CHAPTER 10

EXPLOSIVES, PYROTECHNICS AND MAGAZINES

One of the most important developments in the history of ordnance was the discovery of explosives. Explosives have advanced from the weak and unstable gunpowder of Roger Bacon to many types of specialized explosives. This chapter will give you a brief history and discussion of the characteristics, uses, and handling of explosives currently used by the United States Navy. It is expected that when you have learned the characteristics of the principal military explosives and something about how they work, you will handle them with respect.

It could be said that naval ordnance is the science of delivering a large quantity of explosives to the enemy and making the material explode where it will do the most damage. Your duty as a GMM in time of war will be to have the missiles assembled and checked and the launching system in top working order to launch warhead-carrying missiles.

What do you do in peacetime? You keep your skills and knowledge abreast of the system so you can keep the missile system in a "go" condition, ready for any service use.

You may already have had experience in handling explosives. You probably have operated the equipment that handles explosive-loaded missiles and their explosive components. If you are stationed where there are other types of explosives, you have probably helped with torpedo warheads, gun type ammunition, and bombs. In any case, it is wise for you to know something about explosives, as you will be associated with them throughout your career as a GMM.

Some general safety precautions to be observed in the handling and stowing of explosives are given in chapter 8 of Seaman, NavPers 10120-E. It's a good idea to review them.

DEFINITIONS

NONMILITARY EXPLOSIVES

The popular nonmilitary definition of an explosion is anything that goes BANG. It is caused by the rapid expansion of gas, accompanied by a noise. For example, when you inflate a tire, you compress the air in it. If you should have a blowout, the air expands again, and you have a small explosion.

In a nonmilitary sense, a mixture of two gases can sometimes explode. An explosive mixture can be formed by hydrogen and air. When you ignite this mixture the reaction gives off gas and heat, and the heat makes the gas expand rapidly, causing an explosion similar to a blowout.

Your car runs by BURNING a mixture of gasoline vapor and air. But under some conditions, this mixture will EXPLODE in the cylinder of your car. When a cheap gas is used, the mixture will start to burn in the cylinder when the spark ignites it. But as the gas burns, pressure inside the cylinder increases. And when this pressure reaches a certain point, the rest of the mixture explodes, making the motor "knock."

You may ask, "What's the difference between burning and exploding?" They both release energy. But the difference is in the SPEED at which they release the energy. A pound of coal has a lot more energy than a pound of TNT. But a missile warhead filled with coal would be a dud. The coal cannot release the energy fast enough to cause an explosion.

Sometimes, however, coal dust (or any other dust that will burn) can explode if it is suspended in the air. Maybe you've read about dust explosions in coal mines, flour mills, or threshing machines.

MILITARY EXPLOSIVES

None of the examples we have given are military explosives. What, then, is a military explosive? Many explosives have been studied for possible suitability for military use. But only a few of them can meet the requirements. Some desirable properties of a _military explosive are:

1. Relative insensitivity to friction and shock; not liable to be detonated by small arms fire.
2. Proper detonating velocity for intended purposes.
3. High power per unit weight.
4. Sufficient stability to retain usefulness for a reasonable time in any climate.
5. High density (weight per unit of volume).
6. Positive detonation by easily prepared primers.
7. Suitability for underwater use.
8. Convenient size and shape to facilitate packaging, shipping, and handling.

PROPELLANTS

The term PROPELLANT is frequently used in connection with guided missiles and space craft. Often it is called fuel. In older military texts it was called a low explosive. As such, it was defined as a slow-reacting explosive which burned rather than exploded. In missiles, the booster propellant is what gives the push or boost to the missile to start it on its way to the target, and the sustainer propellant carries on after booster burnout. Actually, it is not slow at all, it only seems slow in comparison with a high explosive. The example of the Tartar, in the previous chapter, illustrates this. A buildup of nearly 2300 lbs. thrust in a fraction of a second of burning is not slow. A propellant must burn, however, and not explode. The amount of thrust per unit weight of propellant varies with the type of propellant. See chapter 3 on thrust buildup. The search for a more powerful propellant is continuous, and is needed especially for space launchings.

In addition to being powerful, the propellant must be safe to handle and store. With few exceptions, solid propellants have been used in missiles because they are easier to handle and store than liquid propellants.

Now that you know some of the properties of a military explosive, let's take a quick look at the development of explosives.

HISTORY OF EXPLOSIVES

For many centuries black powder was the only known explosive. It was in the 13th century that Roger Bacon, an Englishman, discovered black powder. There is evidence that the Chinese knew the effects of gunpowder several centuries before this era. The Greeks used a product related to gunpowder, called Greek fire, and a number of experimenters in Europe had made combinations of chemicals that made explosive substances, but the mixture made by Roger Bacon was the beginning of our modern product.

In the 14th century. Berthold Schwarz. a German, invented a gun and used black powder to propel stones from it. This may be considered the real beginning of the history of military explosives. In spite of other developments, black powder remained a major military explosive through the 19th century.

Modern history of explosives began in 1838 when Pelouze, a French chemist, prepared nitrocellulose by nitrating paper. But it was not until. 1845 that Schoenbein, a German chemist, discovered guncotton. He found that nitrated cotton burns quietly in the open, but when confined in a small space, it can explode violently.

Shortly after the discovery of guncotton, Sobrero, an Italian chemist, experimented with nitroglycerin. He found that even a small shock or jar would make it explode. This sensitivity factor makes nitroglycerin useful commercially, but of no use for the military.

But in 1866, Alfred Nobel of Sweden found that he could make nitroglycerin safe to handle by soaking it up in Kieselguhr - a porous kind of earth. He called the mixture DYNAMITE. Today there are many types of dynamite, but they are all nitroglycerin soaked up in some kind of porous material. Dynamite is one of the most important commercial explosives today, but it has little military value.

Black powder has many disadvantages as a projectile propellant. For one thing, it made big clouds of black smoke that blocked the gunner's view of his target, and interfered with his aim for his next shot. For another, it fouled the gun barrel with unburned particles and with glowing coals that made reloading dangerous. It also revealed the location of the gunner.

So chemists began trying to make a smokeless powder that would not foul the gun bore. The Prussians were the first to succeed. About 1884, the French produced the first practical military smokeless powder. They called it Poudre B. It consisted of nitrated cotton, gelatinized and mixed with paraffin or vaseline.

In 1887, Nobel invented BALLISTITE, a double-base smokeless powder made of nitrated cotton and nitroglycerin.

(This is the Alfred Nobel who set up the trust fund and established the conditions for the Nobel Peace Prize awarded each year to some person adjudged to have done outstanding work in the promotion of peace.)

In the same year, the British began producing CORDITE. Cordite has the same ingredients as ballistite, with vaseline added.

Picric acid was probably the first high explosive to be used extensively as a bursting charge. For over a hundred years after it was discovered (1771), picric acid was used as a yellow dye, before it was found that it was a high explosive. During World War II, the Japanese used picric acid as their favorite bursting charge. The American Forces used a related compound - ammonium picrate, better known as Explosive D.

Prior to World War II, all mines, depth charges, depth bombs, and torpedoes were loaded with TNT. To provide a larger explosive force, Torpex was developed; it is far more powerful than TNT. Torpex proved to be unstable and was replaced by HBX. The need for powerful blast effect led to further developments of such explosives as Tritonal, Minol, and RDX. RDX is used extensively in mixtures with other explosives as a filler for missile warheads.

The expanding techniques of modern warfare lead to more and more specialized requirements for explosives. Future developments may be chiefly mixtures of currently known explosives with other materials. But in some cases, the requirements can be satisfied only by new and more powerful explosives, which are presently being sought.

CHEMICAL NATURE OF AN EXPLOSION

The chemical reaction that takes place during an explosion can be either of two types, depending on the nature of the explosive.

Black powder, for example, explodes by oxidation. As you've probably heard, it's a mixture of potassium nitrate, charcoal, and sulfur. All three are solids. To produce an explosion, you apply heat to the mixture. What happens? At the point where you apply heat, the potassium nitrate (KNO_3) gives up its nitrogen and part of its oxygen. The sulfur and charcoal combine with oxygen to form sulfur dioxide, carbon dioxide, and carbon monoxide. All three of these are gases.

In burning, the sulfur and oxygen release heat that does two things. First, it increases the pressure of the gases. Second, it spreads the reaction to all the nearby particles of powder. The reaction continues through the mixture, at the rate of several hundred feet a second, until all the powder has burned.

Other explosives, such as TNT and nitroglycerin, have a different reaction. Each is a chemical compound, rather than a mixture. (In a mixture, two or more ingredients are commingled but not changed; in a compound there is a union of two or more ingredients in a definite proportion, resulting in a new substance.) But the molecules of the compound are highly unstable. You might say there's a "tension" inside them. You start an explosion by applying a shock or a sharp jolt, rather than heat.

When it gets jolted, the unstable molecule flies apart, releasing energy in the form of heat. It usually releases two gases - nitrogen and nitrous oxide. It may also release oxygen, which combines with hydrogen and carbon in the molecule to form gases. The heat not only increases the pressure of the gases, but converts all the other products of the reaction into gas. The sudden release of energy applies a jolt to all the nearby molecules, so that the reaction travels through the whole mass of explosive. (In TNT and other high explosives, the reaction travels through the mass at a speed of several miles a second.)

CLASSIFICATION OF MILITARY EXPLOSIVES

We can classify military explosives by their composition, the nature of their reaction, their sensitivity, the way we initiate the reaction, and by the way we use them in service.

COMPOSITION

By composition, we can divide military explosives into two groups - explosive mixtures and explosive compounds.

An explosive mixture always includes a substance that can burn (such as carbon or sulfur) and a substance that can supply the oxygen for burning (such as a nitrate or a chlorate). We can change the characteristics of the explosive, within limits, by changing the proportion of its ingredients. The most familiar example of an explosive mixture is black powder.

An explosive compound has a fixed chemical composition. So we can't change its characteristics by changing the proportion of ingredients. (But both the degree of purity and the size of the particles affect its explosive characteristics.)

To make these explosive compounds, the manufacturer usually starts with a hydrocarbon- an organic compound of hydrogen and carbon. He then makes the molecules unstable by a process called nitration, which adds nitrates or nitro compounds to various parts of the molecules. A detailed description of the manufacturing process, replete with pictures, is given in OP 5, Vol. 2, Ammunition Ashore, Production and Renovation. Familiar examples of explosive compounds are TNT, cellulose nitrate (used in making smokeless powder), ammonium picrate, and tetryl.

(There are some explosives that won't fit in either of the above classes. For example, dynamite is a mixture of nitroglycerin and some absorbent substance such as sawdust. Ballistite (used as a rocket propellant) is a mixture of nitroglycerin and cellulose nitrate.)

NATURE OF THE REACTION

We can divide military explosives into low and high explosives, according to the speed at which the reaction takes place.

In low explosive, the change to gas is comparatively slow; actually, it's fast burning. We call this reaction deflagration. In this reaction, the particles burn in rapid succession. The heat from one burning particle ignites the unburned particles next to it, and so on until all the explosive has burned. Black powder, smokeless powder, and ballistite are all low explosives. The term low explosive, however, has been dropped from military terminology in favor of the term propellants. Propellants are distinguished from explosives (in military usage) by their function, which is to propel projectiles, rockets, guided missiles, depth charges, and other munitions from guns or launchers, to the target. They can be made to burn at controlled, predetermined rates to produce the gases which develop the high pressure and provide the propulsion force. Propellants can be made to detonate under certain conditions, mentioned below.

When you set off a high explosive, the first particles to explode send a shock wave through the whole mass of explosive, and the change to gas is almost instantaneous. We call this reaction detonation. Dynamite, nitroglycerin, TNT, HBX, and RDX are all high explosives.

The violence of an explosion depends on how fast the explosive detonates, how much gas it produces, and how hot the gas is. The speed of detonation depends on the kind of explosive, how dense it is, and how tightly it is confined. For example, a thin layer of black powder in the open will burn without exploding. In the barrel of a torpedo tube, an impulse charge of black powder will burn fast enough to furnish the necessary push for firing the torpedo. But if it's very tightly confined, black powder will sometimes detonate like a high explosive.

When a low explosive (propellant) deflagrates, the hot gas gradually builds up pressure and applies a pushing force to anything around it. When a high explosive detonates, the pressure builds up so fast that it has a shattering effect, rather than a pushing effect. The shattering effect of an explosion is often called brisance. A brisant explosive is one in which the pressure builds up rapidly.

SENSITIVITY

Explosives differ greatly in the amount of energy it takes to set them off. The most sensitive explosives will detonate if you give them a small jolt. The least sensitive will usually absorb a lot of punishment without detonating. (But you can't depend on it; all explosives must be handled carefully.)

A good example of an insensitive explosive is ammonium picrate (Explosive D), which is used to fill armor-piercing projectiles. An armor-piercing projectile must not explode until it's detonated by its fuze, after it has penetrated the enemy armor. Ammonium picrate is insensitive enough to resist the shock of firing from a gun, and the shock of impact against armor plate. But when it does go off, it's almost as powerful as TNT.

Some of the most powerful explosives are among the least sensitive. HBX, for example, is a powerful explosive, but it usually takes a severe shock to make it detonate.

When we select an explosive for any special purpose, sensitivity is an important thing to consider. The main charge in a warhead must be fairly insensitive, so that it will be reasonably safe for you to handle. A booster charge must be more sensitive than the main charge. And a primer or a detonator must be quite sensitive, so that a fairly small shock will start the explosion.

But even primers and detonators can't be too sensitive. They must be safe to handle; and in a missile warhead, they must resist the shock of launching. A few explosives are too sensitive to be of any military use at all. Nitrogen tri-iodide, for example, is so sensitive it will explode if you touch it.

Figure 10-1 shows you the explosive train that takes place in an armed missile warhead when the firing system is actuated by a proximity fuze. (The proximity fuze is actuated by the target.) The detonator is then fired by the electric current from the fuze. The detonator in turn fires the booster charge. The shock from the booster causes the disrupting (main) charge to explode, causing the explosion that destroys the target.

The safety and arming device (S&A) makes sure that the warhead cannot detonate until the missile is a safe distance from the ship.

METHOD OF INITIATING THE EXPLOSION

The two most common ways to initiate an explosion are by heat and shock. We use heat to initiate the low explosives used for propellants and impulse charges. In guns, torpedo tubes, and depth charge projectors, the flash of flame from a primer provides the heat. The primer contains a small amount of extremely sensitive explosive. It may be set off by a spark from an electric squib, by the shock of a firing pin striking it, or by other means. The flash of flame ignites the propellant. A primer may be used to initiate a detonator.

Only the most sensitive of high explosives can be reliably detonated by heat alone. To initiate the high explosive charges of projectiles, torpedoes, depth charges, and missile warheads, we apply a strong, sudden shock. To provide the shock, we use a smaller charge of a more sensitive high explosive, either in contact with the main charge (burster, fig. 10-1) or very near it. The smaller charge can be detonated by heat, or by the shock of a firing pin.

AUXILIARY CHARGES

In many instances an intermediate or auxiliary charge is needed between the initiator and the main

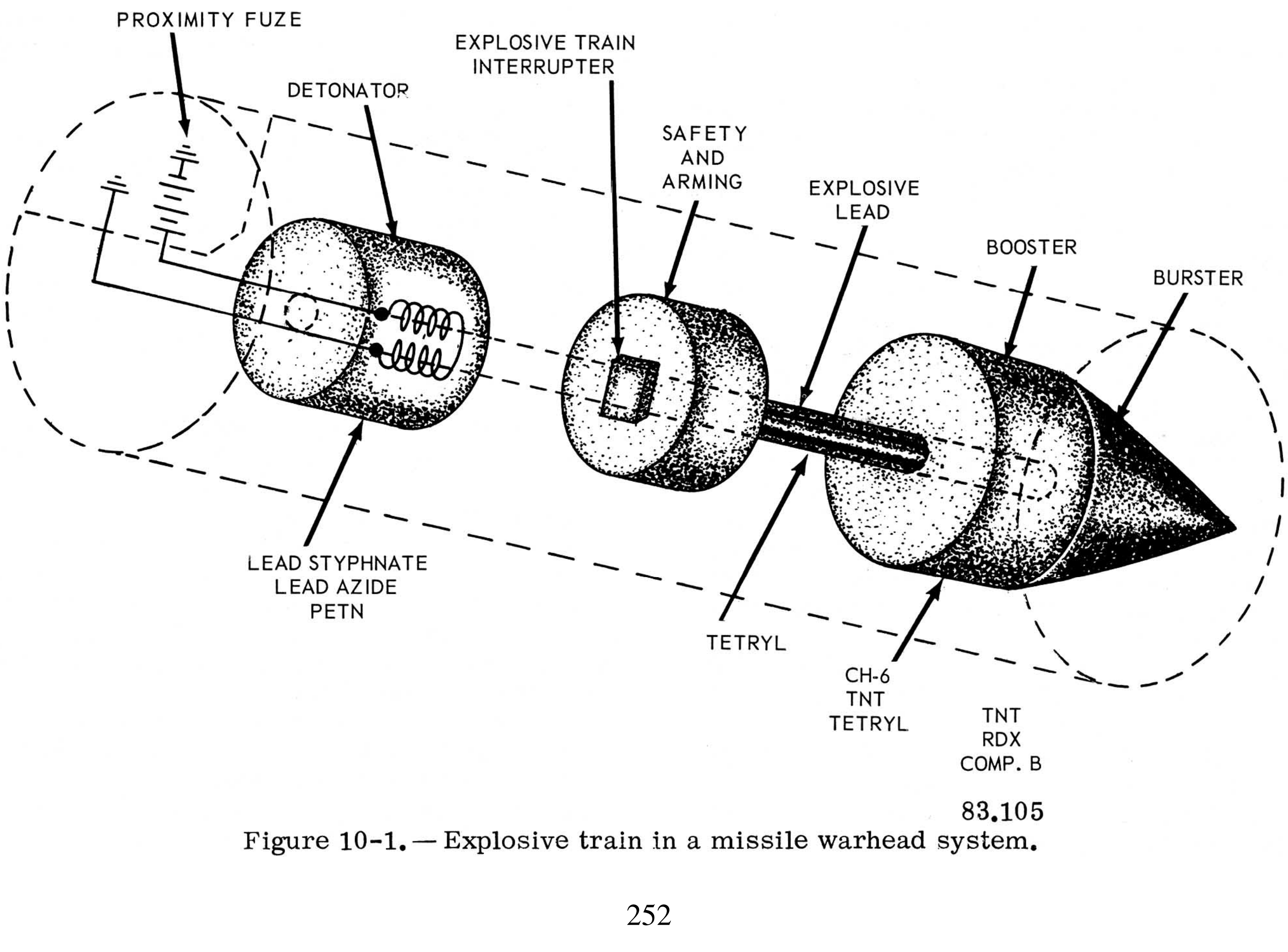

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Figure 10-1. — Explosive train in a missile warhead system.

charge of explosive to ensure successful initiation. An auxiliary charge used with a bursting charge is called a booster (fig. 10-1). It consists of a moderately sensitive high explosive to increase the shock of the detonator. Thus, the basic high explosive train consists of the detonator, booster, and bursting charge, but often there are auxiliary parts. Such a train might include a primer, delay pellet, detonator, booster, auxiliary booster, and burster.

INFLUENCE DETONATION

A third way to initiate an explosion is by influence. You can sometimes detonate a charge of a high explosive by exploding another charge near it. In that case, we say that the second charge explodes by sympathetic detonation. (But it is the shock provided by the first explosion that causes the second one.) This is the technique used in missile warheads.

The distance at which an influence explosion can occur depends on several things: first, the amount and brisance of the first explosive; second, the sensitivity of the second explosive; and third, the material that lies between the two charges. For example, the shock wave will travel a considerable distance through steel, a shorter distance through water, and not far at all through air.

SERVICE USE OF EXPLOSIVES

According to their use in service, military explosives can be divided into four classes:

1. Propellants and impulse explosives
2. Disrupting explosives
3. Initiating explosives
4. Auxiliary explosives

We use propellants and impulse explosives when we want a steady PUSH. For example, when we fire a projectile from a gun we want a pushing force. We want this force to continue as long as the projectile is in the bore, so we use a low explosive-smokeless powder. For the impulse charge in torpedo tubes and depth charge projectors, we use black powder, another low explosive. To propel a missile, we use a double-base compound; that is, a combination of two propellants bound together by small amounts of other ingredients. Figure 3-23 shows different shapes of propellant grains and the text discussed methods of controlling burning rate.

We use a disrupting explosive when we want a shattering effect. When we fire a missile at an aircraft, we want the missile's warhead to shatter into fragments, so we use a disrupting explosive.

High explosives such as TNT J RDX, and HBX are all disrupting explosives.

We must choose explosives carefully, so that each will do the job we want it to do. Both a low and a high explosive may release the same amount of energy, but there is a difference in how fast they release it. Here is an example. Suppose your car is stalled with a dead battery, and you ask your friend for a push. What you need is a steady push, applied over a distance of 20 or 30 yards, so that you can accelerate to starting speed. Your friend could apply the same amount of energy to your car by crashing into the back of it at 50 miles an hour, but that wouldn't help you get started.

For this same reason, you wouldn't use TNT for a propelling charge in a missile booster. If you did, it would blow the booster case to bits. You'd think twice before you tried it again, if you were still alive.

As we explained earlier, you must apply energy to make a charge explode. For that purpose we use an initiating explosive. To ignite a propellant, we need a flame. To detonate a disrupting charge, we need a shock. We often use lead azide mixed with some flame producing material as an initiator for both propellants and disrupting charges, because it produces both a shock and a flame.

We use a primer to ignite a propellant. A common primer is a small container that holds a pellet of fulminate of mercury and a small charge of black powder. When you fire it, it produces a long spear of flame that ignites the propellant.

We use a detonator to set off a high explosive charge. The detonator usually contains a charge of lead azide or fulminate of mercury, either alone or combined with granular TNT or tetryl. When it's fired, it provides the shock that detonates the main charge.

With a big charge of propellant explosive, or with relatively insensitive high explosives such as TNT, we need an auxiliary explosive between the initiator and the main charge. The auxiliary explosive provides enough heat or shock to make sure the main charge goes off properly. The intermediate charge we use with propellants is called an ignition charge. It consists of granular black powder. With high explosives, the intermediate charge is called a booster.

It consists of a moderately sensitive high explosive, such as granular TNT, tetryl, or CH-6 (fig. 10-1).

Look back at chapter 3 and 4 and the illustrations of the main components of missiles. Several of the pictures point out the booster, which contains propellant. Figure 3-27 shows the location of the igniter in the BT-3 missile. Figures 3-30 and 3-31 show the booster propellant and the sustainer propellant in the Tartar missile. The booster, sustainer, and warhead are pointed out in several of the drawings in chapter 4.

CHARACTERISTICS OF MILITARY EXPLOSIVES

Here are some of the most common military explosives, and some of their characteristics. Many of them you will actually handle, either as impulse charges or in the warhead, booster, or detonator of missiles. We've included a few others in the list, just to give you some background information on other explosives the Navy uses. The list is in alphabetical order, so you can use it for future reference.

AMATOL is a high explosive, made by mixing TNT and ammonium nitrate in various proportions. The Navy has used it from time to time as a bursting charge for projectiles. A 50-50 mixture is just as powerful as TNT, and it's cheaper. Its chief disadvantage as a projectile filler is that it is very hygroscopic (absorbs moisture readily), although it stores well if protected against moisture. When fired, it makes practically no smoke. A TNT explosion produces a cloud of black smoke, which makes spotting easy. In wartime, if there were a shortage of other high explosives, the Navy could use amatol as the main charge in mines.

AMMONIUM NITRATE is a high explosive. The Navy has little use for it, except in making amatol. Ammonium nitrate is quite insensitive, yet it is a powerful explosive. It is used extensively in making commercial dynamite.

AMMONIUM PICRATE. (See Explosive D.)

BALLISTITE is a low explosive mixture, of almost equal parts cellulose nitrate and nitroglycerin. It was one of the first military smokeless powders, and at one time it was widely used as a propellant. But as a propellant, it causes serious erosion of the gun bore. The Navy no longer uses it, except as a rocket propellant and in some guided missile boosters and sustainers.

It is very useful for that purpose, since it burns evenly and uniformly at the low pressures developed in a rocket motor.

BLACK POWDER is a low explosive mixture that burns very fast when it's confined, even slightly. For many years black powder was the universal military explosive. It served not only as a propellant, but also as the bursting charge for projectiles and torpedo warheads.

Black powder is now obsolete for both these uses. As a propellant it burns too fast; as a bursting charge it burns too slowly. Figure 10-2A shows a profile of one of the old-time guns that used black powder. The breech end of the barrel had to be thick, to keep the sudden force of the explosion from breaking it. And the barrel had to be short; the gas from a black powder explosion can't maintain its pressure for any great distance of projectile travel.

Figure 10-2B shows the profile of a newer gun. Since smokeless powder burns slower than black powder, the thick breech is no longer necessary. And the barrel is much longer.

The Navy still uses black powder for some purposes. You can change the burning speed to some extent by changing the size of the grains. The bigger they are, the slower they burn.

At present, the Navy uses five different sizes of black powder grains. The largest ones are 6-sided grains with rounded ends. The next smaller size is called cannon powder. We use it as an ignition charge for turret-gun powder bags. We use the three smaller sizes either alone or combined with other explosives - as burster charges for special projectiles, in primers, and in fuze delay trains.

If kept dry, black powder will remain stable almost forever. Moderately high temperatures don't affect it. But black powder deteriorates when it's damp.

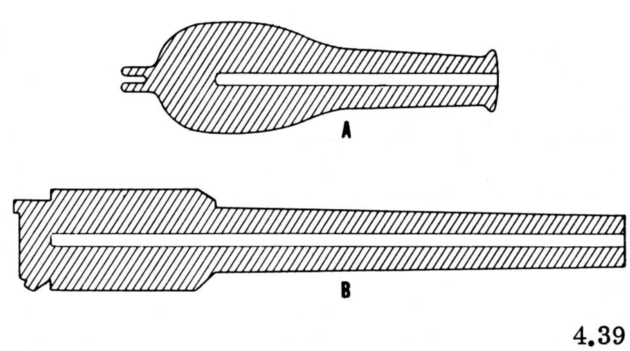


Figure 10-2.—Gun barrel profiles: A The old look, for black powder; B. The new look, for smokeless powder.

When it's exposed, black powder is probably the most dangerous explosive you'll find aboard a Navy ship.

It's extremely sensitive to shock, friction, and sparks - including those too small to see. If spilled on the deck, you can ignite it by walking On it. So, if you should spill any, you'll have a dangerous situation. Wet the powder immediately, scoop it up, and heave it overboard. Be sure the powder is thoroughly wet before attempting removal. A small spill can be covered with a dripping wet cloth to saturate it before wiping it up. All work in the area must be suspended until the powder is cleaned up.

CH-6 is a mixture of RDX (97.5%), graphite, and other chemicals which reduce the mixture's sensitively.

COMPOSITIONS A, B, C, (See RDX.)

CORDITE is a smokeless powder. It is the standard British propellant. It is cheaper than our smokeless powder, and it has a more uniform action in the gun. But we don't use it because it quickly wears away the gun bore.

CORDITE N (SPCG), a later development, avoids this drawback. Cordite N is very cool burning with very little smoke and no flash. It is a triple-base propellant, rather new in the U. S. Navy. It is an opaque, chalk-white color, and yellows with age.

CYCLONITE. See RDX.

DYNAMITE is too sensitive for military use. We rarely use it even for demolition work, because a stray rifle bullet could make it detonate.

EXPLOSIVE D (ammonium picrate) comes in the form of red or yellow crystals. It's almost as powerful as TNT, but not nearly as sensitive. That makes it useful as a burster charge in armor-piercing projectiles and armor-piercing bombs. (A projectile gets a very severe shock when it strikes armor plate. But, to be effective, it must not detonate because of that shock. It must be detonated only by its fuze, after the projectile has penetrated the armor.)

For a long time the composition of Explosive D was a secret. That is why we spoke of it in code, rather than by its right name.

FULMINATE OF MERCURY (mercury fulminate) is a yellowish-white crystalline powder. It's the most sensitive explosive in common service. We can use it for only one purpose: to initiate the action of other explosives, either directly or through an auxiliary explosive. In primers, it may be mixed with other flame-producing materials.

GUNCOTTON, a form of cellulose nitrate, was the first modern bursting charge. Its early uses included loading into mines and torpedo warheads. Because of its sensitivity when dry, its susceptibility to deterioration, and its relatively low power, guncotton has generally been replaced by TNT and other explosives.

HBX is one of the most important developments in the field of explosives. It was developed by the U. S. Navy to take the place of torpex because torpex is too sensitive. HBX is very nearly as powerful as torpex, but much less sensitive. It is chemically stable and noncorrosive, and is in the same general class as TNT for safety in handling. HBX-1 and HBX-3 are used as explosive fillers in underwater ordnance, replacing TNT filler.

LEAD AZIDE has a high temperature of ignition and is less sensitive to shock and friction than mercury fulminate. The brisance of lead azide increases as the pressure applied to it increases. It is less brisant and has less explosive power than mercury fulminate.

Lead azide is poisonous, slightly soluble in hot water and in alcohol, and very soluble in a dilute solution of nitric or acetic acid in which a little sodium nitrate has been dissolved. Lead azide reacts with copper, zinc, cadmium, or alloys containing such metals, forming an azide which is more sensitive than the original lead azide. Because it does not react with aluminum, detonator capsules for lead azide are made of this metal. The hygroscopicity of lead azide is very low. Water does not reduce its impact sensitivity, as is the case with mercury fulminate. (See OP 5, Vol. 1 for instructions if you must destroy some lead azide. Ammonium acetate and sodium dichromate are used to destroy small quantities of lead azide.) The velocity of detonation of lead azide is approximately 17,500 feet per second. Its color varies from white to buff.

Lead azide may be used where a detonation is caused by flame or heat. It has been adopted as the detonator of major caliber base-detonating fuzes, of point-detonating fuzes, and of auxiliary-detonating fuzes. It is also used in priming mixtures.

Lead azide is completely stable in storage, even at high temperatures. However, it produces an intensely poisonous, highly flammable gas when enclosed.

LEAD STYPHNATE comes in two forms - (1) the normal, which appears as six-sided monohydrate crystals, and (2) the basic, which appears as small rectangular crystals. Lead styphnate is particularly sensitive to fire and the discharge of static electricity; when dry, styphnate can be readily ignited by static discharges from the human body. The longer and narrower the crystals, the more susceptible the material is to static electricity. Lead styphnate does not react with metals. It is less sensitive to shock and friction than mercury fulminate or lead azide. Lead styphnate is very slightly soluble in water and methyl alcohol and may be neutralized by a solution of sodium carbonate. The velocity of detonation is approximately 17,200 feet per second. The color of lead styphnate varies from yellow to brown. Lead styphnate is used as a component in primer and detonator mixtures. It is stable in storage, even at high temperatures.

NITROGLYCERIN is a colorless, oily liquid, a little heavier than water. It is very simple to make; and after it is made, it is very easy to blow yourself to pieces with it. Some experimenters say it takes a small jolt to detonate nitroglycerin; others say it takes only a dirty look.

Nitroglycerin is an important commercial blasting explosive, but it is too sensitive for military use. It is, however, one ingredient of double-base powder, which is colloided so that the nitroglycerin is desensitized. These powders are used by the U. S. Navy as gun and rocket propellants. It is also colloided with guncotton or mixed with inert material to make commercial dynamite, frequently used for construction blasting.

PETN (pentaerythritoltetranitrate) was one of the compounds developed in the search for an explosive more powerful than TNT. It is one of the most powerful of all modern high explosives. The Navy sometimes uses it in detonating and priming mixtures. PETN is used in the explosive train detonators in many U. S. Navy missile warhead systems. It is often used in primer or detonating cords in demolition work. During World War II, a mixture of PETN and TNT was sometimes used as the main charge in mines and torpedoes.

PICRIC ACID (tri-nitro-phenol) comes in pale yellow crystals. It was probably the most important projectile-bursting charge used during the Spanish-American War and World War I. Since its melting point is too high for safe casting, it was usually mixed with other explosives to lower the melting point. When it was used alone, it was press-loaded in the projectile cavity. The British call picric acid lyddite. The French name is melinite; the Japanese name is shimose, the Italian name is pertite. It is most generally used in its converted form, ammonium picrate, or Explosive D.

RDX is a powerful high explosive, of greater brisance than TNT. In pure form, it is too sensitive for military use. To make RDX safe for military use, it is mixed with oils, waxes, or less sensitive explosives. It is important because of its high power and good chemical stability.

The Navy uses different mixtures containing RDX:

1. Composition A is a mixture of RDX and wax. This mixture has about the same sensitivity as Explosive D, but it is more powerful. It is beginning to replace Explosive D as a projectile filler.
2. Composition B is a mixture of RDX, TNT, and wax. It is used for filling projectiles, bombs, and missile warheads.
3. Composition C is a plastic explosive mixture - you can mold it by hand into any desired shape. It is often useful in demolition work, since you can mold it around the object you want to destroy. Composition C-4, the one you'll most likely find in use, is white in color and has a texture like putty. Composition C-4, like Composition C-3, is manufactured in 2 1/2- pound blocks. But C-4 does not exude oil like other Composition Cs do. These compositions are about 25% stronger than TNT.
4. HBX, described earlier, contains 40 percent RDX, plus TNT and some other ingredients.
5. Another explosive has been developed, designated H-6. It is similar to HBX but is considered superior to it. It is used in bomb type ammunition, and is a cast filler.

SMOKELESS POWDER is a low explosive. It is the standard propellant for all Navy guns. It comes in the form of cylindrical grains, in a variety of sizes, with one or more perforations running the length of the grain to increase its burning rate (fig. 10-3). When they're fresh, the grains are gray or buff colored, with a translucent, horny appearance. Older powder may be brown or black.

Chemically, smokeless powder is cellulose nitrate, or pyrocotton, prepared by putting ordinary cotton through several processes, then colloiding with ether and alcohol.

The manufacturer of smokeless powder, after washing and boiling the pyrocotton, extracts as much water as possible by passing it through wringers. He then adds alcohol, and extracts the remaining water. After removing the excess

53.144
Figure 10-3.—Smokeless powder grains.

alcohol, he adds the proper amount of ether. The ether and alcohol, working together, soften the pyrocotton into a colloidal mass. This soft material is then extruded in the form of perforated rods, which are cut into grains of the desired length. These grains of smokeless powder must dry for several months before they're ready for service use.

The stability and useful life of smokeless powder are affected adversely by moisture and heat. The storage conditions for smokeless powder are therefore very important.

TETRYL comes in yellow crystals or granules. Its chemical name is tri-nitro-phenyl-methyl-nitramine. It's a high explosive, more powerful and more sensitive than TNT. The Navy uses tetryl extensively as a booster, especially in mines, and torpedo and missile warheads. A mixture of tetryl with fulminate of mercury is sometimes used as a detonator. Tetryl is also used in explosive leads.

Tetryl is a derivative of methyl-aniline and is classified as a nitro aromatic compound. It is a fine crystalline material practically insoluble in water, but soluble in acetone, ammonia, ether, carbon tetrachloride, and benzol. Tetryl melts at about 130°C. Heated above its melting point, it undergoes gradual decomposition, and explodes when exposed to a temperature of 260°C for five seconds. Tetryl will corrode steel when in the dry or moist state. It is practically nonhygroscopic (after proper drying) but moisture does interfere with its effectiveness. Tetryl is chemically stable at ordinary temperatures. It is more sensitive to shock or friction than TNT, arid more powerful than TNT. Tetryl is more sensitive to detonation by mercury fulminate or lead azide than TNT and is readily exploded by penetration of a rifle bullet. It can be initiated from flame, friction, shock, or sparks, burns readily; and is quite likely to detonate if burned in large quantities. The velocity of detonation of tetryl is approximately 24,400 feet per second. When pure, tetryl is light yellow, but is usually gray after loading because of the graphite mixture used in the loading process.

Tetryl is sensitive to mechanical shock, and it is used as a booster charge between the fulminate of mercury or lead azide detonators and the high-explosive bursting charge. It is also used as a filler in small-caliber projectiles. Tetryl is loaded in pellet form, the pellets being pressed after being mixed with small quantities of graphite which serves to lubricate it while it is being pressed.

Tetryl is poisonous when taken internally and causes dermatitis on contact with the skin. Precautions are therefore necessary regarding the handling and packing of the dry material. Special precautions must be taken to prevent ignition or explosion from friction or blows resulting from rough handling. Tetryl should be kept dry and protected from high temperature and sparks.

TNT (trinitrotoluene) is probably the best known of all military high explosives. When it is pure, TNT is a white crystalline substance. When impurities are present, its color varies from yellow to dark brown. It is chemically stable as long as you protect it from moisture and extremely high temperatures. You can store it for years without any chemical change. And, compared with most high explosives, TNT is relatively insensitive and safe to handle.

An advantage of TNT is its low melting point. It can be melted and poured into mines, torpedo warheads and projectile cavities, where it will harden when it cools. In its cast form, TNT is hard to detonate. It needs a powerful booster of tetryl or granular TNT. However, components containing TNT, such as bombs, depth charges, warheads, and similar munitions containing TNT bursting charges, are subject to sympathetic detonation. This makes it necessary to store such munitions separately, especially away from fuzes, detonators, and fire hazards that could start a detonation. Also, it cannot be roughly handled without danger.

Instances on record show that it can be detonated very easily if the combination of conditions is just right for it.

WARHEADS AND FUZES

Like any other vehicle, the guided missile must carry some form of useful burden if it is to accomplish the intended objective. In missile terms, the useful burden is called the payload. Physically, the payload merely occupies one or more of the sections of the airframe, and it contributes nothing to the functions of the vehicle, such as guidance, propulsion, or control. But in the total system, it is the component of greatest value, since all the actions of the missile serve as the means for ensuring the effective delivery of the payload.

In research and test missiles, the payload often consists of telemetering units, which collect data during flight, convert the information into radio signals, and transmit them to receivers at a recording site. In some test missiles, dummy payloads are carried which have the same physical characteristics as the corresponding devices which the missile will carry as an operational weapon. But in its military role, the guided missile is launched with a payload composed of one or more warheads and one or more fuzes. The warhead is a device capable of destroying or damaging an enemy target. The fuze is a triggering mechanism used to initiate the actions of the warhead and determines the exact moment of release of the destructive forces.

In the discussion of explosives you have seen two spellings, FUSE and FUZE. The Navy makes a distinction in their meaning. Fuze was defined earlier. A FUSE is a protective device inserted in series in an electrical circuit. An explosive fuse is a conduit that leads fire from one place to another. A firecracker fuse is a familiar example. Primacord, used to detonate explosives in mining and quarrying, or for demolition is another example. When the fuse is lighted, the flame follows the train of powder in the center of the cord.

The fuze used to detonate weapons is a mechanical or electrical device but may include a fuse train of black powder.

TYPES OF WARHEADS

Many of the warheads developed for other kinds of weapons can be modified or adapted for use in guided missiles. Some of these may present special problems to the missile designer, but almost any sort of destructive device employed in conventional weapons may also be carried by guided missiles. Among the types of warheads which might be used are: external blast, fragmentation, shaped charge, explosive pellet, biological, and atomic.

External Blast Warheads

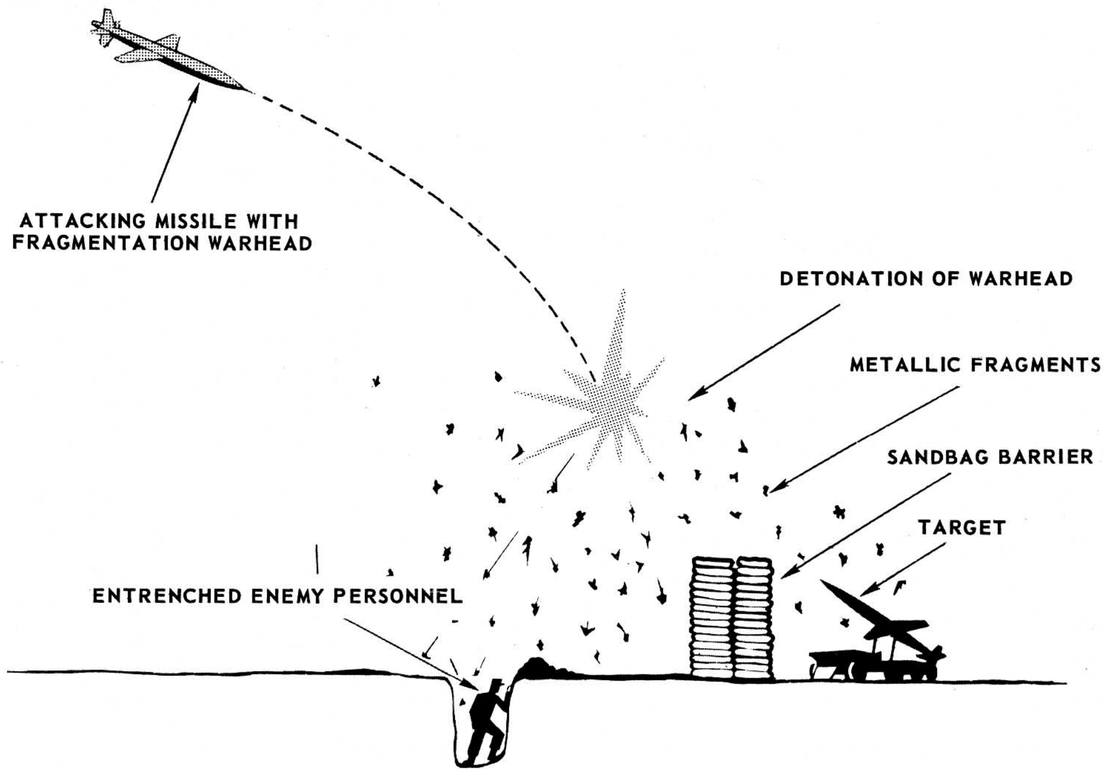
This type of warhead causes damage by means of a high pressure wave, or blast, which results from the detonation of an explosive substance. When set off by a suitable impulse, the explosive material undergoes a sudden chemical change in which energy is released almost instantaneously. Gaseous products are formed and large quantities of heat are generated. The destructive effect results from the high pressure produced by the rapid heating of the gases.

Blast warheads are very effective against ground targets, and have been used in many surface-to-surface and air-to-surface missiles. They are less effective against aircraft, since in the atmosphere the pressure wave dissipates rapidly with distance, and the explosion must take place very near the aircraft in order to damage it. Large blast warheads can cause great damage to ground installations, which must be of special construction to withstand them; and damage occurs hundreds of feet from the point of detonation. The V-1 buzz bomb, which carried a warhead consisting of about 2,000 pounds of high explosive, caused destruction and damage over an area equal to an average city block.

Torpedoes use a blast type of warhead. Since water is incompressible and relatively dense, the pressure waves created by the explosion are transmitted to the target practically undiminished, and damage it.

Fragmentation Warheads

These warheads operate by bursting a metal case containing a high-explosive charge. Upon explosion, the container is shattered into hundreds of fragments which fly out at high velocities; and these are capable of damaging targets at considerable distances from the point of detonation. For this reason, this sort of warhead is very effective against aerial targets and is often employed in air-to-air and surface-to-air missiles. Usually the warhead does not penetrate the target but is detonated by the fuze at some distance from the target. This increases the chances of a hit. See figure 10-4.

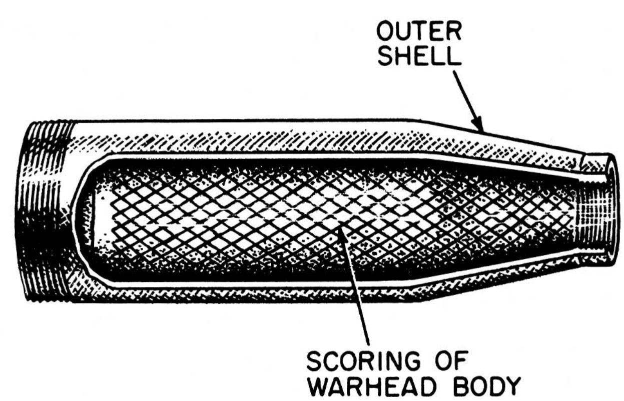


144.14
Figure 10-4. — Effect of fragmentation warhead on surface target.

The factors which influence the destructive action of the warhead are the size of the fragments, their velocity, and the angle at which they are ejected. Fragment size is controlled by the designer by weakening the case at certain points. The fragment velocity is controlled by the shape of the container, the ratio of explosive weight to metal weight, and by the type of explosive used. The angle at which most of the fragments are emitted depends on the shape of the container and the point within it at which the detonation takes place. On modern missiles fragmentation is not a hit-or-miss affair. Theories are checked out on scale models and test firings substantiate the value of controlled designs. Various shapes and sizes of fragments have been tested against different targets. Figure 10-5 depicts one type of controlled fragmentation warhead.

Shaped Charge Warheads

Shaped charges, also called cavity charges, make use of the Munroe effect, in which the explosive power is concentrated by shaping the explosive material. Experiments show that if a regular cavity such as a conical hole is molded into the side of an explosive charge nearest the target, the effect on the target is increased over the effect obtained with the same charge without the cavity. The presence of the hole brings about a concentration of the



144.16
Figure 10-5. — Controlled fragmentation warhead.

explosive force similar to the way in which light can be focused into an intense beam by a glass lens.

In the explosion of a shaped charge, a beam of very hot gas, called the jet, is ejected. In it, the gas particles have an extremely high velocity. If the cavity is lined with some material that can be broken into small pieces or can be melted by the explosion, the efficiency of the charge is greatly increased. The small particles of the liner are carried by the jet, which is increased in weight, and as a result, it can penetrate a thick target, acting somewhat in the manner of a needle. Among the applications of the Munroe effect are the Army's bazooka projectile and also certain types of demolition charges used to blow holes through reinforced concrete structures.

When employed in guided missile warheads, shaped-charge explosives have possibilities of great effectiveness against both aircraft and heavily armored surface targets.

Explosive Pellet Warheads

A warhead of this type contains a number of small explosive charges, or pellets, each of which is separately fuzed. When the main warhead is detonated, the pellets are ejected but withstand the force of the explosion and are hurled intact toward the target. The pellets then detonate either on impact or after penetrating the target skin. The total destructive effect combines both blast and fragmentation effects, since blast damage is great when the individual charge is exploded, regardless of whether the explosion occurs at the skin of the target or after penetrating it.

The explosive pellet is an ideal weapon for use against enemy aircraft. Its full development is dependent upon perfecting a fuze for the individual charges that can withstand the initial blast of the principal warhead while still ensuring explosion on or within the targets.

Chemical Warheads

This type may contain either war gases or incendiary materials. Warheads containing gases may liberate any of the well-known types such as mustard gas, lewisite, or some newly developed chemical. The effects produced are either denial of the use of the target area or personnel casualties within the area. Missiles equipped with chemical warheads also serve as possible counterthreats to initiation of gas warfare by the enemy.

A variety of disabling gases have been developed. The length of disability and the type of disability can be varied with the type of agent used, the method of application, the terrain, the weather, and other factors. Agents dispersed as a vapor or aerosol usually have a short period of effectiveness. In the category of riot-control chemicals are the tear gas type and those that produce nausea and vomiting.

The most important advantages of chemical agents are the area coverage and penetration effects. Agents dispersed as gas or aerosol penetrate structures and incapacitate hidden enemies that could not be reached by conventional weapons. At the same time, the lives of the innocent are spared. The effects of the disabling chemical wear off before long, and without after effects. This is far different from the gas warfare of World War I, when deadly chlorine gas and mustard gas were used.

It takes no great depth of thought to realize that it is much more humane to overcome the enemy by disabling him temporarily (and maybe making him uncomfortable for a few hours) than by blasting him to bits.

Another type of chemical warhead is the incendiary warhead. It contains a material that burns violently and is difficult to extinguish, while covering a large area after release from the warhead. Incendiary weapons are useful principally against ground targets. There are several types of chemicals used to cause fires, and different rules for handling apply to each.

There are many more chemical agents used in warfare. Disaster Control (Ashore and Afloat), NavPers 10899-B, has a lengthy chapter on the different types of chemical agents used, their effects, and how to protect yourself against them. Reading that chapter can be very enlightening. You may be sure that all major nations have an arsenal of chemicals to use in warfare. You need to know how to protect yourself against the different varieties.

Biological Warheads

A biological weapon delivered by a missile would contain living organisms capable of disrupting personnel activities in the target area by causing sickness or death to the inhabitants. Not only can micro-organisms be used against people, but also against animals and vegetation. Such use could destroy or greatly reduce the food supply and the raw materials for factories. Water supplies can be contaminated. Biological agents are difficult to detect. For a revealing discussion of the possibilities of this type of warfare, plus methods of detection and protection, read chapter 4 in Disaster Control (Ashore and Afloat), NavPers 10899-B.

Atomic and Thermonuclear Warheads

In this type, destruction and damage result from the processes of atomic fission or fusion. The destructive effects are blast, heat, and liberation of radiation. The detonation results in death, sickness, and the denial of the use of large areas as a result of the release of radioactive elements.

Volumes have been written about the effects of nuclear weapons, all based on the results of the two bombs dropped on Japan in World War II. Some information has been added from the experimental tests made since then but the statistics of human and material destruction hark back to the original drops. All other figures on human destruction are estimates of what could happen, however accurate those estimates might be. We know that nothing can survive at ground zero, where the weapon strikes. The area of total destruction varies with the size of the weapon. Beyond this area of complete devastation, shelters can save the lives of many, by protection against falling buildings, fires, thermal radiation, and nuclear radiation. One of your basic texts, Basic Military Requirements, NavPers 10054-C, devotes a chapter to Nuclear, Biological, and Chemical (NBC) defense.

Several of our Navy missiles are capable of carrying a nuclear warhead. This means that we can send this destructive force far into enemy territory, away from our own personnel. We know, too, that other major powers have nuclear missiles. Therefore, you must learn what means of protection against their effects you have aboard ship, as well as how to fire the lethal missiles.

Continuous Rod Warheads

Fragmentation-type explosive devices such as fragmentation grenades, bombs, and projectiles are well known and have a long tradition of use in conventional weaponry. They are effective, but they do leave something to chance. The pattern of fragment distribution is necessarily random, and the fragments tend to be irregular in size (and hence in lethality) in spite of pineapple like or waffle-like patterns in the fragmenting body.

The purpose of the continuous rod warhead is to menace aircraft within a lethal radius. In this type of warhead, the warhead energy is used to expand rods radially into a ring of metal which can lengthen and thus increase its diameter rather than produce an expanding shell of small fragments. Upon detonation the continuous rod warhead expands radially into a ring pattern. The intent is to cause the connecting rods, during their expansion, to strike the target and produce damage by a cutting action.

Other Types of Warheads

Several other types of special warheads may be used. These include: radiation, anti radiation, illumination, psychological, exercise, and dummy warheads.

RADIATION warheads may use radiological material in the same manner as chemical or biological agents, scattering the radioactive material according to plan. The possibilities and ramifications of this type of warfare will not be explored further here.

ANTIRADIATION WARHEADS carry material that will jam enemy radars. The Shrike missile is of this type. It is intended to home on enemy radar installations and silence their transmitters. The ARM-l missile being developed is similar to the improved Shrike.

ILLUMINATING warheads have long been used in projectiles during night attacks to point out or silhouette enemy fortifications or other targets. This has been especially useful during shore bombardment. Illuminating warheads are also used in aircraft bombs and rockets to assist in the attack on ground targets and submarines. No application has been made in guided missiles.

PSYCHOLOGICAL warheads do not carry lethal or destructive agents, but carry material designed to create a psychological effect on the enemy, rather than actual physical damage. Payloads may be propaganda leaflets, mysterious objects that appear dangerous, or inert or dummy warheads. Decoy warheads may carry "window," which causes false radar echoes or noise-makers to confuse sonar operators of antisubmarine ships.

A dummy warhead has only the outward appearance, the size, shape, and weight of a real warhead. It is used in training and practice operations.

EXERCISE or training warheads do not contain any explosive material but otherwise contain parts of a real warhead, so they can be assembled, disassembled, tested for electrical continuity, and other wise used for training exercises.

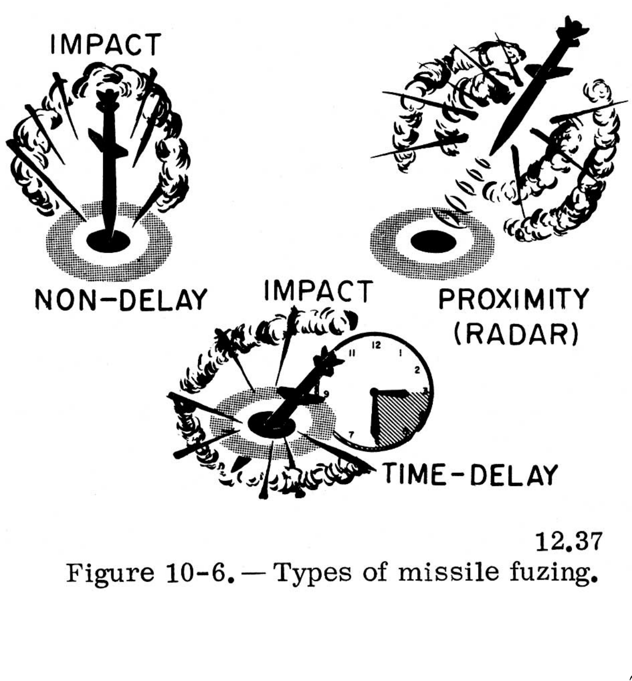
The ASROC (Rocket Thrown Torpedo) uses a torpedo for its warhead.

TYPES OF FUZES

The missile warhead is activated by tile actions of one or more fuzes, which release tile destructive forces after certain conditions have been fulfilled. The type of fuzing employed determines whether tile warhead is detonated at a distance from the target, upon impact with it, immediately following penetration, or at some fixed time after penetration of tile target skin. The missile warhead is generally detonated in one of the three relations with the target shown in figure 10-6.

The most effective type of fuze for a given missile depends upon the nature of tile target and the possibilities of tile warhead for causing damage. The type often employed in missiles are the impact, time ground-controlled, and proximity fuzes.

Fuzes may also be classified according to their location, as nose fuzes, tail fuzes, or other.



12.37
Figure 10-6. — Types of missile fuzing.

Impact Fuzes

Impact fuzes are actuated by the inertial force exerted when the missile strikes the target. If detonation takes place at the moment of impact, the fuze is of the non-delay, or instantaneous type. If the detonation takes place some time after impact the fuze is said to be of the delay type. This short delay time permits the weapon to penetrate the target before it explodes. Impact fuzes are also called contact fuzes.

Ground-Controlled Fuzes

In ground-controlled fuzes, some device is used for measuring the distance from the missile to the target. The control device is not mounted in the fuze but on the ground; and when the proper space relationship exists between the missile and its target, a signal is sent to detonate the fuze from the control point on the ground.

Time Fuzes

Time fuzes, or time-delay fuzes are fuzes that are preset to detonate the warhead after a specified lapse of time after launching. One type has a burning powder train' another type has a clocklike mechanism. In either type, the time cannot be changed after the missile is launched. A missile may have to maneuver to intercept its target, and the variation in time, however slight, precludes the use of a fuze with preset timing. However, Subroc uses a timer that closes the firing contacts when the preset time (in the water) has elapsed. The timing device is actuated when the depth bomb strikes the water.

Proximity Fuzes

Fuzes of this type are actuated by the influence of some property of the target and are detonated at a distance which allows maximum damage to take place. Five general classes of proximity (also called VT, or variable-time) fuzes can be distinguished according to the property to which the device responds. These are electromagnetic (radar and radio), pressure, acoustic, photoelectric, and electrostatic fuzes.

ELECTROMAGNETIC FUZES. - These fuzes may operate with radio, radar (microwave), infrared, or ultraviolet waves. The basic proximity fuze must have a transmitter-receiver, a means of amplifying the return signal so it will be strong enough to activate the detonator, electrical safety devices to prevent premature detonation, and a power supply to set off the fuze. The miniature transmitter in the fuze transmits high-frequency radio waves, which are reflected from the target as the missile approaches it. Because both the missile and the target are moving with respect to each other, the reflected signal, as received at the missile, is of a higher frequency than the transmitted signal. The two signals, when mixed, will generate a Doppler frequency, the amplitude of which is a function of target distance.

At the proper time, the action of the reflected waves causes an electronic switch to close and fire the detonator. Fuzes of this kind have been developed to a high degree of accuracy and dependability. They operate effectively both in darkness and daylight and in all kinds of weather. However, they are subject to jamming by false information from the target. This can make the fuze inoperable or, worse yet, cause it to detonate before it comes within lethal range of the target. Some counter-countermeasures have been devised to offset the effects of enemy countermeasures. One method is to add a contact fuze so that if the proximity fuze fails the other fuze will act. Two of our missiles, Sidewinder and Sparrow, use such a system.

PRESSURE FUZES. - The pressure that activates these fuzes may be air pressure or water pressure. Those that are actuated by water pressure are called hydrostatic fuzes. Some of our depth charges have fuzes preset to actuate at a certain depth, where the preset pressure is reached. Another type is actuated by the variations in pressure in the ocean caused by the passing of a ship or submarine. They must be so designed that they will not be set off by the natural movement of the waves.

Fuzes that are actuated by air (barometric) pressure might be used against stationary ground targets. As barometric pressure over different parts of the earth is subject to frequent change, it is difficult to use a preset altitude (or barometric pressure) as the triggering quantity for a guided missile whose target may be a considerable distance from its launching point. Polaris is one missile that is detonated at a preset height above the target, with the fuze activated by the barometric pressure.

Fuzes acted upon by the surrounding medium (air or water) are also called ambient fuzes. Proximity fuzes which respond to changes in pressure generally lack the sensitivity and reliability required for guided missile applications, but in some cases they are useful against surface targets.

ACOUSTIC FUZES. - These are actuated by sound waves from the target. They must react only to specific sounds, not to all sounds. The problems of the acoustic proximity fuze were studied by the Germans at Peenemunde to determine the characteristics of these devices in supersonic missiles. Their wind-tunnel experiments proved that sound waves can be received readily by missiles traveling at speeds in excess of sound velocity. The acoustic fuze has the valuable property of all-weather, day-or-night effectiveness; but it also has the disadvantage that it is subject to local vibration and noises generated within the vehicle as well as to the sound waves by which it senses the target. The need for sensitive but selective acoustic fuzes is one of the reasons for the Navy studies on sounds made by fish and sea mammals. Acoustical sensors are still used to activate mines and torpedoes.

PHOTOELECTRIC FUZES. - Photoelectric fuzes react to external light sources, and ordinarily they are inoperable at night or in conditions of low visibility.

ELECTROSTATIC FUZES. - The Germans also investigated the possibilities of the electrostatic system of fuzing in which the detonating influence is the electric field of the target. Attempts to develop the fuze were unsuccessful - probably because of the variable nature of the electrostatic field surrounding possible targets, Air targets become electrostatically charged as they pass through the air, but water vapor or rain dissipates much of the charge, which poses a problem for the fuze. Electrostatic fuzing has application over short distances.

MAGNETOSTATIC FUZING. - Magnetic sensors measure changes in the earth's magnetic field or the presence of a source of magnetic flux. The magnetic field of the earth at any given point remains practically the same unless disturbed by some other force. Any steel ship has a permanent magnetic field of its own, peculiar of itself. Such a ship passing over a magnetic mine would detonate it. Degaussing or deperming was made a requirement for all Navy ships to reduce losses from mines. These processes remove much but not all of the magnetic charge of a ship, Magnetostatic fuzing is being developed for use in missiles. Equipment to measure the intensity of the earth's magnetic field at a point or in a reference frame is still in the developmental stage. It would be used with the guidance system.

Of these various types of proximity fuzes, the radio system appears to be the most reliable and effective for missile applications. Future developments may change this.

SAFING AND ARMING (S&A) DEVICES

Each fuze has a safing and arming (S&A) device to control the detonation of the payload so that there will not be a premature detonation, or a dud. The safety devices included in the S&A must prevent accidental activation, so the missile can be transported, stored, handled, tested, and launched. The purpose of the primary safety mechanism is to prevent accidental activation. The secondary safety device must overcome countermeasures and false signals and permit activation only upon receipt of the specified signal. The increase in enemy countermeasures has made this more complex.

Since the arming device is actuated by a specific signal, such as radar waves from a target, the countermeasure may supply a false signal by a decoy or some other method to deceive the arming device. The safety device must prevent arming by the false signal. This is a complex problem that requires constant study. To increase the chances of detonation at the best time and place, the weapon designer may put in duplicate systems (redundancy), or he may put in two types of fuzes so that if one fails there is another to take over.

PYROTECHNICS

PYROTECHNICS is a Greek word for fireworks. The Navy uses fireworks not for celebration, but for illumination, screening, marking, and signaling. An example is the illuminating projectile or star shell (SS) used to illuminate targets for gunfire. This is actually a pyrotechnic device, even though it is encased in a projectile body of standard external shape, and is fired from a standard rifled gun.

In the following sections we shall take up pyrotechnics launched by hand or from special projectors, or simply held by hand. All the pyrotechnics we shall study here are intended for signaling.

The Navy issues pyrotechnics not only for use aboard its surface combat ships, but also for use by aircraft, submarines, motor torpedo boats, and merchant ships, as well as for use ashore. However, we can here discuss only those issued as ship's pyrotechnics. For the others, see OP 2213 (second revision) Pyrotechnic, Screening, and Marking Devices.

The pyrotechnic units we shall take up are-

1. Markers, location, marine
2. Signal lights, and the pyrotechnic pistols and projectors used in firing them
3. Distress and hand signals
4. Navy lights
5. Flash signals
6. Smoke and flare markers

MARKERS, LOCATION, MARINE

Markers, location, marine (formerly called Depth Charge Markers) are of two general types - those for day use (Mk 1 Mod 3) and those for night use (Mk 2). The marker for daytime use spreads a patch of chrome yellow dye on the water; the night type burns with a yellow flame for 45 to 55 minutes. Both types are used to indicate the point of discharge of depth charge barrages and to provide a reference point for further antisubmarine attack. (A Mk 1 Mod 2 marker, still occasionally used, has green dye. It should be used only for practice sessions since green is the distress signal used to mark downed aircraft in search and rescue operations at sea.)

The Marker, Location, Marine Mk 1 Mod 3 (fig. 10-7) is a cylindrical waterproofed container about 12 inches long and 3.5 inches in diameter. When you pull the ring attached to the safety pin and release the safety lever, the primer ignites the time fuze. Fifteen seconds later the black-powder charge bursts the two dye containers and scatters the dye. The marker is dropped about 25 yards from the actual point where the depth charge itself was launched, so that the depth charge's "boil" when it bursts will not dissipate the slick of dye. Never pull the pin until the marker is to be launched. After the pin is pulled, keep the safety lever firmly against the marker body until it actually leaves your hand.

WARNING: If the marker is accidentally dropped after the pin has been pulled, clear the area. Don't try to retrieve the marker and make it safe again; it cannot be done.

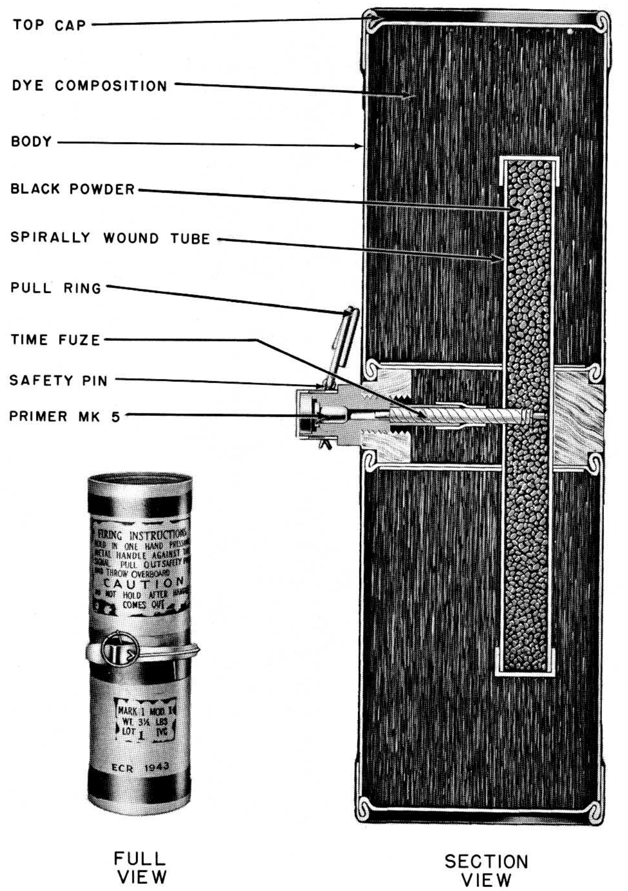


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Figure 10-7.—Marker, location, marine Mk 1 Mod 3 (day).

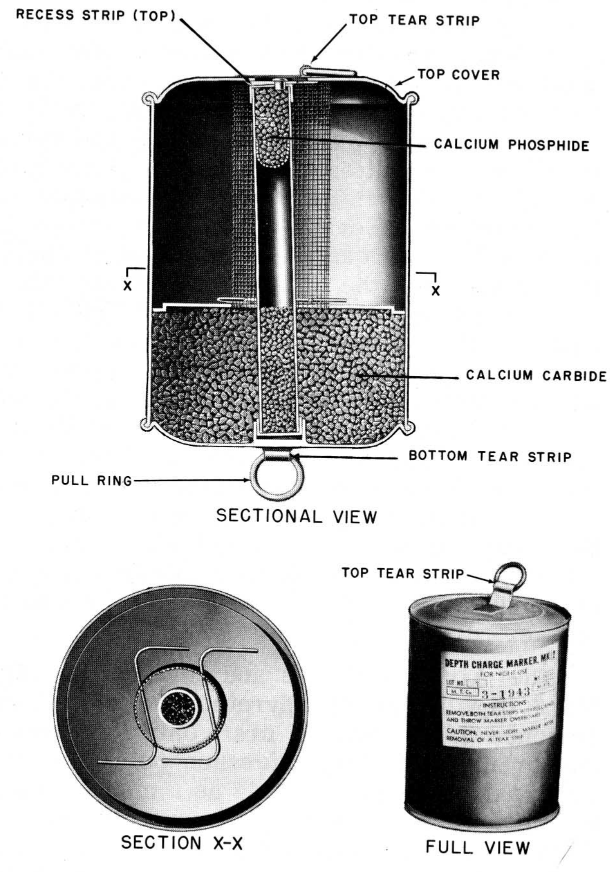

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Figure 10-8.—Marker, location, marine Mk 2 (night).

If exposed to moisture, the dye in the marker cakes and doesn't spread very well in the water. The markers should, therefore, be kept dry. Markers, location, marine can also be launched from aircraft.

The Mk 2 (night) marker is a sealed metal cylinder 7 inches high and 5 inches in diameter, shown in figure 10-8. It contains two chemicals. One of them is calcium carbide, used back in the horse-and-buggy days for carriage lamps. When wet, calcium carbide gives off acetylene, a gas that smells bad but burns well. The other chemical (calcium phosphide), when wet, gives off a gas that ignites by itself, without help from matches, ignition charges, or the like. This ignites the acetylene, which burns with a white flame.

To operate the marker, pull the rings on the marker to open the holes which allow water to get to the chemicals. Then throw the marker overboard, allowing a short time lag, so as to avoid the depth charge "boil." The flame should appear within no more than 90 seconds. Don't remove the tear-strip rings until ready to cast the marker overboard. Never handle or carry the markers by their tear-strip rings.

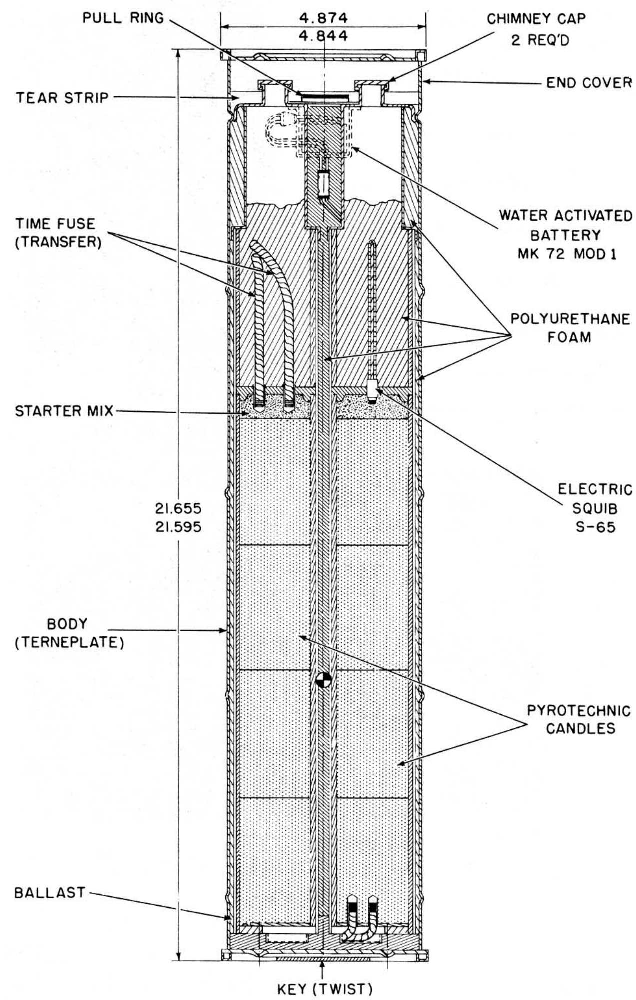
The Mk 2 (night) marker should be inspected while in stowage for damaged tear strips. Markers with damaged strips should be disposed of immediately as unserviceable.

This marker may also be launched by hand from aircraft at altitudes up to 3000 feet.

SMOKE AND FLARE MARKERS

For night or day reference marking on the ocean's surface, Marker, Location, Marine Mk

58 Mod 0 is used chiefly by aircraft patrols in ASW but also is used for search and rescue operations, man-overboard marking, and similar applications. It can also be dropped over the side from surface ships. It is approximately 21 1/2 inches long and weights about 12 3/4 pounds. It contains a battery that is activated by sea water, an electric squib, some starter mix, two pyrotechnic candles, and a transfer fuse between the two candles. Before launching, the tear tapes over the water port must be removed so that the sea water can enter to activate the battery. The battery current then energizes the electric squib which ignites the starter mix, which in turn lights the pyrotechnic candle. When the first candle has burned out, in about 20 minutes, the second candle is started by the transfer fuse. Figure 10-9 illustrates this marker. Several other types of markers are in use, but the present modifications require launching from aircraft to provide the force needed to rupture the dye marker or to activate the smoke and fire marker.



83.189
Figure 10-9. — Cross-section view of Marker, location, marine Mk 58 Mod 0.

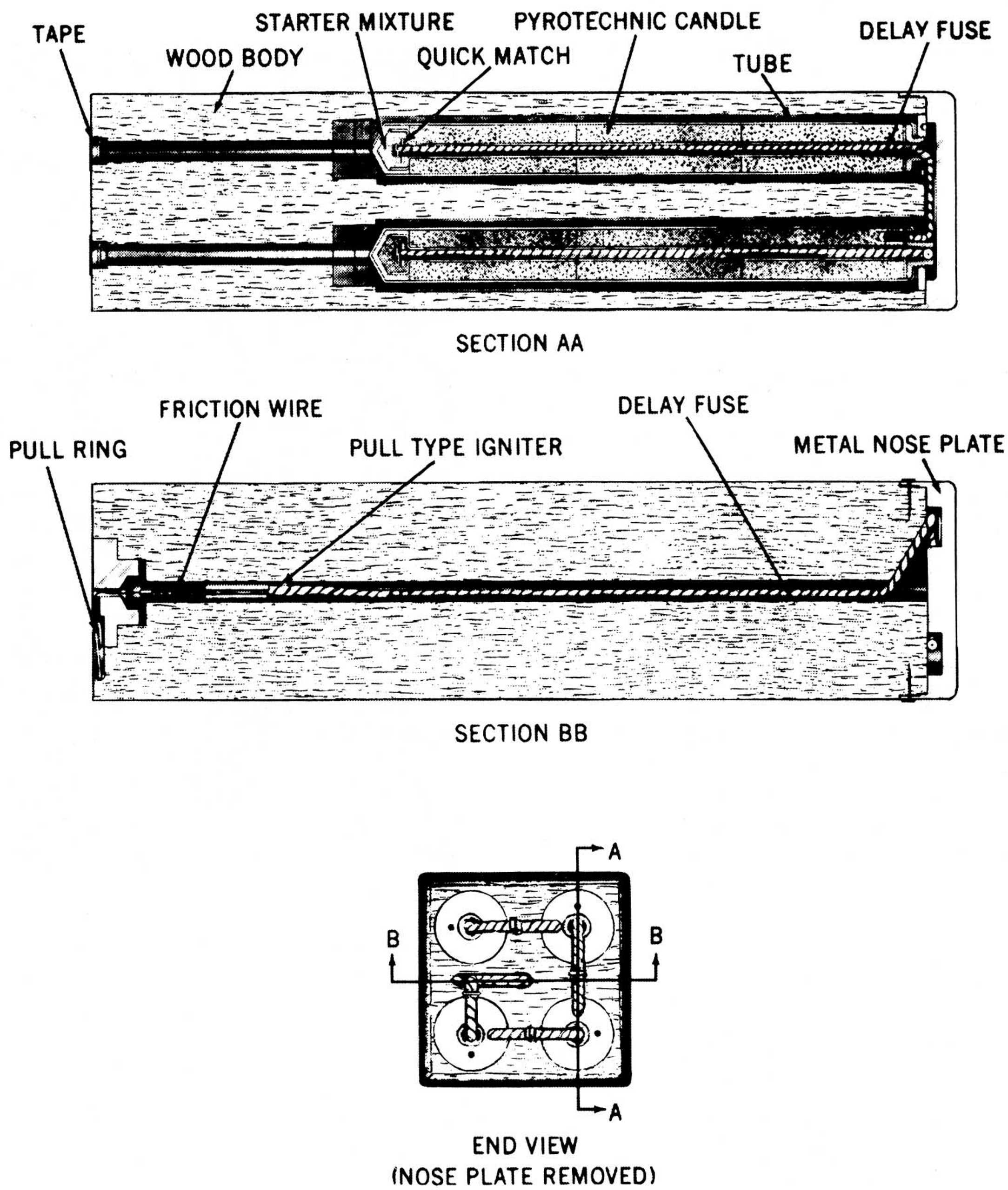
The Aircraft Smoke and Illumination Signal Mk 6 (fig. 10-10) is a pyrotechnic device that is launched from surface craft only to produce a 4 day or night floating reference point. One of its ~ principal particular uses is as a man-overboard ~ marker. It was previously approved for launching from low performance aircraft as a long-burning marker but has been superseded for these purposes by Marine Location Marker Mk 58.

This device consists of a wooden body with a flat, die-cast metal plate affixed to one end to protect it from water impact damage and to maintain it in the correct floating attitude. There are four flame and smoke emission holes in the opposite end, each capped and sealed with tape. The pull wire ring, also at the emission end, is likewise covered with tape.

The Mk 6 signal has a direct-firing ignition system. Ignition results from pulling the pull ring. The pull ring is pulled by hand, and the device is thrown into the water immediately. The pull wire ignites a 90-second delay fuze which ignites the quickmatch at the top of the first of four candles. The quickmatch ignites the first candle starting mix which, in turn, initiates burning of that candle. Expanding gases of combustion force the cap and tape from the emission hole, allowing smoke and flame to be emitted. When the first candle is nearly burned out, a transfer fuze carries the ignition to the quickmatch of the next candle in series. This process continues until all four candles have burned. The yellow flame and gray-white smoke are produced for a minimum of 40 minutes.

After the tear strip on the shipping container has been removed, the following rules shall apply:

1. The tape over the pull ring shall not be disturbed until immediately before hand launching the signal. This tape not only prevents an accidental pull on the pull ring, but also protects the igniter assembly from moisture which might render the signal useless.



83.203

Figure 10-10. — Aircraft smoke and illumination signal Mk 6.

WARNING: This signal is initiated by the physical movement of a friction wire through ignition compound. Extreme care must be taken to prevent tension on the pull ring during all handling operation.

2. If this device is prepared for launching and is not launched, the pull ring must be securely retaped into position at the top of the signal without exerting any pulling force on the pull-wire igniter.

3. Under no circumstances shall these signals be stowed or restowed with their pull rings exposed or with any wires, strings, or other material of any kind joined to their pull rings.

All safety precautions pertaining to this signal shall be observed. In addition, the following specific rules apply:

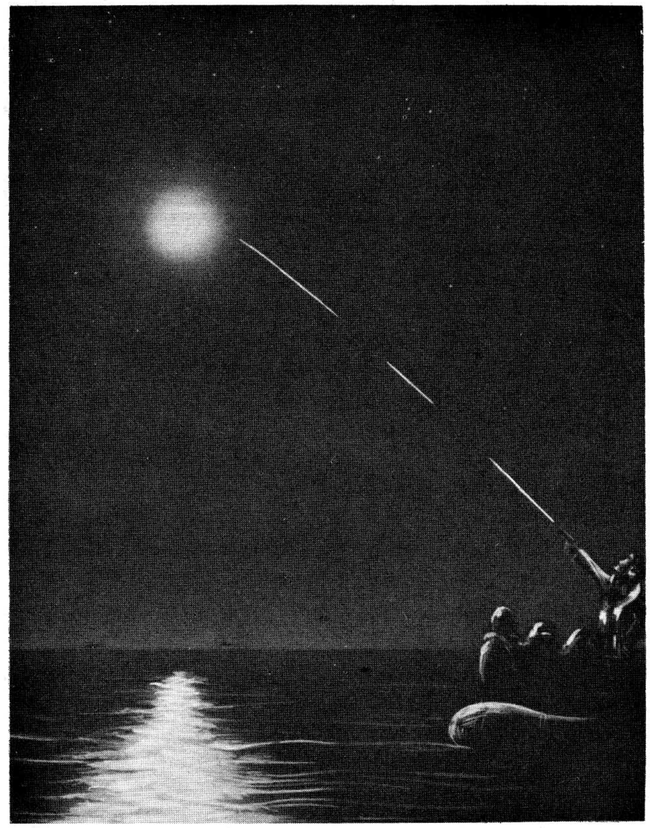
1. Do not remove the tape over the pull ring until immediately before launching.

2. The Mk 6 signal must be thrown over the side immediately after pulling the pull ring. This device contains a maximum 90-second delay element between initiation and candle ignition.

3. In all handling, extreme care must be taken to avoid pulling on the pull ring. Any slightest movement of the friction igniter may start the ignition train.

SIGNAL LIGHTS

Signal lights, often called Very lights (not because they are very light. but because that is what they were called by the French. who originated them), are similar to standard shotgun cartridges in appearance. When fired from the proper pistol or projector, a burning star (somewhat like a star from a Roman candle) shoots high into the air, as shown in figure 10-11. The one shown also has a tracer.



83.109
Figure 10-11.—Signal light with tracer, fired from a pyrotechnic pistol.

The Mk 2 signal light is available in three colors - RED, GREEN, and WHITE. Each cartridge has a percussion primer and a propelling or expelling charge of ten grains of black powder, which projects the burning star to a height of about 200 feet. The star charge is a tightly packed cylinder wrapped with a quick match (a fast-burning fuse), which ignites it when fired. The star charge is separated from the expelling charge by a shock-absorbing wad of hard felt. The cartridge is closed by a wad which is marked so that the color of the star can be determined by feeling it, as shown in figure 10-12, so the correct shell can be selected in the dark.

The RED star may be identified by its corrugated closing wad, the GREEN star has a smooth closing wad, and the WHITE star has a small conical boss on its closing wad. Each of the three colors may also be identified by the corresponding color of the paper on the cartridge.

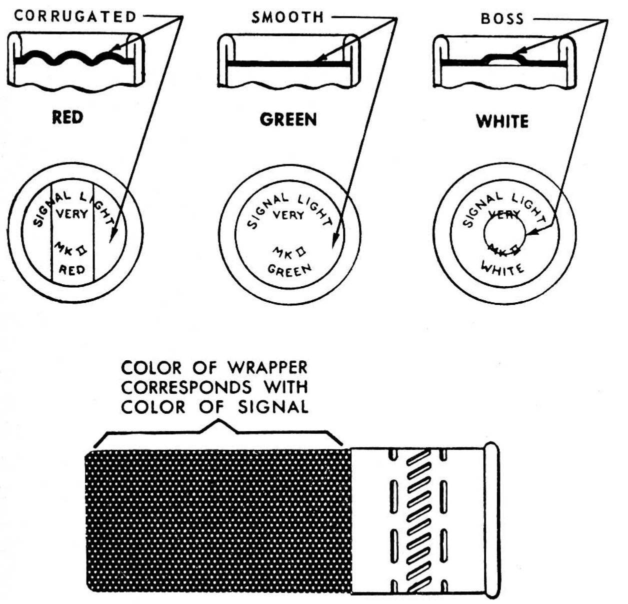
The burning time for each of the stars is approximately 6 seconds.

The lights are available in combination kits known as Service Box, Signal Pistol Mk 5; and Reserve Box. Signal Pistol Mk 5. Unless packed in kits, signal lights are packed in a metal can in units of ten; and 100 cans, or 1,000 signals, are packed in a wooden case for shipment purposes.

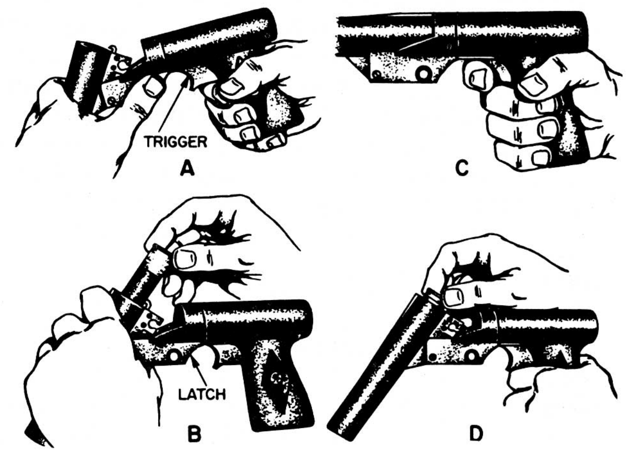
Signal pistol Mk 5, for firing signal light Mk 2, is a single-barrel, breech-loading pistol, 11 inches long. Metal parts are mounted on a plastic frame. A cartridge belt (Mk 1) and holster are issued for use with the pistol. Figure 10-13 shows how to use the pistol.

1. To load the pistol, depress the latch button below the barrel. At the same time pull the barrel downward, as in part A of the figure. Then insert the signal light shell (as in part B of the figure). Push the barrel upward again until it latches closed. The pistol is now ready to fire.

2. To fire the pistol, aim it upward at the desired angle, but clear of other ships or personnel. Pull the trigger, as shown in figure 10-13C. Keep your elbow slightly bent when firing, to absorb the shock of recoil without having the pistol knock itself out of your hand.



83.110
Figure 10-12.—Markings on Signal light Mk 2 Mod 0 (Very light).



83.111
Figure 10-13.—Operation of Signal Pistol Mk 5: A. Depress latch and pull down barrel; B. Insert Signal Light Mk 2; C. Barrel latched closed, finger on trigger; D. After firing, open pistol and extract shell.

3. To extract the expended shell, break the pistol open again as in step 1, and pull it out of the chamber, as in figure 10-13D.

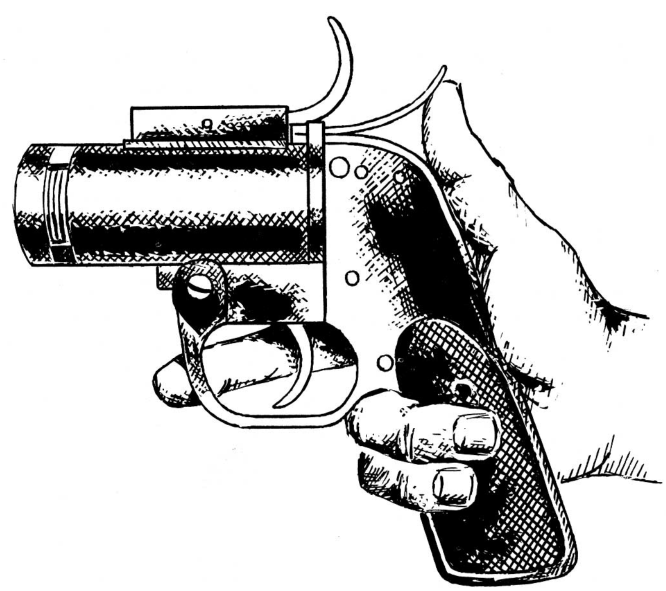
Signal pistol Mk 5 must be kept in serviceable condition at all times. Clean it thoroughly after each time it is used. Wipe down all parts with a cloth impregnated with light machine oil. After assembly, wipe the exposed parts with a dry cloth. Swab the barrel with a cloth dampened with acetone or other solvent to remove powder residue.

While loading, firing, or unloading a pyrotechnic pistol, care must be taken to avoid pointing the muzzle in the direction of the users body, other personnel or vessels.

If a pyrotechnic pistol is loaded and not fired, it must be unloaded immediately because it has no positive safety features. The pistol is always cocked as long as the breech is closed.

Pyrotechnic Pistol AN-M8

A pistol similar to the Mk 5 signal pistol is Pyrotechnic Pistol AN-M8 (fig. 10-14). It can be used with a number of signal lights of shotgun-shell shape. Some of these shells



83.190
Figure 10-14.—Pyrotechnic Pistol M8; tripping breech lock.

have paper cases and some have aluminum cases. Aircraft Red Star Parachute Signal M11 is fired only to denote aircraft distress, but the other signals that can be fired from Pyrotechnic Pistol AN-M8 are used for signal and identification purposes, and may be fired from aircraft or surface ships. The use of the different colors of signals was outlined in the text Seaman, NavPers 10120-E, particularly with regard to their use in lifeboats.

DISTRESS SIGNALS

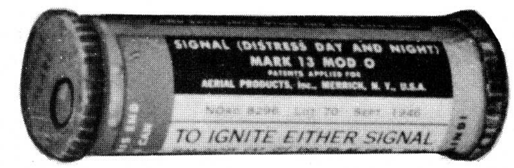
There is something Biblical about the distress signal Mk 13 Mod O. Like the famous pyre in EXODUS, it provides by day a pillar of smoke, and by night a fiery light. It's mighty comforting to have in a life raft or life vest. The signal kit in inflatable lifeboats has 12 of these signals.

The Mk 13 Mod 0 signal (fig. 10-15) is a metal cylinder about 5 1/8 inches long and 1 5/8 inches in diameter. It weights between 6 and 7 ounces. One end contains a canister which, when ignited, produces orange smoke for about 18 seconds. The other end contains a pyrotechnic flare pellet which will burn 18 to 20 seconds.

Each end of the metal tube is enclosed by a soldered cap with a pull ring through which you can put your finger. When you pull the cap loose, a brass wire attached to its inside surface moves through a cap coated with a composition that ignites by friction, setting off either the flare or the smoke canister (depending on which ring you pull). The metal caps of the signal are covered with paper when issued; you must remove the paper before the pull rings are accessible.

The signal body carries illustrated instructions for use. The flare end has embossed projections extending around the case to identify it as the right end to use at night. When you use the signal, point it away from the face and hold it at arm's length at a 30° angle after it ignites. After one end of the signal has been used, douse the signal to cool the metal parts. Keep it so that the other end can be used if necessary. Each end is separately insulated and waterproofed. Never try to use both ends at once. When using the smoke signal, keep it to leeward.

These signals are shipped in wooden boxes containing 100 units, and are also available in metal cans containing four units, for stowage in life boats, floater nets, etc. Avoid rough handling. Stow in a cool, dry place, in accordance with standard pyrotechnic stowage rules.



3.246
Figure 10-15.—Distress Signal Mk 13 Mod 0.

Signal, Illumination, Marine AN-M75 is an emergency rescue signal small enough to be carried in the pockets of life vests or flight suits and on liferafts. It contains two pyrotechnic stars that are projected by ejection charges. The igniter assembly is thrown about 10 feet from the signal, and the first delay charge is ignited. This ignites the expelling charge for the first star. After ignition, the first star burns 4 to 6 seconds. The used signal (or one that fails to fire) should be thrown overboard.

NAVY LIGHTS

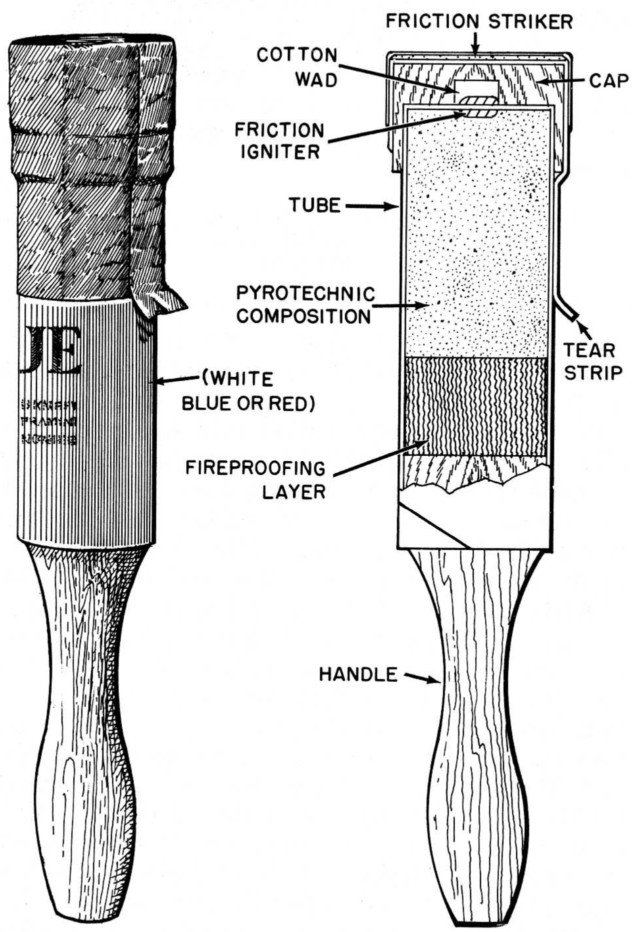
Navy lights are hand torches which burn with a brilliant light visible at night up to 3 miles away. They come in three colors; blue, white, and red. Navy blue light Mk l Mod l burns between 60 and 90 seconds; Navy red light Mk 1 Mod 0 burns between 150 and 180 seconds, and Navy white light Mk 1 Mod 2 burns 60 to 70 seconds. The three lights are similar in appearance and construction (fig. 10-16).

Navy lights consist of a paper tube, which contains the pyrotechnic substance, with a wooden handle at one end, and at the other end a cover with an exterior coating of abrasive like that on the scratching side of a safety match box. A tear strip protects the cover's exterior.

The upper end of the paper tube, beneath the cover, is capped by a fabric impregnated with igniting compound similar to that on the head of a safety match.

To ignite the Navy light, tear off the protective strip, remove the cover, and scrape the inverted cover across the top of the paper tube. When you do this, it's advisable to hold the light pointing AWAY from you at an angle of about 45°, to avoid contact with hot particles falling off the pyrotechnic candle. Hold the light at that angle throughout the burning.

Navy lights Mk 1 Mods 0, 1 and 2 are shipped in metal containers with 6 or 12 lights packed in



83.112
Figure 10-16.—Navy lights.

each, and enclosed in cardboard cartons holding 12 boxes (72 to 144 lights). Navy blue light Mk 1 Mod 1 is also shipped as part of the Reserve Box, Signal Pistol Mk 5. These lights deteriorate when exposed to moisture. Do not remove them from their containers until ready for use. For the same reason, keep them away from water or moisture. Lights which have been left in open containers for more than 6 months should be turned back to the nearest ammunition depot or magazine at the earliest opportunity. Lights which have become chemically encrusted, or which give off an acetic acid (vinegar) odor, should be immediately disposed of. Put them in a weighted sack and dump them overboard in 500 fathoms of water and 10 miles from shore. Note the following SAFETY PRECAUTIONS in the use of Navy lights:

1. Select carefully the place at which the lights will be burned, because burning particles dropping from the lighted candles can start fires.
2. Always hold the light up at an angle of 45° and point it to leeward while it's burning.

It must be remembered that all pyrotechnic and screening devices, while designed and tested to be safe under normal conditions, are subject to accidental ignition because of a wide variety of circumstances. The general rule to follow is: "Be constantly aware that pyrotechnics contain chemical components that are intended to burn with intense heat, and act accordingly."

FLASH SIGNALS

Missile targets used in training are expensive. To prevent destroying a practice target, an exercise head is put in a missile in place of a warhead. Since we want to know if an exercise missile has approached within lethal range of a target, flash signals are installed in the exercise head. These signals contain pyrotechnic material. When the material is ignited it produces puffs of smoke, and you get a visual indication that the missile has passed close by the target. The flash signal contains a primer and some flash powder. At intercept, an electrical impulse from the fuze ignites the primer, which fires pyrotechnic material (black powder and coated magnesium powder).

STOWAGE OF PYROTECHNICS

The dangerous nature of pyrotechnics was appallingly demonstrated by the catastrophic fire on the USS Oriskany, which started from a pyrotechnic flare, dropped in handling.

The extreme sensitivity of pyrotechnic material makes it mandatory to store it in special pyrotechnic lockers away from other ammunition. Pyrotechnics are, in general, a fire hazard. Many of them deteriorate under high or variable temperatures. Some are badly affected by moisture. The storage place must be dry, well ventilated, not subject to direct rays of the sun or other heat source, and must have firefighting equipment handy. Since many pyrotechnic items can be set off by a blow, they must be handled with great care. Be very careful not to bump or drop them; remember the Oriskany. Flash signals and flares can be set off by electromagnetic radiation. They must not be exposed in line with radars or other sources of electromagnetic radiation. (The radiation is also harmful to you; see chapter 12.) Missiles are not stored with the flash signals in them. The flash signals must be installed just before the missile is to be used for practice, and if not expended, must be removed before the missile is returned to the magazine. The men who do this work must be instructed in the precautions necessary. See OP 4, Ammunition Afloat, Volume 2, (second revision). (Flash signals are restricted to research and development use.)

Pyrotechnic and screening devices are normally equipped with some type of safety pin, lock, or tape that is designed to prevent accidental activation of the initiation mechanism. Such equipment must not be tampered with, struck, bent, or otherwise damaged or removed until immediately before it is intended to launch the device. Any devices that show signs of damage to safety features are considered unserviceable and must be carefully segregated for prompt disposition in accordance with current instructions.

If a pyrotechnic device should be accidentally ignited, its functioning will, in all cases, result in a fire hazard. In a confined area, the gases generated by this combustion could present a serious toxic hazard. Signaling devices containing propellant charges which are designed to propel the pyrotechnic candle into the air create an extremely dangerous missile hazard if they are accidentally ignited. Pyrotechnic compositions characteristically contain their own oxidants and therefore do not depend on atmospheric oxygen for combustion. For this reason, the exclusion of air, by whatever means, from a pyrotechnic fire is usually ineffective. Many pyrotechnic mixtures" particularly illuminating flare compositions, burn with intense heat (up to 4500°F). Normally available extinguishers are of little or no value in fires of this kind. Carbon dioxide extinguishers, in addition to being ineffective, are potential sources of danger in that they tend to produce oxygen which supports combustion. Foam type extinguishers are equally ineffective because they work on the exclusion-of-air principle. It is recommended, therefore, that water, in flooding quantities and at low pressure, be used to cool the surrounding area and thus prevent spread of the fire.

Pyrotechnics that are activated by water, such as markers, location, marine, must not be stowed in compartments where there are sprinkler systems. Do not fight fires in them with water.

As most pyrotechnics deteriorate with age, the oldest ones should be stowed nearest the front of the locker so that they will be used first.

APPLICATION OF EXPLOSIVES IN RIM

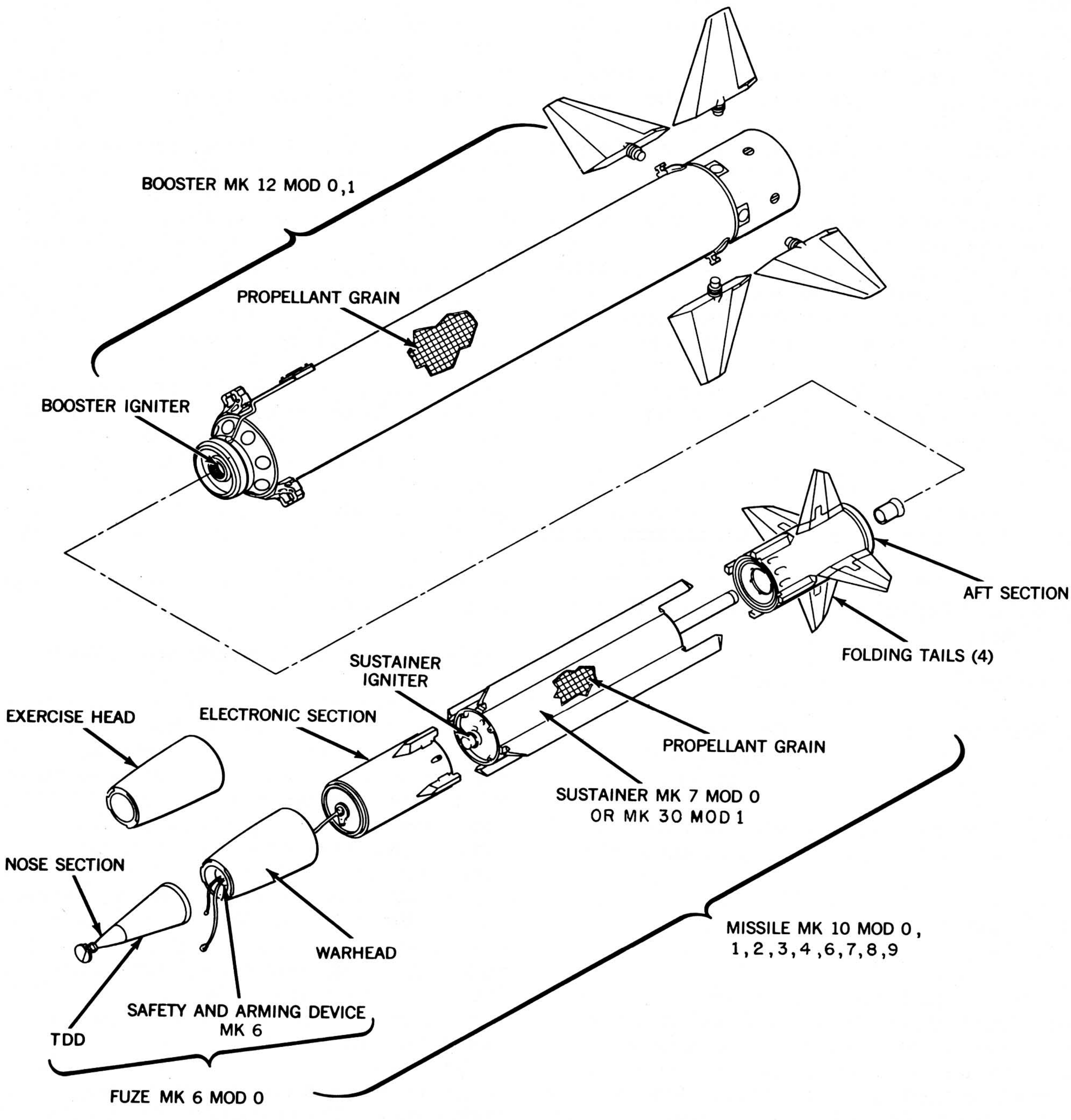
So far in this chapter we have discussed the "raw materials" used in explosives. Also we have covered, in a general way, types of warheads and fuzes. With this background, we can turn our attention to specific applications of explosives in missile components. Figure 10-17 shows a breakdown by sections of the TERRIER BT-3 missile round. The complete round is designated as Mk 2, and is made up of Guided Missile Mk 10 Mods 0,1, or 2 mated with booster Mk 12. The numbers of the round, sustainer, and missile used with improved versions of the BT-3 missile (BT-3A, and BT-3B) are indicated on the illustration, but the basic outlines of components are not changed. The HT-3 and HT-3A use the same booster and sustainer but have a different missile, which is not indicated on the illustration. One of the big differences not shown in figure 10-17 is the fact that the BT-3A and BT-3B can carry a nuclear warhead. Because the BT-3 and its later versions are widely used in the fleet, we are using it as a study example. Other TERRIER types, TARTAR, TALOS, and STANDARD missiles contain functionally similar components; so what you learn here also applies to these missiles.

MISSILE SECTIONS AND THEIR EXPLOSIVES

The BT-3 is composed of six sections:

1. Nose section
2. Fuze section
3. Warhead section
4. Electronic section
5. Sustainer section
6. After section

Explosives are used in all sections except the nose and electronic sections. The fuze section



83.113
Figure 10-17.—Location of explosives in Terrier BT-3 (and modifications) missile rounds.

contains the Target Detecting Device (TDD for short). Inside the warhead is the Safety Arming Device (more frequently called the depth charge S&A device). The S&A device is electrically connected to the TDD. These two units make up the fuze. As you learned earlier, the sustainer contains the propellant that keeps the missile flying after booster burnout. The aft section contains two gas generators. One generator drives a hydraulic pump which provides hydraulic power for the steering control system. The other generator drives an electrical alternator which provides electrical power to electrical and electronic circuits in the missile.

Table 10-1 lists some of the explosives, propellants, and pyrotechnics in the principal hazardous units of the BT-3. We have not listed all the hazardous units but just enough of them are mentioned to show the application of the . basic explosive compounds you studied earlier in this chapter. For a complete list, look in the OP for the missile weapon system on your ship. One volume is devoted to general and specific safety precautions applicable to missile components. Here you will find a table which lists all the hazardous components in the missile of interest and the type of explosive in each component. pyrotechnic magnesium powder

Table 10-1.—Explosive, Propellant, and Pyrotechnic Material of BT-3 Round.

ITEM	DESCRIPTION
1. Warhead explosive charge	Composition B
2. Fuze booster	CH-6
3. Sustainer igniter	Composition B—KNO_3 (potassium nitrate)
4. Flash signal pyrotechnic	Black powder and magnesium powder

BT-3 FLIGHT TERMINATION SYSTEM

Before we leave the subject of explosives, we should discuss in more detail warheads and fuzes. Earlier we discussed the many types of warheads and fuzes, but now let's look at a specific application for them. The BT-3 is still a good representative example, so we'll stick with it. Other missile warhead systems are similar to the BT-3s. They differ only in detail.

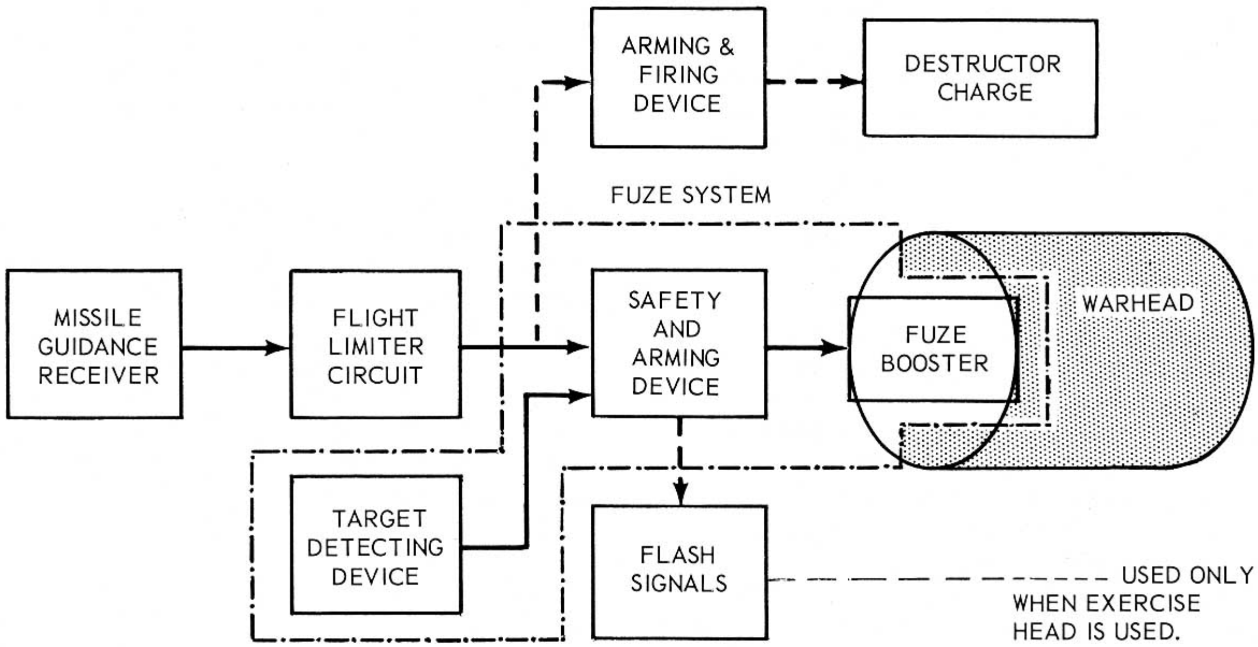
Flight Termination with a Warhead

A warhead system consists of a warhead and a fuze. The warhead system is only part of a larger system called the Flight Termination System. As its name implies, the purpose of the flight termination system is to end a missile's flight. And it usually does, with a big bang. When the missile intercepts the target, a firing pulse from the fuze sets off the warhead. Also, should the flight of the missile become uncontrolled for any reason, a firing pulse from the flight limiter circuit will detonate the warhead. Figure 10-18 shows a block diagram of the flight termination system. In the diagram you will find the two units - flight limiter and fuze - that start the action to detonate the warhead. The flight limiter will send out a firing pulse if there is a failure in the missile receiver or missile power supply, or if the missile flies out of the beam. These are unplanned failures, but you can deliberately make similar failures occur. For instance, you can cut off guidance beam transmission at the radar. The missile does not see a beam and the flight limiter circuit senses a receiver failure. The warhead is subsequently detonated. You can see that essentially the flight limiter is a safety device. If a missile goes out of control, it will automatically destroy itself before it endangers your ship or others in the task force.

Flight Termination with an Exercise Head

The same principle applies if the missile is fitted with an exercise head instead of a warhead. An exercise head is used for missile flight evaluation. The exercise head contains telemetering equipment which sends information about the missile's performance back to the firing ship. This type head contains a small destructor charge. When this charge is detonated, the force from the charge blows out bits of the exercise head. These jagged edges of the exercise head left after the explosion make the missile aerodynamically unstable. The surface of the missile is no longer streamlined, and the missile is torn to pieces by the force of the air stream.

When the exercise head is used, the fuze firing pulse (at intercept) ignites two pyrotechnic flash signals. These signals are mounted in the exercise head and give visual indication of target interception. Sometime later the flight limiter circuit initiates the explosive train to detonate the destruct charge. This destructor charge in the exercise head is not the same as the self-destruct unit in the warhead which destroys the missile if it gets off course (or if for some other reason the missile will miss



83.114
Figure 10-18.— BT-3 flight termination system.

the target and must be destroyed). Some recoverable missiles have been designed for training use, and they represent a great saving. They are especially useful for antimissile target practice.

DISPOSING OF DAMAGED OR DEFECTIVE EXPLOSIVES

In the paragraphs above we talked about missiles destroying themselves, and you have read in the newspapers about destruction of the huge rockets used in satellite launching. Is it the fault of the explosive or of some part of the mechanism, electrical or electronic systems? Can the flaws be determined and corrected before launch? We will consider here only the possibilities with explosives.

You cannot test an explosive because to do so would destroy it. You can look at it, feel of it, smell it, but you cannot try it out. Your missiles come aboard with the explosives enclosed, so you cannot see the explosive nor feel it. Visual surveillance is all the inspection you can give it. Examine the exterior of the rocket motor, the sustainer, and the warhead for any signs of exudates or corrosion. Also take note of any dents or breaks in the container. A dented component may have to be returned to the depot. With care, corrosion, if not too deep, can be removed. The removal of exudates is more of a problem. Low grades of TNT exude a dark oily substance that is highly flammable. It is much more sensitive than the TNT itself, especially if it is absorbed by wood, rags, or other cellulose material.

Since most of the TNT now used in explosives is high grade, there is little likelihood of exudates. If you find any, carefully collect a sample to be sent to the U.S. Naval Ordnance Station, Indian Head, Maryland, for analysis. Use a wooden spatula to scrape up your sample; scraping with metal can cause an explosion. Exudate can be washed off with acetone or alcohol, but IN NO CASE should soap, washing compound, or other alkaline substance be used. In the meantime, separate the components in question from other explosives until you receive word about what to do with them.

The solid propellants used for rocket motors and sustainers in missiles are as stable as smokeless powder or more so. No tests are authorized for shipboard use. Proper stowage conditions, careful handling, and visual inspection are required. If a case has been punctured or severely dented, or has been dropped (specified in the OP; usually over 5 feet), it shall not be used but must be returned to the depot. If it is considered too unsafe to hold until it can be shipped it should be dumped in deep water without delay, or segregated until safe disposal is possible. A warhead that shows signs of physical damage or corrosion should be returned to the depot. If an exercise head is accidentally dropped, it should be sent to the depot.

Very Sensitive Explosive Components

Fuzes, S&A devices, and pyrotechnics are more sensitive than propellants. A fuze or an S&A device that has been dropped from a height of over 5 feet shall not be used; return it to the depot with a written explanation of what happened. If a fuze or an S&A device becomes armed, it must be dropped in deep water (over 500 fathoms deep and at least 10 miles from shore).

Any pyrotechnic material that appears damp or deteriorated must not be returned to the locker but must be expended as soon as possible by dumping in deep water or by returning it to the depot. You remember that we covered pyrotechnics that may not contact water. Smoke- making devices that have been in the water or have misfired may not be taken on the ship.

Signals with cracked bodies, bent fins, deformed tail tubes, or with any other visual defect that might make them unserviceable must be discarded for disposal, either by deep water submergence or return to depot. Do not attempt to disassemble or repair faulty signals.

MAGAZINES

The term "magazine" applies to any compartment, space or locker which is used, for the stowage of explosives or ammunition of any kind.

The term magazine area includes the compartments, spaces, or passages on board ship containing magazine entrances, which are intended to be used for the handling and passing of ammunition. The term is also used to denote areas adjacent to, or surrounding explosive stowages, including loaded ammunition lighters, trucks, and railroad cars, where applicable safety measures are required.

Since missile magazines are not common cargo or living space, but are used for storage of missile rounds, they are protected by their location in the ship, usually below the waterline. They are insulated against moisture and excessive heat. Besides, they are equipped with sprinklers for protection against fire and possible explosion, as well as for emergency cooling. Smothering equipment is provided to put out electrical and oil fires. And they may be equipped with heating and air-conditioning units to keep the spaces within certain temperature limits.

No matter how effectively the above systems work, the only way you can be sure of safe missile stowage is by routine effective inspection and maintenance of the magazines.

The magazine is intended for storage of live missile rounds and for the equipment used to handle them - and for these only. It is no place for empty paint or grease cans nor for stowing paint brushes, oily waste rags, or similar fire hazards. And what goes for material also goes for men. Nobody but those authorized should ever be admitted to a magazine. Even they should be there only when they have business there, a magazine is no place to sit around and "shoot the breeze."

Missile magazine maintenance is chiefly a matter of inspections, cleaning, sprinkler and smothering systems testing, and occasional painting, replacement of lights, fixtures, etc. Magazines are inspected daily; other magazine work is done in accordance with rules laid down by the weapons officer, and will vary from ship to ship.

MAGAZINE TEMPERATURE CHECKING

The main item of daily routine inspection is to check the most important and single factor that affects powder and propellant stability - the temperature - and record it.

To check the temperature, you need a thermometer, of course. But an ordinary thermometer won't be enough. Temperature readings are customarily taken in magazines only once a day. The common type of thermometer tells you what the temperature is at the time you read it. But what was it when you weren't around? You need a thermometer which can record the HIGHEST temperature reached up to the time the reading was taken.

You'll find on the magazine bulkhead, therefore, a MAXIMUM-MINIMUM THERMOMETER (fig. 10-19). This instrument is a U-shaped mercury-filled glass tube with two bulbs. It shows the extreme temperatures, both high and low, indicated since the thermometer was last ZEROED.

You read the PRESENT TEMPERATURE on the instrument by noting the level in either arm of the tube. (Both sides should read approximately the same.) The temperature recorded

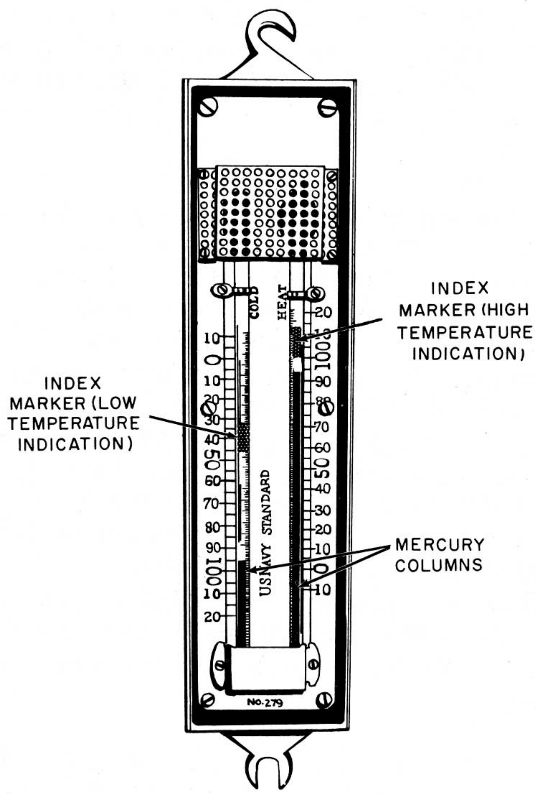


Figure 10-19.—Maximum-minimum thermometer. 5.65

in the pictured instrument is around 95°, which would call for some drastic action if it were actually on a magazine bulkhead.

You read the MAXIMUM TEMPERATURE by noting the level of the BOTTOM edge of the little steel index marker against the right-hand scale, which increases UPWARD. (The picture shows it at just over 100°, another excessive temperature for a magazine.)

You read the MINIMUM TEMPERATURE (here a little over 45° similarly, on the lefthand scale against the bottom edge of the little steel marker. The minimum scale increases DOWNWARD.

To zero the instrument, you run a little horseshoe magnet against the glass tube to draw each steel index marker down to the level of the mercury. Zero the thermometer on both sides AFTER you have recorded the maximum and minimum readings.

Magazines are usually equipped with two maximum-minimum thermometers - one in the coolest part of the magazine, and one in the warmest. Others may be used where it is considered necessary to have additional data on parts of the magazine that may get too warm-bulkheads near steam lines, for example.

RELATIVE HUMIDITY INDICATORS

Because many types of explosives are adversely affected by humidity, there must be some form of humidity control in the storing of guided missile explosive components. Many of the individual components, before assembly into the missile, are packaged in sealed containers in which there is a quantity of desiccant, usually silica gel, to absorb the moisture. Each container has a humidity indicator which changes color as the humidity increases. If the container has been properly sealed there should be no appreciable change. If there is no directive or instruction that specifies, your officer will decide whether to ret-urn the component to the depot or to repackage it. The OP for your missile prescribes the frequency of inspection (perhaps weekly), and gives instructions for replacing the desiccant.

The humidity of the magazine must also be checked regularly. One method is by use of a wet-bulb thermometer or psychrometer. The thermometers must be calibrated, and if properly used, they can give fairly accurate results.

ALARM AND SENSING DEVICES IN MISSILE MAGAZINES

Alarm systems are provided on most ships to indicate the presence of fires, overheated conditions in the magazine, or water leakage through the sprinkling system main control valve. The alarm indicator may be a buzzer, a light, or a small drop type enunciator. The water leakage alarm system is activated by a water switch on the dry side of the sprinkling system main (group) control valve.

Another type of alarm system used is actuated by heat. The alarm sounds when the temperature in an ammunition storage area rises to a danger point. Due to this warning, the temperature can be reduced before sprinkling becomes necessary.

A later development in alarm system now in use is the pry-a-larm. This system functions according to an entirely different principle: The trigger of the pry-a-larm detector is activated by minute particles of combustion. NOTE; Formation of combustion particles occurs in all types of fires and in smoldering or overheated materials. The small combustion particles are invisible, but they are usually present before there is any other evidence of fire; the larger particles are visible in the form of smoke.

However, most of the particles are too small to be seen by the naked eye.

The pry-a-larm system has several advantages which are as follows:

1. The system provides an early warning which permits safe evacuation from the damaged area and gives the damage control time to fight the fire while it is still small and controllable.
2. The system may be adjusted (calibrated), to ensure proper operation, regardless of its location onboard ship.
3. A standard two-wire circuit is used with the electrical circuit associated with the pry-a-larm system. Due to the low current used in the circuit, a thin-walled conduit can be used.
4. Any failure of wiring or of other essential parts is immediately indicated on a trouble board.

The most important part of the pry-a-larm warning system is the sensing element called the detector head. Basically, the detector head consists of two ionization chambers and a cold-cathode tube.

The specially designed cold-cathode tube is connected in parallel with two ionization chambers. The trigger-electrode of this tube is connected to the junction point of the two chambers. When combustible particles are present, the current in the outer chamber decreases, causing the voltage at the trigger-electrode of the tube to increase. The increased voltage on the trigger-electrode causes the tube to conduct sufficient current for operating the alarm system.

An automatically operated alarm system is tripped when the temperature reaches a preset degree, or, in another system, by the rate of rise of the temperature.

In some magazines the sprinkler system is turned on automatically when the temperature reaches a certain point. A pneumatic release pilot valve (PRP) opens the valve to the sprinkler pipes when the temperature reaches the critical point. The valves for electrical operation are motor operated, with hand-controlled or thermostatically controlled switches. If water-activated explosives have to be stowed in a magazine where there is a sprinkler system, the sprinkler system must be secured so there cannot be accidental sprinkling.

Testing Alarm Systems

On a periodic basis, sprinkling system alarm circuits should be tested. These tests involve checking the electrical continuity of the switch circuits. The leakage alarm (water switch) shown in figure 10-20 is activated by water, when water enters the switch housing the contacts of the switch are shorted and the alarm is energized. To test this type of switch proceed as follows:

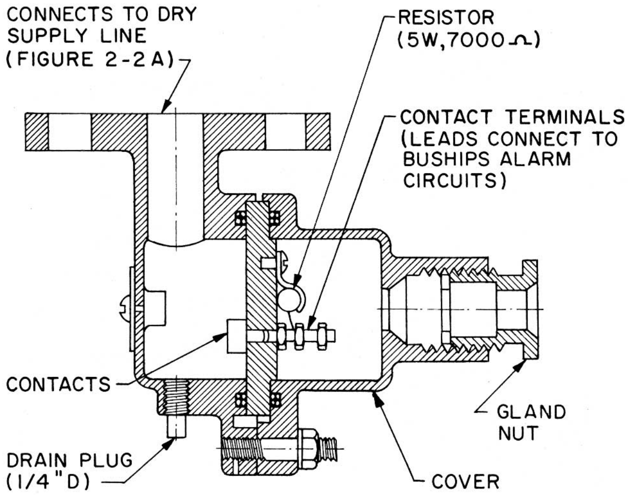
1. Notify all personnel concerned that a test of the alarm system is being conducted.
2. Obtain a bulb-type battery filler, and a small container in which to catch water.
3. Partly fill syringe with fresh water.
4. Remove drain plug on water switch (fig. 10-19) and place syringe stem flush against the drain opening. Slowly squeeze the syringe to force enough water into switch housing until the two contacts are shorted. This will energize the leakage alarm; the alarm should be located in the ship's damage control central.
5. When verification from D.C. central has been received that the alarm system is working properly, drain the switch housing and replace drain plug.

Moisture within the switch housing can cause the alarm system to be activated. Ensure that the water switch (leakage alarm) is completely dry after testing.

FIRE SUPPRESSION SYSTEMS

In the following discussions the Mk 13 launching system will be used as a representative example of fire suppression systems because the magazine contains three of the four systems we will describe. The fire suppression system in the missile magazine consists of two carbon dioxide systems, a sprinkling system, and a missile water injection system. Fire or extreme heat in either of the protected areas activates the associated carbon dioxide system, blanketing the equipment or missiles with carbon dioxide. The sprinkling system sprays seawater on all missiles in the magazine during a fire or extreme heat. This system activates only if the temperature continues to rise after the carbon dioxide system activates. The missile water injection system directs a stream of water into the rocket motor of any missile that inadvertently ignites in the magazine.

Three of the fire suppression systems described in this chapter activate automatically and all four are independent of each other. In addition, the carbon dioxide systems and the



84.331
Figure 10-20. — Sprinkling system water switch SIZ2.

sprinkling systems have independent controls for manual activation.

SPRINKLER SYSTEMS

The sprinkling system in the magazines below decks for the spare components is usually part of the sprinkling system that includes the ammunition magazines. The piping system technical manual or the damage control manual should be consulted for information on the specialized systems provided for missile spaces.

The sprinkling systems are supplied from the firemain. The efficiency of operation depends on maintaining full working pressure in the firemains and keeping the system free of debris. Marine growth can foul the firemains, particularly in tropical waters, where weekly flushing may be necessary. Acid cleaning of firemain piping is done at overhaul.

Magazine sprinkling systems consist of the following components: a gate (root) valve provided with a device (not a padlock) for securing it in the open position, a globe valve type sprinkling valve (normally closed), either a separate test casting or a testing feature incorporated in the sprinkling valve, a sprinkling alarm device (circuit FH), and the distribution piping in the form of a grid. The magazine group control valve may serve one or more magazines and may be located either in the handling room, in the adjacent passageway, or in one of the magazines. Whenever a group control valve serves more than one magazine, a stop valve and check valve or stop-lift-check valve is provided in each branch line. This prevents back flooding through the system in the event one of the magazines of the group becomes flooded as result of damage. The valve can also be used for isolating the sprinkling system in a particular magazine when desired. The stop-lift-check valves should be locked (not padlocked in the check position).

SPRINKLERS IN MISSILE MAGAZINES

As a typical example of the sprinkling systems installed in missile magazines (for the assembled rounds), the Mk 13 launching system, Guided Missile Magazine Mk 8 Mod 0, will be used. The system may be actuated automatically by one or more heat-sensing devices, or manually by local or remote controls. The sprinkler heads shower salt water spray down into the ready service area. The pneumatic release pilot (PRP) valve is connected by pneumatic lines to the heat-sensing devices (of which there are 12). Normal temperature variations do not cause the PRP valve to open, but a sudden rise in temperature will. When the sprinkling system is actuated, a sprinkling alarm sounds. If there is leakage into the dry supply line, a leakage alarm sounds. Figure 10-21 shows schematically some of the components of the sprinkler system in this magazine. The piping can deliver 10 gallons of water per minute to each sprinkler head, and the whole ready service area can be quickly saturated. Drains at the base drain off the water.

SALT WATER SPRINKLING SYSTEM

The main control valve in the salt water system shown in figure 10-22 functions similarly to the valve operated by hydraulic fluid used in most gun and turret sprinkling systems except that the salt water operated valve cannot be opened or closed mechanically. The water operated valve contains a sight tube that indicates the condition (open or closed) of the valve.

Note: On some ships the salt water system was installed without changing the main control valve.

A local control panel for a typical missile magazine sprinkling system mounts four manually operated valves: a manual control valve, a pressure cutoff valve, an automatic operation cutoff valve, and a pressure gage cutoff valve.

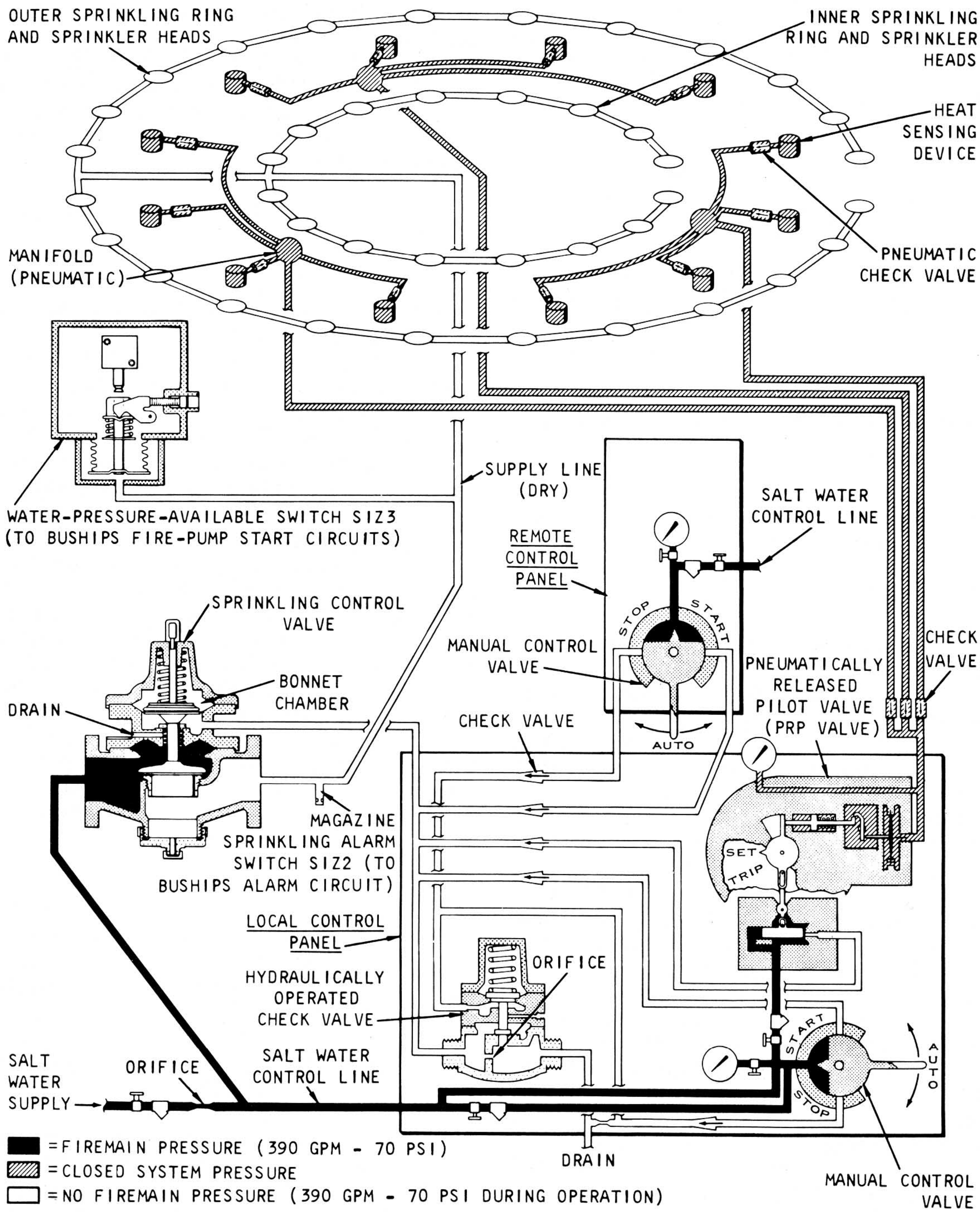


Figure 10-21.—Sprinkler system operation (schematic), Guided Missile Magazine Mk 8 Mod 0. Launching System Mk 13 Mod 0.

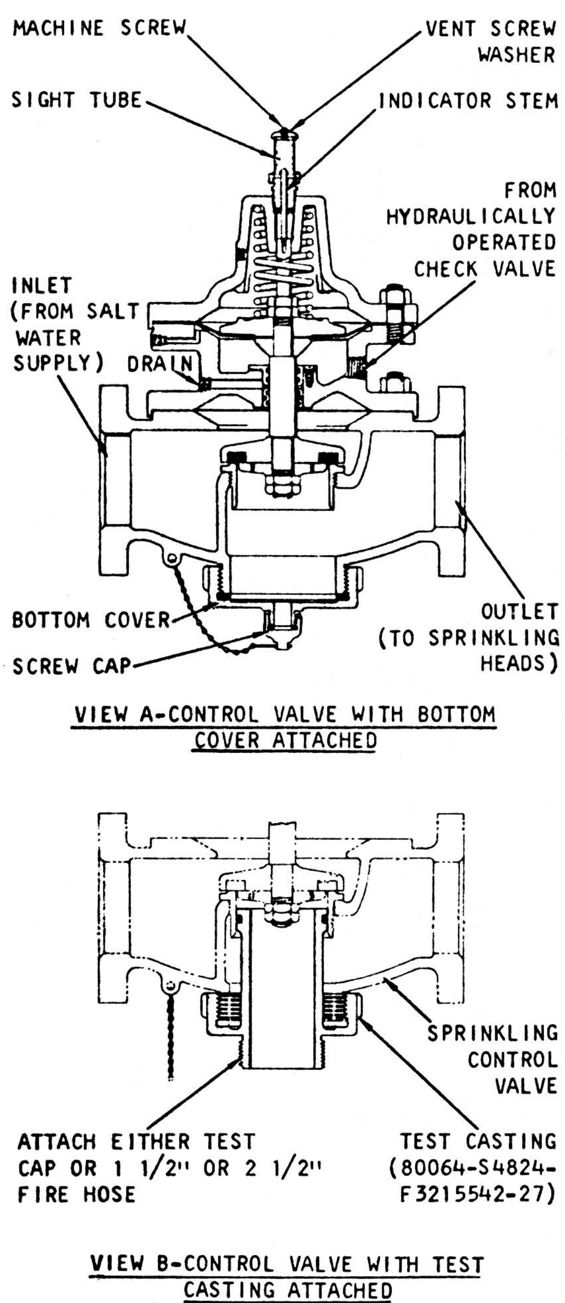


Figure 10-22. — Salt water operated sprinkling (main) control valve. 84.314

The panel shown in figure 10-23 also mounts five 1-way check valves, a hydraulically operated check valve, a pneumatically released pilot (PRP) valve, and a pressure gage.

The manual control valve is a 3-position and a 3-way valve. The three positions and functions of the valve are as follows:

1. AUTO - Permits automatic operation by blocking the passage of water through a manual control valve.
2. START - Permits water from the firemain to be ported up through a one-way check valve to the piston of the sprinkling system main control valve located in the magazine, thus initiating sprinkling action.
3. STOP - Permits water from the firemain to be ported down through a one-way check valve to the hydraulically operated control valve (pressure-operated check valve). With firemain pressure on this valve, the pressure from the sprinkling system main control valve piston is vented to tank, thus preventing any further sprinkling.

The pneumatically (air operated) released pilot (PRP) is normally closed. When actuated, it directs water from the firemain to the piston of the sprinkling system main control valve. The pilot valve is actuated by sensing devices in the magazine area (see fig. 10-21). This valve and the sensing devices will be described later in this chapter.

The pressure gage at the control panel shown in figure 10-23, indicates the firemain pressure. A manually operated cut off valve and a vent plug are provided to isolate the gage and to vent any air trapped in the pipe leading to the gage.

Salt water strainers are provided in the firemain input line and in the line to the automatic pilot valve (PRP). Drain cocks are usually provided to drain off any sediment collected in the strainer.

The remote control station shown in figure 10-24, which works in conjunction with the local control station, consists of a gage, firemain water pressure connection, strainer, two cut off valves, and a three-way manually operated control valve.

The three-way manually operated control valve of the remote control station functions like the manual control valve of the local control station and is operated in the same manner.

To follow the operation of the sprinkling system refer to figure 10-21. Firemain pressure which operates the main sprinkling control valve is shown leaving the wet side of the main control valve and passing through a cut off valve and strainer to the three-way manually operated control valve and the PRP valve. If the automatic pilot valve is actuated or the three-way valve is positioned to START, firemain pressure

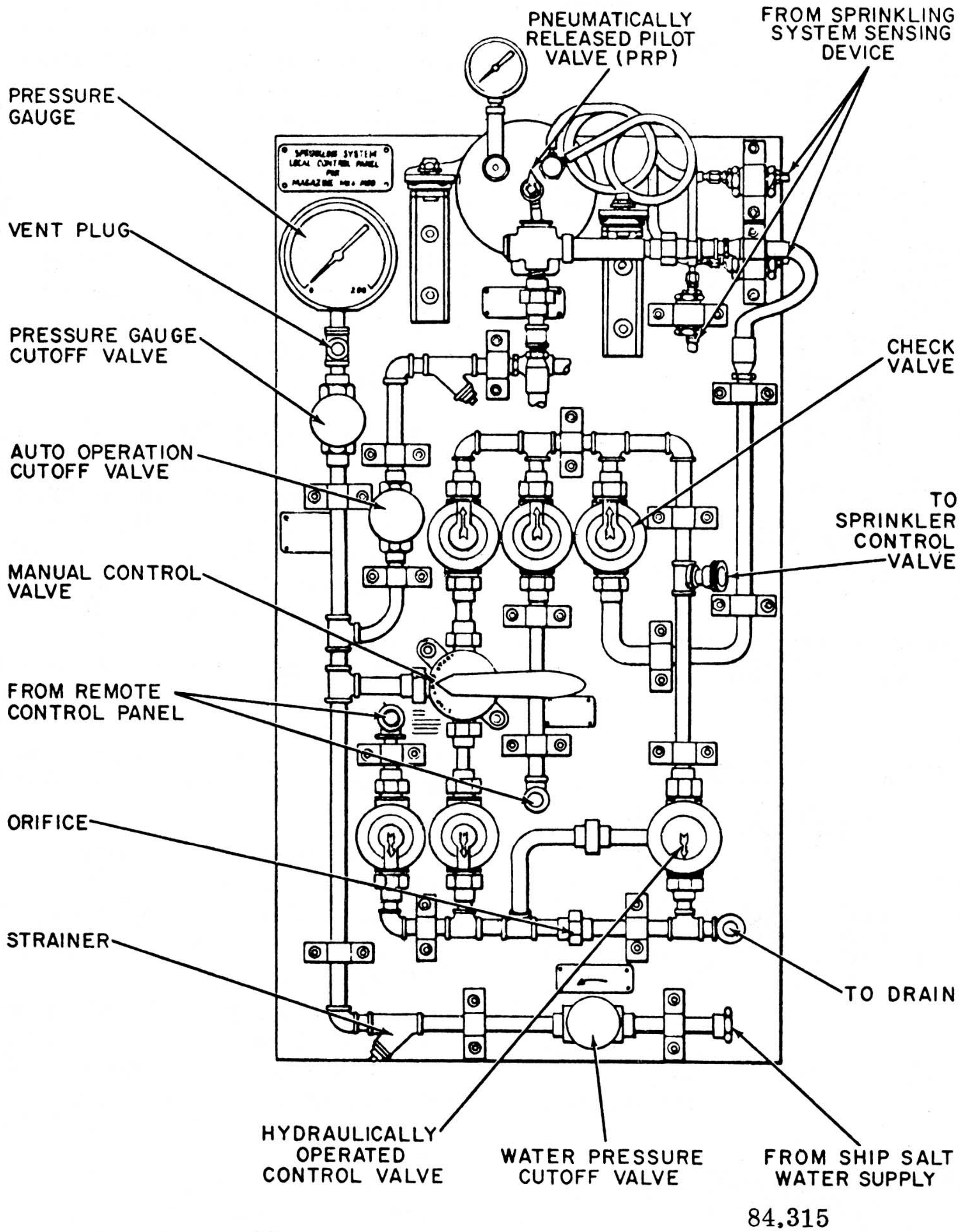
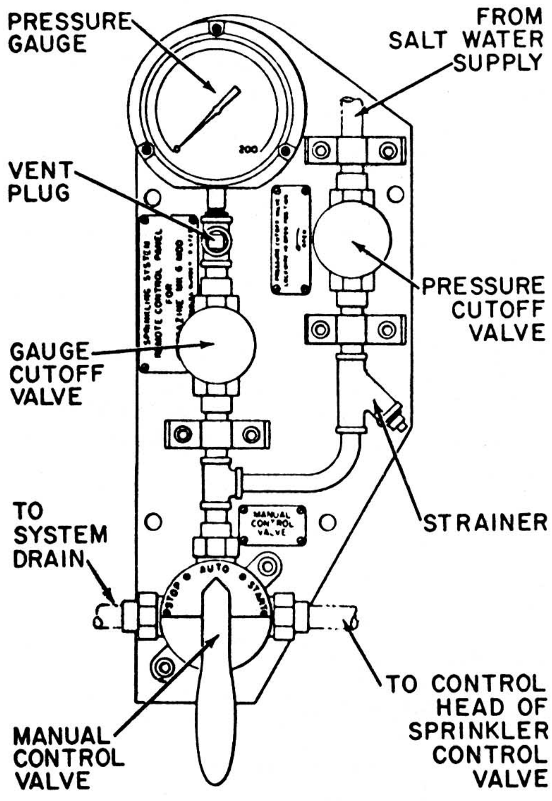


Figure 10-23.—Sprinkling system, local control panel.

is ported through a one-way check valve to lift the main sprinkling control valve and activate the sprinkling system.

Once the sprinkling system has been activated, it can be stopped by positioning either one of the three-way control valves to STOP. This action ports water from the firemain to the hydraulically operated check valve, causing the check valve to lift and connect the line from the main control valve to drain. Note there is no stop line from the PRP valve to the hydraulically operated check valve; therefore, if the sprinkling system is activated by the PRP valve, it must be manually stopped by one of the three-way control valves.

The orifice that connects the main sprinkling control valve and the three-way control valves to



84.316
Figure 10-24. — Sprinkling system, remote control panel.

drain is too small to prevent operation of the sprinkling system, but large enough to prevent possible leakage around the three-way control valves and PRP valve from building up pressure and activating the sprinkling system.

The function of the pressure switch, leakage alarm, and air-charged lines will be described later in this chapter.

The latest improvement in automatic sprinkling systems involves the use of firemain pressure to activate a wet type system. The wet type sprinkler system differs from the dry type, in that the sprinkler pipes between the magazine sprinkling control valve and the sprinkling heads are filled with nonpressurized fresh water. A combination valve and sprinkler head replaces the open orifice type of spray head. The sprinkler head valve is held closed by 50 psi water pressure which is supplied from a 20 gallon fresh water accumulator tank. Actuation of the PRP valve or operation of the manual three-way valve, immediately releases the 50 psi control pressure and blocks off the accumulator tank. At approximately the same time, the main sprinkling control valve opens allowing water at firemain pressure to wet down the magazine.

Testing The Sprinkling System

Once a month air test the pneumatic lines in the sprinkling system for tightness and operability of the heat-sensing devices, and test the sprinkling system for proper operation of the valves.

Once each quarter, air test the dry lines for unobstructed flow between the sprinkling control valve and the sprinkling heads, flush the associated firemains for unobstructed flow, clean the salt water strainer and clean the drain hole in the sprinkling control valve.

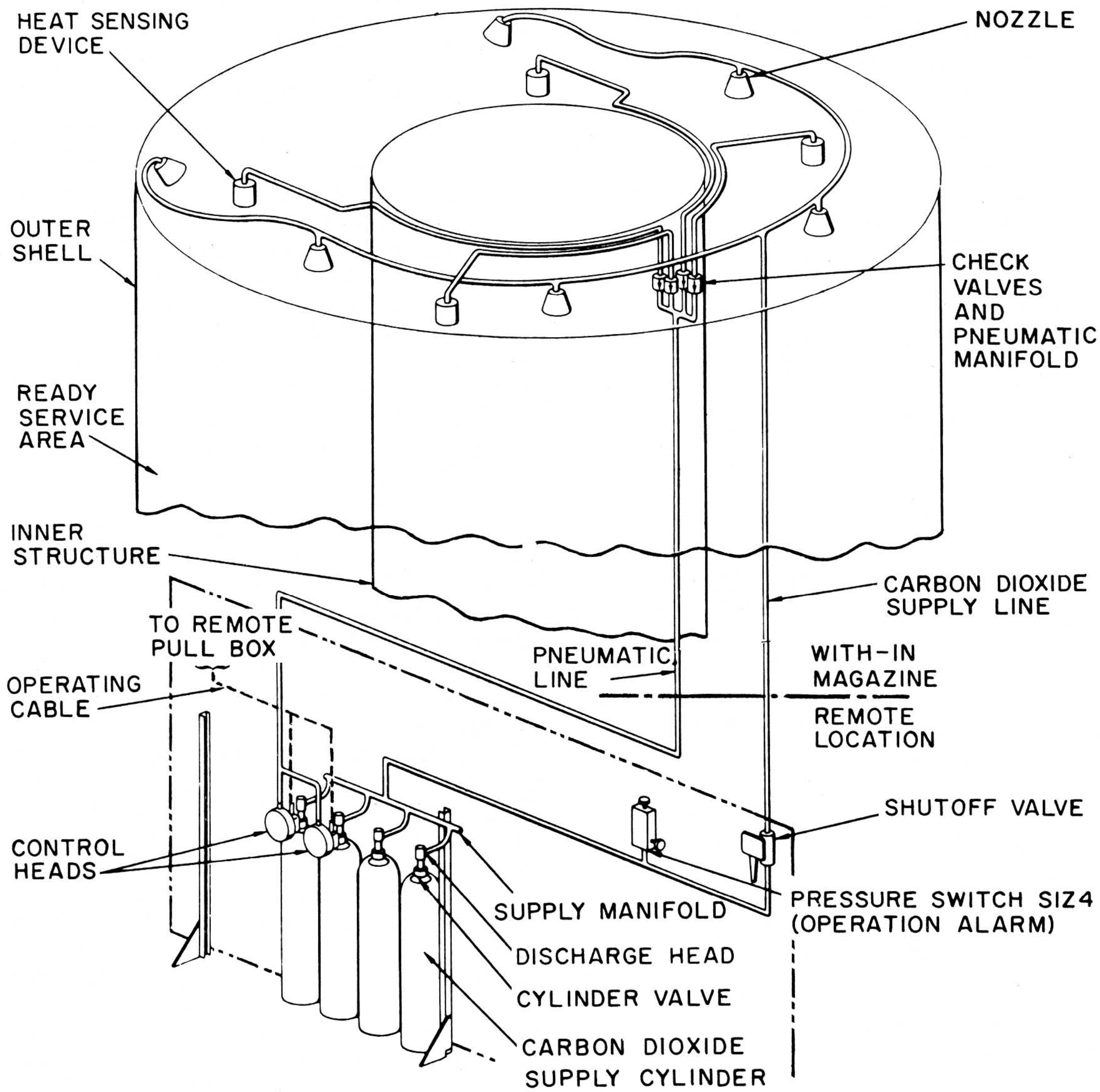
Of course, you are not going to turn on the sprinkling system and wet down the magazine each time you test the sprinkling system. For both the airtightness test and the operational test you will need a test casting, a spanner wrench, a firehose or a test cap of the correct dimensions (fig. 10-22), and a small container to catch any salt water drip. The OP for the system will tell you the items needed. The OP also gives the step-by-step instructions for each test.

The man doing the testing must be inside the magazine and therefore the magazine must be immobilized until he is finished with the test and is out of the magazine. [Before entering the magazine, position the Magazine Safety Switch on SAFE and remove the switch handle so the magazine power drive cannot be inadvertently started. Also, close the two shutoff valves that serve the magazine carbon dioxide systems. These valves are located adjacent to the magazine access land are normally locked open; unlock and close them before entering the magazine.

When automatic sprinkling systems on ships are performing improperly, assistance from the designated contractor may be requested according to NavShipInst 9480.13.

CARBON DIOXIDE (CO_2) SYSTEMS

The primary components of the carbon dioxide systems are six heat-sensing devices, six supply cylinders, three pneumatic control heads, eight discharge nozzles, two shutoff valves, two operation alarm switches, and two remote control pull boxes. The components of the outer and inner carbon dioxide systems are identical; the systems differ only in the number of components that are needed.



83.116
Figure 10-25.—Outer CO_2 system arrangement, Mk 13 Mods 0, 1, 2, and 3 launching system, Guided Missile Magazine Mk 8 Mod 0, and Mk 108 Mods 1, 2, and 3.

The magazine of the Tartar launching system has an installed carbon dioxide system, which is really two independent systems, one for the inner ring and another for the outer ring of the magazine. The outer system has more components than the inner system because it covers a large area. Each system automatically floods its area with carbon dioxide if its heat-sensing devices detect excessive temperatures. Each system can also be manually or remotely actuated.

The carbon dioxide supply cylinders, figure 10-25, located below decks near the magazine structure, contain liquid carbon dioxide at 850 psi at 70°F. Each cylinder has a 50-pound capacity and weighs approximately 165 pounds when fully charged. Each cylinder is equipped with a discharge head to which is connected a supply hose that leads to a common manifold. Control heads are installed on two of the four discharge heads. Pneumatic lines connect the control heads to a pneumatic manifold. Pressure originating in one or more of the heat-sensing devices is transferred through the pneumatic manifold to the control heads on two of the cylinders.

Each control head has a lever for manual operation. A safety locking pin secures the operating lever. A line to the top of each control head contains an operating cable that goes to a remote control box shown in figure 10-25.

When tripped, a discharge head on each cylinder directs carbon dioxide into the supply manifold and on to the discharge nozzles. The control heads trip the discharge heads on the control cylinders. Carbon dioxide flowing through the supply manifold trips the other two discharge heads.

When carbon dioxide is released, it operates a pressure switch outside the magazine; the switch operates an alarm. The pressure switch can also be operated manually and reset. As the liquid CO_2 is released from the orifices it becomes "snow" which quickly cools the magazine and puts out the fire. (The "snow" will blister the skin; do not touch it.) WARNING: Close shutoff valves (one for the inner system and one for the outer system) on carbon dioxide systems before entering the magazine. Areas flooded with carbon dioxide cannot sustain life.

WARNING: If a fire occurs in the installation. do not enter it, do not open hatches, and do not start the ventilating system for at least 15 minutes after the system has been flooded with carbon dioxide. After the 15-minute wait for the cool-off period, thoroughly ventilate the installation for 15 minutes before entering. Post another person outside as an observer and standby. If it is necessary to enter the magazine before it is thoroughly ventilated, wear a fresh-air mask or other type of self-contained breathing apparatus. Do not use a filter type mask or a canister gas mask.

The entire supply of carbon dioxide is released when the system is activated. Afterward, the empty cylinders have to be replaced with filled cylinders, and the control heads (fig. 10-26) have to be reset manually. A large screwdriver is needed to turn the reset shafts clockwise until the arrows point to SET.

Although the base structure of Magazine Mk 108 Mods 1, 2, and 3 has been extensively redesigned, there has been no change in the carbon dioxide system.

Testing CO_2 Systems

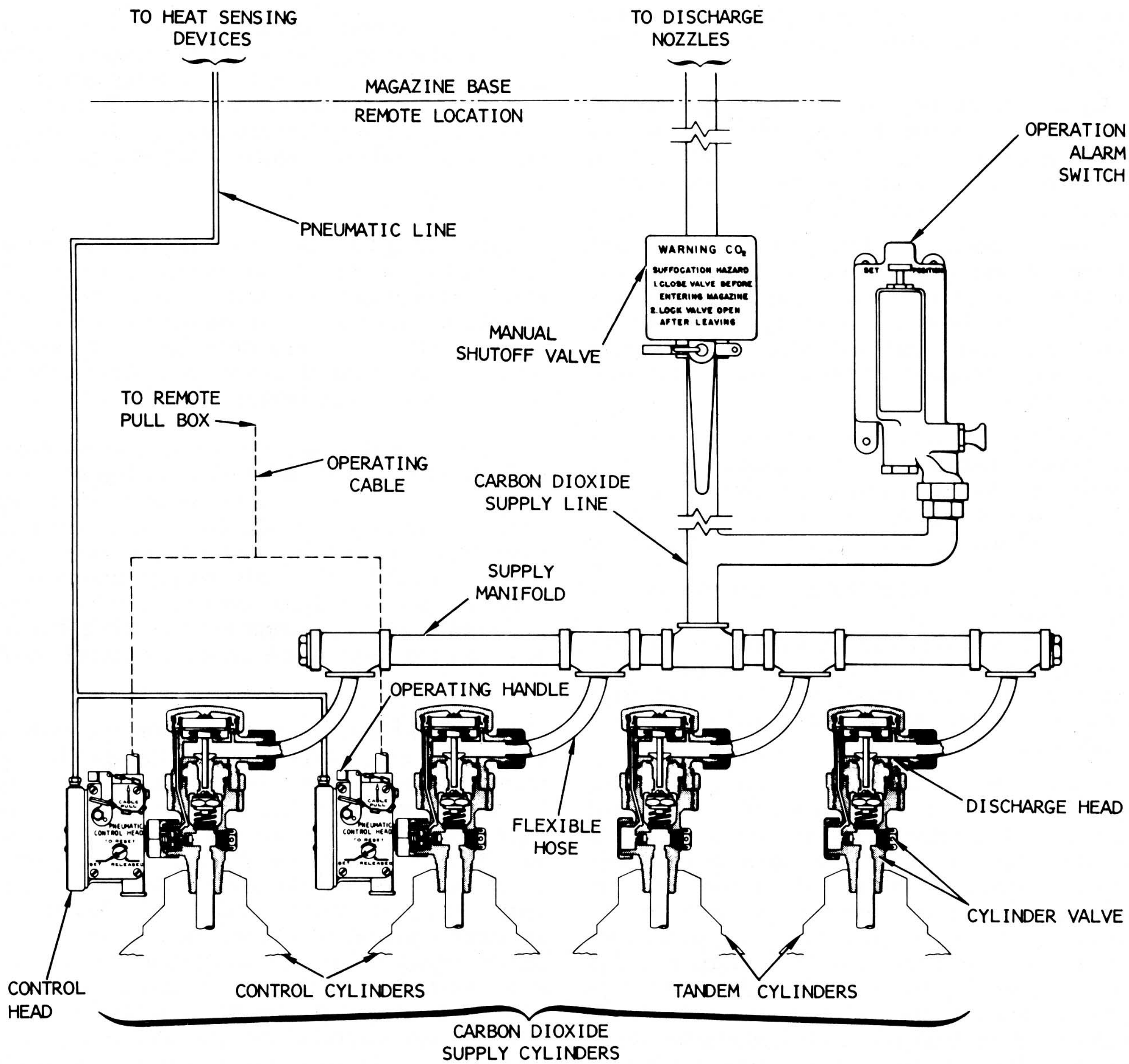
Carbon dioxide systems must be inspected and tested monthly. Inspect for breakage in tubing, pipes, and hoses. Check that all tubing is properly supported and strapped in place. Replace any damaged parts immediately, using only the special, heavy tubing required for the pneumatic lines.

Air testing the CO_2 systems for tightness and operability of the heat-sensing devices also checks the automatic operation of the alarm switches. Checking the manual operation of the alarm switches is done separately. The operability of the control heads and the pneumatic check valves is also tested.

No carbon dioxide is used in making the tests - the CO_2 supply must be closed off before beginning the tests. To perform the air test you will need test caps for all the nozzles, an air pressure gage, a hand pneumatic pump, an adapter to connect the ship's air supply line and air gage to the Navahos carbon dioxide supply manifold, and an adapter to connect" the air gage and the pneumatic hand pump to the pneumatic line.

The outer and inner carbon dioxide systems are tested separately. Remove the nozzles and insert the test caps. Disconnect the discharge heads on the CO_2 cylinders and connect the air gage and the ship's air supply line, using the adapter, to the carbon dioxide manifold, apply 20 psi air pressure to the carbon dioxide line. This should activate switch SIZ4 (fig. 10-25), an audible alarm should sound, the visual alarm should light, and the ventilation systems should shut down. If any of these do not function, you will need to get the NavShips instructions for repair, and correct the trouble. Next, apply 90 to 100 psi air pressure, secure the air supply, and hold for 5 minutes. If there is any drop in pressure, look for leaks by applying soap suds at the joints of fittings. Replace leaky parts and test again.

When testing the operation of the control heads on the carbon dioxide cylinders and the pneumatic check valves, be sure to observe all the cautions in the instructions in the OP, and perform the steps in the order given. Do not let the carbon dioxide discharge from the cylinders during the test.



83.204
Figure 10-26.—Carbon dioxide system controls.

USE OF FOAM IN FIREFIGHTING

You learned about the use of foam on class B fires (involving substances like oil, gasoline, kerosene, other liquid fuels, and paint) when you studied Basic Military Requirements, NavPers 10054-C, and you have had training in using the foam equipment. In addition to the standard oils and liquid fuels, various rocket fuels now have to be considered in the same fire category. For fighting fires in some type of nuclear warheads, a blanket of foam has been found most effective.

Foam protection is provided for Talos magazine areas, assembly areas, and mating and checkout areas by means of nozzles near the deck level, supplied through a fixed piping. A cutout and a visible indicator are provided. The foam systems are not automatic in operation. On CG class ships, foam is provided to the magazine deck only.

For the Terrier missile system, nozzles near the deck level, supplied through fixed piping, give foam protection to the magazines. Foam protection for the assembly compartments and for the strikedown and the checkout compartments is provided by foam hose lines. Foam systems are nonautomatic; but they are interlocked with the access door, and have interior and exterior indicators.

Mechanical foam is produced by mechanical mixing of foam fluid dissolved in water with air, making a tough blanket of air-filled foam bubbles. Chemical foam is the result of a chemical reaction between chemical powders in contact with water, or by mixing two fluid chemicals. The foam-producing equipment is under NavShips cognizance, and descriptions of installation will be found in NavShips publications. Chapter 93 of NavShips Technical Manual 0901-930-0003 (formerly NavShips 250-000, now issued as a pamphlet) describes the methods of producing foam for firefighting. It also describes the use of spray or fog in firefighting. These two methods, foam and fog, are used most on deck and on hanger decks and elevators. The fog is very effective in cooling and smothering a fire but there is danger of the fog nozzle coming into contact with electrical equipment.

WATER- INJECTION SYSTEM

The purpose of the water injection system is to provide an instantaneous and continuous jet spray of water toward the exhaust of any missile accidentally ignited in the magazine.

In the Mk 13 Mod 0 launching system the missile water injector system contains 96 water injector units (fig. 10-27) in the magazine base. Each unit consists of a standpipe, that is threaded into one of the Circular water mains, and a water injection nozzle threaded into the standpipe. A fresh water tank is charged at approximately 200 psi until injector actuation at which time pressure is reduced to firemain pressure. The connecting line from the fresh water supply to the firemain contains a check valve as does the firemain line. Water from the fresh water tank or the firemain goes through a water main to a manifold, which distributes water into the two circular water mains in the magazine base. The mains supply water to the standpipes and detector nozzles.

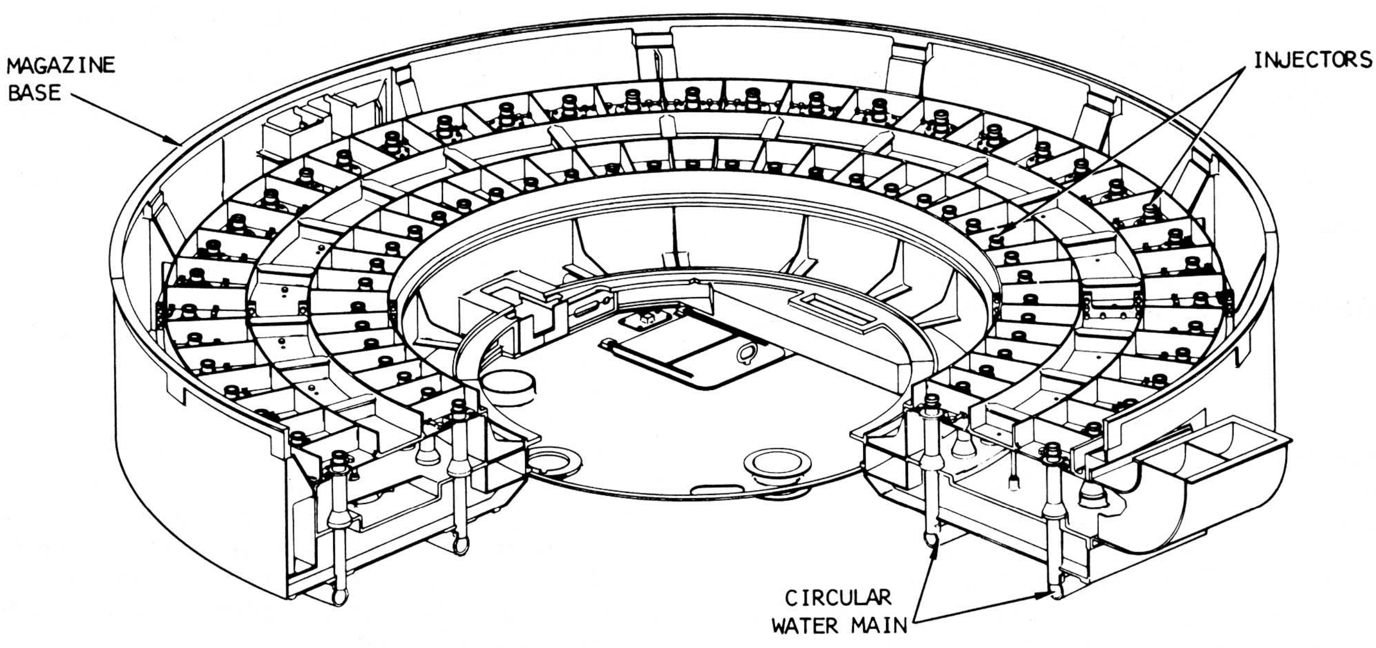


Figure 10-27. — Base of magazine Mk 8 Mod 0, launching system Mk 13 Mod 0, showing water injectors.

The nozzle body contains a closure piston, an actuation piston, lock balls, and a cover diaphragm secured by a cover sleeve shown in figure 10-28. Three lock balls in the throat of the nozzle hold the closure piston in place against water pressure from inside the nozzle. This piston blocks the flow of water out of the nozzle until the system activates. A gold-wire spring holds the actuation piston in place above the closure piston until missile exhaust activates the system and breaks the spring. A cover diaphragm keeps the nozzle clean.

If a missile ignites in the magazine, exhaust from the missile exerts pressure on the actuation piston in the nozzle. This pressure breaks the gold-wire ring, allowing the actuation piston to move down. The three locking balls then fall out of the throat and into the center of the nozzle.

As the locking balls disengage from the nozzle throat, water pressure from the fresh water tank forces the closure piston, the lock balls, and the actuation piston out of the nozzle, along with the stream of fresh water. A flow detector, in the line between the fresh water tank and nozzles, responding to the flowing water, closes contacts in the circuit to start the firepump, to energize the alarm system, and to activate the drain eductor system.

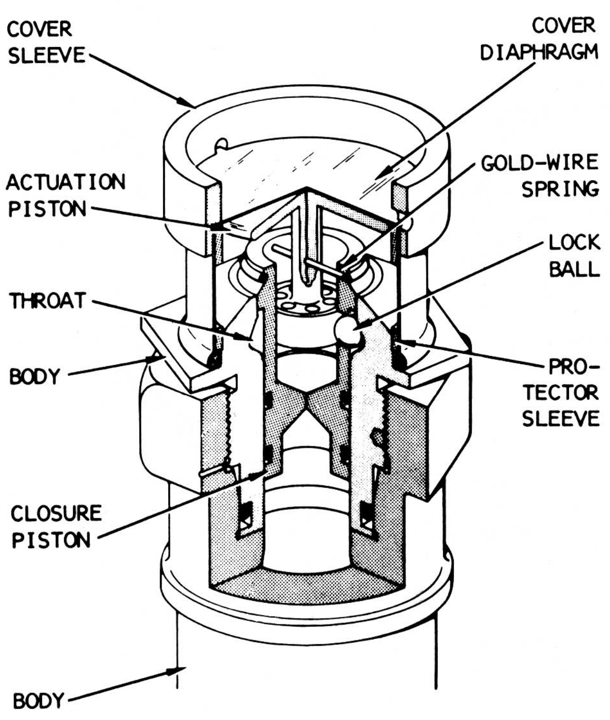


Figure 10-28.— Water injection detector nozzle.

With the firepump started sea water is available to the injection system. When the water pressure from the tank decreases to firemain pressure, sea water from the firepump opens a check valve and starts flow into the injection system. At 70 psi firemain pressure, the injector nozzle will discharge at the rate of 180 gallons per minute.

During burning of an electrically ignited missile motor, the missile exhaust is forceful enough to prevent water flow for a fraction of a second. During this brief period, the injection system obstructs the missile exhaust flow. For this reason the nozzle has been made small and the cover sleeve purposely made of a material (nylon plastic) that will break away when subjected to the exhaust stream.

To stop the flow of water into the water injection system, a remote shutoff valve must be closed, and the firepump circuit must be opened at the switchboard. After components of activated nozzles are replaced and the compression tank is filled and recharged, the system must be reset.

The water injection detector nozzle in the Mods 1, 2, and 3 is the same as in the Mod 0, but the stand pipes and associated piping have changed due to the changes in the base structure of the magazine. The stand pipes extend below the bottom plate of the base structure. The associated piping is below the base structure, passing under it, not through it. The base structure has been strengthened and provisions made for mounting the elbow-shaped exhaust duct for the plenum chamber.

Testing Water Injection Systems

The injection system has to be inspected and tested at intervals determined by ship's policy. Maintenance is then performed as shown necessary by the inspection and tests.

The inspection of the nozzles has to be performed inside the magazine, working in an empty cell. If no cell is empty at the time, hoist one missile onto the launcher. Then set the Magazine Safety Switch to SAFE on the panel to inactivate the power drives, and remove the switch handle from the panel. Also, before entering the magazine, close the shutoff valves on the CO_2 system, and shut off the water pressure in the firemain leading to the injectors.

One crew member, on instructions from the man in the magazine, manually indexes the ready service ring to position him over the next nozzle, and so on until all nozzles have been inspected. Each nozzle is removed for inspection, using a special wrench. Be careful not to apply force or drop anything on the nozzle end. A force of 16 pounds will trigger it.

After all nozzles have been inspected, turn on the water pressure in the firemain and proceed to bleed each standpipe. To do this, loosen the nozzle with a special wrench, two or three turns, until water appears. Then, tighten the nozzle again until leakage stops. Inspect the rubber cover on the face of the nozzle, and replace it if it is damaged. It is cemented in place.

When all this is completed, recharge the compression tank (62-1/2 gallons of fresh water and 200 psi air pressure). When the crewman is out of the magazine, return the switch handle to the panel, replace the handcrank on the power-off brake, open and lock the two shutoff valves on the C~ system, and, if a missile was placed on the launcher to empty a cell, return it to the cell.

If there is a drop in the air pressure in the fresh water compression tank, check for leakage in the system by checking each nozzle and standpipe. Observe the same precautions for working in the magazine as you did for inspecting the operability of the nozzles and standpipes.

Some instructions require only a spot check of nozzles, and a complete check is not made unless one or more faulty ones are found in the spot check. Review the latest instructions for your system.

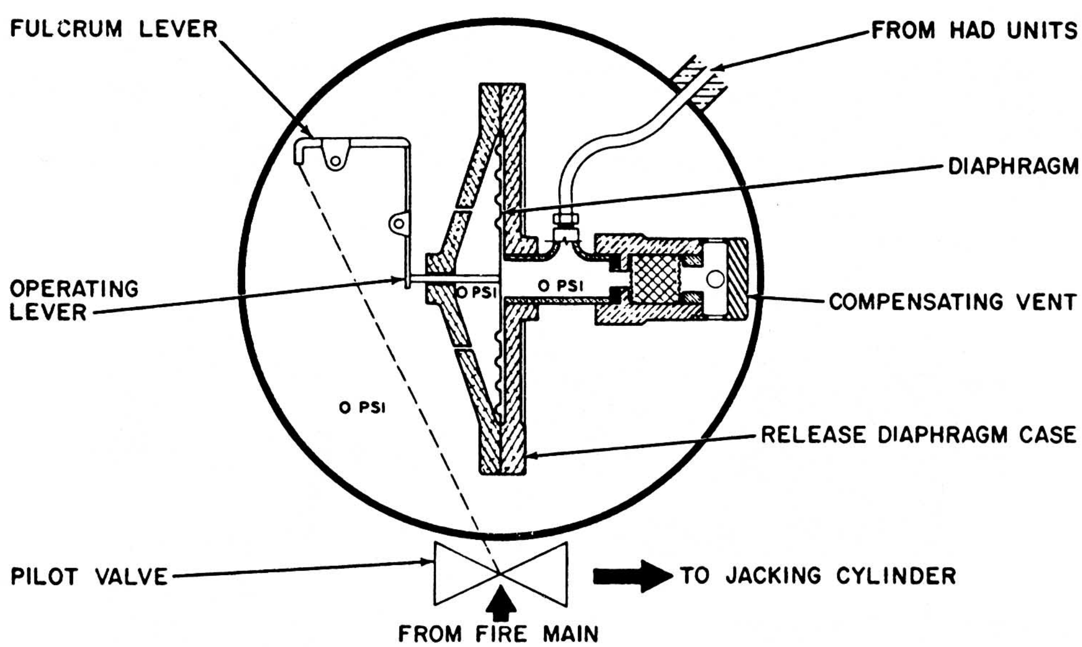
AUTOMATIC CONTROL DEVICES

Most missile magazine sprinkling systems are equipped with some type of automatic control device. These control devices are actuated by heat-sensing elements in the magazine area.

The automatic control devices actuate the same sprinkling system main control valve which is operated by the remote and local control stations. The devices are designed to actuate when a rapid rise in temperature occurs or when the heat exceeds a fixed temperature.

PRP Valve

The PRP valve assembly (fig. 10-29) consists of a bronze case which encloses a release diaphragm, chamber, linkage, springs, and a pilot valve shaft and levers. The shaft and levers are connected to the PRP which opens and closes to control the main control valve. The shaft and levers are arranged so that any sudden pressure



84.320
Figure 10-29. — Pneumatically released pilot valve (PRP) schematic.

increase causes the diaphragm to extend into the diaphragm chamber and to trip the operating lever out from under the fulcrum lever. When the fulcrum lever is released, the pilot valve is opened by spring action.

Slow changes in pressure between the inside and outside of the diaphragm chamber are equalized by the compensating vent shown in figure 10-30. This vent is installed in the line connecting the manifold fitting to the inside of the diaphragm chamber and discharges into the bronze case on the outside of the diaphragm chamber.

One side of the release diaphragm case is open to the interior of the bronze pneumatically released pilot valve case. The other side of the release diaphragm is connected to the tubing from the compensating vent fitting and from the HAD's.

A lever is provided on the front of the PRP case to reset the PRP after operation. An air valve and gauge are also provided on the front of the PRP case to pressurize the system by means of a hand pump when testing for air leaks. The cap covering the adjustment for water side of the PRP valve is locked in position by the manufacturer so that valve setting cannot be tampered with and the cap will not vibrate loose. A metal tag is also attached to the case by the manufacturer warning personnel not to open casing for adjustment.

HAD Unit

The earliest application of automatic control for sprinkling systems is the heat actuated device (HAD) shown in figure 10-31. The device, encased in wire guards, is a pneumatic thermostat which consists of a hollow brass-chamber whose capacity is about 14 cubic inches. One or more HAD's are located in the protected compartment and create the pressure necessary to actuate the PRP valve when the rate-of-rise of the temperature becomes excessive.

The excessive heat is absorbed by the HAD and is utilized to heat the air trapped in the system. The heated air expands and creates a pressure which is transmitted through 1/8 inch tubing to the PRP diaphragm, causing the PRP valve to trip and actuate the sprinkling system. The device functions when the internal pressure is equivalent to the pressure produced by 6 to 10 inches of water within 10 seconds after the HAD has been exposed to external heat.

When the heat is absorbed by the device at a slower rate than the one previously mentioned, the system does not function, since provision is made within the pneumatic release pilot valve (PRP) to allow for normal temperature changes within the compartment.

Fixed Temperature Unit

The fixed temperature units (FTU's) are designed to actuate the automatic control device when the temperature reaches a predetermined value.

Note: The temperature rise must be slow, otherwise the HAD unit will actuate the automatic control device before the FTU can function.

An FTU shown in figure 10-32, consists of a spring-loaded cap which is held in place by indium solder. This solder is made of such material that it melts at the predetermined maximum setting for the protected compartment.

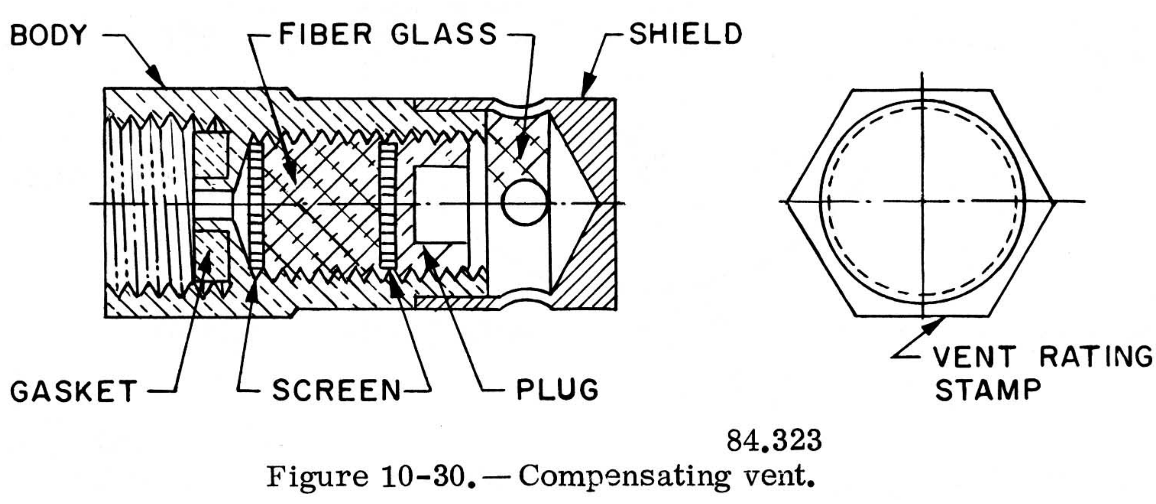


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Figure 10-30.— Compensating vent.

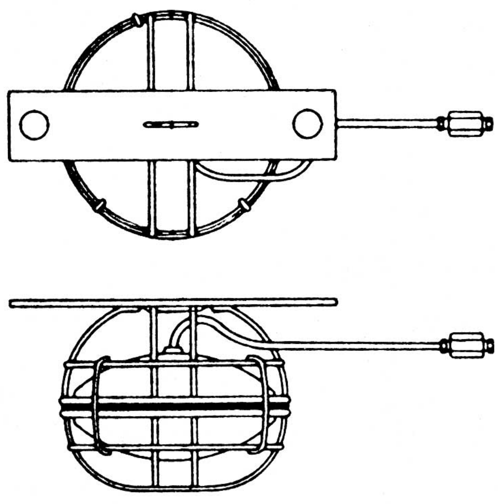

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Figure 10-31. — Heat actuated device (HAD).

When the FTU cap is freed, the pressure in the PRP valve case is released, causing the automatic control device to actuate.

A schematic of an automatic control system consisting of a PRP valve, HAD units, and FTU units is shown in figure 10-33. In figure 10-32 it is assumed that the temperature in the protected compartment rises at a slow rate. As the temperature rises, the HAD's respond by transmitting the heat in the form of air-pressure to the PRP diaphragm. Since the air-pressure rise is slow, it is equalized within the PRP diaphragm case by the compensating vent, thus preventing the PRP valve from being actuated. However, when the temperature in the protected

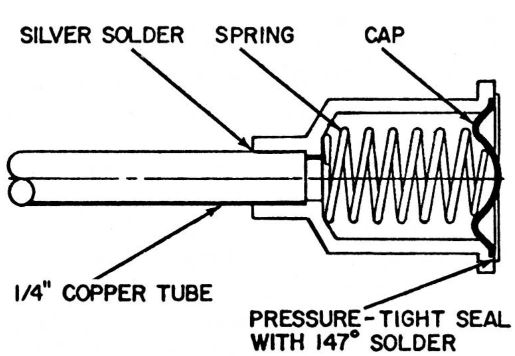

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Figure 10-32. — Fixed temperature unit (FTU).

compartment reaches the predetermined maximum level, the FTU opens and vents the air pressure built up in the diaphragm case, causing the PRP valve to trip.

Thermo-Sylphon Unit

The latest control device for automatic sprinkling systems combines the features of a HAD and an FTU. This device, known as the thermo-sylphon heat sensing device, is used on many of the newest types of sprinkling systems.

A thermo-sylphon heat sensing device shown in figure 10-34, consists of a bellows normally enclosed in a mesh cage. The bellows are expanded and held by a fusible link against spring pressure. The device, automatically actuates a PRP valve when there is a rapid temperature rise or when the fusible link melts.

When a rapid temperature rise occurs in a magazine or ready service area, the resultant sudden pressure increase in the bellows is transmitted to the PRP valve causing it to activate the sprinkling system. Normal temperature changes also cause air in the bellows to expand and contract. However, these normal pressure changes are vented by the compensating vent in the PRP valve.

When the temperature in a magazine area reaches a predetermined value, it causes the fusible link to melt, releasing the compressed spring, and causing the bellows to collapse. As the bellows collapse, a pressure is developed that actuates the PRP valve.

Note: The fusible pin (link, lug, slug) of a heat-sensing device, in a particular sprinkling system, will melt at a predetermined temperature. For example; the Mk 13 launching system magazine has sixteen heat sensing devices. Twelve of these devices are used with the salt water sprinkling system. The fusible pins in these devices will melt at 174 degrees F. The four remaining heat-sensing devices are used with the carbon dioxide (CO_2) system. The fusible pins in these devices will melt at 158 degrees F.

It is imperative that when replacing a fusible pin on a device that has been activated, a pin with the same melting point as the original pin must be installed.

TEST SPRINKLING SYSTEM

Once a month (1) airtest the pneumatic lines in the sprinkling system for tightness and operability of the heat sensing devices, and (2) test the sprinkling system for proper operation of the valves.

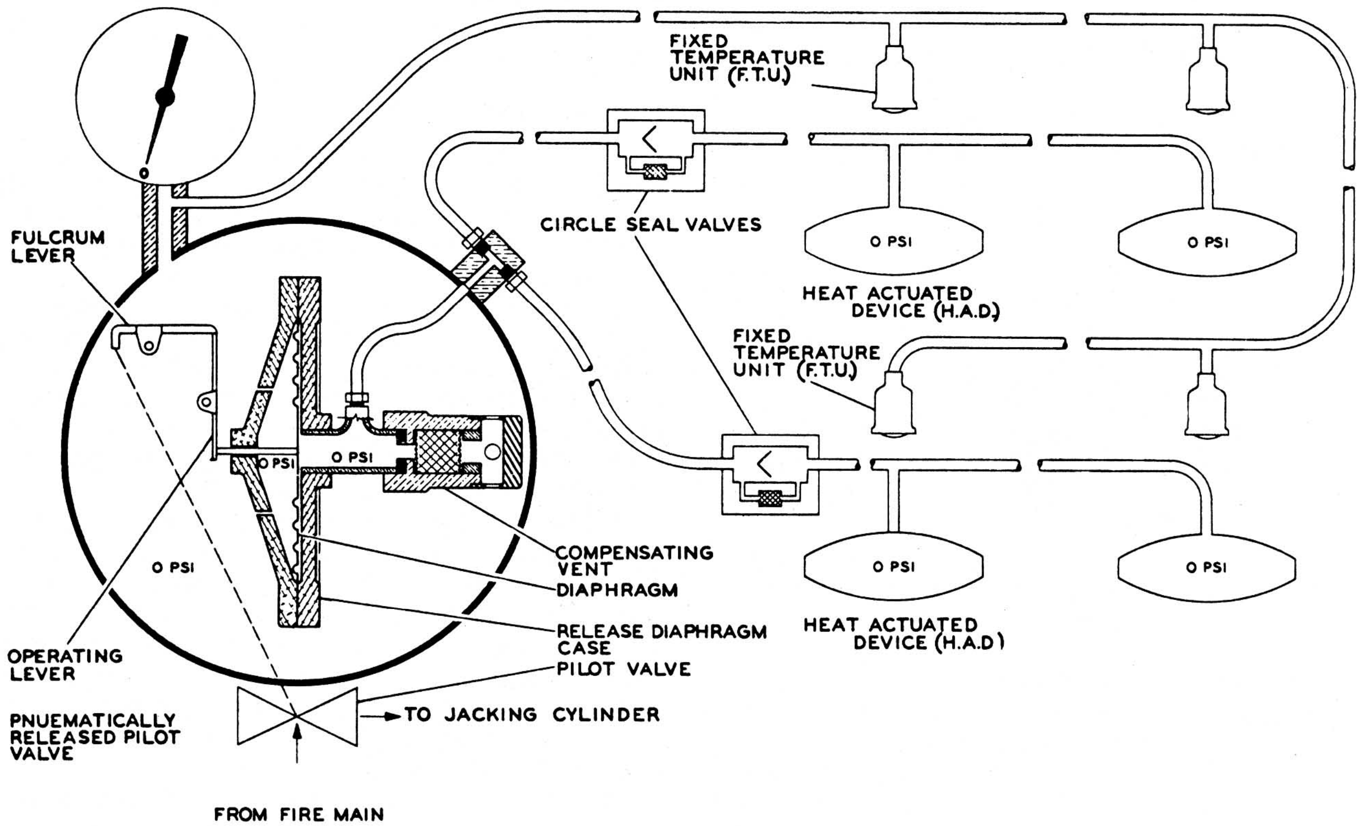

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Figure 10-33. — Sprinkling system automatic control system, schematic.

The once every quarter airtests of the dry lines for unobstructed flow between the sprinkling control valve and control heads and flushing the firemains for unobstructed flow was covered earlier in this chapter.

Airtest (Tightness)

To airtest the sprinkling system monthly for tightness and operability of the heat sensing devices, proceed as follows:

1. Obtain the following equipment:

a. A test casting
b. A spanner wrench
c. A hand pneumatic pump
d. Either a 1-1/2 inch fire hose or a test cap (2-1/2 - 7-1/2 N.H. thread) having a petcock
e. A small container in which to catch salt water

2. Using the spanner wrench, remove the bottom cover of the sprinkling control valve. Then screw in the test casting, shown in figure 10-22B.

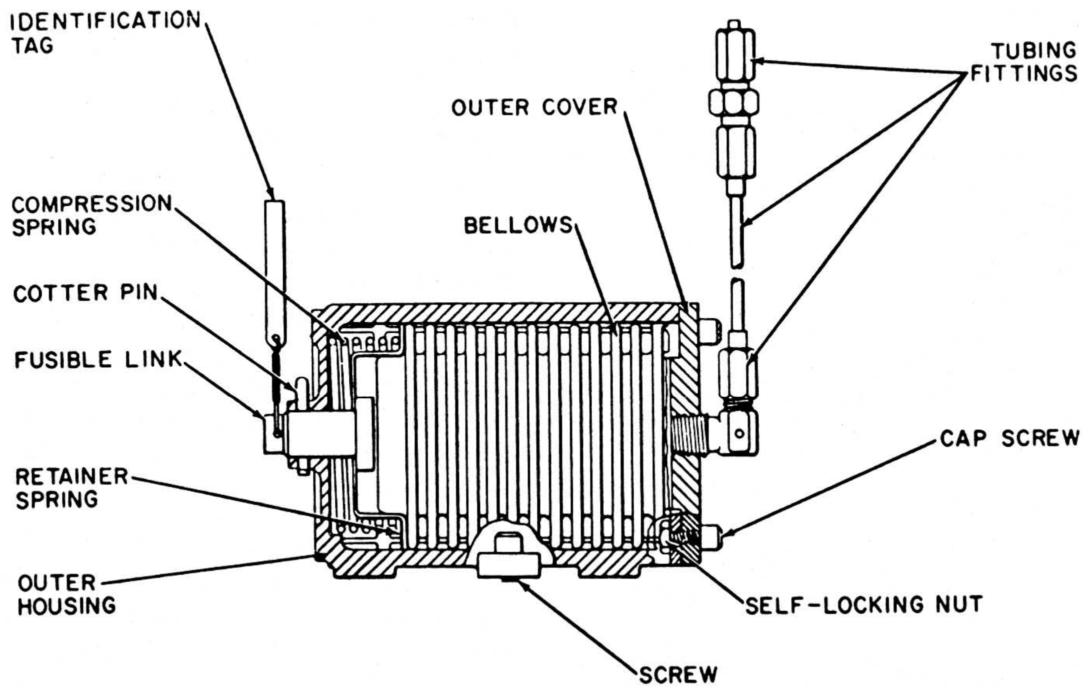
3. To the threaded end of the test casting, attach either a fire hose or, if available, the test cap. If the fire hose is used, the hose should be led to a convenient drain.

4. Close the normally locked open globe valve in the 3-1/2 salt water supply main.

5. Connect pneumatic pump to air valve on PRP valve (fig. 10-35). Remove cap at the bottom of gage to get to the air valve to connect pneumatic pump to PRP valve.

6. Slowly pressurize system until a pressure of at least eight ounces is obtained. Because of the slow passage of air through the vents, some additional pumping of air may be required before obtaining a balance.

7. After the balance is obtained, stop pumping and hold the pressure for five minutes. The pressure should not drop during this period - even the slightest drop in pressure is serious,



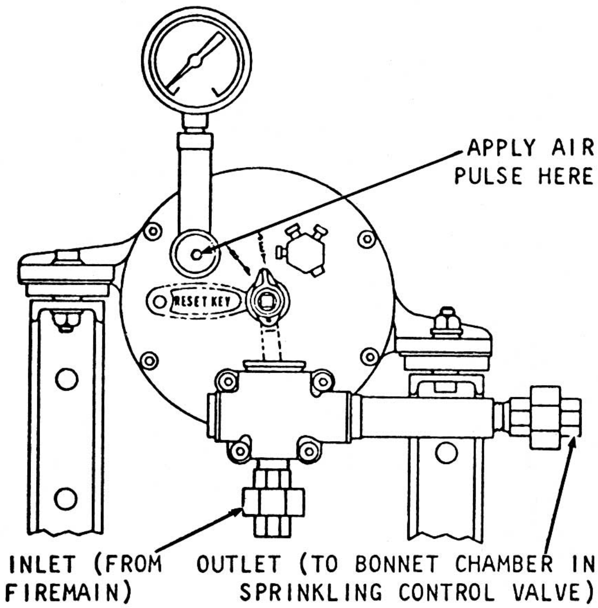
84.328
Figure 10-34. — Thermo-sylphon heat sensing device.

for it indicates a leak which may prevent automatic operation of the system at the time of a fire. If the gage does not retain eight ounces of pressure for five minutes, first check the fitting on the hose line for the pneumatic pump to be sure it is not the type that holds the air valve open, thereby permitting pressure to escape. Look for a leak by applying soap suds to the fittings near the PRP valve and subsequently at the fittings near the heat sensing devices. Do not use a movable jaw wrench when tightening fittings. NOTE: If the leak is within the PRP valve, replace this valve with a new unit. Do not open the PRP valve case under any circumstances. Turn in defective valve to the nearest naval stocking activity. Repeat airtest with replacement valve.

8. To test action of the heat sensing devices, punch the air valve fully open. Sudden release of pressure in the PRP valve case and pneumatic lines should trip the sprinkling main control valve; allowing water to flow into the test casting. (Actuation of the PRP valve simulates the condition created when the sealing disc (cap) of an FTU is ejected when the indium solder melts or the bellows of the thermo-sylphon device collapses due to melting of the fusible link.)

9. Wait about two minutes (see note below), and then reset the tripping mechanism on PRP valve by gripping the reset lever with the reset key and turning the lever to SET (fig. 10-35). Be sure the lever latches at SET before removing key. Note: The two minutes wait is necessary to allow time for pressure on both sides of the valve diaphragm to equalize. Unless the pressure is equalized the PRP valve will not latch at SET. If after two minutes the valve does not set, again slowly pressurize the system as in step 6, wait five minutes, then punch the air valve wide open. Wait another two minutes, and then reset the valve. If the valve still fails to reset, or will not trip to begin with, replace it with a new unit. DO NOT OPEN THIS VALVE UNDER ANY CIRCUMSTANCES. Turn in the defective valve to nearest naval stocking activity. Repeat airtest with replacement.

10. With the PRP valve reset and the air vented from the system, totally immerse the most remotely located accessible HAD in a container of water. (Water temperature should be at least 200° F.) The PRP valve should trip in a maximum of 5 seconds. Check the sprinkling main control valve to ensure that it is open. To expedite the test, cool the HAD with cold water or ice. Reset



84.329
Figure 10-35. — Pneumatically released pilot valve.

the PRP valve and check to ensure the sprinkling main control valve is closed.

10a. (Figure 10-35 apply air pulse here approximately 8 ounces). This does the same thing as if the heat actuated device (HAD) had functioned or the thermo-sylphon device had functioned due to a fast rise in magazine temperature.

11. Open globe valve in the 3-1/2 inch salt water supply main and lock open. Remove fire hose or test cap from the test casting on the sprinkling main control valve. Have a small container available to catch salt water trapped within test casting. Then remove test casting, check to see that there is no leakage past valve seat, and screw on the bottom cover to the valve, using the spanner wrench.

GENERAL INSTRUCTIONS AND SAFETY

In a study of safety precautions, it is difficult to cover every possible situation that may arise and which, if improperly handled, may produce serious results. However, if a thorough understanding of the basic ideas behind the precautions is developed, unsafe conditions can be recognized and corrected and further suitable action can be taken instinctively when the unexpected occurs.

Safety is everyone's responsibility. Awareness of danger, knowledge of how danger can be avoided, and constant vigilance are the three basic requirements to prevent accidents when working with explosives, including missiles and missile components.

Safety precautions, rules, and regulations for handling explosives should be made the subject of frequent instruction, and the necessity for strict compliance with these procedures should be so firmly fixed in the minds and habits of new men that they will invariably and subconsciously thereafter react in an emergency according to the instructions previously received. Attention is especially invited to the fact that in the early stages of the use of explosives, experience was gained at a great price- not only in dollars, but in human lives.

No relaxation should be tolerated, since this tends to create the impression that the rules are arbitrary. Men tend to become careless and indifferent when continually engaged in work with explosives and, as long as no incident occurs, are inclined to drift gradually into neglecting the necessary precautions. Nothing but constant vigilance on the part of officers and petty officers in charge will ensure the steadfast observance of the safety rules and regulations which experience has taught to be necessary.

It is of primary importance in the safety program that all persons should be thoroughly indoctrinated before their first occasion of working with explosives. This indoctrination must include personal safety, material protection, accident prevention, and initial actions to be taken if a dangerous situation starts to develop. THERE IS NO VALID REASON FOR FAILURE TO COMPLY WITH SAFETY REGULATIONS.

Missiles, as well as gun ammunition, bombs, rockets, and torpedoes, are extremely dangerous; therefore, constant vigilance and intelligent supervision must be exercised during handling and storage of these items.

Handling of missiles and explosives shall be kept to a minimum and performed only with authorized handling equipment. Live missiles shall never be used to check out the equipment.

Missile boosters shall be handled with extreme care. A slight blow may crack the propellant grain and cause an explosion when the weapon is fired. Care shall be taken that no heat is applied to or near boosters.

Missile warheads are classified as bomb-type ammunition; therefore all general safety precautions for handling high explosive and bomb-type ammunition shall be exercised when warheads are being handled.

Warheads must be grounded at all times when outside their shipping containers. The container shall be grounded before it is opened prior to removal of the contents. Empty containers must be grounded before a warhead is inserted. Physical contact of a container to ships metal deck would be an adequate ground.

Steel instruments or tools that may cause sparks shall not be used for cleaning or scrapping exudite from, or for assembly or disassembly of warheads.

A warhead that is cracked, dented, bent, or that otherwise shows signs of physical damage or corrosion shall not be used. Warheads that cannot be used should be returned to a depot.

Only authorized personnel shall remain in the area when a warhead is being installed or removed.

When fuzing a warhead, ensure that the threads are clean and in good condition; the fuze must not be forcibly screwed into or out of, its cavity. Place a light film of silicone grease on threads and fuze body for lubrication; do not use an excessive amount of grease.

Any warhead, live or inert, that fails to mate for any reason should be returned to a depot.

Exercise heads shall be handled in accordance with the greatest hazard posed by the material contained within.

If an exercise head is accidentally dropped, it should be returned to a depot.

A fuze or an S&A body that is cracked, dented, bent, or that shows other signs of physical damage shall not be used; it should be free from rust or other corrosion.

An S&A device shall be in the SAFE condition before installation. It shall not be installed into a warhead unless the warhead is assembled in a missile, except where otherwise directed.

Any fuze or S&A device that has been dropped from a height of over five feet shall not be assembled to a missile or warhead, but should be returned to a depot, with attached explanation.

Fuzes and S&A devices shall not be tested aboard ship; neither shall they be disassembled for any reason. They are a sealed assembly and shall not be repaired, modified, or broken down.

Fuzes, boosters, detonator, etc. are loaded with explosives which are sensitive to shock and friction. They must be handled with care at all times.

No explosive shall be removed from a wooden container by inserting a wire, nail, or sharp instrument.

No explosive component shall be disassembled, nor shall any attempt be made to modify or repair it, except by specific approval from NavOrd.

As explosives go, black powder is one of the most dangerous. It must always be handled with the greatest care. A few of its properties and precautions that should be observed in handling it are:

1. It possesses practically unlimited stability if stored in tight containers and kept dry. (Black powder, and assemblies containing it, should be regarded as unserviceable if they have become damp or wet.)

2. It deteriorates irregularly when moist.

3. It is not affected by moderately high temperatures. 4.

It is highly flammable and sensitive to shock, friction, and sparks.

5. If you can, avoid opening containers of black powder in the presence of other explosives or ammunition. The maximum limit that you can expose in a magazine is 25 pounds.

Pyrotechnics and pyrotechnic ammunition (except illuminating projectiles) shall be stored in cool, dry magazines below decks, preferably above the water-line, or in special pyrotechnic lockers located on the weather decks of surface ships. Submarines shall stow pyrotechnics and pyrotechnic ammunition in approved designated places.

If the quantity of any type pyrotechnic ammunition is large, it shall be stored separately from other types of pyrotechnics.

That part of signaling pyrotechnics for boats shall be packed in watertight boxes and may be stowed in boats as required by existing instructions.

Smoke bombs, float lights, smoke boxes and similar pyrotechnic smoke-making ammunition shall be stored, preferably, in dry, cool locations above decks, owing to the difficulty of combating the objectionable smoke in case of fire in these materials.

Chemical ammunition, as a rule, shall be stored in dry, well-ventilated enclosures on the upper decks, convenient for jettisoning in an emergency.

The different types of chemical ammunition shall, if practicable, be stowed separately. Separate stowage is mandatory if the quantity of any type chemical ammunition is large.

Smoke signals are subject to spontaneous combustion if they become moist. Their stowage in compartments below the waterline is, in general, undesirable because of the relative inaccessibility of many such compartments.

Aboard ship, smoke and gas producing pyrotechnics should be stowed above decks. Pyrotechnics such as Marker, Location, Marine Mk 2 and others which generate flammable gases when moist, should also be stowed topside and separate from other pyrotechnics.

NUCLEAR SAFETY PRECAUTIONS

Since the warheads of some of your missiles contain a nuclear component, you need to know how to handle nuclear materials. The nuclear component is enclosed in explosives, so the rules for safety in handling explosives are applicable. If something happens that causes the explosive to detonate, some nuclear material will be released and there will be a radiation problem. If there is a fire it can cause the explosives to detonate and thus break the container of nuclear material. This does not mean there will be a nuclear explosion. The chances of full nuclear detonation occurring unintentionally are almost infinitesimal, but there can be an escape of some nuclear radiation in an accident or incident. Observe the two-man rule whenever you assemble, disassemble, test, package, unpackage, or handle a weapon containing a nuclear component. Wear your dosimetric device (film badge or other personal type dosimeter) to measure any radiation present. If there is a nuclear accident or incident. get out of the area quickly, holding your breath to avoid inhaling particles, and secure the area. Call for the decontamination team to take care of the radiation problem.

The rules for procedures in case of nuclear accident or incident are given in OPNAVINST 8110.16C. Part of it deals with procedures in case of nuclear-loaded plane crash-lands and burns. First, rescue personnel if at all possible. Then proceed with firefighting. A GM T should safe the fuzing and firing system as quickly as possible. If the fire cannot be controlled before it engulfs the weapons, push the weapons overboard.

In summary. THINK SAFETY. Study the intent of safety regulations.

Safety is a state of mind, develop it so safety becomes second nature to you in your work as a GMM.

It is well known in the Navy that almost all fatal accidents are caused by carelessness on someone's part. A man who violates safety rules risks not only his own life, but the lives of his friends and shipmates.

Remember. "ETERNAL VIGILANCE IS THE PRICE OF SAFETY."