CHAPTER 2

Smoke and Incendiaries

Smoke and incendiaries are combat multipliers. Their effective use on a target can provide tactical advantages for offensive and defensive operations. For example, smoke has long been employed as a means of concealing battlefield targets. Additionally, incendiary fire damage causes casualties and materiel damage and can also impact psychologically.

Smoke

Chemical smokes and other aerosol obscurants can degrade the effectiveness of sophisticated antitank guided missiles (ATGMs). The precision guidance systems of ATGMs are typically electro-optical devices and generally operate in the near-, mid-, or far-infrared portions of the electromagnetic spectrum, rather than in the visible light band of the spectrum. The use of smoke in the target area can be a convincing combat multiplier offensively and a dynamic countermeasure defensively. Smoke should be of primary interest to all commanders and staff planners because the proper use of smoke can provide many operational advantages.

Smoke has four general uses on the battlefield—obscuring, screening, deceiving, and identify ing/signalling. Obscuring smoke is placed on an enemy to reduce vision both at, and out from, the position. Screening smoke is used in friendly operational areas or between friendly units and the enemy. Deceiving smoke is used to mislead the enemy. Identifying/signalling smoke is a form of communication that has multiple uses. Overall, the objective of smoke employment is to increase the effectiveness of Army operations while reducing the vulnerability of US forces. Specifically, smoke can be used to accomplish the following:

- Deny the enemy information.
- Reduce effectiveness of enemy target acquisition.
- Disrupt enemy movement, operations, command, and control.
- Create conditions to surprise the enemy.
- Deceive the enemy.

During offensive operations, smoke can screen the attacker while an attack is carried out. Some offensive applications include concealing movement of military forces and equipment; screening locations of passages through barriers; and helping to secure water crossings, beachheads, or other amphibious operations.

For defensive operations, smoke can be effectively used to blind enemy observation points to deprive the enemy of the opportunity to adjust fire, to isolate enemy elements to permit concentration of fire and counterattack, and to degrade the performance of threat ATGMs.

There are generally two categories of smoke operations on a battlefield-hasty and deliberate smoke. Hasty smoke operations are conducted with minimum prior planning, normally to counter some enemy action or anticipated action of immediate concern to a commander. Hasty smoke is usually used on small areas, is of short duration, and is most often used by battalion or smaller units. Deliberate smoke is planned in much greater detail. It is often employed over a large area for a relatively long period by brigades, divisions, or corps. For further information on hasty and deliberate smoke operations, refer to FM 3-50.

The following paragraphs on smoke operation contain information on smoke characteristics, diffusion of smoke, weather effects, hasty and deliberate smoke operations, and tactical considerations.

Characteristics

Smoke is an aerosol that owes its ability to conceal or obscure to its composition of many small particles suspended in the air. These particles scatter or absorb the light, thus reducing visibility. When the density or amount of smoke material between the observer and the object to be screened exceeds a certain minimum threshold value, the object cannot be seen.

The effectiveness of smoke used to obscure or conceal depends primarily on characteristics such as the number, size, and color of the smoke particles. Dark or black smoke absorbs a large proportion of the light rays striking individual smoke particles. In bright sunlight, a large quantity of black smoke is required for effective obscuration because of the nonscattering properties of the particles. At night or under low visibility conditions, considerably less smoke is needed.

Grayish or white smoke obscures by reflecting or scattering light rays, producing a glare. During bright daylight conditions, less white smoke than black smoke is required to obscure a target. Years of experience with smoke screen technology have shown that white smoke is superior to black smoke for most applications. Available white smoke includes white phosphorus (WP) and red phosphorus (RP) compounds, hexachloroethane (HC), and fog oil (SGF2). WP, RP, and HC are hydroscopic—they absorb water vapor from the atmosphere. This increases their diameters and makes them more efficient reflectors and scatterers of light rays. Fog oils are nonhygroscopic and depend upon vaporization techniques to produce extremely small diameter droplets to scatter light rays. The reflecting and absorbing qualities of smoke are illustrated in Figure 2-1.

Smoke, when placed between a target and a viewer, degrades the effectiveness of target-acquisition and aiming systems. The amount of smoke necessary to defeat aiming and acquisition systems is highly dependent upon the prevailing meteorological conditions, terrain relief, available natural light, visibility, and the attenuation effects of natural particles in the atmosphere. Other factors that must be considered include smoke from battlefield fires and dust raised by maneuvering vehicles and artillery fire.

The ability to detect and identify a target concealed by such a smoke screen is, in turn, a function of target-to-background contrast. Additionally, the amount of available natural light, the position of the sun with respect to the target, the reflectance of the smoke screen and the target, and the portion of the electromagnetic spectrum to be attenuated below the threshold contrast for detection will impact on detecting and identifying a target.

Diffusion

The diffusion of smoke particles into the surface and planetary boundary layers of the

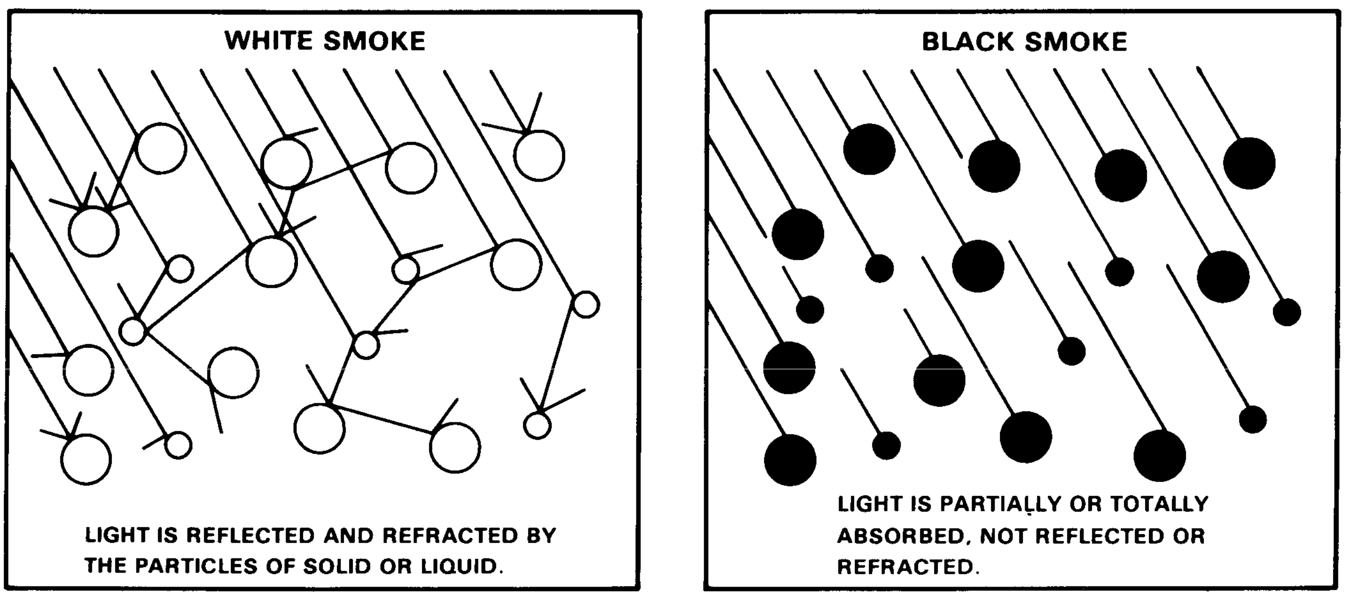

Figure 2-1. Action of smoke particles on light radiation.

atmosphere generally obeys physical laws. Diffusion is governed by wind speed, turbulence, stability of the atmosphere, and terrain. The diffusion of smoke, as used on the battlefield, originates from four basic source configurations. These may be defined as continuous point sources, instantaneous point sources, continuous line sources, and area sources. A continuous point source may bethought of as a smoke release from a single smoke generator or smoke pot. The bursting of a projectile containing WP is considered to be an instantaneous source. A series of generators, set up crosswind, represent a line source. Munitions which scatter smoke-generating submunitions in an area are considered an area source.

Weather Effects

Meteorological conditions that have the most effect on smoke screening and munitions expenditures (including the deployment of smoke generators) include wind direction, relative humidity, visibility, and atmospheric stability. To be effective, an obscuring screen must be placed in an advantageous position with respect to the prevailing wind direction. The target area to be screened must be defined in terms of whether the prevailing wind direction is considered to be a head or tail wind, a quartering wind, or a flank wind. Figure 2-2 illustrates these conditions. It must be remembered that flanking winds can be from either the right or left side of the screening area and that there are four quartering-wind directions. Wind direction is critical for determining the adjustment or aim point for screens deployed by artillery or mortars and also for the placement of generators if used to produce either hasty or deliberate smoke.

As smoke is released into the atmosphere, it is transported and diffused downwind. The plume is depleted quite rapidly by atmospheric turbulence. The obscuration power of the plume becomes marginal at relatively short downwind distances and must be replenished at each point where the attenuation of a line of sight approaches a minimum. The transport wind speed and direction for a diffusing plume in the surface boundary layer of the atmosphere occurs at a height of about half of the plume height. Usually, this would be a height of about 10 meters. For smoke operations, then, speeds and directions should be obtained for a height of about 10 meters above the surface.

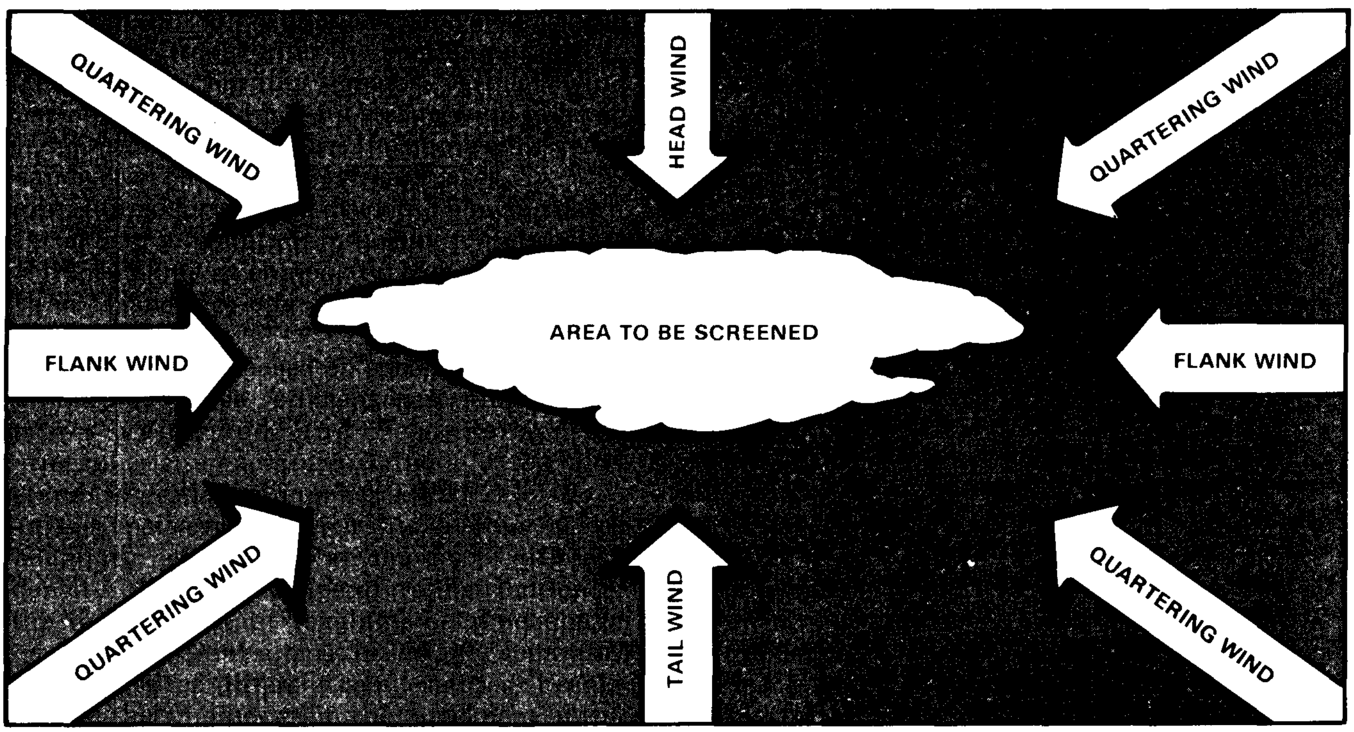

Figure 2-2. Prevailing wind directions.

The relative humidity of the atmosphere is important to the use of smoke on a battlefield. As previously stated, WP, RP, and HC smoke compounds are hydroscopic—they absorb moisture from the atmosphere. As relative humidity increases, the amount of screening material available for target obscuration increases. For example, the HC compound is considered to be only about 70-percent efficient; that is, for every 100 grams of HC in a munition, only 70 grams are available for screening. If the relative humidity yield factor is then added in, the screening power of HC increases. This is shown in Table 2-1. Applicable technical references indicate the amount of HC or WP contained in various munitions. For example, the 105-millimeter WP (M416) round contains 6 pounds of WP; the 155-millimeter HC (Ml16A1) round contains 5.45 pounds of HC; and the 76-millimeter WP (M361A1) round contains 1.38 pounds of WP (453.6 grams equals 1 pound).

Table 2-1. Smoke yields for HC and WP in various relative humidities.

RELATIVE HUMIDITY %	100 g HC (70% efficient)		100 g WP (100% efficient)	
	YIELD FACTOR	YIELD	YIELD FACTOR	YIELD
10	1.46	102 g	3.53	353 g
20	1.52	106	3.72	372
30	1.59	111	3.91	391
40	1.73	121	4.11	411
50	1.89	132	4.34	434
60	2.11	148	4.65	465
70	2.40	168	5.10	510
80	3.25	228	5.88	588
90	5.72	400	7.85	785

Phosphorous compounds are considered to be better screening agents than HC. This is because WP and RP have large yield factors for various relative humidities. Yields for WP are also shown in Table 2-1. Upon ignition, WP burns at a temperature of about 800°C to 850°C. As a consequence, the smoke from a WP munition pillars, creating an excellent vertical screen, especially with high relative humidities. However, only about 10 percent of the smoke generated from WP munitions is available for screening near the ground. This should be considered when planning smoke missions.

Battlefield visibility can be practically defined as the distance at which a potential target can be seen and identified against any background. Reduction of visibility on a battlefield by any cause reduces the amount of smoke needed to obscure a target.

Turbulence, atmospheric instability, and wind speed can have an adverse effect upon smoke expenditures. Unstable conditions are usually considered to be unfavorable for the use of smoke. Under calm or nearly calm conditions, the use of smoke is also sometimes unsatisfactory. In general, if the wind speed is less than 3 knots or greater than 20 knots, smoke can be an unsatisfactory countermeasure on the battlefield.

Operations

Smoke operations are of two types: hasty and deliberate.

Hasty Smoke

Hasty smoke generally is placed in the area to be screened by artillery, smoke pots, or mortar projectiles. Obscuring smoke usually is employed on enemy forces to degrade their vision both within and beyond their location. Screening smoke is used in areas between friendly and enemy forces to degrade enemy ground and aerial observation and to defeat or degrade enemy electro-optical systems. Screening smoke also may be employed to conceal friendly ground maneuver. Deception or decoy smoke is used in conjunction with other measures to deceive the enemy regarding friendly intentions. Decoy smoke can be used on several approaches to an objective to deceive the enemy as to the actual avenue of the main attack.

In the offense, hasty smoke may be used to establish screens, enabling units to maneuver behind or under screens and deny the enemy information about strength, position, activities, and movement. Ideally, a screen should be placed approximately 500 to 800 meters short of the enemy to allow for maximum visibility for mounted forces during the final assault. Hasty screens on the flanks also can be used. Flanking screens can be produced with mechanized generators. Hasty obscuring smoke also may be placed on enemy strongpoints.

On defense, hasty smoke may be used to impede and disrupt enemy formations. It also may be used beyond the forward line of own troops (FLOT) to silhouette Threat targets as they emerge through the smoke and are engaged. Smoke screens also may be used to conceal defensive positions and cover disengaging and moving forces. Mechanized smoke generator units are ideal for this type of hasty smoke.

Figure 2-3 shows the positioning of an obscuring hasty smoke cloud on enemy forces for tail wind and head wind conditions. Figure 2-4 illustrates screening smoke for flank and quartering winds ahead of an advancing force. Figure 2-5 is an example of mechanized units generating a smoke screen for a counterattacking force.

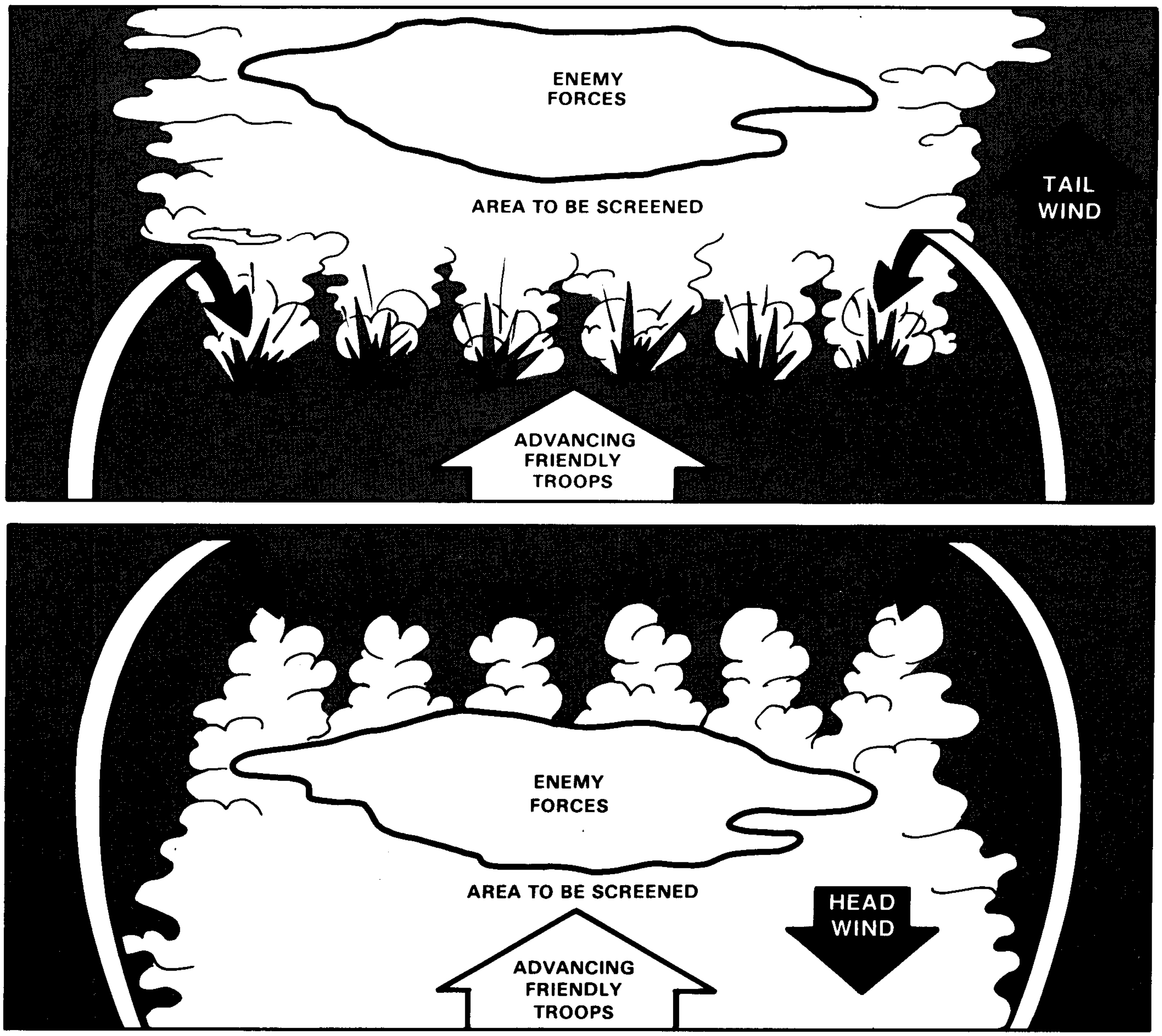

Figure 2-3. Obscuring smoke clouds for tail and head wind conditions.

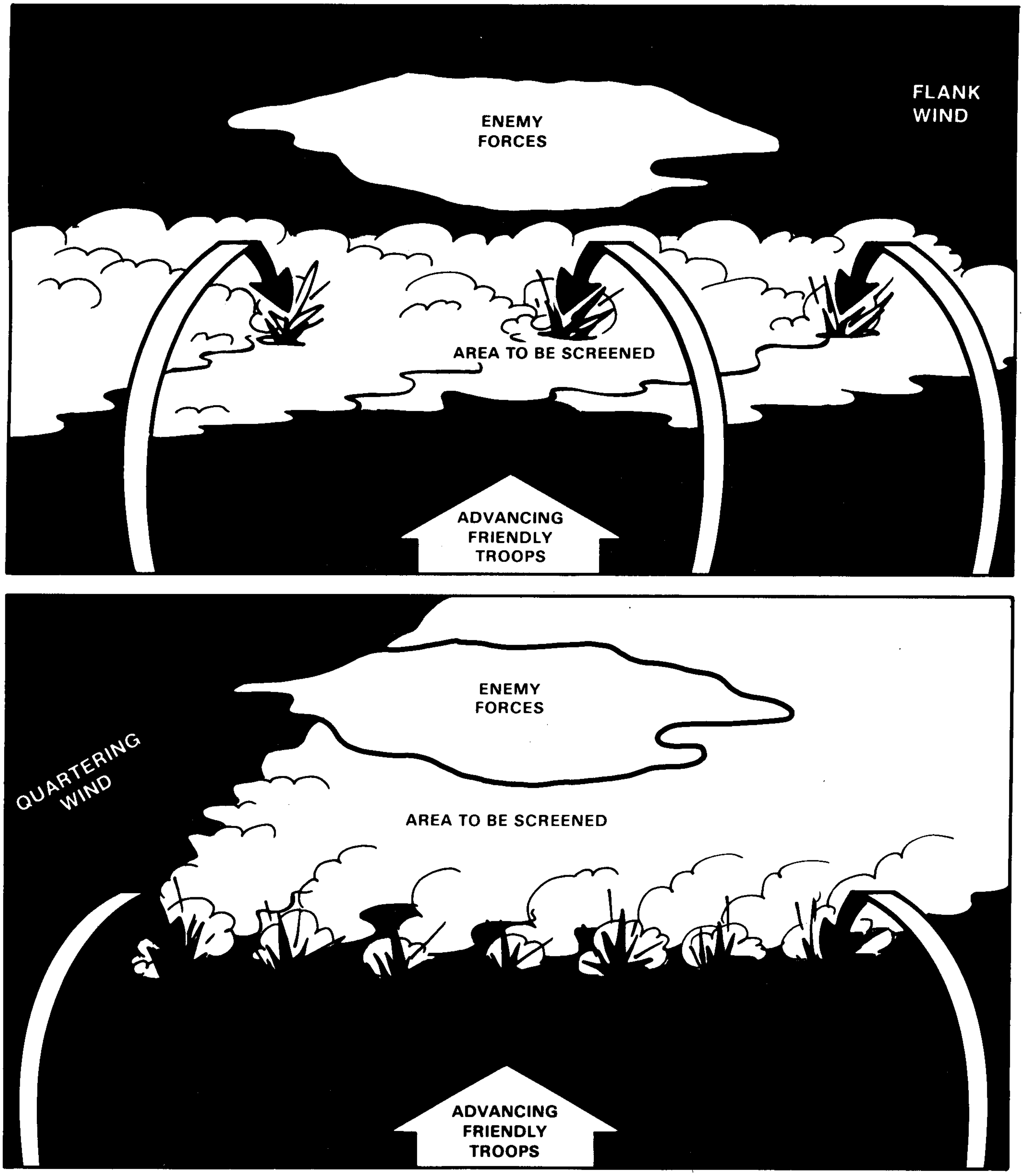

Figure 2-4. Screening smoke cloud for flank and quartering wind conditions.

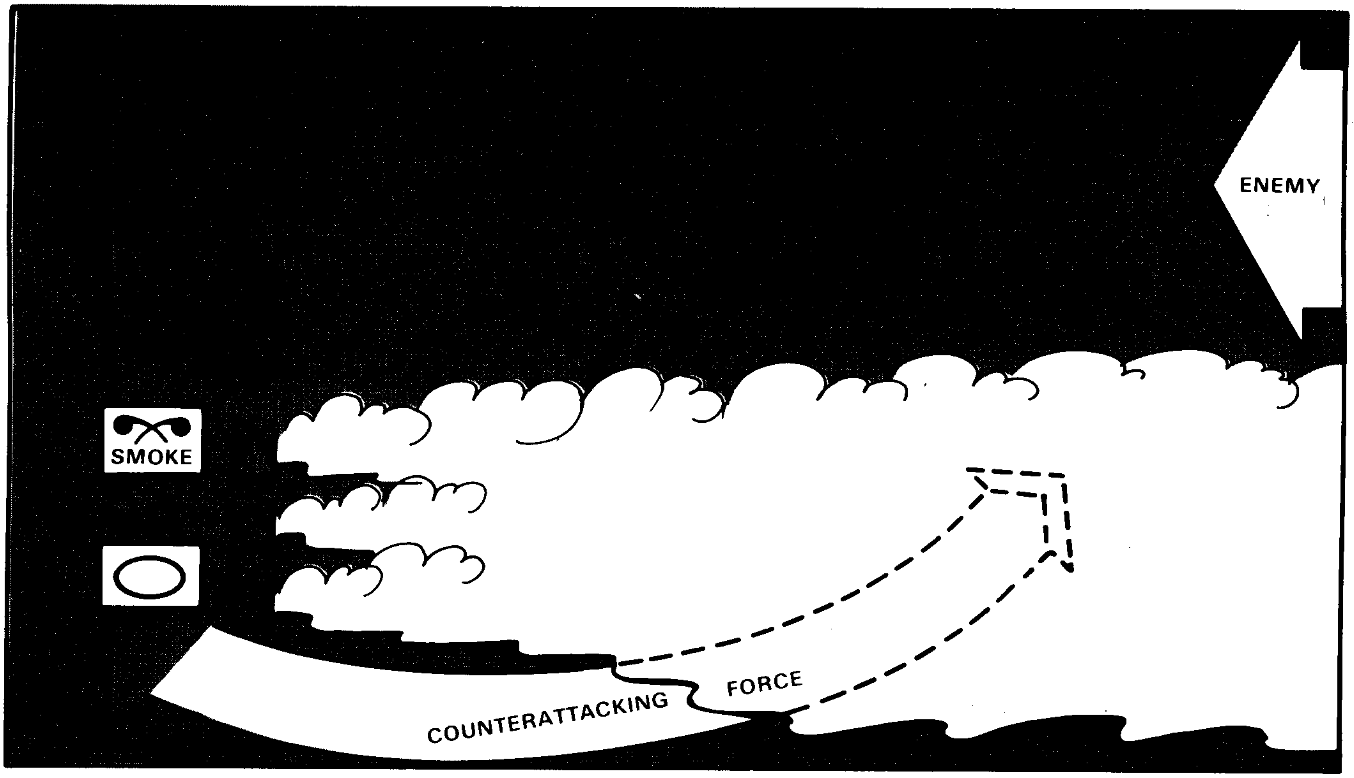

Figure 2-5. Mechanized smoke vehicles screening a counterattacking force.

Deliberate Smoke

Large area smoke screens generally fall within the realm of deliberate smoke in that they are usually planned well in advance of the operation. Large area screening or the establishment of a smoke blanket or haze is generally carried out by the use of smoke generators. Generators usually are positioned in a line source configuration at a right angle to the prevailing wind direction. Usually, if the terrain allows it, the generators are evenly spaced along the smoke line. Generators are ideal for screening river crossings if the prevailing wind direction is upstream, downstream, or a tail wind.

The employment of large smoke is probably most effective if the screen is generated before sunrise when stable conditions and light-to-moderate winds are most likely. Screens generated in these conditions will remain close to the ground with only moderate vertical diffusion. Screens also reduce incoming solar radiation reaching the ground so that convective turbulence is suppressed, similar to overcast weather conditions. Thus, smoke hazes and blankets can be maintained and remain useful for longer time periods.

The use of large area smoke screens in any area depends upon the prevailing wind direction. Operators must be prepared to shift their generators to preselected locations if the wind direction changes.

Tactical Considerations

In addition to the importance of wind direction, relative humidity, visibility, stability, and turbulence to the successful completion of a smoke mission, the effects of terrain and soil conditions should be considered. Terrain effects discussed in Appendix C apply to smoke as well as NBC agents. A diffusing smoke plume also tends to follow the terrain-influenced surface winds. Also, in forests and jungles smoke has a tendency to be more evenly dispersed and to persist longer than over more open terrain.

The condition of the soil influences the effectiveness of artillery-delivered and mortar-delivered smoke but has very little direct effect upon screening or obscuring smoke. An impacting smoke munition bursting in soft soil loses effectiveness since part of the filling compound is driven into the dirt. In some cases, totally ineffective screens result if smoke munitions are delivered to a boggy or swampy target area.

A last point to consider involves wind direction effects upon smoke screens. Munitions expenditures for a screen deployed in quartering wind conditions must be increased by a factor of about 1.5 over a flank wind direction condition. For head and tail winds, expenditures are three to four times those for flank winds. Thus, reduction in expenditures owing to visibility and relative humidity effects may be negated by wind directions.

Incendiaries

Weather conditions have little influence on incendiary munitions themselves. Wind and precipitation, however, may greatly influence the combustibility of the target and its susceptibility to fire spread. The purposes of incendiaries are to cause maximum fire damage on flammable materials and objects and to illuminate. Initial action of the incendiary munition may destroy these materials, or the spreading and continuing of fires started by the incendiary may destroy them. Incendiary materials used include gasoline gels, burning metals, incendiary mixes, and white phosphorus.

To be effective, incendiary munitions should be used against targets susceptible to fire or heat damage. A considerable part of the target must be flammable, so the fire can spread. Fire walls and cleared lanes offer some resistance to the spread of fires.

Winds assist in the effectiveness of incendiaries, increase the rate of combustion, and can spread fires downwind more rapidly. Actually, each large fire can create a wind system of its own. This wind system results from the tremendous heat generated and the resulting vertical wind currents. Incoming winds can feed more air to the fire. This increases the rate of combustion, which, in turn, can increase the wind. In extreme cases, this wind is called a fire storm and sometimes exceeds 60 knots.

Smoke, sparks, and flames fly in the direction of the wind. Incendiary strikes (at successive targets) should be planned to begin with the farthest downwind target and proceed upwind. This will prevent aiming points from becoming obscured by smoke traveling downwind of initial fires. Additionally, the position of friendly forces or facilities that must not be damaged must be considered (in relation to the wind direction) when planning incendiary strikes.

Temperature, temperature gradient, and clouds have little if any effect on incendiaries. Humidity also has little effect upon incendiary munitions but may affect combustible material. Wood, vegetation, and similar material absorb some moisture from the air over a period. If relative humidities have been high for some time, as in the tropics, it may be more difficult to achieve combustion from incendiary action.

Rain or snowfall, even when light, can render grass and brush quite incombustible and make a continuing fire unlikely. Heavy timbers are not affected unless they have been exposed to long periods of precipitation. Combustible materials exposed to rain may be susceptible to fire damage, such as in mass incendiary attacks. In these attacks, the heat of combustion may be sufficient to dry combustible materials in the target area.

In regions of high humidities, such as the tropics, mass incendiary attacks generate tremendous amounts of heat, causing vertical wind currents. This rising air can cause thunderstorms, counteracting the effects of the incendiaries.

It is difficult to extinguish burning metals with water; a spray actually speeds the burning. Water surrounding the area of burning metals prevents fire spread. Water extinguishes burning phosphorus, but unconsumed particles will burn again when dry.

Three elements of terrain affect the efficient use of incendiaries. These are soil, vegetation, and topography. The type of soil affects the impacting of the munition; combustibility of the vegetation affects the efficiency of the incendiary; and topography influences wind speed and direction.