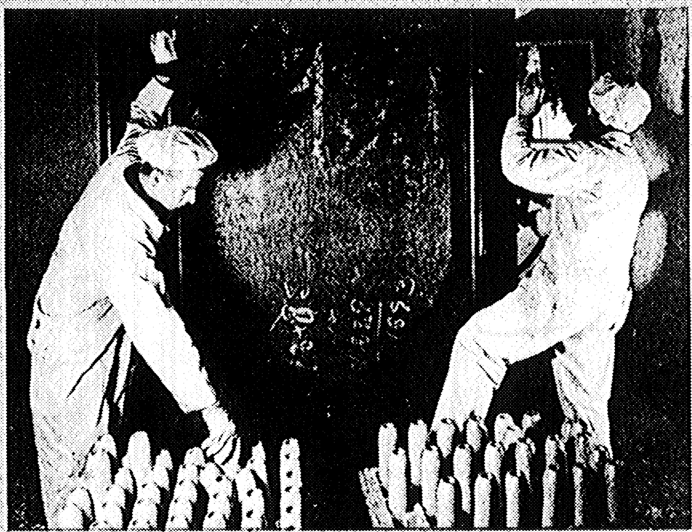


PREPARING TO DRILL 6-inch shell. Workman is adjusting dust shield. The actual drilling operation is shown in the photograph below.

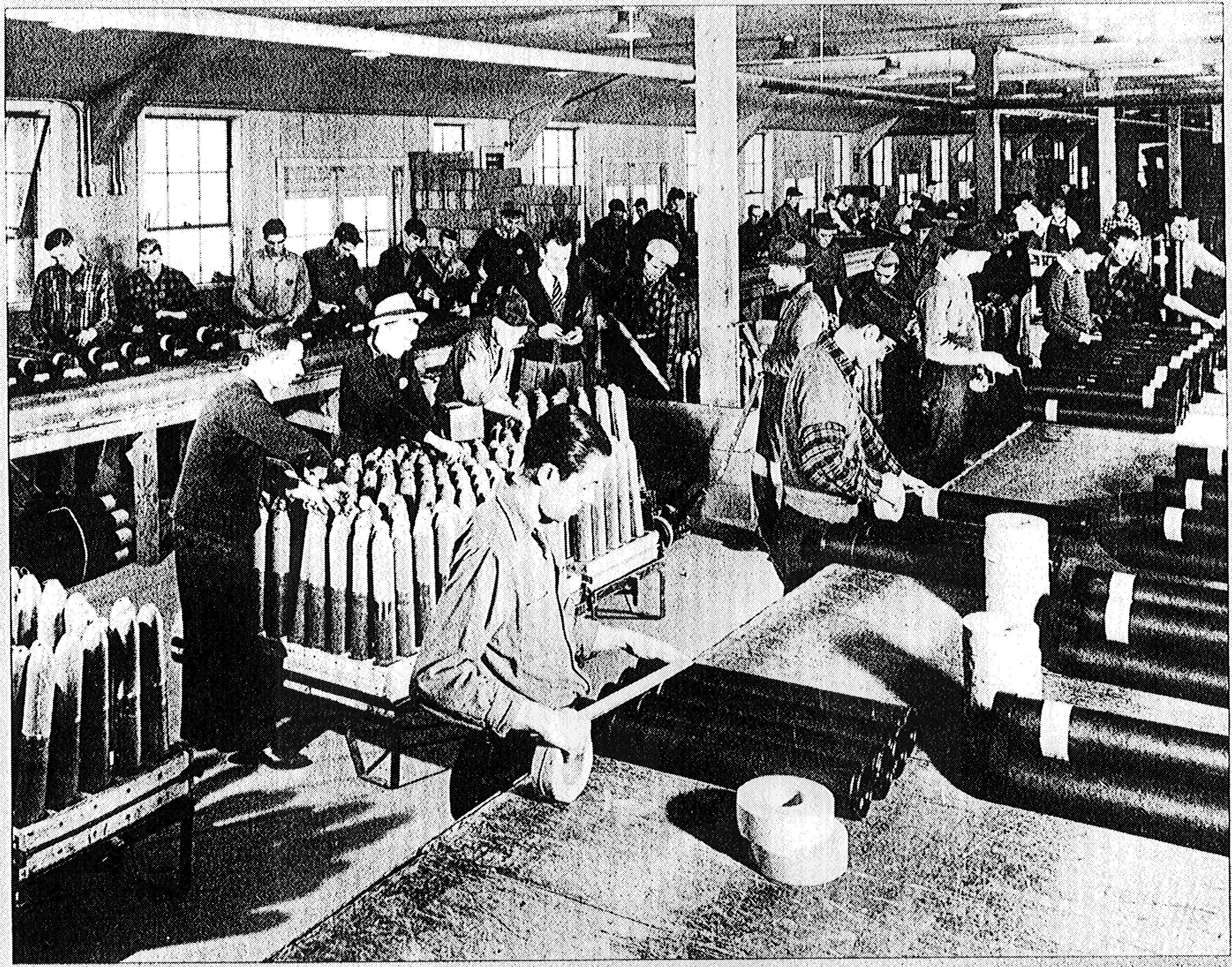
DRILLING 6-INCH SHELL. This operation provides necessary hole in TNT topping for insertion of booster.



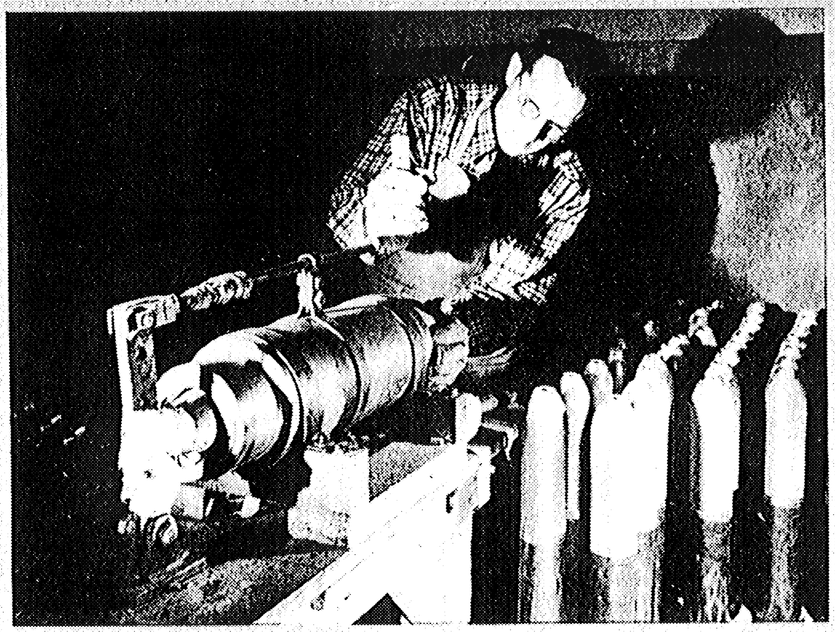
LOADING 75 MM SHELLS into box car for shipment. Each crate contains 12 shells. Crates are strongly braced in car to prevent jarring movement during transit.



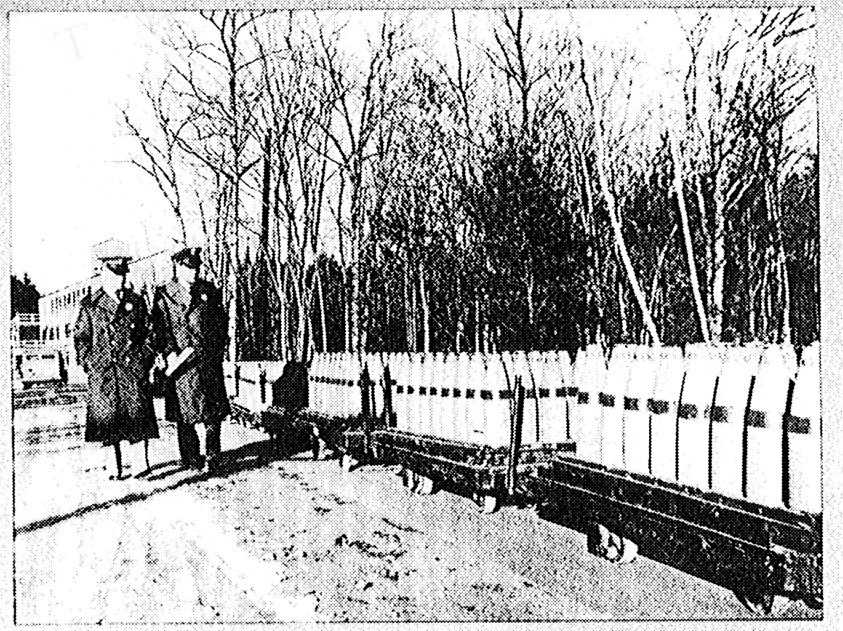
DRILLING 75 MM SHELL behind steel safety barricade.



PACKAGING 75 MM COMPLETE ROUNDS



CHAMBER GAUGING 75 MM COMPLETE ROUNDS



TRANSPORTING 6" HOWITZER SHELLS

EARLY INCENDIARIES

THE *Pirotechnia* of Vannoccio Biringuccio (1540) has now for the first time been translated completely and published in an English version.

A review of the English translation of Smith and Gnudi is published in the book review section on the succeeding pages.

It is the earliest printed work which covers the whole subject of metallurgy. Its tenth book constitutes what is probably the first printed treatise on fireworks for war and for recreation. The present importance of incendiary bombs makes it interesting to see how they were used in Biringuccio's time, to examine what he had to say about them four hundred years ago. The advantages to be gained by using them were at that time surprisingly similar to the advantages to be gained from them today. Our interest in incendiary bombs, we must also admit, is heightened by the pleasant glow of satisfaction which we experience because of our having loaded the famous bombs which General Jimmy Doolittle dropped on Tokio. The Secretary of the American Institute of Mining and Metallurgical Engineers has kindly given us permission to reprint portions of Smith and Gnudi's translation of Biringuccio's *Pirotechnia* along with some of the pictures, reproduced from the original woodcuts.

The reader will see that flame projectors, incendiary grenades and projectiles, and sticky incendiaries, which remain attached to a suit of armor until the wearer is forced to remove it, are no new things under the sun.

Chapter V:

How Fire Tubes Should Be Made for Defending or Assaulting Batteries or Gates, for Burning Supplies, or for Festivals.

Fire tubes are commonly made in order to frighten horses or to harm enemy soldiers, but although fire issues from them, they do not cause much damage because they cannot be used at a distance. If you wish to use them, you are not able to approach close to the enemy, for if there is anyone who is afraid, he does not let you approach nor does he come near you until he sees that they have finished burning. Thus, in short, the assault with this is one that is seen beforehand, and for which there is always time to decide on some action in defense. It is indeed true that they are beautiful things to see and when the name "tubes of fire" is heard it terrifies those who do not have a defense ready. When four, six, or indeed ten or twelve of these are put in the hands of as many courageous and united men, they are surely good in forcing passage on a guarded bridge, or in entering or holding a gate, road, or other narrow place. They serve also for setting fire to dwellings or the enemy's supplies, carts, bridges, and all those things in the service of the enemy that are easily set on fire. They would also serve well to lay waste a land. Above all, they are good in naval battles.

Chapter VI:

The Method of Making Metal Balls Which Burst in Many Parts, for Shooting on Armies Lined Up in Battle.

The good and lofty men of intelligence are constantly discoverers of many beautiful things, because of their kindness or because they are

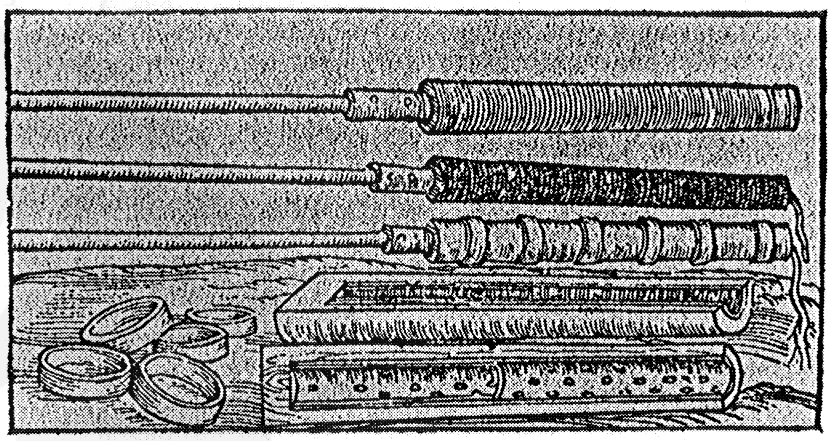


Figure 80. Large fire tubes reinforced with wire and bands, and a lined wooden tube serving as a light gun.

driven by necessity. Either they shorten the method of making them after they have seen them, or they think how they can be increased in power or how they can be used for various effects in addition to the one intended by the inventor. Certainly all the effects described to you in this Tenth Book derive from gunpowder. When so many properties and so much strength were observed in this, it was thought that by enclosing it in some strong thing that had the power to resist it, gunpowder would produce a marvelous effect. And thus they made a tube of bronze or iron which they closed with a wooden plug. They applied fire, and when they saw how forcefully this plug issued they thought of making one that would come out and strike in order to destroy things. They made an instrument of bronze or of iron and put some powder and a round stone inside, and called it a spingard. Developing then from this, various sons were born, both small and large ones and of various shapes depending on the opinions or desire of the masters or of the princes who had them made.

Not yet satisfied with the great harm that they caused in shooting stones, they found a way of making balls of iron, as I have demonstrated. Not yet satisfied even with these, in order to injure men more than the aforesaid ones do, the good men of intelligence have thought of making those hollow balls of metal, and have given them a way of bursting into many pieces so that each piece may strike a blow. And whereas, with the shooting of an ordinary ball with a gun only one arrived among the people, this ball that breaks in pieces is equivalent to many. Thus they proceeded to make these hollow balls of metal and filled them with strong powder through a little hole. The fire is introduced with a fuse when they are shot with a gun or launched in some other way by men. Thus the powder that is inside ignites on arriving and, since it has no escape, bursts the ball into many pieces among the enemy.

I have seen two kinds of these. One is made hollow merely by casting in the ordinary way, employing a core of moulding clay made exactly round with a strickle. Over this a covering is applied of tallow or wax or the whole thickness is formed of clay, and this is turned down with an iron tool to leave as much thickness as you wish it to be in metal, after it has been moulded in halves in moulding clay or in boxes with river sand baked for casting in powder, as is done for small bells.

Alternatively, you can do this by making a pattern of wood or lead and moulding from that. Likewise you could mould the core with the same powder in order to do it more quickly. In moulding, make its little iron pieces project for holding the core in the middle. They could also be moulded in plaster of Paris and cast in wax to that thickness which you wish them to be in bronze. To make the core, they could be filled inside with plaster of Paris, ashes, and liquid clay or burned young ram's horn.

Now having made your gates and vents and the supports for the core in whichever one of these ways pleases you most, cast them in a brittle material, that is, copper strongly corrupted with tin, or cast iron. Finally, take out the clay of the core through the little hole that you left there, and, when empty, fill the balls through this hole with fine powder when you wish to use them. In shooting them, they are shot more forcibly with a gun or with a ballista and with greater safety for whoever has to shoot them. In the hole you have left put a fuse of cotton prepared with saltpeter, sulphur, and gunpowder as I have taught you in another place. This should be just long enough so that when ignited it may introduce fire in the powder at the time that you wish. When ignited, the ball will break in many parts, as you can understand since it is not a material capable of resistance, and every part spreads out hither and yon, driven with a very great violence.

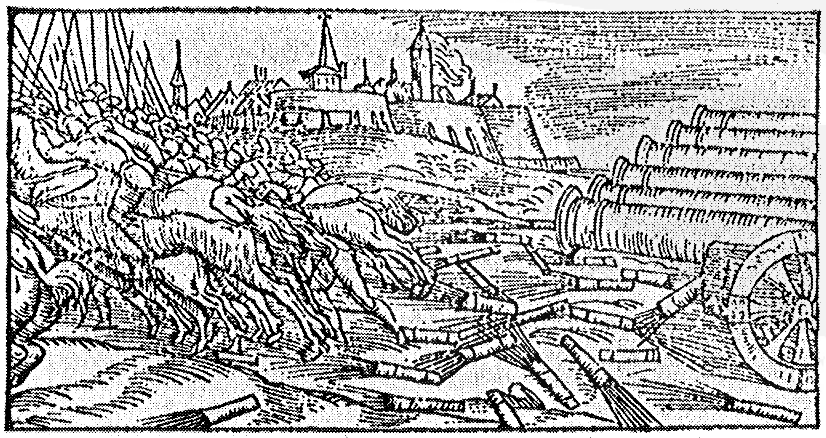


Figure 81. A battery of guns discharging small fire tubes among cavalry.

Chapter VII:

Methods of Making Tongues of Fire to Be Tied on the Ends of Lances like Squibs.

In order to defend batteries or to make a stratagem at night in making an assault it is useful to tie certain tubes of paper on wooden forms to the ends of the lances of the cavalry, or on the ends of the pikes of infantrymen. These are made in the form of rockets or squibs, half a *braccio* or more long, and are full of coarse gunpowder in which are mixed pieces of Grecian pitch, sulphur, grains of common salt, iron filings, crushed glass, crystalline arsenic, and the like. Their very shape gives a hold at the foot, and they should be well packed and full. Then, having put in a good fuse and turned the fire-emitting end toward the enemy and having tied it well to the lance or pike, at the proper time cause them to burn as you wish. From the thing made in this way you will see issue a fearful very hot tongue of fire more than two *braccia* long, full of explosions and horror. This works much better if used when the weather is mild or when you are aided by the wind. This thing serves very well in battles at sea as well as in its effects on land.

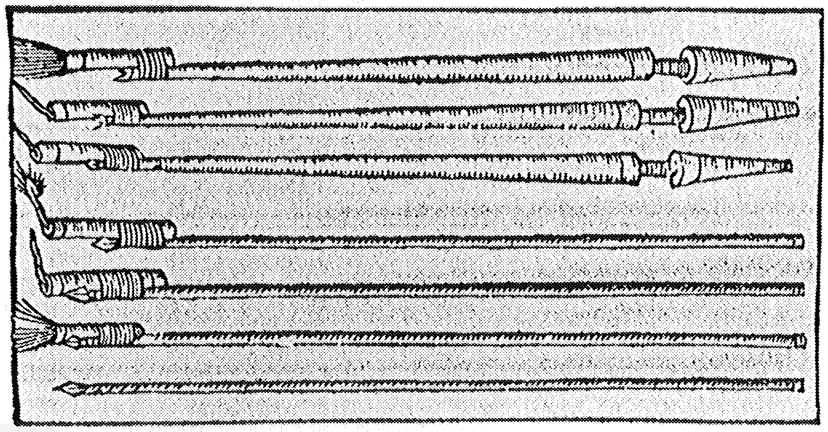


Figure 82. Lances and pikes with small fire tubes attached.

Chapter VIII:

The Methods of Preparing Fire Pots and of Making Balls of Incendiary Composition to Be Thrown by Hand.

There have always been in this world men of such keen intelligence that with their discourse they have been capable of infinite and various inventions that are as beneficial as they are simultaneously harmful to the human body. Wherefore, from day to day, we see unfolded before our eyes some of these that greatly astound our minds, and we remain so stupefied that when we think of them we are not able to control our faculties for some time, both from considering by what necessity or purpose these men were goaded, as well as from contemplating the profound subtlety of their discoveries, which, in truth, are such that they are awarded the greatest commendation by noble minds. By following their counsels and with their aid, there have been some astute and clever captains who have had certain pots or balls of earthenware carried by their infantry, expressly filled with compositions of powder or other unctuous liquors disposed to ignite easily. When they meet the enemy in battle and come up close to them, they try to strike vigorously with these in the first assault in an effort to throw them into disorder and to make them give way by breaking them up and drawing them out of formation. The smoke is harmful, but the fire very much more so.

These are made in this way. Take the number of vessels that you have to make — it does not matter whether they are raw or baked as long as they are well freed from the moisture of the clay — and fill them a little more than half full with coarse gunpowder which has mixed in it pounded Grecian pitch and at least a third of crushed sulphur. Then pour in a covering a *dito* thick of strained pig fat mixed with powder. This keeps it from falling out when it is thrown and keeps the fire slower until it reaches the enemy. When this has been made, open up the pig fat a little at one side when you wish to throw it and put in a little fuse or a little good powder and apply fire, holding it in your hand until you see that the fire has taken hold well. Then throw it, choosing your time.

A liquid composition is also made in a kettle in which are put pork fat, petroleum oil, oil of sulphur, live sulphur, doubly refined saltpeter, aqua vitae, Grecian pitch, turpentine, and some coarse gunpowder. Having liquefied everything well over a fire, stir it thoroughly with a stick so that it may be well incorporated, and proceed to fill all the pots or vessels that you have with this composition in the desired amounts. Then put a layer of good gunpowder over them so that they will ignite easily when desired, and let them stand. Use them when you wish, throwing them with slings, or tied with ropes or iron wire like a whip handle, or in other ways of throwing by hand.

With this same composition you can also fill certain linen cloth sacks. These are wrapped with ropes and are shaped like balls. They are shot from iron *cerbottana* like the balls from fire tubes. You could also smear this composition on everything that you wish to burn easily, like gates of earthworks, wooden bridges, carts, munitions, ramparts defending batteries, and similar things, for it is inflammatory material and, when inflamed, it penetrates and maintains a strong fire. You could also bind this at the end of the iron on the pikes of foot soldiers by filling with it a purselike bag, made for carrying the fire among the enemy or any other place at which you wish to throw so that it may ignite and burn.

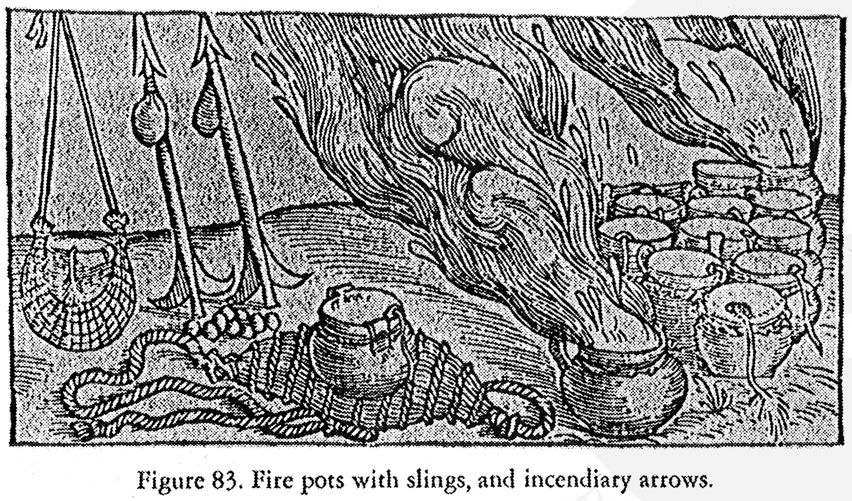


Figure 83. Fire pots with slings, and incendiary arrows.

Chapter IX:

The Manner of Compounding Various Incendiary Compositions Which Are Commonly Called Fireworks.

Every dry thing that burns easily and multiplies or maintains fire by its own intrinsic nature can be put into an incendiary composition and various effects are produced. Some of these things are mineral combinations, like sulphur or its oil; some others, hot, dry, and subtle substances, like saltpeter; and some are unctuous things, like fats and oils of any kind; while some serve because of dryness, like pith and wood. Some of these things are natural and some artificial.

But now I set aside the search for these differences in their composition. This is what I have found among all the ancient and modern things that I have been able to seek, and first, back in the time of Alexander the Great. Marcus Graecus, who was perhaps the inventor or a great experimenter and practicer of such things, writes of many of them. I have chosen some among these, and one is this: In order to make it, he took Grecian pitch, alchitran, live sulphur, tartar, sarcocolla, niter, and petroleum oil, one part of each, and, in addition, a double amount of quicklime. He mixed it all with oil of egg yolks. Having put it in a well-covered and closed vessel of glass or glazed earthenware under warm manure, he left it for a month. Then, having liquefied it over a slow fire, always keeping the vessel well closed, he finally put this liquor in hollow sticks, in little pots, or in vessels expressly made, all with a little fuse fitted in the middle. If I should have to do this, I would say that a little gunpowder should be put in, which should give beginning to the fire so that it would ignite more easily.

I have also found that another fire is made. For this sulphur is taken, or oil of sulphur if it is possible to obtain, petroleum oil or some rock oil, juniper oil, very well-refined saltpeter, and for one part of each of these five parts of asphalt; in addition, take goose or duck fat, pure black pitch, varnish, pulverized dove's dung, and enough aqua vitae to cover all the aforesaid things. Then it is put in a glass vessel under warm manure for twenty-five to thirty days, after the mouth has been sealed with some wax. Then it is put on a slow fire so that it may all incorporate better. With this composition hollow sticks are then filled or pots and similar vessels to be thrown by hand. In addition, also, take a ball of stone with a ring in the middle to which is attached a rope of one or one and a half *braccia*. On this ball put pieces of tow or linen well soaked with this composition, smearing them well. Then light the fire, swing it around by hand until you feel that it has entered its flight with all the force that it can be given with this motion, and release it. They can also be thrown with ballistas as the ancients used to do or, if desired, with guns as the moderns do. In the latter you can throw not only the ball made of this composition but also one of stone in which an iron ring is fitted and well fixed. To this ring is attached one or more pieces of washed and baked rope that has been very well soaked in this composition. Or if you do not wish to attach ropes, make a little sack of thick heavy cloth and fill it with this composition and attach it to the stone with the ring described, and shoot it with whatever instrument pleases you most. By putting the material in a sack that has the shape of a ball, as above, it can also be thrown with a sling or with a pike that has a hollowed piece of wood or iron bands fitted to the point so as to hold it; as you swing this, the sack comes out and takes the path that you intend it to.

Another incendiary composition is made by taking liquid varnish, oil of live sulphur, oil of egg yolks, oil of turpentine, juniper oil, linseed oil, and petroleum or rock oil, and further, half of the amount of the composition of oil of aqua vitae, and also enough fine powder of dry laurel to thicken the whole, with an equal amount of saltpeter. All these things are put together in a narrow-mouthed vessel of glass or of glazed earthenware that is very well closed with wax so that it does not breathe. Then it is kept in putrefaction in warm manure for three months and shaken four or six times every month. Then, having brought this composition to this point, when you wish to use it you must grease that thing or put some of it in that vessel where you wish the fire to operate. This fire is such that it ignites at once when fire is applied with gunpowder or a fuse, and it is inextinguishable until either the thing or the composition itself is wholly consumed. If it is thrown burning on armor it makes it so glowing hot that whoever is wearing it is compelled to take it off if he does not wish to burn with it.

BOOK REVIEWS

THE PIROTECHNIA OF VANNOCCIO BIRINGUCCIO. *Translated from the Italian with an Introduction and Notes by Cyril Stanley Smith and Martha Teach Gnudi, Publication Sponsored by the Seeley W. Mudd Memorial Fund. New York: The American Institute of Mining and Metallurgical Engineers, 1942. xxvi, 476 pages. Illustrated. 19.2 x 26.6 cms. Price $5.00 net.*

This is the first complete English translation of the earliest printed work which covers the whole subject of metallurgy. It describes not merely the smelting of metals by the action of fire but also the casting of bells and of cannon, the making of coins, the ores from which the metals are obtained, other minerals and the chemical substances procurable from them, the assaying of ores, the construction of furnaces, the uses and applications of fire in carrying out chemical operations, particularly distillations, and fireworks for entertainment and for war. The book is handsomely bound and beautifully printed, on cream-colored paper, with wide margins — one thousand copies by Carl Purington Rollins, Printer to the University, at the Printing-Office of the Yale University Press, in July, 1942. A Foreword by Harvey S. Mudd is followed by an Introduction which comprises an essay on the Life of Biringuccio by M. T. G., accounts of the Background of the *Pirotechnia* and Its Place in Metallurgical Literature by C. S. S. and of the Editions of the *Pirotechnia* by C. S. S., and Remarks on the Translation by M. T. G. Appendix A reproduces Figures from other sources illustrative of Biringuccio's descriptions, Appendix B discusses Weights and Measures, Appendix C is a List of Editions of the *Pirotechnia,* and Appendix D is a Bibliography.

Biringuccio's *Pirotechnia,* first printed at Venice in 1540, was the earliest of the four great classics of metallurgy. The second, Agricola's *De re metallica* was first printed at Basel in 1556. The two authors were contemporaries, and were known to each other, for Biringuccio acknowledged that he secured certain information on silver ores from Agricola's earlier work on mining, *Bermannus,* 1530, and Agricola admitted that he "refreshed his memory" from Biringuccio's book but actually lifted from it, without further acknowledgment, Biringuccio's accounts of the distillation of mercury and of sulfur, of the making of glass and of steel, of the recovery by crystallization of saltpeter, alum, salt, and vitriol, and of less important matters. Of the other two great classics of metallurgy, the *Aula Subterranea* of Lazarus Ercker was first printed at Prague in 1574, and the *Arte de los metales* of Alvaro Alonzo Barba a full century after Biringuccio at Madrid in 1640. All four retained their authority until the new chemistry of Lavoisier made it desirable to have new descriptions of the chemical substances and processes.

Biringuccio (1480-1539) acquired his knowledge of mining and metallurgy by travel in Italy and Germany and by practicing these arts in various executive positions which he secured either directly or indirectly through the good offices of the Petrucci family of Siena to which family he was loyally devoted. He travelled in Germany before 1507 and again between 1526 and 1529. In 1529 he cast a huge culverin for the Florentine Republic. In January and February, 1531, he served as one of the Senators of Siena, and in 1535 he succeeded the famous Baldassare Peruzzi as architect and director of the Opera del Duomo. During the years, 1531 to 1535, he was also employed at different times to cast arms and construct fortresses for Pier Luigi of Parma, Ercole d'Este, and the Venetian Republic. At the time of his death, before April 30, 1539, he was head of the papal foundry and director of papal munitions.

The *Pirotechnia* exhibits its author as a practical man, broadly informed but not scholarly, acquainted with theories and able to evaluate them, urbane, and possessing an active sense of humor. That he was a genuine chemist, cognizant of the fascination of his science but not deluded by it, is evident from his remarks about alchemy.

"Nevertheless, even though the goal of this art were emptiness, as many believe, it is indeed so ingenious a thing and one so delightful to students of natural things that they cannot forego the expenditure of all possible time, labor, and expense. Besides the sweetness offered by the hope of one day possessing the rich goal that this art promises so liberally, it is surely a fine occupation, since in addition to being very useful to human needs and convenience, it gives birth every day to new and splendid effects such as the extraction of medicinal substances, colors, and perfumes, and an infinite number of compositions of things. It is known that many arts have issued solely from it; indeed, without it or its means it would have been impossible for them ever to have been discovered by man except through divine revelation."

His attitude toward theories, his general kindliness and lack of dogmatism, are manifest from the manner in which he concludes his discussion of the noise which guns produce.

"Thus, for these reasons, and for no other (since I do not know how to understand any other), I believe that the noise and great sound heard in shooting guns arise. Now, if these reasons of mine have weight with you or with others, I shall be glad to have told them so that you may have this information, but if they do not have this effect, you will pardon my meager philosophy, which extends no farther, and accept my desire to try to give you what I can."

His clear-headedness and sense of humor are further indicated, among many examples, by his account of the "Girandoles, Which Were Once Customarily Used in Some Tuscan Cities for Magnificent Display for Public Festivities on Solemn Feast Days."

"If you have never seen a girandole, as perhaps you never have, you may understand what it was when you hear it named. Indeed, although it was a beautiful thing and cost much money, it was a useless thing to make. Nevertheless those times were truly golden, that is, they had much gold to spend for things without consideration of the expense, and fireworks had no other purpose than amusement and endured no longer than the kiss of a lover for his lady, if as long . . . Then these figures were placed wherever they seemed most fitting, by arranging the combinations of vessels above vessels or other attached things with which they attained a height of thirty or forty *braccia,* depending on the knowledge or the desire of the master or of whoever paid the bills."

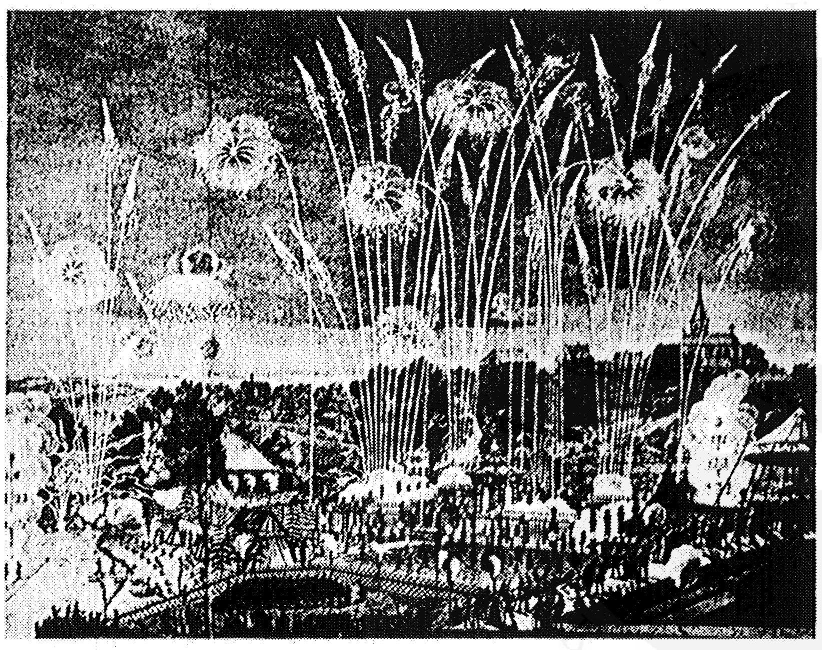
The tenth book of the *Pirotechnia* describes the preparation of saltpeter and gunpowder, subterranean mines, bombs, grenades, flame throwers, incendiaries, and display fireworks, and constitutes one of the earliest printed treatises on military and civil pyrotechnics. Smith and Gnudi make a very important observation about it, an observation which we have not seen noted before, namely, that it is this book which Peter Whitehorn translated in large part and, with Biringuccio's illustrations, reproduced without acknowledgment in his book, "Certain waies for the orderyng of souldiers in battelray . . . and moreover, howe to make saltpeter, gunpoulder and diuers sortes of fireworkes or wilde fyre", London, 1560 (2nd ed., London, 1588). The credit which has been given to Whitehorn in discussions of the history of black powder ought rather to be given to Biringuccio.

Biringuccio's black powder formulas (parts by weight) are indicated below in the table where the percentage compositions are also set down for readier comparison.

	For heavy guns	For medium guns	For arquebuses and pistols	
Saltpeter ..	3 (50.0%)	5 (66.6%)	10 (83.3%)	13½ (79.4%)
Charcoal ..	2 (33.3%)	1½ (20.0%)	1 (8.3%)	2 (11.8%)
Sulfur	1 (16.6%)	1 (13.3%)	1 (8.3%)	1½ (8.8%)

The first of these compositions is the slowest, the last is the liveliest and best, and the others are intermediate between the two. While we now regulate the speed of our powder by varying the size of the grain, Biringuccio, it seems, regulated it by varying the composition. He described a wet-mix method which he considered to be the best and quickest way of making gunpowder. His descriptions of girandoles and pyrotechnic wheels are the earliest with which we are acquainted.

TENNEY L. DAVIS



FIREWORKS IN THE SIXTEENTH CENTURY

MANUAL OF EXPLOSIVES, *Military Pyrotechnics, and Chemical Warfare Agents. Composition, Properties, Uses. by Jules Bebie, Ph.D., Consulting Chemical Engineer, Professor of Chemical Technology, Washington University. The Macmillan Company, New York, 1943. xvi+171 pages. 14.0 x 21.3 cms. Price $2.50.*

This book is improperly named as a manual. It is a dictionary of terms commonly used in the field of explosives and war chemicals. The book is obviously an emergency effort handicapped by a shortage of time and necessarily incomplete. The author gives us a frank statement on this point: "With no claim for completeness, an earnest effort has been made to list all of the more important explosives, explosive mixtures, modifying and addition agents, and particularly those which are actually being used or which have been used as far back as World War I."

The dictionary contains 536 entries of which 157 describe explosive materials, either single substances or mixtures, 7 refer to explosive devices, 80 to non-explosive components of explosive or pyrotechnic compositions, 8 to pyrotechnic compositions or devices, 36 to chemical and accessory materials, 37 relate to chemical warfare agents and devices, and 211 are for synonyms, trade names, Army or Navy nicknames, abbreviations, etc., and supply cross references to other entries under which the materials in question are described. The Preface (4½ pages) is followed by a section (2 pages) on Nomenclature, Arrangement, and Abbreviations, and by an Introduction (14½ pages) which contains a brief account of the history of explosives and includes a Chronology (8 pages) of the principal events in that history. The latter supplies a valuable background of information. The alphabetical list is followed by a Bibliography, which includes books, bulletins, manuals, catalogues, and articles in periodicals; also by a list of 39 recent patents.

WALTER H. LILLARD

THE RIFLE IN AMERICA, *by Philip B. Sharpe, with an introduction by Julian S. Hatcher, Lieutenant-Colonel, United States Army. 641 pages. Illustrated. William Morrow and Company, 1938. $10.*

Here is *the* definitive work on American rifles, a truly encyclopedic volume covering the history of the rifle in America and American riflemakers from the Colonial musket down through the Army's new Garand semi-automatic. Anyone interested in shooting, whether novice or oldtimer, will find hours of absorbing reading in this book. Mr. Sharpe has performed a real service for riflemen in collecting so much heretofore scattered material and assembling it interestingly in a single volume.

The author writes as an expert on this subject. Philip B. Sharpe is both a firearms enthusiast and technician. Guns and ammunition are his hobby as well as his life work. He is, among other things, Firearms Editor of Outdoors Magazine, Firearms Technical Adviser to the American Fiction Guild, the author of "The Complete Guide to Handloading" and other books, and a collector of old guns. Mr. Sharpe knows rifles from muzzle to butt plate and writes in an easy, anecdotal style that makes interesting reading even when his subject matter inclines to be technical.

"The Rifle in America" gives actual details of every standard rifle, both sporting and military, ever made in this country. At least, if any are omitted this reviewer is not aware of it. The rifles are divided into makes and the models are listed and described chronologically, which makes for easy reference. In describing the various guns, Mr. Sharpe gives detailed information about each — its dimensions, caliber, operating mechanism, and so forth, and tells both its faults and virtues. In tracing the development of the modern rifle, Mr. Sharpe shows how changing conditions, such as the growing scarcity of game and war experience, have brought about changes and improvements in weights, calibers, sights, materials and ammunition. The history of the great arms manufacturing companies is given, with many anecdotes about the gun geniuses who founded them.

For the beginner, there are chapters on how to choose a gun and ammunition, how to care for a rifle, and pointers on good shooting practice. There is an exhaustive chapter on the military rifles of World War I, and interesting speculations on the future of the American rifle.

In a comprehensive appendix, the author describes and illustrates all the modern American cartridges and gives tables of ballistic specifications and barrel dimensions.

The excellent illustrations in "The Rifle in America" add greatly to its value as a reference work. There are many photographs of historically interesting old guns, as well as diagrams of the operating mechanisms of many modern rifles. The only fault that this reviewer could find with this book is the index, which might be more comprehensive. But this is a small fault to find with a study so admirable in every other respect.

KENNETH H. THOMPSON

NATIONAL FIREWORKS, INC.

WEST HANOVER, MASSACHUSETTS

DIRECTORS

GEORGE J. J. CLARK, CHAIRMAN

E. V. BABBITT	ROBERT H. LOOMIS
FRANCIS BARRETT	DANIEL NEEDHAM
DAVID BLACK	GEORGE K. PERKINS
G. LORING CLARK	GEORGE J. THOMAS
W. MELVIN CLARK	T. T. TOOLE
STANLEY H. CLARK	C. WILLIAM WANNEN
GEORGE W. LANE, JR.	RICHARD WHITNEY

EARL H. WILLSON

F. WILLIAM ANDRES, SECRETARY OF BOARD

BOARD OF DIRECTORS

PRESIDENT
GEORGE J. J. CLARK

EXECUTIVE VICE-PRESIDENT
E. V. BABBITT

VICE-PRESIDENT
GENERAL MANAGER
C. W. WANNEN

INSPECTION
T. N. AIKENS

RESEARCH & DEVELOPMENT
TENNEY L. DAVIS, PH. D.

TECHNICAL
C. G. STORM, PH. D.

PRODUCTION VICE-PRESIDENT
GENERAL PLANTS MANAGER
DAVID BLACK

TECHNICAL ASSISTANTS
C. P. T. KAFFKE
W. THRASHER

ASSISTANTS
A. A. BORLAND
H. B. KING
W. TRETHAWAY, JR.

ORDER CONTRACT—ADMINISTRATION
M. M. READ

PRODUCTION PLANNING—CONTROL
G. W. KELLER

ENGINEERING
J. G. ALEXANDER

SAFETY PLANT—PROTECTION
J. H. HAYES

EDUCATION—TRAINING
W. H. LILLARD, M. S.

ADVERTISING
E. W. FLINT

WEST HANOVER, MASS.
C. B. ALLEN, MANAGER PLANT #1
C. P. T. KAFFKE, MANAGER PLANT #2

ELKTON, MD.
T. B. DUTCHER, PLANT MGR.

CORDOVA, TENN.
ED. H. LUCE, PLANT MGR.

CHILLICOTHE, OHIO
J. W. VANSTONE, PLANT MGR.

HALIFAX PROVING RANGE
HALIFAX, MASS.
MAINTAINED FOR THE U. S. NAVY

BRUNSWICK PROVING RANGE
BRUNSWICK, TENN.
OPERATED FOR THE U. S. NAVY

ORGANIZATION CHART

OFFICERS

GEORGE J. J. CLARK, President
E. V. BABBITT, Executive Vice-President
C. WILLIAM WANNEN, Vice-President and General Manager
DAVID BLACK, Vice-President and General Plants Manager
GEORGE W. LANE, Jr., Vice-President, Chairman Finance Committee
W. MELVIN CLARK, Vice-President and Director of Purchases
FRANCIS BARRETT, Treasurer
G. LORING CLARK, Assistant Treasurer
DANIEL NEEDHAM, General Counsel

EXECUTIVE ASSISTANTS
W. MELVIN CLARK, V. P.
L. K. LARSON
GEORGE K. PERKINS
H. A. POTSDAM
G. J. THOMAS
T. T. TOOLE
RICHARD WHITNEY
E. H. WILLSON

TREASURER
FRANCIS BARRETT

CO-ORDINATOR
GEORGE K. PERKINS
WASHINGTON, D. C.

GENERAL COUNSEL
DANIEL NEEDHAM
OF THE FIRM OF
SHERBURNE, POWERS & NEEDHAM

ASSISTANT TREASURER
G. LORING CLARK

CONTROLLER
W. J. EDWARDS

RESIDENT COUNSEL
WALTER WHITE

PUBLIC RELATIONS
CAMERON BECK

PERSONNEL
W. G. MARTIN

TRAFFIC--SHIPPING RECEIVING STORES
FRANK LARKIN

MEDICAL
JOSEPH DUNN, M. D.

PURCHASING
HAROLD B. CHASE

METHODS--TIME STUDY
HERBERT WERNER

LABOR RELATIONS
LOUIS J. BRANN

MAYFIELD, KY.
C. F. COOKSON, Plant Mgr.

BRISTOL, VA.
H. B. CARTER, Jr., Plant Mgr.

MAYS LANDING, N. J.
A. H. BIRD, Plant Mgr.

AMERICAN FIREWORKS
RANDOLPH, MASS.
H. L. RAPP, Plant Mgr.

SUBSIDIARIES

NATIONAL PLAYTHINGS
WATERTOWN, MASS.
FRED A. WADE, Plant Mgr.

WAREHAM SHIPYARDS
WAREHAM, MASS.
E. L. GOODWIN, Plant Mgr.

NATIONAL FOUNDRY
WHITMAN, MASS.
JOS. ANDERSON, Manager

GEORGE J. J. CLARK, President and Founder of National Fireworks, Inc., and a pioneer in the manufacture of fireworks and military pyrotechnics.

E. V. BABBITT, Executive Vice-President of National Fireworks, Inc., managing head of the company during its war expansion.

A RECORD OF PERFORMANCE

National Fireworks, Inc.

NATIONAL FIREWORKS, INC., was the seventh plant in the United States to win the coveted Navy "E" pennant and Navy Ordnance flag, symbols of Excellence in production for Victory. This award was made on January twelfth, 1942. Since then, the company has been awarded, at six month intervals, the Navy Burgee Pennant with Anchor and Star, the Army-Navy "E" pennant, and four renewal stars. Specifically, these awards were made in recognition of National's record in turning out 20 MM anti-aircraft shells of various types for the U. S. Navy . . . an outstanding performance that is being paralleled in every other department, hence enabling the Navy "E" to fly proudly over all the many divisions of National's war activities.

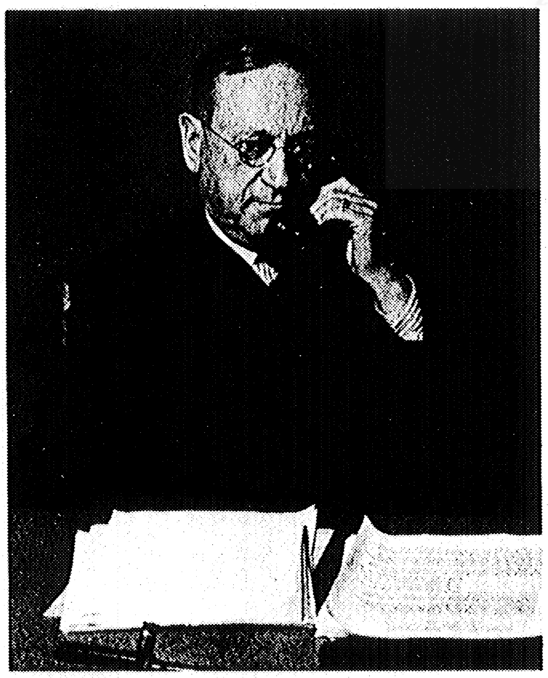
National Fireworks went to war fourteen months before Pearl Harbor—breaking ground for its first new shell loading plant on November 1st, 1940, and pouring its first shell for this global war on March 1st, 1941, for the British Government, when this plant was put into production. A veteran war plant of World War I, the company was called upon early in this war to convert and expand its plant facilities for total war service, and today it ranks as the largest privately-operated ammunition loading plant, in every field excepting small arms ammunition, in the United States.

It is interesting to note that the site of the company's main plant at West Hanover, Massachusetts, has been historically associated with this Country's wars since before the American Revolution. It is located on a stream along which were the sites of several early iron foundries and forges which manufactured cannon, cannon balls, and anchors for the war-ships of the U. S. Navy, in the Revolution, the War of 1812, and the Civil War. The administration offices are on the exact site of an early cannon foundry mentioned in "The History of Shipbuilding on the North River," by L. Vernon Briggs in 1889, and described as follows:

> *"About 1710, 'Mighill's Works,' or the 'Drinkwater Iron Works,' were erected here by one Mighill, probably a son of the Rev. Mr. Mighill, who was settled over the South or Second Society in Scituate in 1684, though little is known of him or his business. Tradition says that he manufactured iron from bog*

BOARD OF DIRECTORS

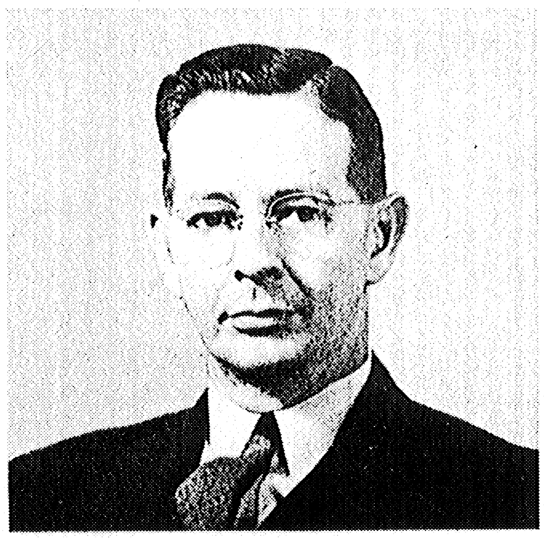
LEFT TO RIGHT: Robert H. Loomis, W. Melvin Clark, George K. Perkins, Francis Barrett, (at rear) F. William Andres, Secretary of the Board, Daniel Needham, George J. J. Clark, E. V. Babbitt, (at rear) George W. Lane, Jr., David Black, George J. Thomas, Stanley H. Clark, C. William Wannen. (Directors not in photograph:—G. Loring Clark, T. T. Toole, Richard Whitney, Earl H. Willson.)



GEORGE W. LANE, JR., Vice-President and Chairman of Finance Committee.

C. WILLIAM WANNEN, Vice-President and General Manager.

DANIEL NEEDHAM, General Counsel, of the law firm of Sherburne, Powers & Needham, Boston, Massachusetts.



W. MELVIN CLARK, Vice-President and Executive Assistant.

GEORGE J. THOMAS, Executive Assistant.

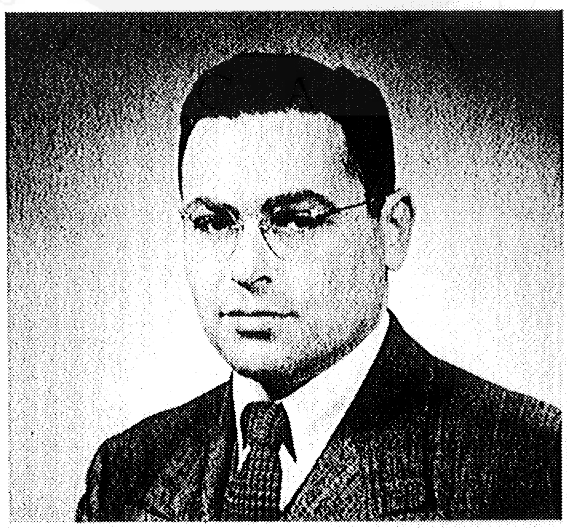
LLOYD K. LARSON, Executive Assistant.

EARL H. WILLSON, Executive Assistant.

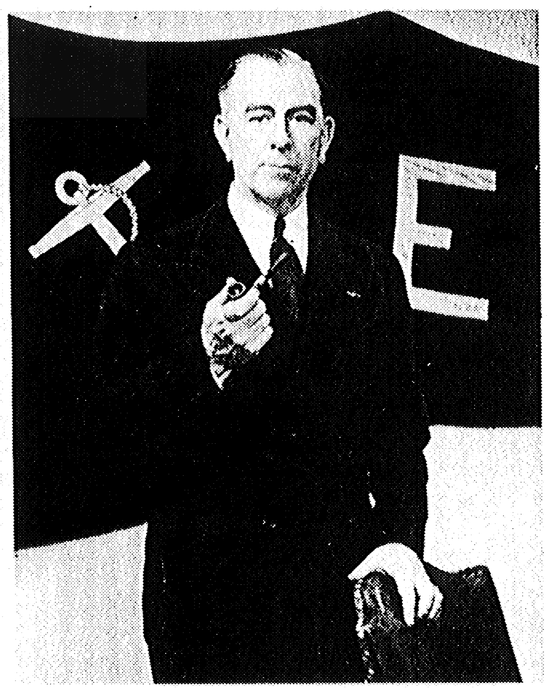
ore, which he dug at 'Cricket Hole,' near the Third Herring Brook, and in the low grounds in the vicinity of Dam Brook, where it can now be obtained in moderate quantities. These works have had many proprietors and tradition says again that, during the Revolution, cannon were cast here and carried down to the old fulling mill near the iron foundry and tested, and that Tilson Gould was killed by the bursting of one of these guns, the pieces of which are said to be still lying in the bottom of the old furnace pond."

National Fireworks, Inc., was founded forty-four years ago by Mr. George J. J. Clark, its present President, for the manufacture of Fireworks. It gradually acquired several other plants for the manu-

RICHARD WHITNEY, Executive Assistant.



HAROLD A. POTSDAM, Executive Assistant.



GEORGE K. PERKINS, Executive Assistant.

T. T. TOOLE, Executive Assistant.

FRANCIS BARRETT, Treasurer.

G. LORING CLARK, Assistant Treasurer.

W. J. EDWARDS, Comptroller.

facture of Fireworks, and for many years maintained complete national distribution, establishing a world-wide reputation for the superiority of its products in this field of commercial pyrotechnics.

During the first World War the company expanded its plant and activities to produce Flares, Signals, and similar Military Pyrotechnics, and was responsible for the development of the Tracer Bullets used in that war, becoming the principal source for that type of ammunition, a fact which in no small measure accounts for the company's early inclusion in the allied munitions program for this war.

The company operates two main plants at West Hanover and seven branch plants located east of the Mississippi River and along the Eastern seaboard, with a combined personnel of about twenty thousand.

Loading ammunition and the handling of explosives required large areas of plant layout, with many small operations buildings properly zoned and safeguarded. The main plant comprises approximately six hundred buildings enclosed in a fenced area of over three hundred acres. The branch plants require similar buildings and acreage, so that it may be seen that the over-all operations of the company have necessitated large building, engineering, and financing programs. To meet the needs of the Government, the company has expended over $6,000,000 on its own account for plant expansion, and in addition $1,000,000 was expended by the British Government. The United States Government has made additional expenditures of about $10,000,000 on government-owned plant facilities, operated by National Fireworks, Inc.

National Fireworks, Inc., was the first private company in the United States to load 20 MM Oerlikon anti-aircraft ammunition, having loaded for the British Government before starting production for the U. S. Government. After the United States entered the war, and the Bureau of Ordnance assumed direction of Navy and Lend-Lease requirements, National Fireworks, Inc., expanded its 20 MM production facilities to meet the progressive needs of the Navy's program in this highly specialized field of loading. Today, in six of its plants, it is carrying the major part of the Navy's 20 MM production program.

As a "loader and filler" of ammunition, National Fireworks, Inc., has executed various contracts for tracer loading ranging from .303 Small Arms Ammunition to 75 MM Armor-piercing Projectiles.

WALTER WHITE, Resident Counsel.

F. WILLIAM ANDRES, Secretary of Board of Directors.

DAVID BLACK, Vice-President and General Plants Manager.

C. P. T. KAFFKE, Technical Assistant and Manager of Main Plant, No. 2.

A. A. BORLAND, Assistant to General Plants Manager.

At its Melt Loading Plant it has loaded with both TNT and Amatol projectiles varying from 2 Pounder high velocity complete rounds to the 6-Inch Howitzer, and the complementary loading of boosters and exploder systems as well as smoke boxes, used in this type of loading.

In the field of fuse loading, our plants have executed contracts ranging from the small 20 MM Detonating Fuse up through the 75 MM and 6-Inch Fuses of various types and designs as well as the fulminate and azide detonators used in loading these fuses of a wide range of design.

In the loading and assembling of complete rounds, ranging from 37 MM to 75 MM, National Fireworks, Inc., has employed both Smokeless Powder and Cordite as propellant charges; in conjunction with these complete rounds there has been loaded and assembled the appropriate type and size of Artillery Primer.

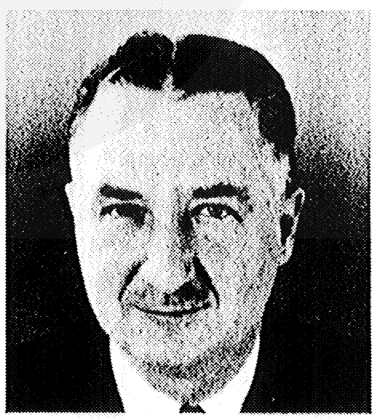
National has loaded, and is loading, substantial quantities of the various types and sizes of Incendiary Bombs, Incendiary Grenades, Oil Bombs and Fire Starters.

It has executed special contracts for the development of High Altitude Anti-aircraft Projectiles of the self-destroying type.

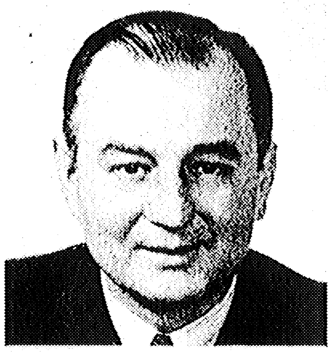
In the Pyrotechnic field, National Fireworks has loaded such items as Flares, Ground Signals, Aircraft Signals, Very Signals, and Miniature Practice Bomb Signals.

WARREN THRASHER, Technical Assistant.

HAROLD B. KING, Assistant to General Plants Manager.



WILLIAM TRETHAWAY, JR., Assistant to General Plants Manager.



J. G. ALEXANDER, Chief Plants Engineer.

T. N. AIKENS, Chief Inspector.

M. M. READ, Contract Administration.

STANLEY H. CLARK, Assistant Plant Manager of Main Plant, No. 1.

CLARK B. ALLEN, Plant Manager of Main Plant, No. 1.

ED. H. LUCE, Plant Manager, Cordova, Tennessee.

ARTHUR H. BIRD, Plant Manager, Mays Landing, N. J.

C. F. COOKSON, Plant Manager, Mayfield, Kentucky.

Another of the Company's principal contributions to the war effort is its development of a highly successful method of grinding magnesium powder, designing and building special machines for this purpose, and becoming one of the largest producers of this vital loading component.

In addition, the Company has available resources and experienced personnel capable of loading and assembling a wide range of types of Artillery Projectiles, Fuses, and HE Aerial Bombs, Detonators of all types, Depth Bombs, and Torpedo War Heads.

At the beginning of the company's expansion for war work, Mr. George J. J. Clark, President and Founder of National Fireworks, Inc., and Mr. E. V. Babbitt, Executive Vice-President, realizing how vast the undertaking might become, speedily assembled a staff of executive, technical, engineering and production experts, many of whom held important ordnance posts during World War I, and others who were at the time actively engaged in ammunition and powder work. This staff of top executives and specialists has been increased as the Company's activities expanded, so that at the present time it numbers about two hundred.

George J. J. Clark, President, and E. V. Babbitt, Executive Vice-President, and C. W. Wannen, General Manager, actively direct the operation of the company.

The Production Department is headed by David Black, Vice-President and General Plants Manager. The Technical Department is in charge of Dr. Christian G. Storm. The Research Department is headed by Dr. Tenney L. Davis.

The company built and maintains for the use of the Navy a proving range for anti-aircraft ammunition, known as Halifax Range, with a Resident Proof Officer in charge, Commander F. J. H. Dawson, R. N., and an adequate staff.

At Brunswick, Tennessee, the company operates for the U. S. Navy the Brunswick Proving Range, which handles the proofing of ammunition from plants located in the Southern and Middle Western states.

The first unit of expansion in 1940 was the development of Main Plant,No. 2, the Beech Hill and Shell Loading plant, together with an enlargement of the facilities existing at Main Plant, No. 1, the original fireworks plant at West Hanover. Main Plant, No. 1,is managed by Mr. Clark B. Allen and Main Plant,No. 2, is managed by Major C. P. T. Kaffke. All the production units of the company are directed by Mr. David Black, Vice-President and General Plants Manager.

The first branch plant at Elkton, Maryland, began operations on March 3, 1941, only a few days after the start of shell loading in Main Plant,No. 2,at West Hanover. The Elkton Plant specialized in the manufacture of RYG fuses for the British during its first six months of operation, and later was enlarged to handle a substantial volume of loading of anti-aircraft shells. This branch is managed by Mr. Thomas B. Dutcher.

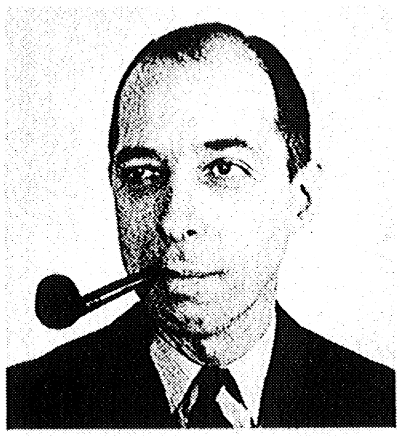
After the entry of the United States into the war, a second branch plant was built at Cordova, Tennessee, near Memphis. This plant began production on March 6, 1942, under the management of Mr. Ed. H. Luce. The Cordova plant loads incendiary bombs, smoke pots and anti-aircraft ammunition.

Five months later, in July, 1942, another branch plant at Mays Landing, New Jersey, went into production on incendiary bomb loading. The Mays Landing Plant is managed by Mr. Arthur H. Bird.

J. W. VANSTONE, Plant Manager, Chillicothe, Ohio.

H. B. CARTER, JR., Plant Manager, Bristol, Virginia.

HENRY L. RAPP, Plant Manager, American Fireworks Co.



THOMAS B. DUTCHER, Plant Manager, Elkton, Maryland.

WILLIS G. MARTIN, Personnel Manager.

Meanwhile, at the Main Plant in West Hanover, large facilities for the loading of 20 MM anti-aircraft ammunition had been developed, and the personnel of this parent plant furnished the supervisory personnel which was assigned to later branch plant expansions. The loading of various types of rapid-fire ammunition was undertaken at the Main Plant during this period. Facilities for the loading of incendiary bombs were developed and large scale production commenced. Military pyrotechnic supplies were produced by another division. The processing of magnesium for loading purposes became an important branch of the Main Plant's production.

The increasing demand for large-volume loading of 20 MM Oerlikon anti-aircraft ammunition brought further expansion in the Summer of 1942, and three more branch plants were under construction—plants which embodied in improved form all the successful features developed during the year and a half of pioneering at the Main Plant.

After many weeks of investigation of possible sites and after careful study of local labor supply, these three model anti-aircraft ammunition loading plants were constructed at Mayfield, Kentucky, Chillicothe, Ohio, and Bristol, Virginia. The Mayfield Plant is managed by Mr. C. F. Cookson, and began production on September 22, 1942. The Chillicothe Plant started production October 1, 1942, with Mr. J. W. Vanstone as manager. The Bristol Plant went into production October 15, 1942, with Mr. H. B. Carter, Jr., as manager.

Another branch plant, American Fireworks Company at Randolph, Massachusetts, started production on November 20, 1942. American Fireworks Company produces a vital component part of the ammunition loaded in the other plants. Mr. Henry L. Rapp is President and Plant Manager of American Fireworks Company.

The company's entire staff of experts, its research laboratories, and production facilities at all times have been placed at the disposal of the government to assist in solving technical problems, and special experimental lots of ammunition have been loaded and tested for the Army and Navy on request.

This record of performance will not be completed until the war is over, and many of the accomplishments of research and production in which the company takes pride necessarily will have to remain docketed as confidential until after the war is ended.

HAROLD B. CHASE, Purchasing.

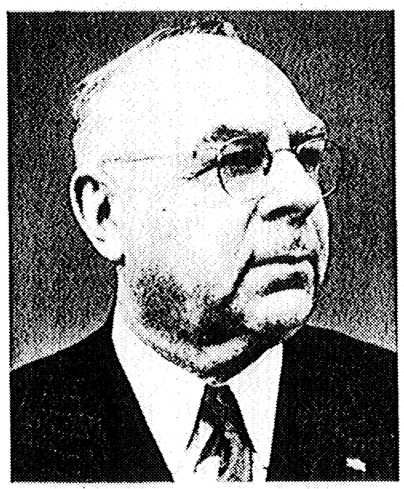
GEORGE W. KELLER, Production Planning Control.

JAMES H. HAYES, Safety and Plant Protection.

FRANK LARKIN, Traffic Manager.

DR. JOSEPH DUNN, Medical Director.

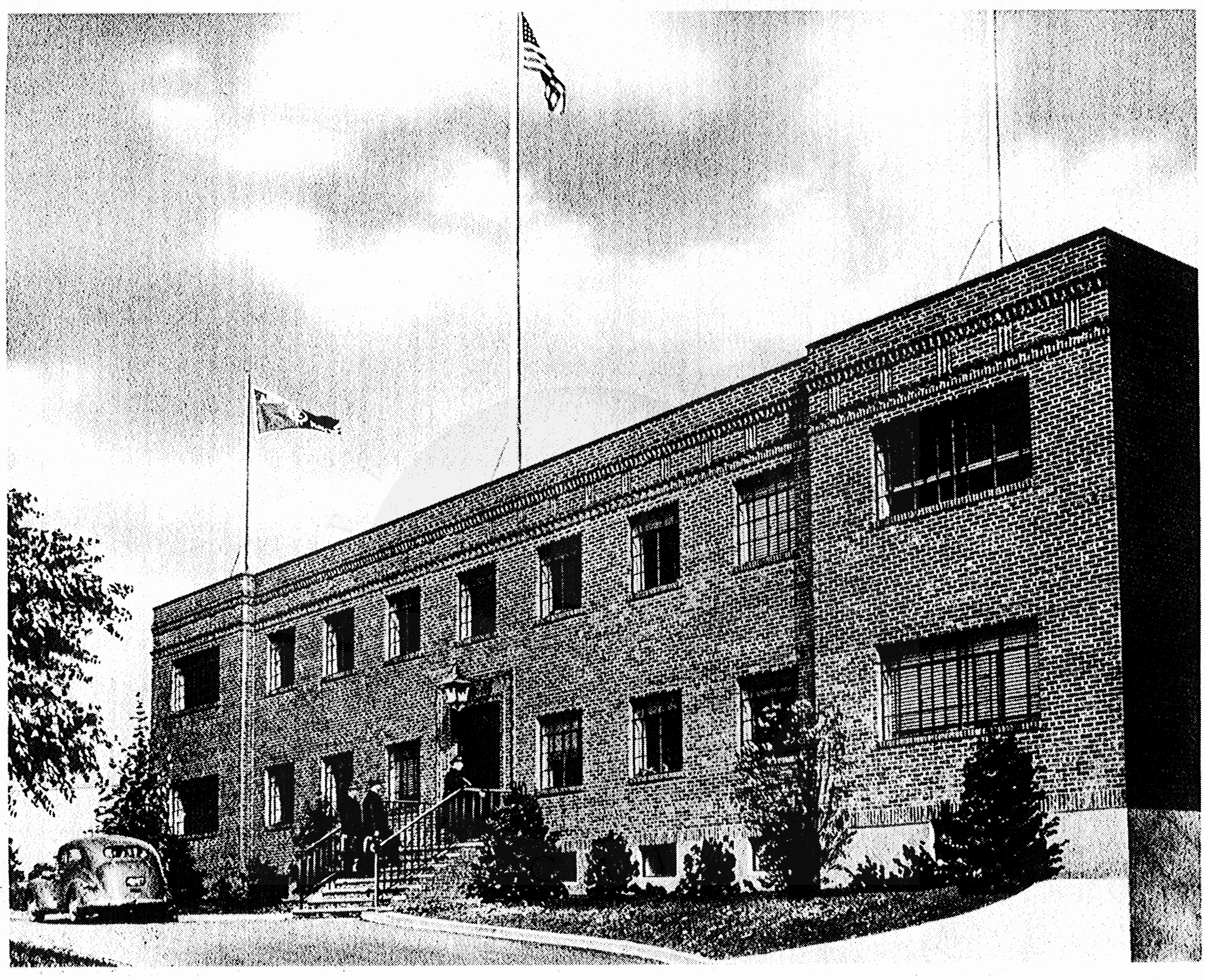
CAMERON BECK, Public Relations.



ERNEST B. JONES, Technical Assistant.

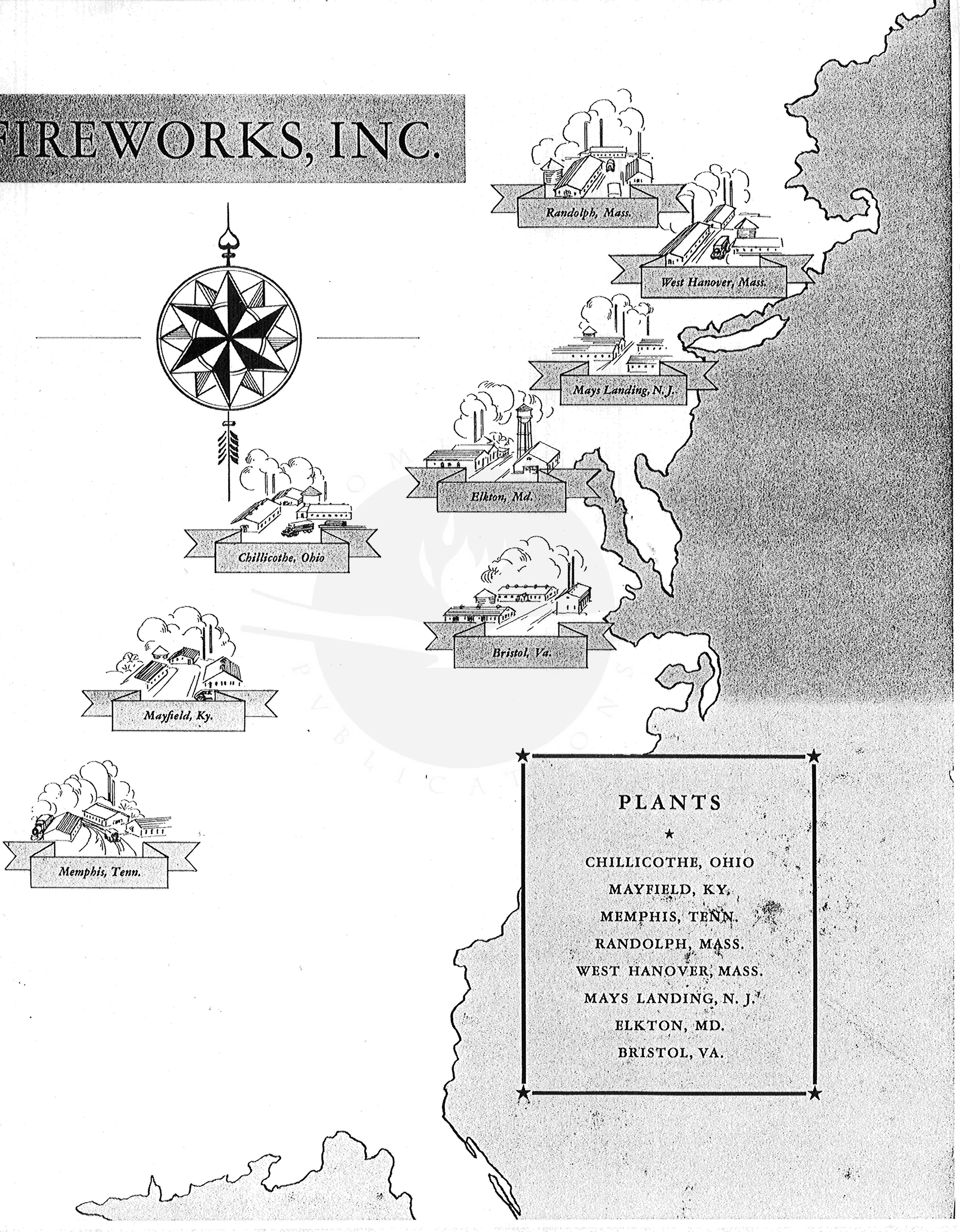
HERBERT WERNER, Methods—Time Study.

PLANT NETWORK OF NATIONAL



Administration Building, National Fireworks, Inc., at West Hanover, Massachusetts. This building houses the administrative staff, the executive offices, and the School of Munitions Technology. Ground was broken for construction in June, 1942 and the building was completed and occupied December 1st, 1942. It was built on the exact site of a proposed building for similar purposes for which foundations were laid near the close of World War I, but which was never erected. Three other large office buildings nearby supplement the office facilities of this Administration Building.

FIREWORKS, INC.



PLANTS

★

CHILLICOTHE, OHIO
MAYFIELD, KY.
MEMPHIS, TENN.
RANDOLPH, MASS.
WEST HANOVER, MASS.
MAYS LANDING, N. J.
ELKTON, MD.
BRISTOL, VA.

PUBLISHED IN THE INTEREST OF THE NATIONAL WAR EFFORT BY NATIONAL FIREWORKS, INC.