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Remote Response Mechanisms

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ABSTRACT

This report on remote response mechanisms for nuclear facility security systems was prepared for use in the Safeguard Regulatory Program of the United States Nuclear Regulatory Commission. The report includes information that will be useful to those responsible for the planning, design, and implementation of physical security systems. It discusses mechanisms that may be controlled remotely to extend the period of time during which security forces can implement effective responses to intruders. Techniques and mechanisms designed to reduce the intruder's capability to perform tasks and/or increase the tasks necessary to accomplish the intruder's objective are described and their characteristics discussed. The importance of the synergism between remote response mechanisms and other components (especially physical barriers) of the safeguard system is emphasized. The methods reviewed in this report are those which might be considered for application. The more exotic and futuristic techniques have been included for completeness and to save systems designers the effort of repeating the literature search required to evaluate them. Inclusion of a particular method does not necessarily represent recommendation or approval for use.

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FIGURES

1. FOREWORD

This report presents methods and mechanisms that may be remotely controlled to support security forces at nuclear reactor and fuel cycle facilities in their response to intruders.

The principal support provided by remote response mechanisms is to extend the period of time during which an effective response can be implemented by security forces. Remote response mechanisms may be used also to reinforce the intruder deterrent and delay features usually provided by physical barriers and other public and employee access control methods in facility security systems.

The methods and mechanisms discussed in the report are for employment primarily against malicious intruders to delay progress toward achievement of the intruder's objective. A limited number of the methods and mechanisms may be useful in the event of accidental or other intrusions that impose little or no threat to the security of the facility.

Decisions concerning when to use remote response mechanisms and the choices of the method, or combination of methods, appropriate for use in any particular case are considered to be prerogatives of security organizations. This report does not recommend the use of specific mechanisms for specific types of intrusion incidents. The primary response to an intruder is considered to be direct action by the security forces, and remote response mechanisms are secondary methods of support for the primary response. The use of lethal methods, in the event that they are necessary to neutralize a threat, is a primary response function. This report discusses only mechanisms that are not intended to permanently injure the persons on whom they are used.

Some of the remote response mechanisms presented in the report will be useful in material access or vital areas and some in protected areas. Areas of use are not recommended except where indoor or outdoor applicability is apparent.

Remote response methods and mechanisms are described and their known effects, capabilities, and limitations are discussed in the text of the report. The report is a survey of methods which might be considered for use in remote response mechanisms. The inclusion of any particular method does not necessarily represent recommendation or approval of its use. The objective of the report is to provide information that will be useful to persons responsible for planning and implementation of security systems for nuclear reactor and fuel cycle facilities. It is designed to identify potentially useful methods. The more exotic and futuristic techniques have been included for completeness and to save systems designers the effort of repeating the literature search required to evaluate them.

Existing literature has been used as the source of this report. It is recognized that additional analysis and testing of many of the devices will be required before a system can be defined. Some of the devices will require additional development work before a judgment can be made as to their usefulness. Persons responsible for development efforts should use caution before rejecting any of the techniques as useless. The rapidly changing state of the art in electronics and other fields will almost surely make some of the techniques, which now are too expensive and technically infeasible, both reasonable in cost and technically feasible. It is not within the scope of this report to do the development or field testing that will be required before an informed judgment can be made. However, some of the potential problems and areas of needed study are identified.

2. BASIC CONSIDERATIONS

2.1 THE INTRUSION NEUTRALIZATION SEQUENCE

The incursion into a safeguarded area by an intruder initiates a sequence of events which is designed to insure neutralization of the incursion before it is successfully completed. Figure 1 shows the sequence of events in a schematic way. The intrusion sequence begins at the moment the intruder violates a secured area and ends when the intrusion is counteracted.

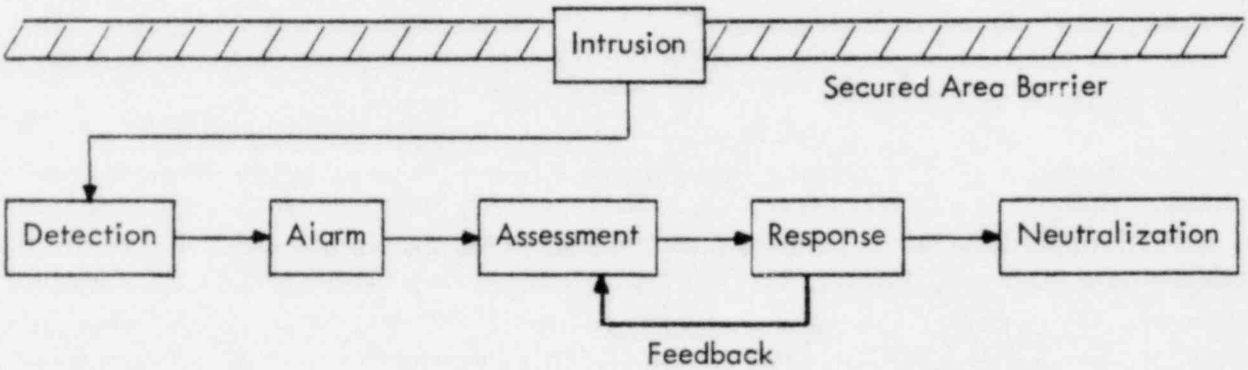

Figure 1. The Intrusion Neutralization Sequence

2.1.1 Intrusion

The possible characteristics of the intruder are manifold. The intruder may be a single individual or a group. The intruder may be ignorant of the facility or very knowledgeable about its layout and functions. The intruder may be in a state of high emotional agitation or calm and rational. The intruder may have no weapons and equipment or be well-armed and equipped. The intruder may use stealth or overt invasion. The intruder may be intent upon annoying, sabotaging, or stealing. The intrusion may be inadvertant or intentional. Since remote response mechanisms are not designed for use against an insider, that is one who is authorized to be in the secured area, this source of potential threat is not considered. However, an individual who is authorized to be in one secured area is considered to be an intruder when he enters another secured area to which he does not have authorized access. For the purpose of this paper, an intruder may have any of these characteristics. The only certainty is that the intruder has illegally entered a secured area through some barrier.

2.1.2 Detection

When the presence of the intruder is detected by some means, the sequence of events which has been designed to counteract the intrusion is set into motion. The detection may be done electronically or visually by various types of sensors or persons.

2.1.3 Alarm

Once detection of an intruder has occurred, the alarm function is initiated. The alarm may be annunciated in a remote safeguards center without the knowledge of the intruder and it may be annunciated locally at the point of intrusion.

2.1.4 Assessment

After the safeguards personnel and system have been apprised of the intrusion, the assessment function is initiated. It may be performed by an electronic system automatically or by security personnel. Either might take into account the number and location of alarms or information gained from assessment devices such as closed circuit television.

2.1.5 Response

Once the situation has been assessed, the response function begins. The primary response method available is the security force. Remote response mechanisms may be used to support the primary response. Decisions concerning the employment of possible responses require at least two facts from the assessment function. The knowledge of the approximate location of the intruder is required to determine which mechanisms or forces are available for use. The assessed extent of the threat imposed by the intruder is required to determine which mechanisms and forces, or combination of methods, are appropriate for use. It is desirable that the effect of the response on the intrusion can be monitored by the feedback of information to those performing the assessment function.

2.1.6 Neutralization

The basic objective of the intrusion sequence is to neutralize any threat to the physical security of the facility. The neutralization function is completed when the threat imposed by the presence of the intruder has been successfully counteracted. The neutralization function can, in fact, be completed at any point in the sequence. A tall fence, a loud alarm, or a sprayed gas might cause the intruder to abort his intended mission before a guard force even responds. However, if the full sequence is completed, the primary intent of remote response mechanisms is to delay the intruder until the security force can respond.

2.2 RESPONSE CONSIDERATIONS

2.2.1 Intruder Advantages

In the event of a deliberate intrusion with malicious intent, the prime objective of the safeguard system is to complete an effective response before the intruder's intent is accomplished. Although the time advantage enjoyed by the intruder ultimately includes all of his planning and preparation phases, the event is timed from the moment the intruder violates a secured area. His time advantage would, therefore, include the time required for the Detection, Alarm, and Assessment phases shown in Figure 1. Concurrent activities then proceed from the moment the Response phase begins; the intruder continues his activities toward his goal while the selected response activities are performed in an attempt to obviate the intruder's success. If the intruder's time advantage is sufficient, he will succeed in his mission.

As shown, the intruder has an initial time advantage afforded by an earlier start than the security forces regardless of the reaction speed of the protection system. The advantage provided to the intruder by the protection system reaction time is increased if the intruder has knowledge of the facility and a planned route to the intended target; the security forces are, of course, denied knowledge of the intruder's plans. The intruder's planned route from the point of detection to the intended target could be shorter than any intercepting route from the location of the security forces at the time they are alerted. The reduction of system response time to practical minimum limits and the physical barriers and other public and employee access control methods usually employed in security systems will reduce the intruder's time advantage. The time advantage can be further reduced, or eliminated, by the use of remote response mechanisms.

2.2.2 Primary and Secondary Responses

The need for discriminate use of response methods and the lack of any existing foolproof security systems that eliminate security forces require reliance upon security forces as the primary response to an intrusion. Secondary response methods may employ remote response mechanisms to support the primary response by security forces. As has been seen, time is vital to the achievement of the basic response objective.

The principal contribution to the response effort by remote response mechanisms is extension of the period of time during which a response can be accomplished by the security force. Generally, remotely controlled mechanisms can respond to an intruder at the site of the intrusion much faster than security forces. Control and communication signals to actuate the mechanisms can be transmitted over substantial distances extremely fast.

Remote response mechanisms will also provide security forces with additional flexibility in the choice of methods to be employed in responses to intrusions. Such mechanisms will be useful in instances where a person-to-person confrontation between security forces and intruders is not practical or desirable, since the mechanisms can be actuated from locations that are remote from the site of the intrusion.

The principal disadvantage of remote response mechanisms involves the potential damage that they can cause to persons and facilities. Since the function of these mechanisms is to reduce the initial existing physical and mental capabilities of the intruder and to create physical obstacles or diversions between the intruder and the intended target, the possibility of some injury to the intruder is apparent.* Because public and political acceptance and

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*Only those methods which are less-lethal, those not intended to cause permanent injury, are considered in this report. The known hazards of each considered method are discussed.

legal and moral considerations require that the severity of the neutralization method be commensurate with the threat, it becomes necessary to provide diversity of response. For instance, a response sufficient to neutralize a well-armed group of terrorists engaged in a forceful entry attempt is obviously not an appropriate response to an intrusion by a child chasing a ball that has landed in a protected area.

Other disadvantages of remote response mechanisms can be their initial and maintenance costs, the danger of accidental actuation, the problems of cleanup and rearming, and interference with normal operations.

The remote response mechanisms reviewed in this report constitute an essentially complete survey of presently known techniques. The inclusion of any particular technique does not necessarily represent recommendation or approval of its use for a particular application or even in general. It is intended to provide the user with an understanding of which devices are best suited for practical use and which are impractical for use at this time.

2.3 DESIRABLE CHARACTERISTICS

The remote response mechanisms to be considered for use in a safeguards system should be evaluated with respect to a set of "desirable characteristics" of such a mechanism. The evaluations should involve at least the characteristics of inexpensiveness, availability, reliability, safety, security, effectiveness, controllability, convenience, and compatibility.

2.3.1 Inexpensive

The lower the cost of a mechanism, the higher it would rate on this characteristic. All phases of the cost of the mechanism must be considered, including capital, installation, maintenance, and operation. The cost of any cleanup and rearming following the use of the mechanism should also be included.

2.3.2 Available

The more available a mechanism from commercial sources, the higher it would rate on this characteristic. A device that is available off-the-shelf is obviously more desirable than one that exists only in prototype form. A device which is theoretically feasible, but does not exist, would be even less desirable.

2.3.3 Reliable

The higher the probability that the device will function if, and only if, properly initiated, the higher it would rate on this characteristic. A perfect mechanism, with respect to reliability, would function properly when initiated by the appropriate signal and would never function unless the proper initiating signal were received. A mechanism should permit verification or testing of its readiness and training in its proper use.

2.3.4 Safe

The higher the probability that a mechanism could not permanently injure a person or damage property, the higher it would rate on this characteristic. A mechanism should be less-lethal to both malevolent and accidental intruders. It should also be less-lethal to employees in the event of accidental initiation. A mechanism should cause no, or only minimal, damage to the area of the facility in which it is used. It should not cause damage to the facility's functioning components, such as utilities or tools.

2.3.5 Secure

The more secure a mechanism from malevolent and accidental interference with proper operation, the higher it would rate on this characteristic. The mechanism should be secure from attempts of an intruder to defeat its proper operation. It should require special tools and/or extensive time periods to be overcome.

2.3.6 Effective

The higher the probability that a particular mechanism will neutralize any threat portended by an intruder, the higher it would rate on this characteristic. It is required that the mechanism be less-lethal. A less-lethal mechanism cannot be totally effective if the neutralization of the threat can be accomplished only by inflicting permanent injury. Mechanisms intended to cause permanent injury are not included in the scope of this report. It is probably most practical to measure effectiveness in terms of the probable length of time that the mechanism will delay the intruder.

2.3.7 Controllable

The more precisely the application of the mechanism can be controlled, the higher it would rate on this characteristic. One aspect of control involves the duration of the application. It should be possible to cut off the mechanism, remotely, in a manner similar to its initiation. For example, it is obviously not desirable to wait while the reservoir of a mechanism is emptied even though the intruder has surrendered. Another aspect of control involves the degree, or levels, of the application. For example, it should be possible to control the force applied to close a remotely controlled door, depending upon the results of the threat assessment.

2.3.8 Convenient

The more convenient and easier a mechanism is to use, the higher it would rate on this characteristic. The operations considered should include initiation, cleanup, reset, and authorized disarm. It also applies, to some extent, to the control operation. A primary problem is that of cleanup. Mechanisms which require extensive equipment, labor, or elapsed time for decontamination of the results of their use are less desirable than those which require only fans, vacuum cleaners, or electronic resetting.

2.3.9 Compatible

The more compatible a mechanism with the routine use and operation of the facility which it is designed to protect, the higher it would rate on this characteristic. Noninterference is desirable for the mechanism during the time it is armed for use as well as for its maintenance and cleanup after its use. It should be compatible with normal personnel and equipment movement, line process flow and control, other safeguards considerations, health and safety policy, and maintenance procedures.

2.3.10 Relationships Between Characteristics

Many of the characteristics relate to each other in such a way as to cause favorable or unfavorable changes in one characteristic when another characteristic is changed. Some of these relationships are fairly obvious and are consistently true. Others are true only part of the time or under special conditions. Figure 2 shows relationships which generally are true even if under special conditions. Positive and negative relationships are indicated by + and -, respectively.

	Inexpensive	Available	Reliable	Safe	Secure	Effective	Controllable	Convenient
Available	+							
Reliable	-							
Safe			+					
Secure	-							
Effective	-		+	-	+			
Controllable	-			+		+		
Convenient	-			-	-			
Compatible	-			+	-	-		-

Figure 2. Relationships Between the Characteristics

As may be seen, most of the characteristics are negatively related to inexpensiveness, that is, the cost goes up when the other characteristics of a mechanism are improved. The relationship between cost and effectiveness is valid primarily if applied within a delay method. Availability generally has a positive relationship with cost, since an off-the-shelf item will usually cost less than a comparable item under development.

Increases in reliability, controllability, and compatibility will generally cause corresponding increases in safety by reducing the chance of injury due to accidental initiation of the mechanism. There is usually a very strong negative relationship between effectiveness and safety since the more effective a method is for halting intruders, the more likely it is to be more harmful. In existing mechanisms, the level of effectiveness which can be attained is severely restricted by safety considerations. In addition, attempts to make a mechanism excessively convenient to use could also adversely affect its safety.

In addition to the negative relationships to cost and safety which were discussed previously, effectiveness is also related, positively, to reliability and security. This is true in the sense that a mechanism with poor reliability or poor security cannot be expected to be as effective if it does not work or is easily circumvented by the intruder. The positive relationship between effectiveness and controllability is especiall valid if some type of real time assessment is available during the mechanisms's use. The negative relationship of effectiveness to compatibility is similar to that between safety and convenience in that excessive consideration of compatibility could adversely affect the mechanisms's effectiveness. Security is negatively related to convenience and compatibility in a similar way. Excessive attempts at compatibility would probably adversely affect convenience.

As may be seen, the relationships are many and varied. Therefore, when a mechanism is analyzed for possible use, it is very important to give careful consideration to the various relationships of the characteristics in light of the specific application. Additional relationships could develop; some of those shown could disappear or even reverse.

2.4 CLASSIFICATION OF INTRUDER NEUTRALIZATION TECHNIQUES

Evaluation of the effectiveness of remote response mechanisms must include consideration of their objectives:

- To provide an extended period of time during which an effective response to an intrusion can be accomplished by security forces and
- To provide a viable alternative to a response by security forces should such be deemed preferable during the Assessment phase in Figure 1.

These objectives are supportive of the basic objective of the sequence shown in Figure 1, that is, threat neutralization. The various techniques or methods of delay or capture which are used by remote response mechanisms can be classified into one of two groups based upon whether they affect the intruder or his task.

2.4.1 Methods to Decrease Intruder's Capability

The first class of methods involves decreasing the capability of the intruder to perform the tasks necessary to accomplish the intent of the intrusion. This class involves temporary impairment of the intruder's physiological or psychological capacity to function normally. The methods involved might affect the intruder's senses, such as his ability to see. They might cause internal trauma, such as vomiting, a feeling of asphyxiation, or muscle tetany. This class would also include methods to decrease temporarily the intruder's ability to concentrate on his tasks, to think clearly, or to comprehend the situation rationally. These methods do not necessarily have any relationship with the tasks which the intruder desires to perform.

2.4.2 Methods to Increase Intruder's Task

The second class of methods involves increasing the intruder's task load which must be completed to accomplish the intent of the intrusion. These methods might require the intruder to perform additional tasks, such as additional doors which are shut and locked remotely. The class would also contain methods which might increase the time required to perform the tasks, such as slippery agents on the floor which make the task of crossing a room almost impossible. The methods in this class do not necessarily have any relationship with the intruder's capability.

3. METHODS TO DECREASE INTRUDER'S CAPABILITY

3.1 GASES

3.1.1 General Comments

A large number of chemical compounds can be mixed with the air in the vicinity of an intruder to produce an environment that is intolerable to an unprotected intruder. Only the compounds used prevalently in law enforcement and which are not intended to cause permanent injury to the persons exposed to them are considered. Some of the compounds are not true gases but rather powder solids or liquids in mist or vapor form. They are included in this section since the term "gas" has come to be used commonly to refer to any air-borne chemicals used in law enforcement and military operations.

The compounds discussed are not intended to be lethal or to cause permanent injury to persons exposed to them. However, they can be lethal and can result in permanent injury if appropriate precautions are not exercised when they are used. The manufacturers of gas dispensing devices, gas masks, and protective clothing publish performance data and recommended use procedures. A list of a number of such manufacturers is shown in Section 10. Extensive research on the effectiveness and toxicology of gases has been conducted and the results documented. Some relevant publications of the results are listed in Section 9.

3.1.2 Historical Use

The use of poisonous gases by the Germans in World War I still has an adverse affect on public acceptance of law enforcement methods employing air-borne chemicals. The word "gas" is associated with deadly poisonous chemicals that are used inhumanely to maim and kill people. Some authorities are attempting to overcome the stigma attached to the word "gas" by replacing "tear gas" as the general term for lacrimators with the term "tear smoke."

The present extensive use of lacrimators and other irritating agents in law enforcement in the United States had its beginning shortly after World War I when law enforcement agencies sought more humane methods than then existed to control unruly crowds and to remove criminals and insane persons barricaded in buildings. They requested assistance from the U.S. Army Chemical Warfare Department, and the compound CN (discussed below) was subsequently developed at Edgewood Arsenal for less-lethal law enforcement use. The CN compound has been in use in law enforcement since the 1930's, and other compounds developed more recently are used extensively at present.

3.1.3 General Effectiveness

The use of gases to incapacitate or delay an intruder may affect persons in the vicinity other than the intruder. Gases used outside may be spread by the wind to expose persons in a fairly large area, since the effectiveness of outdoor use depends on coverage of an area large enough to prevent easy escape to fresh air. The effectiveness of gases used outdoors is highly dependent upon the wind direction and velocity to disperse the gas over an area large enough to prevent easy escape to fresh air and in concentrations sufficient to be effective. Wind can carry the gas away from the intruder if it is blowing in the wrong direction. When there is no wind, it may be difficult to spread the gas over an area large enough to prevent escape to fresh air or to project the gas far enough to reach the intruder in effective concentrations. Considerable research on the use of vortex rings to disperse gases has been conducted by the Ballistic Research Laboratories at Aberdeen Proving Ground, Maryland. The results of the research may be useful in dispersing gases in outdoor areas when practical methods of producing the vortices are developed. Extensive decontamination of the area is not usually required after gases have been used outdoors. Gases used inside a building may be spread through the building by the air conditioning system or may be exhausted from the building by ventilation systems left operating in the space where the gas is needed. Heavy use of gas inside a building can result in the need for extensive cleanup and decontamination measures and may cause the building to be uninhabitable until the decontamination is completed.

The potential user of gases should become thoroughly familiar with their toxicological effects prior to using them.

3.1.4 Protection

Security forces using gas must be provided with gas masks and, if they are required to be exposed to heavy concentrations, with protective clothing. Gas masks are difficult to use when wearing glasses. Special glasses with small wire earpieces will permit the mask to seal at the side of the face. Personnel wearing contact lenses should avoid exposure to the lacrimator gases because the profuse flow of tears will cause the lenses to be displaced on the eyeball or fall off and become lost.

3.1.5 Countermeasures

Various countermeasures to defeat the use of gas have been attempted. For example, wet wool blankets used as temporary filters and smearing the skin with a paste made of eggs, baking soda, and water have been tried. However, the only countermeasures known to be effective are the gas mask and protective clothing.

3.1.6 Tear Gas

Chloracetophenone (CN) has been used extensively by law enforcement agencies since the 1930's to control unruly crowds and to flush out hidden or barricaded fugitives. It is available commercially in grenades, canisters, projectiles, and shells that dispense the compound in a mist, smoke, vapor, or fine dust.

CN is classified as a lacrimator and is designed to reduce temporarily the physical capabilities of persons subject to it by causing a stinging, burning sensation of the skin, breathing discomfort, and partial or total blindness. A person exposed to CN will usually notice an initial odor that has been compared to that of grape, locust, or apple blossoms; followed in a few seconds by a burning, stinging sensation of the face, a profuse flow of tears, and breathing discomfort. There may be a burning, stinging sensation of the skin in areas where perspiration occurs.

The incapacitating dose of CN is usually expressed as the product of the concentration present in the air and the time of exposure. The concentration is stated in milligrams of CN per cubic meter of air and the time of exposure is stated in minutes. A dose of 20 milligram minutes per cubic meter is estimated to be sufficient to incapacitate 50% of the persons exposed. A dose of 14,000 milligram minutes per cubic meter is estimated to be lethal to 50% of the persons exposed (Ref. 1, p. 16).

Susceptibility to CN will vary with the individual. Persons with light skin, blonde hair, and freckles are generally more susceptible than persons with well-tanned or dark skin and dark hair. Some persons are allergic to CN and, when exposed to it, will break out with a rash of small blisters similar to that caused by poison oak or poison ivy. Narcotic addicts, alcoholics, and persons under the influence of alcohol or narcotics may be affected only slightly by exposure to CN. When CN has been used in incidents involving insane persons and those under the influence of LSD, it has been effective in some cases and not effective in others. CN will have little or no effect on some animals. For instance, horses are not affected because they have no tear ducts. Dogs have been tied up and exposed to CN, and they made very little attempt to move away from the CN.

Persons who are not allergic to CN will usually recover from its effects within 30 minutes to 1 hour after being in fresh air. An allergic reaction to CN may take 1 to 4 weeks to clear up. A prescription medicine that works well on some individuals is Valisone 0.1% or Synalar 0.025% (Ref. 1, p. 10). Some persons involved in civil disturbances who have been exposed to CN have been observed to re-expose themselves, apparently without fear, after 10 to 15 minutes in fresh air.

The usual treatment of persons who have been exposed to CN is to get them to fresh air, facing the wind, if any, and holding the eyes open. If the discomfort continues, cold water may be splashed on the face or a wet towel may be held on the face to relieve the stinging, but the eyes and face should not be rubbed. A person exposed to a heavy concentration of CN should have their clothing removed, fresh clothing provided, and should be taken to a doctor or hospital for treatment. A common treatment is to wash out the eyes with a solution of boric acid or a 2% solution of sodium bicarbonate. In addition, irritated skin areas should be sponged with a solution of 4% sodium sulfite in 50% alcohol (Ref. 1, p. 9).

3.1.7 Irritant Gas

Orthochlorobenzylidene malononitrile (CS) has been used by English military forces and law enforcement agencies since the late 1950's. The first large scale use of the compound was during the Cyprus riots. The U.S. Army replaced CN with CS in 1959 due to the greater effectiveness and larger safety factor of CS. It was used as a nonlethal military weapon in Vietnam. Law enforcement agencies are converting to the use of CS in most types of incidents where CN was used previously. CS is available commercially in grenades, canisters, projectiles, and shells that dispense the compound in a mist, smoke, vapor, or fine dust. "A given weight of CS is approximately ten times as potent as the same weight of CN" (Ref. 2).

CS is classified as an irritant agent and a lacrimator. It is designed to reduce temporarily the physical capabilities of persons exposed to it by causing a burning, stinging sensation of the skin, irritation and pain in the eyes and upper and lower respiratory tract, and partial or total blindness. A person exposed to CS will usually notice a pungent peppery odor followed in about 1 or 2 seconds by a burning, stinging sensation of the face and other skin areas, a tightening, crushing feeling in the chest, and a burning sensation in the respiratory tract accompained by a copious flow of tears. The irritation of the respiratory tract will usually cause coughing, sneezing, salivation, congestion of the nasal passages and wall of the pharynx, noticeable nasal drip, and a general feeling of suffocation. The irritating, burning sensation of the skin is increased by moisture.

The incapacitating dose of CS is usually expressed as the product of the concentration present in the air and the time of exposure, with the concentration stated in milligrams per cubic meter and the time stated in minutes. A dose of 10 milligram minutes per cubic meter is estimated to be sufficient to incapacitate 50% of the persons exposed, and a dose of 79,000 milligram minutes per cubic meter is estimated to be lethal to 50% of the persons exposed (Ref. 1, p. 16).

The usual treatment for persons exposed to CS is similar to that for CN exposure. The person is taken to fresh air, facing the wind, if any, with the eyes held open. The blindness and stinging sensation will usually be relieved in approximately 10 to 30 minutes. Persons who have been trapped in a heavy concentration of CS should be taken to a doctor or hospital for treatment. A usual treatment is a cold shower followed by sponging the affected skin areas with 5% solution of sodium bisulfide. Hot water should not be used first (Ref. 1, p. 15).

3.1.8 Chemical Mace

Phenylchloromethylketone (the active compound in Mace) was developed in 1961 by Alan Litman, a physicist working for General Ordnance Equipment Corporation, Pittsburg, Pa. To protect the patent rights of the corporation, the contents of the compound were not revealed to the public until 1969. Chemical Mace is available in pressurized aerosol containers.

Mace "was designed to be sprayed at the face of an individual; and before it is effective, it has to strike the face or the eyes. Mace is somewhat effective as a deterrent when it comes in contact with the facial skin, but it is much more effective when fired directly into the eyes. There are certain nerve endings in the face that are not common to other parts of the body; and when the Mace contents strike the face, they evaporate, forming a film which is transferred to the eyes causing tears to flow. If the Mace is fired directly into the eyes, the same reaction will occur but it will be more effective than if contact were made with the facial skin" (Ref. 1).

"Initially, there is a stinging sensation which takes place in 1 to 2 seconds. Then a feeling of temporary displacement of oxygen in the lungs, intense tearing, and temporary loss of vision occur. Some individuals become very dizzy or stunned and seem to lose their sense of balance" (Ref. 1).

"There are a few things to remember: Mace should not be used and fired directly at an individual's eyes at a distance of under 2 feet. The force of the stream projected from the large units can cause some damage and for this reason it is not recommended that it be used at close distances. Once a person has been incapacitated to the point where he has lost control of himself and cannot close or blink his eyes, he should not be subjected to any more of the fluid from the Mace. If the officer using the Mace can see that it has struck an individual, that should be sufficient to take care of him, bearing in mind that if he falls within the group of less susceptible persons described in 3.1.6, Mace may not have any effect upon him at all" (Ref. 1).

"It is also recommended that after the individual has been subdued his face should be washed off with cold water within a matter of 30 minutes. Under no circumstances should any grease, salve, or oil be used to treat the area which Mace has come in contact with. Grease and oil trap the gases in the skin and will cause a severe rash or burn" (Ref. 1).

3.1.9 Irritant Sickening Agent

Diphenylaminechlorarsine or Dinhydrophenarsazine (DM) was patented in Germany in 1913. In the U.S., Major Roger Adams of the U.S. Chemical Warfare Division developed the DM compound in 1918 and, as a result, the agent has also been called "Adamsite" (Ref. 1, p. 12).

A person exposed to DM will usually notice an odor similar to that of pungent smoke and a tickling sensation of the air passages of the nose which soon causes repeated sneezing followed by a nasal flow of viscous mucus. As the chemical particles settle in the exposed person's lungs, they cause violent coughing and sneezing, a severe headache in the region of the forehead, pains in the chest, and nausea. These reactions are followed by violent retching, vomiting, and, in heavy concentrations of DM, a skin rash (Ref. 1, p. 12).

The general treatment of a person after exposure to DM includes fresh air, clean clothes, and hospital care for 1 to 3 days. Alcohol, small amounts of ammonia, or chlorine from a can of bleaching powder are inhaled periodically. The eyes are washed with a 2% solution of sodium bicarbonate, using an eye cup. The skin is washed with a solution of bleaching powder, such as that made by Clorox, Hyclorite, or Zonite, in the ratio of a tablespoon of bleaching powder to a glass of water. The skin is then rinsed thoroughly with water (Ref. 1, p. 13).

3.1.10 Gas Selection

Of the gases discussed above, CN and CS are the two used most frequently in law enforcement and appear to be the two most applicable to security operations at nuclear reactor and fuel cycle facilities. Both of these compounds are composed of very small solid particles ranging approximately from 1 to 10 microns in size. These particles are heavier than air but are small enough to be air-borne. When dispensed properly in air, they are carried by air currents in much the same manner that smoke is carried.

3.1.11 Decontamination

Consideration should be given to decontamination when gas is used in a building. CN and CS are solid particles that tend to cling to the building surfaces and to penetrate porous materials such as curtains, carpets, and upholstered furniture. A contaminated space should be ventilated by opening doors and windows; a portable fan to move the contaminated air in one direction to the outside is helpful. Moveable porous materials should be taken outside. The surfaces of the space can be cleaned with a commercial type vacuum cleaner or, if a residential bag-type vacuum cleaner is used, the bag can be wetted to help filter and contain the contamination. In the event of heavy concentrations of CS, the floor of the space should be mopped with a water solution containing 10% Monoethanolamine (MEA) and 3% Triton X-100 or Igepal CO-630. If these are not available, detergents such as Tide or Joy may be used. A cleaning solution recommended by Thompson S. Crockett in the "Police Chemical Agents Manual" consists of 1 part MEA, 10 parts distilled water, and 0.5 part Triton X-100 or Igepal CO-630. If distilled water is not available, the solution can be made with tap water, using twice as much Triton X-100. The solution is said to dissolve CS in approximately 2 minutes, after which it can be flushed with water. In the event of heavy concentrations of CN, the affected area may be washed with a strong solution of soda ash or alcoholic caustic soda; a 5% solution of sodium carbonate or sodium bicarbonate may be used. The decontamination solutions may damage the finish of the surfaces where they are used (Ref. 1, p. 72). Smith & Wesson Chemical Company markets a decontamination kit which includes chemicals, gas mask, spray tank, rubber gloves, protective clothing, and detailed instructions.

3.1.12 Dispensing Devices

No gas dispensing devices that are specifically designed to be remotely controlled are known to be available as off-the-shelf items. However, some existing devices might be adapted for remote control.

3.1.12.1 Guns. Tear gas pistols and revolvers for dispensing CN have been generally available to the public since the late 1920's. Pen-type guns and push-button-type dispensers that fire a shotgun pattern of heavy droplets at an effective range of 12 to 15 feet are available at present. These devices are not considered to be adaptable for use as remote response mechanisms because their small size limits range and effectiveness. In addition, the probability of injury to the eyes is great since most of the devices must be discharged directly at the eyes to be effective.

3.1.12.2 Projectiles. Shells firing ballistic projectiles loaded with gas with effective ranges in excess of 100 yards and a variety of gas grenades are commercially available to law enforcement agencies. Grenade delivery methods include manual tossing and device launching. Launching may be done with specially designed launching guns or with shotguns, rifles, or pistols using launching adapters. In some cases, specially designed launching ammunition with ranges up to approximately 125 yards may be used. The projectiles may be loaded with a single gas, with a combination of gases, or with gases and smoke. All gas grenades are sized to be held in the hand, and their total weight varies approximately from 2.5 ounces to 24 ounces. The gas may be dispensed from grenades instantaneously when the grenade explodes or may be dispensed continuously by discharging the contents through escape ports in the body of the grenade within pre-set time periods. The pre-set discharge periods range from 0.1 to 45 seconds. Instantaneous discharge grenades are loaded with a powder that explodes when ignited by the burning primer delay powder, rupturing the casing and releasing the contents. Continuous discharge burning-type grenades contain a fuel that is ignited by the primer to burn and increase the pressure inside the casing, forcing the contents out through escape ports in the casing. Most grenades are fitted with a bouchon safety lever actuating device similar to that shown in Figure 3.

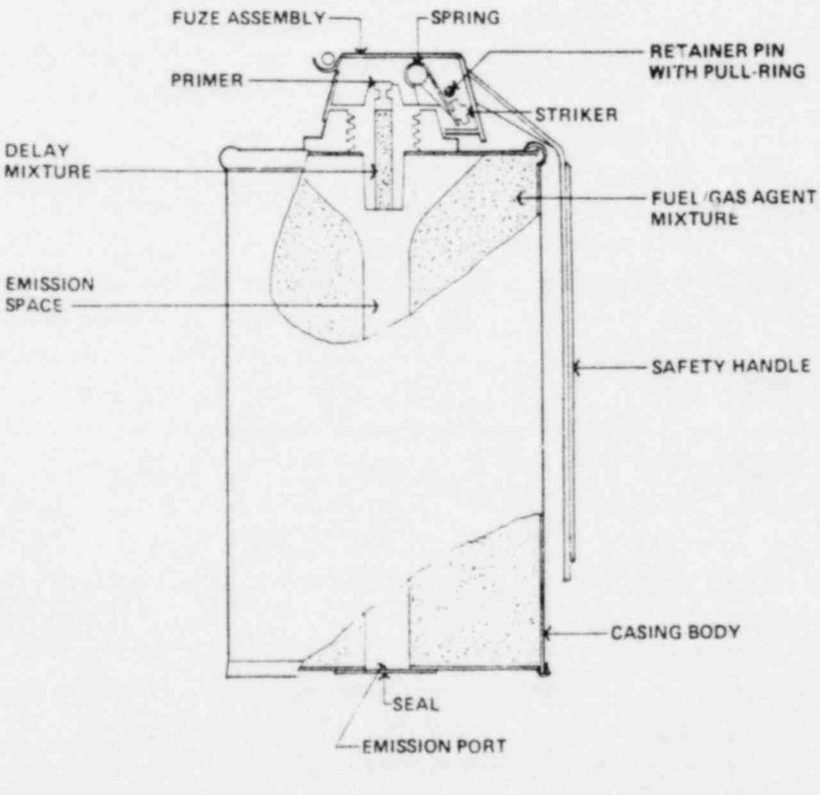

Figure 3. Example of Projectile Dispensing Device

The technology involved in adapting gas grenades for remote control is relatively simple. A clamp could hold the grenade body in place and a simple mechanism, remotely controlled by radio or wireline signals, could be devised to withdraw the retainer pin. Alternately, the retainer pin, safety handle, and striker could be removed and the mechanism could strike the primer cap directly. More complex technology would be required to adapt existing launching devices to arm grenades and launch them into predetermined areas. The technology required for launching would be simplified by remotely controlling the firing of existing available shells that launch gas-filled ballistic projectiles, eliminating the need to arm the grenades. However, it is apparent that simpler, less costly, safer, and more reliable methods than any of these should be considered for dispensing gas by remote control.

3.1.12.3 Aerosol. A simple and reasonably practical method of dispensing gas by remote control appears to be the use of aerosol-gas mixtures. Pressurized canisters can be filled with the desired gas in premeasured doses, in an aerosol mixture with a pressurizing gas, and the mixture can be released by remote control. The dose of irritant must be sized carefully to fill the enclosed space with a concentration sufficient to be effective and insufficient to be lethal. The release of the container contents must not reduce the oxygen content of the space below the level necessary to sustain life (approximately 19%). The pressurized canister should be located so as to be tamper-proof, and the discharge nozzle should be aimed to minimize the probability of injecting the irritant forcefully into the eyes in the event of an accidental discharge.

A large variety of containers is available commercially for the pressurized gases used in industry, home-craft, and portable fire extinguishers. These containers could be adapted simply by adding a reliable electrically or hydraulically operated valve designed for the required pressure and flow characteristics. The valve can be selected from the vast variety of control valves available commercially at present. A commercially available pressure actuated valve in the outlet of the canister would enable changing the canisters or removing the control valve. Such a device is opened by screwing in the control valve assembly and closed by pressure in the tank when the assembly is unscrewed. A manually operated stop valve between the control valve and the canister would serve the same purpose. Maintenance on the mechanism would consist of periodic checking for leaks and weighing the canister every 6 to 12 months to be assured that there had been no substantial loss of contents. The installed cost of the device should range approximately from $180 to $200, depending primarily upon the size of the container. The major reliability factors to be considered are the valve and control circuitry. Only highly reliable, industrial-quality valves and controls should be employed in the mechanism. The simplicity of this mechanism is indicated in Figure 4.

3.1.12.4 Indoor Installation. A mechanism similar to the one shown in Figure 4, which is installed in a building space that is air conditioned or ventilated, will require additional control consideration. The spread of gas through the air conditioning system and the removal of the gas by the ventilating system can be prevented by reliable, commercially available, motorized dampers that close when the gas device is actuated. The damper operators can be connected in parallel with the gas control valve in the control circuit. The spread of the gas from the space where it is released to other areas of the building can be minimized by reliable, commercially available, remotely controlled door operators that

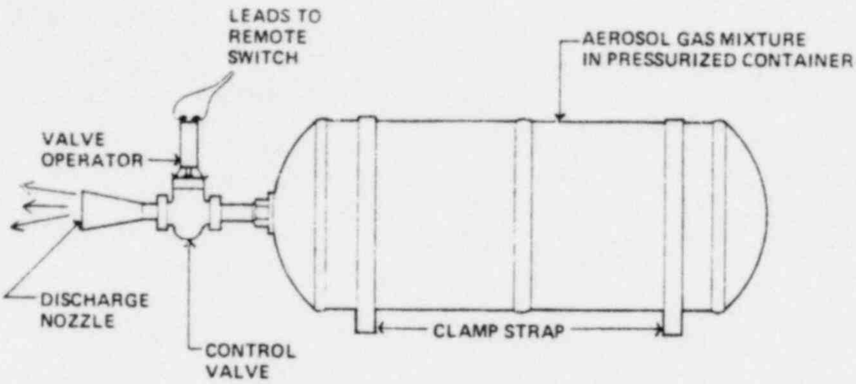

Figure 4. Example of Aerosol Dispensing Device

close selected doors when the gas is released. The door operators can be connected in parallel with the gas control valve circuit or can be operated independently by one or more other circuits. The costs of the dampers and door operators must be included in estimating the cost of specific installations.

3.1.12.5 Foggers. Outdoor dispensing of gases to incapacitate, delay or repel intruders by remote control can be accomplished by adapting any of a number of commercially available fogging machines. Some of the machines that are available at present are described briefly below:

General Ordnance Equipment Corporation markets two fogging machines: Two models of the PepperFog CS Tear Smoke Generator, MK XII and MK XVII. The MK XII employs the resonant pulse-jet principle to dispense the chemicals. The output of this machine is estimated to be equivalent to five burning-type continuous discharge grenades per minute. It has a loaded operating weight of 27 pounds and is designed to be portable. It will operate continuously for 45 minutes. The approximate dimensions of the machine are shown in Figure 5. The engine is essentially a tube with a glow coil in a combustion chamber, an intake valve, a supply of fuel and irritant agent, and an air pump at one end; at the other end is a discharge opening. It has one spark plug connected to an "A" size lantern battery for initial ignition. The fuel tank has a capacity of 0.2 gallon and fuel consumption is approximately 0.25 gallon per hour. The tank for the irritant agent has a capacity of 1 gallon. The pressure in the fuel tank causes a mixture of fuel and air to enter the combustion chamber, and the cycle is repeated many times per second. The irritant agent in the pressurized tank is released by a trigger valve and is injected into the flow of hot gases in the tube. The irritant is vaporized by the hot gases and is carried with them and discharged from the tube. When the irritant vapor is discharged, it comes in contact with the much cooler air and condenses, forming very fine particles. The size of the particles is controllable from 1 to 50 microns. The burning gases in the combustion chamber heat the glow coil, and no further spark ignition is required.

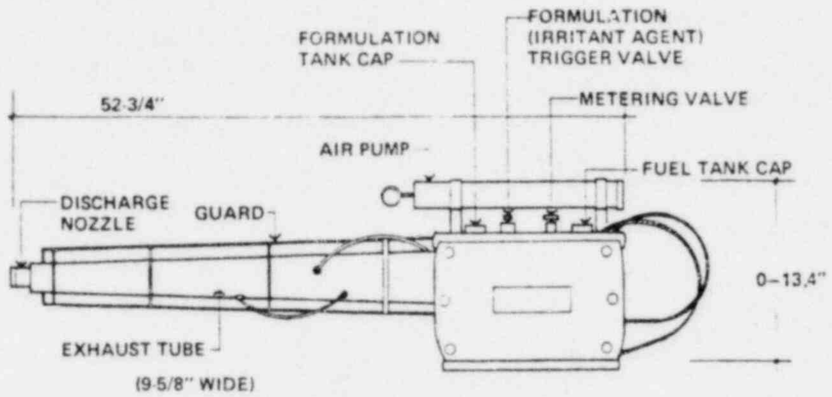

Figure 5. The PepperFog CS Tear Smoke Generator

The MK XVII employs a two-cycle, internal combustion, gasoline fueled lawn mower-type engine. The irritant gas is dispensed by being fed into the exhaust system of the engine from two pressurized 1-quart cartridges. This machine will project the irritant gas approximately 40 feet, and effective ranges up to 200 feet are possible with ideal wind conditions. The output of this machine is estimated to be equivalent to five burning-type continuous discharge grenades per minute. The operator is provided the option of changing between the two cartridges of irritant gas. This machine weighs 36 pounds fueled and loaded.

Federal Laboratories, Inc., markets the Turb-A-Fog Tear Gas Dispenser: a fogging machine that employs a two-cycle, internal combustion, gasoline engine with the irritant fed from a pressurized canister attached to the engine. The canister provides enough of the irritant agent for 4.5 minutes of continuous operation, and the canister can be quickly replaced by the operator. The machine weighs 30 pounds.

The U.S. Army Land Warfare Laboratory has developed a vehicular CS disseminator that feeds liquid irritant agent by gravity from a reservoir into the exhaust system of a four-cycle, internal combustion, motor vehicle, gasoline engine which discharges 1 quart of the irritant in 10 minutes through the engine exhaust system. A number of similar systems are used extensively, at present, in the fogging operations involved in insect control.

3.1.12.6 Fogger Installation. Any of the existing fogging machines with four-cycle, internal combustion, reciprocating gasoline engines could be adapted easily to be remotely controlled; to operate at a fixed location and to dispense irritant gas when actuated. A commercially available electrical contactor, actuated from a remote switch, can be employed to start and stop the engine and the irritant feed. Weatherproof sheet-metal housings — presently available for engine-driven, emergency electric power generators — can be adapted easily to protect the engine. Continuous operation could be several hours, depending upon capacity of the fuel and irritant agent tanks. The cost of such an installation is estimated at $4000 to $5000, and maintenance will be approximately the same as that for an engine-driven, electric power generator of the same horsepower.

Adaptation of the fogger machines that employ the resonant pulse-jet principle may provide more flexibility at less cost than using four-cycle, internal combustion reciprocating engines. The MK XII could be adapted for remote control to dispense irritant gas or smoke by mounting it on a fixed foundation or on a stand that would enable it to be aimed by remote control. The installation should provide protection for any parts of the machine that need to be protected from the weather. The installation could be enclosed with a chain-link fence or mounted on a tower to discourage tampering. The technology necessary to remotely control the machine exists and could be adapted readily. The fuel valve and formulation trigger valve could be replaced with simple open-close valves with remotely controlled operators, and the spark plug can be energized by a simple remote switch. The capability to aim the MK XII might be provided if it were combined with a remotely controlled mount, such as the one discussed in Section 3.4.4.

The cost of the MK XII is approximately $585. The instrumentation necessary to provide remote control is estimated to cost less than $150; a foundation and simple mount for stationary operation will cost approximately another $150. The cost of the remotely controlled searchlight mount, mentioned above, is approximately $2800. The engine should be very reliable after it is running. The tank pressurization and fuel and formulation feed controls should be highly reliable, industrial quality, components. Maintenance will consist primarily of cleaning the machine after it has been used. The manufacturer's published literature includes detailed maintenance and operating instructions.

3.2 SCREENING SMOKES

3.2.1 Description of Method

Screening smokes may be used in several ways. They may be used by security forces to conceal their exact position and direction of movement. They may also be used to obscure an intruder's vision of the intended target, other members of the intrusion team, or other physical features in the smoke-screened area. A smoke is a cloud of minute solid or liquid particles suspended in a gaseous medium, usually the air. The particles of smokes used most prevalently in military and law enforcement operations will vary in size from particles that may be seen by the unaided eye to those approaching the size of a single molecule.

3.2.2 Application Considerations

The impact of wind conditions upon the outdoor effectiveness of screening smokes is similar to that discussed in Section 3.1.3. However, the effectiveness of screening smoke is affected more seriously by wind conditions because smokes require denser concentrations than gases. The use of remotely controlled dampers and door operators to prevent the spread of gases in buildings is necessary for screening smokes and is discussed in Section 3.1.12.4. The adaptation of mechanisms for remotely controlled dispensing of gases discussed in

Section 3.1.12 and shown in Figures 3, 4, and 5 are applicable for screening smokes. Decontamination of the building or outdoor area where screening smokes are dispersed is usually not required.

Smoke-producing chemicals are available to the military and law enforcement agencies as burning candles, grenades, shells with ballistic projectiles, and in liquid and powdered form in canisters. Available dispensing methods include detonation, burning, and spraying. Smoke-producing chemicals that are used most prevalently in law enforcement are discussed.

3.2.3 FM

Titanium Tetrachloride (FM) is a colorless liquid that melts at -22° F and boils at 275° F. It can be dispersed easily by detonating devices or by spraying it into the air. When the liquid is atomized in the air, it hydrolyzes; forming a smoke of the corresponding hydroxide. Titanium hydroxide is deliquescent, and the smoke becomes composed of solid and liquid particles. The hydrochloric acid, being hygroscopic, helps to form the smoke. The smoke is considered harmless and only slightly irritating. This compound is soluble in ethylene dichloride and ether and is neutralized by alkaline solid or solution. This chemical has been used extensively in such activities as detecting leaks in air conditioning ducts, to give a visual representation of air patterns from air conditioning supply air diffusers, identification of manholes in a particular sewer line where several lines are close together, and a number of other similar uses.

Contact of the liquid with skin can cause burns similar to those caused by strong acids. Usual treatment is washing the affected area with copious amounts of water, then with sodium bicarbonate solution, and then treatment similar to that for ordinary burns. The smoke is slightly irritating to the throat.

Proper amounts of titanium tetrachloride and concentrated ammonium hydroxide may be mixed in a selfsustaining chemical reaction to produce a very dense screening smoke (ref. 3). This technique has several advantages over atomizing FM into the air. It eliminates the problem of the hydrochloric acid byproduct by neutralizing it into ammonium chloride and water. Also, it does not depend on moisture in the air for success, since it continually produces its own water.

3.2.4 FS

The composition of the FS smoke-producing chemical is about 55% sulfur trioxide and about 45% chlorsulfonic acid by weight. The mixture was developed by the U.S. Department of the Army at Edgewood Arsenal during 1929-30 to satisfy a requirement for a more effective and less expensive smoke-producing chemical than FM. It melts at -22° F and boils (decomposes) at 176° F.

The purpose of the chlorsulfonic acid constituent of the mixture is to keep the sulfur trioxide in a liquid state at the lowest temperatures likely to be encountered. Chlorsulfonic acid has fair smoke-producing qualities but the sulfur trioxide is the major contributor to the smoke production of the mixture.

The mixture can be dispensed with detonating devices or by spraying into the air. Both constituents of the mixture depend upon hydrolysis to produce smoke. The sulfuric acid formed by the hydrolysis reaction continues to absorb moisture until an equilibrium condition is reached with the water vapor present. High humidity conditions increase the effectiveness of the smoke produced. Liquid FS has the corrosive properties of strong mineral acids. The smoke is slightly irritating to the skin and throat but is considered harmless.

The mixture can be neutralized by an alkaline solid or solution. Treatment for burns resulting from contact with the liquid is usually the same as FM which is discussed above.

3.2.5 White Phosphorus

White phosphorus (WP) and the smoke-producing mixture (HC) are suitable for dispensing by burning or detonating devices only. White phosphorus has had considerable use in warfare, and the HC smoke-producing agent has been used extensively in law enforcement and military tactical situations. However, both are considered too dangerous to use in remotely controlled response mechanisms because it is necessary to dispense them by detonation or burning.

3.2.6 Smoke Selection

FS and FM smoke-producing agents appear to be the most practical of the available agents for use by security forces at nuclear reactor and fuel cycle facilities. Either of the chemicals will form an effective obscuring screen when properly dispersed. Both agents produce a white smoke which obscures by scattering light rays, by reflection and refraction, more than by actual obstruction of the rays. This scattering of light rays is not affected significantly by the size of the particles that form the smoke, provided they are large enough to reflect the light at all. The scattering effect is very dependent upon the concentration of the particles; the denser the distribution of the particles, the more complete is the diffusion of the light rays.

The smoke produced by the FS mixture has a greater total obscuring power than the smoke from FM. However, the FS smoke is considerably more corrosive to metals and fabrics than the FM smoke. The ammonium chloride byproduct of the FM-ammonium hydroxide system can also cause corrosion of nuclear material and, therefore, should be isolated from it.

It has been found that the ammonia does not contribute to severe irritation which might require medical care (ref. 4). However, significant cases of noticeable irritation may occur. In the event that only FM is dispensed, marked or severe irritation is the major effect regardless of exposure duration. Mechanical or carcinogenic effects of a titanium oxide burden in the lungs have apparently not been reported.

3.2.7 Countermeasures

The only apparent countermeasures to screening smokes are to disable the dispensing mechanism, avoid the smoke-screened area, or wait for the smoke to clear.

3.3 COMMUNICATIONS

3.3.1 Description of Method

The most apparent uses for remote response communications are their employment to dissuade intruders from further encroachment upon the facility premises and to delay the progress of intruders who persist in further encroachment.

Communications that convey a threat to the intruder may have a dissuasive effect whether the threat is stated or implied. Signs posted prominently on the facility premises may convey threats of personal injury and legal prosecution by the use of strong wording. Example phrases are: "authorized use of lethal force," "trespassers will be prosecuted," and "warning: vicious guard dogs." The threats stated on signs may be intensified by the additional implied threat of apprehension by conveying information to the intruder that the intrusion has been discovered. Information notifying the intruder that the intrusion has been detected may be transmitted by an audible alarm, by floodlighting the area of the intrusion, by illumination of warning signs with flashing lights, and other similar methods. The mechanisms employed in the notification can be controlled automatically or can be actuated from remotely located control devices that are initiated manually. Visual communications can include a warning and instructions to the intruder, but the warning and instructions may be more effective if spoken. The use of voice warnings and instructions will be more useful if the intruder is provided with the means to reply.

One-way communications can be used in attempts to dissuade the intruder from further encroachment by warning of the probable consequences. Such warnings should include instructions concerning how the intruder may act to avoid injury. The well-trained and highly motivated intruder will probably not be diverted by one-way communications, except momentarily. If the intruder's response to communications can be seen and heard by security forces, the effectiveness of the method will be further improved. The tasks that an intruder must perform to achieve his objective can be increased significantly if two-way communications can be established. This will enable efforts to dissuade or negotiate with the intruder and to employ other delaying tactics, such as confusing or misleading communications and information overload.

The effectiveness of communications employed as a remote response method of dissuasion is dependent entirely upon the capability of the intruder to understand the information. Communications employed to delay the intruder, who persists in further encroachment after being warned, may be designed to be distracting, confusing, and misleading.

Communications requirements, systems, and equipment for security operations at nuclear facilities are thoroughly covered by related work of the Safeguards Program of the Nuclear Regulatory Commission in Security Communication Systems for Nuclear Fixed-Site Facilities, report NUREG/CR-0508, by Larry Howington. The communications methods and mechanisms discussed below are confined to those that may be used to communicate with intruders at locations remote from security forces.

3.3.2 Availability

A great variety of reliable communication equipment and components is available commercially. Commands, warnings, and instructions can be given to an intruder by audio and visual techniques. Visual feedback to the individual originating the commands will enable formulation of subsequent commands and provide confirmation of the effectiveness of the commands. The commands can be provided by remotely controlled signs, loud-speakers, or electronic megaphones ("bull-horns"). The feedback can be provided by microphones, speaker microphones, position sensors or closed circuit television.

3.3.3 Wired Public Address

A wired public address system may be installed with sufficient speakers and audio power output to completely cover the area of interest. The number of speakers, speaker size, speaker characteristics, and speaker location must be based upon the environment in which they are to be employed. Ceiling-mounted speakers may be used in office areas, speakers mounted in enclosures can be used in high-bay areas, and pole-mounted, outdoor-type speakers may be used to cover outside areas. The ceiling-mounted speakers may be employed as speaker microphones to enable two-way communication with the intruder, but the other types of speakers listed can be used only for one-way communications. Altec Sound Products, Amperex Electronic Corporation, Atlas Sound Division of American Trading Products Corporation, Bell Telephone Corporation, Electro-Voice Division of Gulton Industries, Inc., and Walker Transducing Systems, Inc., are just a few of the many sources of high-quality speakers and speaker systems.

3.3.4 Electronic Megaphones

Hand-carried, electronic megaphones can project the human voice great distances, dependent upon the area, local audio absorbative media, and ambient noise. If one is within sight of an intruder, but not within talking distance, such a device could be extremely useful in establishing communication with the intruder. Observation of the intruder could provide the helpful feedback necessary to adjudge further action.

3.3.5 Signs

Commercially available electric signs have been used to establish one-way communication; such as highway signs used to warn of traffic hazards, ice, high water, etc., and advertising signs. However, these techniques are not considered to be very effective for communicating with highly motivated intruders.

3.3.6 Radio-Controlled Public Address

Another technique that is usable under special circumstances is a radio-controlled, public address system. If a temporary facility is established, or an emergency public address system must be installed and there is insufficient time for installing the necessary wire lines, radio receivers can be used to power each installed speaker. Selective address techniques will enable selecting a single speaker, a group of speakers, or all speakers at any one time. This technique is expensive, as it will incur a $500 to $1200 additional cost for each radio receiver used, and it is usually not as reliable as a wire-line system. However, it can be installed quickly, irrespective of distance between the control point and the locations of the speakers.

3.3.7 Countermeasures

The obvious countermeasure to the use of communications with the intruder as a security response method is for the intruder to disable or simply ignore the communications. It is also possible that an intruder may not be able to understand the language used. However, if attempts to communicate can capture the intruder's attention, at least a diversion will be accomplished. Any diversion will increase the tasks that must be performed to achieve an intruder's objective.

3.4 LIGHT

3.4.1 Description of Method

The manipulation of lighting mechanisms by remote control may be useful in methods of response to intruders. Remotely controlled light sources can be used to reveal an intruder's location at night. Visible light can distract the intruder by serving notice that the intrusion has been detected. Infrared light sources and special viewing devices will enable observation of intruders in the dark without their knowledge. Sudden fluctuations from brilliant illumination to a very low light level environment can reduce significantly an intruder's ability to see in the low light level environment. Strobe-light flicker can have a distracting and, perhaps, a disorienting effect on an intruder.

For the purpose of decreasing an intruder's capability to perform tasks, the reduction of ability to see in the dark appears to be the most useful function of the techniques mentioned above. The human eye is extremely adaptable to slow changes in light level. It performs effectively in a range of illumination level changes of approximately 100 million to 1. However, the adaptation of the eye necessary to see at different levels of illumination is not instantaneous (Ref. 5). In a sudden change from a very low illumination level to a very high level, it will take at least a few seconds for the eye to adapt to the higher level. The adaptation time can approach 1 minute. The recovery time for a sudden change from a very high illumination level to a very low level is considerably longer. Recovery of maximum sensitivity can take up to 30 minutes or more.

3.4.2 Countermeasures

The obvious countermeasures to the use of high-intensity lighting to decrease night vision are to disable the light, to avoid looking at the light source, to close the eyes during the period of high-intensity illumination, and to use a flashlight when the light is turned off. However, avoidance of looking at the light source is a distraction and will not prevent a delay in adapting to the darkness when the light is turned off. Closing the eyes during the period of high-intensity illumination will decrease an intruder's ability to perform tasks as will the handling of a flashlight. The use of a flashlight can reveal the intruder's position and activity.

3.4.3 Application Considerations

Lighting fixtures inside a building and outside area lighting can be controlled by remotely located switches in almost any conceivable combination. The installation of special high-intensity fixtures for area lighting or in buildings is quite expensive and probably not justifiable as a remote response method unless the intense lighting level is required for another purpose. Remote control of the normal lighting in a building may be useful in security responses to intruders; but, if a building space is to be darkened, the emergency lighting in the space must be remotely controlled also. A practical application of lighting as a remote response method appears to be the use of searchlights in outdoor areas. Searchlights can also be used for night surveillance of the area and to decrease an intruder's ability to see in the darkness when the light is turned off. Search lights are available commercially with a variety of output intensities and accessories.

3.4.4 Varo Searchlight

A remotely controlled searchlight with a television camera mount and gimbal assembly is marketed by Varo, Inc., Texas Division, Garland, Texas. A complete control system for aiming the searchlight and television camera is furnished with the assembly. A sketch of the assembly is shown in Figure 6.

The Varo Searchlight Position System is a lightweight, gimbal-mounted searchlight with a bore-sight TV camera mount. The system is available with or without the TV camera. The searchlight is a modified 1 kW AN/VSS-3A military light and provides an intense beam of visible or infrared light which is continuously variable from 1° to 7° in width.

The searchlight uses a 1 kW Xenon short-arc lamp and operates on 24 to 28 volts dc. Maximum power is 1.6 kW and maximum current is 58 amperes. It has a metal parabolic reflector, motor-driven focus-defocus control, air-to-air cooling system using an integral intake exhaust blower, and is provided complete with control box and remote control panel. The system can be completely controlled from the 19-inch rack-mounted control panel furnished with the assembly, including turning the searchlight on and off, azimuth and elevation movement, and beam width adjustment. A standard 525-line TV camera equipped with any C-mount lens which provides operational ranges in excess of 1000 meters is available, as is a

9-inch, 525-line TV monitor. Horizontal turning is ±190°; elevation adjustment is from directly overhead to 20° below horizontal, and the mechanical stops are fully adjustable.

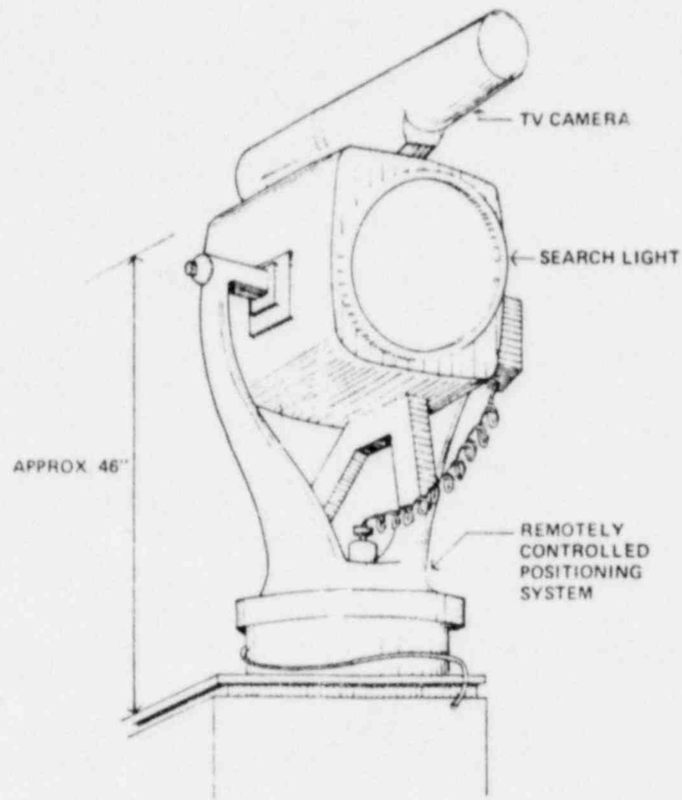

Figure 6. Remotely Controlled Searchlight with Television Camera

This assembly, which can be installed on a tower or other elevated position, can be used to verify perimeter intrusions and to track intruders within range of the light and camera. Visible light can be turned on and off to cause temporary periods of night blindness and infrared light and viewing devices can be used for surveillance during the periods when the visible light is off. The cost of the complete assembly is approximately \$8000 to \$9000. The cost of a similar, but smaller, remotely controlled complete assembly with a 300-watt searchlight is approximately \$3500.

The advertising literature published by the manufacturer states that the versatility, reliability, and maintainability of the assembly have been proven by many years of various military applications.

3.5 ELECTRICAL

3.5.1 Description of Method

Electrical shock mechanisms may be developed for noninjurious uses in security operations, but very little development or evaluation work has been done regarding their use. The Shock Baton, for use in crowd control, is simply a baton that can be used to impart an electrical shock to the person touched with it. This device is apparently an adaptation of the electric cattle prod which has been used for many years to aid in loading and unloading cattle. It is not considered to be suitable for use as a remotely controlled response mechanism. The TASER is a device that is intended to incapacitate a person by electric shock. This device, when actuated, launches two darts connected to wire leads that are connected to a battery in the hand-held launching device. Contact of the darts with the person's body completes the electrical circuit, causing the current to flow through the wires and the person's body. This device is not considered to be suitable for use as a remotely controlled response mechanism. There has been considerable public resistance to the use of the Shock Baton and the TASER.

Memories of the often-lethal electric fences at Nazi concentration camps, the electric chairs used to execute criminals, and "fear of the unknown" resulting from a lack of public knowledge will have a detrimental effect upon public acceptance of remote response mechanisms employing electric shock.

3.5.2 Fence

The only electric shock method known to be available at present that may be remotely controlled and used in a security response to an intruder is the electrically charged fence. Such fences, used at present to confine livestock, remain charged continuously so that the confined animals are electrically shocked whenever they brush against the fence. The technology required to enable a fence to be electrically charged or not charged, as desired, would consist of installing a simple on-off switch in the electric circuit and remotely locating the switch. However, an electrified fence will more probably increase the tasks to be performed by an intruder rather than decrease the intruder's capability to perform tasks.

3.5.3 Water Jets

The U.S. Army Limited War Laboratory has published a report cataloguing riot control concepts (Ref. 6). The report mentions concepts for vehicular-mounted, electrified telescoping booms and electrified water jets for clearing crowds from the streets. The electrified water jet concept in a fixed installation may have limited applicability as an outdoor remote response method. The report estimates the development cost of the concept at $6000 and the hazard involved in its use as minimal. It also cautions that use of the method could endanger vital organs, such as the eyes.

3.5.4 Development Guidelines

The U.S. Army Human Engineering Laboratory at Aberdeen Proving Ground, Maryland, has conducted research that may be useful in the development of remote response mechanisms employing electrical shock. The results of the research were published in January 1976, in Technical Memorandum 3-76, Modeling for Less-Lethal Electrical Devices (Ref. 7). The following is quoted from this publication:

"CONCLUSIONS

General

Although electrical less-lethal weapons appear to show great promise for noninjurious application, little effort has been directed toward their development or evaluation. The basic model developed for the evaluation of less-lethal weapons is applicable to electrical devices, although more basic data needs to be gathered prior to useful evaluations.

Specific

An 'average' man will be unable to release a wire conducting 15 ma (60 cycle AC) through his body to ground. A highly motivated man has managed to release a wire carrying 25 ma.

Currents from 18 to 11 ma are sufficient to paralyze muscles of respiration for the duration of the shock.

Prolonged exposure to currents just in excess of NLG* current may result in exhaustion, asphyxiation and death.

Currents of the magnitudes mentioned above are sufficient to produce serious burns under certain conditions.

NLG current is minimized when AC frequency is held between 10 and 100 Hz.

Direct current results in internal heating effects rather than muscle contractions. However, circuit interruption or gross current variation results in severe muscle contraction. Maximum voluntarily accepted DC release current is on the order of 76 ma.

Subjecting an individual to 3 times his let-go current should not, in most cases, result in ventricular fibrillation.

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* NLG current refers to "no let go," i.e., the current in a wire at which a person holding the wire is unable to release it.

Human susceptibility to surge current is highly variable, with damage as minor as startle effects and as major as severe burns, paralysis, and long-term mental deterioration.

Cardiac arrest as a mechanism of effectiveness is not only very risky and dangerous but most likely will not produce the desired effects in the required time frames.

Although electrical energy can be used to depolarize and render a target unconscious, the response is not instantaneous.

RECOMMENDATIONS

Research and development efforts should be pursued for less-lethal electrical weapons in that this approach possesses many of the desired features for less-lethal weapon application.

Good public relations are essential and must be developed for electrical less-lethal weapons along with the technical development of such items."

3.5.5 Countermeasures

The obvious countermeasures to response methods employing electric shock are to insulate against the transmission of the current, to interrupt the circuit by cutting the conductors, to ground the circuit, or to avoid contact with the conductors.

3.6 SOUND

3.6.1 Description of Method

An audible alarm might deter an intruder or, at least, cause an alteration of the intruder's plan. Intense noise may be used to decrease an intruder's ability to perform tasks. Noise can interfere with speech intelligibility, cause dizziness, equilibrium loss, pain, and nausea. The effects of noise are well documented:

> "Hundreds of studies have been conducted dealing with the effects of noise upon man. The number and variety of both independent and dependent variables that have been investigated is almost endless. Typical independent variables have included noise intensity, frequency composition, duration, regularity, relative location, and a wide variety of human mental and physical characteristics. Typical dependent variables have included physiological effects and the efficiency of mental and performance functioning under a wide range of task requirements" (Ref. 8, p. 16).

"Several authors have presented evidence that exposure to extremely intense noises (greater than 120 dB) may result in disturbing physiological effects in human subjects. Persons subjected to jet aircraft noises of approximately 140 dB for moderate time durations have complained of a variety of symptoms associated with severe disequilibrium, e.g., loss of balance, dizziness, nausea, and involuntary eye movement" (Ref. 8).

"A 100 dB masking noise at frequencies comparable to the human voice (600-4800 Hz) is sufficient to preclude effective verbal communications between two individuals separated by a distance of six inches (Ref. 8).

"At extremely high levels of intensity, especially for infra- and ultra-sonic [sic] frequencies, physiological disturbances may also lead to severe performance decrements" (Ref. 8, p. 19).

"High intensity noises in the infra-sonic (5-20 Hz) and ultra-sonic [sic] (16-20 kHz) ranges may cause extreme disruption of a variety of physiological processes, although little empirical evidence has been gathered to support this viewpoint" (ref. 8, p. 18).

"Subjective response to the sound emitted from ultrasonic instruments increased with the intensity of the noise levels. At 80 dB, individuals expressed no effect, but they chose to turn the instruments off when not in use. At 90 dB, individuals had a feeling of malaise, fatigue, or would leave the location where the ultrasonic instruments were operating. These levels compare with reported threshholds of discomfort at 120 dB and pain at 142 dB for audio frequency noises. The frequency where the greatest sensitivity and pain were experienced was in the 22,400 to 28,000 third octave band. The reason for this sensitivity isn't clearly understood, but the measurements indicate it to be caused by a very narrow band sound" (Ref. 9, p. 136).

3.6.2 Availability

The availability of mechanisms that are designed to produce high-intensity sound, which may be useful in remote response methods, is extremely limited. Astrosystems International, Inc., developed a high-intensity sound generator, employing two hot gas intersecting jets. The generator would produce a 126 dB sound pressure level at a distance of 500 feet, with most of the energy between 2.5 and 80 Hz. A prototype was produced in 1966, but present availability and pricing are not known. The French have conducted experiments using an infrasonic energy generator to induce both physical and physiological effects. This use of very low frequency sound has not been proven, but the cost of development has been estimated, by the U. S. Army Limited War Laboratory, to be approximately $25,000; the cost of a generator was estimated to be $2500. The U. S. Army Ballistics Research Laboratories report, Gradient and Less-Lethal Devices in Control of Urban Violence, mentions "The Curdler (People Repeller)." It was suggested that this device be mounted on a helicopter and connected to the military HPS-1 speaker system. The device was described as being capable of reproducing and amplifying sound comparable to that experienced when standing behind a jet aircraft. No availability or cost data were included in the report.

3.6.3 Countermeasures

Sound attenuating protective ear plugs or covers will reduce the effectiveness of high-intensity sound substantially. The simplicity of this countermeasure, the need to protect persons other than the intruder, and the lack of available hardware are the principal disadvantages of using high-intensity sound as a remote response method.

4. METHODS TO INCREASE INTRUDER'S TASKS

4.1 PHYSICAL BARRIER

4.1.1 Description of Method

Intruders using a facility's normal avenues of access, such as roadways and building corridors, can be delayed by physical barriers placed in the paths of normal access by remotely controlled mechanisms. The delay achieved by remotely controlled physical barriers will depend upon the type of barrier used and the countermeasures available to the intruder.

4.1.2 Fence Gates

Gates in fences can be opened and closed and locked in either position by remote control. Usually, commercially available gates are constructed to provide approximately the same barrier to access, when they are closed and locked, as the fences in which they are installed. Gates that operate by sliding open or closed are more sturdy than swinging gates. Sliding gates are supported at the top by a metal track on which the gate carrier mechanism rolls or slides; swinging gates have no track. Wider openings are possible with sliding gates than with swinging gates. A typical sliding gate assembly is shown in Figure 7.

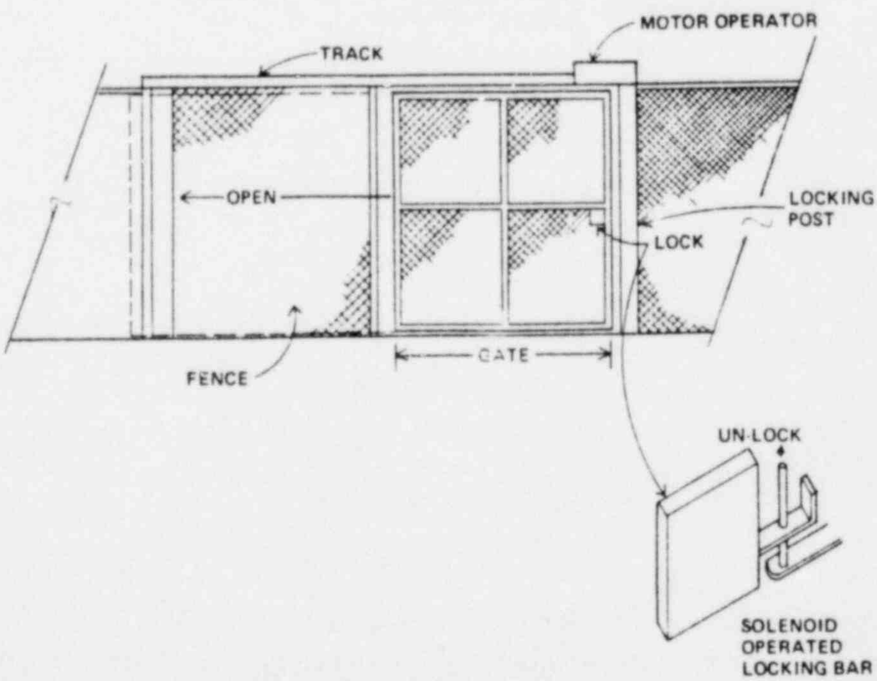

Figure 7. Typical Sliding Gate Assembly

The closing speed of a remotely operated sliding gate is approximately 30 feet per minute. The installed cost of a heavy-duty gate assembly, which includes lock, controls, track, motor, and carriers for an opening 12 feet wide and 8.5 feet high, is approximately $6000 to $8000.

Countermeasures to remotely operated gates are to crash through the gate with a heavy vehicle, cut the lock or cut a hole in the fence, obstruct the gate travel path to block the gate open, climb over the fence or tunnel under it.

The probability of an intruder having the capability to crash through a gate with a vehicle can be reduced significantly by remotely controlling a steel crash beam to drop across the gate opening. This mechanism may also be used across vehicular access openings in buildings.

4.1.3 Vehicle Gates

A mechanism marketed by Folger Adam Company, Joliet, Illinois, is designed to deny vehicular access by remote control. Their No. 420 Crash Beam assembly will lower a 6-inch deep "H" section steel beam weighing 15.5 pounds per linear foot across a roadway and lock it in place, when the mechanism is actuated from a remote location. In the event of a power failure with the beam lowered, it may be unlocked with a key and raised manually to any desired position. The mechanism is apparently constructed ruggedly, and maintenance should be minimal. The installed cost of the assembly is approximately $10,000.

The capability of the crash beam assembly to deny vehicular access will depend greatly upon the adjacent fixed physical barriers. These fences or walls must be of sufficient strength to prevent a vehicle from by-passing the crash beam.

4.1.4 Wheel Traps

Another type of mechanism that may be useful in responses to vehicular intrusions is a wheel trap installed in the roadway. These devices can be installed in roadways to damage the tires of vehicles traveling in either direction on the roadway when the mechanisms are actuated. The model with the patented safety teeth could be installed to permit normal flow of traffic in one direction. A remotely controlled model could be installed in the same traffic lane with the teeth set to puncture the tires of vehicles traveling in the normal direction for the lane. The remotely controlled model would be actuated only in response to an intrusion. Two remotely controlled models could be installed to trap a vehicle between them when they are actuated.

Maintenance on these traffic controllers should be minimal and will probably consist of keeping the device drained, free of debris, and the moving parts free to operate.

The effectiveness of using wheel trap mechanisms in vehicular intrusion incidents will depend greatly upon the provision of fixed physical barriers to prevent vehicles from going around the wheel trap mechanism.

The TRAF-I-TROL, made by Auto Parks, Inc., is a remotely controlled mechanism designed for installation in a roadway to force the vehicular traffic to move in one direction. When this mechanism is actuated, a row of sharpened steel spikes, which are angled to puncture the tires of vehicles moving in the wrong direction, are projected above the surface of the road. The sharpened spikes remain below the road surface until the mechanism is actuated. The cost of this mechanism is approximately $450. The cost of the flush-mounted mechanism is approximately $475 per 72-inch-long section. The surface-mounted model costs approximately $390 per 36-inch-long section, and the version with safety teeth costs $750 per 72-inch-long section.

4.1.5 Spring Steel Tapes

The U.S. Army has evaluated several types of mechanisms that may be used to emplace barricades. A mechanism which has been evaluated at Fort Belvoir, Virginia, consists of a barbed, helical, spring, steel tape compressed to a closed coil and packaged in a polyurethane foam container. This mechanism contains sufficient tape to form a barbed barricade 30 inches high and 76 feet long, when the coiled spring is released.

Another barricade emplacement mechanism prototype has been developed by Frankford Arsenal and tested at Fort Bragg, North Carolina. This mechanism consists of 450 feet of high-strength, barbed, rectangular steel wire coiled in a 6-inch diameter cylindrical container with the wire still under tension. When the coil is released, the wire is propelled out of the cylinder to a distance of approximately 80 feet.

Test and evaluation of the two barricading methods have shown them to be technically feasible, but they have not yet been produced in a form for user application. It is conceivable that barbed, personnel barriers that are rapidly emplaced could be useful as remote response mechanisms. The application engineering necessary to adapt these mechanisms for remote control should be relatively simple. Two difficulties in using these barricade emplacement devices are apparent. The most obvious difficulty is that a person in the projection path of the wire could be injured seriously when the coil is released. Another difficulty may be the removal of the barricade after it has served its purpose. A sketch of this type of mechanism is shown in Figure 8.

Figure 8. Example of Spring Steel Tape

4.1.6 Building Doors

Doors in buildings can be remotely controlled to provide physical barriers in normal access passageways in the event of an intrusion. The effectiveness of the barrier provided by a remotely controlled door will depend upon the type of door and lock and the countermeasures available to the intruder. Doors closed and locked in response to an intrusion become part of the physical safeguard system and may be evaluated under the provisions of the Barrier Technology Handbook, SAND 77-1033, Sandia Laboratories, November 1976, revised October 1977. Evaluation of the barrier effectiveness of remotely controlled doors is outside of the scope of this report. A wide variety of remotely controlled doors is available commercially; such as solid wood, hollow core wood, glass, hollow core metal, metal-clad wood, and wood with a variety of synthetic facing materials. Doors for security applications are available in tool-resistant, bullet-resistant, blast-resistant, and fire-resistant models. Other available special purpose doors are water-tight, pressure-tight, fume-tight, sound-retarding, heat-insulating, and radiation shielding. Doors can be made approximately as secure as the walls in which they are installed.

The most prevalent door operations are swinging, sliding, and swing-up or roll-up overhead operation. Reliable remote control systems are available commercially for all of these operations. Maintenance requirements of the operators and control systems will vary with the particular system, but required maintenance is generally minimal for the products of the well-established and experienced door-operator manufacturers. The power for operating the doors may be hydraulic, pneumatic, or electrical. The available control systems usually include safety provisions to minimize the probability of a person being injured by operation of the doors.

The manufacturers of equipment for use in detention facilities have developed a variety of remotely controlled door operating and locking mechanisms. They, and the institutions that use the mechanisms, have extensive experience in the effectiveness, costs, maintenance, and reliability of the various available mechanisms. A list of detention equipment manufacturers that may be contacted for detailed information is shown in Section 10. Generally, the equipment is highly reliable, effective against the use of most ordinary hand tools, and relatively maintenance-free in an environment other than one where vandalism is prevalent. The cost is considerably greater than standard commercial service door systems.

A number of manufacturers of detention security equipment provide designs, hardware, controls, and installation of remotely controlled door operating systems. These systems include keyless mechanical operation, keyless electric operation, electric operation with provisions for unlocking with a key and manual opening of the door, and dual operation using mechanical or electrical operators. Several of the manufacturers market complete central control systems with control consoles which have controls for operating the doors, closed circuit television for monitoring the doors and corridors, and indicators for fire and other alarms. Locking mechanisms that project bolts from the door into the frame at all sides of the opening at several points on each side are available. Other mechanisms lock only the bottom and top of the door. Some use a continuous solid steel bar to seal and lock the strike side of the door.

The cost of a remotely controlled door system with tool-resistant glass view panel, sliding operator, lock, electrical remote control, and mechanical backup operator is approximately $1500 per door.

Bank vault doors, blast-resistant doors, and radiation-shielding doors will provide the barriers that are much more difficult to penetrate than the detention doors discussed above because of their massiveness and more secure sealing and locking mechanisms. However, they are vastly more expensive, and their use will probably be limited to very special applications.

The obvious countermeasures to remotely controlled doors are to pass through the doorway before it is closed, to disable the control system before it can be used, or to obstruct the opening so the door cannot close. After the door is closed and locked, the principal countermeasure is penetration using power drills, saws, explosives, or hand tools, such as sledge hammers, chisels, crowbars, and cutting torches. All of the countermeasures, other than passing through the opening before the door is closed, will delay the intruder. The amount of delay will depend upon the intruder's equipment and skill and the difficulty involved in disabling the operation of the door or penetrating it.

4.1.7 Mobile Steel Tape

Coiled barbed steel tape can be used as a mobile barrier in a manner similar to doors and gates. Intertwined helical coils of the tape would be attached horizontally to a steel framework that encompasses the area to be protected. The framework and flexible maze of coils would be attached to a lifting system of cables and pulleys which could be operated on-site or remotely. Extra coils could be mounted at area entrances to give additional protection at these vulnerable points. The entire system would be lifted above the area's work space during normal operation. It could be quickly lowered to floor level during non-operating hours or in response to assessment of an intrusion alarm, thus providing an additional protective barrier.

4.2 DOGS

4.2.1 Description of Method

Mechanisms to remotely control trained guard dogs can be useful in security force response to intruders. Dogs can function in detection, prevention, and response situations. They are available through leasing agreements and outright purchase. A well-trained guard dog may cost from $1000 to $3000 and may be expected to be of guard service between the ages of 2 and 10 years.

4.2.2 Direct Control

Guard dogs may be trained for general service, but are thought to be more effective when trained for duty at a specific location. It is important that a dog have the fewest number of handlers practical. One handler per dog is ideal; however, in applications where this would be impractical, a dog should never have more than three handlers. A guard dog should not be expected to serve on guard duty for 24 continuous hours. There should be a "shift" of dogs to prevent fatiguing any one dog.

More than one dog may be used for guard duty when the area to be patrolled is sizeable. Well-trained dogs behave well together and normally present no problems when stationed in the same general area. When a dog guards a particular area or zone, as opposed to being moved to different installations, the usual reaction is that he becomes more protective of the area. It is recommended by many dog trainers that the handlers arrange for an occasional agitation of the dog to maintain the ultimate in protectiveness.

Armed security forces working in conjunction with the dogs would offer more immediate control over the dog and the intruder as well.

Some dogs may be trained to patrol the outer perimeter of a security area; these particular dogs are more dependable when stationed in the same general area. Those dogs trained to be of service in a building are more efficient when utilized for duty in a building or buildings.

4.2.3 Remote Control

Another possibility to consider in the use of guard dogs is remote control. A study was done by the U.S. Army Land Warfare Laboratory at the Aberdeen Proving Ground to develop procedures whereby a dog handler could control the off-leash movement of a dog from distances of 50 to 150 meters by remote means in an unrestricted environment. In the experiments, several dogs were successfully conditioned to change direction according to tone signals. Excursions of 1/2 mile or more were made under the control of such signals. Automated procedures to train dogs for similar excursions were developed. In these procedures, the learning contingencies of reinforcement were arranged by a computer control system.

Westinghouse Electric Corporation, Systems Development Division, Baltimore, Maryland, has developed and tested an electronic Dog Handler System (Ref. 10) for the U.S. Army Land Warfare Laboratory at Aberdeen Proving Ground, Maryland. The system consists of a control unit held by the operator and a remote unit mounted on a harness on the guard dog. The control unit transmits control tones to the dog and receives readouts of the dog's heading, range, and azimuth with respect to the operator and the dog's actions (sit, stand, motion). The remote unit receives control signals, produces appropriate tones that are audible to the dog and transmits the heading, range, azimuth, and actions data back to the control unit.

It is conceivable that dogs could be trained to attack intruders upon a command consisting of a radio signal tone transmitted from a remote location and received by a small radio receiver attached to the dog.

4.2.4 Disadvantages

The principal disadvantages of using remotely controlled dogs as a response method are the potential for a dog to inflict unreasonable injury on an intruder and the cost of the training, care, and feeding of the dogs. The maintenance of the remote control mechanisms should be minimal, if they are handled with reasonable care.

A legal consideration involved in the use of guard dogs is the potential for a dog to do unreasonable harm to an intruder. In many states, it is permissible to retain a trained guard dog on the premises as long as you have posted signs warning of "No Trespassing Allowed." This warning is sufficient to release a property owner from any liability incurred if an intruder is attacked by a guard dog within the confines of the protected premises. Some dogs are more ferocious than others. This is not totally dependent on training or breed, but differs with each individual dog.

4.2.5 Countermeasures

The obvious countermeasures to the use of guard dogs are to escape from the dogs, neutralize them, or interfere with the control signals. Any of these countermeasures can involve a significant increase in the tasks to be performed by the intruder when well-trained dogs and well-designed equipment are employed.

4.3 NETS

4.3.1 Description of Method

Nets are used in the trapping of wild animals and birds; but at present, there are no net release mechanisms suitable for use as remote response methods known to be on the market. However, a net could be designed to be manually or automatically released to delay or capture an intruder. This method would be most effective when used in a controlled, confined area, such as a hallway, and might be activated automatically by use of a detection sensor or actuated by a remotely controlled release device. Plastic webbing, projected over a group of intruders, could be used to temporarily immobilize the group by restricting movement.

4.3.2 Development Efforts

A method for projecting a net over the heads of rioters is under development by the U. S. Army Limited War Laboratory, Munitions Branch. The concept for this method involves firing many single lines from two vehicles simultaneously so that the lines interlace in the air and settle down on the rioters as a net. The weight of the net is estimated at 250 pounds and the cost of the system at $2000. The concept involves firing 50 lines from each of the two vehicles, and effective range is estimated at 200 to 300 feet. This concept has not been developed to the point that it is ready for practical application. The two vehicles involved in the concept could be replaced with stationary mechanisms, and the technology necessary to develop a reliable remote control system should be relatively simple. It is apparent that a mechanism that will project 50 lines through the air for 200 to 300 feet could be injurious to any persons that may be struck by the missiles carrying the lines. Another disadvantage of this method would be the cost involved in wasting the lines after firing since recovery, disentanglement, and reloading of the lines would probably cost more than new lines.

4.3.3 Disadvantages

The principal disadvantages of using nets are the lack of available release mechanisms suitable for remote control, the limited number of areas where nets would be effective, and the difficulty of concealing them.

4.3.4 Countermeasures

The obvious countermeasures to nets are to disable the mechanism before the net is released, avoid the area protected by the net, or escape by cutting or disentangling the net or by crawling under the edge of the net. The effectiveness of nets used as remote response mechanisms will depend upon the materials employed in their fabrication and the resources available to the intruder. The technology necessary to design and construct reliable remote response mechanisms using nets exists and only application engineering would be required.

4.4 WATER JETS

4.4.1 Description of Method

High-pressure water jets can be used to hold back an intruder, cause a loss of balance, and increase the tasks the intruder must perform to accomplish the objective of the intrusion. High-pressure water jets have been used extensively in riot control operations to disperse crowds. The Germans developed water cannons for use in World War II.

4.4.2 Continuous Stream Jets

The U.S. Army Land Warfare Laboratory investigated the use of water cannons against structures in Vietnam. It has developed and tested a skid-mounted system designed to be transported on a 2-1/2-ton truck for use in civil disorders. The skid-mounted system is capable of holding back a 200-pound man at ranges of 75 to 80 feet for a period of 5 to 8 minutes (Ref. 11, p. 7). A summary of the continuous stream flow tests is presented in Table 1 from reference 11. The stopping distance was defined to be the closest approach that a 200-pound man could make toward the deluge nozzle.

Table 1

SUMMARY OF CONTINUOUS STREAM FLOW TESTS

Nozzle Size (inches)	Nozzle Pressure (psi)	Flow Rate (gpm)	Stopping Distance (feet)
1/2	96	72	39-45
1/2	135	85	54-60
1/2	190	100	56-59
5/8	160	146	75
5/8	190	158	80
1	96	290	80
1	44	195	55

A more extensive testing program was conducted to relate measurable water stream parameters with physiological effectiveness. The 5/8-inch nozzle with a continuous flow rate of 158 gallons per minute is capable of holding back a 200-pound man at ranges in excess of 75 feet. At the "stopping distance" range, the subject had difficulty advancing or maintaining balance, was being bruised, and was preoccupied with protecting his head and eyes.

4.4.3 Intermittent Stream Jets

The tests were repeated using an intermittent stream of water with several on-off cycle durations. The minimum effective pulse duration is limited by the opening-closing time of the valve. The results of the intermittent flow tests are summarized in Table 2 from reference 11. The figures in Table 2 indicate that the 5/8-inch nozzle with intermittent flow and an average flow rate of 75 to 100 gallons per minute is capable of holding back a 200-pound man at ranges in excess of 75 feet. The intermittent water stream extends the engagement time from 5 to 8 minutes. "Test subjects expressed the opinion that the intermittent stream flow was a more effective deterrent than the continuous water stream. The 1-inch nozzle size produced greater range effectiveness but at a higher water consumption rate" (Ref. 11).

4.4.4 The Portable Pumping System

The portable pumping system (Ref. 11) consists essentially of a commercially available skid-mounted, gasoline-engine-driven, fire fighting, pump unit. It is equipped with a deluge nozzle and an 800-gallon water tank.

Table 2

SUMMARY OF INTERMITTENT STREAM FLOW TESTS

Nozzle Diameter (inches)	Pressure (psi)	GPM From Flow Chart Based on Continuous Operation	Estimated Actual GPM with Pulsing	Pulse Duration (seconds)	Time Between Pulses (seconds)	Effective Range (feet)	Remarks
5/8	150	141	56.5	0.2	0.5	60-70	
5/8	150	141	70.5	0.5	1.0	65-75	
5/8	150	141	70.5	1.0	2.0	65-75	Rioter may be able io throw missiles.
3/4	150	205	82.0	0.2	0.5	70-80	Water slugs painful at 75 feet.
3/4	150	205	102.4	0.5	1.0	75-80	Water slugs painful at 80 feet.
3/4	150	205	102.4	1.0	2.0	-	No improvement, stream appeared to be unstable at continuous operation.
13/16	150	275	110	0.2	0.5	70-80	Stream was unstable, water rod fuzzy, no pain felt.
13/16	150	275	137.5	0.5	1.0	80-90	Stream unstable, no pain.
5/8	175	152	60.7	0.2	0.5	75-85	Painful at 80 feet.
5/8	175	152	76	0.5	1.0	75-80	Nozzle appeared to be overloaded and erratic.
3/4	175	218	87.2	0.2	0.5	80-90	
3/4	175	218	109	0.5	1.0	85-90	
13/16	175	298	119.2	0.2	0.5	90-95	
13/16	175	298	149.0	0.5	1.0	95-100	

The skid-mounted pump unit is a Hale Fire Pump Company Model 30FS-F250. It is capable of pumping up to 300 gallons per minute at 340 psi pressure. The pump is driven by a 250-cubic-inch displacement, gasoline-fueled engine which has a 138-hp rating at 3400 revolutions per minute. Total weight of the skid-mounted, engine-pump unit is 1300 pounds.

A raised platform of 1/8-inch thick, diamond pattern, steel plate deck is mounted above the engine-pump unit for the operator to stand on. The deluge gun (nozzle) is an Elkhart Model No. 292-6 with 360° horizontal rotation and 90° vertical elevation. Control of flow through the nozzle is by a special motor-driven ball valve with an automatic variable cycle on-off or manual control.

The 800-gallon water storage tank is constructed of copper-bearing, 12-gauge steel. It is of welded construction with interior baffles to prevent water surge. The tank is equipped with a sump to permit maximum use of the water before refilling. The pump, tank, and deluge gun are piped to permit refilling from a pond or from a hydrant. A by-pass valve and line is incorporated in the system to prevent overheating of the pump during periods when the pump is running but the nozzle valve is closed.

The entire self-contained system (consisting of water tank, pump, engine, platform, deluge gun, and piping) is mounted on a skid frame. Suitable lifting eyes and a lifting sling are provided for loading and unloading the system onto and from the load-bed of a 2-1/2-ton truck. The empty system weight is 3100 pounds. Filled with water, the system weight is 9800 pounds.

4.4.5 Ballistic Water Cannon

The U.S. Army Land Warfare Laboratory has developed and tested a ballistically operated water cannon that shoots slugs of water propelled by explosive cartridges. The mechanism will fire in single-shot or semi-automatic operating mode and has an effective range of approximately 70 feet. The water quantity used by this mechanism is considerably less than that used by stream jet systems.

4.4.6 Application Considerations

The high-pressure water jet method could be adapted for use outside of buildings as a remote response mechanism. The water could be supplied from water distribution mains, a reservoir, or a surge tank fed by a water main. The pump can be a commercially available pump, powered by an electric motor operated by a remotely controlled motor starter. The discharge nozzle can be stationary and pre-aimed or can be instrumented for remotely controlled aiming. The 5- to 8-minute engagement time provided by the portable unit could be extended considerably in a fixed installation with a larger supply of water. Water monitors used in fire protection systems are commercially available with remote control of the nozzle azimuth, elevation, and water stream pattern. Such water monitors could be adapted easily for use in a high-pressure water jet system. The installed cost of such a system is estimated at $6000 to $7000 without the drainage required to carry off the water. Careful design of the system and selection of its components should result in high reliability. A fixed installation high-pressure water jet system is diagrammed in Figure 9.

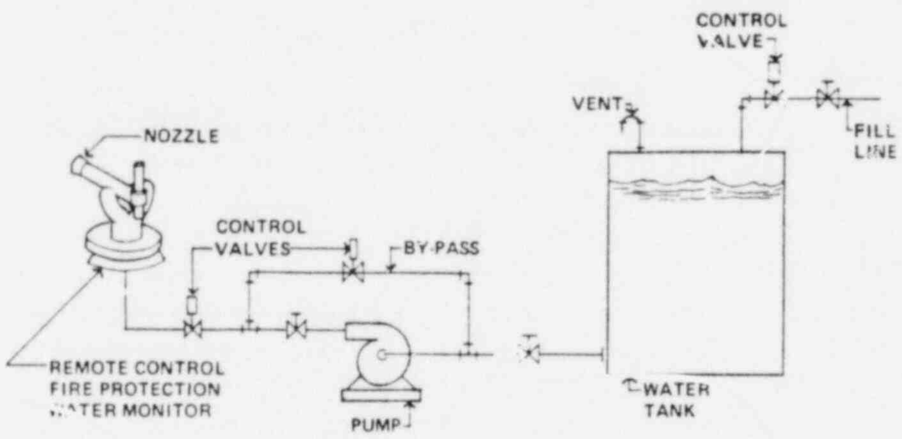

Figure 9. Fixed Installation High-Pressure Water Jet System

Major disadvantages of using water jets are the necessity of providing a drainage system to carry off the large quantity of water and the cost of the facilities necessary to furnish the water used by the mechanism. Use of high-pressure water jets inside of buildings is impractical because of the damage to the building that could result from the release of the large quantities of water.

The ballistic water cannon is not considered suitable for remote control operation because of its aiming accuracy requirements.

4.4.7 Countermeasures

The only apparent countermeasures to the water jet response method are for the intruder to avoid the jet, wait until the water supply is exhausted, or disable the mechanism before it is employed.

4.5 ROBOTS

4.5.1 General Comments

Remotely controlled robots have been used for a number of years in industrial operations involving the manipulation of dangerous materials. The British Army is presently using mobile robots in their military operations in Ireland. These military robots are remotely controlled to transport and position explosive charges, then move away from the area; at which time, the charges are detonated by radio controlled fuses.

Mobile robots may be developed, in the future, to the point that they are practical for use as remote response mechanisms. At present, their availability is extremely limited, their cost is extremely high, their reliability and effectiveness are not proven extensively, and maintenance and operating cost experience concerning mobile robots is very limited.

4.5.2 Sentry II

Quasar Industries, Inc., Rutherford, New Jersey, markets a robot designed specifically for surveillance and security operations. Their Sentry II Robot is described in the company's published literature as follows:

The Sentry Robot presents a psychological impact and is able to cover large areas on its own. Since it is totally independent of outside power, mechanisms, and assistance, it can continue to function even if other equipment alarms, phones, and power supplies have been tampered with. Additionally, the robot allows security personnel safety in surveillance by attracting attention to itself and, at the same time, provides advance information. The Sentry II is designed to meet a specific customer's requirements.

It is 9 feet tall, weighs approximately 900 pounds, and the case in which it is contained is 6 feet wide. The superstructure is made of stainless steel, and the body skin is armour fiberglass. It is powered by a 6 hp electric motor that has a duty cycle of 12 hours. The defense mechanism employs sonic, electrical, strobe light, and nitrious oxide techniques. The guidance system utilizes internal gyro, implanted track, and homing override. The sensing system combines sonar, optical, color and patterns, voice recognition, sound, motion, radar, and authority identification capabilities. The robot travels in "Slow Cruise" (1 to 7 mps), "Fast Cruise" (8 to 12 mps), and "Pursuit" (30 mph), by means of four undercarriage trucks, two tires each.

The Sentry II is currently available for production number selection, starting at a base price of $75,000, on a 12-month lead time. Custom requirements, detection, deterrent, identification subsystems, installation, and employee training are quoted separately.

The Sentry II has several options available. While the robot is in the nonactive stages of its physical surveillance, it may automatically continue surveillance from an optional, charging-base platform to continuously maintain peak power potential. The robot may be programmed to orchestrate the video transmission of an intrusion by a full system of surveillance cameras through its on-board computer to allow security office full visual observation of the event occurring. Also, the robot may have optional, on-board, ionization chambers connected to the on-board computer which will allow Sentry II to detect microscopic ash particles in the air; thus sounding its alarm system in the incipient stage of a possible fire.

Computerized, remote telephone system allows Sentry II to verbally contact up to six locations or individuals in addition to the standard warning to the main security area (i.e., fire department, police, company executives, etc.).

4.6 SLIPPERY FOAM

4.6.1 Description of Method

The foams used at present in fire fighting may be useful to increase the tasks an intruder must perform. Foam can be spread several feet thick over the ground to obscure visibility of the surface and cause it to be slippery. A room in a building can be filled with foam to above the intruder's eye level to obscure visibility and cause disorientation.

4.6.2 Generators

The foam generators used in fire fighting produce foam from a water/detergent solution by exposing the solution to a flow of air. One type of generator employs a net or screen coated with the solution and blows air through the coated net or screen to create the bubbles that form the foam. Another type of generator employs a specially designed nozzle that aspirates air into a sprayed stream of the water/detergent solution to form the bubbles. The foam generators commercially available at present will achieve expansion of the liquid solution in ratios ranging between 100 to 1 and 1000 to 1. They produce a foam of uniform bubbles at rates of approximately 1200 to 22,000 cubic feet per minute. The generators will project the foam approximately 25 feet from the nozzle, and chutes are available for extending the range up to 50 feet.

Foam generators are available as skid-mounted assemblies for fixed or mobile installations and in portable models. The foam-producing chemicals are available in 5-gallon cans and 55-gallon drums. Weights of the generators vary from approximately 10 pounds for the smallest portable model to about 400 pounds for the largest model. Fixed installations, including storage tanks for 350 gallons of foam chemical, weigh approximately 1300 pounds. Smaller tanks, down to 15-gallon capacity, are available in size increments of 25 to 50 gallons. The assemblies are available with electric motor, gasoline engine, or water turbine drives for the fan. Controls for manual and automatic operation are available. The technology involved in designing a fixed installation for remote control would consist of relatively simple application engineering. Reliability requirements for fire-fighting equipment are very rigid, and it is expected that the foam generators that are available commercially are very reliable. However, no reliability figures are shown in the manufacturer's published literature. A diagram of a foam generator for fixed installation is shown in Figure 10.

The costs of foam generators for fixed installations will vary with the capacity and the piping and foam storage required. A fixed installation similar to the one shown in Figure 10, which has a foam liquid storage capacity of 50 gallons and a generating capacity of 12,000 cubic feet of foam per minute, will cost approximately $8000. The cost of the foam generator mechanisms will vary approximately from $750 to $3000. The liquid foam costs about $8.50 per gallon.

Maintenance of a fixed installation, foam generating system will consist primarily of keeping the liquid foam tank supplied, periodic testing of the system to see that the components are operating, and cleaning and refilling the system after it is used.

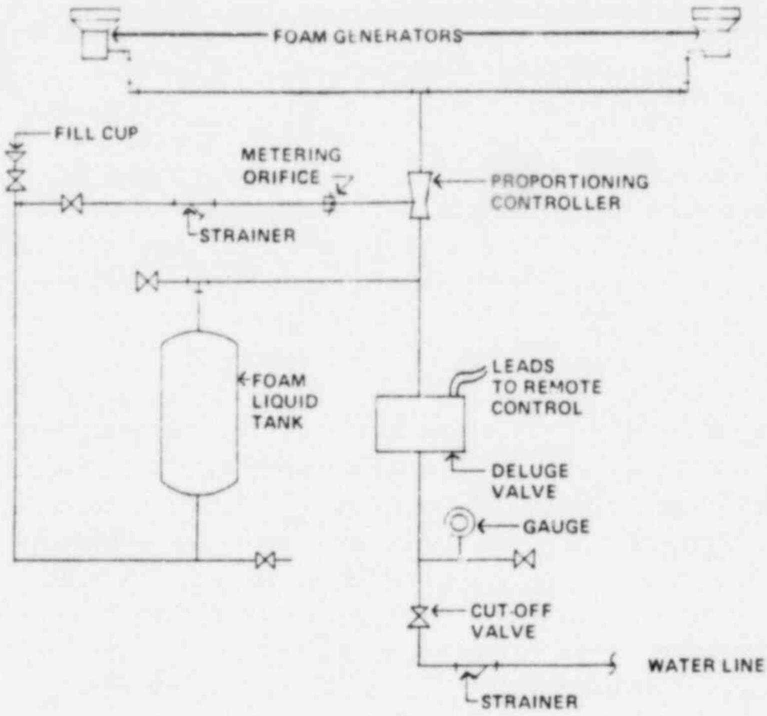

Figure 10. Diagram of Foam Generator for Fixed Installation

4.6.3 Cleanup

A disadvantage of using foam, as a remote response method in a building, is removing the foam. It is anticipated that extensive mopping and cleanup will be required. However, the published literature of one manufacturer states that:

"Tests conducted by Massachusetts Institute of Technology conclude that high expansion foam can be used to extinguish fires in electronic compartments with little or no damage to the equipment from the foam. If the foam is allowed to dissipate, a very minute residue will be found which can be swept or vacuumed up easily." (Ref. 12).

Foam removal and cleanup requirements should be thoroughly investigated before a foam generator is installed in a building. Outdoor use of foam should not require extensive cleanup operations.

4.6.4 Safety

The hazard involved in using foam to decrease the capability of an intruder to perform tasks would apparently be very low. The following is quoted from the published literature of one manufacturer:

"Submergence in high expansion foam for limited periods of time is not harmful. Tests conducted on dogs at the Copenhagen University Institute for Experimental Surgical Research indicated submergence in 850:1 expanded foam for time periods in excess of 6C minutes would not be harmful.

To minimize discomfort, cover the nose and mouth with hand or handkerchief to break the bubbles, and breathe normally. Even if unconscious, breathing should not be difficult.

Care should be taken to move as little as possible when submerged in foam as there is loss of orientation from inability to see or hear. It is strongly recommended that whenever possible self-contained breathing apparatus be used when moving through the foam and that personnel in the foam be evacuated as quickly as possible."

4.6.5 Countermeasures

The only obvious countermeasures to the use of foam are to disable the generator before it can be used, avoid the area where foam may be used, or wait for the foam to dissipate.

4.7 STICKY FOAM

Sandia Laboratories has developed and tested a system which very rapidly fills a volume, such as a corridor, with an almost impenetrai le barrier of fire-retardent sticky foam. This foam will hold an intruder in an immobile stc e.

A mock-up system for one installation was designed to dispense 990 cubic feet of sticky foam. The cost of the installation, excluding command and control functions, was about $10,000. The cost of the chemical mixture was minor.

The only apparent health hazard of the foam is that suffocation could occur if the intruder's air space were eliminated. This danger could be minimized by careful measurement of the amount of chemicals to match the part of the volume which is to be filled. Problems resulting from accidental initiation during normal operation in the area could be reduced by careful design.

The cost of cleanup of sticky foam is not low. There is a solvent for the foam; however, since a large volume of it is required, this method of cleanup is not practical. In the tests, hoes, rakes, large sheets of plastic, peelable paint, and solvent reduced the cleanup time to less than a week.

5. MISCELLANEOUS TECHNIQUES

5.1 GENERAL COMMENTS

The civil disturbances of the late 1960's in the United States sparked an intense interest by law enforcement agencies and the military in the development of less-lethal methods of riot control. Many of the techniques resulting from that interest exist in concept only. Some were developed into prototypes and a few were developed fully and put into production. A majority of the techniques are either inherently not suitable or not developed sufficiently to be suitable for use in remote response mechanisms. However, some of the techniques may be of interest to persons responsible for the planning, design, and implementation of remote response mechanisms. Technical Report 69-14, Riot Control: Analysis and Catalog (Ref. 6), prepared by the U.S. Army Limited War Laboratory, Aberdeen Proving Ground, Maryland, catalogs a large number of riot control techniques and a variety of materiel for such use. The techniques and materiel presented in this section are excerpted from Technical Report 69-14.

5.2 PHYSIOLOGICAL CHEMICAL AGENTS

5.2.1 Dimethylsulfoxide

Dimethylsulfoxide (DMSO) has the unique capability to penetrate human tissue and carry with it dissolved chemical agents; hence, absorption of chemicals into blood and tissue can be made very rapid and specific. DMSO may be injurious to some local body organs but has not been fully tested.

5.2.2 Itch-Inducing Agents

Itching powder prepared from the tropical plant cowhage (Mucuna pruriens), proteolytic enzymes, and dilute acid solutions induce itch. Particular attention needs to be given to side effects, safety, and problems of cleanup associated with the use of itch-inducing agents. These efforts should be blended with a search for an appropriate synthetic substance.

5.2.3 Pain-Producing Drugs

Pain can be induced chemically through intradermal injection of inorganic or organic acids. Depending on the nature of the acid, pain may last for 6 to 22 minutes. Oral intake of certain thymol ether derivatives by human subjects have produced severe aching and tenderness of all muscles of the body, especially of the arms and legs. A 20-mg dose produces violent muscle pains, violent headache, vomiting, and difficulty in breathing.

5.2.4 Sticky Aerosol/Jets

Sticky substance could be an irritant with malodorous, itching, nauseous, or other agents. It might also contain a certain substance which attracts a subsequently released insect swarm.

5.2.5 Sedative Aerosol

Sedative secondary tranquilizing effect could be aerosolized and disseminated as spray to produce hypnotic effects, drowsiness, and sleep.

5.2.6 Pepper Extract

Liquids could contain the burning agent pepper (capsaicin) as an active ingredient.

5.2.7 Pore-Closing Aerosol

Astrigent, pore-closing aerosols used in conjunction with heated air blasts would be most discomforting.

5.3 IMMOBILIZING AGENTS

5.3.1 Immobilizing Agent

Water-soluble chemicals which will harden rapidly on clothing or skin, thereby impeding movement of target personnel, could be included in reservoirs.

5.3.2 Anti-Friction Spray

Natural lubricating oils could be sprayed on surfaces to make them become slippery.

5.3.3 Low-Friction Polymers

Various low-friction polymers (Teflon) and slippery liquids (Slippo) are commercially available. If the coefficient of friction is reduced below 0.5, walking becomes progressively more difficult and a slippery floor effect can be created.

5.3.4 Instant Mud

A concrete mixer could be used in conjunction with a pressurized dispenser.

5.3.5 Instant Banana Peel

Nontoxic white powder known as Rio-Trol is dusted onto a surface, then watered down. The powder then turns into a thick paste, fills in the rough spots in a sidewalk or street, and forms a slick film. The result is a patch of pavement that is almost too slippery to stand on and almost impossible to move across.

5.3.6 Thermocapture

Thermosetting plastic is sprayed by hose or splattered by canister. The plastic would begin to set making movement increasingly difficult.

5.3.7 Instant Jungle

A large projectile filled with a quick-setting gel and a small amount of explosive should form an effective barricade.

5.3.8 Instant Cocoon

Plastic spray which sets quickly to tough pliable membrane is available. Such a spray could be used to immobilize and, if necessary, encapsulate from the neck down.

5.4 HEAT

A heat gun can be used to deliver up to 1000° F without danger of open flame. It could be used for emergency heating of field stations or for flushing out barricaded intruders from enclosed areas. Low-temperature flame or hot-gas dispensers (120° to 180° F range) could be used to cause extreme discomfort to rioters.

5.5 LIGHT

5.5.1 Bright-Light Mob Dispersal

High-intensity light directed toward a mob during hours of reduced light could be an effective device for dispersal. The necessity of avoiding light with the eyes would cause mass confusion and subsequent dispersal. Light source would be a reflector-equipped, hand-held candle holder, similar to the Battlefield Illumination System narrow frequency light source. It is used for the purpose of destroying night vision.

5.5.2 Manipulation of Street Lights

Manipulation of street lights in patterns could drive individuals from a darkened place to light.

5.5.3 Disorienting Holography

Large, reconstructed volume holograms can be used as disorienting devices. They can project larger-than-life images above eye level that look three-dimensional. With variations in technique, one can project several images of different colors starting from the same original object.

5.5.4 All-Purpose Riot Light

This light projects a 50,000 cp light beam for about one-half mile. It will operate from a vehicle electrical system or from a portable battery pack.

5.6 ELECTRICAL

5.6.1 Multiple Cattle Prod Boom

A boom fitted with multiple cattle prods attached to a tractor-mounted telescoping arm could be used to sweep an area.

5.6.2 Extended Electrified Boom

A vehicle with extensions which reach from curb to curb is being used by riot-control forces in West Berlin. The rioters touching the vehicle receive an electrical shock. The carrier vehicle is a modified armored personnel carrier. The boom is a fence-like fitting on the front which extends a foot past each side of the vehicle. Attached to each end is a section which folds back about 3/4 of the length of the vehicle and may be swung forward to present a barrier.

5.7 ROBOTS

5.7.1 Robot

A mechanized man-robot ("Hardiman") is being developed under joint Army-Navy sponsorship. It will allow a man to push, pull, manipulate, walk, lift, or climb with a load of up to 1500 pounds. An external skeleton with mechanically powered muscles fits over the operator's body.

5.7.2 "Man-Horse"

The mechanism uses two-way cybernetic control to perform superhuman feats of strength. It can be equipped for remote control and manipulation of the device.

5.7.3 Mechanical Bee

A miniaturized, pulse-jet, radio-controlled aircraft could be used to herd or limit movement. Hypodermic needle would paralyze when it crash-strikes selected victim.

5.8 HIGH-VELOCITY AIR

High-velocity air blasts have been used by the French in anti-riot operations. The units are essentially small aircraft engines with propellers. Possible variation could include heated air and a stream of water directed into the air blast to form a drizzle.

5.9 MECHANICAL BARRIERS

5.9.1 Nylon Barrier

Rapidly erected barriers are needed to prevent entry and vandalism of public buildings and utilities and to prevent looting of stores. A nylon barrier could be used as an ensnarement device. The nylon roping would be dispensed by means of an "Archolithic Gun" using a portable air compressor mounted on a 1/2- or 3/4-ton vehicle. The air compressor should have a minimum capacity of 30 cubic feet per minute at 100 psig pressure.

5.9.2 Metal Barrier

A method is required to afford protection to property such as plate glass display windows of stores. The proposed device is a standard metal barrier placed over the windows to deter breaking and entering. It is proposed that this barrier be charged with a low voltage similar to that used in electric fencing. The energy will not be drawn from the on-site electrical system but be supplied by an auxiliary device and have the capability of being command initiated.

5.9.3 Barbed Wire

In the early stages of a riot, it is important to keep the riot from spreading. Hasty barricades are required to control foot and vehicular traffic. Coils of wire could be carried in a trailer and dispensed from a container by spring action similar to that of a "Slinky-Toy".

5.9.4 Window Shield

Acrylic plastic (Plexiglas) shields can be placed behind conventional plate glass windows to withstand heavy impact. They are available in various thicknesses and sizes which may be easily cut and installed.

5.9.5 Foam Barrier

Foam barricades would be placed by hose. Using quick-setting foam, a barrier of several feet in height and perhaps the same thickness could be built up quickly.

6. CONTROL CONSIDERATIONS

6.1 INITIATION METHODS

6.1.1 General Comments

Remote response mechanisms may be controlled automatically, may be actuated by a signal that is initiated manually, may be manually operated, or the control system may include a combination of these techniques. Detailed treatment of control methods is outside of the scope of this report. However, descriptions of the various control options and their capabilities and limitations are generally available from the manufacturers of the mechanisms or from control system vendors. This section of the report discusses basic considerations involved in the control of remote response mechanisms.

6.1.2 Automated

Automatic control of remote response mechanisms, where the mechanism is actuated by a device that senses the presence of an intruder, will have very limited usefulness in security systems. The usefulness of control techniques where mechanisms are actuated by some act of an intruder will be limited also. Such control techniques could be used to actuate devices that will cause no harm to a person in the event of inappropriate actuation. In addition, they could be used in applications where the devices are disabled during normal operating hours and are then activated during off-duty hours in conjunction with physical barriers or other safeguard devices. Safety considerations will require a more thorough assessment of the incident than it is practical to provide in automatic control systems before they actuate most types of remote response mechanisms.

6.1.3 Manual

Manual initiation of a signal to actuate a response mechanism located remotely from the place of the signal initiation appears to be the most practical control method for remote response mechanisms. This control method enables the person initiating the signal to assess the intrusion, decide whether or not a mechanism should be actuated, and select the particular mechanism for actuation. This method also enables the person initiating the control signal to respond to a reassessment of the incident. In the case of some remote response mechanisms, such as those using foams and those using gases and smokes outdoors, this method will enable the person initiating the signal to control the operating time of the mechanism.

Manual operation in the field of remote response mechanisms will be most useful as a method of overriding inoperable control systems of either the automatic or manual type. For instance, manual opening of the deluge valve on a foam system such as shown in Figure 10.

6.2 ASSESSMENT DATA

Correct assessment of the intrusion is vital to the safe and effective use of remote response mechanisms. Knowledge of the location of an intrusion is necessary to determine which remote response mechanisms are available. The assessed extent of the threat imposed by an intruder is necessary to avoid harm to a person posing little or no threat to the facility and, in the case of some mechanisms, unnecessary expense such as for cleanup. Although some of the remote response methods may be effective in dissuading, repelling, incapacitating, or capturing an intruder when actuated, their usefulness will be increased greatly if their effect upon the intruder can be assessed. Assessment of the effects of remote response mechanisms upon intruders will provide information necessary to adjudge further action regardless of whether or not the mechanism is effective. A security system employing remote response mechanisms should include provisions for the acquisition and assessment of as much pertinent information as possible before and after the mechanisms are actuated. The assessed information should be readily available at the location of the remote response controls.

6.3 EXTENT OF CONTROLLABILITY

The extent of controllability of remote response mechanisms should be kept in mind when they are actuated. Remotely controlled valves are usually opened or closed, but modulating valves are available. Door and gate control systems usually provide for the door or gate to be opened, closed, stopped in any position, locked open or closed, and reversed in movement, as desired. Most door and gate control systems have a built-in safety control that will stop their movement automatically when an obstacle is encountered. Some systems require only a very slight resisting force to stop the movement, others require resisting forces in the order of 30 to 40 pounds. Electric motors and pneumatic or hydraulic operators are usually reversible and provide for some adjustment of operating speed. Wheel traps may be controlled remotely to extend or retract the blades. Spring steel tapes are not controllable after the coil is released. Nets will not be controllable when they are released. Aerosol canisters containing pressurized gases or smokes may be required to discharge their contents very rapidly to be effective. The control valve on such mechanisms should not be relied upon to control the amount of the gas or smoke to be discharged. The canister should be filled with a premeasured dose that is sized for effectiveness and safety in the space where it is to be released. The person initiating a signal to actuate a remote response mechanism should be thoroughly familiar with the extent of its controllability. Training will be required for the operation of remote response mechanisms, especially those with sophisticated control systems such as searchlight positioning, water jets, and gas or smoke dispensing. Special training of personnel and dogs will be required for effective use of remotely controlled dogs.

6.4 CONSEQUENCES OF USE

The consequences of actuating remote response mechanisms should be thoroughly understood by the person initiating the actuation signal. This understanding should include a concept of the probable effectiveness of the mechanism. There is a probability of the mechanisms affecting persons other than intruders. Some of the mechanisms require decontamination or cleanup of the areas where they are used. Replacement of some of the materials dispensed will involve expense. The consequences of unnecessary actuation can be costly and harmful to personnel in the vicinity of the mechanisms. Control systems should be designed and installed to minimize accidental actuation. Training of security personnel should include thorough indoctrination in the possible results of operating the mechanisms.

6.5 COORDINATION OF SYSTEMS

Control systems for remote response mechanisms should be coordinated with other elements of the security system as well as with each other when more than one mechanism is used. The release of gas or smoke in a building space that is air conditioned, ventilated, or open to the outdoors or other building spaces will require damper and/or door controls to prevent the spread of the gas or smoke to areas where it is not required. The use of foam in a building can be made more effective by controlling doors to confine both the foam and the intruder. The controls for wheel traps, gates, crash beams, and vehicular access doors in buildings will need to be coordinated to be effective against vehicular intrusions. Physical barrier mechanisms should be coordinated with fixed physical barriers. Correlation and display of intruder detection device locations with remote response mechanism locations and types at the security control center will be very helpful.

6.6 COUNTERMEASURE

The design and installation of control systems for remote response mechanisms must take into account the probability of countermeasures by intruders, failure probabilities, and the environment where the controls are installed. The system should include tamper and failure detection capabilities. All components of the system should be as reliable as available technology and economic considerations permit. The control circuitry and devices should be designed and installed in a manner that will minimize accidental actuation. Disablement of the system by tampering or signal interference should be made as difficult as possible. Maximum practical protection of the control devices from harmful effects of the environment where they are installed should be provided.

7. SYSTEM DESIGN CONSIDERATIONS

7.1 IMPLICATIONS OF THE SYSTEM APPROACH

It is necessary to emphasize the implications of and need for adopting a system design approach to the task of designing a safeguard system. Because of the fuzziness of many of the objectives and of the techniques used to measure the performance of a given system against those objectives, it is not possible to achieve a true optimal design in the classical sense. This is true because the procedure used to resolve conflicts between objectives will vary between decision makers. Nevertheless, it is imperative that the designer avoid clearly suboptimal solutions to the design problem. The implication of this is that the designer must pay careful attention to the trade-offs between different types of remote response mechanisms and the trade-offs between these mechanisms and other system components. In some circumstances, this could imply that it is possible to achieve the system objectives without the use of any remote response mechanisms. The important point is to achieve the overall system objectives. For instance, the designer has several methods of minimizing the time advantage of an intruder at his discretion. Two such means would be to improve the detection capability and to insert delay time in the intruder's path through improved physical barriers or by the use of remote response mechanisms. The choice will depend on the unique circumstances of each facility. In this light, the major advantage of remote response mechanisms is that they give the designer another option for achieving the overall system objectives. In summary, it should be emphasized that a systems designer should not become too dedicated to a particular approach while striving to achieve the safeguard system objectives; rather he should seek the best combinations of components to meet these objectives.

A second important implication of the system approach arises from the inherent synergism of the system components. Often, any given component will be almost useless in and of itself. For almost any given component, there is an easy countermeasure given the proper equipment and training of the intruder. For instance, to counteract the gases reviewed in this report merely requires the proper protective clothing and gas mask. Furthermore, more physical barriers can be overcome by the proper expenditure of labor. But, the quantity of labor that an intruder can expend while wearing the clothing required to protect him from the gases is considerably lower than that possible without such clothing (Ref. 13). A similar synergistic relationship exists with the use of obscuring smokes in conjunction with visually demanding tasks. In fact, such synergism is displayed between most properly matched parts of system components. In summary, the old adage that the whole is greater than the sum of the parts is never more true than in the case of a safeguard system. Hence, the complexities of a designer's task are made more difficult because he must carefully orchestrate the synergistic effect that usually develops between components. This synergism seems to be most pronounced between the components of the physical barrier and remote response mechanisms.

7.2 EVALUATION OF TECHNIQUES

In order to develop and evaluate various system designs, specific data concerning the various components are required. Such data on components other than remote response mechanisms are beyond the scope of this report. An attempt has been made, however, to present such data for each major delay technique which may be used in remote response mechanisms. Table 3 summarizes how each technique might be measured on each of the desirable characteristics. It must be recognized that these subjective evaluations will vary both between applications and within a given application. This is especially true when synergistic effects are considered. Some of the techniques are effective for very specific, limited applications; others rate highly in many areas but are rather ineffective or easily overcome. In addition, there is an obvious variation by installation in the relative importance of the various characteristics. It appears that the characteristics of safety, effectiveness, and reliability should usually be considered among the most important, while controllability and convenience are of least importance with respect to the other characteristics.

The remote response mechanisms reviewed in this report constitute an essentially complete survey of presently known techniques. The inclusion of any particular technique does not necessarily represent recommendation or approval of its use for a particular application or even in general. It is intended to provide the user with an understanding of which devices are best suited for practical use and which are impractical for use at this time.

Even though the odds of the use of such mechanisms are low and are even lower for a second use, the chance of accidental initiation or intended use against an intruder are real. Also, the device might be actuated for the purpose of testing it, verifying its readiness, or training personnel on how to use it for maximum benefit with minimum personal danger. Therefore, even though it is unlikely for a given site to be attacked even once, it is necessary to consider the possibility of multiple uses.

Consideration must be given to the location of the device with respect to the target of the intruder. That is, the closer an intruder gets to his target, the more severe the device should be.

7.3 COMBINATION OF TECHNIQUES

The concept of using several techniques which have a positive synergistic relationship can be used to great advantage in a system. The use of multiple types of devices also permits the designer to increase the potency of the system as the distance between the intruder and his target decreases. The following examples illustrate these points.

A maze of barbed steel tape can be lowered into position during unmanned periods. Upon positive assessment of an intrusion, the FM portion of the system would be activated. To overcome this combination, the intruder must accomplish a very intricate visual task when vision is essentially impossible. If tear gas were added to the system, an even more effective system is produced. The wearing of protective clothing and masks would not only add

Table 3

DELAY TECHNIQUE RATINGS
("+" is Relatively High; "o" is Average; "-" is Relatively Low)

Technique	Characteristic								
	Inexpensive	Available	Reliable	Safe	Secure	Effective	Controllable	Convenient	Compatible
Tear Gas (CN)	+	+	+	o	o	+	o	+	+
Irritant Gas (CS)	+	+	+	o	o	+	o	+	+
Chemical Mace	+	+	o	o	o	o	o	+	+
Irritant Sickening Agent (CM)	+	o	+	-	o	+	o	+	o
Screening Smoke (FM)	+	+	+	+	o	+	o	+	+
Screening Smoke (FS)	o	+	+	o	o	+	o	+	o
Screening Smoke (WP)	o	+	+	-	-	+	-	o	-
Communications	+	+	+	+	+	-	+	+	+
Light	o	+	+	+	o	o	+	+	+
Electrical	o	-	+	-	o	o	+	+	o
Sound	o	-	+	o	-	o	+	+	+
Gates	o	+	+	+	o	-	+	+	+
Wheel Traps	+	+	+	+	-	-	+	+	+
Spring Steel Tapes	o	o	o	-	+	o	-	o	+
Doors	o	+	+	+	o	o	+	+	+
Mobile Steel Tapes	+	+	+	+	+	+	+	+	+
Dogs	o	+	o	-	-	o	+	o	+
Nets	o	-	o	o	o	-	-	o	+
Water Jets	-	+	+	+	o	o	+	-	-
Robots	-	-	o	o	+	o	+	o	+
Slippery Foam	o	+	o	+	o	o	+	o	o
Sticky Foam	o	o	+	+	+	+	o	o	-

to the equipment requirements of the intruder but would also decrease his ability to work to overcome the other delay components.

Another system might use a sequence of doors and gates which would be secured during unmanned periods or could be automatically secured during an intrusion. Upon positive assessment of an intrusion, the FM portion of the system would be activated. This combination again requires the intruder to accomplish a visually demanding task when he cannot see what he is doing. The addition of tear gas to this system would also make it more effective.

As a third example, a sequence of doors and gates operated as described in the previous system could be used in conjunction with slippery foam. This system would require the intruder to penetrate barriers under the difficult circumstance of inability to stand or move. The addition of FM to this system would decrease the intruder's ability to perform his other tasks.

As a final example, the use of a system of gates and sticky foam in a corridor or foyer area could be very effective. The gates would be secured during unmanned periods or intrusions. Upon positive assessment of an intrusion, the sticky foam portion of the system would be initiated. Multiple nozzles along the edge of the floor would quickly make movement extremely difficult. In a short time, movement would be almost impossible and vision would be obscured.

Although many more combinations of techniques are possible, only those which appear most promising for general applications were discussed above. For particular situations, other combinations may prove to be more practical or more effective. Communications may be beneficially added to almost any system of combinations as may be seen in Table 3.

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10. MANUFACTURER'S LITERATURE SOURCES

10.1 CONTROLS

Fisher Controls Company
1900 Fisher Building
Marshalltown, Iowa 50158

The Foxboro Company
86 Neponset Avenue
Foxboro, Massachusetts 02035

Honeywell, Inc.
Mail Station G2118
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Skokie, Illinois 60076

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Worthington Pump, Inc.
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Mountainside, New Jersey

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16. ABSTRACT *(200 words or less)*

This report on remote response mechanisms for nuclear facility security systems was prepared for use in the Safeguard Regulatory Program of the United States Nuclear Regulatory Commission. The report includes information that will be useful to those responsible for the planning, design, and implementation of physical security systems. It discusses mechanisms that may be controlled remotely to extend the period of time during which security forces can implement effective responses to intruders. Techniques and mechanisms designed to reduce the intruder's capability to perform tasks and/or increase the tasks necessary to accomplish the intruder's objective are described and their characteristics discussed. The importance of the synergism between remote response mechanisms and other components (especially physical barriers) of the safeguard system is emphasized. The methods reviewed in this report are those which might be considered for application. The more exotic and futuristic techniques have been included for completeness and to save systems designers the effort of repeating the literature search required to evaluate them. Inclusion of a particular method does not necessarily represent recommendation or approval for use.

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