HARDNESS AWARENESS SEMINAR

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ABSTRACT

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report discusses nuclear and nonnuclear hardness in general terms. As an introduction this report contains an overview of the potential types of threats, the resulting hostile environments and effects, and some hardening techniques which have been used. Some of the potential impacts of logistic actions involving hardened systems are discussed. This discussion includes both positive and negative impacts on system survivability. The objectives and need for a logistics survivability program, including surveillance, are discussed.

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HARDNESS AWARENESS

SEMINAR

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ABSTRACT

This report discusses nuclear and nonnuclear hardness in general terms. As an introduction this report contains an overview of the potential types of threats, the resulting hostile environments and effects, and some hardening techniques which have been used. The emphasis is placed on the potential impacts of logistics support of hardened systems.

PREFACE

This report shows how Air Force logistics support of hardened weapon systems can impact the system survivability. Before addressing impacts, a discussion is presented on nonnuclear and nuclear weapons, their effects, and some techniques used to harden systems.

The author wishes to thank the individuals within the Air Force Logistics and Systems Commands who have furnished information for this report. In particular, the nuclear survivability engineers at the Ogden Air Logistics Center, Hill Air Force Base UT and Lt Col J. F. Goble, Headquarters Air Force Logistics Command, deserve special mention for their assistance in developing the section involving logistics impacts.

Finally, the assistance of Ms. Nancy Stites, Air Force Acquisition Logistics Division, as the final reviewer and typist also warrants special thanks.

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1.0 Introduction

Ever since man has been fighting one another, survivability has been important. Shields offered protection from clubs, arrows, spears and other thrown objects (Fig 1.1). Armor was better than shields, but after a while even armor became inadequate for protection. And on...and on...and on.

In the late 1960's and early 1970's the US Air Force began to recognize the need for a formal survivability program. Since 1973, the Air Force Survivability Program has been under the auspices of AF Regulation 80-38, "Management of AF Survivability Program."

Air Force Systems Command (AFSC) has and continues to design, develop, and field systems which meet stated survivability requirements. We in Air Force Logistics Command (AFLC) must be able to support these systems without inadvertently degrading their survivability.

This seminar is designed to make you, the people of AFLC, aware of survivability and how you can preserve it or degrade it in your daily work.

The objectives of this seminar (Fig 1.2) are to provide a basic understanding of:

a. The meaning of hardness, survivability, and vulnerability.

b. The basic Air Force and Logistics Command regulations controlling survivability.

c. The process of establishing survivability requirements.

d. Some of the hostile threats.

e. Some of the man-made hostile environments created by different weapons.

f. Some of the effects of those hostile environments.

g. Some of the techniques used in hardening an item/system against each environment.

h. How job performance can impact hardness.

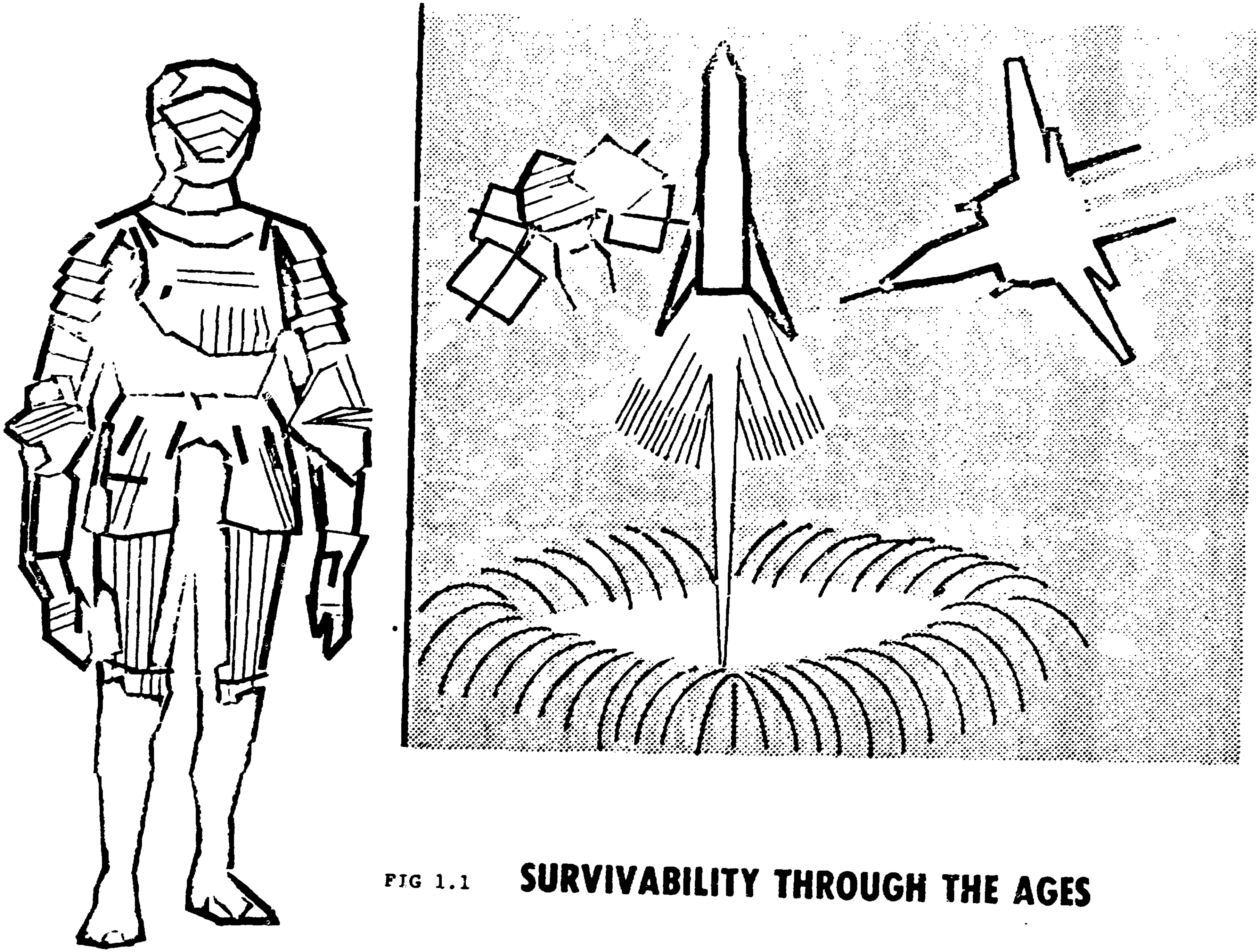


FIG 1.1 **SURVIVABILITY THROUGH THE AGES**

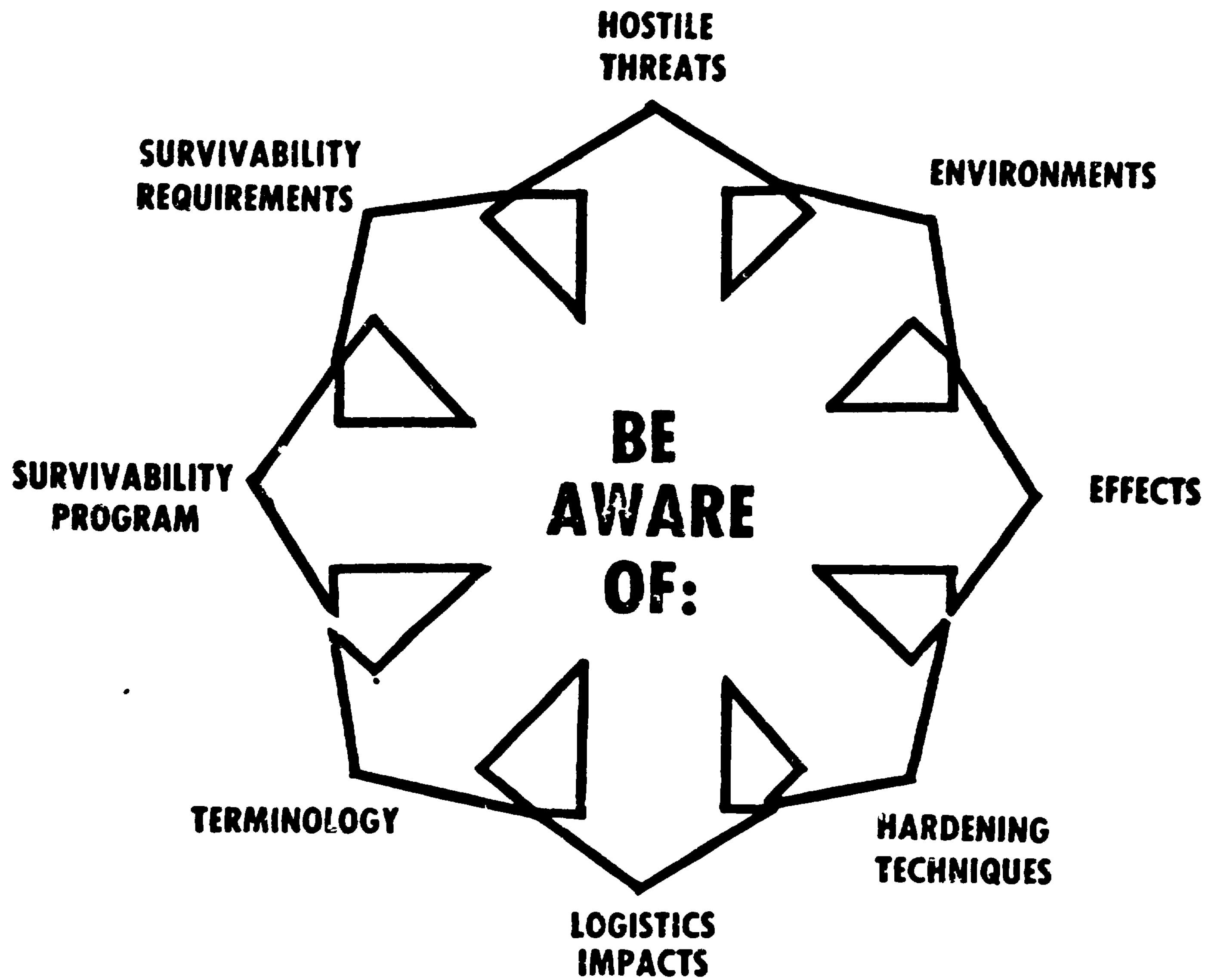


FIG 1.2 **SEMINAR OBJECTIVES**

To accomplish these objectives this presentation is broken into the following eight major areas:

a. Definitions and terminology.

b. Survivability program

(1) Objectives

(2) AFLC responsibilities

c. Establishment of requirements

d. Threats

e. Hostile environments

f. Environmental effects

g. Hardening techniques

h. AFLC/ALC Survivability Program/actions.

2.0 Terminology

Before getting into the basic definitions, I would like you to consider the following real life situation (Fig 2.1):

1. Assume that you need to protect your car against -20°F weather.

2. According to the antifreeze manufacturer, you must put 4½ quarts of antifreeze into your radiator.

3. But since you have only 4 quarts, that is all you put in.

4. Now I ask you - will your block crack if the temperature drops to -20°F? Only when you drive your car will you know for certain.

To this simple analogy we can apply some of the basic terminology used in nuclear hardness programs (Fig 2.2).

1. -20°F is the CRITERIA against which you want to protect your car.

2. If you add 4½ quarts, we say that you have HARDENED your car to the criteria level.

3. But if you added only 4 quarts, then your car is VULNERABLE.

4. Whether or not the block will crack when subjected to the criteria (that is, whether or not it is SURVIVABLE) can only be determined when you try to use the car.

Now let us look at how the Air Force defines the three major terms (Fig 2.3). They are presented here to insure that each and every one here knows what we are discussing. The source of these definitions is AFR 80-38.

1. HARDNESS: A measure of the ability of a system to withstand exposure to one or more of the effects of either nuclear or nonnuclear weapons. The measurement is against what is called a "criteria level." The criteria level is normally found in the system specification and is determined by looking at different scenarios.

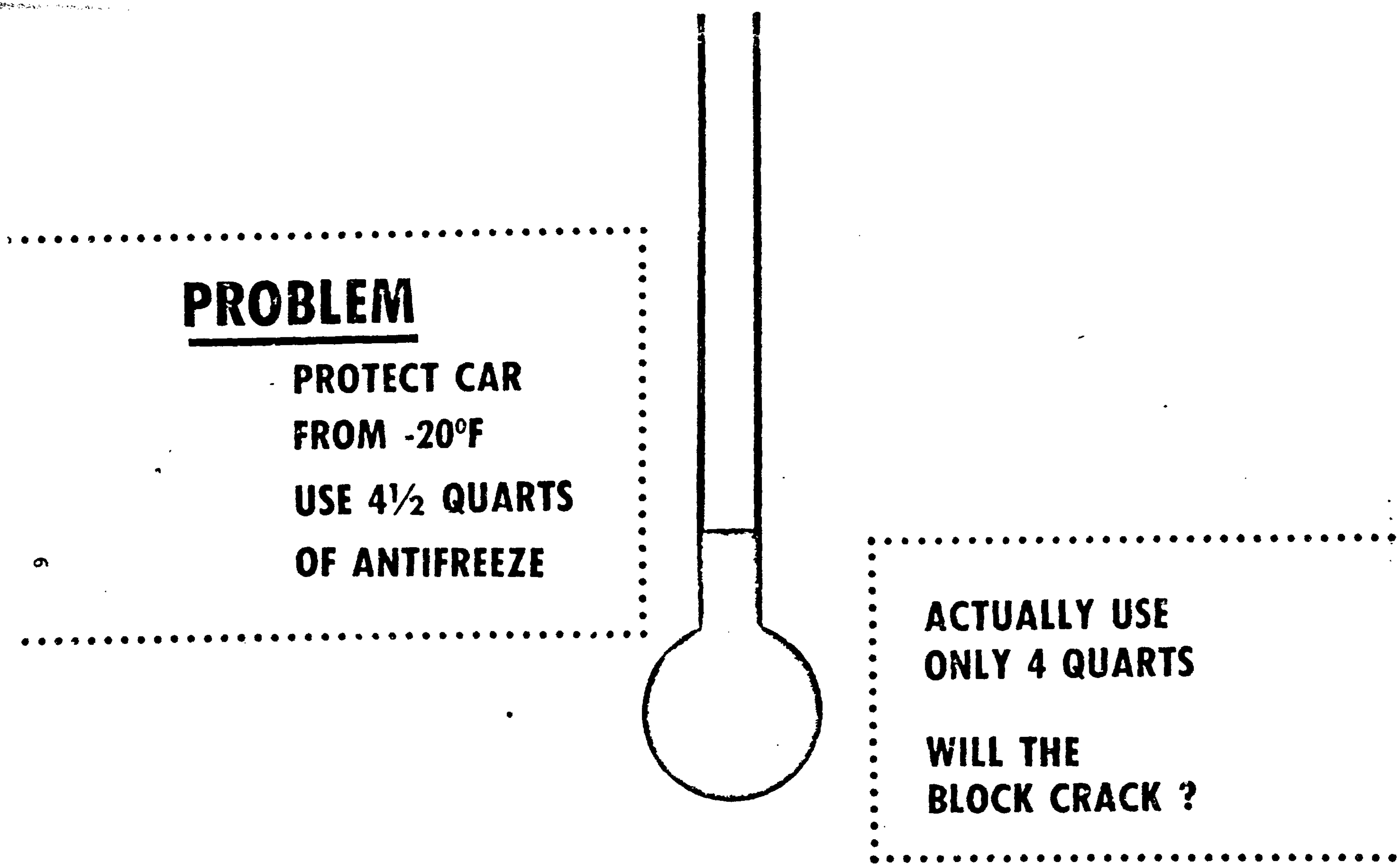


FIG 2.1 PRACTICAL SURVIVABILITY PROBLEM

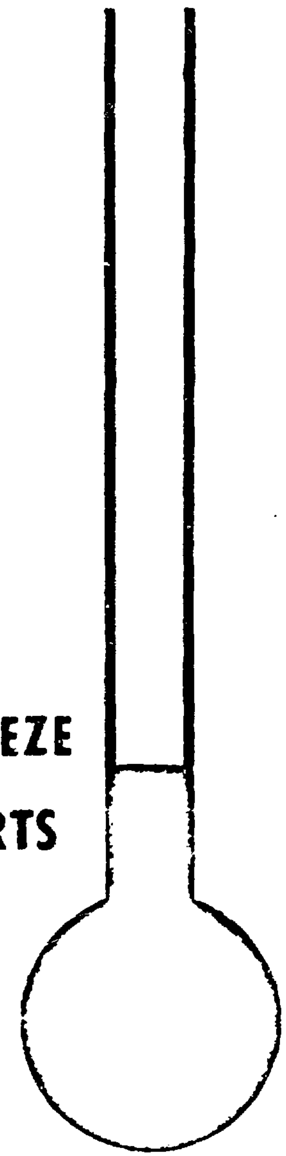
PROBLEM

PROTECT CAR FROM -20°F

USE 4½ QUARTS OF ANTIFREEZE

ACTUALLY USE ONLY 4 QUARTS

WILL THE BLOCK CRACK



TERMINOLOGY

CRITERIA

HARDENING

VULNERABLE

SURVIVABLE

FIG 2.2 PRACTICAL SURVIVABILITY PROBLEM WITH TERMINOLOGY

HARDNESS	A MEASURE OF THE ABILITY OF A SYSTEM TO WITHSTAND EXPOSURE TO ONE OR MORE OF THE EFFECTS OF EITHER NUCLEAR OR NON-NUCLEAR WEAPONS.
SURVIVABILITY	THE CAPABILITY OF A SYSTEM TO AVOID AND WITHSTAND A MAN-MADE HOSTILE ENVIRONMENT WITHOUT SUFFERING AN ABORTIVE IMPAIRMENT OF ITS ABILITY TO ACCOMPLISH ITS DESIGNATED MISSION.
VULNERABILITY	THE CHARACTERISTICS OF A SYSTEM WHICH CAUSE IT TO SUFFER A DEFINITE DEGRADATION AS A RESULT OF HAVING BEEN SUBJECTED TO A CERTAIN LEVEL OF EFFECTS IN AN UNNATURAL HOSTILE ENVIRONMENT

FIG 2.3 AFR 80-38 DEFINITIONS

2. SURVIVABILITY: The capability of a system to avoid and withstand a man-made hostile environment without suffering an abortive impairment of its ability to accomplish its designated mission.

3. VULNERABILITY: The characteristics of a system which cause it to suffer a definite degradation (incapability to perform its designated mission) as a result of having been subjected to a certain level of effects in an unnatural (man-made) hostile environment.

The interrelationship of these terms can be stated as follows: If a system's hardness is below the criteria level, then it is vulnerable to weapons effects. But, if the system can still perform its mission, then the system is survivable.

3.0 Survivability Program

Knowing what the basic terms mean, we can now begin to look at the basic objectives of the Air Force Survivability Program and the responsibilities of AFLC/ALCs.

3.1 Objectives

The AF Survivability Program is designed to accomplish four objectives (Fig 3.1). They are to assure that:

a. Air Force systems and mission equipment are capable of surviving the effects of a man-made hostile environment.

b. Survivability is fully considered in each USAF system program during the acquisition life cycle. Remember that the acquisition life cycle's final phase is "deployment."

c. System survivability is reevaluated throughout the acquisition life cycle of each system when either the hostile environment, the system or the mission is altered. You in the ALC certainly alter the system by such actions as Engineering Change Proposals (ECPs) and parts substitution.

d. System hardness is maintained throughout the acquisition life cycle of each system.

3.2 AFLC/ALC responsibilities

To accomplish these four objectives, AFLC/ALC has several responsibilities. These are given in paragraph 11, AFR 80-38 and the AFLC Supplement to AFR 80-38 (which is currently being revised at AFLC). Let us briefly go through these responsibilities (Fig 3.2). AFLC will:

a. Have a survivability program that will achieve the survivability program objectives after transfer of Air Force engineering responsibility (AFER) to AFLC. This program ideally will have been developed by AFSC with inputs from AFLC and the using MAJCOM. Then AFLC will only need to continue the program.

ASSURE THAT

- SYSTEM/EQUIPMENT CAN SURVIVE MAN-MADE HOSTILE ENVIRONMENT EFFECTS.
- SURVIVABILITY IS FULLY CONSIDERED DURING ACQUISITION LIFE CYCLE.
- SURVIVABILITY IS REEVALUATED THROUGHOUT LIFE CYCLE WHENEVER HOSTILE ENVIRONMENT, SYSTEM, OR MISSION IS ALTERED.
- HARDNESS IS MAINTAINED THROUGHOUT ACQUISITION LIFE CYCLE OF EACH SYSTEM.

FIG 3.1 **AF SURVIVABILITY PROGRAM OBJECTIVES**

AFLC WILL:

1. HAVE SURVIVABILITY PROGRAM TO ACHIEVE SURVIVABILITY PROGRAM OBJECTIVES.
2. PERIODICALLY DO ENGINEERING AUDIT/REVIEW FOR DESIGNATED SYSTEMS HAVING HARDNESS REQUIREMENTS.
3. SUPPORT OTHER COMMANDS IN IMPLEMENTING THEIR AFR 80-38 RESPONSIBILITIES.
4. COLLABORATE WITH AFSC TO ASSURE THAT:
   - AFSC DEVELOPED HARDNESS DOCUMENTATION IS ADEQUATE.
   - MAINTENANCE/REPAIR PROCEDURES AND EQUIPMENT PROVIDED BY AFSC CAN PROVIDE CONTINUED HARDNESS AFTER ENGINEERING RESPONSIBILITY TRANSITION.
5. SUBMIT SURVIVABILITY MANAGEMENT STATUS REPORT AS REQUIRED.
6. DETERMINE SURVIVABILITY IMPACT OF EACH MODIFICATION.
7. INSURE PROGRAM/CONTRACTUAL DOCUMENTATION INCLUDES PEOPER HARDNESS CRITERIA AND REQUIREMENTS FOR SURVIVABILITY ANALYSIS, TESTING, AND MAINTAINING HARDNESS.
8. COLLECT .OMBAT DAMAGE DATA.
9. REVIEW AFSC SURVIVABILITY TECHNOLOGY PROGRAM PERIODICALLY.
10. ASSURE SYSTEM HARDNESS IS MAINTAINED AND IS NOT DEGRADED BY ANY TECHNICAL ORDER CHANGE OR MODIFICATION PROGRAM.

FIG 3.2 **AFLC SURVIVABILITY RESPONSIBILITIES**

b. With assistance from the operating command, perform an independent engineering audit or review periodically for each designated system that has hardness requirements for which AFLC has AFER. This will determine if there is any justification for making survivability modifications to the system. The audit or review will look for changes in tactics, threats, attrition data and the current survivability technology. The results of the audit or review will be documented in an assessment statement on the system.

c. Support AFSC and the operating command in implementing their responsibilities of AFR 80-38. We will not go into these responsibilities, however, if any of you are interested you can find these responsibilities in AFR 80-38, paragraphs 10 and 12, respectively.

d. Collaborate with AFSC during the early phases of system acquisition to assure that (1) hardening documentation developed by AFSC is adequate and (2) the maintenance and repair procedures, as well as equipment provided by AFSC, are capable of providing continued hardness after AFER transition.

e. Submit an annual Survivability Management Status Report. This report is required for each designated system that has hardness requirements and AFLC has engineering responsibility.

f. Determine the survivability impact of each modification to any hardened system for which AFLC has engineering responsibility. Hopefully this impact study will be completed and the results made available to the proper decision makers prior to approval of the modification. There may be some instances where an emergency modification must be initiated before a survivability impact is done. However, the impact study must still be accomplished.

g. Insure that all program documentation and contractual documents issued by the systems manager includes the proper hardne s criteria and requirements for survivability analysis, testing, and maintaining hardness. This can only be done if all ALC people are aware of hardness as they develop the documentation and/ or if all documentation is submitted to a survivability/ hardness expert for review.

h. Collect combat damage data in cooperation with AFSC. This data will be used to determine the effects of damage on system design, performance, reliability, maintainability, and support costs. Notice that this is the first time that the interrelationship of the "ilities" is implied. More will be said about this later.

i. Review AFSC survivability technology program periodically to identify any potential improvements that can be applied to a system for which AFLC has engineering responsibility. When a modification is being developed, the ALC may be able to maintain the system hardness for a lesser cost if current survivability technology is applied. If the technology is currently available, the total cost may be less than paying someone to start up a line to build old technology.

j. Assure that system hardness is maintained and is not degraded by any technical order change or modifications program. This applied to each system that has hardness requirements and for which AFLC has engineering responsibility.

To accomplish the AFLC responsibilities, an AFLC Supplement to AFR 80-38 has been written. Within the supplement are the responsibilities of the Air Force Acquisition Logistics Division and the Air Logistics Centers. Since AFR 80-38 addresses systems which have hardness requirements, let us quickly review how these requirements are developed.

3.3 Establishing requirements

We have looked at the survivability program objectives. Now let us look at how AF survivability requirements come into existence (Fig 3.3).

First, identification of what is thought to be a General Operational Requirement (GOR) is generally done by the using major command (MAJCOM) although AFLC can submit a GOR. This is normally a result of looking at threats and our ability to counter these threats. The threats are defined by the intelligence community, and the ability to counter the threats is usually determined by studies done by the using command, Air Staff and/or the Department of Defense. As a result of these studies a possible need for a new capability might be identified by the using command. This need is then translated into a draft GOR, which used to be the Required Operational Capability (ROC).

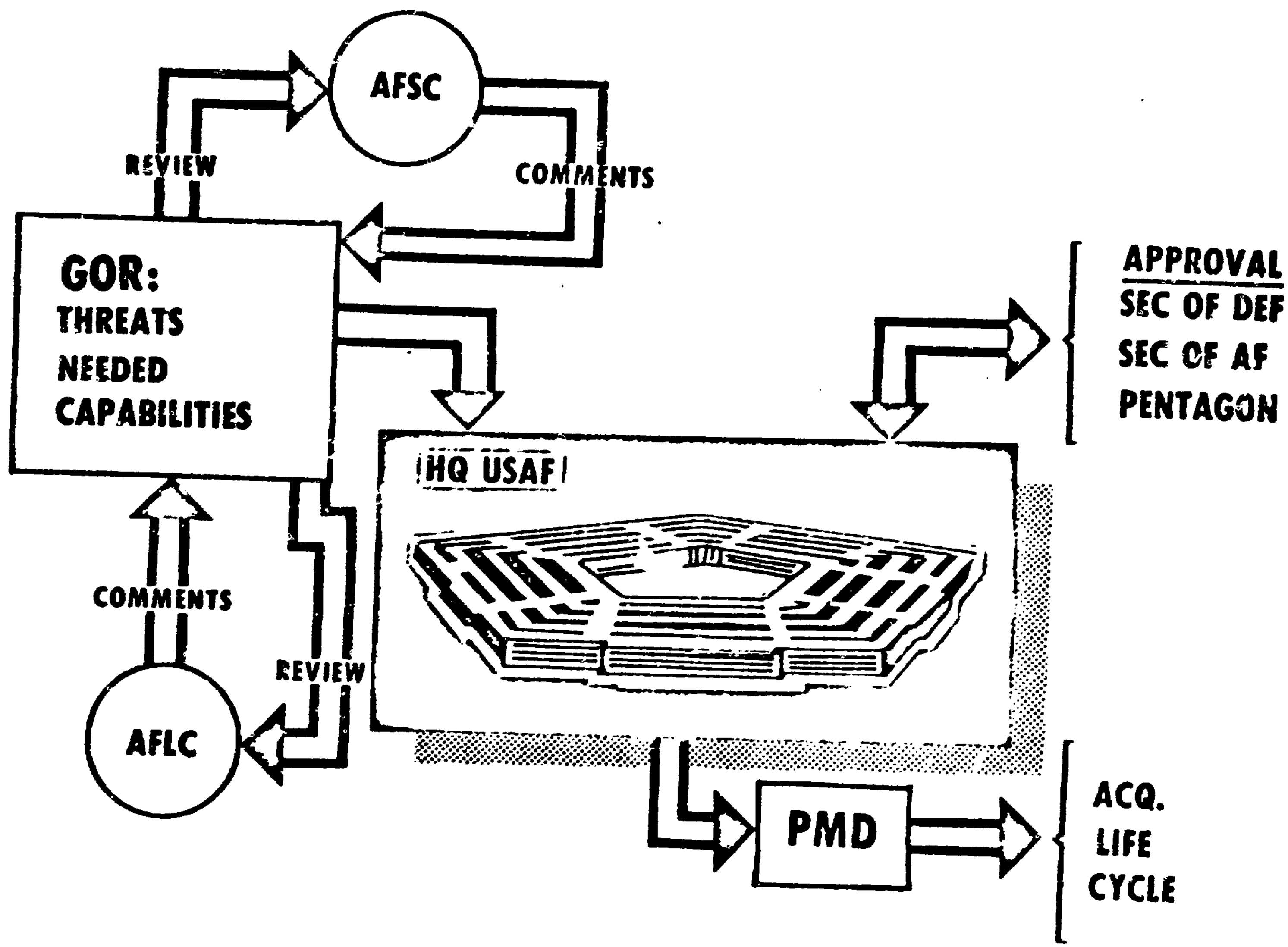


FIG 3.3 **ESTABLISHMENT OF SURVIVABILITY REQUIREMENTS**

The draft GOR is sent for review to AFSC and AFLC. These commands review the draft and submit their comments to the using MAJCOM for inclusion in the published GOR.

The MAJCOM publishes the GOR and formally submits it to HQ USAF, AFSC, and AFLC. Again, AFSC and AFLC review the GOR, but this time their comments are submitted to HQ USAF. HQ USAF staffs the GOR and resolves any questions. The Mission Essential Need Statement (MENS) is generated at Air Staff. The MENS is used to describe the mission and to justify the initiation of a new major system acquisition (DODD 5000.2).

The final approval of the GOR/MENS is granted by either HQ USAF, Secretary of Air Force, or Secretary of Defense. The primary factor which determines the approval level is the projected cost. Regardless of the level of approval, if approval is granted then HQ USAF writes a Program Management Directive (PMD) and sends it to appropriate command(s).

The issuance of the PMD for new major systems initiates the acquisition life cycle. The five phases of this life cycle are conception, validation, full scale development, production, and deployment. Although our main logistics activities occur in the deployment phase, we in Logistics Command must be actively involved in all phases of the acquisition life cycle. The five acquisition phases are impacted by hardness as follows (Fig 3.4):

PHASE	IMPACT
Conceptual	Threat Evaluation & Definition
Validation	Hardness Criteria Development
Full Scale Development	Survivability Design & Test Verification
Production	Hardness Assurance
Deployment	Hardness Maintenance (including surveillance)

Since the first area of impact addresses threats, let us look at the various threats.

CONCEPTUAL PHASE	VALIDATION PHASE	FULL SCALE DEVELOPMENT PHASE	PRODUCTION PHASE	DEPLOYMENT PHASE
THREAT EVALUATION AND DEFINITION	HARDNESS CRITERIA DEVELOPMENT	SURVIVABILITY DESIGN AND TEST VERIFICATION	HARDNESS ASSURANCE	HARDNESS MAINTENANCE

FIG 3.4 **ACQUISITION LIFE CYCLE AND SURVIVABILITY**

4.0 Threats

There are several different ways to categorize the types of threats (Fig 4.1). Some of the ways commonly used are to call them either: conventional or unconventional; tactical or strategic; guided or ballistic; and finally either nuclear or nonnuclear.

As far as the Air Force is concerned, the survivability programs categorize the threats as either from nuclear or nonnuclear weapons. The first paragraph of AFR 80-38 states this fact. Without this direction much confusion would result because of the different ways people want to label weapons and threats.

Using the two basic threat categories, we can now identify several specific types of threats or environments within these two main groups (Fig 4.2a). These specific threats must be considered in establishing the requirements and specifications for aerospace systems and in providing logistics support to these systems.

4.1 Nonnuclear

There are several sub-categories in the broad class of nonnuclear threats. The main sub-categories are: small arms weapons and anti-aircraft artillery; missiles (surface-to-air and air-to-air); electromagnetic radiation (EMR); lasers; chemical weapons; and biological weapons.

The last three threats (lasers, chemical, and biological weapons) and their resulting hostile environments will not be addressed any further in this seminar. Some current effort is being expended in studying the effects of at least one of these types of weapons; however, almost everything is classified.

This leaves four sub-categories in the nonnuclear threats group: small arms, anti-aircraft artillery, missiles, and EMR. By looking at these threats from a different viewpoint, the nonnuclear threats can be categorized as nonexplosive projectiles, explosive projectiles, and EMR (Fig 4.2b).

4.2 Nuclear

Only two sub-categories are considered in the broad class of nuclear threats. They are tactical and strategic

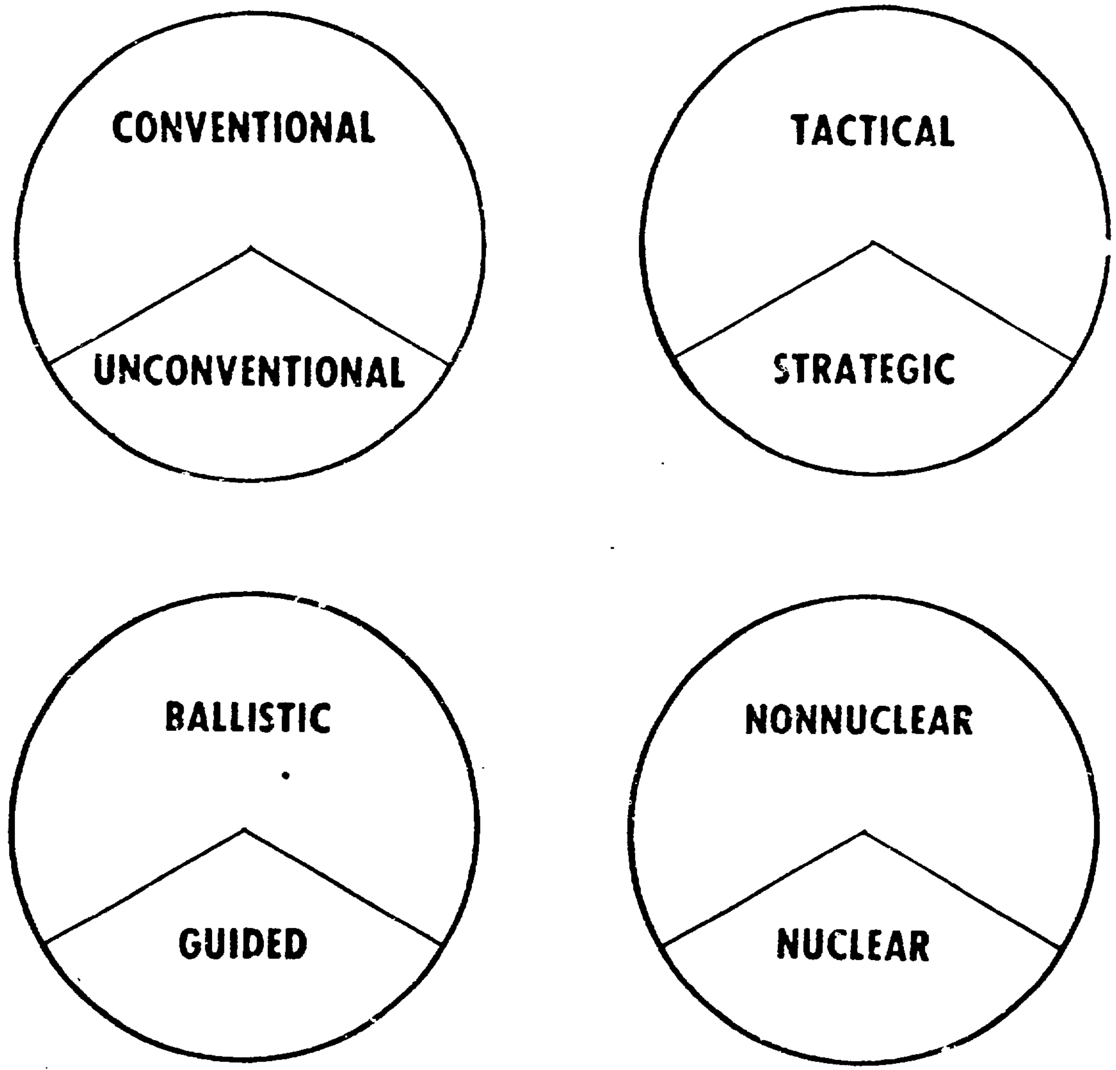


FIG 4.1 **THREAT CATEGORIES**

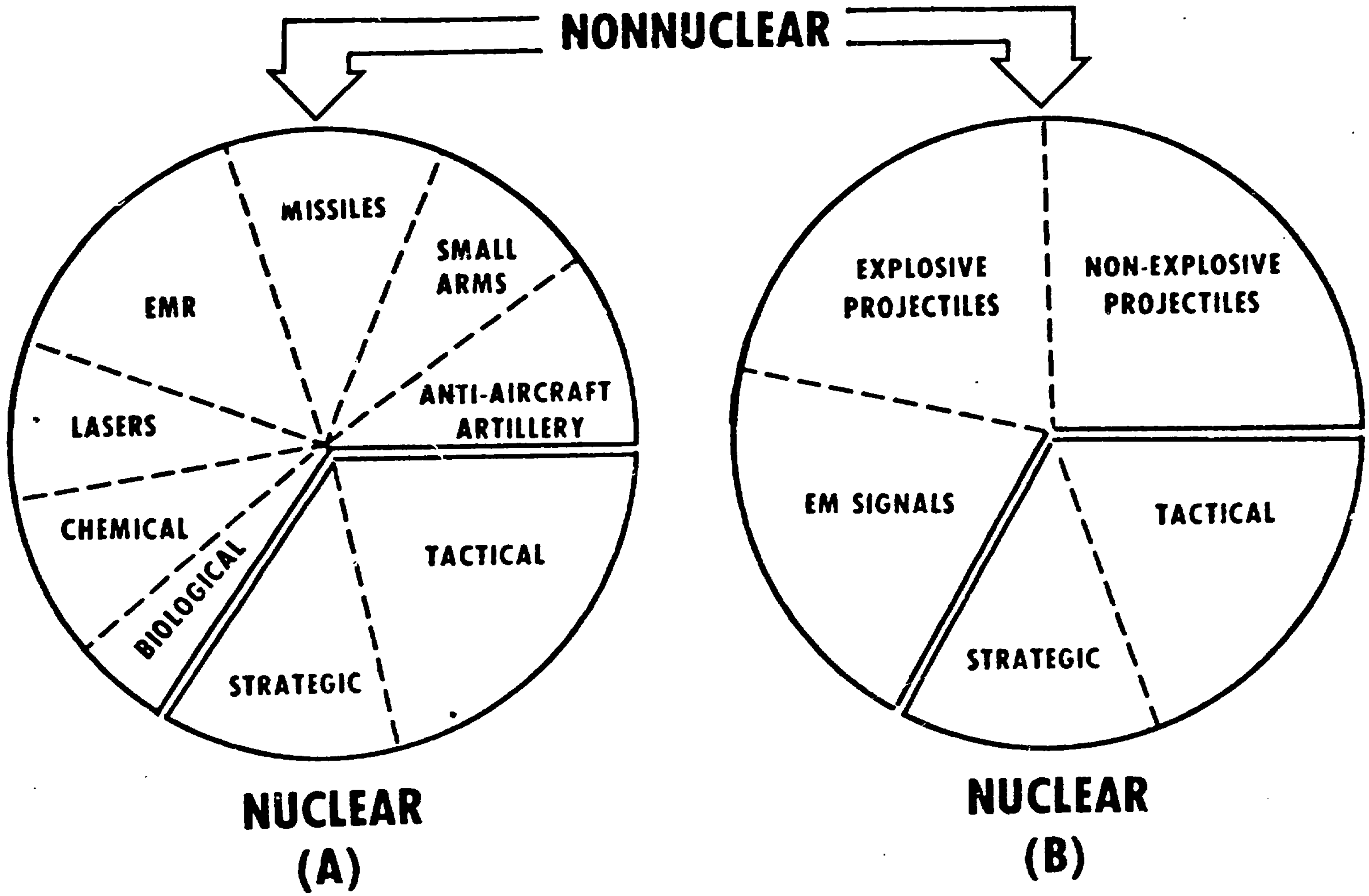


FIG 4.2 **TYPES OF THREATS**

nuclear weapons. However, the hostile environments resulting from either a tactical or strategic nuclear weapon are basically of the same types. The major difference is the level or order of magnitude of the environment. To keep this course unclassified, the actual levels will not be discussed; however, if you have a valid need to know, I am certain that you can find out these levels for specific systems/weapons.

Each threat or weapon-type produces a variety of potential hostile environments. We will look at the different environments and then their potential effects upon an aerospace system.

5.0 Hostile environments

(Fig 5.1) The hostile environments resulting from either nuclear or nonnuclear threats depend on the type of weapon and, in the case of explosions, the point of detonation relative to the weapon system. In the case of nuclear weapons, another important factor is whether the detonation was below the surface, at the surface, in the atmosphere, or outside of the atmosphere (exoatmospheric).

We will first consider the nonnuclear environments resulting from the threats just discussed. Then the nuclear environments will be briefly looked at.

5.1 Nonnuclear

(Fig 5.2) Looking at the nonnuclear threats we find that the environment is either a result of non-explosive projectiles, explosive projectiles (including missile warheads), or some type of electromagnetic signal. Let us look more closely at these hostile environments.

Non-explosive projectiles are those items such as bullets which are designed not to explode. The normal range of sizes of this type projectile is 7.62mm - 23mm (0.3 in - 0.9 in). This represents the range of weapons from the AK-47 automatic rifle through the guns on the MIG fighters. There are several types of these projectiles and each presents some unique effect on aerospace systems. The non-explosive projectiles can be categorized as a solid ball, armor piercing (incendiary or non-incendiary), and tracers.

Explosive projectiles are designed to cause damage/destruction as either a direct result of the explosion or as a result of the effects of the produced fragments and/or the blast of the explosion. Whether the explosive projectile is a relatively small explosive bullet or a large missile warhead, the type of resulting hostile environment is the same, but the magnitude is much different.

An enemy can generate . ectromagnetic signal to jam our systems, electroni...ly camouflage their systems, or interrupt control signals from our aircraft to electronically guided missiles.

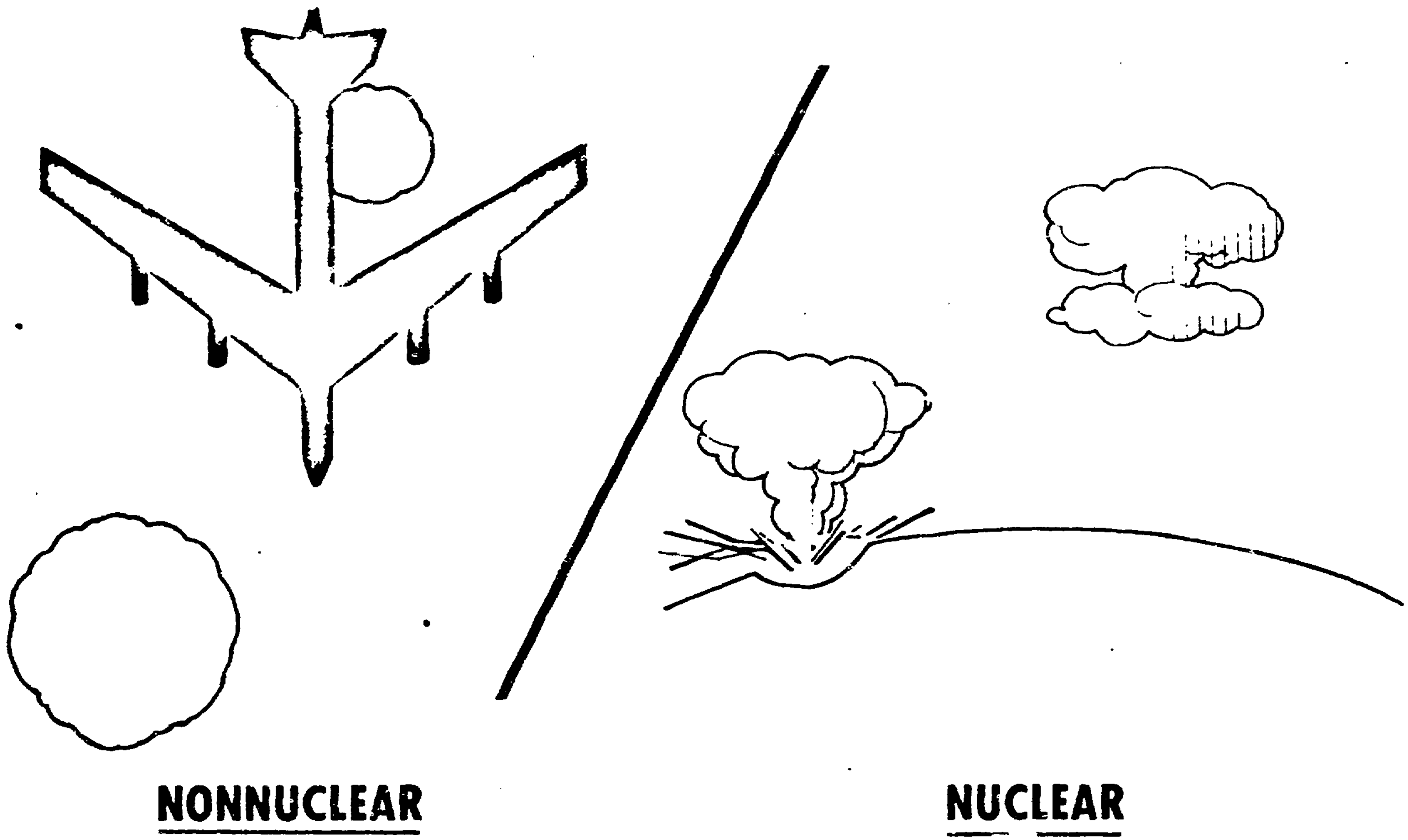


FIG 5.1 HOSTILE ENVIRONMENTS VS DETONATION POINT

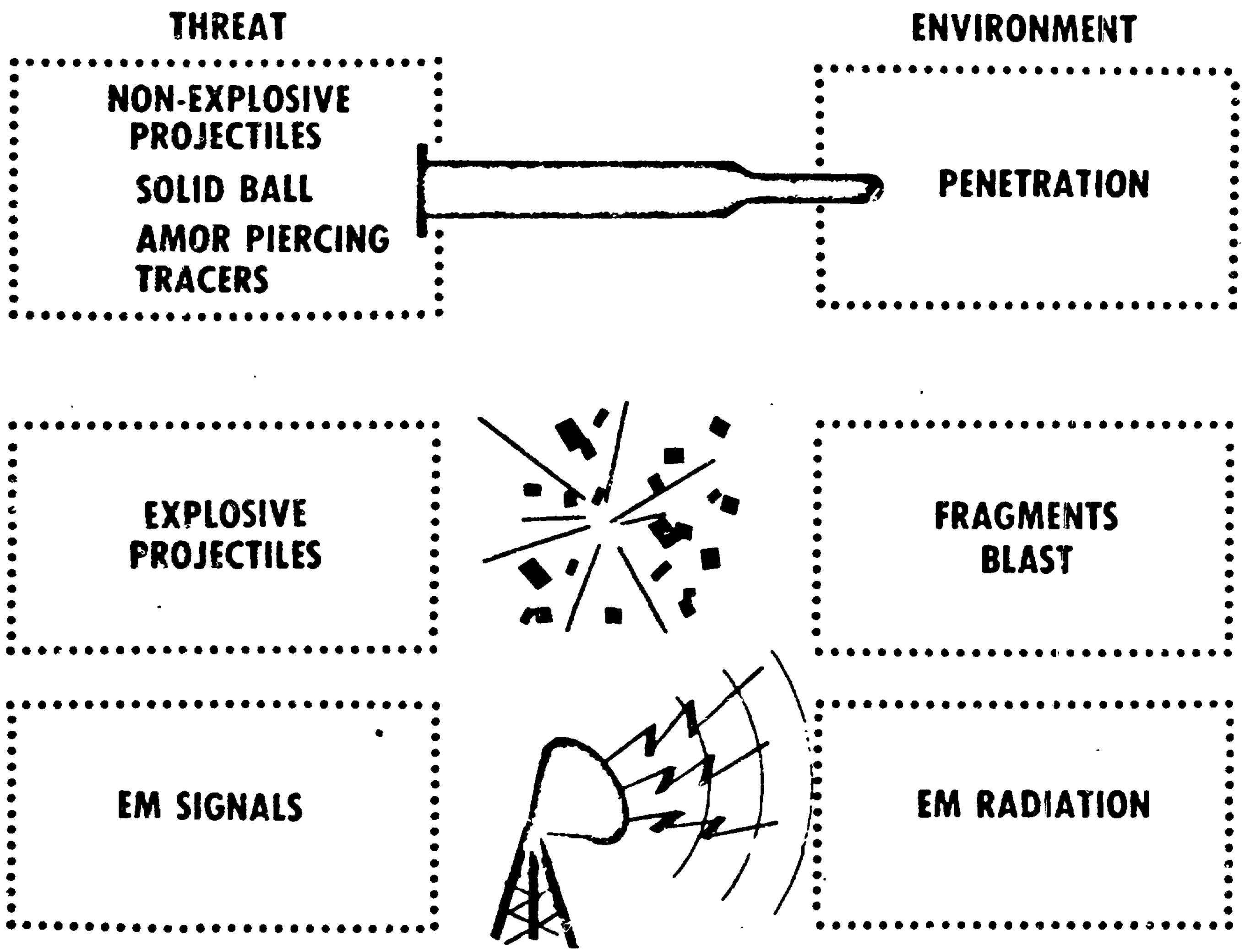


FIG 5.2 **NONNUCLEAR HOSTILE ENVIRONMENT**

5.2 Nuclear

As previously mentioned, one of the primary factors which determines the hostile environments resulting from a nuclear explosion is the point of detonation. In this awareness seminar we are only concerned with identifying the hostile environments which might affect an aerospace system. We will not go into the details of how to compute the actual environmental levels reaching any system. (Fig 5.3) The hostile environments which can be produced by a nuclear explosion are: a fireball, an electromagnetic pulse, thermal radiation, nuclear radiation (primarily neutrons, gamma rays, and x-rays), airblast, noise, ground shock, crater, ejecta/debris, and fallout.

The first environment is that of the nuclear fireball. Now all of us at one time or another have seen pictures of the fireball. For all practical purposes any system which can be directly affected by the fireball will be destroyed. It is not practical to design a system to withstand the tremendous heat within a fireball. Therefore, the fireball is not an environment for us to concern ourselves with any further.

The second environment caused by a nuclear explosion is an electromagnetic pulse. This is commonly called "EMP." EMP is "a high intensity pulse of radiofrequency energy produced by the electric charge and current distribution about the point of detonation of a nuclear weapon." This can be thought of as a gigantic lightning bolt, but several subtle differences between the two exist. The nuclear explosion causes charged particles to be created. These are trapped by the earth's magnetic field. This can cause severe communications problems when electrical signals are propagated through the atmosphere.

By thermal radiation, the third nuclear environment, we mean the tremendous amount of heat energy emitted by a nuclear explosion. The resulting thermal (heat) energy can be many times greater than the thermal energy from the sun. The energy spectrum of this type of radiation includes, but is not limited to, the visible, the ultraviolet, and the infared wavelengths.

The fourth nuclear environment is called nuclear radiation. There are several types of nuclear radiation;

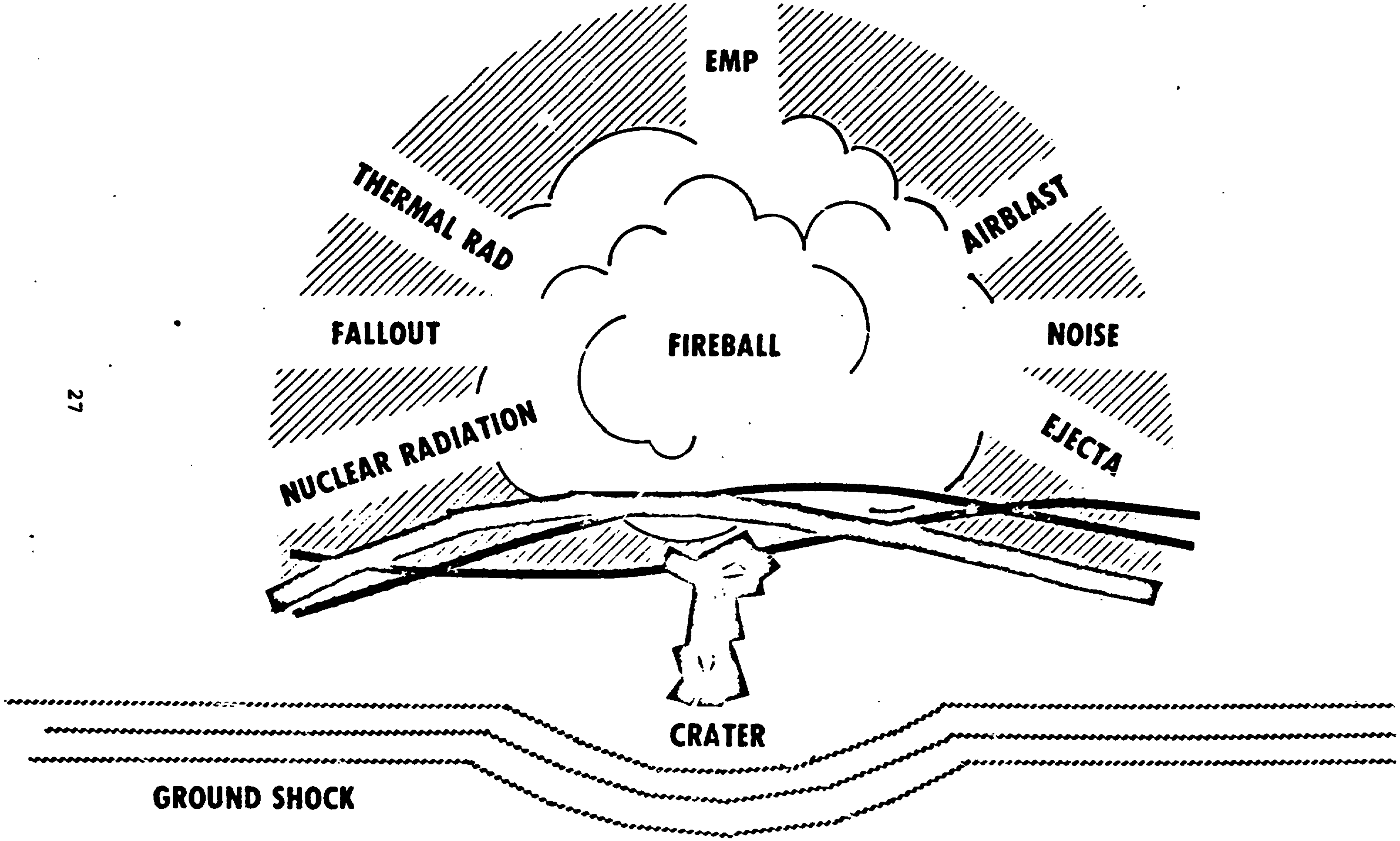


FIG 5.3 **NUCLEAR HOSTILE ENVIRONMENTS**

however, we are concerned primarily with gamma rays, x-rays, and neutrons. Gamma and x-rays are electromagnetic in character (i.e., they consist of oscillating electric and magnetic fields.) They also can be thought of as charged particles such as electrons. The neutron is an uncharged particle, but can cause internal changes in materials to take place. For these reasons nuclear radiation is an environment of concern to us.

The next nuclear environment is airblast. Airblast is caused by the expanding gases in the fireball creating a shock wave in the atmosphere. This shock wave moves outward from the point of detonation. Airblast can be divided into two sub-environments. The first is overpressure (transient pressure exceeding atmospheric pressure) and dynamic pressure (high velocity). The overpressure caused by this shock wave may be hundreds of pounds-per-square-inch (PSI). Remember that the normal atmospheric pressure at sea level is only 14.7PSI. The airblast can strike any exposed surface and penetrate any structural opening (i.e., airducts to underground structures). In addition, airblast can cause two other environments: noise and ground shock.

Noise can be any sonic disturbance. Thus, the airblast can cause noise. The noise can be so intense as to cause injury to exposed personnel. More about this when we start talking effects.

Ground shock can be the result of the airblast exerting pressure on the earth's surface or of a surface/sub-surface nuclear detonation which rapidly compresses the ground at the point of detonation. In either case ground shock can be thought of as an extreme earthquake. The Alaskan earthquake was just a tremor in comparison. If the nuclear explosion is a surface or sub-surface burst, then a crater will be produced. The crater will cause the surrounding soil to be compressed and stress to propagate through the soil. The soil is either blown out of the hole, carried up into the atmosphere, or burned away.

This gives the last two nuclear environments: debris and fallout. Debris is the soil ejected outward and can be thought of as high velocity bullets. The size varies from microscopic dust particles up to boulders.

Fallout is the relatively small particles which are carried upward into the atmosphere cloud. The largest of the sucked-up particles immediately begin to settle to earth, but the microscopic particles can remain airborne for years. This fallout is radioactive and therefore can be extremely dangerous. The rate and area of fallout is dependent upon such atmospheric conditions as wind direction and speed and whether or not precipitation is occurring.

We have just identified the threats/hostile environments (Fig 5.4). Let us now look at the effects of these environments.

THREAT	HOSTILE ENVIRONMENT
NONNUCLEAR	NON-EXPLOSIVE PROJECTILES EXPLOSIVE PROJECTILES EM SIGNALS
NUCLEAR	FIREBALL EMP THERMAL RADIATION NUCLEAR RADIATION NEUTRONS GAMMA RAYS X-RAYS AIRBLAST NOISE GROUND SHOCK CRATER EJECTA/DEBRIS FALLOUT

FIG 5.4 HOSTILE ENVIRONMENT VS THREAT

6.0 Effects

In looking at some of the effects resulting from a weapon system being exposed to a hostile environment, we will follow the same sequence as previously. Before getting into specifics, I would like to make a few general comments:

a. We will not be looking at all possible effects caused by each environment. It would take months to do this.

b. Much has been written on specific efforts (e.g., "Vulnerability Analysis of the A-10 Aircraft to Impacting 23-mm HEIT and 57-mm HE Projectiles, SA-7 Missile Warhead, and a Proximity-Fuzed Surface-to-Air Missile," ASD). If you have a specific need or problem, you might find a report has already been written about that specific problem or one very similar. Therefore, one should make certain that the question at hand has not already been answered. The cost of a report in time and money is usually much less than the cost of analysis, research, and/or testing.

Let us now look at the effects of nonnuclear and then nuclear environments.

6.1 Nonnuclear

The nonnuclear threats of projectiles (explosive and nonexplosive) can destroy or damage an Air Force system through the following three weapon effects: penetration, blast, or ignition (Fig 6.1).

The penetration effect can be a result of a non-explosive projectile, an explosive projectile which has not exploded, or a fragment produced by an exploded projectile. The following are some of the possible results of a penetration (Fig 6.2).

a. A crew member is killed or incapacitated. This is especially critical when the crew consists of only the pilot.

b. The fuel tank may be punctured or a line cut. If the tank is not self-sealing, enough fuel may be lost to cause the plane to make an undesired landing. Even

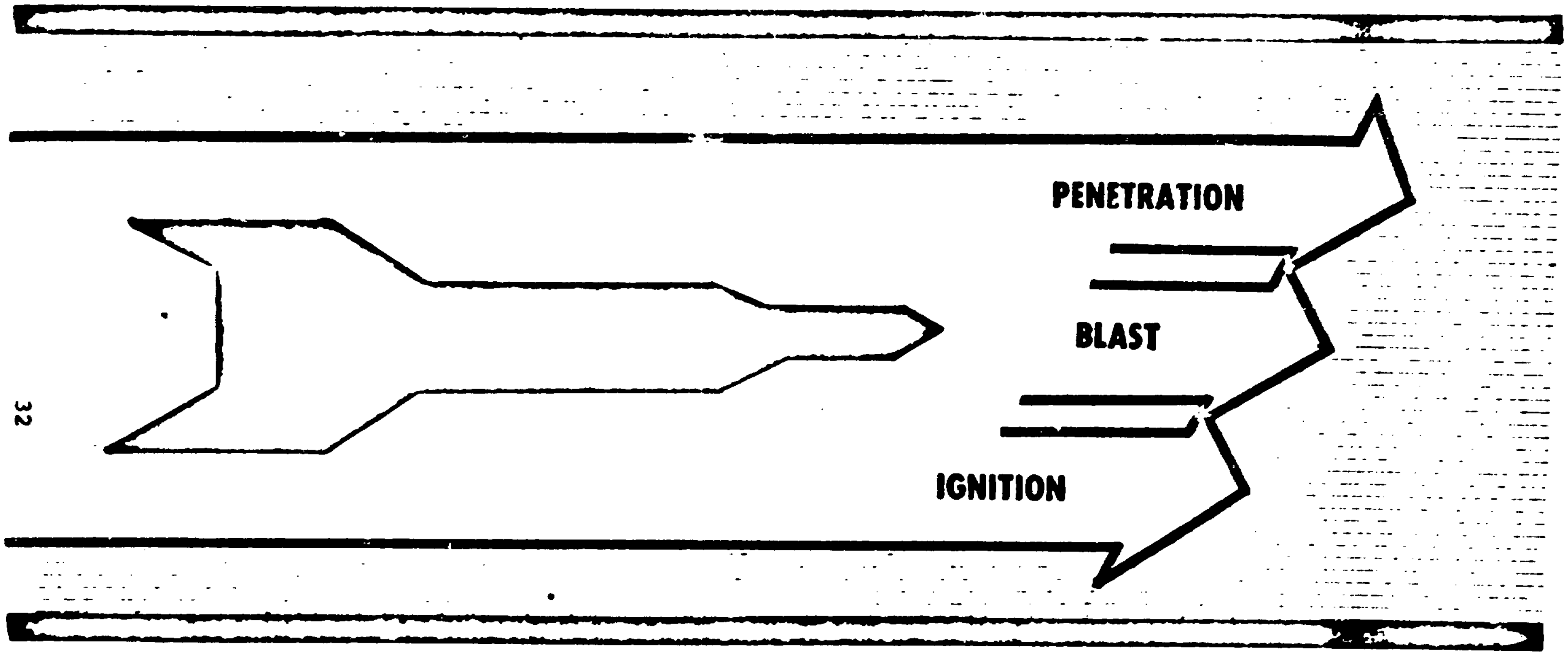


FIG 6.1 **EFFECTS OF PROJECTILES**

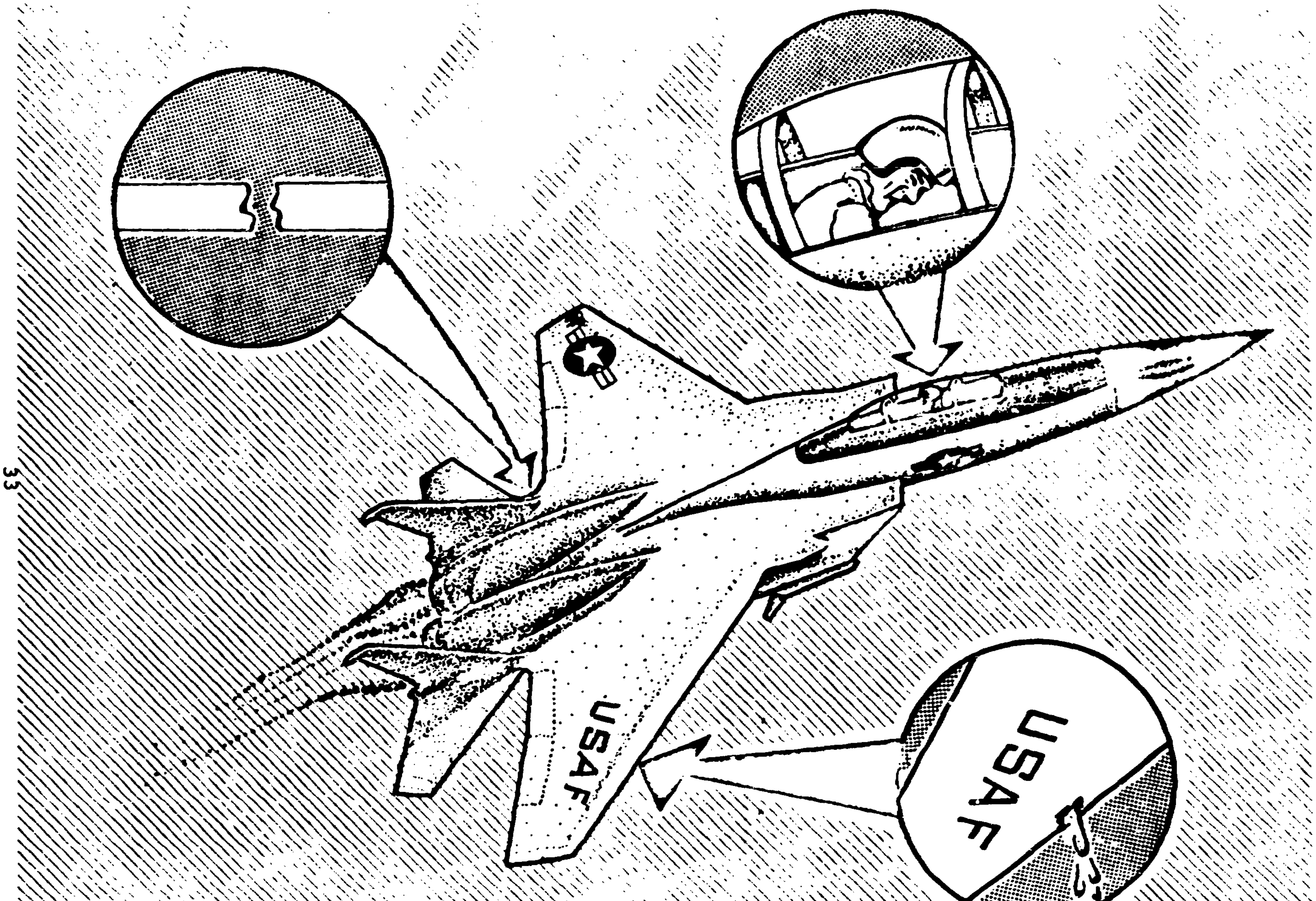


FIG 6.2 **PENETRATION EFFECTS**

if the tank is self-sealing the penetrating projectile may cause hydraulic ramming resulting in a massive tank rupture.

c. Control cables or lines may be severed or damaged. This may result in an uncontrolled flight, an inability to launch weapons, or an inability to make a safe landing.

d. Other mission essential equipment may be made inoperable. Mission essential as used in this seminar is defined as any item within the system which is required to accomplish the system's wartime mission.

Blast from an explosive projectile is the second nonnuclear threat effect. The explosive projectile may range from a 23mm explosive round from a MIG up to a missile warhead, either AAM or SAM. The explosion may take place outside or inside the aerospace system. The major blast effects (Fig 6.3) upon an aircraft may be:

a. Destruction of the aerodynamic stability of the airplane. The damage/loss of control surfaces might cause crashing.

b. Rupturing of the fuel system by an internal blast.

c. An inability to release weapons. This may be a result of jammed bomb bay doors or bent launching rails.

The third and final projectile threat is ignition. This may be caused by a live tracer or an exploding projectile. Naturally, the primary areas of concern center around flammable fluids. The results are obvious.

The final nonnuclear environments, electromagnetic signals generated by an enemy, may cause a jamming of our equipment (Fig 6.4). The results could be a partial or, worse yet, a total mission failure. For example, a missile launched from an airplane, but controlled by electronic signals may never reach its target if the enemy can interrupt these control signals.

Also, if the control communications are jammed, then command and control capabilities of a system can be

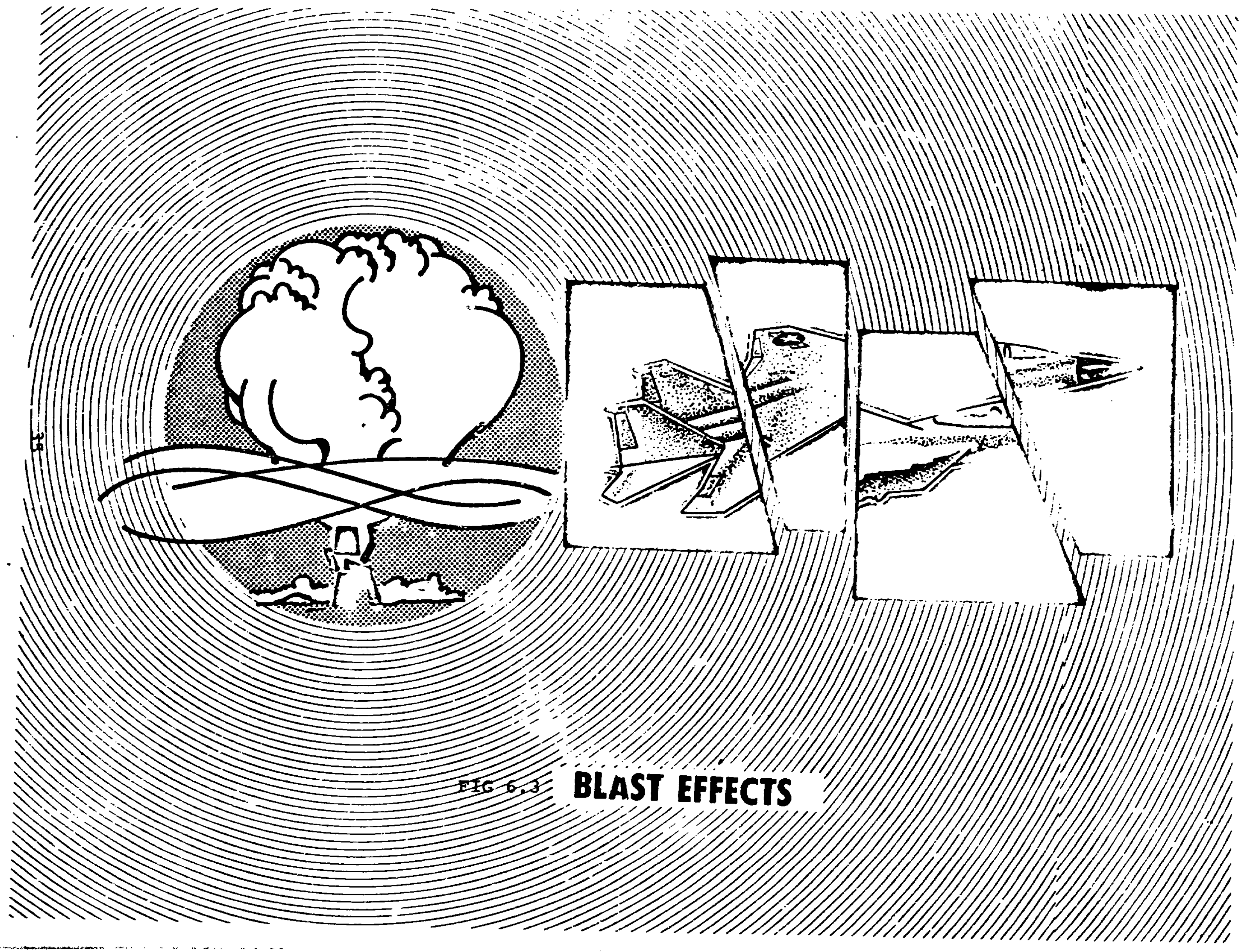


FIG 6.3 **BLAST EFFECTS**

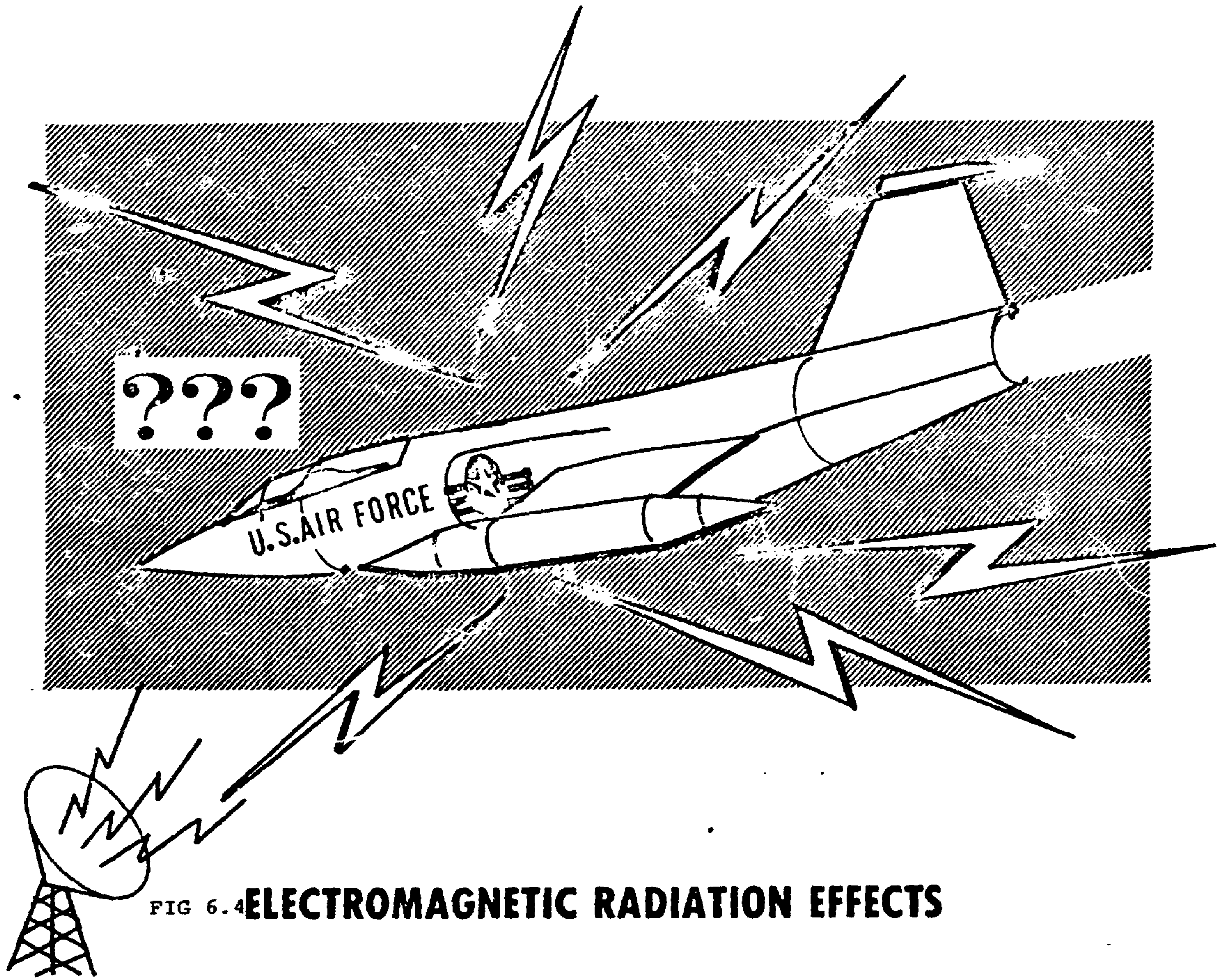


FIG 6.4 ELECTROMAGNETIC RADIATION EFFECTS

lost. Without proper control, the usefulness of a weapon system is drastically reduced.

6.2 Nuclear

Now let us turn our attention to what are commonly referred to as "nuclear effects." These are the effects of the various hostile environments resulting from a nuclear detonation. Let me emphasize here that we are going to speak in generalities only! Let's not fool ourselves into thinking that this awareness seminar will make anyone smart enough to solve a specific nuclear hardness problem.

Before investigating the effects of specific environments (Fig 5.3), two main facts must be considered. First, the actual effects are very dependent upon the weapon yield (size of warhead); the point of detonation relative to the earth; the distance of the system from the explosion; the system being studied; and the atmospheric and soil conditions (if applicable). The second fact that must be considered is that nuclear effects are synergistic (i.e., the total effect or damage to the system may be greater than the sum total of the individual effects). For example, in studying the effect of airblast one usually does not normally consider the fact that the structural characteristics may have been altered by the thermal radiation. Let us now consider the effects of each nuclear environment.

The first nuclear environment is the electromagnetic pulse (EMP). The nuclear explosion causes charged particles to be created. These are trapped by the earth's magnetic field. EMP can, in a very simplistic manner, be thought of as a giant lightning bolt and may create hundreds of thousands of volts per meter of electromagnetic energy. Some of the effects of EMP upon a system are (Fig 6.5):

a. Disrupts atmospheric propagation of communication signals. We probably all have tried to listen to an AM radio during a lightning storm so we have a very rough idea of this effect.

b. Spurious high voltage and current pulses can be produced by induction in antennas and cables through openings in structure. This can damage electronic devices

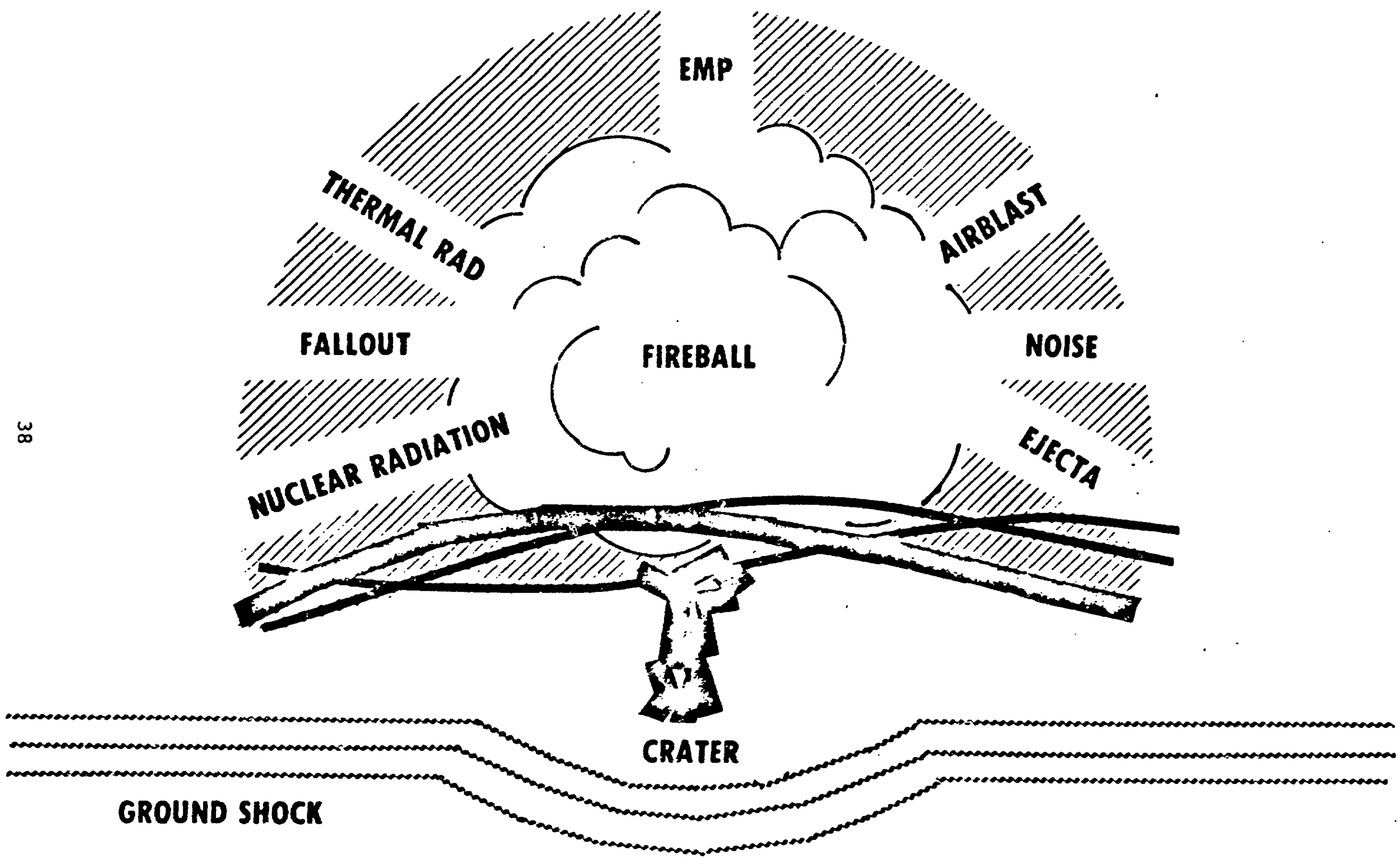


FIG 5.3 **NUCLEAR HOSTILE ENVIRONMENTS**

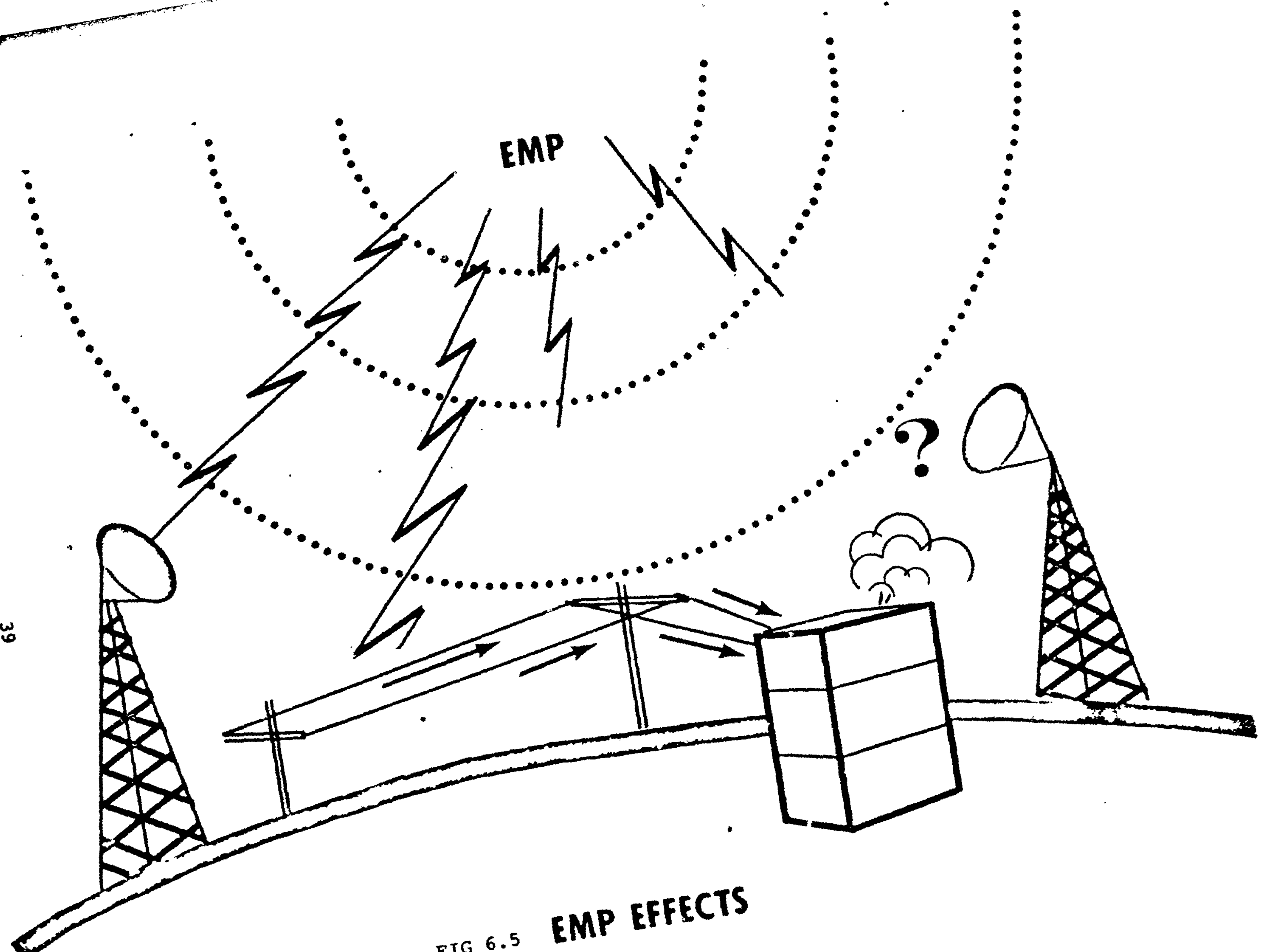


FIG 6.5 **EMP EFFECTS**

internally or possibly melt the exterior junctions. This damage is similar to a lightning-induced voltage surge.

c. Memory devices can be damaged or disturbed by the magnetic field pulse.

The effects of thermal radiation, the second nuclear environment, can also destroy systems. Recall that thermal radiation is similar to, but many, many times greater than the sun. Some of the thermal radiation is in the visible spectrum. The effect is that anyone without special protective devices looking at the explosion when it occurs will(Fig 6.6):

a. Be at least temporarily blinded and may well be permanently blinded. The human eyelid does not react fast enough to close. If this happens to a pilot, he won't be able to fly the plane, let alone land it.

b. The exposed skin may receive burns ranging from first to third degree.

In addition to these human effects, thermal radiation can cause:

a. Spontaneous ignition. This can be significant if the crew is not protected from nuclear effects.

b. Ablation of structural material. This means simply that the outer layer of material may be burned away or evaporated. If this happens unexpectedly, the aerodynamics of the airplane or missile are changed.

c. Structural properties may be drastically altered even if the structure's outward appearance is only changed slightly. This may be the "straw that broke the camels back" - synergistically speaking.

Nuclear radiation causes different effects than thermal radiation. Nuclear radiation consists primarily of neutrons, gamma rays, and x-rays. We can think of this radiation as being generated by a colossal cobalt treatment machine or a bare nuclear reactor. X-rays are like gamma rays except that x-rays have less energy and a lower frequency. In this seminar we are concerned with only an understanding of what the effects of this radiation are, not the detailed physics of the radiation.

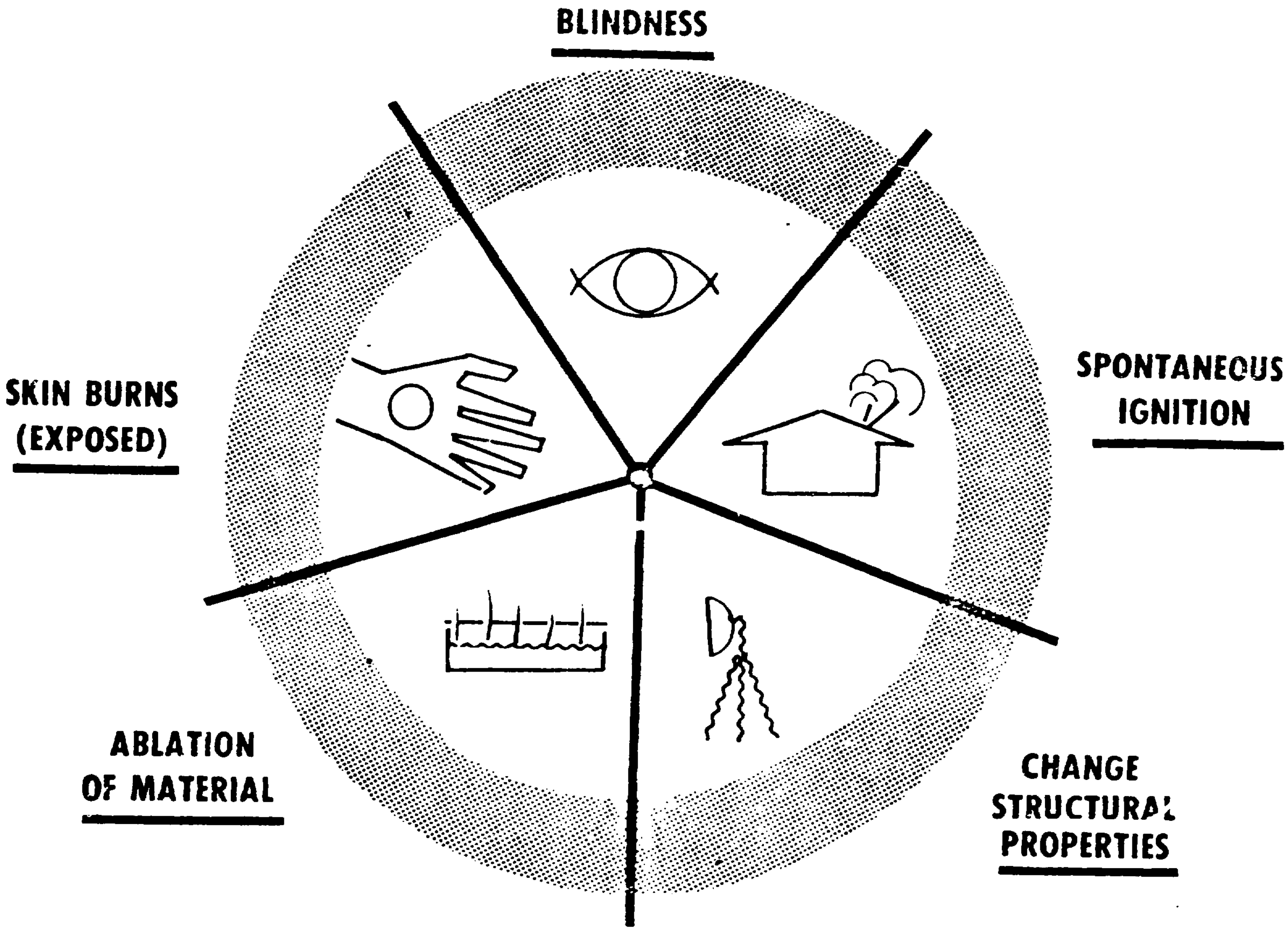


FIG 6.6 **THERMAL RADIATION EFFECTS**

There are two basic effects of nuclear radiation (Fig 6.7):

a. Nuclear radiation can cause biological damage. The effects can range from instantaneous incapacitation to long-term effects. Usually the incapacitating effect is the major radiation effect of concern to us. The person won't be able to perform the mission.

b. Nuclear radiation can damage or degrade electronic equipment (particularly semiconductors). Three major types of damage can result involving electronic equipment. They are displacement damage, surface damage, and photocurrent effects. Since just about every Air Force system contains some electronics let's briefly look at these three modes of damage, but remember out goal is to only be aware of the effects.

(1) Displacement damage reduces the lifetime, the concentration, and the mobility of the carriers within the semiconductors when exposed to neutron radiation.

(2) Surface damage is caused by ionizing radiation (x- and gamma rays) affecting semiconductor surfaces. The net result may be a failed semiconductor.

(3) Photocurrent effects are transient changes in the device. These changes can cause a current to be induced within the semiconductor. These effects may cause the circuit to malfunction and therefore, the mission to be uncompleted.

Two different effects of airblast, the fourth nuclear environment, are possible (Fig 6.8). As previsouly mentioned, airblast can cause a shock to be induced into the ground. The effects of this air-induced ground shock will be mentioned later. The second possible airblast effect is direct damage or destruction to a structure.

Most, if not everyone, has seen damage caused by very high winds. This gives a very rough idea as to some of the damage which can be caused by airblast (e.g., buildings damaged/destroyed, antennas destroyed, and structural failure of aircraft).

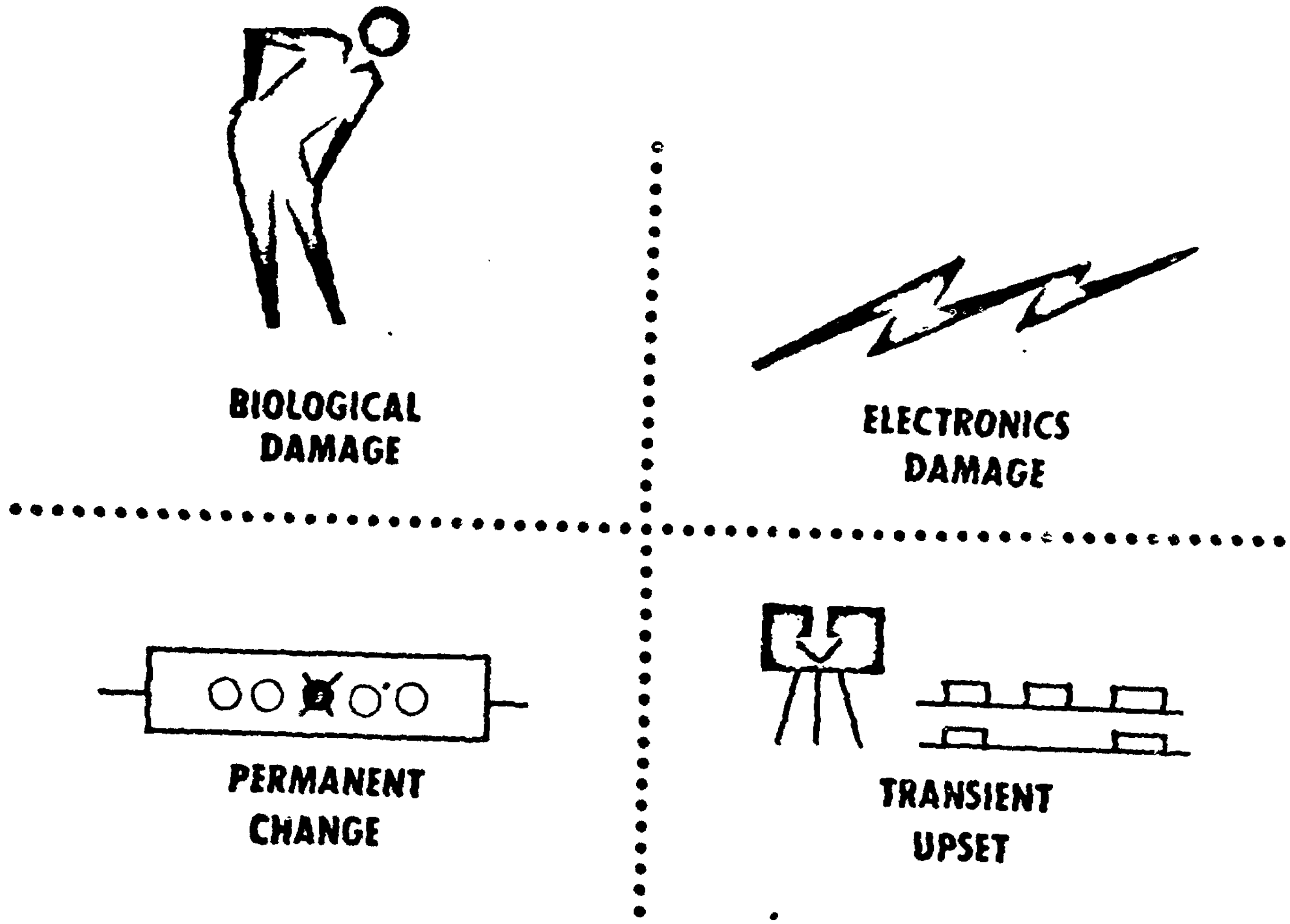


FIG 6.7 **NUCLEAR RADIATION EFFECTS**

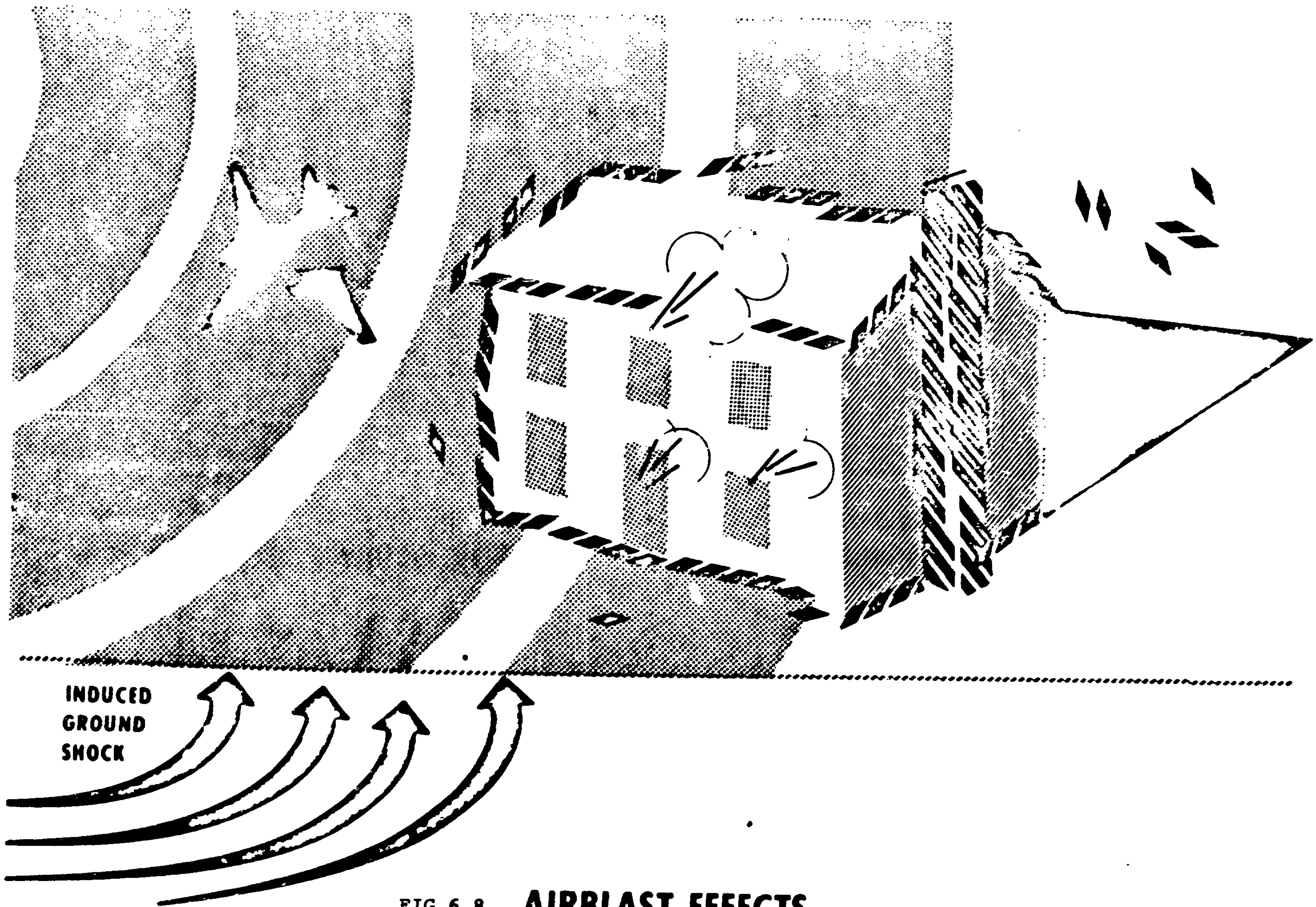


FIG 6.8 **AIRBLAST EFFECTS**

Acoustic noise can cause injury to personnel and equipment or cause verbal communications to be impossible (Fig 6.9). People's eardrums can be broken, or a person's ability to reason can be impaired so much that they cannot perform even simple tasks. Even if a person can do his/her job, the noise in the facility might be so great that talking might be impossible. Anyone who has ridden in an automobile with the window rolled down just enough to cause a whistling (i.e., noise) knows that communicating may be very difficult, if not impossible.

Also, since noise is just vibrating air some equipment may have vibrations induced into them. This can cause problems like chattering relays which in turn can generate spurious electrical signals.

The effects of ground shock (Fig 6.10) have probably been seen by each of us. Remember, we said earlier that ground shock can be thought of as a gigantic earthquake. Therefore, the damage effects are very similar. Structures, cables, and other equipment which are buried can be crushed, ruptured, or shaken into a failed condition. Above ground structures may collapse as a result of ground shock, airblast or a combination of these two hostile environments. Aircraft normally are not designed to survive a hostile ground shock environment.

No system has been designed to withstand the cratering environment. Enough said about cratering.

However, some systems are designed to survive the debris environment caused by a nuclear detonation. Some of the major effects of debris are (Fig 6.11): piling up and preventing entrances from opening; piling up and attenuating radiated signals to and from antennas; impacting on above-ground structures and damaging or destroying them; or falling into a buried structure when the entranceway is opened resulting in damage to equipment and/or personnel.

Fallout, the final nuclear environment, can have two types of effects: immediate and delayed. The radiation effects from the fallout depend upon how "radioactive" the fallout is and how long the person is exposed. Short exposures to large amounts of radiation may cause a person to become so sick that the job cannot be performed. Long exposures to small

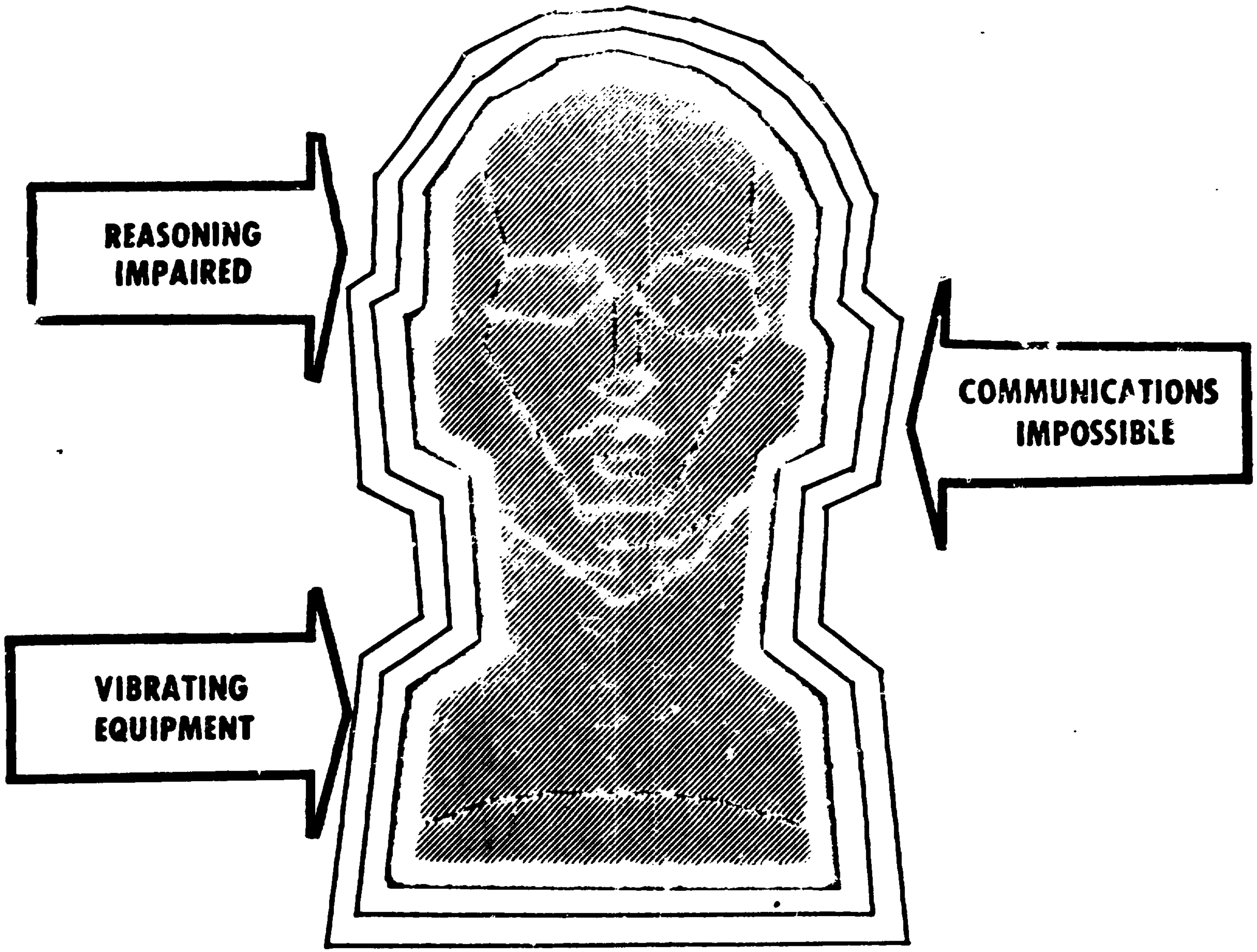


FIG 6.9 **ACOUSTIC NOISE EFFECTS**

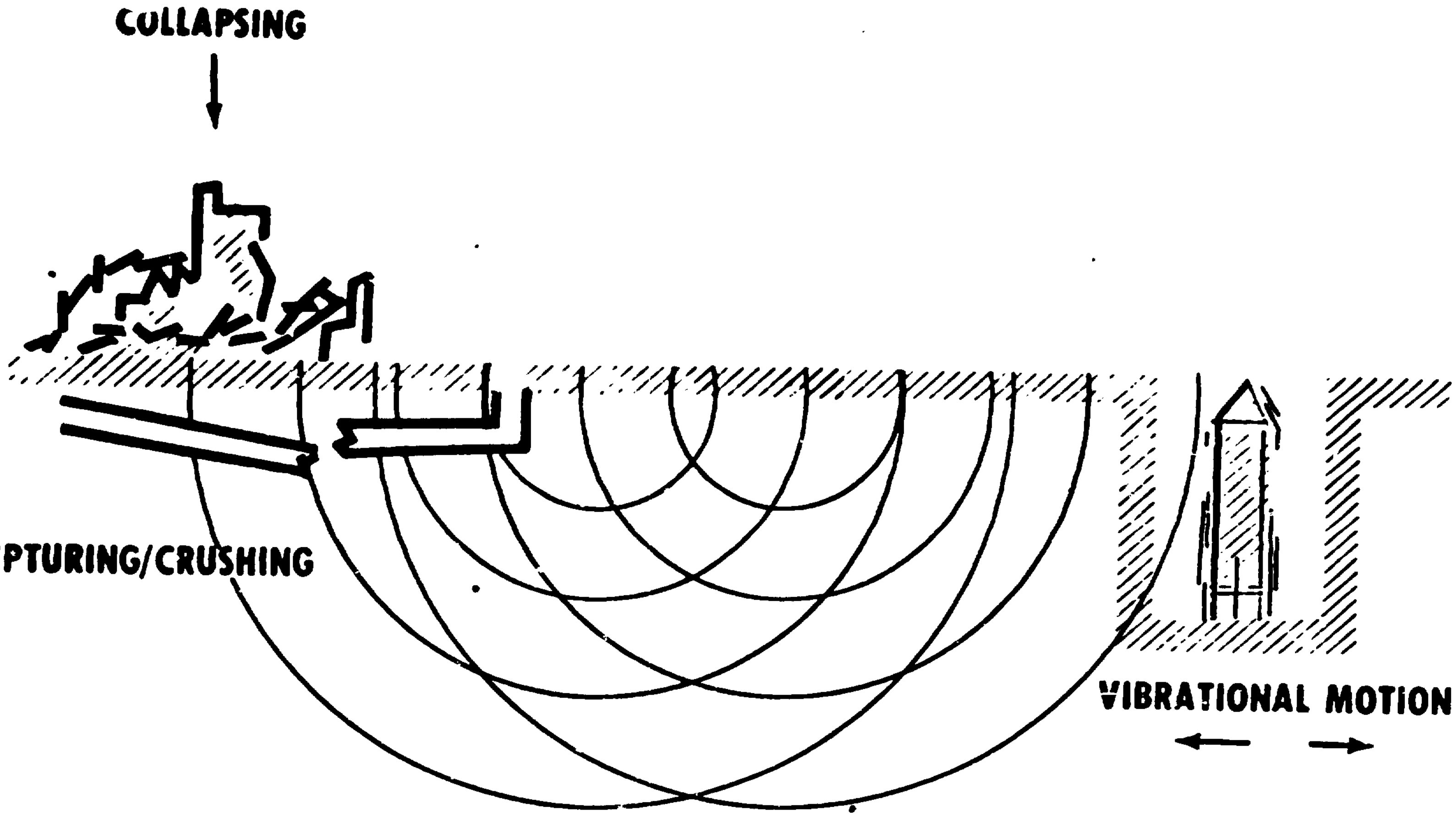


FIG 6.10 GROUND SHOCK EFFECTS

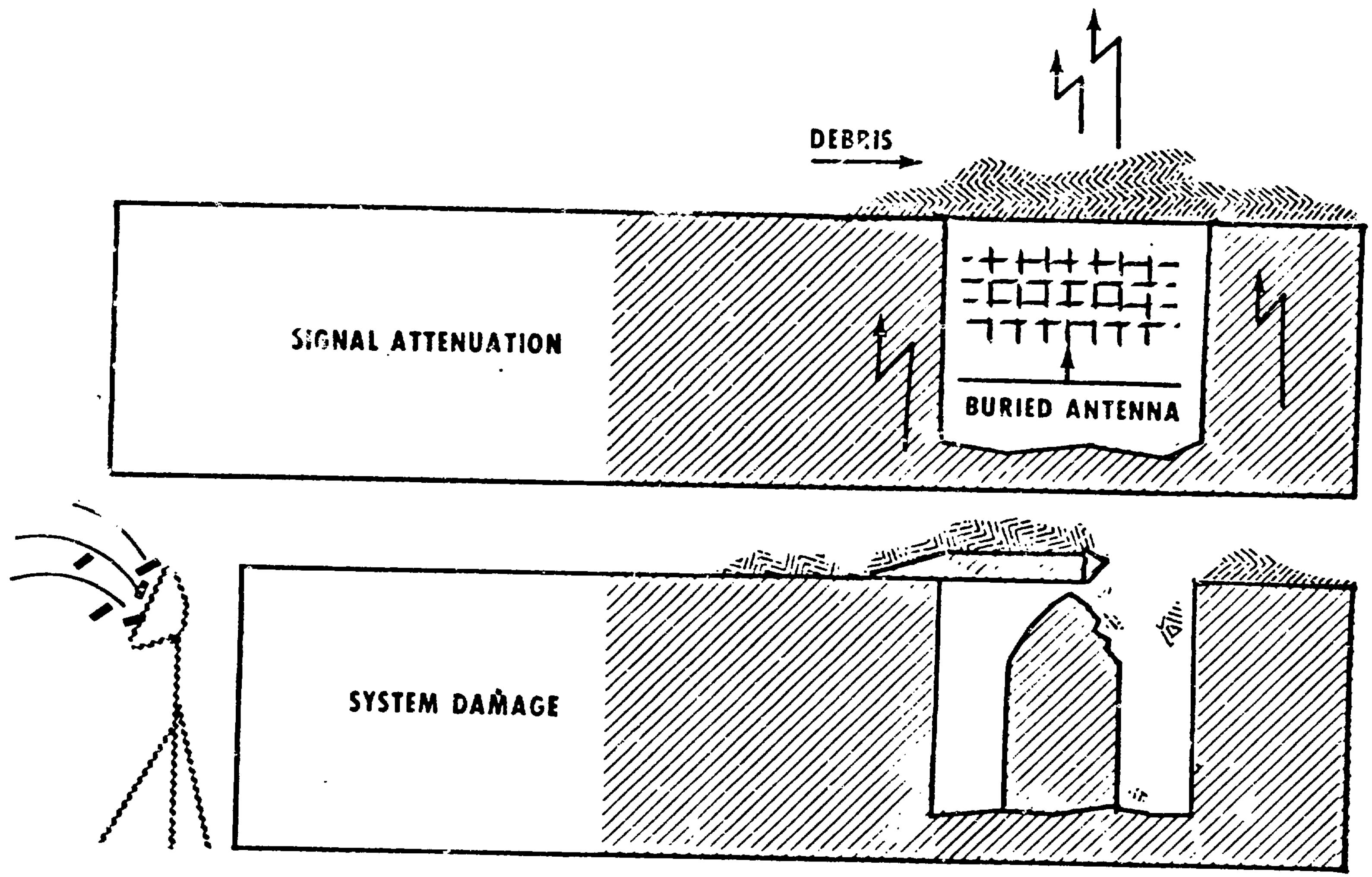


FIG 6.11 **EJECTA/DEBRIS EFFECTS**

amounts of radiation can also cause a person to be sick. The important effect is that radiation sickness may result from exposure to radioactive fallout.
We have now looked at the types of man-made, hostile environments and some of the possible weapons effects. (Fig 6.12)

HOSTILE ENVIRONMENT	SOME WEAPONS EFFECTS
NON-EXPLOSIVE PROJECTILES EXPLOSIVE PROJECTILES	PENETRATION SHOCK/BLAST IGNITION
EM SIGNALS	JAMMING
FIREBALL	TOTAL DESTRUCTION
EMP	DISRUPTS COMMUNICATION INDUCED VOLTAGE/CURRENT MEMORY DEVICES DISTURBED
THERMAL RADIATION	SPONTANEOUS IGNITION ABLATION CHANGE MATERIAL CHARACTERISTICS BLINDNESS SKIN BURNS

FIG 6.12 **POSSIBLE EFFECTS VS HOSTILE ENVIRONMENT**

HOSTILE ENVIRONMENT	SOME WEAPONS EFFECT
NUCLEAR RADIATION NEUTRONS GAMMA RAYS X-RAYS	DEGRADE/DESTROYS ELECTRONIC EQUIPMENT BIOLOGICAL
AIRBLAST	INDUCED GROUND SHOCK ABOVE-GROUND STRUCTURES DAMAGED/DESTROYED
NOISE	PERSONNEL INJURY EQUIPMENT DAMAGE VERBAL COMMUNICATIONS DEGRADED
GROUND SHOCK	STRUCTURAL/EQUIPMENT DAMAGE
CRATER	DESTRUCTION

FIG 6.12 (CONT.) **POSSIBLE EFFECTS VS HOSTILE ENVIRONMENT**

HOSTILE ENVIRONMENT	SOME WEAPONS EFFECT
EJECTA/DEBRIS	STRUCTURE/EQUIPMENT DAMAGE/DESTRUCTION ATTENUATE COMMUNICATIONS TO/FROM BURIED FACILITIES BLACKAGE OF ENTRANCE/EXISTS
FALLOUT	IMMEDIATE: SICKNESS/DEATH DELAYED: SICKNESS/DEATH

FIG 6.12 (CONT.) **POSSIBLE EFFECTS VS HOSTILE ENVIRONMENT**

7.0 Hardening Techniques

We have now looked at the types of man-made, hostile environments and some of the possible system effects of these environments. Recall that we do not harden against some environments (i.e., the fireball or crater). When hardening a specific weapon system against the other environments, two questions must be answered: (1) which of the environments are of concern, and (2) to what level must this system be hardened for each environment of concern? These same questions must be answered when supporting a hardened system. The techniques will be discussed in the same sequence as the effects.

7.1 Nonnuclear

In the next few minutes some of the nonnuclear hardening techniques will be discussed. We will not be able to address all such techniques, but the important idea to understand is that hardening techniques against nonnuclear hostile environments are available, and they may have been designed into the system. We in logistics must insure that they are not inadvertently removed or degraded from the system design.

A system can be hardened against penetration effects by any or all of the following techniques (Fig 7.1):

a. Employing redundant systems or subsystems. The redundant systems are generally positioned so that a single penetration will probably <u>not</u> destroy both the primary and backup systems.

b. Using armor or shielding to protect highly vulnerable sections of the system. The type, thickness, and shape of the armor selected by the SPO is determined by the hostile threat which must be withstood.

c. Using self-sealing fuel tanks with internal foam. The self-sealing ability is used to keep fuel in the tank so that the aircraft has a chance to recover at a base. The foam is used to avoid the hydraulic ram effects which can cause the tank to rupture.

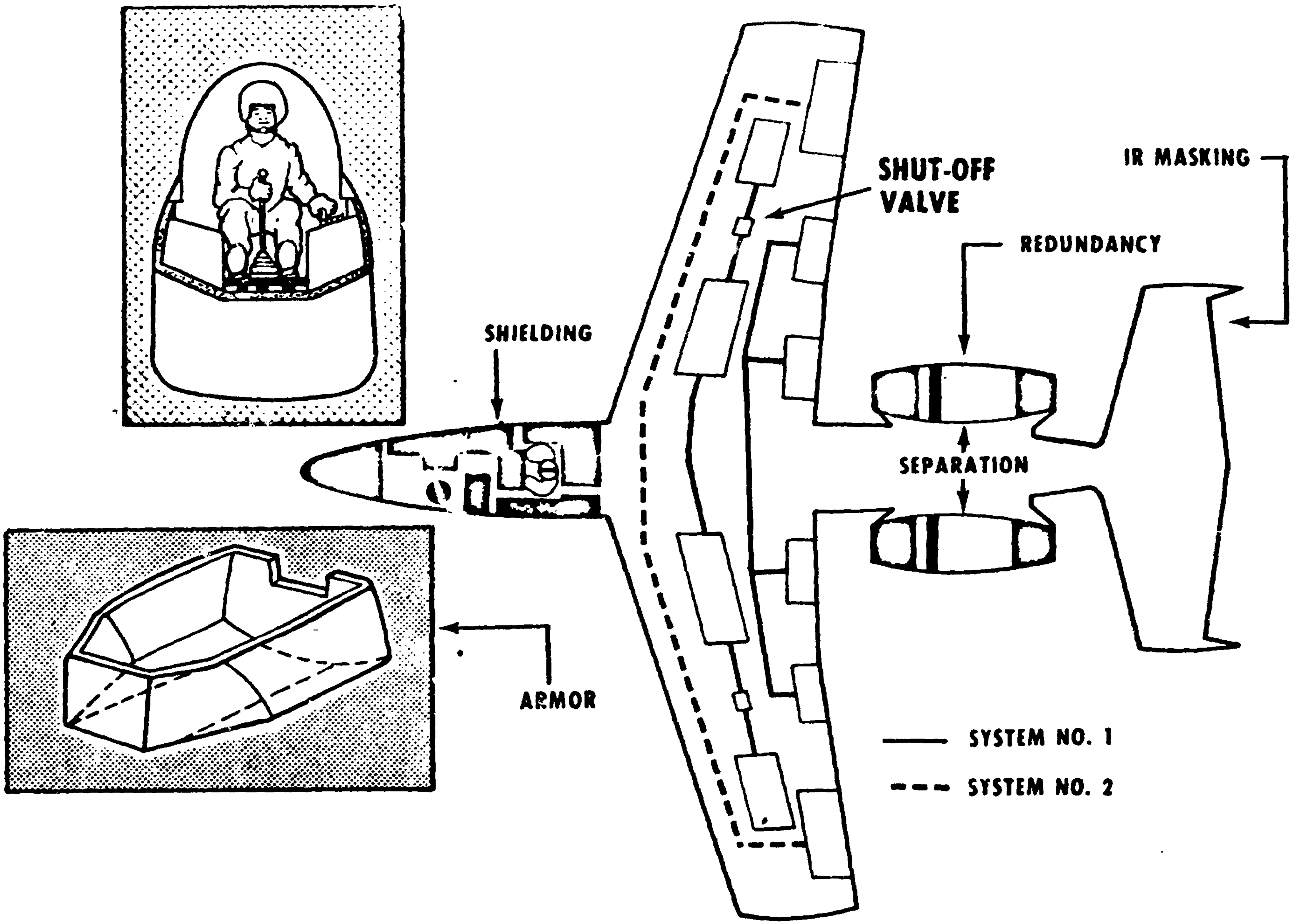


FIG 7.1 **PENETRATION HARDENING TECHNIQUES**

d. Burying vulnerable mission essential equipment deep in the system. The intent is to allow the "nonessential" equipment to stop the bullet before it gets to the essential parts.

A system can be hardened against blast effects by any or all of the following techniques:

a. Strengthening the structural design of the aircraft.

b. Placing special foam in certain void areas in the aircraft. The wings on the A-10 have a special foam to decrease the blast effects (Fig 7.2). The special characteristics of the foam (type and density) are critical.

A system can be hardened against the effects of ignition by any or all of the following techniques:

a. Using less flammable fluids where possible.

b. Using self-sealing fuel tanks to keep highly flammable fuel where it belongs (Fig 7.3). Notice that this is the second effect which can be defeated by this technique.

c. Using fire extinguishing system when ignition cannot be prevented. This may allow the aircraft to make it to a recovery base.

A system's survivability can be increased against some electromagnetic radiation (EMR) effects (Fig 7.4) by using any or all of the following techniques:

a. Minimizing the radar cross-section through design.

b. Jamming the enemy's EMR detectors (i.e., electronic countermeasures).

c. Minimizing the EMR emitted by the aircraft. This may eventually make use of fiber optics technology instead of electrical signals.

7.2 Nuclear

Now let us look at some of the hardening techniques used to increase system survivability against nuclear weapons effects. Remember that we do not harden against

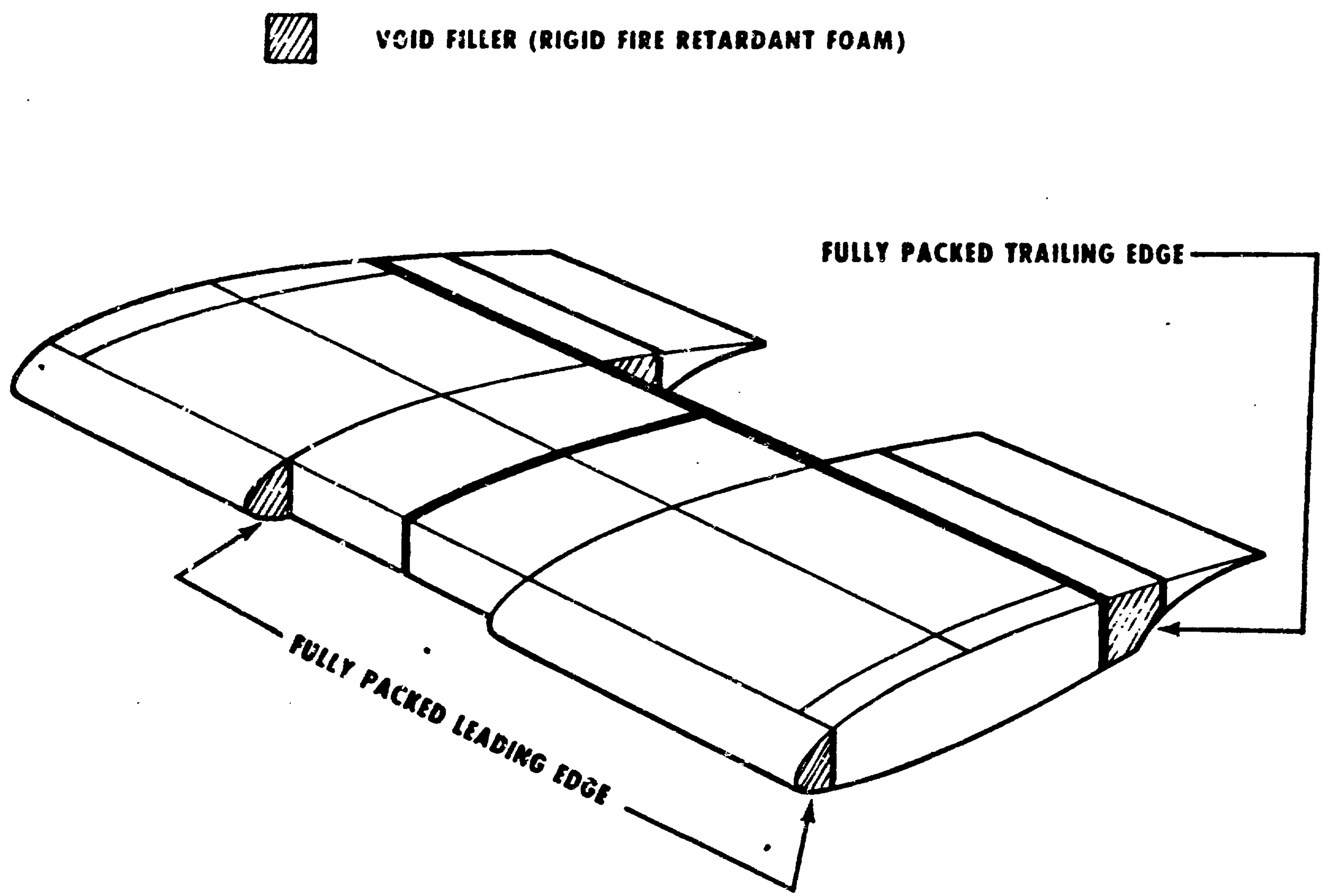


FIG 7.2 **BLAST HARDENING TECHNIQUES, A-10 WING PROTECTION**

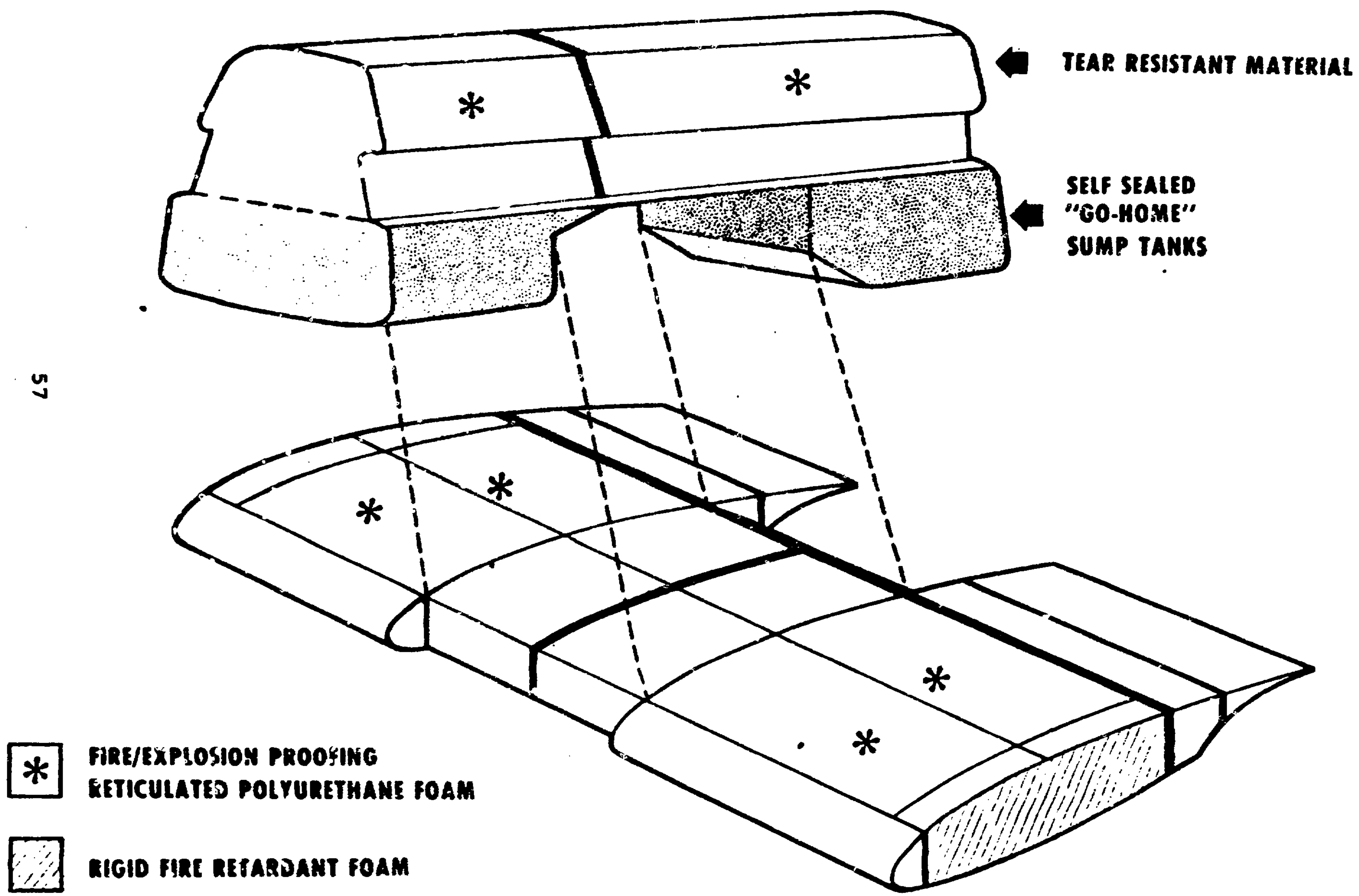


FIG 7.3 **IGNITION HARDENING TECHNIQUES, A-10 WING PROTECTION**

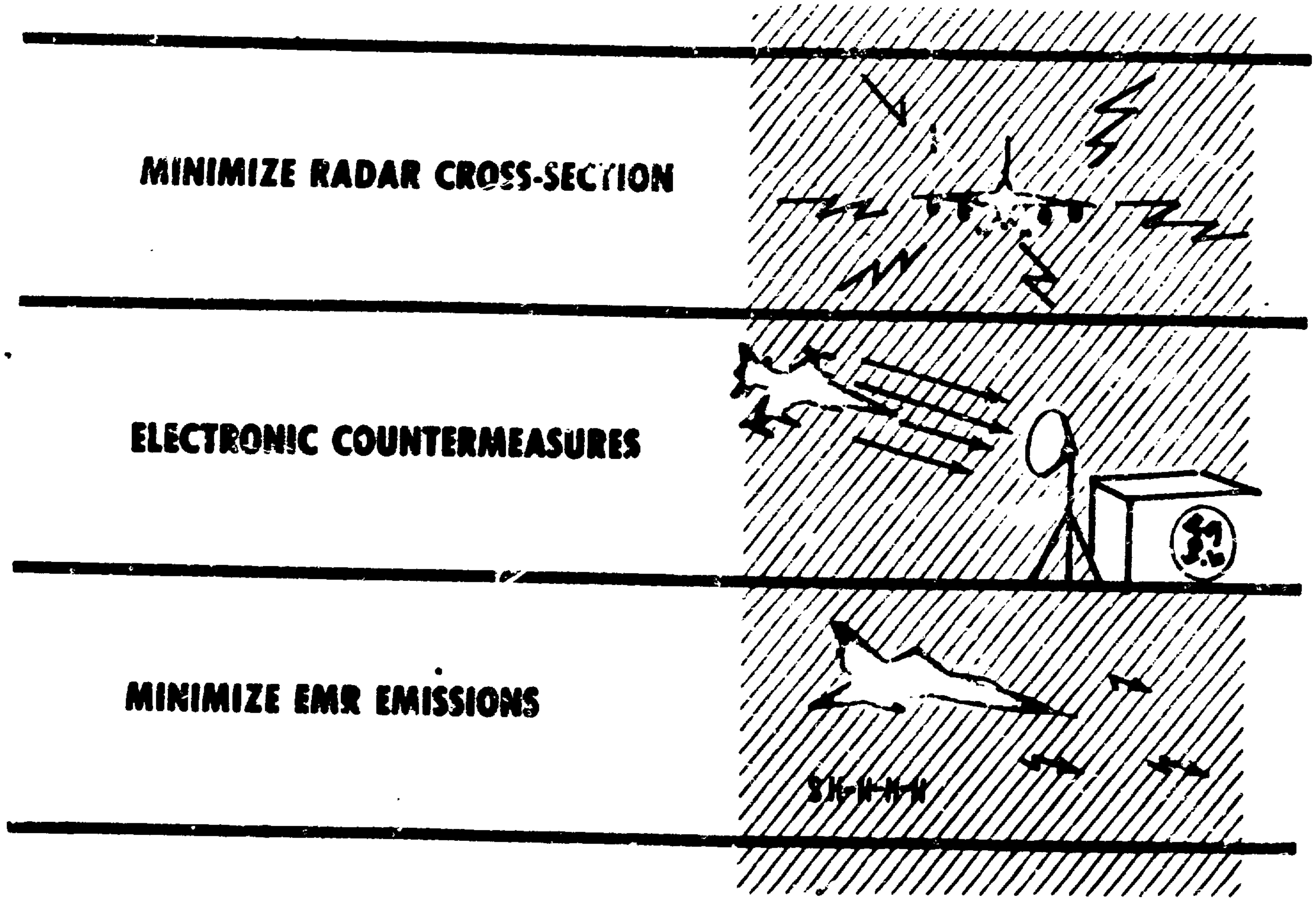


FIG 7.4 **EMR HARDENING TECHNIQUES**

either the fireball or the cratering effects.

Some of the techniques used to harden a system against the effects of EMP (Fig 7.5) are:

a. Using special shielded enclosures and conductive seals. These are normally grounded so that the electromagnetic energy is kept out of the interior of the system or subsystem.

b. Using special electrical surge arrestors to prevent large pulses of energy from getting into the delicate circuits.

c. Designing the circuits so that they are shut down or put into a stand-by mode during the major part of the pulse. This is called circumvention.

d. Selecting special piece parts which are harder than other pieceparts. These special parts are less susceptible to being damaged by a pulse of energy.

Some of the techniques used to harden a system against the effects of thermal radiation (Fig 7.6) are:

a. Burying the structure underground.

b. Painting the exposed surface with a highly reflective coating.

c. Designing the exposed surface with extra material which can burn-off without degrading the system performance.

d. Placing special thermal curtains or shields in the cockpit. These are to prevent injury to the crew and to prevent cockpit fires.

e. Wearing of special photochromic lenses to prevent injury to crew's eyes.

f. Selecting materials which are less susceptible to thermal efforts.

Some of the techniques used to harden a system against the effects of nuclear radiation (Fig 7.7) are:

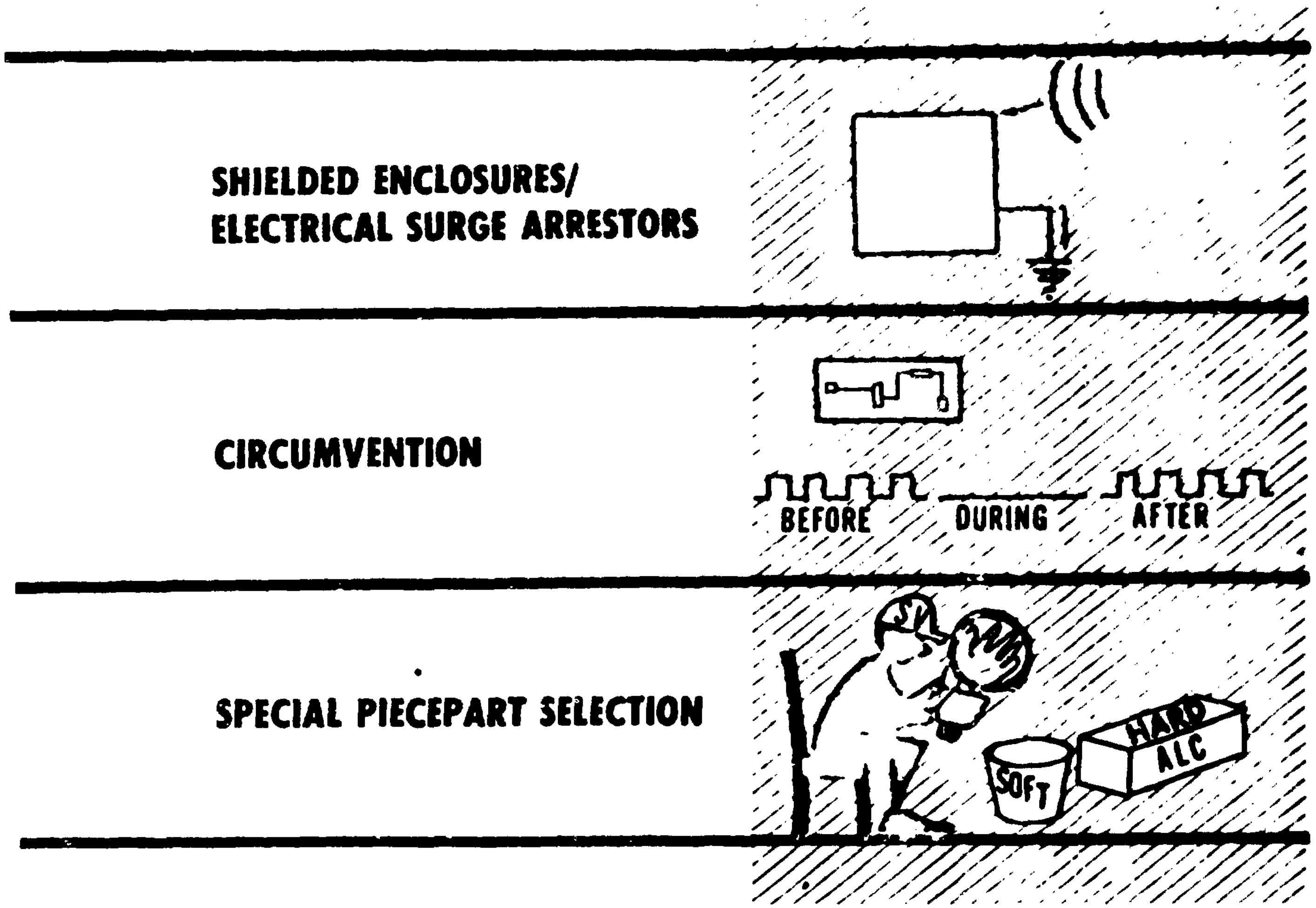


FIG 7.5 **EMP HARDENING TECHNIQUES**

BURYING	
SPECIAL PAINTS	
EXTRA MATERIAL	
THERMAL SHIELDS*	
PHOTOCHROMIC LENSES	

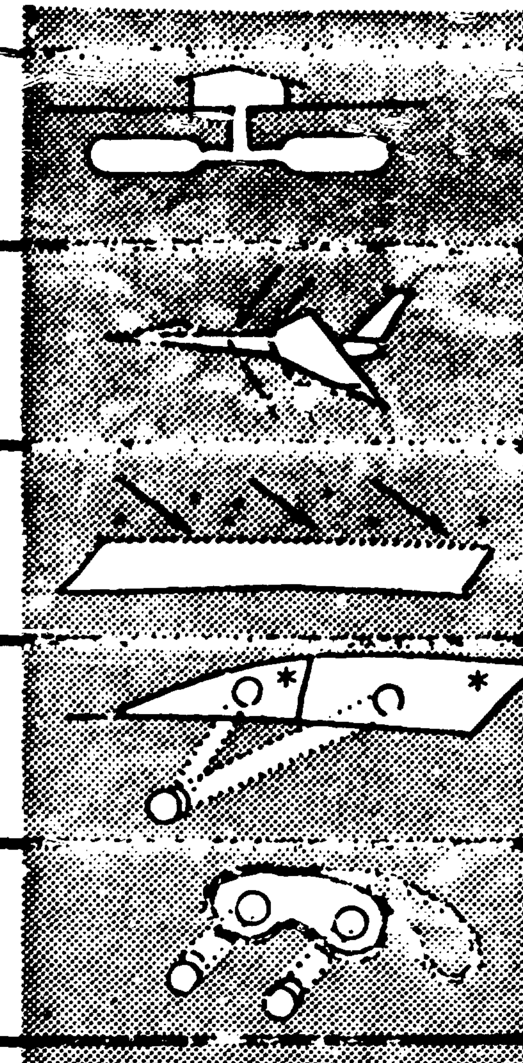


FIG 7.6 **THERMAL RADIATION HARDENING TECHNIQUES**

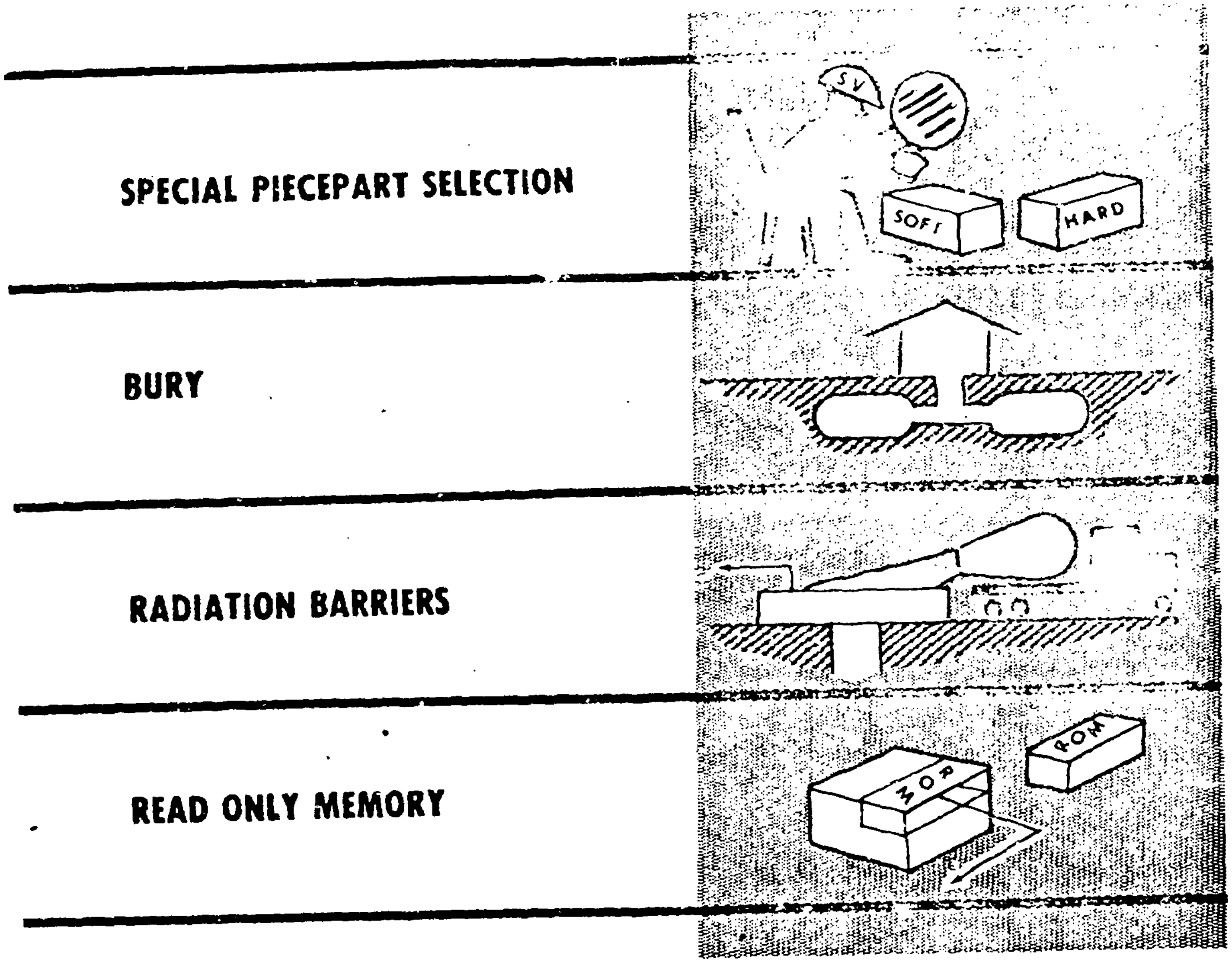


FIG 7.7 **NUCLEAR RADIATION HARDENING TECHNIQUES**

a. Using special pieceparts that have been specifically produced to operate during and/or after exposure to radiation.

b. Burying the equipment underground or deep within the piece of equipment.

c. Making the structure between the vulnerable piece of equipment and the radiation source to act as a radiation absorber.

d. Using a memory system which cannot be destroyed by radiation effects. Read only memory is often used.

Some of the techniques used to harden a system against the effects of airblast (Fig 7.8) are:

a. Burying everything possible including such items as antennas.

b. Using blast valves which are designed to close off the facility from the outside air and using an environment control system (ECS).

c. Designing special baffles within engine inlets or special airblast attenuating ribs within such tunnels as the one designed for M-X. These decrease the levels of airblast by disrupting the flow of air.

d. Incorporating special structural designs and materials.

The technique used to harden a system against the effects of noise is simply to "button-up" the facility. This keeps the noise outside. The actual techniques are the same as some used to harden against airblast.

Some of the techniques used to harden a system against the effects of ground shock (Fig 7.9) are:

a. Designing structures to withstand certain levels of ground shock.

b. Suspending or "shock isolating" sensitive equipment such that the shock is attenuated before reaching the equipment.

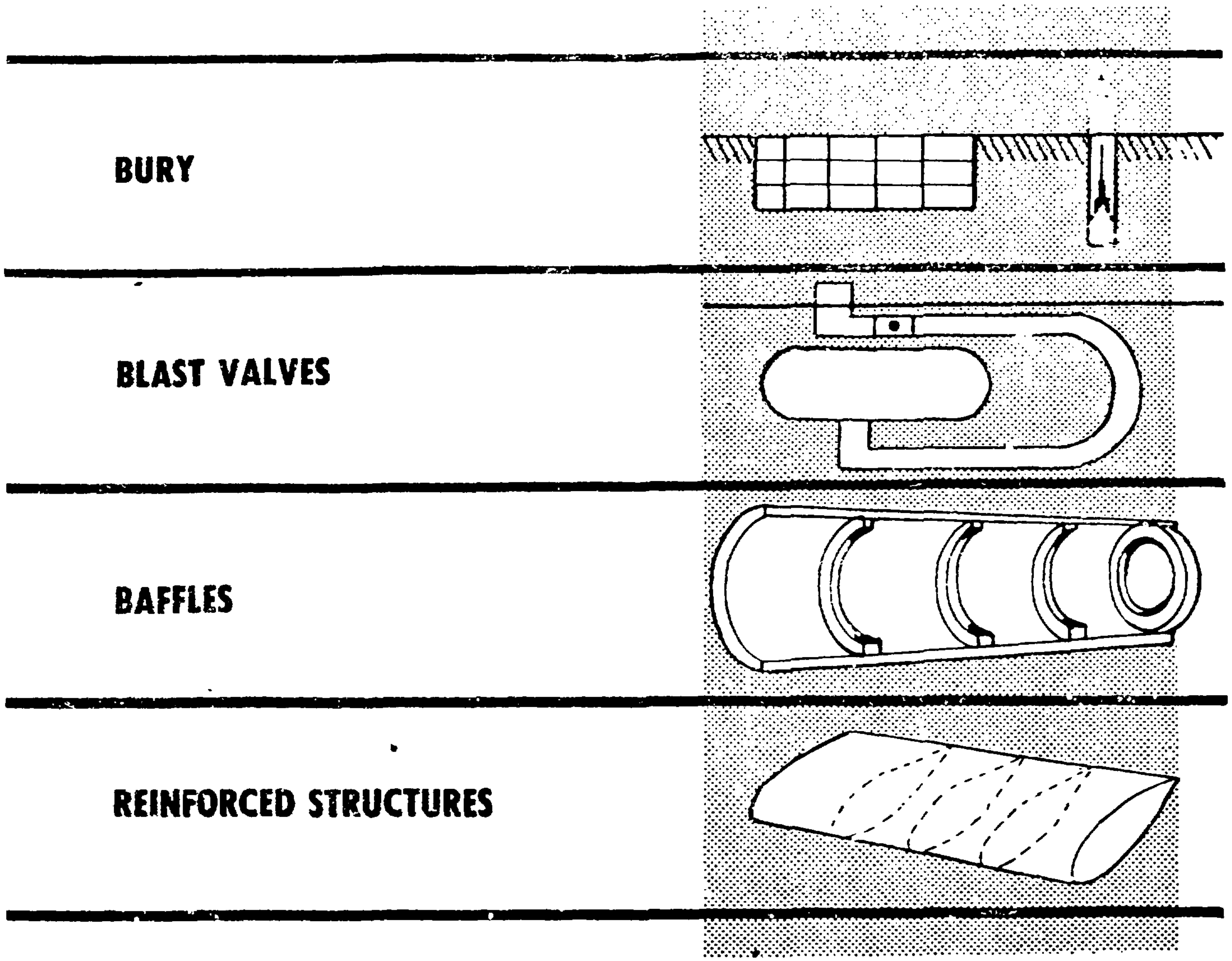


FIG 7.8 **AIRBLAST HARDENING TECHNIQUES**

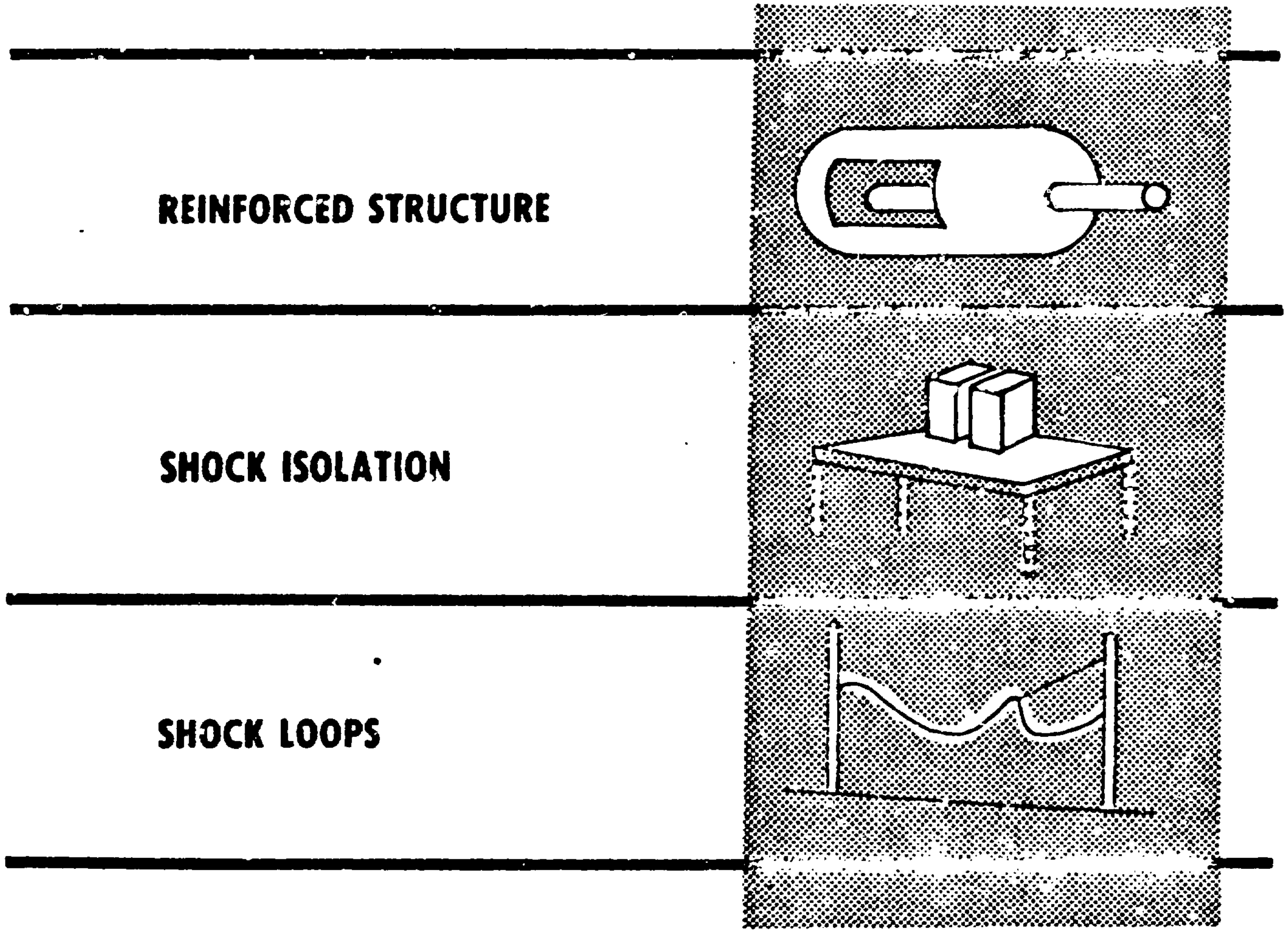


FIG 7.9 **GROUND SHOCK HARDENING TECHNIQUES**

c. Using extra lengths of cable in the form of "shock loops." This is done to prevent cable separation if a shock is experienced.

Some of the techniques used to harden a system against the effects of ejecta or debris (Fig 7.10) are:

a. Burying the structure underground.

b. Designing the communication system such that the antenna can receive and/or transmit signals through the debris layer, or the antenna can be raised up through the debris.

c. Using special "break-out" exits. These can be in the form of a snowplow silo door or the segmented trench breakout concept of the M-X program.

d. Using some type of collecting system to prevent the debris from falling into the facility and damaging the system equipment. In the Minuteman system these "debris bins" are an integral part of the silo door.

e. Covering the vehicle with special material to allow flying through "dust" clouds.

The main technique used to harden a system against the effects of fallout is filtration. An environmental control system with special filters is used. The airborne radioactive particles are filtered out of the atmosphere before the air is passed into the structures interior (Fig 7.11).

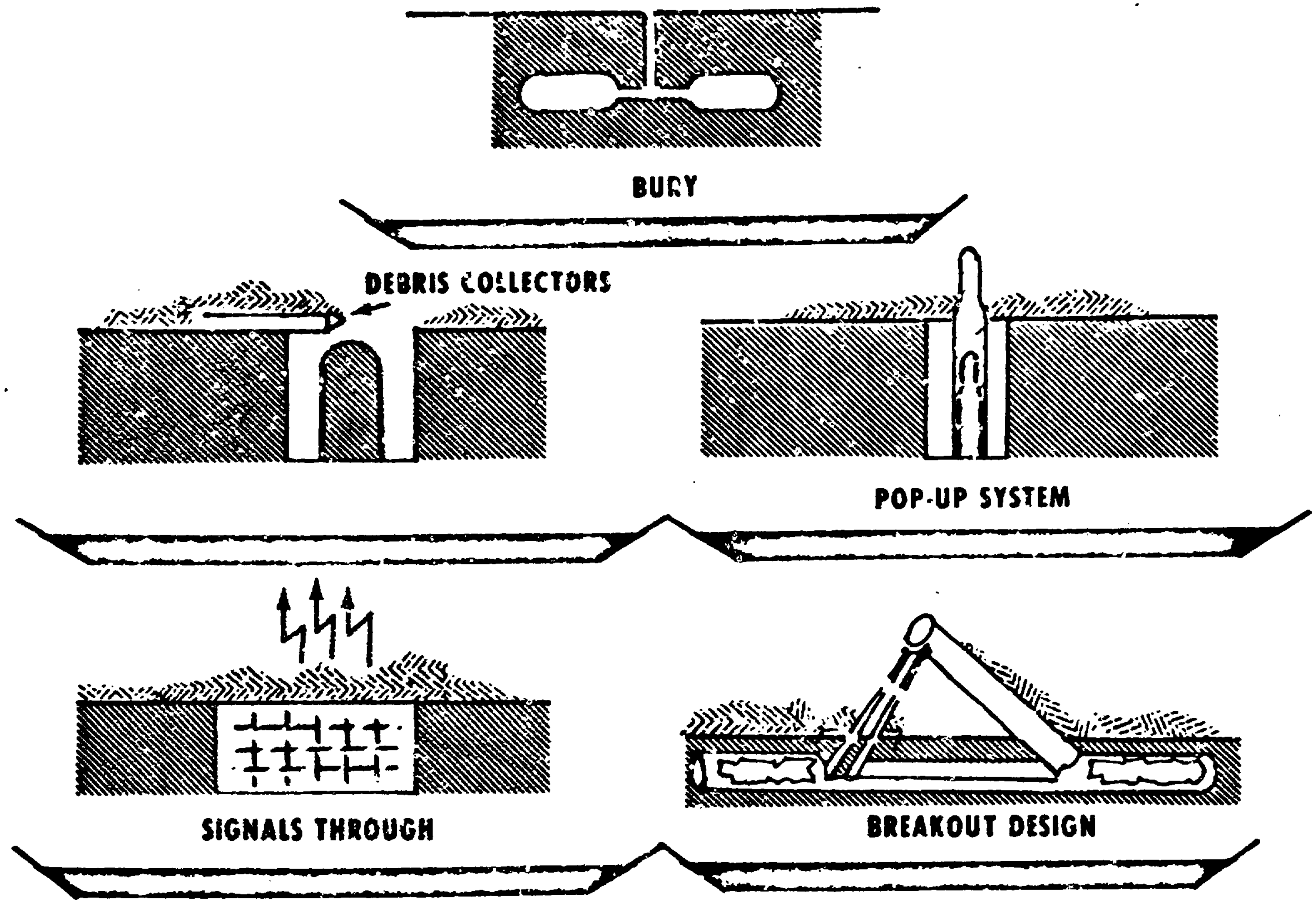


FIG 7.10 **DEBRIS HARDENING TECHNIQUES**

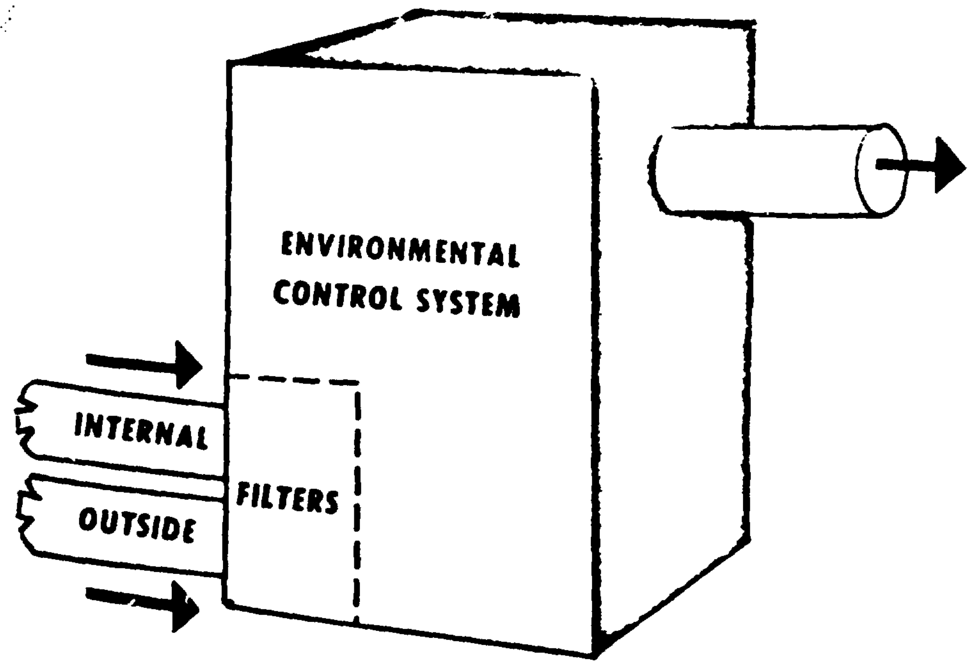


FIG 7.11 **FALLOUT HARDENING TECHNIQUES**

8.0 Potential impacts of logistics support

We have now looked at the various types of threats, hostile environments, their effects, and some of the techniques used to harden weapon systems (Fig 8.1 and 8.2). In addition, we have looked at the logistics responsibilities within AFLC organizations. Now we want to look at some of the potential impacts that job performance might have upon system survivability. Your specific jobs all impact the ALC's ability to manage, redesign, reprocure, repair, survey, and assess the weapon systems levels of hardness.

8.1 Air Force Acquisition Logistics Division (AFALD)

As AFLC's spokesman to the development community, AFALD must insure that if a system has survivability requirements, then all esentials for logistics support must be furnished or planned for by AFSC. Such things as General Operational Requirements, Request for Proposals, Statements of Work, and Data Item Descriptions must include the required items necessary for AFLC to maintain the system survivability. To accomplish this, a hardness maintenance program must be developed. The logistics integrators working with the SPO have this overall responsibility; however, AFALD/PTEA's survivability engineer is available to assist these logistics representatives.

AFALD works with the AFSC SPOs to insure that the necessary technical data, support equipment, and training are identified and procured at the appropriate phase of the acquisition life cycle. The logistics survivability responsibility usually moves to an ALC within a month or two of the production decision.

8.2 Air Logistics Centers (ALCs)

At the ALC, management of the system survivability extends from the commander all the way down to individuals working on specific projects. Hardness of a system can be inadvertently degraded by any manager. If hardness is not considered along with all other factors (Fig 8.3) when a person is making a decision, then that decision may actually degrade hardness. Also budgetary and manning requirements must include hardness requirements.

HOSTILE ENVIRONMENT	SOME WEAPONS EFFECTS	SOME HARDENING TECHNIQUES
NON-EXPLOSIVE PROJECTILES	PENETRATION	ARMOR MATERIAL SELECTION REDUNDANT SYSTEMS BURYING VULNERABLE EQUIPMENT
	SHOCK/BLAST	VOID FILLER FOAM STRENGTHENING STRUCTURE
EXPLOSIVE PROJECTILES	IGNITION	FOAM IN FUEL TANKS SELF-SEALING TANKS LESS FLAMMABLE FLUIDS FIRE EXTINGUISHING SYSTEMS
EM SIGNALS	JAMMING	MINIMIZING RADAR CROSS-SECTION MINIMIZING EMR EMISSIONS ELECTRONIC COUNTERMEASURES

FIG 8.1 **NONNUCLEAR ENVIRONMENTS, EFFECTS AND HARDENING TECHNIQUES**

HOSTILE ENVIRONMENT	SOME WEAPONS EFFECTS	SOME HARDENING TECHNIQUES
FIREBALL	TOTAL DESTRUCTION	NONE
EMP	DISRUPTS COMMUNICATION INDUCED VOLTAGE/CURRENT MEMORY DEVICES DISTURBED	SHIELD ENCLOSURES WITH CONDUCTIVE SEALS ELECTRICAL SURGE ARRESTORS CIRCUMVENTION SPECIAL PIECEPARTS SELECTED
THERMAL RADIATION	SPONTANEOUS IGNITION ABLATION CHANGE MATERIAL CHARACTERISTICS BLINDNESS SKIN BURNS	BURY STRUCTURE SPECIAL PAINTING OF EXTERIOR SURFACES EXTRA MATERIAL TO "BURN-OFF" SELECTING SPECIAL MATERIALS THERMAL CURTAINS PHOTOCHROMIC LENSES
NUCLEAR RADIATION NEUTRONS GAMMA RAYS X-RAYS	DEGRADE/DESTROYS ELECTRONIC EQUIPMENT BIOLOGICAL	SPECIAL PIECEPARTS SELECTED BURYING EQUIPMENT: UNDERGROUND DEEP WITHIN SYSTEM USE RADIATION BARRIERS USE READ ONLY MEMORY DEVICES

FIG 8.2 **NUCLEAR ENVIRONMENTS, EFFECTS AND HARDENING TECHNIQUES**

CONT.

HOSTILE ENVIRONMENT	SOME WEAPONS EFFECTS	SOME HARDENING TECHNIQUES
AIRBLAST	INDUCED GROUND SHOCK ABOVE-GROUND STRUCTURES DAMAGED/DESTROYED	BURYING BLAST VALVES SPECIAL INLET BAFFLES REINFORCED STRUCTURES
NOISE	PERSONNEL INJURY EQUIPMENT DAMAGE VERBAL COMMUNICATIONS DEGRADED	"BUTTONING-UP" BAFFLES
GROUND SHOCK	STRUCTURAL/EQUIPMENT DAMAGE	REINFORCED STRUCTURES SHOCK ISOLATION SHOCK LOOPS
CRATER	DESTRUCTION	NONE
EJECTA/DEBRIS	STRUCTURE/EQUIPMENT DAMAGE/DESTRUCTION ATTENUATE COMMUNICATIONS TO/FROM BURIED FACILITIES BLACKAGE OF ENTRANCE/EXISTS	BURYING POP-UP ANTENNAS SPECIALLY DESIGNED "BREAK-'OUT" EXITS SPECIALLY DESIGNED DEBRIS COLLECTORS SPECIAL PROTECTIVE COATINGS
FALLOUT	IMMEDIATE: SICKNESS/DEATH DELAYED: SICKNESS/DEATH	FILTRATION, ECS SELF-SUPPORTING FACILITY

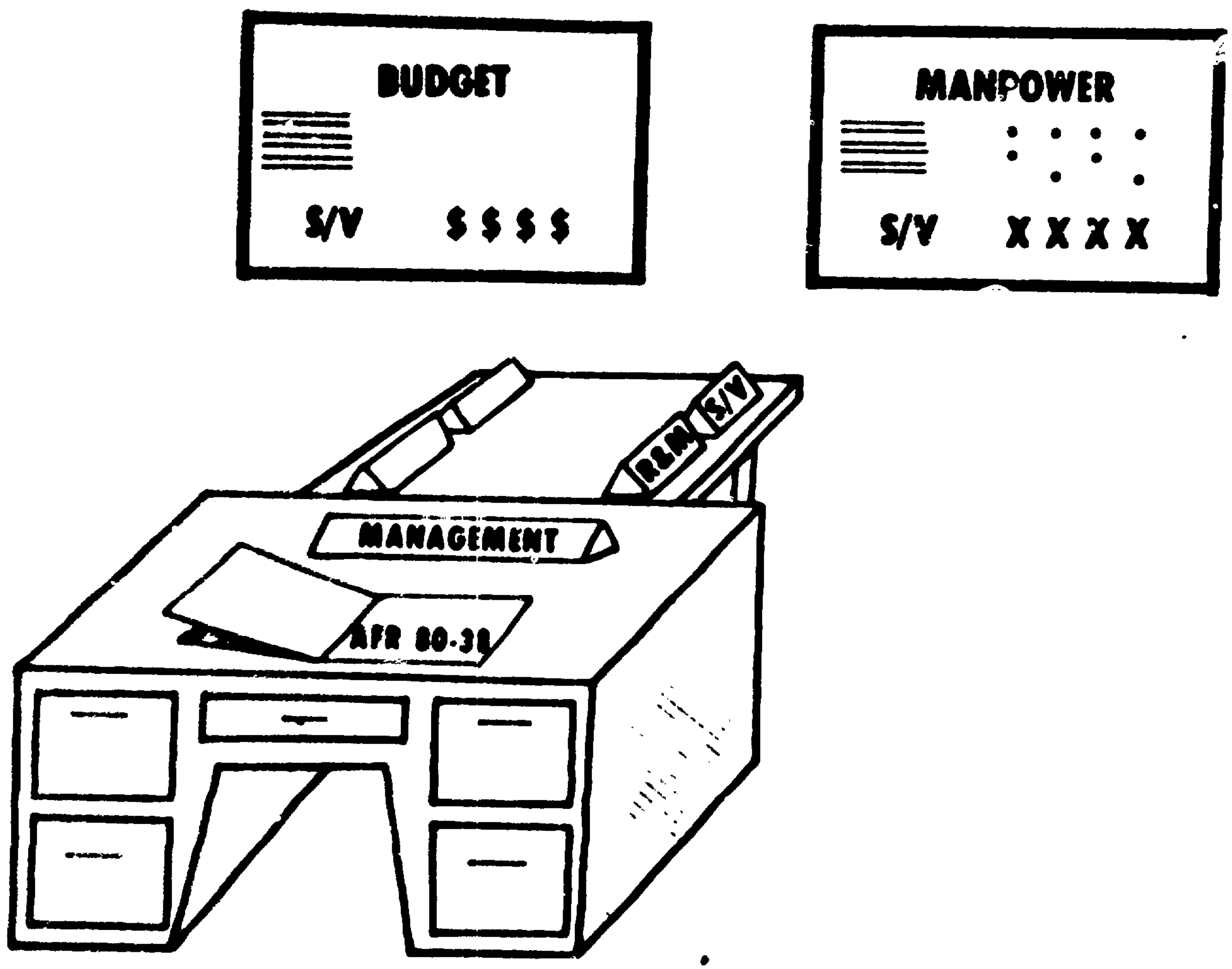


FIG 8.3 **MANAGEMENT CONSIDERATIONS**

Everyone involved in redeisgning any portion of the weapon system has a responsibility to insure that they do not degrade the survivability (Fig 8.4). For example, anyone considering a change in material or design layout, must consider the impact upon system survivability. The new material may be lighter in weight, but more vulnerable to the designed-against threat; whereas, the original material was chosen because of its hardness properties. Repositioning an item to make easier access for maintenance may also make the item more vulnerable. Whatever the redesign effort entails, it must meet the original design specifications and requirements. This includes any special analysis and/or testing to verify that the redesigned equipment does, in fact, meet these requirements.

Reprocurement actions by an ALC must be done so that system and item survivability is not degraded (Fig 8.5). This is especially critical in buying spare pieceparts (i.e., hardness critical items). Logistics management of hardened parts has been identified as a problem and AFALD/AQI has written a project report on this subject ("Management of Nuclear Hardened Parts," dated October 1977).

To insure system survivability, all applicable technical data must be up-to-date and consulted when buying spares to insure that the correct requirements (specifications, processes, special hardness tests, quantities, etc.) are identified and made an integral part of the procurement package. Even if the correct requirements are identified, the system may be degraded through reprocurement if any relaxation of the requirements is allowed. This relaxation might be done to decrease the cost or to allow more companies to compete. Cost savings are important, but they cannot be allowed if the system survivability would be degraded.

Any repair action accomplished at the depot on a hardened system has the potential of degrading the hardness. The "human factor" is a potential enemy to maintaining hardness (Fig 8.6). The desire to do an outstanding job can degrade hardness. For example, an overzealous maintenance person painting some electrical ground path inadvertently degrades that system's hardness.

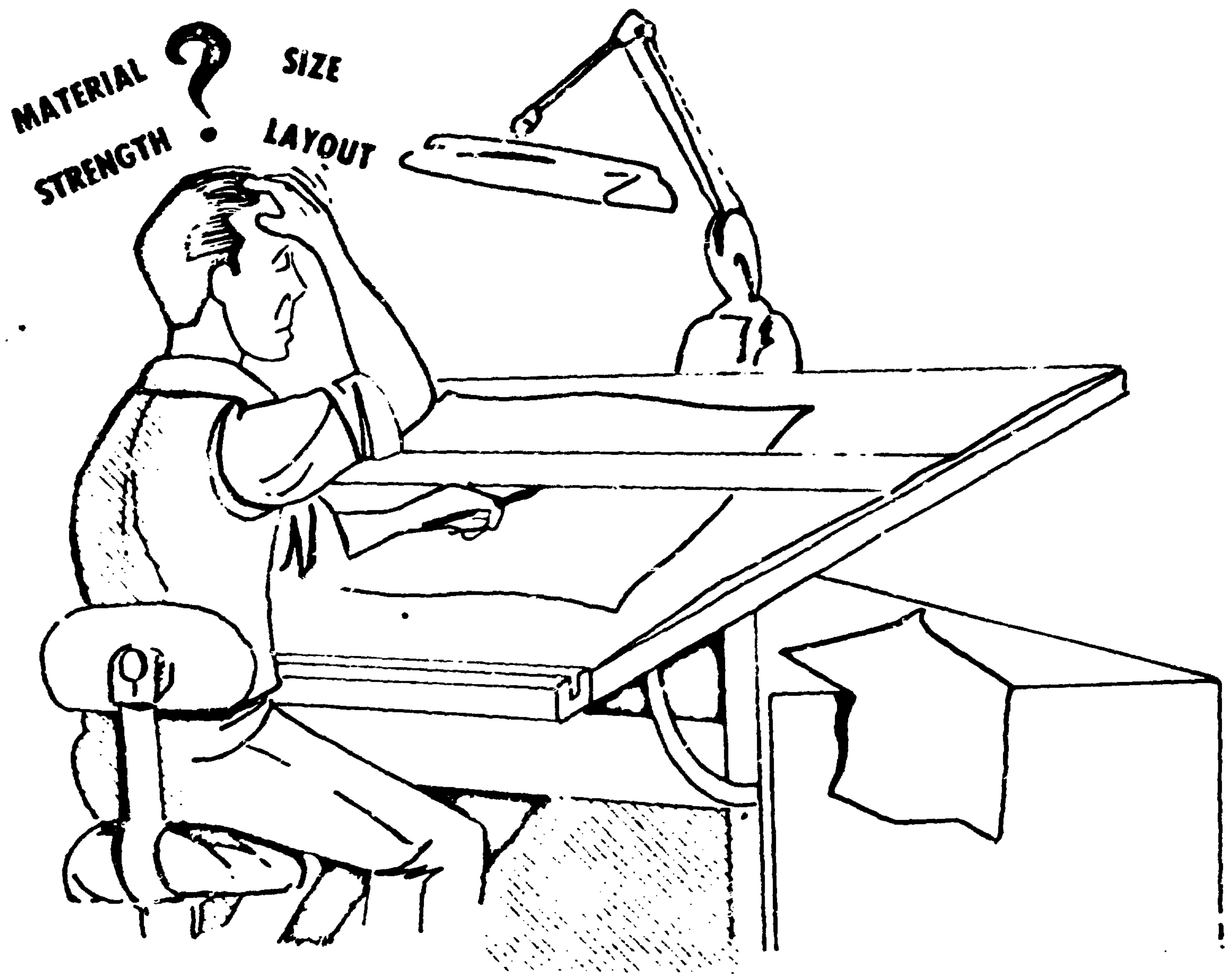


FIG 8.4 **REDESIGN AND SURVIVABILITY**

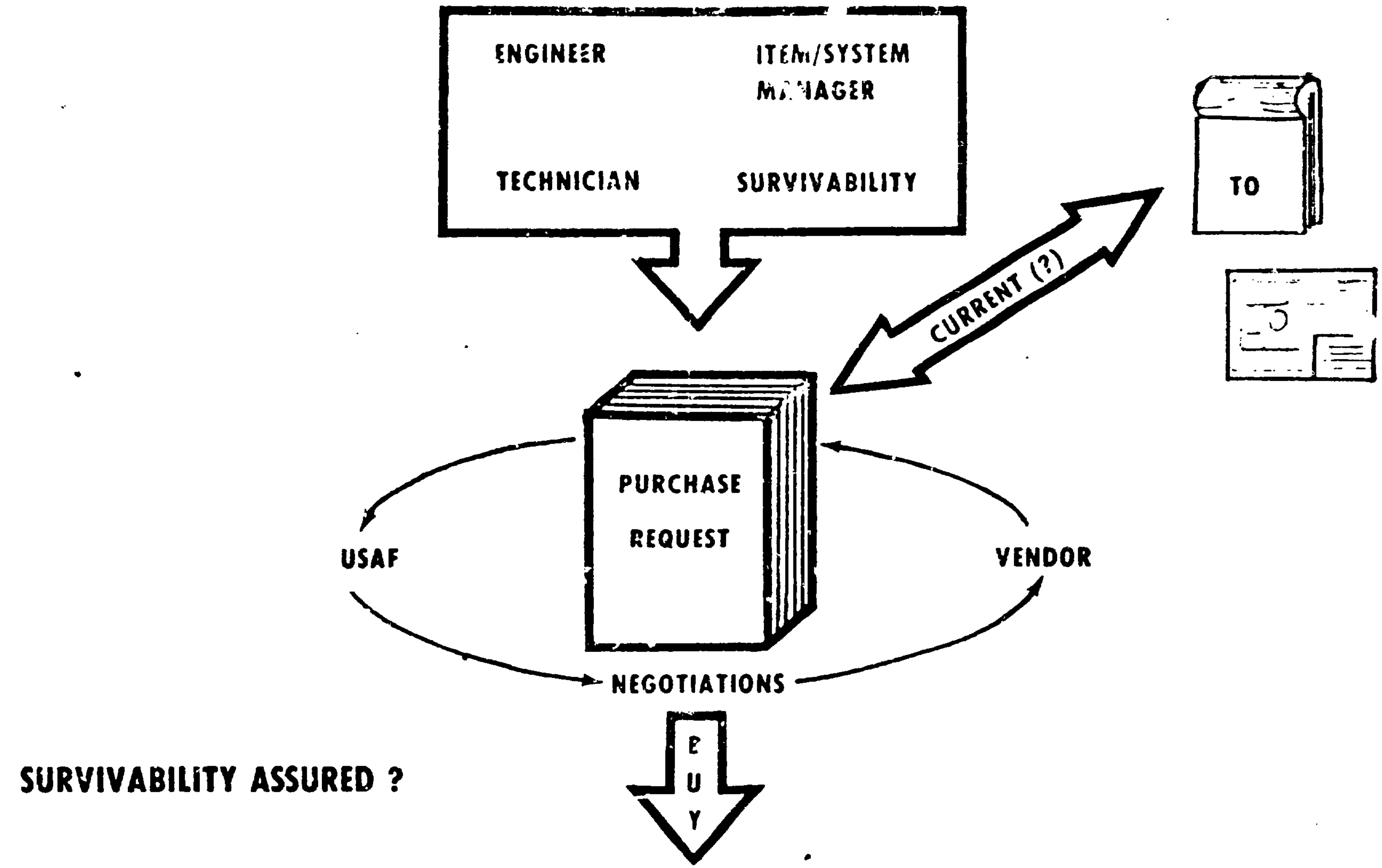


FIG 8.5 **REPROCUREMENT AND SURVIVABILITY**

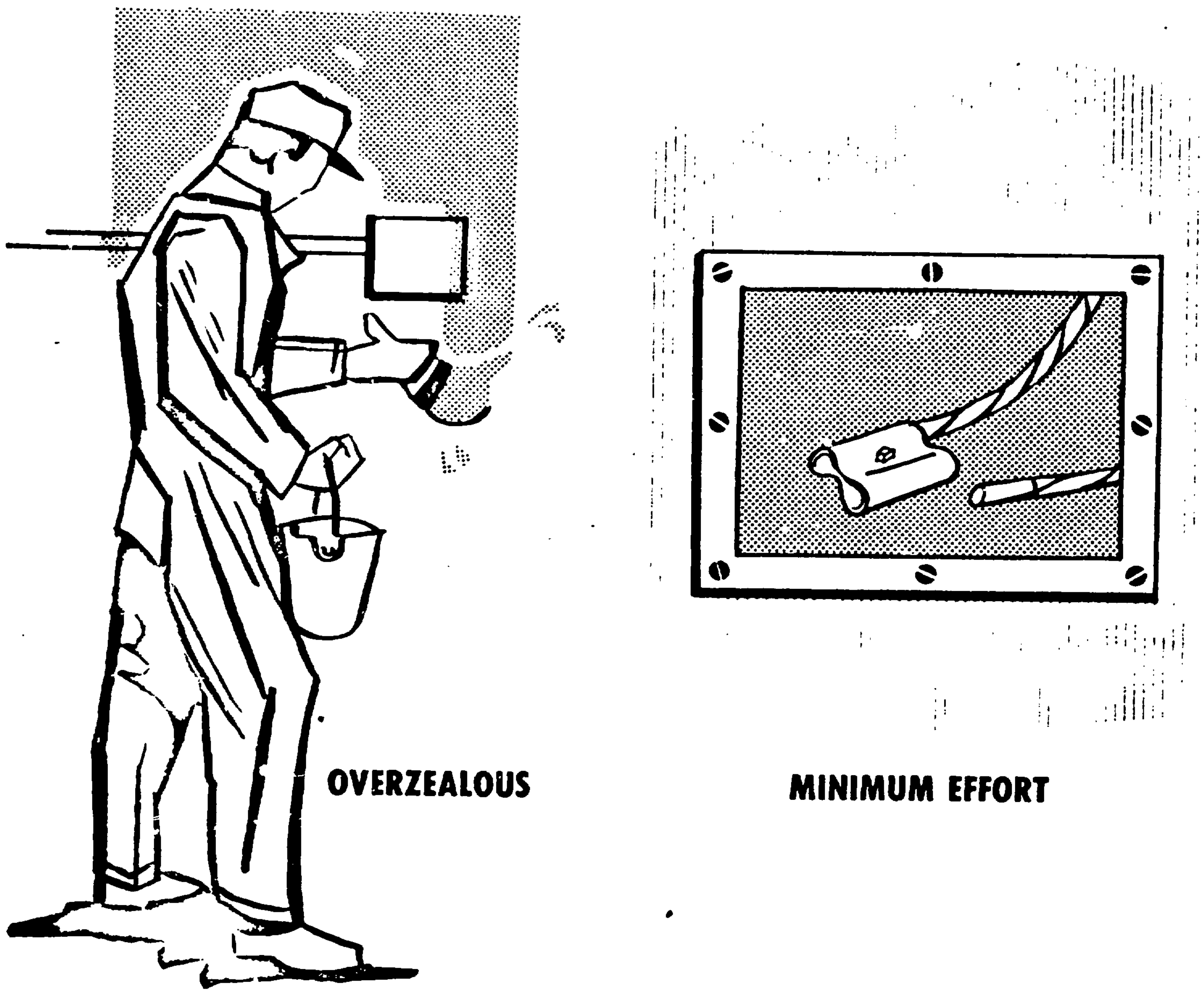


FIG 8.6 **MAINTENANCE DEGRADES SURVIVABILITY**

At the other end of human behavior is exerting the least effort needed to get the system "fixed." If someone relies on tightening a fastener without applying the T.O. - specified torque required to maintain hardness, then the system's hardness has been degraded. Another way to degrade hardness is to leave work undone, but covered up. When the box cover was removed, a cable connection was found to be incomplete. Many other ways exist that can cause hardness degradation during maintenance.

During maintenance actions the most current technical data (TOs, engineering drawings, and any other data) must be strictly followed. Of course, this assumes that the technical data has been kept current by incorporating all survivability maintenance procedures and that nothing required to maintain hardness has been deleted.

The fifth area of logistics, that of hardness surveillance, may be one of the more challenging areas. The purpose of the surveillance program is to monitor hardened items and systems to detect any degradation and to recommend necessary fixes to the system manager (Fig 8.7). This program might make use of visual inspections and special tests to collect sufficient data for system impact studies. Through a surveillance program the ALC can detect degradation trends with adequate lead time to incorporate fixes before the system is totally degraded.

The ALC must man-load and fund the hardness surveillance program. This includes the people to manage and conduct the program, to analyze the resulting data, and to make the necessary recommendations.

The final area of logistics responsibility is the reevaluating and reporting on system survivability (Fig 8.8). A reevaluation or assessment of the system's survivability must be done whenever either the hostile environment, the system, or the mission is altered. This implies a close interface with the using command. Also, an annual Survivability Management Status Report is required by AFR 80-38/AFLC Supl 1 for each designated system that has hardness requirements and for which AFLC has AFER.

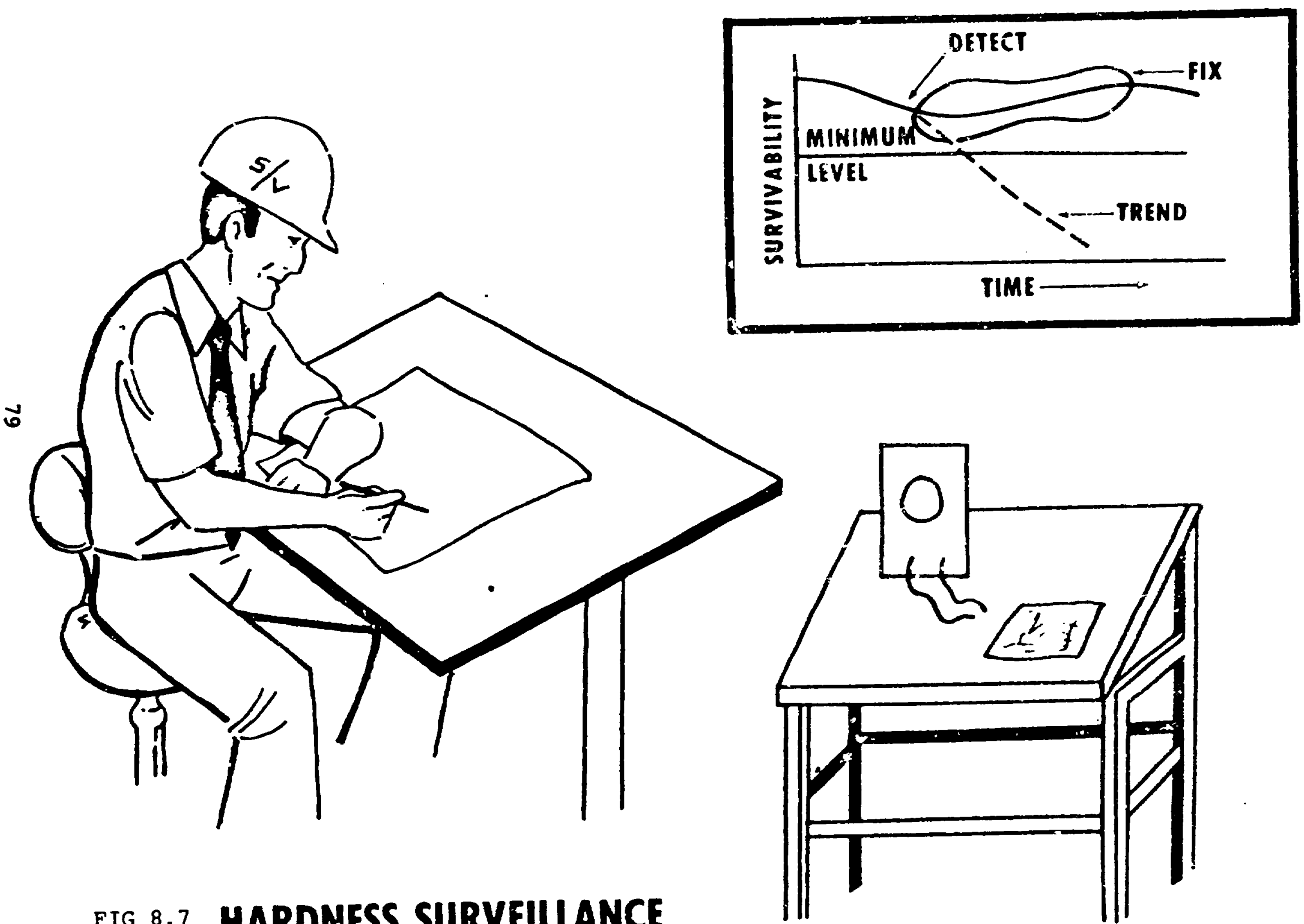


FIG 8.7 **HARDNESS SURVEILLANCE**

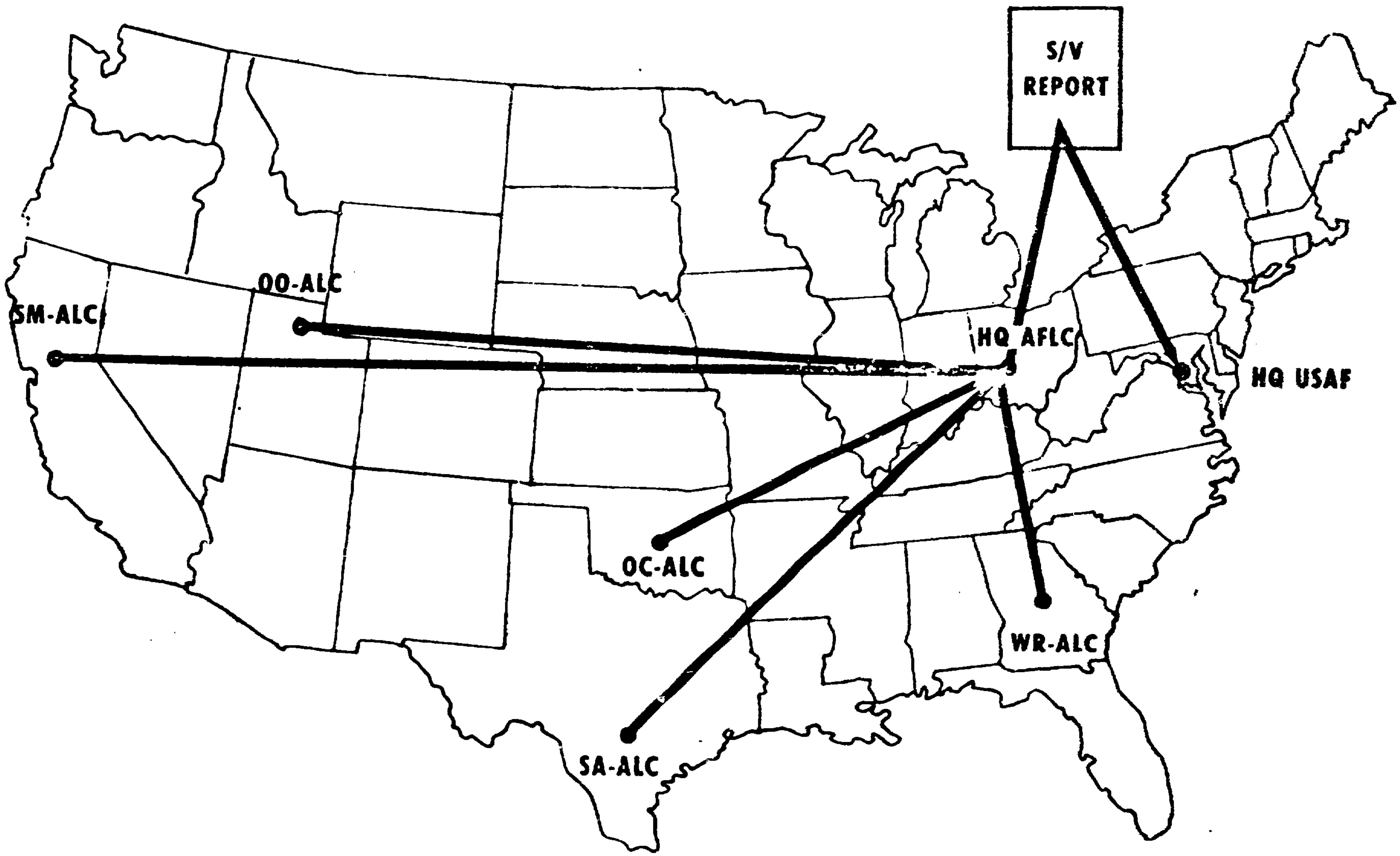


FIG 8.8 **SURVIVABILITY MANAGEMENT REPORTING**

9.0 Conclusions

In conclusion, we have taken a very quick look at several aspects of survivability and the potential logistics impacts. AFLC, through AFALD and the ALCs, can impact system survivability throughout the entire acquisition life cycle. You should now be aware of the types of threats, the resulting hostile environments, their possible effects, some hardening techniques against these effects, and some of the potential logistics impacts.

Hopefully this hardness awareness seminar has shown you the need for special care in providing logistics support to hardened systems.

LIST OF ABBREVIATIONS

AAM	Air-to-Air Missile
AFER	Air Force Engineering Responsibility
AFLC	Air Force Logistics Command
AFR	Air Force Regulation
AFSC	Air Force Systems Command
ALC	Air Logistics Center
AQI	Director of Logistics Integration
ASD	Aeronautical Systems Division
ECP	Engineering Change Proposal
EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
GOR	General Operational Requirement
MAJCOM	Major Command
MENS	Minimum Essential Need Statement
M-X	Missile-X
PMD	Program Management Directive
PSI	Pounds-Per-Square-Inch
ROC	Required Operational Capability
SAM	Surface-to-Air-Missile
SPO	System Program Office
TO	Technical Order