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A BRIEF SURVEY OF NONLETHAL WEAPONS (U)

Report No. RACIC-TR-66

Sponsored by
Advanced Research Projects Agency
ARPA Order No. 1509

April 30, 1971

by
E. E. Westbrook and L. W. Williams

RACIC
BATTelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
PREFACE

This study was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by the Foreign Technology Division, Wright-Patterson Air Force Base, Ohio, under Contract No. F33657-71-C-0029.

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ANNOTATED BIBLIOGRAPHY ON NONLETHAL WEAPONS
INTRODUCTION

(1) This brief survey of nonlethal weapons and the supplemental
bibliography (see Appendix following reference list at end of report)
was prepared by members of the PACIC staff. It has been organized
for two sections:

(1) Statement of the Problem. Summarizes the general criteria
for the use of nonlethal weapons and the desirable and
unacceptable characteristics of such weapons.

(2) Chemical Incapacitating Systems. Describes various types
of chemical agents, their effects on the body, and various
methods of administration.
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STATEMENT OF THE PROBLEM

(1) At the outset it should be stated that no weapon system, even one
which has been very carefully contrived, can be made entirely nonlethal, par
ticularly the mechanical problems encountered in such systems and partly becau
of the difference in response of individuals to a given level of stress.

(2) The development and implementation of nonlethal weapons systems are
officially premised upon at least three assumptions. First, it is assumed that
the persons against whom a nonlethal weapon is to be directed are not already
under the control of whoever is to use the weapon. The nonlethal weapon, like
any other weapon, is intended to extend the operator's control over the behavior
of individuals who are otherwise would be relatively autonomous. More specifically,
nonlethal weapons are generally intended to prevent an individual from engaging
in undesirable acts. This brings the discussion to the second assumption
underlying nonlethal weaponry. It is normally assumed that a nonlethal weapon
will be employed in a tactical conflict between individuals or groups. This
assumption imposes certain criteria upon the design and choice of weapons,
such as the requirement for immediate effect. These criteria will be discussed
further shortly. The third assumption behind nonlethal weaponry is that it is
desirable not to have greater effect upon the target individual than is necessary
to control his behavior in the immediate tactical situation. Thus, the use of
deadly force, or force excessive to that required to accomplish the immediate
task, or of force or control techniques which will have long-lasting or permanently
tarring effects is deemed undesirable. Apart from the moral arguments in
favor of the use of nonlethal weapons, public officials find it prudent to
respond to public opinion and try to minimize the political and legal repercussions
which often follow the use of deadly force. The desirability for nonlethal force
is further accentuated when there is a danger of innocent bystanders being

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The police and the law enforcement of internal security forces, in the United States and other law enforcement agencies are especially sensitive to possible injury, permanent disablement and wrongful death and seek to maximize capture rates and minimize casualties.

While the precise physiological and psychological effects of nonlethality will vary from item to item, it is possible to establish general criteria which can be used to assess the acceptability of particular weapons.

Nonlethality

(1) The desirability for nonlethality has already been noted. It is well, however, to stress that nonlethality is best stated in terms of what may be statistically expected when a particular weapon is used against some normal distribution of individuals. Nonlethal weapons, like lethal weapons, depend for their effects upon a number of factors all of which cannot be compensated for in the design of the weapon itself. Among these factors are operator skill, the conditions under which the weapon is employed, the response of the target individual to the weapon, and the physical and psychological health of those against whom the weapon is employed. When designing a nonlethal weapon, it is necessary to optimize trade-offs between its nonlethality and its incapacitating potential. The ideal balance of absolute incapacitation reliability and absolute nonlethality (i.e., 100 percent of survival of persons affected) is probably beyond the present state of the art.

Incapacitation Potential

(2) Given restrictions on the employment of lethal force, the concern has been to discover ways to exercise nonlethal force which is readily applicable to tactical conflict situations, which can be used against an individual who is beyond arm's length from the operator (ruling out overpowering the individual physically), and which will prevent the target individual from engaging in undesirable behavior. This latter ability to "incapacitate" might be defined as the ability of the weapon in question to prevent an individual from engaging in goal-directed behavior which the operator of the weapon finds undesirable. Typically this class of undesirable behavior includes a range of violent and criminal acts. The mode of incapacitation is variable, depending on whether an attack is made upon a person's ability to concentrate attention on his
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Given the intended use of nonlethal weapons in tactical conflict situations, it is usually desirable that their effects occur within a period of seconds or possibly a few minutes after they have been used. Otherwise, these weapons would be of little or no value in preventing specific violent or criminal acts.

(U) Immediacy of Effects. Given the intended use of nonlethal weapons in tactical conflict situations, it is usually desirable that their effects occur within a period of seconds or possibly a few minutes after they have been used. Otherwise, these weapons would be of little or no value in preventing specific violent or criminal acts.

(U) Temporariness of Effects. It is generally desired that the effects of nonlethal weapons have a duration great enough to allow their operators to gain control over the target individuals or over the terrain being contested or both. When used against groups of individuals as in riot control, it is desirable that nonlethal weapons disrupt group processes and thereby diminish the effectiveness of that group's goal-directed behavior long enough to either thwart the aims of the group, capture the members of the group, or achieve another similar purpose. However, incapacitation which endures for longer than is necessary to achieve immediate tactical aims is at least an inconvenience and might become an outright burden on those using the nonlethal weapon. This is more the case as incapacitation approaches 100 percent.

(U) Reversibility of Effects. Once a nonlethal weapon has been used and the operator's goal achieved (e.g., clearing a street, capturing a criminal), it is desirable to "turn off" the effects if they are such as to endure over time. Being able to reverse the effects of these types of nonlethal weapons makes it easier to transport or interrogate a prisoner, minimize inconvenience to bystanders being affected, etc. The methods used to reverse...
The temporariness and reversibility of effects are distinctly critical in the reason that these features help to minimize the likelihood of accidents caused by employment of a nonlethal weapon. For example, a person who has been attacked with a disorienting chemical agent could injure himself, perhaps fatally. If this person happens to be a bystander who is not placed under care, and especially if the effects of the agent last for some time, then the probability of such accidents is substantial. This is clearly an unacceptable outcome of the employment of nonlethal weapons.

(U) Minimal Side Effects. The less frequently that side effects occur with a given nonlethal weapon, the more it is possible to standardize procedures subsequent to its employment. In addition, the less extensive and enduring these side effects, the less probable that complications or death might result from using the weapon. The less likely are such side effects as disfigurement or lasting disablement, the more readily a given nonlethal weapon will be accepted, so long as it is an effective incapacitant.

(U) Predictability, Obviousness, and Reliability of Principal Effect. As was said above about minimal side effects is related to the need to be able to predict precisely upon the principal effect of a given nonlethal weapon. The user of a nonlethal weapon should know ahead of time how an affected person will behave and this behavior should be patently obvious to the user. This will help the user to fully exploit the advantages of the weapon and at the same time it will assist him to recognize when unusual and possibly dangerous secondary effects occur, signaling the possible need for professional medical aid. At the same time, if the operator does not have confidence in the effectiveness of the nonlethal weapon, resulting perhaps from its inability to consistently incapacitate persons or its inconsistency of function, then the weapon will probably not be employed even when it is available.
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CHEMICAL INCAPACITATING SYSTEM

Chemical incapacitation is used to effect a great deal of damage to non-combatant populations in a non-lethal weapons system. It is quite possible that non-lethal chemical agents will always be the most effective, since if properly applied, they should be able to remain one of the most potent of the chemical weapons.

In spite of the above claims, in this area in recent years for the prospect of developing unification or inactivation or chemical experimental warfare, the "suitability" list of weapons (high explosives are most acceptable) have been used to design, such as nitrogen gas in World War II while this was of course much more severe than any of the agents now in use, much of the furor over its use was undoubtedly psychological nature. Actual fatalities from mustard gas amounted to less than 2 percent of those who were exposed to it sufficiently to be listed as casualties. This was a larger percentage of deaths than that from all other causes. Polls have shown that where the public is made aware of the facts surrounding chemical agents, they are more amenable to their use (1). As more confrontations on campuses and civil violence of the type experienced recently take place, chemical agents may well become a more readily accepted item in police and military arsenals.

(2) While many of the advantages and disadvantages of chemical weapons systems are specific to particular agents and systems, some general observations can be made:

---

**In 1966, an extensive report on chemical incapacitating agents ["State-of-the-Art" on Incapacitation of Voluntary Muscular Activity (L), PACIC Report No. 64-171-7 (AO 373 233)] was prepared for ARPA by Dr. C. A. Lutz, Associate Chief of the Atomic Chemistry Division at Battelle-Columbus; Dr. M. S. Sadove, Head of the Division of Anesthesiology, University of Illinois College of Medicine, Chicago, Illinois; and Dr. J. L. Schmidt, Clinical Associate Professor at the University Medical School and Principal Physician at Cermak Memorial Hospital, Chicago, Illinois. This report provides a comprehensive study of three main classes of agents: (1) those that are skeletal-muscle depressants, (2) those that affect the central nervous system, and (3) those that affect the cardiovascular system. Miscellaneous additional chemical agents as well as biological agents are also discussed. The data presented in this report on the various agents which are in use today are still valid as are many of the conclusions and suggestions for future research, since the technology does not change rapidly. Of the many areas in this field that are still valid as are many of the conclusions and suggestions for future research, since the technology does not change rapidly.
1. A wide variety of agents are available for use in the nonlethal Chemical Agents. 
2. Chemical agents may be utilized in situations where combatants and noncombatants are present. 
3. Many compounds, particularly those acting upon the central nervous system, are effective by several routes of administration including intravenous, subcutaneous, and respiratory. Thus, they can be disseminated as aerosols for administration via the respiratory tract or by means of a non-lethal dart for subcutaneous administration. 
4. The effects of many agents may be reversed by the use of suitable antidotes. 

Disadvantages:
(1) Agents which are dispersed in the most common ways (fog, aerosol, powder smoke) are highly susceptible to unpredictable atmospheric phenomena. 
(2) Agents in these forms may be blown back to hamper friendly personnel. 
(3) Most agents now in use have a rather narrow margin of safety (that between the effective and dangerous dosage). Moreover, in the case of many agents now available, the condition produced within this margin of safety is not sufficient to deter all highly motivated individuals. 
(4) Action is not sufficiently rapid to successfully counter an opponent armed with a conventional lethal weapon. 
(5) In the case of some of the milder agents (such as CN) victims frequently develop a tolerance to its action which renders it much less useful on a continuing basis. 
(6) The effects of a chemical (often the difference between lethality and non-lethality) are often a function of dosage, and dosage is difficult to regulate accurately under riot or battle conditions. 
(7) As mentioned earlier, the use of chemical agents of any type is disasteful to many people. Recent executive decisions have indicated a national policy unfavorable toward the offensive use of some types of chemicals. 

Criteria for Selection of Nonlethal Chemical Agents

1. The following criteria, from the Field Chemical Agents Manual, is representative of the constraints placed upon civilian law enforcement.
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1. Accessibility - The minimum criteria in agent selection in all police. All or partial effects, involve until their utility and viability be sought in greater detail later in the application. The minimum criteria is that the agent be non-lethal in any concentration likely to be developed in police application.

2. Effectiveness - The agent should:
   a. Produce rapid physiological action.
   b. Produce desired effects in low concentrations, somewhere in the range of a few milligrams per cubic meter of air.
   c. Permit rapid recovery without lasting effects when subject is removed from the contaminated area.

3. Deliverability - The agent must be deliverable in sufficient concentrations by delivery systems adaptable to police requirements arising from the nature of field operations.

4. Non-Persistency - The agent must be temporary in duration of its effectiveness and should not present major decontamination problems. Persistency is a product of several factors including the nature of the agent, method of dissemination, weather, and the area contaminated.

5. Stability - The agent should be stable over wide ranges of temperature variation and storage conditions. It must be compatible with selected delivery systems.

6. Acceptability - The use of the agent must be tolerated by the general public. A negative response on the part of most of the citizens in a community to a specific agent may well offset any advantages that the agent might otherwise offer.

7. Cost Effectiveness - The total cost of the delivered agent must be proportionate to its effectiveness and competitive with acceptable alternatives. In addition, the cost of chemical munitions must be responsible in relation to police resources.
The Search for Suitable Compounds

Taking note that a relatively small number of compounds meet the strict requirements of effectiveness and safety, several of those from Table I which appear to show special promise are discussed below.

Irritants

(i) A sensory irritant produces a reversible incapacitation as a result of sensory stimulation following contact with skin, eyes, or mucous membranes. The obvious advantage of such an irritant is the speed with which it acts, since it acts directly upon the nerve endings.

(ii) Since World War I, the most widely used irritant has been CN (tear gas). Recently, however, it has been replaced in many instances with CS whose action is more rapid and whose effects are more severe. CS has had wide usage in Vietnam, although reports from there have most often dealt with the use of CS along with lethal weapons. The use of CS as an agent for softening the enemy so that he could more easily be engaged with conventional weapons is not the most effective indicator of its utility in a situation where lethality is not desired.

(iii) Other examples of respiratory irritants with approximately the same effectiveness as CS are: EA3547, Compounds 126312, EA3365, EA2542, EA1778, EA922, and capsaicin. None of these compounds has any lasting effect once the victim is no longer breathing contaminated air.

(iv) The possibility exists, however, that one of the aromatic arsenicals, such as DM, might be used to produce both short-term irritation and longer term systemic effects. These systemic effects which begin about 30 minutes after exposure and last for several hours involve headache, nausea, intestinal cramps, diarrhea, and general depression.

(v) A number of agents, notably CX, produce intense pain almost immediately upon contacting the skin, but since response to pain is somewhat dependent on motivation and other factors, CX might most effectively be used in conjunction with some of the other irritants.
Analgesics

Possibly the best known of the analgesics is morphine. While
highly effective, it does not have the desired safety margin for use as a
pain-relieving agent. Research is being carried on to produce compounds which have
a more favorable margin of safety without losing the desirable analgesia and
analgesic effects (5).

A typical example of a morphinelike analgesic is CS4640 (etonitazene),
which can cause physical knockdowns of test animals at the microgram (of agent)
per kilogram (of body weight) range. CS4640 as an analgesic is approximately
1000 times as potent as morphine. As the compound now exists, the safety margin
is rather small in primates (5).

Anticholinergics (Causing Prostration)

Probably the most promising of the anticholinergics (agents which
block the passage of impulses through the parasympathetic nerves) are the
cholinolatates. These compounds produce such symptoms as rapid heart rate,
loss of coordination, blurred vision, delirium, high blood pressure, vomiting, and,
in some cases of higher dosages, coma. Moreover, these symptoms can be produced for
several hours to several weeks depending upon the agent and dosage. Some of the more active of these compounds are listed in Table 1 along
with BZ as producing prostration. They are effective at a dosage of 1 microgram/
kilogram of body weight (6).

Emetics

The agents which induce vomiting apparently act by stimulating
a part of the brain known as the chemoreceptor trigger zone. As incapacitants,
they are fairly effective and work rapidly although not instantaneously. At
present, the most promising of the vomiting agents is Compound 22892b
(100 micrograms/morphine) (7).

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Conclusions

It can be readily noted that there are a variety of possibilities for further development of chemical agent capability. Among the more promising options are the irritants because of their mode of action and safety ratio. At present, however, CS, CN, and related irritants are likely to remain the standards in both the military and police arsenals.

Delivery Systems for Chemical Agents

A number of effective devices exist for the delivery of presently used chemical agents. Many of these, with minor modifications, could accommodate the chemicals which are currently under development and testing.

Among these devices are grenades, of both expulsion and pyrotechnic types, special ammunition, and man-portable or vehicle-mounted dispersers. There are also available a number of chemical shells, rockets, and bombs, but these have not been included since their size, weight, and velocity make them lethal weapons if only for mechanical reasons. These could, of course, be considered in tactical situations where some casualties could be tolerated.

Grenades

Probably the most common delivery device for both CN and CS in riot-control situations is some type of grenade launched either with a grenade launcher or, more commonly, thrown by hand.

One common type of grenade is the expulsion type which utilizes an explosive charge to either emit the agent through a series of ports in the container, or through the rupture of a frangible container. Included in this type of grenade are those employing the new piston release technique which involves the use of a powder charge to activate a piston which literally pushes the agent out of an exit port located at the base of the grenade. Some of these grenades are designed so that the escaping agent creates a rocket effect causing the grenade to skitter along the ground. Extensive tests at Edgewood Arsenal have shown that this type of grenade is not likely to cause serious injuries.

The pyrotechnic grenade releases its agent through a burning pyrotechnic substance which will burn on ignition. This...
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Dispersers

A number of dispersers, employing both external sources of
mechanical gas or an engine-powered blower to expel the
chemical agent are in
use. These vary from 10 to 50 pounds for man-portable units to
several hundred
pounds for locomotive or truck-mounted devices.

The standard types of military dispersers are shown in
Figures 7 through
8 (pages A-17 through A-23). Figures 11 and 12 (pages A-24 and A-25) show dis-
persers currently used by civil law enforcement agencies.

Liquid Stream Projectors

(1) Somewhat related to the dispersers are those devices which shoot a
solidified stream of some liquid incapacitant at an individual human target.

(2) The advantages of this type of weapon are a better selectivity of individual
targets and a somewhat more persistent effect from the agent since it is projected
as a liquid stream rather than as a vapor. The main disadvantage of this type
weapon is its short range.

(3) In 1965 the Research Analysis Corporation published a report on a
project carried out for APPAR/AGILE on the feasibility of designing a weapon
that would project a stream of incapacitating liquid for a distance of at least
60 yards. Of the various materials studied, capsicum oleoresin, a derivative

of 3-thiobenzaldehyde, was selected. The Chemical Agents Manual, provides an excellent review of
methods for chemical weapon delivery systems and techniques relating to chemical agents.

A 1960 edition of the philosophy and legal aspects of using these
chemical weapons on hostile, non-hostile, and friendly forces, including physiological and psychological
effects of chemical agents; first aid and decontamination; and chemical munitions
as a weapon of war. Preparing this manual may be secured from the
American Institute of Police, Inc., 1319 Eighteenth Street, N.W.
Washington, D.C. 20036. 703-7222.
Military and Police Munitions

(U) A variety of cartridges are available for use by both the military and police. Some, like the Federal Laboratories' Short Range Shell, shoot a cloud of micropulverized CN or CS directly from the muzzle of the gun in the same manner as shot from a shotgun shell. Others fire pyrotechnic- or expulsion-type projectiles for as much as 500 yards although most have an effective range of around 150 yards. Several typical military cartridges are described below. Some munitions employed by the police are illustrated and described in Figures 13 through 15 (pages A-26 through A-28).

(U) Military XM674 CS Riot Control Cartridge. The item furnishes Army units engaged in riot control with a capability of employing small quantities of incapacitating riot control at ranges beyond that of existing riot-control grenades.

(U) The cartridge is contained in a 38-mm-diameter aluminum case approximately 9 inches long and can either be fired hand-held, with the M79 grenade launcher, or with the M8 flare pistol. It projects a nonhazardous rubber container, which is filled with a CS pyrotechnic mixture, for a distance of 65 to 90 meters when fired from the M79 or M8 weapons. Shorter distances are obtained when hand fired (approximately 45 meters). The container emits CS for approximately 10 to 40 seconds.

(U) The XM674 cartridge differs from the E20R3 and XM651E1 40-mm rounds in that the E20R3 and XM651E1 can be fired only from the M79 grenade launcher and have higher velocity, and range, and betteraimability. The XM674 cartridge contains approximately twice the amount of CS as the other...
Military XM65E3 40-mm Tactical CS Cartridge. This cartridge can be fired from the M74 or M509 single-shot launchers or from the XM74 automatic launcher. Weighing 194 grams with a payload of 75 grams, the cartridge utilizes a pyrotechnic tube. This item is presently in engineering development.

Military E8 CS Launcher and Cartridge. The E8 CS launcher consists of a launcher module with 16 firing tubes, each containing four E23 35-mm CS cartridges (44 E23 cartridges/launcher), a firing train, and a folding firing stand for ground emplacement. A carrying harness with adjustable, padded, shoulder straps, quick-release cord, and waist strap is provided for back-pack carry. Weight of the total assembly is about 35 pounds.

(U) The E8 launcher is fired electrically or manually. The E23 cartridges impact over an area 40 meters wide extending 80 to 230 meters in range, producing a uniform and effective CS aerosol within 15 to 30 seconds.

(U) The launcher platform has an elevating mechanism for firing at six different elevations from 0° to 90°. Range from launcher to center of target thus can be varied from point blank to 150 meters. After firing the entire unit is discarded.

(U) The range of this weapon is up to 230 meters. It is nonlethal in the impact area, but its high muzzle velocity creates a lethal hazard at the muzzle during firing.

Darts

(U) The use of darts as a means for injecting an enemy with an incapacitating agent has been discussed as a possibility by a number of writers (12-14). While darts have not actually been used sufficiently on human subjects to compile an accurate history on their use, several instances of their use have been reported.

(U) Several years ago a psychotic prisoner who was trying to escape from the Athens, Georgia, jail was subdued by means of a dart loaded with sodium amytal. The equipment used was that commonly used by veterinarians and conservationists in subduing animals (14a). More recently, a number of tests have been made using mature student volunteers by a psychiatrist, Dr. William C. Conner of Emory University and the Palmer Chemical and Equipment

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In these tests, a small dart with a needle 4 inch in length containing apomorphine was used. Within 75 seconds, the victim felt chilled and became glassy eyed, and his blood pressure dropped. In minutes the victim was nauseated. For an hour after this, he was actually ill and nearly completely immobilized. Present forms of this equipment are quite limited as to range, but research is underway to improve the design.

(U) Tranquilizing darts have been used for a number of years in subduing wild or frightened animals until this practice has become quite routine. A large number of agents have been used for this purpose, none of which are entirely safe, since all require a rather accurate dosage based upon the weight of the animal.

(U) The advantages and disadvantages of darts as nonlethal weapons may be summarized as follows:

Advantages:

(1) The use of a dart allows selection of an individual target - perhaps the leader of a group or a particularly destructive person - without injuring others around him.

(2) The user can choose from a variety of agents to fit the specific situation.

(3) The dart can more nearly represent a nonlethal substitute for a bullet than any other chemical delivery system.

(4) Because of its selectivity and because the identity of the agent being used is not readily discernible, the dart possesses a psychological advantage not shared by many of the other systems. The victim may wonder what he has been hit with and whether or not it is essential that he find an antidote.

Disadvantages:

(1) Certain mechanical hazards are present with any system which utilizes a sharp-pointed projectile propelled at fairly high velocity. The eyes would be particularly vulnerable to such a device as would certain of the arteries of the head and neck. Possibly a safer device would be one that fires a blunt rubber or gelatin projectile.
In critical situations with the target individual and
released a chemical agent on impact.
When used at close ranges, the needle of the dart may
be used in the causing severe pain without discharging
the chemical agent. Presumably this danger could be
eliminated by using needles made of softer material.

(4) The dosage is critical with chemical agents now in use.
A person using such a weapon under battle or riot conditions
cannot be expected to always choose the correct dosage
based upon the size of his intended victim. The only
practical solution to this problem is the discovery and
use of drugs with a greater margin of safety which may be
used safely on individuals of different sizes.

(4) The darts now in use must depend upon their terminal velocity
in order for penetration to take place. This requires the
projectile to possess a very high initial velocity. Perhaps
an answer to this problem would be a dart with a spring-
loaded needle which is triggered and penetrates upon impact
regardless of its terminal velocity.

(5) Darts are not regarded by many as an "acceptable" weapon.
Apparently, when a weapon or device is of recent development
and is used initially on animals and gains acceptance in
this use, it seems to render it "unsuitable" for use
against humans however practical and humane it might be.
Another example of this kind of thinking is the use of the
electric cattle prod against human subjects.

(U) In short, systems using darts appear to show promise as nonlethal
weapons especially if a number of problems surrounding their use can be resolved.
The hazards connected with their use seem less important when considered against
the alternative of lethal weapons.

(U) At present, tranquilizing darts are fired either by means of
air-activated guns or by means of blanks of the type used for driving nails
into concrete floors.

(Fig. 10 (page A-29) shows the "Cap-Chur" dart which is typical at
the dart used often used. The "Cap-Chur Charge" is a small explosive charge
triggered upon impact, forcing the drug into the target.
Smoke

The use of smoke per se as a technique for obscuring the vision of workers of crowds is currently out of vogue. This is probably due to the widespread availability of agents such as CN which more effectively achieve the desired results.

- The chief advantage of smoke over tear gas is that upon dispersal or being blown by the wind it does not irritate bystanders, nor does it exhibit lingering contamination effects.
- Smoke is also generally less expensive than tear gas.
- Most of the tear-gas munitions incorporate a smoke component in order that crowd control forces can see which areas have been treated.
- Many of the devices and techniques used to disseminate smoke are similar to those used for the dissemination of tear gas. These devices and techniques generally exhibit the same advantages and disadvantages (e.g., fire hazards) whether used for disseminating smoke or tear gas.
- While in some tactical situations it might be desirable to use colored smoke either as a signal or because of increased Total Obscuring Power (TOP), there is evidence that many components of colored smoke are carcinogenic.
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USE OF THE ELECTROMAGNETIC SPECTRUM FOR INCAPACITATION

Photic Driving and Incapacitation

The supposed utility of visible flickering light as an incapacitating technique is premised upon its effect on the electromagnetic behavior of the human brain. It has been noted that epileptics and certain otherwise normal individuals exhibit an abnormal alpha brainwave signature when undergoing a seizure. The nature of the alpha brainwave is such that it has a frequency of 8 to 12 cycles per second; it increases in frequency when an awake resting subject closes his eyes; it decreases in frequency when a subject engages in mental activity; it is blocked when a subject focuses visual attention on an object; it can be "driver"ed, i.e., a light flickered near the alpha frequency can cause the alpha frequency to entrain or adapt to that frequency. The concept behind suggestions for using flickering light as a nonlethal incapacitating technique is that an altered alpha signature will produce altered cerebral behavior, i.e., a decreased capacity to engage in goal-directed behavior (e.g., as with an epileptic seizure). Without going into a detailed discussion of all the research literature, the following general points can be made about the effectiveness of flickering light as an incapacitating technique.

1) Photic driving of the alpha signature is thought to be possible in approximately 30 percent of the population. Estimates of the portion of the population which can be "significantly" affected by flickering light range from about 1 to 5 percent, with most estimates at about 1 percent.

2) "Significant" reactions to flickering light tend to be predominantly subjective and exhibit little or no objective relevance. Among these reactions, photic driving produces severe incapacitation, e.g., grand mal seizures in a portion of the subjects. Even among those epileptics...
(U) Since the light wave is diminished by mental activity and directed visual attention (20), it is expectable that even with a subject in whom flickering light can induce some degree of incapacitation task orientation would diminish the significance of this incapacitation (21). Task performance is generally unimpaired under conditions of flicker. The researcher found that "there was no significant difference between performance with and without flicker of repeating digits, addition, or serial subtraction, and no change in tapping rate could be associated with either an increase or decrease in flicker frequency". Another experiment involved rifle aiming accuracy. Under conditions of no ambient lighting and a bright flickering-light performance was impaired. However, with a low level of ambient light the flickering light apparently had no effect on performance (21). The first set of results might be attributable to the need for some minimal ambient illumination in order to use the standard sights on a rifle.

(U) Among pilots tested for the effects of flashing lights, the most common reactions were boredom and annoyance (23). Under normal stimulation, as in actually piloting an airplane, it is doubtful that boredom or this source of annoyance would be significant.

(U) The reported cases where otherwise normal individuals succumbed to flickering lights are quite rare and comprise an insignificant portion of the population, most of which has been exposed to many of the sources of flicker which are sometimes reported to incapacitate individuals (e.g., flashing lights, sunlight shining through trees, venetian blinds, etc.) (21). Effects achieved among otherwise normal subjects in the laboratory might be attributable to the laboratory setting itself. Drowsiness might occur in any setting where there is low ambient lighting and little or no noise or other stimulation. Kinesthesis (sensation of body movement) might result from eye movement and "drifting" of the optic afterimage. This same eye behavior might produce a mild motion sickness, i.e., the "nausea" reported in the literature. The range of conditions producing elicited desired reactions in the laboratory (e.g., number of seconds, colors of lights) is so wide that it would be difficult
Visual Impairment

The significant impairment of vision is difficult to achieve and at the same time frequently involves lasting physical damage.

The Visible Spectrum

Most of the work on the use of the visible spectrum to impair vision has dealt with the effects of dazzle. The following conclusions have been reported:

(1) The closer an object is to a source of glare, the more the glare interferes with the visibility of that object (24).

(2) For a given flash brightness, the flash covering the fovea will have its full dazzle effect only if its angular radius exceeds about 3 degrees. Smaller flashes yield progressively reduced disabling effects (24).

(3) In general, the adaptation of a given part of the retina is independent of that of another part; e.g., dark readaptation in a part of the retina which is affected by moderate glare will occur independent of that part affected by extreme glare (24).

(4) Recovery time after exposure to glare tends to be quite rapid, but the fovea tends to recover much more rapidly than does the peripheral retina (24).

(5) There is a tendency toward linearity when recovery time is plotted against flash intensity, at least over certain ranges of intensity (21, 25). (See Figure 18, page A-31.)

(6) There is a highly significant difference in the recovery of certain subjects (24).

(7) Recovery time to a given level of peripheral acuity depends on the product of flash luminance and duration (24).
Infrared

(U) Light sources with a high level of infrared can produce temporary glare blindness. However, the same luminance and exposure time without the infrared component will yield the same glare effect, and infrared in sufficient quantity can cause irreversible damage to the eye. Higher intensities of visible light can cause irreversible damage to the eye. It is believed that the resultant lesions are caused by the absorption of the visible light by the pigmented portion of the retina and the consequent degrading of the visible light into infrared or heat.

(U) The lenses of younger people transmit more infrared, making them more susceptible to retinal burns. The same is true of the aphakic or lensless eyes. Burns of this nature might be relatively painless. They probably occur most often from looking at the sun, as in a solar eclipse.

(U) One source of such retinal burns which is of interest to the military has been the nuclear fireball. It was concluded that in the worst circumstances, when the light from the fireball was focused directly on the fovea, it might still be possible for tasks to be performed by relying on off-center vision.

(U) A long-term effect associated with frequent exposure to light near or at sufficient intensity to cause retinal burns is the development of cataracts (the period before onset appears to vary from 2-1/2 months to several years). Less intense infrared exposure (e.g., temperature of 1500 C and 540 lux) is accredited with producing cataracts after a latent period of 20 to 40 years. Uncontrollable factors, such as general physiology, race origin, or dietary deficiencies might affect susceptibility to infrared cataracts.

(U) Infrared would probably be of limited utility in a tactical confrontation due to the possibility of an affected individual relying on off-center vision. If the criteria of temporariness and reversibility of effects are adhered to, the value of infrared for this type of application is further diminished.

Ultraviolet

(U) While ultraviolet rays can cause problems with the human eye, they are generally of limited significance for purposes of incapacitation. Both shorter and longer ultraviolet rays are absorbed by the cornea and conjunctiva.
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A very little ultraviolet radiation penetrating to the choroid results in damage. Ultraviolet radiation does not penetrate the lens to any significant degree; it does not normally pose the problem of retinal lesions (24, 26).

Exposure to ultraviolet radiation can result in the onset several hours later of conjunctivitis or retinitis. Exposure to a welder's arc or to near-field glare can produce discomfort such as a feeling of grit in the eyes, photophobia, and watering of the eyes. There is normally a delayed onset and recovery is usually complete (23, 27).

Due to the prolonged onset of symptoms, ultraviolet radiation is of little significance in determining the outcome of a tactical confrontation.

Laser Radiation

(U) Laser radiation has been suggested as a source of flash blindness or choroidal burns. Laser radiation differs from conventional light sources in that it is a coherent beam and is from a narrow spectral band.

(U) In order to affect vision, the laser must be aimed directly at the eye (25). This diminishes its practicality in a confrontation situation. The greatest danger to the eye, i.e., choroidal burns, appears to occur from relatively prolonged exposure to the laser beam (24).

(U) It has been suggested that a stacked blinking system of lasers might be used to produce flash blindness of several seconds' duration (28). Flash blindness from laser radiation can be prevented by shielding the eyes with any opaque material. In addition, atmospheric dust, haze, or fog would reduce the effectiveness of a laser (24).

(U) The efficiency of optically pumped lasers is only 2 to 3 percent, meaning that energy requirements are inordinately great. Conventional light sources, such as the carbon arc lamp, should be approximately 100 times more efficient than the laser for the production of flash blindness (24).

Microwaves

(U) The possible use of microwaves to incapacitate individuals, as has been suggested in connection with personnel barriers, appears to be infeasible unless mobility is desired. The action of microwaves is such as to...
SOUND AS AN INCAPACITANT

(U) There have been numerous suggestions, especially in the popular literature, that sound at a range of frequencies and intensities might be used to control crowds while doing individuals no particular harm. Despite impressions to the contrary, this application of sound is less than an accomplished science.

(U) An immediate possibility for using sound to control crowds is the use of loud noises to scare people or to interfere with communications. The Coloskop cartridge developed by Colt Industries might scare members of a crowd with its loud report, but they would probably become accustomed to it. The use of high-intensity sound, such as is produced by sirens, to interfere with communications in the crowd has the disadvantage that control forces might also have difficulty in communicating and that hearing loss might occur.

(U) One device which was recently patented is reputed to generate sound "so offensive and repugnant that hearers leave the scene, but no permanent injury is caused." No independent assessment of this device has been found.

(U) Most of the suggestions for using sound to control human behavior failed to solve one or more of such problems as operator protection, increased selectivity of sound and selectivity of target, the problem of undesired effects (e.g., breaking windows along a city street), and the differential effect of individuals to the same frequencies and intensities.
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(U) Low-frequency sounds and infrasounds appear to have the greatest potential of controlling human behavior because human organs exhibit low-frequency resonance characteristics. It is reported that the chest and abdomen at 1 resonate at about 3 cps, the head at about 20 cps, the arm and shoulder at about 3 cps, and the spine at about 5 cps. Subjects exposed to such sounds report a number of discomforts. Many exhibit physiological responses such as dizziness, lower blood pressure, increased heart beat, lasting interference with hormone secretion, and decreased visual acuity. At a pressure of 150 db small animals exhibit occasionally fatal damage to the ganglion cells(30).

(U) While there has been discussion of the use of low-frequency sound to cause members of crowds to lose control of their sphincter muscles, it appears that little work has been done to implement these suggestions(31).

(U) The greatest danger of the use of sound to control humans appears to be hearing loss. At 90 to 120 db temporary and possibly permanent hearing loss occurs. Most subjects experience pain at about 140 db, and at about 160 db the eardrum is torn. In the range of approximately 120 to 140 db effects such as irritability, inefficiency, tiredness, sterility, headaches, insomnia, increased excitability, and increased blood pressure have been noted. At levels above approximately 135 to 140 db, it has been reported that equilibrium is disturbed, there is a feeling of oppression, the central nervous system is stimulated (e.g., nausea, tendencies to vomit, difficulty of orientation), there is decreased attention to correct work procedure, and efficiency is decreased(30,31).

(U) Ultrasounds (i.e., >20 kc/sec) apparently pose a minimal threat to man at moderate-to-low intensities. They pose a greater threat to insects and animals due to their thermal effects(30).

BARRIERS AND MECHANICAL DETERRENTS.

(U) This final general category of nonlethal weapons is described in functional terms. It includes barriers in the usual sense as well as devices which inflict physical discomfort through direct mechanical or electrical action.

(U) Barriers and mechanical deterrents have long been used as a means of controlling mobs and unruly individuals. Because of this long history of use and consequent familiarity, these devices can often be employed in situations
The use of more sophisticated means, such as chemical weapons, would be unacceptable to the general public. While the logic of this attitude might be subject to argument, the attitude itself must be considered in the process of choosing the precise type of nonlethal weapon system to be used. Thus an individual may well be forced to choose something less than the ideal system in favor of something more "acceptable".

(U) In addition to the fact that these are familiar devices for the control of violence, another advantage stems from the very simplicity of many of them. Even though a particular device may be rather severe in effect, it is likely to be more nearly acceptable if its mechanism and effect are immediately evident and well understood. Accordingly, while a device such as a billy club may be capable of inflicting more serious injury, it is likely to occasion less outcry than the use of chemical agents of the CS-CN type. A great variety of devices whose effect is largely mechanical are available, allowing the user a range of choice in fitting the weapon to the situation.

(U) It is difficult to generalize about the disadvantages of barriers and restraining devices as many of the disadvantages are peculiar to individual systems. However, several factors should be borne in mind when one considers their use. A number of the barrier systems (e.g., barbed wire, barbed tape, inflatable barriers) are costly. Some are quite cumbersome, requiring heavy expenditures of machine or manpower for their emplacement. In addition, most of them have no built-in decay mechanism, so a costly cleanup operation is required after the emergency situation has passed. If this cleanup is not accomplished promptly, persons not involved in the conflict are caused inconvenience. It is, perhaps, this lack of flexibility which is the most serious disadvantage of the barrier systems.

(U) The characteristics worthy of mention of the other items included in this section will be discussed individually.

(U) In summary, while many of the devices described in this section show less potential for flexibility of use than a number of the chemical weapons in use and under development, they are well known by the public and are currently in the police and military arsenals. For this reason, they are likely to remain in use for a long time.

(U) These devices serve, in general, to mechanically prevent rioters from attaining their purposes and may have the effect of discouraging all
Conventional Barriers

(1) Physical barriers are barriers in the usual sense, intended to control or limit the movement of a crowd. The barriers most useful in crowd-control situations must be easily transported, readily emplaced, effective, resistant to damage or displacement, and convenient to remove when desired. Of course, they must be as inexpensive as possible. Three types of physical barriers will be considered here: (1) barbed wire, concertina wire, and barbed tape, (2) inflatable barriers, and (3) nets.

(2) Several examples of barbed wire and its variants have undergone testing by the U. S. Army in recent years on the basis of both barrier effectiveness and cost. Among those items which have been tested are:

(1) Standard barbed wire consisting of two-strand No. 12 wire with four-point barbs spaced 4 inches apart (Figure 19A, page A-32).

(2) German barbed tape which has four-point barbs spaced at 1-inch linear intervals (Figure 19B).

(3) Barbed-wire concertina made up of single-strand coiled spring wire with four-point barbs spaced 2 inches apart; each roll opens to form a cylinder 50 feet long and 36 inches in diameter (Figure 19C).

(4) German barbed-tape concertina consisting of a strip of barbed tape crimped around a core wire; rolls of this material open to form cylinders 40 feet long and 33 inches in height (Figure 19D).

(5) Rapidly Emplaced Antipersonnel Obstacle (REAPO), which is formed from steel tape with 1-7/8-Inch barbs located on 4-inch centers (Figure 20A, page A-33).

(6) The General Purpose, Barbed-Tape Obstacle (GPBTO) which is fabricated from 5/8-Inch tape with barbs located every 4 inches on center; this material opens to form a double helix with the outside coil...
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reverse wound and 180 degrees out of phase with the outer coil (Figure 208).

(U) Neither the RLAM nor the GBITO have proven to be worthy of further study at this time. The RLAM has been judged poor from the standpoint of reliability and ruggedness, and in any case would be too expensive for most applications. The GBITO has similar deficiencies and, in addition, does not meet command-control and booby-trap requirements.

(U) Inflatable barriers have been investigated, and a number of manufacturers have expressed interest in further developing them. At present, however, no agency appears interested in buying a number of units. Although seemingly vulnerable to knives, proper design can essentially eliminate this problem. Deployment and removal would be very quick. The barrier is completely passive, with no risk of such injuries as might be inflicted by barbed wire. The inflatable barrier's prime disadvantage is its probable high cost relative to other devices. In any case, such barriers are not currently available off-the-shelf.

(U) Finally, various nets can be used to constrain a crowd or riot. They have the advantage of being "see-through" and easily transported. Erection could be quick if supporting structures were available; otherwise, anchoring the net would be a major handicap. We know of no nets presently designed for the express purpose of crowd control. Those systems which we can envision would be relatively expensive.

Other Passive Impediments to Movement

(U) Recognizing the limitations of conventional "barriers", as discussed above, a number of other passive means for controlling crowd movement have been studied. These include caltrops, slippery liquid, foams, and "spider web". Caltrops are four-pronged objects made of sharpened wire constructed so that one point is always vertical. Such devices can pierce shoes and inflict serious injury (Figure 21, page 33).

(U) Caltrops show some promise from the standpoint of cost and effectiveness. They have the advantage of being very rapidly emplaced. Some firms are now producing caltrops held together by a degradable material which eventually render them ineffective.
1. Although caltraps have proven to be fairly effective, especially when used by their human employment, there appear to have been some reports that it was either at the expense of the life or that of service personnel. Possibly some persons feel that a caltrap is not a "suitable" weapon -- that is, that the effects are potentially inhumane. Certainly a caltrap barrier would have a cruel appearance - and effect.

2. A very interesting type of impendiment is that created by the applications of certain liquid polymers (sometimes called "instant banana peel"). These reduce friction to the point that walking or running on a surface coated with them is next very difficult. While this material presents some difficult cleanup problems, it is a very humane way to frustrate a crowd and therefore its application would not be psychologically counterproductive (34).

3. Similar to "instant banana peel" in that it lowers the coefficient of friction making walking difficult, Teflon confetti may well have application in making any kind of purposeful movement difficult for the mob. This material would be particularly effective when spread two or more layers thick, since the material would be sliding on itself. Obviously it would find a more useful application on a paved street than on bare soil or grass. The material is rather expensive at this time because of its difficult working properties, but undoubtedly the price would drop as the substance becomes more widely used (34).

4. Various foam machines, adaptations of the type used in firefighting, can have applications in controlling crowds. It is reported that individuals finding themselves in the midst of the substance become disoriented and lose motivation. Suffocation is not supposed to be a problem since the bubbles burst in the nose and mouth when inhaled. A fairly sizeable barrier may be formed relatively quickly (14). The composition and generation of the foam determines its forking and hence the degree of difficulty in cleanup. Foam could easily be used in combination with instant banana peel, but the already difficult cleanup problem would then be compounded. Foam shares some of the psychological advantages of instantly instant banana peel, but would probably not be acceptable to quite the same degree. Being engulfed in foam would very likely be a frightening experience.

5. A "spider web" is a type of adhesive which can be sprayed out of a very fine filament which float through the air until they impinge upon to which they attach. This material would appear to...
Mechanical Deterrents

In this category are grouped those weapons which have a direct mechanical effect and can be selectively employed against individuals and groups. Among these are conventionally powered firearms which fire nonlethal projectiles such as rubber bullets, wood pellets, or special shotgun pellets. The latter devices have one thing in common: they incapacitate by impact. The victim is either injured or subjected to enough pain to deter him from aggressive action. Of course, some danger of serious injury is always present when these methods of incapacitation are applied. The danger can be lessened, but not eliminated by careful and thorough training in their use.

One wooden pellets like those of the "Multiple Baton Shell" are fired from a gun with a 1-1/2-inch-diameter barrel. The pellets are said to inflict about the same amount of punishment as a billy club. Rubber projectiles are fired in the same manner and produce about the same effect. There is no inherent difference in interior and exterior ballistics between projectiles made of rubber and those made of wood, while there would be differences in terminal ballistics due to differences in mechanical properties of the materials, it is doubtful that there would be significant differences.
The shell has been designed to produce a loud report and bright muzzle flash giving it some value as a psychological weapon (39).

Research has also been carried out on weapons which project electrified bats, rubber or putty-like bullets (38-40), and similar items. The literature indicates that, at present, none of these have a safety factor favorable enough for widespread use. Nevertheless, rubber bullets have been reported in use during recent riots in Northern Ireland. So far as is known, no detailed report has been published regarding their effectiveness.

Water cannons and high-pressure fire hoses have been used against crowds with varying success. Variations in weather conditions and crowd desire vastly and obviously affect results. The initial cost can be low since firefighting equipment can be borrowed for riot-control purposes. Specially designed and built vehicles, on the other hand, would be relatively expensive.

Electric prods, or electrified batons have been used quite successfully in the past for dispersing crowds (34). They are not as effective when the crowd has on dry, heavy clothing. Increase of voltage to overcome this disadvantage could make the device potentially harmful (heart arrest, etc.). Public acceptance of such devices seems low, perhaps because of an association with cattle prods.

Many types of prods, clubs, batons, etc., have been used for riot-control purposes. All require significant training to fully realize their effectiveness. Quarter staffs, riot batons, nightsticks, billy clubs, saps, and flails all depend on skillful use to be effective and nonlethal or non-permanently injurious. The cost of the training required can offset the inexpensive purchase price. It does not appear practical to construct a club or prod which cannot produce permanent injury. Indeed, some command-type weapons are designed to be fatal and are not useful in less than critical situations. This general type of weapon has been used for centuries and is in some places highly refined today. Many examples of these weapons are used in oriental martial arts.

Further development has taken place, however. In 1964, the Research Analysis Corporation, under contract to the Advanced Research Projects Agency, designed a billy club based on a Japanese weapon of similar design. The club is made of a size which could be concealed on a person. Extending the club to a length of 60 inches extended its length. To aid rapidity, the device also featured an extendible self-locking button in the forward section (41).
MISCELLANEOUS

Dogs have been used very successfully to control crowds where their handlers have been well trained. A few dogs with skilled handlers can effect control of a crowd which is out of proportion to their real strength. Indiscriminate, immoderate, and well-publicized use of dogs has, however, put them in a bad psychological light.

(U) A further disadvantage of dogs is that the dog and handler must be treated as an integral unit which tends to limit their usefulness. Then too, the dog requires continual care and training.

(U) Men on horseback have long been used successfully to control crowds and even riots. Horses do require substantial and continuous outlay for maintenance. When and how to employ horse-mounted men would depend somewhat on the degree of disorder, since a crowd could maim or otherwise disable a horse if sufficiently motivated.

(U) The Research Analysis Corporation investigated the possibility of developing a liquid cold weapon. While it was determined that a small weapon of this type could be produced using cold brine as an agent, it was judged not to be practical since a small weapon would not have the required capacity.

(U) The marking of people for later apprehension is another technique which has been tried in some situations. In a hostile crowd, attempts to arrest individuals may provoke the crowd to more violent actions. Very often the police will not be physically able to make an arrest anyway. It may be possible to meet such situations by marking individuals or vehicles with some suitable material for later apprehension. The specific materials proposed range from visible dyes, to invisible markings (sensitive to ultraviolet light for example), to odor-identifying markings (sensed by dogs or gas chromatographs).

Photography may facilitate identification but light conditions and identifying features limit the usefulness of photographs. Paint guns, such as Nel-Spot 707, are available but have not received extensive use to our knowledge. Marking with a visible or colored dye seems to act as a deterrent for some individuals who will immediately leave the crowd to avoid being sprayed.
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## TABLE 1. CHARACTERISTICS OF CHEMICAL I. E.A.

<table>
<thead>
<tr>
<th>Incapacitating Effect</th>
<th>Agent Symbol or Identification Number</th>
<th>Chemical and/or Common Name</th>
<th>Status</th>
<th>Time to On of Effect</th>
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<tbody>
<tr>
<td>Irritation</td>
<td>CN</td>
<td>Chloracetophenone</td>
<td>Standard</td>
<td>Immediate</td>
</tr>
<tr>
<td></td>
<td>CS</td>
<td>O-chlorobenzylidene</td>
<td>Standard</td>
<td>Immediate 10 sec, depending on concentration</td>
</tr>
<tr>
<td></td>
<td>EA1277</td>
<td>1-chloro, 9-10 dihydroarsacridine (Excelsior)</td>
<td>Research</td>
<td>Immediate</td>
</tr>
<tr>
<td></td>
<td>EA3625</td>
<td></td>
<td>Research</td>
<td>Almost immediate</td>
</tr>
<tr>
<td></td>
<td>BBC</td>
<td>Bromobenzyl cyanide</td>
<td>Standard</td>
<td>Immediate</td>
</tr>
</tbody>
</table>

EA3547  
126312  
EA3365  
EA2542  
EA1778  
EA4922  
Capsaicin
<table>
<thead>
<tr>
<th>Time to Onset</th>
<th>Duration of Symptoms</th>
<th>Summary of Characteristics and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate</td>
<td>About 3 min in clean air</td>
<td>Produces lachrimation and general severe irritation of eyes, nose, throat and chest, together with burning of sweaty skin areas; until recently this was the standard 'tear gas' used for riot control and as a training aid in CB instruction; it is a relatively mild deterrent to motivated personnel</td>
</tr>
<tr>
<td>Immediate to 10 sec, depending on concentration</td>
<td>About 10 to 15 min in clean air</td>
<td>Produces choking sensation in throat and upper respiratory tract leading to violent coughing; difficulty in breathing (which tends to induce panic), immediate lachrimation and involuntary eye closure; dizziness, running nose and extreme burning irritation of sweaty skin; high concentrations induce nausea; CS is replacing CN as the standard agent for controlling riots; it is approximately 10 times as effective as CN</td>
</tr>
<tr>
<td>Immediate</td>
<td>1 to 5 min; incapacitation symptoms persist for 1 to 2 hr</td>
<td>General severe irritation of chest and throat; lachrimation, running nose, headache</td>
</tr>
<tr>
<td>Almost immediate</td>
<td>About 60 min</td>
<td>Effects very similar to those of CS but much longer lasting; the dose required is much higher than that for CS; recent clinical trials suggest that it may be necessary to reject this material</td>
</tr>
<tr>
<td>Immediate</td>
<td>Variable, minutes to hours</td>
<td>A liquid tear gas producing severe lachrimation and involuntary eye closure; there is some danger of permanent eye damage from liquid splash</td>
</tr>
</tbody>
</table>

The effects produced by each of these agents are similar in severity to those of CS
<table>
<thead>
<tr>
<th>Agent Symbol or Identification Number</th>
<th>Chemical and/or Common Name</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>Diphenylamine chlorarsine (Adamsite)</td>
<td>Standard</td>
</tr>
<tr>
<td>DC</td>
<td>Diphenyl cyanoarsine</td>
<td>Standard</td>
</tr>
<tr>
<td>CN-DM</td>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>228926</td>
<td>N-propylnorapomorphine</td>
<td></td>
</tr>
<tr>
<td>Cutaneous pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CX</td>
<td>Phosgene oxime</td>
<td>Research</td>
</tr>
<tr>
<td>Potential, no current status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eledoisin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bradysin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary blindness</td>
<td></td>
<td>Research</td>
</tr>
<tr>
<td>EA1972 (DC)</td>
<td>Dimethyl diglycolate</td>
<td>Research</td>
</tr>
<tr>
<td>3010-1</td>
<td>N-benzylpropyl-4- piperidyl phenyl cyclopentyl glycolate hydrochloride</td>
<td>Research</td>
</tr>
<tr>
<td>Temporary blindness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dime etmethyl ether</td>
<td></td>
<td>Research</td>
</tr>
</tbody>
</table>

**CONFIDENTIAL**
<table>
<thead>
<tr>
<th>Onset</th>
<th>Duration of Symptoms</th>
<th>Summary of Characteristics and Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 3 min</td>
<td>15 min to several hours</td>
<td>This agent affects both the respiratory tract and the vomiting center; symptoms include extreme discomfort, nausea, severe coughing and sneezing, lachrymation, severe headache, pain and tightness of chest, continued vomiting; large doses cause diarrhea which may persist for long periods.</td>
</tr>
<tr>
<td>Immediate</td>
<td>30 to 60 min</td>
<td>Effects very similar to those of DM with a shorter time to onset; large doses will extend nausea and diarrhea to many hours.</td>
</tr>
<tr>
<td>Immediate</td>
<td>15 min to 2 hr</td>
<td>This mixture produces effects characteristic of both agents, giving immediate onset and symptoms extending over at least 2 hr, according to the dose received.</td>
</tr>
<tr>
<td>Immediate on eyes; 1 to 5 min on skin</td>
<td>Variable 1 to a few weeks</td>
<td>Nettlelike effects with severe burning pain on skin.</td>
</tr>
<tr>
<td>Immediate</td>
<td>Undetermined</td>
<td>Severe incapacitating pain and swelling under skin similar to wasp sting.</td>
</tr>
<tr>
<td>Immediate</td>
<td>2 to 3 days</td>
<td>Blurred vision, eye fogging, temporary partial blindness resulting from corneal opacity; the effects appear to be completely reversible.</td>
</tr>
<tr>
<td>Immediate</td>
<td>Undetermined</td>
<td>Clinical trials are required with this material.</td>
</tr>
</tbody>
</table>

- Not known for man -

Undetermined

This effect produces symptoms of unsteady gait, dizziness.
<table>
<thead>
<tr>
<th>Agent Symbol or Identification Number</th>
<th>Chemical and/or Identification Name</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>No names yet assigned to these compounds</td>
<td>Skatole, Mercaptans, Pelargonyl morphalide</td>
<td>Research</td>
</tr>
<tr>
<td>BZ/119902</td>
<td></td>
<td></td>
</tr>
<tr>
<td>119902/EA3443</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EA 3382</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EA3382/220548</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EA2148A</td>
<td>Sernyl</td>
<td>Research</td>
</tr>
<tr>
<td>302089</td>
<td>Triazaspirodecanes</td>
<td>Research</td>
</tr>
<tr>
<td>EA2233</td>
<td>3,4, 2-dimethylheptyl tetrahydrocannabinol (O-acetyl derivative)</td>
<td>Research</td>
</tr>
</tbody>
</table>

**CONFIDENTIAL**
| Time to Onset
<table>
<thead>
<tr>
<th>Duration of Symptoms</th>
<th>Summary of Characteristics and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Not known for man -</td>
<td>Some odors are particularly objectionable to certain people; it appears that there is a relationship between racial origin and the acceptability of particular types of odor.</td>
</tr>
<tr>
<td>- Not known for man -</td>
<td>Anticholinergic effects with those of morphineline-like materials will give rapid reversible and long-lasting paralysis as a result of disturbance in function of the central nervous system, impaired motor coordination and, possibly, convulsions; animal results suggest that in man symptoms might appear in 10 to 20 min and persist for several hours; all these mixtures will produce these effects, but clinical research is still awaited to support the use of any as an agent.</td>
</tr>
<tr>
<td>- Not known for man -</td>
<td>Symptoms induced include ataxia, spatial distortions, nausea, vomiting, and analgesia, leading to anesthesia; low doses produce psychotropic effects while high doses produce anesthesia.</td>
</tr>
<tr>
<td>- Not known for man -</td>
<td>Intravenous dose of 0.25 mg/kg produces quiet sleep from which subject can be easily awakened; intravenous dosage of 20 mg/kg produces sedation, allaying of anxiety and reduced motivation.</td>
</tr>
<tr>
<td>Variable, 15 to 60 min</td>
<td>Lowered blood pressure sufficient for casualty to remain aware of circumstances when prone, any attempt to rise produces immediate collapse; additional effects produced include hallucinations, euphoria, ataxia, and sluggishness.</td>
</tr>
<tr>
<td>Process of Nervous System</td>
<td>Agent Symbol or Identification Number</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Mental effects</td>
<td>EA1729</td>
</tr>
<tr>
<td>Prostration</td>
<td>BZ</td>
</tr>
<tr>
<td></td>
<td>EA3834</td>
</tr>
<tr>
<td></td>
<td>EA3695</td>
</tr>
<tr>
<td></td>
<td>302196</td>
</tr>
<tr>
<td></td>
<td>226101</td>
</tr>
<tr>
<td></td>
<td>302668</td>
</tr>
<tr>
<td></td>
<td>CS4640</td>
</tr>
<tr>
<td></td>
<td>EA3580-A</td>
</tr>
<tr>
<td></td>
<td>EA3580-B</td>
</tr>
<tr>
<td>Time to Onset of Symptoms</td>
<td>Duration of Symptoms</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>1 - 2 min</td>
<td>10 to 12 hr</td>
</tr>
<tr>
<td>1/2 to 2 hr</td>
<td>2 to 4 hr, possibly up to 5 to 6 days according to dose</td>
</tr>
<tr>
<td>20 sec</td>
<td>4 hr</td>
</tr>
<tr>
<td>1 to 2 hr</td>
<td>12 to 18 hr</td>
</tr>
</tbody>
</table>

*CONFIDENTIAL*
<table>
<thead>
<tr>
<th>Agent Symbol or Identification Number</th>
<th>Chemical and/or Common Name</th>
<th>Status</th>
<th>Time to of Symp (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EA3443</td>
<td>4-methyl-4-piperidyl cyclo butyl phenyl glycolate</td>
<td>Research</td>
<td>5 to 8 h (peak)</td>
</tr>
<tr>
<td>EA3167</td>
<td>3-quinuclidinyl phenyl cyclopentyl glycolate</td>
<td>Research</td>
<td></td>
</tr>
</tbody>
</table>

(a) Adapted from data in Reference 1.
(b) Mydriasis is a long-continued or excessive dilation of the pupil of the eye.
<table>
<thead>
<tr>
<th>Time to Onset of Symptoms</th>
<th>Duration of Symptoms</th>
<th>Summary of Characteristics and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 8 hr (peak effect)</td>
<td>48 to 100 hr (mydriasis)</td>
<td>Similar effects to BZ, but more toxic; no undesired side effects</td>
</tr>
</tbody>
</table>

- Not known for man -
Description: The ARC-M7A2 and M7A3 CS riot hand grenade is a cylindrical metal container filled with pyrotechnic CS mixture and fitted with an M201A1 grenade fuze which is screwed into a fuze adapter in the top of the grenade. Three emission holes are located in the top of the grenade. The emission holes are covered with adhesive tape to protect the filling from moisture. The M7A2 differs from the M7A3 only in the way in which the filling is manufactured. The M7A2 is filled with a pyrotechnic mix and powdered CS agent in gelatin capsules. The M7A3 is filled with a pyrotechnic mix and pelletized CS agent.

Characteristics:

- **Total Weight**: 16 oz
- **Fuze Time**: 0.7 to 2.0 sec
- **Filler Weight**: 9.5 oz
- **Burning Time**: 15 to 35 sec
- **Height**: 5-3/4 in.
- **Range**: 35 m (hand tossed)
- **Diameter**: 2-1/4 in.
- **145 m (rifle fired)
- **Container Body Material**: Steel
- **Manufacturer**: Military
FIGURE 2. NORTHROP RUBBER BALL GRENADE (U)

Description: This device, available to law enforcement agencies, contains 40 grams of CS and 40 grams of pyrotechnic agent. Four emission holes are located in the body of the grenade. During discharge the grenade moves rapidly along the ground, propelled by the escaping agent. There is no explosion or fragmentation of the grenade body.

Characteristics:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Weight</td>
<td>0.46 lb</td>
</tr>
<tr>
<td>Filler Weight</td>
<td>100 g</td>
</tr>
<tr>
<td>Height</td>
<td>4-3/4 in.</td>
</tr>
<tr>
<td>Diameter</td>
<td>3-1/4 in.</td>
</tr>
<tr>
<td>Fuze Time</td>
<td>2.5 sec</td>
</tr>
<tr>
<td>Burning Time</td>
<td>10 sec</td>
</tr>
<tr>
<td>Range</td>
<td>Hand tossed</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Northrop Carolina, Inc.</td>
</tr>
<tr>
<td>Container Body Material</td>
<td>Rubber</td>
</tr>
</tbody>
</table>

*Data from Reference 7.*
FIGURE 3. FEDERAL TRIPLE CHASER GRENADE (U)

(U) Description: Available to civilian law enforcement agencies, this grenade separates into three parts which bounce along the ground, functioning like three separate grenades. Agent is discharged from the emission holes in each section. There is no further explosion or fragmentation of the three sections once initial separation has taken place(3).

(U) Characteristics:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Weight</td>
<td>24 oz (CN)</td>
</tr>
<tr>
<td></td>
<td>20.5 oz (CS)</td>
</tr>
<tr>
<td>Filler Weight</td>
<td>290 g (CN)</td>
</tr>
<tr>
<td></td>
<td>265 g (CS)</td>
</tr>
<tr>
<td>Height</td>
<td>6-1/4 in.</td>
</tr>
<tr>
<td></td>
<td>(with fuze)</td>
</tr>
<tr>
<td>Diameter</td>
<td>2-5/8 in.</td>
</tr>
<tr>
<td></td>
<td>(at base)</td>
</tr>
<tr>
<td>Container Body</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Fuze Time</td>
<td>2 sec</td>
</tr>
<tr>
<td>Burning Time</td>
<td>25 sec</td>
</tr>
<tr>
<td>Range</td>
<td>Hand tossed</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Federal Laboratories, Inc.</td>
</tr>
</tbody>
</table>

(Drawing and data from Reference 3.)
Description: The XM7E1 is intended to replace the M7 series grenade now in use. The CS pyrotechnic mixture will effectively blanket an area of at least 100 square meters to a height of at least 2 meters. The range and the effective area affected by the agent will vary somewhat with the velocity and direction of the wind. The XM7E1 fuze contains two safety features: the safety pin and the safety latch. The safety pin is located through the safety latch and the XM7E1 fuze body. The safety latch, a component of the safety lever, is engaged with a lock pin located through the XM7E1 fuze body.

Characteristics:

- **Total Weight**: 350 to 400 g
- **Filler Weight**: 200 g
- **Casing**: Spherical
- **Fuze Time**: 2 ± 7 sec
- **Burning Time**: ..
- **Range**: .. Hand tossed (approx. 35 to 45 m)
- **Manufacturer**: Military
Description: This grenade is a special-purpose, bursting-type used to control riots, mobs, and other disturbances. It is designed to minimize casualties from flying fragments by utilization of a frangible plastic body.

The spherical body of the grenade consists of two plastic hemispheres cemented together. The grenade is filled with approximately CS1 (micropulverized CS) and is fitted with a detonator-type fuze. The fuze assembly is contained in a slider which moves in an integrally molded burster well. A safety pin retains an arming sleeve which controls the fuze action. After the safety pin is withdrawn, release of the arming sleeve permits the spring-loaded slider to travel the length of the burster well to impact on a firing pin at the bottom of the well, exploding the detonator, shattering the grenade, and dispersing the CSI filling.

Characteristics:
- Total Weight: 8 oz
- Filler Weight: 2 oz
- Height: 3-5/16 in. (with fuze)
- Diameter: 2-7/8 in.
- Fuze Time: 1.4 to 3 sec
- Burning Time: 
- Range: Hand tossed (approx. 40 m)
- Hand tossed
- Manufacturer: Military

(Drawing from Reference 3; data from References 3 and 8.)
Figure 6. Federal Blast Dispersion Grenade (U)

(U) Description: This grenade, contains either CN or CS, has a fuze time of 2 seconds. Upon detonation, the container ruptures along the grooves, its side and releases a cloud of agent. Discharge is instantaneous. The metal body remains in one piece, with only the fuze and top plate being thrown clear during the functioning of the grenade.

(U) Characteristics:

- Total Weight: 15-1/2 oz (CN), 15 oz (CS)
- Filler Weight: 220 q (CN), 220 q (CS)
- Height: 6-1/4 in.
- Diameter: 2-5/8 in. (at base)
- Container Body Material: Aluminum
- Fuze Time: 2 sec
- Burning Time: 
- Range: Hand tossed
- Manufacturer: Federal Laboratories, Inc.

(Drawing and data from Reference 3.)
(U) Description: The M3 disperser is designed to disseminate micropulverized riot-control agents. It consists of an M9 disperser gun connected by an 3 hose to a modified M2A1 Portable Flamethrower Fuel and Pressure Unit. The M9 gun permits release of micropulverized CS (CS-I) in short bursts or in one continuous discharge. This is a military unit but may be loaned to civilian police agencies under emergency conditions.

(U) Characteristics:

Weight (Operational) . . 55 lb (approx.)
Operating Pressure . 30 to 90 psi (discharge)
Available Air Pressure . . 1700 to 2100 psi (high pressure section)
Agent Capacity . . 8 lb of CS1 (4 lb in each task)

Range . . . . . . . . 40 ft (in still air)
Duration of Fire . . . . . . . . . . . . . 20 sec
Area Coverage . . 2300 to 3800 m²

Manufacturer . . . . Military (4 lb in each task)

Drawing from Reference 3; data from References 3 and 8.)
FIGURE 8. MILITARY DISPERSER, RIOT CONTROL AGENT, HELICOPTER- OR VEHICLE-MOUNTED, M4 (U)

Description: The M4 military disperser is a vehicle-mounted riot control agent designed to forestall, disrupt, and end civil disturbances. It is used to disperse rioting crowds and control civil disorders. The disperser contains a pressurized gas tank and a nozzle for spraying the agent.
The unit consists of a pressure regulator, various controls and instruments, and is securely mounted on a tubular frame. It is intended to be utilized immediately for use. The upper is a sheet aluminum cylinder, and 10-foot stages are provided for securing the disperser in the helicopter or vehicle. A 10-foot discharge hose is furnished for discharging the agent outside the helicopter or vehicle. A flexible nozzle (for helicopter mounting) and an M4 irritant agent disperser gun (for vehicle mounting) are provided, either can be attached to the 10-foot discharge hose. The M4 disperser may be mounted in the cargo compartment of the Army helicopters H-19 or larger. The major advantage of this means of dissemination is the large area coverage achieved and the ability of the helicopter to hover or fly slowly over a specific area while dispersing an agent.

(United States) Characteristics:

<table>
<thead>
<tr>
<th>Weight (Operational)</th>
<th>208 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Pressure</td>
<td>45 ± 5 psi (discharge)</td>
</tr>
<tr>
<td>Available Air Pressure</td>
<td>2000 psi (high-pressure section)</td>
</tr>
<tr>
<td>Agent Capacity</td>
<td>50 lb of CS1</td>
</tr>
<tr>
<td>Range</td>
<td>40 ft (in still air [with gun]) 50 to 150 ft from helicopter (helicopter elevation; 75 to 100 ft)</td>
</tr>
<tr>
<td>Duration of Fire</td>
<td>2 min (gun) 20 sec (helicopter hose)</td>
</tr>
<tr>
<td>Area Coverage</td>
<td>Discharge distance: 1200 to 1500 m</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Military</td>
</tr>
</tbody>
</table>

(Photo and data from Reference 8.)
FIGURE 9. MILITARY DISPERSER, RIOT CONTROL AGENT, HELICOPTER- OR VEHICLE-MOUNTED, M5 (U)

(U) Description: The M5 disperser is designed to disseminate micropulverized riot-control agents either from the air or from a vehicle. The M5 is a product improvement of the M4; it is lighter in weight, has a larger volume of discharge air, utilizes commercially available components, is simpler to operate, and can utilize prefilled agent containers. Field filling of the agent container can also be accomplished. The M5 disperser consists of an agent container tank, two air cylinders, a tubular aluminum frame, an M9 riot-control-agent disperser gun (for vehicle mounting) with a 12-foot hose, a 12-foot discharge hose (for helicopter mounting), and various controls and instruments. Fittings and holddown straps are provided for securing the disperser in a helicopter or ground vehicle.
Characteristics:

**Weight** (Operational): 200 lb

**Operating Pressure**
- 45 to 55 psi (discharge)
- 200 to 2000 psi (high-pressure section)

**Available Air Pressure**: 200 to 2000 psi (high-pressure section)

**Agent Capacity**: 40 lb of CS1

**Range**
- 40 ft (in still air [with gun])
- 50 to 150 ft from helicopter (helicopter elevation: 75 to 100 ft)

**Duration of Fire**: 2 min (gun)
- 20 sec (helicopter hose)

**Area Coverage**: 50,000 m² (est.)

**Manufacturer**: Military

(Drawing from Reference 3; data from Reference 8.)
Description: The M106 disperser is used to disseminate micropulverized riot-control agents for control of riots, mobs, or other disturbances or for such purposes as blowing riot-control agents into tunnels or underground fortifications to flush out personnel from subject area. The M106 disperser is a commercial agricultural fertilizer-sprayer adapted for military use. It consists of a 450-cfm axial-flow blower powered by a two-stroke engine. An auger in the disperser receives the micropulverized agent, disperses it, and an air jet is utilized to blow the agent. The disperser also has a 60-foot hose and 10 feet of parachute. The disperser weighs 35 pounds.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (Operational)</td>
<td>35 to 37 lb</td>
</tr>
<tr>
<td>Operating Volume</td>
<td>450 cfm</td>
</tr>
<tr>
<td>Agent Capacity</td>
<td>8 lb of CS1</td>
</tr>
<tr>
<td>Range</td>
<td>40 ft (in still air)</td>
</tr>
<tr>
<td>Duration of Fire</td>
<td>4 to 5 min</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Military</td>
</tr>
</tbody>
</table>

(Photo and data from Reference 8.)
FIGURE 11. PTG-100 AND -200 DISPERSER (U)

(U) Description: This disperser (PTG-200 is illustrated above) utilizes either micro-pulverized CN or CS, with an agent capacity of 5 or 10 pounds, depending on whether one (PTG-100) or two (PTG-200) tanks are used. The unit employs dry nitrogen pressure to expel the chemical agents. The agent is released in short bursts utilizing a trigger located on the discharge hose nozzle. The unit is designed to be reloaded in the field without tools, and agent formulations are available in stainless steel containers to facilitate this operation.

(U) Characteristics:

<table>
<thead>
<tr>
<th>Weight (Operational)</th>
<th>37 lb (PTG-100)</th>
<th>46 lb (PTG-200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent Capacity</td>
<td>5 lb (PTG-100)</td>
<td>10 lb (PTG-200)</td>
</tr>
<tr>
<td>Range</td>
<td>75 ft (in still air)</td>
<td></td>
</tr>
</tbody>
</table>

Duration of Fire... Variable
Manufacturer... B & H Enterprises, Inc.

(Drawing and data from Reference 3.)
FIGURE 12. GOEC MK-XII PEPPER FOG (U)

(U) Description: The Mark XII-A Generator (Pepper Fog) employs the resonant pulse-jet principle to generate hot gases flowing at high velocity. The high-velocity gases atomize the liquid formulation (CS, CN) instantly so that it is vaporized and condensed so rapidly that thermal breakdown of the chemical is nonexistent or negligible. The fog particle size is controllable from 1 to 50 microns and beyond, with smaller particle sizes associated with lower formulation flow rates.

(U) Characteristics:

Weight (Operational) . . . 27 lb
Agent Capacity . . . 1 gal (liquid)

Duration of Fire . . . 10 to 20 min
Manufacturer . . . General Ordnance Equipment Corporation

(NOTE: specifications are for the newer Mk-XII-A which is shorter in overall length and slightly modified from the Mk-XII shown here.)

(Drawing and data from Reference 3.)
Description: The AAI projectile may be fired from all unchoked 12-gauge shotguns. The injection-molded plastic projectile contains 3 cubic centimeters of CS in solution. The round will effectively contaminate a 9 x 12-foot room. Following impact and perforation of window or plate glass, the projectile disintegrates and instantaneously disseminates the liquid riot agent throughout the enclosed atmosphere in the form of a vapor-microparticle aerosol. The projectile has a flat trajectory out to 100 yards and is nonlethal beyond 250 yards. Tests indicate penetration capability against automotive safety glass at 100-foot range; 1/4-inch-thick plate glass or double window plus aluminum screen at 100-yard range.

Characteristics:

- Total Weight: 17.2 q
- Filler Weight: 3 cc
- Fuze Time: Impact
- Agent Emission Time: Instantaneous
- Manufacturer: AAI Corporation
- Maximum Range: 500 yd
- Muzzle Velocity: 1000 fps
- Size: 12 ga
- Body Material: Plastic, injection molded

('Drawing from Reference 3; data from References 3 and II.)
**Description:** This munition can be fired from both 37- and 38-mm weapons. At 37.5° elevation the shell will hit the ground at about 90 yards. Shorter ranges are secured by bouncing the shell along the ground or by firing at very high elevation. When the gun is fired the projectile is propelled from the gun and the delay is ignited. Approximately 3 seconds later the delay ignites the burster, which ruptures the projectile along rupture grooves to instantaneously release a cloud of micropulverized agent. The aluminum projectile body will remain in one piece and no metal fragments are thrown off during discharge.

**Characteristics:**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Total Weight</td>
<td>8.5 oz (CS or CN)</td>
</tr>
<tr>
<td>Filler Weight</td>
<td>80 q (CS or CN)</td>
</tr>
<tr>
<td>Delay Time</td>
<td>3 sec</td>
</tr>
<tr>
<td>Agent Emission Time</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>Maximum Range</td>
<td>90 yd</td>
</tr>
<tr>
<td>Muzzle Velocity</td>
<td>140 fps</td>
</tr>
<tr>
<td>Caliber</td>
<td>1-1/2 (38 mm)</td>
</tr>
<tr>
<td>Body Material</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Federal Laboratories, Inc.</td>
</tr>
</tbody>
</table>

(Drawing and data from Reference 3.)

**UNCLASSIFIED**
FIGURE 15. FEDERAL SHORT RANGE SHELL (U)

(U) Description: This shell is fired directly at the bolt level of the target. In still air the maximum immediate range is about 50 feet, but a favorable wind will carry the agent to more than 60 yards. When this shell is fired, a cloud of micropulverized agent (CS or CN) is ejected directly from the muzzle of the gun. With the evaporation of three light wads, the entire discharge consists of filler. This munition can be fired from both 37- and 40-mm weapons.

(U) Characteristics:

- Total Weight . . . 8 oz (CS or CN)
- Filler Weight . . . 8 oz (CS or CN)
- Agent Emission Time . . . Instantaneous
- Maximum Range . . . 25 to 30 ft (in still air)

Caliber . . . 1-1/2 (38 mm)
Body Material . Aluminum
Manufacturer . Federal Laboratories, Inc.

(Drawing and data from Reference 3.)
FIGURE 16. FLYING HYPODERMIC SYRINGE (U)
UNCLASSIFIED

DYE MARKER DART

This dart is loaded with a small amount of dye in a bright, visible color. It can be employed with various liquids such as special stretch fluids or fuels in darts as special security devices.

The uses of such a projectile are to mark or identify individuals in a crowd where contact and arrest are impractical. It has the effect of destroying anonymity.

HYPODERMIC SYRINGE PROJECTILE

Hypodermic syringes in dart form for animal control is a proved, practical humane practice. This projectile can accurately deliver and inject a toxic dose into unapproachable animals.

Pressurized ampules are available for loading by veterinarians. The serum is injected by compressed air behind a piston after the needle has come to rest in flesh. The dart's superb accuracy is a considerable factor in its usefulness.

TRAINING DART

This projectile is provided in similar weight and balance to the various "live" darts to give a similar trajectory pattern so that the trainer can get the feel of the gun without expending expensive rounds. It can be fired indefinitely at "soft" targets—a mat or pad is suggested as a backstop for training.

TEAR GAS DART

This dart is designed to carry 2.5 cc of liquid tear gas that covers an area of 12" to 15" in diameter. It has a safety spring clip. The clip is withdrawn on loading, making the projectile ready for firing.

The tear gas is extremely effective when applied to the person even if the hit is not in the direct area of the eyes. It's practical to shoot at ranges from 10 to 30 yards.

FIGURE 17. DYE MARKER DART, HYPODERMIC SYRINGE PROJECTILE, TRAINING DART, TEAR GAS DART (U)
FIGURE 18. RECOVERY TIME FROM FLASH BLINDNESS AS A FUNCTION OF BRIGHTNESS OF FLASH(25)
FIGURE 19. OBSTACLE MATERIEL: BARBED WIRE, GERMAN BARBED TAPE, BARBED-WIRE CONCERTINA, AND GERMAN BARBED-TAPE CONCERTINA (U)(33)
UNCLASSIFIED

FIGURE 20. OBSTACLE MATERIEL: REAPO TAPE AND GPBTO TAPE (U)(33)

FIGURE 21. OBSTACLE MATERIEL: CALTROP (U)(33)
ANNOTATED BIBLIOGRAPHY
ON
NONLETHAL WEAPONS (U)

GROUP 3
Downgraded at 12-year intervals; not automatically declassified

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person, is prohibited by law.
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Chemical Agents and Delivery Systems


   This paper discusses both lethal and incapacitating chemical and biological weapons, including antipersonnel agents. An example of an incapacitating biological weapon is Venezuelan equine encephalitis. The risks of using such weapons are discussed and their military shortcomings are considered. Incapacitating chemical agents with both long-term effects (e.g., BZ) and short-term effects (e.g., CS) are discussed. The use of CS and of antipersonnel agents in Vietnam is reviewed, and the advantages and dangers of such use are discussed.


   (G) This report summarizes information that suggests criteria that could serve as general guidelines for improving hardware and tactics for dealing with crowd-control problems. It is suggested that control options should make use of troop mobility, graduated levels of nonlethal force, selective removal of individuals, controlled dispersal, communication with the crowd, observation and identification of crowd participants, and self-policing by members of the crowd. The discussion of nonlethal forces includes consideration of chemical agents.


   (U) Compound 302,668 is a glycolate which has potent anticholinergic activity. In this study, human subjects inhaled an aerosol of the compound to estimate the

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* Numbers identify documents held in the RACIC data base, and PSI numbers identify documents from the Physical Security Information Analysis Center at Fort Belvoir; PS numbers indicate documents available from the Defense Documentation Center (DDC), Cameron Station, Alexandria, Virginia 22314. Neither RACIC nor DDC is able to make secondary distribution of these documents; however, they may be requested from the originating agency or DDC.

(U) WHO ME is a malodorous substance, developed during and after World War II, with the chemical composition, by volume: 20 percent phenyl mercaptan, 10 percent diethyl sulfide, 10 percent isovaleric acid, and 60 percent t-butyl mercaptan. This report discusses work to develop WHO ME as a riot-control and troop-training agent. This included work to thicken the substance and development of a frangible dissemination container. The container chosen was a hollow eggshell treated by immersion in a 10 percent waterglass (sodium silicate) solution for several days. The shell was sealed with epoxy cement and a small aluminum cap. Field tests were conducted and it was found that one egg containing about 40 ml of WHO ME readily contaminated the air in summer weather for a distance of at least 100 yards downwind. Psychological tests of the effectiveness of WHO ME are still needed.

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4. **Tests** on chemical agents conducted to date have been qualitative in nature, and the vast bulk have been used in small-scale experimental situations. The duration of incapacitating effects for each compound has been determined using the incapacitating concentration which is incapacitating to 50 percent of the subjects.

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This study confirmed that Negroes are less susceptible to irritant dermatitis from CS2 than are Caucasians. On both forearm and back, the production of minimal perceptible erythema required approximately twice the exposure time on Negroes. If the barrier layer of skin is removed, the difference is lost. There is no racial difference in the stinging sensation caused by CS penetrating through the transappendageal route. The difference in the melanin content of the barrier layer between the two races may account for the difference in reactivity, possibly by reacting with CS.

This report summarizes current knowledge regarding the effects of CS and CN agents on human eyes. It draws both on experimental work and on reports resulting from the actual use of these agents. A summary of documented eye injuries involving CN agents presented tabularly and discussed in some detail. Causes of these injuries, i.e., the CN or blast and fragments, cannot be determined because of imprecise reporting procedures. Experimental work related to distance from gun to pistol and to the age of pellets is discussed. Experimental work with CS on human volunteers at Edgewood is reviewed. Nothing other than transient effects on the eyes has been found and visual accuracy has been found to return to normal several minutes after exposure.

The status of research relating to toxic compounds and their possible role in chemical warfare is reviewed. It contains very detailed information on "standard" chemical agents, irritants, depressants, plant poisons, toxins, and poisonous marine and land animals. The report contains primarily data available up to July 1966.
A survey of various weapons has shown that a projectile fired from a conventional 12-gauge shotgun is the most practical method for dispersing small volumes (3 ml) of anti-riot agents at ranges up to 300 feet. The 12-gauge anti-riot round discussed is presently suitable only for flushing out persons barricaded in a room or vehicle, and may not be fired directly at a human target. It is also suggested that CS is the only practical and acceptable agent, currently available, for military use in civil disturbance situations. Finally, an ultraviolet light fluorescent-dye substance (sodium fluorescein) is recommended for covertly dye-marking rioters. It is pointed out, however, that there is presently no noninjurious frangible round that could deliver the dye at a human target at ranges up to 300 feet.


(2) The Army CS systems, including those under development to meet ENSURE requirements, are described. The data provided for systems under development reflect characteristics of the present design configurations. The information provided in this report is based on the best data available at time of publication and may differ from that given in official Army documentation.


(3) The purpose of this study was to determine and define potential hazards from operational use of the E49 CS.
skittering canister to personnel against whom it might be employed. Two sources of hazards were identified: (1) trauma from blunt impact by the canister, and (2) contact burn from the ignited C4-pyrotechnic mix disseminated from the canister orifice.

(U) Canisters dropped from an altitude of 250 feet, the approximate distance of fall when the item is dropped from a low-flying aircraft, produced little damage when impacted against gelatin-filled and -coated human skulls and liver- goat targets. Likewise, the risk of serious injury from skittering canisters is slight except in the case of the eyes.


(U) This report is one of the most complete works available on the chemical agents used by civilian police forces. The various chapters deal with policy and procedure; an introductory discussion of chemical agents; dissemination and delivery systems; the tactical use of chemical agents; aerosol irritant projectors; protective masks; first aid and decontamination; chemical agent training; and prestock, procurement and storage of chemical munitions. Numerous sketches and line drawings are used to represent employment techniques, equipment and munitions. The appendices contain information on legal decisions in cases stemming from the use of chemical munitions.


(U) Units have been developed for dispersing CS from the exhaust of a military jeep. These units are capable of delivering 1 quart of a 4 percent solution of CS in methylene chloride into the exhaust. They operate in 6 to 8 minutes with an engine speed of 1500 to 2000 rpm. When dispersed, the CS solution is completely vaporized by passing through the venturi and covers a large target area in a minimum time. The vehicle's engine and exhaust are not adversely affected by the operation.


(U) The Chemical Agent Research (CAR) Project involved synthesizing or otherwise obtaining chemicals of value
as incapacitants in man and screening them in animals for toxicity and general symptomatics. Compounds that had improved properties over known incapacitating agents, or with unusual biological effects, were studied in detail to qualify them for testing in humans. Seventy-eight new compounds were synthesized under this contract, making a total of 1357 compounds submitted under the CAR project since 1963. Evaluation of several active glycolates culminated in recommendation of CAR 302,775, 3-((1-azibyclo[2.2.2]oct-2-ene) methyl a-cyclopentyl a-phenylglycolate, for preclinical evaluation. When compared with EA 3580 A, EA 3834, and CAR 302,668, it had the shortest onset time and in the rabbit mydriasis (a long-continued or excessive dilatation of the pupil of the eye) test the longest duration. It was found more potent than CAR 302,668 but less potent than the other two compounds.


(U) The legal implications related to the offensive and defensive firing of tear-gas pens are discussed, and the pathologic findings in injuries in an experimental animal are presented, as well as an original method for quantitative determination of chloroacetophenone in tissues and body fluids by toxicologic methods.


(U) This report describes the XM674 40-mm CS riot-control cartridge and the XM675 40-mm red smoke training cartridge. Both can be projected by the M79 grenade launchers or the M8 pyrotechnic pistol or hand-fired to ranges of 70 to 100 meters. They will permeate an area of about 35 square meters to a height of approximately 2 meters.

18. Witten, B., NONLETHAL AGENTS IN CRIME AND RIOT CONTROL (U), Memorandum No. EATM 133-I, Chemical Research Laboratory, Edgewood Arsenal Research Laboratories, Edgewood Arsenal, Maryland (July 1968), 28 pp (CONFIDENTIAL/Group 3) (PA 33,928).

(U) The two most promising classes of incapacitating agents for use in crime and riot control are the sensory irritants and compounds that act on the central nervous system. Sensory irritants are effective on direct contact with the eyes but are not suitable where
A dispenser system for delivering bagged CS2 from helicopters has been developed and tested. The system releases 2,090 0.35-pound bags of powdered CS2 from an altitude of 1,500 feet or higher. This amount of CS2 creates an intolerable contamination level over an area about 50 meters wide and 150 to 200 meters long. The dispenser is made of lightweight aluminum and is suspended from the helicopter by means of a sling and cargo hook. Fully loaded, it weighs about 1,000 pounds and any helicopter equipped to lift this weight can be used as a carrier. It can be jettisoned by the pilot at any time.


This short article explains how nonlethal weapons might aid in combating crime more than does the conventional sidearm. Some of the candidate nonlethal weapons are the tranquilizer dart, tear-gas spray dispensers, and chemical dyes and marking agents. The article also deals somewhat with the philosophical desirability of nonlethal as opposed to lethal weapons.


This report traces the history of the employment of CS in Vietnam, and presents current usage practices and doctrine. It includes detailed examples of the actual use of CS weapons and provides a catalog of CS weapons available for use in Vietnam. A picture is given of the present and prospective employment of CS in Vietnam and has been developed from discussions in the field with troops and officers who have employed CS, from recent news analysis of the use of CS in Hue during the last intensive period, from perusal of many after-action reports, including some in which detailed discussion with participants was possible, from news
The purpose of this research program was to discover chemical compounds that incapacitate or immobilize humans. Approximately 720 numbered compounds were either synthesized or acquired from other sources. They were examined by a battery of tests in a variety of animal species and their types of pharmacological activity and potency were determined. More than 40 tests were used including the CRL mouse primary screen and other standard pharmacological procedures. New procedures were also designed and used to measure specific types of activity. The compounds studied represented about 20 chemical classes.

A literature search and a research program were conducted to provide basic information necessary for an overall improvement of chemical-agent dissemination techniques. Emphasis was placed on explosive and pyrotechnic processes. Material pretreatment, atomization, electrostatics, and ultrasonic processes were also included. Natural aerosol formation processes were studied as well to determine if some aspect of these processes could be adapted to chemical agent dissemination. This report summarizes the results of that research and answers many questions that arise regarding dissemination techniques.

X-651E1 (.U) cartridge is intended for use in special situations by conventional forces. It is fired from a special transport launcher and is effective in small, isolated, concealed areas, up to 5000 cubic feet in volume. It is designed primarily to incapacitate or immobilize personnel and equipment, cutout areas, occupied or unoccupied vehicles, and similar facilities.
This report discusses the role of nonlethal weapons in law enforcement activities. They are considered appropriate for two major classes of situations: those in which an organized group of officers is confronted with a large number of people who must be controlled or dispersed; and those in which one or a few officers must apprehend one or more criminals or suspects or are confronted with people who must be controlled. Recommendations are made regarding research and development that is needed in the areas of: weapon development, problem analysis, determination of objectives, test and evaluation, and reportage and training.

Chemical weapons discussed include Mace, long-range spray guns, specific agents, darts, and methods of indirect incapacitation, such as vomiting agents and sneezing powders.


(U) This report reviews the characteristics and effects of CS agent. It also discusses the standard CS munitions and dispenser systems.

27. CHARACTERISTICS OF RIOT CONTROL AGENT CS, Special Publication No. EASP-600-1, Edgewood Arsenal, Maryland (October 1967) (UNCLASSIFIED) (PS-1-C-440), AD 661 319.

(U) This is a brief report summarizing current knowledge on the riot-control agent CS, its history, its characteristics, its dispersal, its effects, and its safety factor.


(U) This report describes the XM47 nonlethal CS riot hand grenade and the XM49 PS/W5 (red or white smoke) training version of it. Both grenades are spherical casings of rubber, about 3-1/2 inches in diameter, containing about fifteen 1/2-gram encapsulated submunitions and equipped with smoke initiation. At a range of 35 to 45 meters, their contents will permeate an area of 150 square meters at a height of about 2 meters.
This study analyzes the use of incapacitating chemical and biological weapons in counterinsurgency situations within the framework of policy concerns: escalation, command and control problems, and political constraints. Implications are derived in the following policy-related areas: (a) limitations on conflict intensity and related limitations on and opportunities for chemical and biological weapon use, (b) the possibility of an overextension of Free World forces in the face of a growing threat of insurgency and instability, and (c) the development of multinational counterinsurgency forces and its implications for the use of chemical and biological weapons.


(U) Chapter 25 deals with the use of the baton, chemical agents, smoke, water, dogs, and sound to combat crowds.


(U) The purpose of the study is to assess the implications of the use of incapacitating weapons in limited war and counterinsurgency operations by an investigation in accordance with the following study objectives: (1) identify probable developments in incapacitating chemical and biological weapons and agents appearing to offer greatest potential; (2) analyze military utility for limited war and counterinsurgency and present concepts for exploitation; (3) assess political-psychological implications based on a historical survey of expressed attitudes within the leadership element of the U. S., and on informed public opinion; and (4) examine military and political usefulness by comparison with the domestic attitudes toward lethal weapons.
This patent covers a device for delivering a number of tear-gas dispensers in a frangible canister. After dispersal from the canister, each sub-munition is to burn a propellant and tear-gas mixture. The advantages of this device for dispersing a tear-gas agent is that each sub-munition is propelled along the ground and becomes hot as the propellant burns. These two factors make it difficult for a person to pick it up and throw it back at control personnel.


(U) The Smith and Wesson-Mercox Dart Projectile Gun is designed for special-situation police and military use where conventional weapons are not desirable. The gun uses .22-caliber blanks to propel a dartlike projectile at various velocities. The darts may carry any of several payloads or warheads, including marking dyes, shaped charges, and hypodermic syringes.

2. PROGRESS REPORT, U. S. Army Limited War Laboratory, Aberdeen Proving Ground, Maryland (June 30, 1966), 182 pp (CONFIDENTIAL/Group 4) (PA 26,286), AD 374 723 L.

(U) This document presents a description and status report of all tasks included in the FY 66 program of the U. S. Army Limited War Laboratory. A number of nonlethal weapon studies are included: application of selected CW agents in unconventional warfare; miniature CS disseminator and personnel marking.


(U) A study was conducted to provide guidelines for obtaining incapacitating agents that act by impairing voluntary muscular activity. Although many such drugs are available, an agent is needed that will be practical where subjects are not under control. A wide variety of agents are discussed. These include curariform drugs, sedatives, tranquilizers, analgesics, halucinogens, antihistamines, seizure-producing drugs, tremor-producing drugs, myalgia-producing drugs, cholinegetic agents, neurotoxins, and venoms. Also discussed are the potency,
(U) This is probably the most thorough descriptive text available on the range of tear gas munitions used by the military and sold on the commercial market. It is somewhat out of date, as new commercial developments have become available since it was written.


(U) This study describes a feasible prototype system that can accurately deliver an incapacitating agent or a marking material 40 to 50 feet. The launcher is designed for simplicity of operation and portability. It utilizes CO₂ to propel a projectile at muzzle velocities below 100 fps. The noise accompanying launching is minimal, making it difficult to detect the firing source. The prototype projectile is a 4.5-inch machined steel cylinder, 0.5 inch in diameter, which contains a .22-caliber blank cartridge and a 0.042-inch³ gelatine capsule as the incapacitating agent or marking material. It is relatively stable in flight and detonates with a sharp report and startling flash under an impact force of less than 2 pounds. On impact the detonation disperses the agent or marking medium.

(U) Optimization of the system would require lighter-weight expendable projectiles with a larger capsule for the agent. For temperatures less than 40 F, added thermal energy for the CO₂, such as body warmth or a heated holster, is required.


(U) The effects of CN, CS, and DM and their toxicity are discussed. DM produces systemic effects in addition to its irritant action and in one case, one of 22 men exposed to DM while asleep in an Army barracks died. This victim

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(U) The design of chemical warfare agents is basically outside the main stream of conventional pharmacologic research. Consequently, the new rationality of pharmacology has been principally directed at therapeutics, prophylaxis, and other problems of health. Some potentially useful areas of physiological disruption are, therefore, not likely to get attention in the conventional pharmacological investigations unless specific support is supplied in those areas by the military.

(U) An exhaustive analysis of the biochemical and physiological functions of the organ systems of the body would provide the necessary basis for a comprehensive rational research program for non-lethal agents, which would be not only strong in the short term, but fruitful and innovative in the long term. This systematic approach to the biochemistry and physiology of incapacitation is here called organ-system analysis.

(U) Organ-system analysis can result in several kinds of conclusions by drawing attention (1) to potentially toxic disruptions for which agents could be designed by a rational approach to the biochemistry of the system in question; (2) to agents whose effects warrant further structure-function studies; and (3) to agents whose utility is now neglected. In the present study, the detailed organ-system analyses are limited to the visual system and to voluntary muscle systems.

42. Kropfa, E. L., STUDY OF INCAPACITATING DARTS (U), Report No. BAT-171-31, from PACIG, Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio, to Advanced Research Projects Agency, Washington, D.C., Contract No. SD-171 (June 30, 1965), 42 pp (CONFIDENTIAL/Group 3) (PA 12,958), AD 367 711 L.

(U) The characteristics and effects of curariform drugs and delivery systems for these drugs are reviewed. It is concluded that for the maximum degree of immobilization without catastrophic nervous and cardiovascular side effects, the curariform compounds might have to be combined with...
The objective of this program was to study the effects of head-on collisions on the overt behavior and on various physiological systems of dogs and cats. The effectiveness of several pharmacological agents as antagonists to these compounds was also studied. A phase of the program devoted to the evaluation of test systems for measuring BZ antagonists was developed. The test systems studied were food consumption in rats, spontaneous activity of rats in jiggle cages, observation of unanesthetized dogs, measurement of blood-pressure responses in anesthetized dogs, and measurement of respiratory and cardiac responses in spinal cats.


(U) This is a short article which describes how the military has had occasion to use CN, DM, and CS in riot-control situations. It notes the reactions of persons subjected to these agents.

Electromagnetic Spectrum


(U) Illuminating candles containing colored flame-producing wafers that provided alternating colors as well as white light have been developed, fabricated, and tested. Seventeen Bright Light Mob Dispersal Candles were burned in Thiokol's light tunnel and four others ignited by hand outside in daylight. The candle consists of a one-inch wafer each of orange and red-flame-producing compositions followed by a special Thiokol 3-B-8 white light illuminant.

(U) The incidental observations of human subjects in a "flicker" environment and the difficulties often encountered by the observers in following the actions of primate subjects who were being exposed to stimuli (often the observers were under considerable discomfort, while the squirrel monkeys were showing little concern) suggests the susceptibility of man to stimuli is greater than that of the lower primates.

(U) Most of the primate subjects were able to deliberately minimize the effects of flicker by the simple expedients of remaining motionless, moving very slowly, or shielding their eyes. Experiments showed that flicker is more effective in creating vertiginous effects in human subjects who are moving than in those who are standing still.


(U) At 6 to 8 cycles per second, the flashing apparently produces an out-of-phase response of the iris and optic nerve. Resulting loss of depth perception leads to an inability to avoid visible obstacles or to aim weapons effectively at moving targets. At 25 cycles per second, the flashing interferes with alpha waves which control the ability of the brain to concentrate.

46. Melton, C. E., et al., EXPOSURE OF MEN TO INTERMITTENT PHOTIC STIMULATION UNDER SIMULATED IFR CONDITIONS, Civil Aeromedical Institute, Oklahoma City, Oklahoma (October 1966), 7 pp (UNCLASSIFIED) (PA 27,463), AD 646 872.

(U) The purpose of this study was to determine whether or not a group of normal young men showed any electroencephalographic changes during and following photic stimulation as it might occur in flight. Ten young men, all volunteers, who had no history of syncope or seizure were exposed to intermittent photic stimulation at each of three frequencies. Analysis of the records taken in Experiment I revealed no evidence of seizure, no syncope, and no photic driving.

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(U) It appears that we (that people are sensitive to only a narrow range of frequencies, generally between 4 and 50 flashes per sec. Laboratory studies have shown that photically induced phenomena occur most readily when the eyes are closed and the flash frequency is close to the resting rhythm.


(U) This study on human responses to light flicker found that in the experiments conducted appreciable ambient light enormously reduced the observed effects. The observed effects were:

(1) Motor coordination was markedly impaired in most cases within a frequency range of from 4.5 to 5.5 Hz. This was observed during walking around obstacles on the laboratory floor and similar activity.

(2) Men seemed more affected than women and younger women more than older ones.

(3) Some subjects experienced a sense of giddiness. In a few instances this began immediately on exposure and in others progressed with continued exposure.

(4) In a few cases there were distortions of perspective in that there was difficulty in determining the relative distances of objects along the line of sight.

(5) There was a wide variation in terms of persistence of giddiness, when induced, following cessation of exposure. Maximum persistence was about 15 minutes and the minimum about 30 seconds.

(6) The most effective duty cycle was about 20 percent. Duty cycles approximating 50 percent and exceeding this were markedly less effective.

(7) No noticeable effects were observed within the alpha rhythm range of 8 to 12 Hz.

(This Page is Unclassified)
At times there was induced a curious optical effect best described as a multiplicity of crawling black shapes in the visual field. This effect occurred at virtually the same frequency for those subjects reporting it and was quite sharply "tunable" in that a frequency change of 1 Hz reduced it considerably.

Most subjects stated that they believed it would be difficult or impossible for them to perform relatively high-skill-type tasks with accuracy during flicker exposure.


(U) This report includes an evaluation of the use of high- and low-power radio waves to effect barriers through which personnel could not penetrate.


(U) Results of nine laboratory experiments are contained in this report. The purpose of the research was to assess the feasibility of using dual-source flickering lights and fluttering tones as harassment devices or as nonlethal weapons. Performance was measured on depth perception, manual dexterity, aiming and tracking, vigilance and cognitive-motor task. Psychophysical judgments of the apparent movement effect produced by two lights flickering out of phase were obtained in one experiment. Post-experimental interviews were given to assess the psychological and somatic symptoms associated with exposure to flicker and flutter.

(U) It was concluded that while dual-source flickering lights produce performance decrement from optimum conditions, they are no more effective than a single light.
The experiments designed to investigate effects of light flickering light are reported. Results indicate a small, but statistically reliable, detrimental effect of lights flickering out of phase on various psychomotor performances.

**Orlansky, C. F., Physiological Phenomena Applicable to the Development of Psychological Weapons, Final Report No. AD-4-10/05-T-1, from American Institute for Research, Washington Office, Silver Spring, Maryland, to Directorate of Armament Development (R&D), Eglin Air Force Base, Florida, Contract No. AF 08(635)-4758 (December 1965), 70 pp (UNCLASSIFIED) (PA 22,054), AD 677 201 L.**

(U) This document comprises a compilation of data, in catalog form, of psychological phenomena applicable to the development of psychological weapons. The information is presented for the use of weapon designers for the express purpose of enhancing the psychological effects of nonlethal weapons. Section Three summarizes the major psychological effects of environment, including the effects of light.


(U) The value of flashing light as a nonlethal military weapon is examined in this report. Anecdotal reports suggest that flashing light can produce effects such as confusion, nausea, disorientation, hypnosis, loss of consciousness, and convulsions. These effects occur only under certain controlled conditions in a laboratory or clinic and affect only a limited portion of the population. The available data indicate that these effects cannot be exploited for military use. There have been no field trials or tests outside a laboratory setting.

**53. A. T., Some Physiological Effects of Flicker and Related Physical Stimuli (U), U. S. Army Limited War Laboratory, Aberdeen Proving Ground, Maryland (February 1965), 103 pp (CONFIDENTIAL/Group 4) (PA 19,008), AD 361 780.**

(U) A number of interesting phenomena of responsiveness to light flicker and other physical stimuli have been turned up, which do not yet appear to have been studied.
In general, this state-of-the-art review indicates that it may be feasible to use high-intensity electromagnetic radiation as a weapon. Specifically, the human eye may be incapacitated by radiation from the visible and infrared portions of the spectrum but in a practical way, apparently not by radiation in the ultraviolet wavelengths.

The stated purpose of the research was to "investigate the potential of flickering light, sound, and suggestion, singly and in combination, for use in psychological warfare".

It was concluded that:

(1) Red flicker was more effective than blue in reducing subject performance.
CONFIDENTIAL

It was found that the average amplitude of the electroretinogram occurring during the first minute of stimulation was larger than that for later times. Clear-cut changes were not apparent in the evoked potentials. With the short-term procedure, an investigation was made of the average response train produced by successive spurs of five flashes. It was found that the first flash of a stimulus train produces the largest response both at the retina and the occipital scalp, then there is an immediate reduction in amplitude followed by some recovery.

It appears that a receptor lacking its full complement of photosensitive pigment transmits the same signals in the dark as a receptor with a nearly full complement of photosensitive pigment that is being illuminated by a steady light. The intensity of this steady "equivalent light" increases very rapidly with the amount of pigment that is lacking, and the relation appears to be approximately exponential. One would like to understand this feature of the adaptation in terms of the mechanism of receptor adaptation, but whatever the explanation, knowledge of the intensity of equivalent light is necessary if sense is to be made of the change in response occurring centrally to the stimuli producing such adaptation.

CONFIDENTIAL
(U) The relative effectiveness of the ordinary verbal method of trance induction is compared with 2 forms of induction utilizing mechanical photic stimulation, and with methods combining the personal and mechanical features. The criterion of trance adopted was the compulsive carrying out of a difficult suggestion. Results show that mechanical procedures alone are ineffective. On the other hand, the addition of a particular sort of photic driving probably improves trance induction, which suggests that induction is a complex matter involving both social interactions and relatively nonmeaningful impacts on the brain.


(U) A method is described for pulsing electronically an Osram XBO 2001 high-pressure xenon lamp. The instrument is being used to investigate the optical hazards accompanying short pulses of radiant energy similar to those emitted by nuclear weapons when exploded at high altitudes.


(U) The data of this and related experiments are used to derive relations between burn diameter, exposure duration, and burn threshold. A calculational method is described which permits calculation of whether or not a burn is to be expected, based upon physical data on the source such as intensity, size, distance, duration, and spectral composition.


(U) This article describes an experimental approach to the study of flash blindness. Two apparently normal subjects may differ by as much as 40 seconds in their recovery from a dazzling flash of 232,000 lux. The mean figures demonstrate that the 16 subjects had
UNCLASSIFIED

I. THE DATA also demonstrate that pupillary size has an important effect upon the time required for recovery from dazzle. In many instances, a subject's recovery time was shortened by as much as 40 percent when the pupillary size was decreased. The explanation of this phenomenon is that the amount of light admitted to the eye varies inversely to the area of the pupillary aperture. Therefore, a smaller pupil admits less light and permits a more rapid recovery.

II. SMITH, C. A., et al. (Department of Neurology and Psychiatry, University of Texas Medical Branch, Galveston, Texas), SOME FURTHER OBSERVATIONS ON THE OPTICALLY ELICITED ANIMAL RESPONSE, EEG Clinical Neurophysiology, Vol 13, pp 141-154 (1961) (UNCLASSIFIED) (PA 12,655).

(L) Observations on the effects of intensity and wavelength of light on electroencephalographic arousal responses have been studied. In addition, arousal response durations of the left and right hemispheres of left- and right-handed individuals have been investigated. Results of studies related to hemispheric dominance indicate that although there was a tendency for the right cerebral hemisphere to show a longer response, statistical analysis of the data revealed no significant difference between the sides.

III. BARRON, Col. R. D. (Canadian Forces Medical Service, Ottawa, Canada), OCCUPATIONAL INJURIES TO THE EYE RESULTING FROM EXPOSURE TO THE ELECTROMAGNETIC SPECTRUM, Medical Services Journal, Canada, Vol XVI, pp 487-500 (June 1960) (UNCLASSIFIED) (PA 12,615 N).

(L) This paper has attempted to review the physical properties of the major divisions of the electromagnetic spectrum, to relate the known hazards to the visual organs from these major divisions to current occupational problems and injuries, and to review the cause, effect, and prevention of such injuries.


(L) Consideration of the whole problem of the ocular hazard, leads to the conclusion that with mild stimuli, that small explosion or a large distant explosion, there actually no problem especially if white floodlighting is provided. Some degree of dark adaptation.

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It is interesting, but it is usually regarded as
something that the average of today rely less on night
vision functions which have been taken over by instruments.

It is true, however, that recombination of moderate severity can also be
generated as giving rise to little difficulty, but in this
case one has to place more importance on training the
pilot not to look at the source after detonation.

Makarov, P. O. (Zhданов State University, Leningrad), EFFECT OF VERY INTENSE
OPTICAL STIMULATION ON THE VISUAL, AUDITORY AND SKIN ANALYSERS OF MAN,

69. Cogan, D. G., M.D. (Boston), OCULAR EFFECTS OF RADIATION, A.M.A. Archives
of Industrial Health, Vol 20, pp 293-296 (July-December 1959) (UNCLASSIFIED)
(UNCLASSIFIED) (PA 13,605).

UNCLASSIFIED
These flicker effects which interfere with consciousness appear at frequencies related to the normal rhythm of the 13, or at 10 cps. Annoying or irritating sensations seem to occur with aperiodic flashes or with rhythmic flashes at 3 to 5 cps. Visual illusions appear to be produced by frequencies above 10 to 12 cps. It appears likely that high intensities of light will be more effective in producing the desired effects of flicker although much remains to be done to determine the optimum light and dark intervals, background contrasts, and effects of stray light.


(U) Adverse sensations including those directly referable to the eye, general unpleasant sensations, twitchings and blinkings as well as those implying interference with consciousness were reported by more subjects and with a greater total of intensities (but not a larger average intensity) with an impressed flicker frequency of 10 cycles per second. Nine, sixteen, and twenty-four cycles were only slightly less effective in this regard. These events were more often reported during the fifth (and last) minute of exposure to the flickering light.


(U) Exposure to intermittently flashing light can result in a variety of untoward symptoms including dizziness and nausea, as well as psychic phenomena. Some of these may persist for several hours after stimulation.


(U) It was demonstrated that red light was at least 10 times as effective in triggering attacks in a case of photogenic epilepsy as were other colored lights tried. Minus red glasses were of considerable aid to the patient.

(U) The idea that dazzle could be used as a weapon was constantly recurring during World War II. On a very bright moonlit night a pilot well caught in the beam of a searchlight is prevented by dazzle from seeing objects on the ground within some 2 miles [3.2 km] of the searchlight. By constantly holding an enemy aircraft in several beams spaced at the corners of a square pattern of 4 miles [6.4 km] side, we might expect to obscure the ground completely. Schemes of this kind fail for two main reasons:

(i) the enormous amount of electric power demanded,
(ii) in the presence of cloud the light reflected back on the ground is insufficiently intense to make objects more visible than if the lights were extinguished. More modest schemes were a little more hopeful. Experiments were made to see if comparatively weak, steady but directional lights of the type of motorcar headlights could be used at spacings of the order of 100 feet [30.5 m] to provide a kind of dazzle-screen against ground attackers. It was found that such a screen, while of some value in concealing ground objects such as men, vehicles, low buildings, etc., produced a useful effect in only a limited period of about 1/2 hour during nightfall.

(U) On the whole, it may be said that dazzle as an actual weapon of war has proved disappointing, while in those cases where it interferes in some measure with efficiency it is not particularly easy to eliminate.

75. Ham, W. T., Jr., et al. (Medical College of Virginia), OPTICAL MASERS (LASERS), Acta Ophthalmologica, Supplementum, Vol 76, pp 60-78 (Undated) (UNCLASSIFIED) (PA 14, 506).

(U) The purpose of this paper is threefold: (1) To give a brief and elementary discussion of the ruby laser, (2) to describe some preliminary experiments with a ruby laser and its associated optical equipment as designed to produce thermal lesions of size and shape comparable to those produced by other methods in this laboratory, (3) to present current data obtained from research on retinal burns which can be useful in the evaluation of ocular hazards from lasers.
UNCLASSIFIED

Sound

UNCLASSIFIED


AN INTENSE NOISE GENERATOR FOR POSSIBLE USE IN TUNNEL CLEARANCE, Technical Note No. N-994, U. S. Naval Civil Engineering Laboratory, Port Hueneme, California (October 1968), 10 pp (UNCLASSIFIED) (PA 34,461), AD 843 468.
consideration - tunnel clearance in Vietnam. It is concluded that infrequent (10 to 100 times per second) but intense explosions from a large pulse tube should provide an intolerable noise level.


(U) All entries in this bibliography include a short annotation except those that carry a "Confidential" security classification.


(U) Studies were made using rodent and squirrel monkey subjects, the drugs DS-2, DS-3, and sound and light stimuli. The principal effort with the rodent subjects included observation and tabulation of the effects of DS-2 and DS-3 while the subjects were under sound and light stimuli, the purpose of which was to ascertain whether there was an enhancement effect in their behavioral responses with below-normal threshold dosages of these agents. The squirrel monkeys were used in an effort to determine the threshold of the observable effects of DS-3 in a primate under normal conditions.


(U) A standard literature study was conducted concerning the effects of very high sound pressures on the human body. The effects of sound on man are discussed on the basis of the symptoms developing in people working under actual noise conditions. Since very high- and very low-frequency sounds, especially, seem to exert a negative effect, they are considered apart in this study. The influence of low-frequency mechanical vibrations on man is discussed also. Finally, a number of conclusions are drawn. On this basis, some careful suggestions are made concerning standard rules on the effects of high-intensity sounds on the human body.
(U) Von Gierke in 1944 established the threshold for pain at approximately 175 dB for static pressures, 165 dB at 3 cps and decreasing to the range of 140 dB from 15 to well above 100 cps. Experiences with whole-body exposures to intense low-frequency noise occurred in submarines during both World Wars. In these cases, middle-ear changes noted among German submarine diesel-room personnel were attributed to the infrasonic and very low sonic noise fields caused by the suction strokes of the engine cylinders.

(U) In a series of tests conducted with the NASA-LPC Low Frequency Noise Facility (140 to 150 dB at mid-band frequencies of 2 to 40 cps), subjects reported an uncomfortable pressure buildup in the middle ear. This effect, however, was almost entirely absent when earplugs were in place.

(U) Maximum-intensity low sonic exposures (140 to 145 dB at mid-band frequencies of 22 to 40 cps) produced moderate chest-wall vibration, a sensation of gagging and perceptible visual-field vibration in all subjects. Post-exposure fatigue was generally present after a day of repeated testing.

(U) In another test, the USAF-RTD Sonic Fatigue Facility was operated at frequencies in the 50 to 100 cps range and voluntary tolerance was reached in 2 minutes at the following intensities and frequencies: 153 dB at 50 cps; 154 dB at 60 cps; 150 dB at 73 cps, and 153 dB at 100 cps. Exposures were stopped at these intensity levels because of the following subjectively alarming responses: mild nausea, giddiness, subcostal discomfort; cutaneous flushing and tingling at 100 cps; severe coughing and substernal pressure, choking respiration, salivation, pain on swallowing, gagging and giddiness at 60 and 73 cps. One subject also developed testicular aching at 73 cps. At 50 cps, one subject developed a transient headache. All subjects exhibited marked fatigue.


(U) This bibliography provides supporting documentation to the final report prepared under this same contract as well.
Results of nine laboratory experiments are contained in this report. The purpose of the research was to assess the feasibility of using dual-source flickering lights and fluttering tones as harassment devices or as nonlethal weapons. Performance was measured on depth perception, manual dexterity, aiming and tracking, vigilance and cognitive-motor tasks. Psychophysical judgments of the apparent movement effect produced by two lights flickering out of phase were obtained in one experiment. Post-experimental interviews were given to assess the psychological and somatic symptoms associated with exposure to flicker and flutter. Few quantitative data were obtained with regard to fluttering tones; however, informal observation led to the conclusion that flutter did not show promise as a harassment device at the intensities investigated.

This report on the current research program dealing with responses of rodents to acoustic and visual stimulation included completion of the preparatory phase and initiation of the experimental program. Categorically, the rodent species tested so far appear to be less "disturbed" by the stimulatory techniques employed so far than did human subjects in earlier casual experiments. It was not, however, anticipated that results with rodent subjects would necessarily have direct applicability to subsequent human studies, but that such studies would be helpful in developing experimental techniques.

Electronics experts have found in the laboratory that an audio note of 12 to 14 cycles per second has a profoundly disturbing emotional effect. Its precise impact on any given person is somewhat unpredictable. Some people are immune to it; others are not. Most react with an inexplicable feeling of deep anxiety.
One, more powerful bull-horns that emit ear-splitting blaring and shrieking noises are one form of anti-riot weapon. They can be used to drown out the rhythmic chanting, singing, and handclapping of some demonstrators used to whip up a crowd to fever pitch. Helicopters, equipped with these powerful portable sound projectors, can hover over a hostile mob or a menacing crowd of demonstrators. Some electronics experts foresee a more futuristic and fantastic type of sonic riot-buster: it is a low-vibration sound which would have the extraordinary ability to resonate the human viscera and thus affect the colon. The effect on a screaming, rock-throwing mob would be the same as a mass attack of uncontrollable dysentery. It should bring any riot to a quick halt.

(2) A revolving, car-roof-mounted flashing spotlight of such brilliance that it will temporarily affect the vision of the rioters is under development. Another device is an inexpensive portable system to electrify a car body. It can be installed on any car, police or military vehicle. A painful, but harmless, shock of high-voltage, low-amperage electricity will shock rioters bent on overturning the vehicle. Persons inside the vehicle are unaffected. Under experimentation is a vehicle-mounted high-pressure system which shoots an electrified stream of water. It gives a harmless but unpleasant high-voltage shock.


There were two main objectives to this program. One was to conduct a literature search into the psycho-physiological effects of high-intensity sound on man. The other was to fabricate and demonstrate a sound generator capable of producing 130 decibels (re: 0.0002 microbar) at 500 feet within the frequency range of 2 to 100 cps.

(U) On the basis of the literature reviewed and discussions with investigators generally considered to be most knowledgeable in balance disruption, it appears that none of the presently known chemical, mechanical, disease, radiation, or electrical effectants provide an efficient means of human incapacitation.


(U) This report reviews a 1964 study conducted by the Falcon Research and Development Company under contract with the Directorate of Armament Development, Aeronautical Systems Division, at Eglin Air Force Base. The stated purpose of the research was to "investigate the potential of flickering light, sound, and suggestion, singly and in combination, for use in psychological weaponry."


(U) This report contains graphs of maximum sound pressure levels and durations of exposures that the Working Group believes would be tolerable and examples of the use of these graphs. This material is followed with background information and a discussion of the rationale, assumptions, limitations, and general problems pertinent to the development and application of a damage risk criterion and related exposure contours.
The purpose for this research was to investigate the potential of flickering light, sound, and suggestion, singly and in combination, for use in psychological anatomy. A search of the pertinent literature was performed followed by individual and group experimentation. The results obtained demonstrated that potential exists for the use of photic flicker as a weapon. Suggestion was effective in the laboratory but ineffective with military groups in an unemotional setting. Further experimentation with photic flicker singly and in combination with suggestion is warranted. Recommendations for further specific research are provided.


(U) A study of the past and current literature on the subject was accomplished and analysis based on best currently available data was made to determine the device size and complexity required to achieve the desired effects at reasonable ranges. The study covered not only the use and effects of audible sound but also the effects of infrasonic and ultrasonic energy.


(U) It is concluded that:

1. In persons exposed to the effect of continuous industrial medium- and high-frequency noise of intensity 85 to 120 db, functional disturbances of the cardiovascular system were frequently observed.

2. Very often the subjects exhibited an instability of the arterial blood pressure. The electrocardiographic data showed bradycardia with a tendency to retardation of the intravascular conductivity, plus a depression of the T-wave that was most frequently observed after physical stress and at the end of the work period.
The primary technical objectives were to establish the characteristics of a gaseous phase detonation system as a source of controlled acoustic power and to demonstrate certain practical aspects of the operation of a single high-frequency gaseous phase detonation tube such as life, reliability, efficiency, and other operational characteristics.

Distraction studies in terms of changes in ambient noise levels was found to be a function of the amount of change. When adaptation of the ear is controlled by use of on-off sound sequences, ignoring distraction, performance is directly related to the on-off ratio early in exposure and inversely related to the ratio later in exposure. At all sound levels performance in noise is better than in quiet. When distraction is taken into account, these results are influenced by the differences in rate and amount of adaptation of loudness and rate of habituation to distraction so that at any given time performance may seem to be decreased, increased or unaffected.

Eighteen subjects were exposed to brief periods of high-intensity intermittent sound at 3 pulses per second and at levels of from 100 to 120 db. Skin temperature, skin impedance, EKG and continuous systolic blood pressure from the finger were recorded. The results indicated little or no effect on all the measures except GSR which showed a linear increase in magnitude of response with an increase in intensity of sound. Comparisons with previous reports on sensory test results are presented.
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The nature of noises in relation to their circumstances, to the physiological and psychophysiological state and to the past training of the hearer was studied. The measurements of the noise levels between 15 and 160 ph according to the sources, the normal and pathological physiological effects of noise on the ear and on other sense organs, the general physiological effects on the organism, as well as the effects of ultrasounds, of vibrations and infrasounds, of shockwaves and of sudden variations in pressure were examined. Noises are harmful above 86 ph, and dangerous above 110 ph.


(U) The effect of noise on time judgments was studied by having four groups of 50 subjects work on a visual-movement projection task in which a moving target disappeared and a guess had to be made as to when the target was under a crosshair. Effects of noise programs (groups) and of trials were significant beyond the .01 level of confidence. The effect appeared to be the same regardless of noise programs and is a fairly smooth negatively accelerated rising curve in which judgment time increases with succeeding trials. The results suggest that appropriately programmed noise distort subjective time.

decibel, the unit of loudness level on a scale beginning at zero for the faintest audible sound and corresponding to the decibel scale of sound intensity as the number of phons of a given sound being equal to the decibels of a tone judged by the listener to be equally loud.
The effects of noise on man are not so simple that they may be studied on the basis of stimulus and response. The effective stimulus may occur during a major portion of a lifetime. The response may not become apparent for years.

Attitudes and even emotional reactions toward sounds are often more closely related to context and past associations than to decibels or even sones. Significant hearing loss can be demonstrated long before the exposure noise reaches or even approaches the level of aural pain. This hearing loss is progressive in the sense that longer exposures produce more loss. Hearing loss is greatest at frequencies above that frequency range in the exposure noise in which there is the greatest concentration of acoustic energy. For a large variety of complex industrial spectra, hearing loss starts in the 4 to 6 kc/s region. Individuals differ greatly in their ability to take noise exposures; the hearing losses they suffer seem unrelated to their psychological attitude toward the noise.

Sound at the transition between audible and ultrasonic frequencies causes nausea and severe headaches. This transition range varies with the individual. Warbling through a frequency range of 14 through 22 kHz would cover the cut-off frequencies of most people. The effects are produced at low intensities but high intensities would insure quicker response. The operator is easily protected from these sounds by ear protectors built into riot helmets. Such sound is effective in causing nausea and headaches without exceeding a damaging intensity level. It would seem that this phenomenon could be useful in riot control and the cost of equipment would be only nominal.

Barriers and Deterrent Devices

Remington's "Modi-Pac" is a 12-gauge shot-type shell in which the lead shot is replaced by polyethylene plastic pellets. These pellets are approximately 0.12 inch in diameter and have a deterrent effect on
The range of the pellets is 20 to 25 yards. At this distance the pellets will not penetrate a target. At close range, the performance is much better. If fired under 5 yards, an officer under attack is provided with more than adequate protection. The shell is a deliberately loud report and a prominent muzzle flash for psychological effect.

WILLIAMS, L. A., and HURLEY, H. J., A COMMENTARY ON SHOT-FILLED BAGS AS NONLETHAL AMMUNITION FOR CROWD CONTROL, from Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio, to U. S. Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland, Contract No. DAAD05-71-C-0163 (December 4, 1970), 15 pp (FOR OFFICIAL USE ONLY) (PA 38,647).

This report consists of a discussion of the use of shot-filled bags as nonlethal weapons, six simple scenarios, and a short test outline of some factors that may affect their use. It is concluded that a shot-filled spin-stabilized bag might be an effective control weapon for a range of about 15 feet to 150 or 200 feet. However, it should be used only after a demonstration of its nonlethality, range accuracy, knockdown capability, and wound potential. Its use should be with actively forward tactics rather than in a defensive or passive mode.


Any standard police or military weapon may be easily converted to fire the Stun Bag which consists of a flat, circular disc of woven material filled with bird shot. After folding to one-third its normal size, it is ejected from a shoulder launcher. It assumes its normal size shortly after ejection. It conforms to the shape of the target on contact and is capable of knocking down or stopping an on-coming person. The blow intensities are well below those believed necessary to produce serious brain injury. It is not anticipated that blows to the chest would cause pulmonary or cardiovascular injury. There is little doubt that a glancing blow will produce tearing and bruising of exposed skin areas.


Wooden pellets, fired by compressed gas from rifle-style launchers, proved to be an effective crowd-dispersal weapon during disturbances at Berkeley. The device, known as the Multiple Baton Shell, was described by Berkeley police as apparently more effective than tear gas. The pellets strike with a stinging impact and have about the same effect as a billy club, but from a range of 40 or more yards, and they are too light to be thrown back with force. In most cases, the pellet does not break the skin, but will break bones at close range.

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(U) This article describes the same pellets reported on in PA 58,643 (Item 106, on preceding page) and presents much of the same information. The pellets are stacked five deep in a metal cartridge like a shotgun shell. They cost about $7 a piece, compared to $13 for a tear-gas canister.


(U) The design of a weapon that will produce nonlethal incapacitation has been accomplished. A low-signature, closed-gas launch system, compatible with the M79 grenade launcher or M16 rifle, is used to fire a deformable, spin-stabilized projectile. This projectile is made of a silicone-rubber material, RTV. Head impact causes short-term loss of consciousness. Tests conducted with subhuman primates have demonstrated the feasibility of the concept and defined the system operating characteristics.


(U) At present, there is little scientifically supported knowledge about the parameters which influence burning time. The majority of the knowledge concerning what affects burning time has been obtained empirically or through trial and error. In order to control the burning time in an efficient manner, the relevant variables must be known. Identifying both these variables and their importance is the purpose of this data collection and analysis.


(U) This report covers an evaluation of seven types of lightweight anti-personnel obstacles: the double-apron fence, constructed of barbed wire and German barbed tape; triple standard concertina (TCS), constructed from barbed wire concertina and German barbed-wire concertina; the rapidly emplaced anti-personnel obstacle (PEAPO); the general-purpose, barbed-tape obstacle (GPBTO); and the caltrop.
111. Samuels, David W., Egger, Donald O., and Campbell, Donald, RIOT CONTROL:
ANALYSIS AND CATALOG, Final Report, Report No. 69-14, Research Analysis
Branch, U.S. Army Limited War Laboratory, Aberdeen Proving Ground, Maryland,
(October 1969), 165 pp (FOR OFFICIAL USE ONLY) (PA 39,060), AD 861 296 L.

A systematic analysis of some types of civil disturbances
and a survey of related developmental materiel are provided.
The major limitation of the analysis is its restriction to
"ghetto"-type riots, necessitated by limitations in time
and available information; however, the materiel items
described are universal in application to various forms
of civil disturbances. The first part of the report analyzes
such riots by identifying common characteristics of a
number of disturbances which have occurred in the United
States and describing the experiences of various security
forces in their control. The latter part of the report
serves as a catalog of materiel items, not already in the
Army inventory, which may be useful in providing a more
flexible response to the special requirements of riot
control.

112. COMPENDIUM COUNTERMINE SYMPOSIUM (U), held March 14, 1968, U.S. Army
Mobility Equipment Research and Development Center, Fort Belvoir, Virginia
(May 1, 1969) (SECRET/NOFORN/Group 3) (PA 36,694), AD 502 129.

The proceedings of this symposium include a
discussion of "caltraps". These are two pieces of
wire joined together so that when thrown they land
on three points and the other point sticks up so
that it will pierce the foot. The delay time which
these produce, not counting the surprise effect, is
better than current standard wire- and concertina-
type obstacles. Caltraps could be air emplaced.

113. GENERAL BASE DEFENSE SYSTEMS. VOLUME VII: COMPONENT CHARACTERISTICS (FACT
SHEETS) (U), Part I, Final Report, Phase Two, for the period July 3, 1967
- July 2, 1968, Report No. LMSC-B095482, from Lockheed Missiles and Space
Company, Sunnyvale, California, to Advanced Research Projects Agency
Washington, D.C., Contract No. DAAHOl-67-C-1384 (July 1968), 346 pp (SECRET/
NOFORN/Group 3) (PA 33,700.4), AD 392 301 L.

Fact sheets are presented on a variety of barriers
for base defense including double-apron fence, high-wire
entanglement, cattle fence, chain-link fence, caltraps
(barbed impediment), barbed wire, and barbed tape.

114. Gluckstein, M.E., SCREENING AND SIGNALING SMOKEs, Ethyl Corporation, Research
Laboratories, Ferndale, Michigan (January 8, 1968), 1 p (UNCLASSIFIED)
(PA 32,149).

Readily disseminated agents for producing either dense
screening smokes or chemiluminescent signaling and marking
smokes have been developed by Ethyl Corporation. Both
types are liquids that react with air and moisture to
form heavy noncorrosive, nontoxic, nonirritating smokes.

(U) The purpose of this program was to develop for operational evaluation an airborne system for effectively interdicting enemy overland infiltration and supply routes. The emphasis was placed on a caltrop device and a simple dispenser to be employed from low-performance, high-payload Army aircraft. Tactical considerations in the use of this device are described.


(U) This article reviews some of the nonlethal riot-control equipment developed since about 1964. Among the devices which are discussed are the shock baton, the MGP-100 grenade which expels a tear-gas charge without fragmenting, the Smith & Wesson Mercoxc dart/projectile revolver, the Chemical Mace, a projectile which produces a flash and loud bang, another projectile designed for use against barricades, the "banana peel" concept, and foam.


(U) The purpose of this evaluation was to determine the operational suitability of an integral screening smoke generator mounted on the UH-1 helicopter and to record the methods used for its employment.


(U) A method of dispersing a small quantity of fog oil into the hot jet-engine exhaust gases of a helicopter was devised. This method consisted of dispersing the fog oil into small droplets through an atomizing nozzle and directing the droplets into the exhaust area where they were vaporized. As the vapor passed into the cooler air beyond the engine, the vapor condensed, forming a very dense cloud of white smoke or fog.

(U) The purpose of this work was to develop an effective, safe, and economical method of generating a smoke screen to provide cover during operations.


(U) This handbook includes a chapter on the history of the pyrotechnic art, a chapter giving a general introduction to the application of pyrotechnic devices to military problems, and chapters on Physical-Chemical Relationships, Visibility, Production of Heat, Production of Light, and Production of Smoke. Chapter 7 deals with the production of tactically useful smoke.


(U) This report covers an investigation of caltrops used as anti-personnel obstacles. The conclusions reached included:

(1) Caltrops will penetrate footgear to inflict puncture injuries on all types and conditions of soil considered except in areas where walking would be difficult because of the depth to which a foot would sink.

(2) The delay time caused by caltrops will exceed that created by triple standard concertina.

(3) Incapacitation results from swelling and pain approximately 30 minutes after injury.
(U) This program was established to determine the feasibility of and to develop procedures and instrumentation for the field evaluation of obscuration agents. Field testing of munitions and analysis of the data were begun. Initial results indicate that obscuration is a rapidly varying function of time with a power spectrum that conforms closely to that of the vertical component of wind velocity near the ground. A number of instrument and procedural modifications were accomplished; recommendations for additional modifications were made.


(U) A review of the literature for chemical smoke agents is presented. Based on this review an experimental program to evaluate new liquid smoke agents was formulated. The results of this experimental program indicated that liquid agents possessing an obscuring power greater than FS can be developed using selected mixtures, solutions, and compounds of phosphorus.


(U) The Japanese have developed a three-section telescopic billy club, which in the collapsed position can be concealed on a person but is quickly flicked into the extended position. RAC has found it is feasible to incorporate an extensible self-locking knife blade in the forward tubular section of a similar club. It is feasible to lock the tubular club sections positively to prevent collapse of the club while in operation. No conclusion was drawn as to the lethality of the extensible blade.
(4) An aerosol spray smoke device for dispensing white smoke has been developed for use in signaling, in target marking, and for screening purposes. The device consists of a steel cylinder (6 inches long and 3-1/2 inches in diameter) containing titanium tetrachloride, white phosphorus in solution with carbon disulfide and carbon tetrachloride, and Freon-12 propellant. In the prototype developed, a brass needle valve is screwed into a threaded opening at one end of the cylinder. When the manually operated valve is opened, a dense, high-quality white smoke is discharged for from 2 to 5 minutes. This smoke is formed by the reaction of the titanium tetrachloride with the moisture in the air to form white titanium hydroxide.


(4) Chapters XVIII and XIX deal with masking smoke compositions and colored smoke compositions, respectively.


(4) This study indicated that a weapon can be designed to eject a stream of salt water propelled by CO₂. However, it was regarded as doubtful that a weapon of this type would produce a positive deterrent to a determined attack. The gun designed was portable but was limited to an effective distance of 30 feet. To be effective beyond this distance, a weapon would have to be larger and, thus, no longer portable.
This study describes and presents illustrations of typical foreign unconventional warfare weapons and devices, including caltrops.


The toxicity values, or ratings by various, but usual routes are reported for the colored smoke ingredients 1-(methylamino)anthraquinone, auramine, kerosene, potassium chlorate, colloidal sulfur, potassium nitrate, magnesium carbonate and charcoal. Tests for carcinogenic action are tabulated for benzanthrone, indanthrene Golden Yellow GK (dibenzo[a,i]pyrene-7,14-dione), 2-(4-dimethylamino-phenylazo)-naphthalene and auramine. Other biological effects of many of the compounds or elements are given.


Some of the nonlethal weapons or agents mentioned in this article include electrically charged vehicles, ultraviolet marking material, electric shocks administered down streams of water, sound projectors, blinding lights, and tranquilizing and "nerve gases".


WP and the modified forms of WP (PWP, PWPV and SWP) in projectiles in general produce better ground smoke screens than any known nonphosphorus screening smoke material. Modified WP fillings for projectiles have been developed which are capable of more than doubling the ground smoke screening of effectiveness of the standard WP-filled projectiles. However, under some conditions, the modified WP fillings produce ballistically unstable rotating-type munitions. It is recommended that a research study be initiated to seek new incendiary fillings for munitions.

(U) Chapter 5 is entitled "Obscuring Smoke for Crowd and Riot Control" and is a quite thorough treatment of smoke munitions and techniques of employment.


(U) This manual is published for the use of the personnel to whom the Generator, Smoke, Mechanical, Pulse Jet, ABC-M3A3 is issued. It contains information on the operation and maintenance of the equipment as well as descriptions of major groups and their functions in relation to the operation of the smoke generator.

155. Finklestein, L., HISTORY OF RESEARCH AND DEVELOPMENT OF THE CHEMICAL WARFARE SERVICE IN WORLD WAR II (JULY 1, 1940 - DECEMBER 31, 1945), Special Publication No. 1-42, U. S. Army Chemical Research and Development Laboratories, Edgewood Arsenal, Maryland (June 1964) (UNCLASSIFIED) (Part I, 172 pp [PA 17,629], AD 461 128; Part II, 171 pp [PA 17,653], AD 461 129; Part III, 396 pp [PA 17,657], AD 461 130; Part IV, 180 pp [PA 17,654], AD 461 131).

(U) This report on screening smokes is one of a series of historical monographs. It covers not only research and development of the Chemical Warfare Service in the area of screening smokes during World War II, but it also presents theoretical and mathematical material pertinent to the subject, regardless of its source.


(U) The Marine Corps tested the Hand Held Wire Gun for possible use as an anti-personnel or riot-control weapon for unconventional warfare. This cylindrical gun is 10 inches long, 3-3/4 inches in diameter, and weighs about 11 pounds. The 450-foot wire coil is wound with sufficient energy to be propelled about 80 feet upon release. It is activated by retracting a pull ring, similar to that on a hand grenade, which is attached to a sear. The wire coil plugs itself out in essentially a straight line in from 6 to 7 seconds. In the tests described here, the gun did not meet Marine Corps requirements.
(U) Nonlethal weaponry is surveyed and an annotated bibliography on the subject is presented. Irritants, analgesics, anticholinergics, and emetics are the chemical incapacitating systems discussed. Delivery systems for the chemical agents are given. Visible, IR and UV light, laser radiation, microwave radiation, and sound are used for distracting and disorientating victims. Barriers and mechanical deterrents are discussed which inflict physical discomfort through direct mechanical or electrical means. The techniques presented in this survey are of value to military and police activities.
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