Section III. FIELD AND ADVANCED BASE VECTOR CONTROL

9–21. Flies

(1) *Relation to man.*—Of the many thousands of species of flies known to science, a number transmit human or animal diseases that may seriously hamper military operations, and untold numbers of others are annoying pests of man. Perhaps the most important of these is the house fly. In addition to being a serious annoyance, it is capable of transmitting disease-producing organisms in its vomit, excrement, and by its contaminated feet. Chief among these are the organisms of dysentery, diarrhea, cholera, and typhoid fever. Blow flies carry many of the same diseases, and in addition their larvae sometimes develop in wounds or natural openings of the body, a condition known as *myiasis*. The stable fly, unlike the above two types, is a blood-sucking fly and is suspected of transmitting anthrax and tularemia. Sand flies (*Phlebotomus*) are tiny blood-sucking flies that transmit a number of subtropical and tropical diseases. Punkies, or salt-marsh sand flies (*Culicoides, Leptoconops,* etc.) are minute blood-sucking flies which cause extreme annoyance to man in many parts of the world. Additionally, in some tropical regions, they transmit filarial worms to humans. Tsetse flies are blood-sucking flies which are of great importance to man since they are the sole disseminators of the trypanosomes that are the causal organisms of sleeping sickness in Africa. Black flies are small, blood-sucking insects which are extremely annoying pests in areas of running streams. They are known to be carriers of human disease parasites in Mexico, Central America, and Africa. Horse flies and deer flies are blood-sucking insects that attack man and animals out of doors. They transmit a number of diseases, including tularemia (from rabbits). Eye gnats are nonbiting flies which are attracted to wounds, pus, and secretions about the eyes and nose. In some parts of the United States they mechanically transmit pinkeye (acute infectious conjunctivitis).

(2) *Characteristics.* All flies resemble one another in having only two wings and in passing through four major stages (egg, larva, pupa, and adult). A brief, generalized description of the biology of each of the principal types follows:

(a) *House fly (Musca domestica).* This fly is known in all the areas of the world and consequently is probably the most widely distributed insect of importance to mankind. Its eggs are deposited in decaying vegetable and animal matter. Garbage, contents of pit latrines, animal manure, spilled animal food, and soils contaminated with organic matter such from washings of any of these items, are favorite breeding places. Each female lays several masses of eggs. Under favorable conditions the eggs hatch in 24 hours or less. The maggots, which are creamy white and about ½ inch long when mature, move about in the breeding medium to secure optimum temperature and moisture conditions. This stage lasts from 3 to 24 days; the usual time in warm weather is 4 to 7 days. When growth is completed, the larvae crawl to the edge of the breeding medium, burrow into the soil or debris, and change into dark brown pupal. The pupal stage usually lasts 4 to 5 days; under very warm conditions, only 3 days may be required. In cold weather, this stage may last for several weeks. When transition from larval to adult structures is complete, the adult flies push open the ends of the pupal cases, work their way to the surface, and fly away. Mating may take place a day or two following emergence. The adult fly is grey in color. The grey thorax is marked with four equally broad, dark longitudinal stripes. The mouthparts are nonbiting, sponging or pad-shaped and adapted for sucking. House flies utilize a wide variety of materials for food, ranging from organic filth to human food stuffs. Because they can take only liquid foods, they frequently moisten substances with a "vomit drop" from the crop. This "vomit drop" dissolves solid materials to be used as food, and most of the material is sucked up again. This, combined with their habit of commonly visiting and walking about over organic filth, accounts for the ease with which they transmit disease organisms to food, and to dining and cooking utensils. Light-colored "fly specks" result from regurgitation; dark spots are fecal deposits, and both serve as additional sources of contamination. When inactive, flies tend to congregate in certain preferred resting places. The proper use of residual sprays for house fly control

requires that the locations of these places be determined. Indoors, flies tend to rest on overhead structures, particularly on cords and the edges of objects. Where temperatures remain high during the night, house flies frequently congregate out of doors on fences, weeds, and in the low branches of trees. Although house flies usually stay within a short radius of the breeding sites, they are able to disperse for distances of several miles. In southern areas, house flies continue breeding at a reduced rate throughout the winter. In more northern areas, house flies probably pass the winter by a combination of adult hibernation and semicontinuous breeding in protected situations.

(b) *Blow fly (Calliphora, Chrysomya, Lucilia, etc.)*.—Blow flies also are known as blue-bottle and green-bottle flies. They may be identified by their large size and shiny blue, green, or black abdomens. They usually deposit their eggs upon carrion; however, they will oviposit upon a wide range of fresh decaying refuse if carrion is not present. Eggs occasionally may be deposited on living animals, although clean healthy animals are rarely attacked. Upon emerging from the egg stage, the larvae feed for a short time on the surface near the egg mass. Later, they bore into the less putrid material within. When fully developed, the larvae leave the breeding medium and burrow into the ground to pupate. The life cycle varies from about 9 to 25 days. Blow flies are keenly perceptive of odors emanating from carrion and will fly long distances in response to such stimuli. Although blow flies may serve as mechanical vectors of disease organisms in the same way as do house flies, they do not present the same public health problem since they rarely enter dwellings.

(c) *Flesh fly (Sarcophaga and Wohlfahrtia)*.—The flesh flies are medium grey in appearance and are often of rather large size. They may be distinguished from other domestic flies by the presence of three black longitudinal stripes on the thorax and a checkered effect on the abdomen with the tip usually red. These flies are commonly referred to as flesh flies, since the larvae of some of them infest living flesh. Many species are known to breed prolifically in animal excrement, especially in dog stools. They differ from all the other domestic flies in that the females deposit living larvae rather than eggs. The flesh flies are often very abundant, but they do not ordinarily enter habitations. They do not appear to be of importance to man from the standpoint of mechanical transmission of disease organisms, nor are they often of much nuisance importance. However, they are important as an indication of the presence of insanitary conditions.

(d) *Bot and warble flies (Gasterophilus, Dermatobia, Oestrus, and Hypodermo)*.—Normally the larvae of bot flies (*Gasterophilus*) inhabit the alimentary canals of animals of the horse family. Larval development requires 10 to 11 months. In the rare cases in which they invade man, they are found under the skin giving rise to a creeping eruption. Among the warble flies, *Dermatobia* is found in the human skin in Central and tropical South America. The larvae of *Oestrus* are found in the nasal cavities and cranial sinuses of sheep, goats, and wild game. In areas where these animals are numerous man may become infested. When this occurs, the larvae are found in the mucosa of the mouth, the nasal passages, and in the conjunctiva. The larvae of *Hypoderma* are located under the hides of cattle, goats, deer and other game animals. They give rise to creeping eruption in man.

(e) *Stable fly (Stomoxys)*.—The stable or dog fly is a blood-sucking fly which greatly resembles the house fly in appearance, but is distinguished from all other domestic flies by its piercing proboscis which protrudes bayonet-like in front of the head. It normally breeds in wet straw, manure mixed with straw, or any piled fermenting vegetation, such as grass, seaweed, and similar materials. Complete development requires from 21 to 25 days. It does not frequent latrines or human food. Since the stable fly does not breed in human excrement, and does not appear to be attracted to feces, garbage, and other filth which are so attractive to the house fly, it is not considered to be an important agent in distributing human diseases. However, its severe biting habits make it a serious morale factor. Related human-biting flies also occur in the muscid genus *Haematobia*.

(f) *Tsetse fly (Glossina)*.—Tsetse flies, which range in length from 6 to 14 mm., can be easily recognized when at rest by the way in which they fold their wings scissor-like above the abdomen, by the characteristic discal cell (meat cleaver shaped) in the wing, and by the prominent biting-type mouthparts. They are restricted to the continent of Africa south of the Sahara Desert. The females produce single fully grown larvae at intervals. These larvae pupate almost immediately in loose soil, moss, and other accumulations of material in the bush. Usually tsetse flies require bush, thickets, or forest to rest and breed in, while open areas, savannah or openings in the forest, are required for feeding. They are severe blood sucking flies which feed on man and other animals.

(g) *Sand fly (Phlebotomus)*.—The members of this group are small blood-sucking, moth-like flies, rarely exceeding 5 mm. in length. Their bodies and wings are densely covered with hairs. The wings are either oval or lanceolate in shape and, when at rest, are held in an arched manner over the body forming a "V." They have a world-wide distribution, occurring in such diverse areas as deserts and jungles, but are absent from the colder parts of the temperate zones. They invade buildings or other habitations to attack man during the evening and night, and hide in dark protected places during the

day. They may be found in the dark corners and near the ceilings of sleeping quarters. The most common outdoor shelters are masonry cracks, stone walls, excavations, animal burrows, hollow trees, and deep cracks in soil. The eggs are laid in similar places where there is an abundance of organic matter and sufficient moisture for their development. Their mode of flight is characteristic in that it consists of short flights alternated with hopping movements. Normally, their range of dispersal is limited to the immediate region of their breeding areas.

(h) *Black fly (Simulium).*—Black flies are small (1–5 mm. in length), dark, stoutbodied, humpbacked flies with short broad wings in which only the anterior veins are well developed. The antennae are short and stubby. The immature stages of black flies develop in running water. Usually, eggs are deposited in masses on aquatic plants, submerged logs, and water-splashed rocks. However, some species drop their eggs while flying over the water surface and the eggs then sink to the bottom. Following an incubation period, the eggs hatch and the new larvae attach themselves by means of silken threads to submerged vegetation, rocks, and logs. Larvae feed on organic particles strained from the water and swept into the mouth by a pair of fan-like mouth brushes. They breathe by obtaining oxygen from the water through three small gills at the end of the abdomen and through the skin of the body. Before pupating, the larvae spin a cocoon which is firmly attached to objects in the water. The larvae then pupate within the cocoon. The pupae breathe through two tufts of respiratory filaments that project from the front end of the body. The total period of the aquatic life stages varies from two to many weeks, depending upon the species, and upon such environmental factors as the temperature and the availability of food. Transformation to the adult takes place within the cocoon. Upon emerging and rising to the surface, the fly takes wing immediately. Like mosquitoes, black flies feed on the nectar of flowers. The females also feed on the blood of wild and domestic animals and birds, and several species regularly feed on man. The males do not bite. Several species are a cause of serious annoyance to man because of the habit of flying closely about the face and of crawling or probing over all exposed skin surfaces. Little precise information is available on the dispersal range of black flies, but it is believed to be more than a mile, particularly where open terrain is concerned.

(i) *Punkies (Culicoides, Leptoconops, etc).*—These blood-sucking flies, often called "no-see-ums" or "salt-marsh sand flies," are extremely small in size (1–5 mm. in length), and have long slender antennae, and narrow wings which are carried flat over the body. Although information on their breeding habits is not complete, some species are known to breed in fresh-water inlets and tidewater pools, in water-holding tree holes, and in the wet decaying humus of densely shaded areas along streams, and in marshes and swamps. Adults may be found as far as 2 to 3 miles from their breeding places. The female inflicts a painful bite, attacking humans chiefly in the evening and the early morning hours. Heavy infestations of these flies will hamper military operations and adversely effect morale.

(j) *Horse and deer flies (Tabanus, Chrysops, etc.).*—Horse and deer flies are robust insects, with powerful wings and large, rounded heads. They range in size from about that of the house fly to nearly an inch in length, prefer warm, sunny situations, and are especially active on humid days. Eggs are glued in layers or masses to rocks or vegetation overhanging water or damp soil. The egg stage is usually less than 2 weeks in length. Upon hatching, the larvae drop into the water or to the ground. Depending upon the species, the larvae require one to several years to complete development. Mature larvae migrate to dryer soil for pupation, where after a week or two the adult flies emerge. These flies inflict exceedingly painful bites and, when numerous, seriously interfere with outdoor operations.

(k) *Screw-worm fly (Callitroga).*—*C. hominivorax*, the screw-worm fly, is a semitropical species recently eliminated from Florida and now occurring only in southwestern United States. This species is the most serious myiasis-producing fly in the United States. It is strictly parasitic, attacking only fresh, clean wounds. At times, it has been a serious plague of livestock, especially of cattle, sheep, and goats. In 1935, there were more than 1,200,000 cases in livestock in Texas alone. Man also may be attacked and 55 cases were reported during the above outbreak. The eggs are usually glued tightly to dry tissues near the surface of the wound. There is a related species known as the secondary screw-worm fly, (*C. macellaria*), which is relatively unimportant.

(l) *Eye gnat (Hippelates).*—Members of the genus *Hippelates* are as a rule very small flies (1.5–2.5 mm. in length) which have been given the name "eye gnats" or "eye flies" because of their special liking for secretion of the eyes. They are also attracted to wounds, pus, and sebaceous secretions. They are extremely annoying to man because of their habit of swarming closely about the face. They are persistent and when brushed away will quickly return. Although these flies are incapable of piercing the skin to take blood, their mouthparts are provided with upturned spines which act as fine cutting instruments. Because of these structures, they are able to abrade the edges of sores and conjunctival epithelium. The life histories of the various eye gnat species are not well known. It has been established, for some species at least, that eggs are laid in newly

turned soils that are rich in humus or vegetable matter.

(3) *Control of domestic flies.*—The successful control of domestic flies depends upon improved environmental sanitation, supplemented by the judicious application of insecticidal chemicals. Prevention of fly breeding or fly entry reduces the disease transmission potential and simultaneously increases the value of any chemical in reducing fly numbers.

(a) *Sanitation.*—Effective sanitation measures and proper policing of grounds are of primary importance in fly control. This is particularly important in view of the many resistance problems now appearing. With proper sanitation, less dependence need be placed on insecticides. The elimination of all sources of attraction for flies is essential. Any fermenting or decaying organic matter or garbage, such as human and animal excrement, dead animals, fish and meat refuse, and discarded food stuffs, are potential breeding places for flies. Proper disposal of food-service wastes is essential to prevent the attraction of flies to the dining facilities area. These wastes include all garbage and such liquids as wash water. Garbage should be deposited in garbage cans equipped with well-fitted lids. The cans should be washed and kept outside of dining facilities, preferably off the ground on a stand or rack. Effective disposal methods must be used for garbage, nonsalvable compressible waste, and rubbish. (See ch. 8.)

(b) *Chemical control.*—For troops in the field, control by chemicals will be a prime necessity.

(*1*) *Control of immature stages.*

(*a*) *General.*—Larviciding usually is not practical in a large program because breeding places are too scattered for efficient treatment. However, its use is indicated for fly control in areas of concentrated fly breeding, such as garbage-handling zones, livestock and poultry farms, piles of compost materials, and carcasses. In all larvicidal treatments, emphasis must be placed upon getting the insecticide to the site where it can act upon the larvae. In order to accomplish this, large quantities of a dilute spray are applied until the breeding medium is well saturated. Since most larvicides also act as adulticides, spray applications should be directed to locations where the emerging adults will contact the chemical when they leave the breeding media. Diazinon, 0.25 percent, appears to give better control than malathion. Extensive reliance on larviciding should be avoided since it probably accentuates the development of resistance. It has been shown by the Public Health Service that it is undesirable to treat privies with BHC, chlordane, or dieldrin, since the production of flies in treated sites actually undergoes a significant increase. Human excrement in privies normally does not produce many house flies. The soldier fly, *Hermetia illucens,* breeds prolifically in untreated privies in a semiliquid medium, a condition fostered by the presence of the soldier fly larvae. House flies do not propagate well in such media. The above insecticides destroy the soldier fly infestation, and the media becomes semisolid in nature which is suitable for house fly breeding. The latter, being resistant to the chlorinated hydrocarbon insecticides, are not affected by treatment, and an increase in the prevalence of house flies results. Treatment with DDT, interestingly enough, results in only a slight increase. In most areas, blow flies continue to remain susceptible to the chlorinated hydrocarbons. However, there are two instances abroad where resistance has developed; in the Belgian Congo, the blow fly, *Chrysomya putoria* (Wied.), is resistant to Diazinon, BHC, and malathion larvicides, and in Austria, *Phaenicia cuprina dorsalis* (Wied.) has exhibited resistance to dieldrin after 3 years of use. Dieldrin has been found to be particularly effective for the larviciding of carcasses and similar blow fly breeding sites.

(*b*) *Insecticides.*—The larvicide should be applied until the breeding medium is saturated to a depth of 2 or 3 inches. In the presence of resistance to the chlorinated hydrocarbons, use a 0.25 percent Diazinon emulsion or solution at the rate of 10 gallons per 1,000 square feet. In most cases, adding sugar to the spray at the rate of 2½ parts of sugar to 1 part of toxicant prolongs the insecticidal activity of these insecticides and further serves as a fly attractant which will lead to considerable adult fly control. Fly breeding in pit latrines can be controlled, where the contents are relatively dry, by sprinkling paradichlorobenzene crystals (PDB), over the contents at the rate of 2 ounces per latrine hole at weekly intervals. This treatment is effective *only* when pits are deep, dry, and unventilated. PDB applied at a rate of 2 ounces per garbage can for home use has been shown to give control for 1–2 weeks.

(*2*) *Control of adults.*

(*a*) *Residual application.*

1. *General.*—The application of insecticides to surfaces where flies congregate is a very effective means of chemical control. The insecticide in a solution, emulsion, or suspension is sprayed directly onto surfaces. The liquid carrier soon evaporates, leaving a viscous or crystalline film of insecticide which adheres to the treated surfaces and kills all contacting insects for an extended period of time. The surfaces to be treated are resting places in buildings, such as overhead structures, hanging cords, moldings, and door and window facings. Resting places such as building exteriors near breeding sites, open sheds, garbage cans, shrubs, and low trees also can be given residual treatments. For best treatment, the spots to be treated should be determined in advance, and application should be only to the actual resting sites. These sites can best be determined with a flashlight at night, and by

looking for the presence of "fly specks." Spray equipment with a fan-type nozzle is recommended for residual applications, and surfaces should be wetted to the point of runoff. Paint brushes and rollers can be used. The use of cotton cords or strips of screen wire soaked or dipped in insecticides and then suspended or nailed in locations suitable for fly resting also has proved to be an effective means of application.

2. *Insecticides.*—Either lindane or dieldrin emulsion, 0.5 percent, can be applied as selective spot treatments. This will provide good control indoors for about a week. Outdoors, 3.0 percent malathion or 0.5 percent Diazinon may be sprayed on protected exterior surfaces around garbage cans and garbage racks, but are more effective if sugar or syrup is added as an attractant to emulsions (2½ parts sugar to 1 part of toxicant). Spray surfaces at a rate of 2 or more gallons per 1,000 square feet. Avoid contamination of food or utensils. Do not use sugar mixtures for interior residual treatments. Do not apply residuals of chlordane, BHC, or dieldrin to privies. (See para. (3)(b)(*1*)(*a*)).

(*b*) *Impregnated cords.*—These "fly cords" consist of cotton cords impregnated with insecticides such as malathion, ronnel, or Diazinon. The installation rate for treated cords is 30 linear feet per 100 square feet of floor area. A 3/16 inch diameter cord is essential for prolonged control with Diazinon. The ronnel-treated cords may be prepared by immersion either in a 25.0 percent xylene-ronnel solution or in a 12.0 percent emulsifiable ronnel concentrate. Ronnel is the first toxicant of relatively low mammalian toxicity to be suitable as a cord impregnant. However, care must be exercised in handling the chemical to prevent skin contamination. Rubber or cotton gloves must be worn when installing the cords. Fly cords are manufactured in 100-foot lengths, with 18-inch secondary cords hanging down approximately 18 inches apart. They are suspended so that the lowest part is approximately 7 feet from the deck, thus avoiding contact with persons using the area. In mess halls it is mandatory that cords not be hung over tables or where food is served.

(*c*) *Space spraying and area treatment.*—This is utilized where residual and larvicidal applications fail to give satisfactory fly control. Standard-issue space sprays, dispersed either by aerosol dispensers or sprayers, can be used effectively inside buildings for the prompt elimination of house flies. They have no lasting effect, and frequent retreatment is necessary. The use of vaporizers is not recommended. Mists may be used for area treatment outdoors during the daytime when flies are active. Mist or dust applications usually are more suitable than fog treatments, since the quantity of toxicant required per specimen is greater for flies than for mosquitos. Water emulsion sprays are more effective than dusts at comparable dosages. Malathion, water emulsion mist-spray (9.5–10.5 gallons, 12.5 percent concentration per mile) has yielded 99.0 percent mortality. Diazinon spray at a dosage of 0.3 pound per acre has given satisfactory control up to 200 feet from the point of discharge. At a dosage of 0.2 pound per acre (32 gallons, 1.5–2 percent concentration per mile) water emulsion of Diazinon or DDVP give equally effective control. Naled has given good kills up to 200 feet at dosages of 0.3 to 0.4 pound per acre (17.5 gallons, 6.0 percent emulsion per mile). During warm weather, house flies rest at night on shrubs, high grasses, and the lower limbs of trees. Surveys to determine these resting places, followed by night application of space sprays, show promise as a control measure where fly populations occur. Particle size of the insecticide is most important in open air space spraying. Field experience indicates that the optimum spray composition should possess droplets in the 20–100 micron-diameter range, with the average droplet diameter being approximately 70 microns. This means that a very wet fog or a fine mist is necessary.

(*d*) *Poison baits.*—Poison baits are being used most effectively in the control of adult flies. The basic formulation of both liquid and dry baits consists of a potent toxicant and a fly attractant. General coverage with baits is not desirable. Observations will show the sites of greatest fly concentration and bait applications should be made at those points. The frequency of application depends largely upon the fly potential present. Where the potential is high, repeated applications (even daily) are necessary. Usually the need for this rate ceases after several weeks of routine treatment so that subsequent coverage can be reduced to less frequent periods.

1. *Insecticides. — Cornmeal-malathion (2.0 percent) bait (dry)* is prepared by placing 3 pounds of finely ground cornmeal in a suitable container; while stirring slowly, add 5 fluid ounces of vegetable oil and 7 fluid ounces of 57.0 percent malathion emulsion concentrate to form a wet mash. Transfer this wet mash into a suitable mixing drum, add 7 pounds of cornmeal, and mix thoroughly. Add ½ ounce (approximately 3 teaspoonfuls) of powdered activated charcoal for color, and 1½ pounds of finely sifted powdered sugar. Mix until thoroughly blended. To prepare this bait with Diazinon proceed as described above and substitute 8 fluid ounces of 25.0 percent Diazinon emulsifiable concentrate or wettable powder for the malathion. Large quantities of bait suitable for use in outdoor breeding areas can be made economically with sand. This bait is prepared by dissolving 10 pounds of granulated sugar in 4 pints of hot water as completely as is possible. Add 4 pints of 57.0 percent malathion emulsion concentrate to 1 pint of water, stir, then mix with the sugar solution. Add this to 100 pounds of dry clean sharp sand (wash if necessary) and mix

well with paddle or hoe until thoroughly dispersed. Spread out in a thin layer to dry. When dry, break up all clumps by rolling or grinding. Store in a dry place and use within 2 weeks. *Sugar malathion bait (wet):* a 2.0 percent liquid bait is prepared by thoroughly mixing 1 gallon of molasses with 2 gallons of water, and adding 9 fluid ounces of 57.0 percent malathion emulsion concentrate. Granulated sugar may be substituted for the molasses at the rate of 0.8 pound per gallon of finished solution.

2. *Application.*—Dry baits are scattered with a shaker-top jar or can over ground and floor surfaces, at a rate of 2 to 4 ounces per 1,000 square feet, wherever flies congregate. Where debris is present, the bait should be placed on a sheet of wood, metal, or other relatively smooth material. The time and effort required for dispensing baits can be minimized through the use of permanent bait stations. This also provides for the continual reduction of the fly population. Plywood trays (1 to 2 trays per 1,000 square feet of floor area) are suitable for dispensing dry baits. Apply other liquid baits with a watering can or with a sprayer, minus the whirl plate, at a rate of 1 gallon per 1,000 square feet of floor or ground area. These baits should not be used in areas where edible products are handled. The Communicable Disease Center, U.S. Public Health Service, Department of Health, Education, and Welfare describes a 1-quart chicken-watering container fitted with a cellulose sponge in the trough to prevent clogging by dead flies as an effective device. Replenishment of the baits usually is required at intervals of 2 to 3 weeks or longer. DDVP at 0.1 percent in a 12.5 percent sugar solution is reported to be a suitable toxicant. The Communicable Disease Center further reports that with an experimental solid formulation of DDVP affixed to the base of the watering container, it is possible to replenish the bait by merely refilling the jar with sugar water as necessary. DDVP is an organic phosphorus compound and must be handled with extreme care.

(*e*) *Mechanical control.*

1. *Screens.*—Screens are necessary to aid in preventing flies from coming in contact with personnel, food, and drink, and thereby spreading diseases. The use of adulticides is much more effective where there is adequate screening. Screens should have a mesh of 18 by 18. Screen doors should be made to open outwards and should be in direct sunlight wherever practicable.

2. *Fans.*—Electric, high velocity fans properly placed over doors or in such positions that a direct air current is blown against the doorway, tend to repel flies from entering when the doors are opened. If the fans are properly placed, they are sometimes useful as a supplementary method of fly control in places where doors must be opened repeatedly, such as mess halls.

3. *Fly paper.*—This material may provide a useful index to fly populations in connection with survey or investigational work but is largely obsolete as a control measure.

4. *Electric screens.*—Electric screens are grills wired for electricity. They are attached to the outside of doors. Such devices are not recommended due to their rather low efficiency in fly control.

5. *Baited traps.*—Many types of traps have been developed for the control of flies. However, their use will not provide adequate control where heavy fly populations exist.

(4) *Control of stable flies.*

(a) *Sanitation.*—The first and most important step in the control of stable flies is destruction of their breeding places. Since stable flies breed in all types of damp decaying vegetable matter, this process involves finding the breeding places and then either destroying these sites or making them inaccessible to the flies. Where breeding is occurring in agricultural wastes, such as straw, manure, and other organic refuse, standard recommended practices should be used for storing or disposing of these materials. For example, wastes either should be maintained dry or spread so thinly that they will not support fly breeding. Stable flies breed very commonly in fermenting marine grass that is washed into windrows on ocean beaches above normal tide levels. Disposal of this material generally is not feasible and chemical larviciding is required. However, the extent and frequency of larviciding can be reduced by careful survey work, since any pile of grass which undergoes inundation for a period of 6 hours or more during the 2-week period required for the development of the immature stages will not require chemical treatments. This is true because such inundation is fatal to most of the larvae and pupae. Therefore, the only windrows of grass suitable for fly breeding are those above normal tide level by storms or during the equinoctial tides.

(b) *Chemical control.*

(*1*) *Control of immature stages.*—Breeding may be controlled by thoroughly wetting the breeding media with one of the larvicidal sprays recommended earlier for house and blow flies. As much as 5 or 10 gallons of spray may be required for each 500 square feet. DDT is not very effective against the large larvae, but after the flies emerge they will crawl over the surface and will be killed by the DDT that has been deposited.

(2) *Control of adults.*—Adult stable flies may be killed with the same materials and in the same manner as recommended for house flies, except that poison baits cannot be used. Where human discomfort is being caused and control measures are not feasible, such as with troops in the field, personal application of standard skin repellent is recommended.

(5) *Control of tsetse flies.*—Because of the diversity of habits among tsetse flies and the practical absence of a free-living larval form, they are difficult to control. Among the many modes of attack utilized

are: the use of traps, introduction of natural enemies, modification of cover, control of game animals, and establishment of fly-barriers by setting up clearings or thickets according to the species involved. DDT and lindane have been used as space treatment applied either from the air or on the ground. Aerial spray of 20.0 percent DDT or the use of fog generators with this material has been effective. Entire river courses have been treated with up to 99.0 percent reduction of adult *Glossina palpalis*. *G. morsitans* normally does not breed along rivers and is more difficult to control, since large areas of forest must be sprayed. Quarantine areas have been set up in various parts of Africa which consist of barriers along roads. Vehicles proceed rapidly through infected districts with all available windows closed. When they emerge from the quarantine area the vehicles are examined and all flies captured and killed. The results have been very good.

(6) *Control of sand flies (Phlebotomus).*—Sand flies have a very short flight range. Elimination of nearby breeding sites will give complete control within a limited area. This may include drainage in such a way as to produce complete runoff and lack of moisture in a given area. Stone and rocky areas may be covered; old rock walls and stone masonry may be either destroyed or may be faced over with mortar to cover cracks and crevices. The flight habits of *Phlebotomus* flies render the species vulnerable to the application of residual sprays. The adult flies frequently rest on outer walls before entering a building. They enter by a series of short, hopping flights with relatively long pauses. Once in a room, they may linger for a time on walls before seeking a blood meal. Application of residual sprays with the equipment and in the dosage recommended for house flies and mosquitoes is suitable for the control of sand flies. Sleeping quarters and rooms occupied after dark should be treated. Spray the inner walls from floor to ceiling and as much of the ceiling as possible. Doors, windows, and screens should be sprayed also. A still greater margin of protection is obtained by spraying the outside of doors, windows, and a foot or two of the wall surrounding these openings. The application of residual spray solutions to tents is recommended. The spray is applied to the interior surface and around the openings, including the flaps, bottom edge, and ventilating apertures. Emulsion formulations should not be used on tents because when so treated they will leak during subsequent rains. In some situations, local area control may be partially obtained by extending the spraying program to include outdoor applications of residual insecticides, thus denying to sand flies the customary outdoor shelters or breeding places, and interposing lethal barriers between the adults and the houses to be protected. The application of sprays to masonry walls, vegetation, bases of trees, and other resting places within flight range of human habitations is recommended for this purpose.

(7) *Control of culicoid biting flies (punkies).*—Many insects are most effectively controlled in the immature stages since at that time they are usually rather definitely grouped. This would apply equally well to culicoid biting flies except for the fact that it is quite difficult to determine where breeding is occurring because of their habit of developing in the soil. In addition, the larvae are very small. Control measures are not often necessary and are seldom completely successful. Careful survey work with soil flotation methods will demonstrate the presence of the larvae, but the procedure is tedious and, even in the hands of experts, subject to a considerable amount of error. Nonetheless, any serious attempt to effect control of human biting species of culicoid biting flies must be preceded by an extensive and careful larval survey. Where the area supporting larval breeding can be determined, it has been demonstrated that control of larvae can be obtained by the application of insecticides directly to the soil (for example, dieldrin applied at the rate of 1.25 pounds per acre, BHC at a rate sufficient to give 1 pound of gamma isomer, or chlordane at 2 pounds per acre). However, this is expensive, since control must be done on an area basis if early entry by adults from surrounding uncontrolled areas is to be avoided. Such heavy treatments are also injurious to many forms of aquatic life. Also, such treatments cause a rapid buildup of resistance. When special control measures are necessary, 10 percent DDT emulsion or 0.4 percent lindane emulsion should be applied as a mist to vegetation around small ponds and other breeding sites. Space application of DDT against the adults as described for black flies and mosquitoes is probably the most effective control measure presently available for bringing some measure of relief to small groups of people. The personal and quarters protective measures recommended against mosquitoes are all equally effective against culicoid biting flies. However, their extremely small size must be kept in mind wherever mesh screens or fabrics are to be used. It has been demonstrated that in order to exclude culicoid biting flies, 20 mesh screening is required. This mesh size will seriously interfere with ventilation. In this connection, the treating of screens with insecticides can be of paramount importance in the control of these insects. By spraying or painting insecticide solutions on the screens all insects alighting on and passing through the screens are affected. The difficulty with this type of control is that the insecticide on the screen wire is soon covered up with windblown dirt and dust particles. Lindane as a 0.1 percent solution or DDT as a 5.0 percent solution applied at the rate of 1 quart to every 250 square feet of screen wire (the point of runoff) has proved to be the most effective way of treating screens. Where lindane is used, only well ventilated buildings should be so treated in

order to avoid undesirable interior concentrations of vapors. The effectiveness of this type of treatment can be improved by adding 10.0 to 20.0 percent lubricating oil to the mixture.

(8) *Control of black flies (Simulium).*—Black flies are most effectively controlled by the application of larvicides to the streams where the immature forms are developing. Where only one brood of black flies emerges annually, a single treatment of streams should markedly reduce the pest problem. More frequent treatments are necessary when two or more generations emerge in a season. It is recommended that larviciding be accomplished with a 5.0 percent solution of DDT and fuel oil applied at the rate of 0.1 part of active ingredient per million parts of water for 30 minutes at the point of application. This dosage will not seriously affect other aquatic life. However, overdosage must be guarded against, since 10 parts per million of DDT will kill fish. Also, emulsions should not be used because of their higher toxicity to fish. To be effective, a black fly larviciding program in wooded areas should include all infested streams within a 5-mile radius. The larvicide should be applied at points as far up stream as can be reached, and preferably in turbulent water to insure adequate mixing. One treatment is sufficient to eliminate larvae for a distance of at least 2 miles downstream. The number of pints of a 5.0 percent DDT solution required for an application can be calculated from the formula $\frac{VWD}{9}$ where V equals average velocity in feet per second, W equals width in feet, and D equals average depth in feet. Treated streams should receive a preliminary inspection 24 hours following treatment and regular re-inspections at 2- or 3-week intervals. A method of liberating the DDT into streams is by the use of plastic blocks. The block is prepared by mixing an insecticide with plaster of paris powder. The materials recommended are 5½ pounds of 25.0 percent DDT, 11 pounds of plaster and 2¾ pints of water. After adding water, the material is stirred and poured into a box, in the center of which is placed a stick. After drying, a long rope is attached to the stick which protrudes from the block, and the entire block is then positioned in the stream. One 3″x12″x¾″ block will control larvae in a flowing stream 30′x1½′x1 mile.

DDT larviciding also can be accomplished with aircraft. Apply the spray by flying the length of the stream, emitting the spray at intervals. Where several streams are involved, it is better to fly parallel swaths across the area at quarter mile intervals. Aerial applications should be at the rate of approximately 0.2 pound of DDT per acre. Because of the long flight range of black flies and heavy population pressure in areas surrounding the control area, aerosols or mist sprayers cannot be depended upon to give effective control. Although the biting rate of black flies is usually much lower than that of mosquitos, personal protective measures against them are just as essential. Due to the large size of their biting punctures, into which an anticoagulant is secreted, black fly bites usually bleed freely. In general, all of the measures described for protection of the individual in his quarters from mosquito biting apply equally to black flies. Since black flies characteristically crawl beneath clothing whenever the opportunity presents, tight fitting cuffs and collars are essential in preventing their bites. Also, due to their small size protective netting and fabric must have a minimum of 20 meshes to the inch and 28 standard wire gauge (S.W.G.) wire or fiber.

(9) *Control of horse and deer flies (Tobanus and Chrysops).*—Little help can yet be given on the control of these pests. Space applications of insecticides similar to those recommended for the control of mosquitoes and black flies may be effective under some conditions, particularly if applied when the adult flies are active. However, in areas of heavy populations of *Tabanus* and *Chrysops*, the use of adulticides has not proved to be really satisfactory. The use of larvicides has the same drawbacks as described for the larval control of culicoid biting flies. The personal protective measures described for mosquitoes will serve equally well for protection against these flies, except that present standard repellents are not as successful as could be desired. Horse and deer flies will freely enter quarters, but not for biting purposes; consequently, the protection of quarters is not a problem here.

(10) *Control of eye gnats (Hippelates).*—The eye gnat species, *Hippelates pusio* and *H. collusor*, are the most troublesome to man within the United States. Efforts to obtain effective control of these species by the use of aerially and ground delivered sprays and aerosol fogs have been generally unsuccessful. Since these flies commonly breed in freshly disturbed soil, successful control can sometimes be accomplished by suitable modifications of local agricultural practices. Cultivation should be avoided whenever possible. The conversion of an area into pasture land may serve to relieve an eye gnat problem. Shallow disking is recommended whenever cultivation cannot be avoided. Soil application of insecticides appears to have some promise. Aldrin at 1 to 2 pounds per acre, chlordane at 4 pounds per acre and lindane at 2½ pounds per acre have been recommended, but these dosages introduce wildlife damage problems. However, both of the above methods presuppose the possession of rather complete biological data on the eye gnat species present, information which in most cases is not yet available. Where eye gnat problems are encountered, and in the absence of control measures known to be locally successful, the assistance of appropriate technical personnel should be solicited.

9–22. Mosquitoes

(1) *Relation to man.*—Mosquitoes rank first among all insects that jeopardize the health of man. The three genera most concerned are *Anopheles, Aedes,* and *Culex.* The genus *Anopheles* contains the species that transmit malaria. Dengue is transmitted only by the genus *Aedes.* The well known mosquito, *Aedes aegypti,* transmits yellow fever. Yellow fever also occurs as an infection of certain animals of tropical forests, where it is transmitted from animal to animal, and incidentally to man, by mosquito species other than *A. aegypti.* Several genera, including *Culex,* transmit the worms that cause filariasis. The causative agent of encephalomyelitis is also transmitted by mosquitoes. Besides serving as disease-bearing agents, many species of mosquitoes are serious pests of man solely because of the irritation caused by their biting.

(2) *Characteristics.*—Mosquitoes deposit their eggs on the surface of water or on surfaces subject to flooding. Larvae hatch and feed on organic matter in the water and, on completion of growth, change into pupae from which the adults later emerge. Mosquitoes are capable of utilizing a great variety of water collections as breeding areas. These include not only ground pools and water in artificial containers, but also such places as water-holding tree holes and leaf axils. Adult mosquitoes, when not actively seeking food, either blood or plant juices and nectar, rest in concealed places. Depending upon the species involved, the distance of dispersal from breeding areas varies from only a few yards to many miles. However, males normally do not fly long distances from the breeding areas and any uncommonly large concentration of this sex usually indicates that the breeding area is nearby.

(3) *Control.*—Mosquito control methods are customarily classified as being either permanent or temporary in type, depending upon whether they are designated to eliminate breeding areas or simply to kill those mosquitoes present at the time. Aside from the elimination of artificial water-holding containers about campsites, permanent control measures have a high initial cost and require extensive periods of time to consummate. Permanent mosquito control measures are considered in detail in NAVDOCKS TP–MO–310 Manual. Consequently, only temporary control methods are presented here.

(a) *Control of immature stages.*—Temporary control of mosquito breeding is accomplished by treating water surfaces with larvicides. Larviciding equipment is described in chapter 10.

(*1*) *Ground larviciding.*—Where there is no resistance, DDT solutions, emulsifiable concentrates, and water-dispersible powders may all be used effectively for larviciding with ground-operated equipment. The use of dusts may be indicated where a heavy vegetative cover must be penetrated or where possible damage to crops, such as rice, is a consideration. Individual applications should be at the rate of 0.2 pound of DDT per acre in draining areas, or in areas where beneficial wildlife occur. If mosquitoes are proved to be resistant to chlorinated hydrocarbons by laboratory tests, malathion at the rate of 0.5 pound of toxicant per acre may be applied. More frequent treatments will be required with this material. However, in some species, larvae and adults have developed resistance to malathion. Paris green pellets applied at the rate of 15 pounds of 5.0 percent granules per acre may be used where the organic prosphorous compounds are no longer effective. Because dilution (percentage of toxicant) and application rate (gallons per acre) vary with the type of equipment employed, with the species of mosquitoes involved and with the geographical area concerned, current recommendations should be obtained from appropriate local technical personnel. Solutions or emulsions are not recommended for application to waters containing valuable aquatic wildlife, since this type of formulation is more toxic to such wildlife than are dusts or suspensions.

(*2*) *Aerial larviciding.*—In larviciding by airplane, DDT, 20.0 percent airplane spray diluted in No. 2 diesel oil, may be used in the absence of resistance. Depending upon the openness of the terrain and the species of mosquitoes being controlled, an application rate of from 0.05 to 0.2 pound of DDT per acre is recommended. In the event mosquitoes are resistant to the chlorinated hydrocarbons, malathion at the rate of 0.5 pound of toxicant per acre, either as a liquid spray, or in granules, can be substituted. Paris green pellets also can be applied from aircraft. All aerial spraying requires approval of the appropriate District Headquarters. (See current instructions of the 6250 series.)

(*a*) Granulated insecticides are dust particles or pellets of bentonite clay or other materials approximately 16–30 mesh in size that have been impregnated with an insecticide. The use of granules is indicated where heavy foliage prevents a liquid spray from penetrating to the water. They may be applied by aerial or ground equipment. Most of the commonly used larvicides can be obtained in this form through open purchase.

(*3*) *Control in water containers.*—Containers such as empty tin cans and old tires, in which mosquito larvae may breed, should be eliminated if possible. Those that cannot be eliminated should be treated with larvicide to control and to prevent breeding. Fire barrels should be treated by adding 1 tablespoonful of 25.0 percent DDT emulsifiable concentrate and stirring. In cases of resistance to DDT, dieldrin-cement pellets will control domestic species. Incorporation of dieldrin water-wettable powder (50.0 percent) in sand: cement (5:1) and application at a rate of one 10-gram pellet (content 16.6 percent dieldrin) to 2 gallons of water, gives long-lasting control in water barrels.

(b) *Control of adult mosquitoes.*—Adult mosquitoes may be controlled by the application of residual and space sprays.

(1) *Indoor control.*—Space sprays are recommended for the interior control of mosquitoes where immediate eradication is required. The standard Navy space spray contains DDT dissolved in an odorless, nonstaining solvent. In addition, a quick-acting, knockdown agent (one of the thiocyanates) is included. The rate of application should be determined by observation. Space sprays also can be effectively applied with pyrethrum aerosol dispensers. Treatment with the standard aerosol dispenser should be at the rate of 6 seconds of discharge per 1,000 cubic feet of space. Space sprays have little or no residual effect and must be reapplied whenever new mosquitoes enter the space. Where frequent re-entry is a problem, or where disease-bearing mosquito species are involved, it becomes necessary to apply residual sprays to all surfaces on which mosquitoes are likely to rest. Residual sprays differ from space sprays principally in possessing a greater concentration of the toxicant material. Only insecticides with long-lasting effects, such as DDT, are suitable for use in residual sprays. Residual treatment for mosquito control should be made with 5.0 percent DDT solution or emulsion. Where rough absorbent surfaces are involved, the use of a 5.0 percent DDT suspension made by mixing a water-dispersible powder in water is more effective than the use of either solution or emulsion. Where mosquitoes are found to be resistant to the chlorinated hydrocarbons, the use of a 3.0 percent malathion solution or emulsion applied as a spot residual is recommended. Where undisturbed, such application will remain effective for several weeks. A residual fumigant method employing DDVP shows promise against anophelines inside homes. The effectiveness varies with the degree of ventilation. Equipment required for residual and space applications is described in chapter 10.

(2) *Outdoor control.*—Space treatment with fogs or mists containing DDT is recommended for the outdoor control of mosquito adults. Insecticidal fogging is considered to be a desirable method for preventing annoyance by mosquitoes in limited bivouac areas only when control of breeding sources is not feasible. Fogging in itself will seldom effect a very complete mortality of the mosquitoes in the control zone, but because of the repellency effect of the fog, it will frequently bring adequate protection for short periods. However, in any area where insect production is continuous and dominated by migratory species, the use of fogging alone is satisfactory only if done on a repetitive basis. When properly applied, fogs do not leave either a dangerous or unsightly deposit. Where this is not a problem, such as in less densely inhabited areas, insecticidal application by means of a mist blower will give satisfactory control.

(a) *Area treatments.*

1. For exterior fogging treatment, use DDT, 8.0 percent in diesel oil solution, applied at the rate of 8 gallons per linear mile. It is recommended that DDT, 20.0 percent aerial spray, be used for making this solution. Fogging should not be accomplished when wind speeds are more than 7 miles per hour, nor when the ground is warmer than the air directly above it. Since fog applications are most effective against flying insects, it should be accomplished when they are active and not when they are resting. Where resistance to DDT is known to exist, ground dispersed fogs of 6.0 percent malathion in fuel oil, at the rate of 8 gallons per mile may be used.

2. For exterior mist treatment use DDT or malathion as a 5.0 percent emulsion applied at the rate of 12 gallons per linear mile. When misting is accomplished on warm days with some upward air currents present and with light winds (5 to 10 miles per hour), effective swath widths of several hundred feet may be obtained over open terrain. Applications by means of a mist blower will generally give more satisfactory control of mosquitoes than will the use of a fog generator. This is due in part to the light residual effect obtained from mist applications and in part to the fact that mists can be applied under a wider range of atmospheric conditions than can fogs. However, penetration of dense vegetation by mists is less satisfactory; valuable foliage can easily be burned by oil-based insecticides; and objectionable residues may result in inhabited areas.

(b) *Residual sprays.*—True residual sprays have a limited exterior applicability for the protection of small camps. The spray is applied to all vegetation surfaces for an area of 100 feet or more around the place to be protected. Apply DDT, 5.0 percent aqueous emulsion, or suspension as a spray, at the rate of 12 gallons per acre (an application rate of 5 pounds of DDT per acre). Where DDT resistance exists, substitute malathion for the DDT.

(4) *Protective measures.*

(a) *Screening.*—Living quarters in permanent or semipermanent camps should be protected with 18 by 18 mesh screening. Where vector species are present, bed nets should be used as additional protection.

(b) *Personal protection.*—Personal application type insect repellent in 2-ounce bottles should be obtained in such quantities as to provide an allowance of three bottles per man per month in areas where mosquitoes are a problem. To use the repellent properly, shake 12 to 15 drops into the palm of the hand, and after rubbing the hands together make an even application to all exposed skin surfaces. Care should be taken to avoid mucous membranes. The repellency usually persists for several hours, but the duration is shortened by such factors as rain and perspiration. Clothing also may be treated with this repellent. Two ounces are sufficient to treat one uniform completely. Long sleeves

and trousers should be the required uniform after sundown in malarious areas. The itching that results from the feeding of mosquitoes or of other blood-sucking arthropods on some individuals usually may be alleviated by use of the following preparation:

Benzocaine	50 grams
Methyl salicylate	20 grams
Salicylic acid	5 grams

Dissolved in 730 milliliters of 95.0 percent ethyl alcohol, and distilled water added to bring the volume to 1 liter.

(c) *Camp location.*—In areas where disease-bearing mosquitoes occur, native environs should be off-limits to all military personnel. Furthermore, care must be exercised to locate camps as far as possible from native villages (at least 1 mile and preferably 2 or more).

(d) *Medicinal prophylaxis.*—The routine administration of a combined chloroquine-primaquine tablet to the men as a prophylactic measure is essential in malarious areas as a supplement to vector control. The treatment of native malaria carriers is also an important fctor in the protection of a landing force.

9–23. Lice

(1) *Relation to man.*—Human lice are responsible for the transmission of epidemic typhus, trench fever, and louse-borne relapsing fever. Louse-borne typhus has been one of the historic scourges of mankind. It is one of the few serious insect-transmitted diseases in which man himself serves as the so-called animal reservoir. Trench fever is thought to be related to typhus fever. It does not kill, but it can be a debilitating epidemic disease among louse-infested troops. Louse-borne relapsing fever is caused by a spirochete and is most prevalent in parts of North Africa and Asia. In addition to serving as the transmitting agent of these serious diseases, human lice are instrumental in causing a great deal of misery among infested people. The human louse species do not infest any other types of organisms.

(2) *Characteristics.*—Two species of lice infest man: the human louse, *Pediculus humanus;* and the crab louse *Phthirus pubis.*

(a) *Human louse.*—Two forms of the human louse exist: the body louse and the head louse. These two forms are quite similar, differing principally in the part of the body normally occupied. The body louse is found upon the body, spending much of its time attached to the undergarments. The head louse is found upon the head and neck, clinging to the hairs. The egg of the body louse is attached to fibers of the underclothing, whereas the egg of the head louse is cemented to the hair. This egg is commonly called a "nit." The eggs of the human louse are incubated by the body heat of the host, hatching in about a week. Hatching is greatly reduced or completely prevented by exposure to temperatures above 100° F., or lower than 75° F. Thus, it is apparent that the intermittent wearing of clothing provides an excellent natural control method for the body louse. The immature lice resemble the adult in body form, becoming progressively larger as development takes place. Frequent blood meals from the host are required, and lice succumb within a few days if denied the opportunity to feed. Head and body lice are normally acquired by personal contact, by wearing infested clothing, or by using infested objects such as combs and brushes.

(b) *Crab louse.*—The crab louse is primarily found upon the hair in the pubic and anal regions, but on occasion may be found on any hairy portion of the body. This insect feeds intermittently for many hours at a time, and is accordingly unable to survive more than a short time away from the host. Crab lice are spread chiefly by close personal contact and, more rarely, are received from surfaces and objects recently used by infested individuals.

(3) *Control.*—Control includes delousing of individuals, the treatment of infested clothing, equipment, and spaces, and prevention of new infestations. Human louse control measures must be accomplished with the knowledge of the medical officer.

(a) *Preventive measures.*—The following preventive measures should be taken:

(*1*) Avoid contact with louse infested individuals or materials.

(2) Observe personal cleanliness, i.e., at least weekly bathing with soap and water, and clothing changes, particularly of the underclothing.

(*3*) Avoid overcrowding of personnel.

(*4*) Instruct personnel on the prevention of louse infestation.

(*5*) Conduct frequent inspections of body and clothing for evidence of lousiness.

(b) *Individual treatment measures.*

(*1*) *Insecticides.*—The louse powder insecticide, 2-ounce shaker can, is a mixture of 10.0 percent DDT in pyrophyllite or talc. It is issued as a finished product for individual use. The dusting powder, 1.0 percent lindane, 2-ounce shaker can, is available for use in areas where resistance to DDT has been demonstrated. Malathion, 1.0 percent dust, will control lice that are resistant to both DDT and lindane and is effective against the eggs.

(*2*) *Body louse.*—For prevention or treatment of infestations of body lice, dust the entire inner surface of underwear and of any other clothing worn next to the skin, including the shirt. Dust along the seams of the outergarments. Rub the treated clothing lightly to spread the powder. About 1 ounce of insecticide per person is required. If clothing cannot conveniently be removed for making application, unbutton the shirt and trousers and dust the powder liberally on the inside of underwear or other garments next to the skin. Then pat the

clothes with the hands to insure even distribution of the powder. Since extra clothing and bedding may serve as a source of reinfestation, these items also should be dusted. Eggs of lice are not affected by DDT, but the young lice are killed soon after hatching. Susceptible lice exposed to DDT can be expected to begin dying in 6 hours, with complete mortallty occurring after 20 hours of exposure.

(3) *Head louse.*—For head lice, apply the powder lightly to the hair and rub in with the fingertips. Do not wash the hair for at least 24 hours. Since the eggs are not killed by the insecticides, second and third applications should be made at weekly intervals for full effectiveness.

(4) *Crab louse.*—For crab lice, apply the powder to all regions of the body having a moderate to heavy growth of hair. Thorough application is important. Do not bathe for at least 24 hours. One or two repeat treatments at 10-day intervals may be necessary.

(c) *Mass delousing measures.*—If 50 percent or more of the unit personnel are infested, mass delousing measures should be taken.

(1) *Delousing powder.*

(a) Bulk-issue 10.0 percent DDT delousing powder is available for use in mass delousing with hand and power dusters.

(b) For small operations the plunger-type hand duster is suitable. This item is equipped with a 6-inch metal extension tube and delivers an even flow of powder. One duster ¾ full holds enough powder to treat approximately 10 individuals. Best results are obtained when dusters are not filled completely.

(c) The standard power dusting equipment item consists of a small portable gasoline engine, an air compressor, 10 lengths of hose, and 20 dusters. The extra dusters are supplied to enable refilling while others are in use. One complete unit is capable of delousing 600 or more persons in 1 hour. The use of this power dusting equipment is especially suited for treating infested persons at military installations, troops in rear areas, prisoners of war, civilians adjacent to troop concentrations in occupied territory, and personnel boarding transports for overseas destinations. Since a period of time subsequent to dusting is required for the elimination of infestation, delousing by dusting will not be used in United States ports of debarkation for infested returning troops, except as a supplement to other measures. Where power dusting equipment is used, about 100 pounds of dusting powder will be required for each 1,000 men to be deloused. Additional powder would be required for extra clothing and bedding.

(d) The dusting of personnel should follow a definite routine to avoid missing portions of the clothing. A suggested procedure, which may be modified as the situation warrants, is outlined in the following steps:

1. Direct personnel to loosen collar, tie, and belt, and to stand with hat in hand.

2. Dust the head first, separating the hair to insure even distribution. The hair should be whitened with the dust.

3. Dust the inside of the hat.

4. Insert nozzle into right sleeve next to the skin, with subject's arm outstretched to the side at shoulder height, and direct powder toward the armpit. Hold the trigger of the power duster down until powder is seen to issue from the loosened neck of the shirt. The subject's face should be turned away from the side being dusted. Repeat for the left sleeve.

5. Insert nozzle in the front of the shirt at collar and direct the powder toward the right armpit, toward the stomach, and toward the left armpit. Operator stands in front, and subject leans forward with head tipped back.

6. Insert nozzle in the front of the trousers, next to the skin, and direct powder toward the right leg, toward the pubic region, and toward the left leg.

7. Insert nozzle in the back of the shirt at the collar and direct the powder toward the right shoulder, toward the small of the back, and toward the left shoulder. Operator and subject remain in same relative position as above, but with head of subject bent on chest. Powder should be dusted on collar itself where lice frequently are found.

8. Insert nozzle in the back of the trousers, next to the skin, and direct powder toward the right leg, toward the buttocks crease, and toward the left leg.

9. When using hand dusters, two full, even strokes in each position are required. With power dusters, a momentary pressure on the trigger is usually all that is necessary. The exact timing must be learned by experience. In dusting women, if the clothing is first loosened at the waist, an extra quantity of dust can be blown in at the sleeves and collar, dispensing with actual dusting at the waist.

10. Because extra clothing and bedding may serve as a source of reinfestation, they also should be dusted.

9–24. Bed Bugs

(1) Detailed information on the relationship to man, characteristics, and control of bed bugs is contained in article 9–34. This information will apply equally well to the control of bed bugs at advanced bases and in the field.

9–25. Cockroaches

(1) Detailed information on the relationship to man, characteristics, and control of cockroaches is contained in article 9–32. This information also applies to the control of cockroaches at advanced bases and in the field.

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9–26. Mites

(1) *Relationship to man.*—Based upon their habitats, mites of medical importance may be classified into 4 groups: nest-inhabiting mites parasitic on birds and rodents, and occasionally biting man; mites parasitic on animals other than man and occasionally biting man; mites parasitic on man; and food-infesting which occasionally attack man.

(a) *Nest-inhabiting mites.*—All of these mites live within the nests of birds and rodents and only attack man when deprived of their normal hosts. Medically, the house-mouse mite is the most important member of this group, since it is a carrier of rickettsialpox from mouse to man.

(b) *Mites parasitic on birds and rodents.*—These mites are parasitic on rodents, birds, and reptiles, and only incidentally attack man. The term "chigger" is applied to the larvae of certain species of this group. Many of the species cause dermatitis to man, and a few transmit scrub typhus (Tsutsugamushi disease), a severe and debilitating rickettsial disease of man endemic to some land areas of the Pacific.

(c) *Mites parasitic on man.*—This group includes the well known scabies or itch mite. The scabies mite is transmitted through close body contact and appears wherever social conditions are such as to cause the excessive crowding of people. This mite burrows into the horny layer of the skin, causing an intense itching, especially at night.

(d) *Food-infesting mites.*—Many species of mites infest dry foods such as bread, cheese, cereals, and smoked meats. Not only do they infest and destroy such foods, but some of them can cause a dermatitis to workers handling infested materials. These mites also have been found to cause certain lung disorders where they are plentiful enough to be inhaled. Some records indicate that these mites may infest the urinary tract in man, causing infection and irritation. In addition, ingestion of infested food materials may lead to digestive disturbances.

(2) *Characteristics.*—Mites may be recognized by the fact that they possess no distinct body segmentation. They are usually very small, some being less than 1/200 of an inch long. After hatching from the eggs, mites pass through 3 active stages: larva, nymph, and adult. The larva is 6-legged and the nymph and adult forms are 8-legged. Relatively little is known about the biology of mites. In those species which transmit scrub typhus, the larval forms are parasitic on rodents, and incidentally on man. This stage is almost microscopic in size and is usually red or pinkish in color. It does not take blood but feeds upon lymph and epidermal tissues which are partially predigested by the secretion of salivary fluids into the host's skin. The nymphs and adults of these mites are free-living and are predaceous upon eggs of small insects and related organisms. The adults lay their eggs on the ground. Chiggers are most often found in damp areas covered with vegetation, such as margins of lakes or streams, shaded woods, high grass or weeds, and berry patches.

(3) *Control.*

(a) *Nest-inhabiting mites.*—Elimination of the house-mouse mite and other important mite species of this group is principally dependent upon control of the hosts. In addition to this measure, it may sometimes be necessary in the case of infested structures to apply chlordane or dieldrin residual sprays in the manner recommended for the interior control of flies and mosquitoes. Where the structure is regularly inhabited by man, applications of chlordane and dieldrin should be restricted to the infested areas only.

(b) *Mites parasitic on birds and rodents.*—Chiggers are the mites of primary importance to man in this group.

(*1*) *Protective measures.*—Personnel operating in areas where chiggers exist and constitute a health hazard should be required to use skin repellents and repellent-impregnated clothing. If troops sleep on the ground, sleeping bags also should be treated with repellent. The use of repellents is not to be regarded as a substitute for area sanitation, but in combat or forward areas repellants frequently may be the only available means of securing protection against chiggers. Skin applications are made by shaking about 12 drops of the standard issue insect repellent, personal-application type, into one hand, rubbing the hands together and applying the repellent in a thin layer over the arms and legs and along the edges of clothing openings. Reapply as required to keep the skin protected. Individuals may impregnate their clothing with this repellent. Ordinarily, 2½ ounces of repellent per uniform is required to give protection. Special effort should be made to thoroughly wet socks, shoe tops and fly; trouser leg cuffs, fly and waist band; and shirt front fly and cuffs. Where large numbers of personnel are involved, it is preferable to mass-impregnate clothing rather than to rely upon individual application. A clothing treatment repellent, which provides protection against a variety of insects, mites, and ticks is available through supply channels (Insect Repellent, Clothing Application). Impregnation may be accomplished by hand dipping the clothing by units in the field or by machine impregnation in fixed or mobile laundry units. Dilution rates vary with method of impregnation and type of cloth used. Treated uniforms should not be worn until after they are thoroughly dried, and untreated underwear should always be worn to prevent skin irritation. Blankets and sleeping bag covers also should be impregnated whenever bivouacs in infested areas are planned. Prolonged or excessive contact with repellent, particularly the concentrate, should be avoided during impregnation procedures. Plastics, such as watch crystals, fountain pens, and pocket combs, may be adversely effected by contact with repellent or with repellent-treated clothing. The

combined use of skin repellent and of repellent-impregnated clothing should give adequate protection for several hours. However, the actual length of skin protection time will vary depending on the amount applied, atmospheric humidity, body perspiration, rubbing of the treated areas, and the individual himself. Adequately treated clothing will give complete protection for a number of days, the exact length of time depending upon the number of washings or of wettings, the fabric involved, and the repellent used. Where possibility of scrub typhus transmission occurs, great care must be taken to insure that clothing is retreated at sufficiently frequent intervals. For the relief of itching caused by chigger bites, use the formulation described in article 9–22, paragraph (4)(b).

(2) *Control measures.*

(a) *Clearance of vegetation.*—Locations which are to be used as new camp sites should be prepared as fully as possible before the arrival of occupying units. A bulldozer should be used if available. All vegetation should be cut level with the ground and burned or hauled away. Chiggers customarily live only in damp shaded soil and any procedure which exposes the ground to the drying effect of sunlight will help to eliminate them. After a thorough clearing, the ground usually dries sufficiently in 2 or 3 weeks to kill the mites. Personnel engaged in clearing operations must use protective measures.

(b) *Use of insecticides.*—In situations where troops must live or maneuver for periods of time in chigger infested areas, it is recommended that area control with residual applications of insecticides be accomplished. Chlordane at the rate of 2 pounds per acre, dieldrin at 1 pound, and lindane at 0.5 pound per acre have been shown to give effective area control of chiggers in the United States. Dieldrin, at the rate of 2.25 pounds per acre, was the insecticide of choice in a test made against scrub typhus vectors in Borneo. The residual effectiveness of any of these materials, when applied at the above recommended dosage rates, will be found to vary with both the species of chigger and the area involved. Consequently, some experimentation with materials and application rates may at times be required. Application can be accomplished either with aqueous sprays, using emulsifiable concentrates or wettable powders, or with dusts. In the use of sprays, the amount of water needed as a diluent will vary, depending on the per-minute output of the equipment used and on the kind and density of vegetation present. It takes 15 to 25 gallons of spray per acre to treat lawns or similar areas, and 50 gallons or more per acre for thorough coverage of heavily vegetated areas. Application rates for dusts will vary from 25 to 50 pounds per acre, again depending upon the terrain. DDT has no value as a residual insecticide in the area control of chiggers (see NAVMED P–5052–21, Scrub Typhus (Mite-borne Typhus Fever, Tsutsugamushi Disease) of 28 June 1962).

(c) *Mites parasitic on man.*—Control measures for scabies or itch mites should be supervised by a medical officer. These operations include the treatment of individuals with either crotamiton ointment, 10.0 percent, or with benzene hexachloride ointment, 1.0 percent gamma isomer (both available from Navy standard medical supply), and the disinfestation of clothing and bedding with heat.

(d) *Food-infesting mites.*—Control of these mites is accomplished through the elimination of infested materials, the sanitation of food storage and handling areas, and the use of appropriate residual sprays.

9–27. Ticks

(1) *Relation to man.*—Ticks are annoying pests and, in addition, some species are transmitters of the causative agents of human and animal diseases. Additionally, in some portions of the world, there occurs in man and in certain domestic animals a condition known as tick paralysis. The exact etiology of this condition still remains undetermined, but the prevailing opinion is that a substance secreted by the tick is responsible for the paralysis. The importance of ticks as transmitters of disease agents has been long recognized. Among the more important diseases associated with ticks are Rocky Mountain spotted fever, Sao Paulo fever, relapsing fever, and tularemia.

(2) *Characteristics.*—There are 4 stages in the development of a tick: egg, larva, nymph, and adult. The eggs are laid on the ground, in the cracks and crevices of houses, or in the nests and burrows of animals. They may be laid in 1 large batch, or in several smaller lots. The period of incubation varies from 2 weeks to several months. The larva is the stage which emerges from the egg. It is very small and has only 6 legs. Usually the larva requires at least 1 blood meal before it can develop to the next stage. The nymph is an 8-legged form which results from the molting of the mature larva. A nymph is sexually immature and lacks a genital opening. All nymphs require 1 or more blood meals before transforming to the adult. Following 1 or more molts of the skin the nymph transforms to the adult. Some adult ticks require a blood meal before copulation; others do not. The 2 principal types of ticks are: hard ticks and soft ticks. The hard ticks, so-called because they possess a hard back, attach themselves to their hosts during the blood-sucking act and may remain there for a considerable period of time before engorgement is completed. The larva and nymph take only 1 blood meal each, and the adult female takes only a single, enormous blood meal before dropping off the host to digest the blood and lay a single large batch of eggs. Most hard ticks have either 2 or 3 hosts during their development. The brown dog tick (*Rhipicephalus sanguineus*)

and the Rocky Mountain wood tick (*Dermacentor andersoni*) are included in the hard tick group. The soft ticks have much the same habits as bed bugs, hiding in cracks or crevices in houses or in the nests of their hosts, and coming out at night to feed on the blood of the host for a short period. The larvae and nymphs generally feed several times before molting. The adult female feeds a number of times, laying a small batch of eggs after each feeding. The fowl tick (*Argas persicus*) and the relapsing fever tick (*Ornithodoros turicata*) are included in the soft tick group.

(3) *Control.*

(a) *Protective measures.*

(*1*) Avoid infested areas whenever possible.

(*2*) Wear protective clothing. High-top shoes, boots, leggings, or socks pulled up over the lower ends of trousers help to prevent ticks from crawling beneath outergarments. At the end of the day inspect the body thoroughly for attached ticks and make sure that none have migrated from infested clothing to bedding or to fresh clothing.

(*3*) Repellents. The application of the standard issue insect repellent, personal-application type, is effective against ticks in the immature stages and gives some protection against adults. The repellent can be applied by drawing the mouth of the inverted bottle along the inside and outside of clothing openings. Two ounces per man per treatment of the proper repellent has proved effective for 3 to 5 days. Impregnation of clothing with insect repellent, clothing-application type, as described for mites in article 9–26 is the method of choice for the protection of troops operating in tick-infested areas.

(*4*) Ticks found with their mouthparts embedded in the skin should be removed at once. Experience has shown that a steady pull with forceps or fingers and using a slight twist is the best method for removing them. Care should be taken not to crush the tick or to remove it so forcibly that the mouthparts are left embedded to become a possible source of infection. The wound should be treated with a suitable antiseptic. Where hair is not involved, the use of scotch tape is an effective means of removing tick larvae and nymphs from the skin.

(b) *Control measures.*

(*1*) *Clearance of vegetation.*—Clearing vegetation from infested areas will aid in the control of ticks and is recommended for bivouac and training grounds. All low vegetation should be uprooted with a bulldozer or cut and then burned or hauled away.

(*2*) *Use of insecticides.*

(*a*) *Outdoors.*—In situations where troops must live or maneuver for periods of time in tick infested areas, area control with residual applications of insecticides should be accomplished. DDT at the rate of 3 pounds per acre, chlordane at 2 pounds, dieldrin at 1 pound, or BHC at 0.5 pound gamma per acre have been shown to give effective tick control in areas of the United States. Application may be accomplished with either sprays or with dusts. DDT has a slow action against ticks and does not always kill those which have become engorged. Gamma BHC kills all stages quickly, including engorged ones, but loses its effectiveness in a shorter time than does DDT. The effectiveness of any of these materials when applied at the above dosage rate will vary with both the species and the area involved. Consequently, some experimentation with various dosages and materials may at times be required. The sprays should be made by mixing either an emulsifiable concentrate or a wettable powder with water. Oil solutions should not be used since they will burn vegetation. The amount of water will depend on the volume output of the equipment used and on the kind and density of vegetation present. It takes 15 to 25 gallons of spray per acre to treat lawns or similar areas, and 50 gallons or more per acre for thorough coverage of wooded or brushy areas. Vegetation should be sprayed to a height of 2 feet. Application rates for dusts will vary from 25 to 50 pounds per acre, depending upon the terrain. Insecticides should be applied as early in the year as ticks are noticed. One application may be effective for an entire season, but if ticks again become annoying, it may be necessary to repeat the treatment.

(*b*) *Indoors.*—The brown dog tick frequently becomes established in dwellings and, under such circumstances, is often very difficult to control. A residual spray of 0.5 percent lindane solution or emulsion is the treatment of choice in such cases. Apply the spray thoroughly to all possible harborages, including such places as baseboards, around door and window moldings, behind pictures, under furniture, around the edges of rugs, on curtains and draperies, and in all cracks. A second or third treatment also may be needed. It should be borne in mind that residual treatments with lindane in living spaces are to be made to infested areas only, and are not to cover more than 20.0 percent of the total wall and floor area. Residual sprays of 5.0 percent DDT solution or 2.0 percent chlordane solution also can be used for control of the brown dog tick, but are generally not as effective as lindane. Recent studies indicate both Diazinon and malathion are effective residual treatments against brown dog ticks. Either Diazinon emulsion (0.5 percent) or malathion (1.0 percent) in deodorized kerosene will provide effective control. Since this tick is usually introduced into living spaces by dogs, control procedures also should include an extensive residual spraying with lindane of the spaces utilized by the dog at night, and a weekly dipping of the dog in a 0.045 percent lindane emulsion. Dusts containing one of the following materials can be applied directly to the dog; lindane (1.0 percent), chlordane (2.0–3.0 percent), DDT (5.0 percent), and malathion (3.0–5.0 percent), generally more than

one treatment is necessary to eliminate the infestation.

9–28. Fleas

(1) *Relation to man.*—Like most other blood-sucking parasites, fleas are intimately connected with the transmission of disease. They are of greatest importance in the transmission of bubonic plague, which alone is sufficient to rank fleas among the most important insect enemies of man. They also transmit endemic or murine typhus and act as the intermediate hosts of certain parasitic worms. Gravid females of the peculiar "chigoe" or burrowing flea (*Tunga penetrans*) penetrate the skin to complete their development, causing skin lesions on the feet of man and of animals. Fleas found outdoors are frequently called "sand fleas"; however, they do not breed in the sand without animal or bird hosts to feed on.

(2) *Characteristics.*—All fleas are ectoparasites of birds and mammals. They are small brown, hard-bodied insects, completely devoid of wings, but equipped with powerfully developed legs especially adapted for jumping. Most fleas remain on their hosts less constantly than do lice, but they visit their hosts more frequently than do bed bugs. The nest or burrow of the host is the home of the egg, larva, pupa, and frequently the adult flea. Flea eggs are oval, pearly white objects dropped at random to the ground, floor or animal bedding, where they hatch into larvae in a few days. Flea larvae, which are tiny, cylindrical, maggot-like creatures with neither legs nor eyes, feed on organic matter and become full grown in about 2 weeks. When they are ready to change into pupae, the larvae spin silken cocoons which are somewhat viscid so that particles of dust and lint adhere to them. Unlike most blood-sucking insects, fleas feed at frequent intervals, usually at least once a day and sometimes even more often. This is due to the fact that fleas are easily disturbed while feeding and seldom complete a meal at one bite. The "chigoe" flea is exceptional in that the fertilized female burrows into the skin of its host, particularly between the toes, under the toenails, and in the tender parts of the feet. Here, nourished by the host's blood, the eggs begin to develop. The abdomen swells almost to the size of a pea with the posterior end of the flea flush with the surface of the host's skin. The eggs mature and are expelled through the tip of the abdomen; the female then shrivels up and drops out or is expelled by ulceration.

(3) *Control.*

(a) *Protective measures.*

(*1*) Avoid infested areas whenever possible.

(2) Wear protective clothing, or at least roll socks up over trousers to prevent fleas from jumping on the skin.

(3) Repellents. The application of standard issue personal-application type insect repellent is effective for short periods.

(b) *Treatment of breeding areas.*

(*1*) In infested buildings, apply a residual spray solution or emulsion containing 5.0 percent DDT on the floors and rugs and on wall surfaces to a height of about 2 feet above the floor, at the rate of 1 gallon per 1,000 square feet. This dosage should be doubled for earthen floors and when spraying beneath buildings. A 2.5 percent malathion solution or emulsion may be used where resistance to DDT has been demonstrated.

(2) Flea infested areas such as yards and under buildings should be treated with a 5.0 percent water emulsion of DDT at the rate of 2 gallons per 1,000 square feet. Where resistance to the chlorinated hydrocarbons is suspected, a 2.5 percent malathion emulsion spray is recommended. Other materials that have provided good control in such areas are lindane, ronnel, and Diazinon (each used at 1 gallon of 1.0 percent per 1,000 square feet).

(3) In some cases the elimination of fleas requires the control of rodents. When flea-borne diseases are present, rat burrows should be dusted with 10.0 percent DDT powder prior to conducting rodent control measures to prevent fleas from leaving dead or trapped rats and migrating to other animal or human hosts in the area.

(c) *Treatment of infested animals.*—Since indoor flea infestation normally originates from infested pets, any program for controlling such infestation must include plans for disinfesting dog and cat pets. Dogs are best treated with dusts containing 5.0 percent DDT, 2.0 to 5.0 percent chlordane, or 1.0 percent lindane. Dogs less than 2 months old and all cats should not be treated with any of these formulations, but can be treated safely with a 4.0 percent malathion dust. Cats also can be dusted with rotenone (1.0 percent) or synergized pyrethrum (0.2 percent). Bedding used by pets should be simultaneously sprayed or dusted. In treating an animal, apply the dust only to the back of the head, back of the neck, and along the backbone to the hips. Only a very small quantity of dust is required and it should be worked down to the skin where it cannot be removed easily by shaking, licking, or rubbing.

9–29. Reduviid Bugs

(1) *Relation to man.*—Reduvild or cone-nosed bugs of several genera, including *Triatoma, Rhodnius,* and *Panstrongylus,* are important to man as vectors of the causative organism (*Trypanosoma cruzi*) of Chagas' disease or American trypanosomiasis. They occur in South America, Central America, Mexico, and Southwestern United States. Briefly, the infected bug bites man, defecates during feeding or soon afterwards, and the infected feces

are rubbed into the site of the bite by scratching or rubbing. Infection also may take place through the conjunctiva, mucous membrane, wounds, or scratches.

(2) *Characteristics.*—Reduviid bugs are nocturnal, blood-sucking insects. They are about ½ to ¾ of an inch in length; the wings are half leathery and half membranous; the head is prolonged and cone-like with a beak divided into 3 segments, folded under between the front legs; the abdomen is flared out and upwards to form a depression for the wings. Nymphs are similar to adults except for being smaller and having wings undeveloped or only partially so. The eggs are deposited in dusty corners of houses or in nests and burrows of animal hosts. The young hatch out as nymphs, obtain blood meals from their hosts, shed their skins and in so doing grow into larger nymphs. This is repeated until they have passed through 5 nymphal stages and finally become adults. The entire life cycle usually requires 1 to 2 years. The normal hosts of these bugs are rats, bats, armadillos, and sloths. Their bite is usually so painless that one who is bitten during sleep is not awakened. Usually there is no reaction to the bite, but in a number of instances individuals have experienced symptoms of dizziness, nausea, and intense itching on various parts of the body.

(3) *Control.*—Destruction of reduviid bugs is difficult. Invasions by them can be prevented by screening and otherwise making habitations insect proof. Nests of wood rats and other host animals should be eliminated in the general area of dwellings, particularly from under structures. For chemical control, lindane or dieldrin as a 0.5 percent solution or emulsion should be used as a residual treatment on the interior walls and floors of quarters at the rate of 1 gallon per 1,000 square feet of surface. When these materials are used, care should be taken not to treat more than 20.0 percent of such surfaces in any spaces regularly occupied by personnel.

9–30. Rodents

(1) *Relation to man.*—The rodent is an ever present menace to operations in the field. Such rodents as rats, mice, and ground squirrels are reservoirs for plague, endemic typhus, tularemia, and other debilitating diseases. When operations become more stable and semipermanent camps are established, the additional problem of property damage and destruction must be considered. The distribution of rodents may be considered worldwide; hence, the problem of their control is faced during operations in any geographical location.

(2) *Characteristics.*—Rats have lived in association with man for ages. This close and long association has produced several species of rats peculiarly fitted for specialized conditions. Three species of common house rats occur generally on the American mainland. In addition to these forms, several other species occur in other areas of the world. The semiwild forms which live in the jungles, forests, and wastelands have little or no contact with man and are relatively unimportant in rodent control; however, military operations and occupation may change this picture to some extent. The most important rats from the medical and economic viewpoint are:

(a) *Norway rat.*—The Norway or brown rat is a comparatively large species, weighing from about 10 to 17 ounces, with a tail that does not exceed the combined length of head and body. This rat is present wherever human activity creates suitable harborages and adequate food supply. It prefers to burrow for nesting and is found mainly in basements, embankments, on lower floors of buildings, in drains or sewer lines, and in the holds or lower decks of ships. Preferred foods include meat, fish, or flesh mixed with a diet of grains, vegetables, and fruit.

(b) *Roof rat.*—The gray, Alexandrine, or roof rat is a good climber and may be found living in trees, vines, building lofts, overhead wiring, and upper decks of ships. The body is generally elongated, the ears are long, and the tail exceeds the combined length of the head and body. There are many variations in color and body types. Its food preference varies with its surroundings, but usually fruit and vegetables are well accepted. The black rat is a specialized type of roof rat which is an excellent climber and is frequently found on ships. The roof rat prefers seeds, cereals, vegetables, fruits and grass, but may subsist on leather goods, chocolate bars, or weaker members of its own tribe.

(c) *Other rats.*—Most parts of the world have one or more species of forest, grass, or arid-land rats. Generally they do not live in close association with man, and are of no importance from a control standpoint except where military camps are established in their immediate environs. Identification of these rodents to species is a task for the trained mammalogist only.

(d) *House mouse.*—The house mouse is commonly associated with man, and unless promptly checked, may cause serious damage to foodstuffs and to other valuable materials. In addition, various species of field mice may on occasion enter habitations in search of food and shelter.

(3) *Control.*—Rodent control programs should include the elimination of food and shelter, the rodent proofing of structures, and the active destruction of rodents by poisoning, trapping, and (if necessary) fumigation.

(a) *Elimination of food and shelter.*—Proper handling of food and prompt disposal of garbage to keep food from becoming available to rats is important in rat control programs. Food storage structures should be completely rat proofed. All supplies should be stockpiled on elevated platforms so that no concealed spaces exist. Garbage should be put in tightly covered cans which should be placed

on concrete slabs or platforms. Surroundings should be carefully policed and garbage removed frequently. No open garbage dump should be tolerated within the vicinity of habitations.

(b) *Rodent proofing.*—Rodent proofing is not generally feasible for troops in the field. However, where structures are built, all necessary openings should be covered with 28 gauge, ⅜ inch mesh galvanized hardware cloth; doors should be self-closing, tight fitting and, where there is special incentive for rats to enter such as doors giving access to galleys and food-storage rooms, equipped with metal flashing along the base; and walls and foundations should be of solid construction.

(c) *Destruction of rodents.*

(*1*) *Poisoning.*—For the destruction of rodents within camp areas, the use of poisons (rodenticides) combined with bait materials is the control method of choice. Because most rodenticides are toxic to man and domestic animals, their use should be accomplished only by appropriately trained personnel and only with the approval of the commanding officer. Anticoagulant compounds are the rodenticides of choice under most conditions. The hazard to persons and pets of anticoagulant rodenticides properly used is less than the hazard of traps.

(*a*) *Anticoagulant rodenticides.*—Warfarin, pival, and fumarin are the anticoagulants presently available or expected to be available soon from standard supply. Warfarin was the first of these to be used extensively by the military. These materials prevent blood clotting and cause capillary damage; death ensues in most cases from internal hemorrhages. At concentrations recommended for rat and mouse control, anticoagulant rodenticides apparently are not detected, or, if so, their presence in food baits is not objectionable to the rodents. It has been a frequent observation, both in the laboratory and in the field, that rats continue to attempt to feed on the baits when so weakened by loss of blood that they lack the strength to stand. Anticoagulants will not give effective control when applied in a single dose, but must be ingested several times, usually five or more. These feedings need not be on consecutive days but should occur within a 10- to 14-day interval.

The control of rodents, including roof rats and house mice, will normally be obtained when the concentration of anticoagulant in the bait is 0.025 percent, or 0.25 mg. per gram of bait. Exposure of anticoagulant baits should be made by establishing an adequate number of protected bait stations. This can be accomplished by placing open trays of bait in rooms or areas where domestic animals and small children can be excluded, or through the use of properly constructed bait boxes when such protection cannot be assured. In many instances baits can be protected by improvised means with materials locally available. Every container of poison bait should be labeled POISON in red, in English (and in the local language, if in a country where a language other than English is used). Feeding stations should be inspected at frequent intervals for the purpose of replenishing the bait supply if necessary. The frequency of inspections and size of bait placements will, of course, depend upon the degree of infestation encountered and in some instances daily servicing of the bait stations may be required during the first 4 to 5 days of a treatment. Bait consumption and rat activity usually drop markedly about 5 days after a rat population begins to feed on anticoagulant baits. Length of time required to achieve control will vary from 2 weeks to months depending upon the availability of food supplies and other factors. Baits should be kept dry during use in order to maintain maximum acceptability. It is often desirable to maintain properly protected bait stations with semipermanent baits after control has been attained and where premises are particularly vulnerable to reinvasion.

Where rat infestation is reported, the use of both poison and traps is a recommended procedure to obtain initial control as promptly as possible. When rats are no longer caught in traps, traps should be removed but poison bait maintained—especially in buildings where food is stored, prepared, or served—unless it is determined that the building is not vulnerable to reinvasion. Any reinvasion of rats is evidenced by a small take of bait. Maintenance of control is almost automatic so long as sufficient good bait is maintained. One to four ounces of bait are suggested as the amount to be placed in each feeding station.

Subsequent inspection will determine the correct amount to be added to each station. In semitropical and tropical areas where rat infestation is frequently general and not confined to buildings, area control must be used in addition to building control. In general, the same exposure technique should be used in employing baits for the control of mice as is outlined for rat control; the principal difference being that a larger number of placements should be made in areas where the mice are known to feed. Feeding stations may in some cases consist of only tablespoonful quantities of bait.

Ready-mixed anticoagulant baits will eventually be obtainable from standard supply. If these baits, which utilize breakfast rolled oats, should for any reason fail to prove acceptable to the local rodents, it may be necessary to do some test baiting in order to learn which foods are most tempting to rodents in that particular area. Cereal baits usually can be made more acceptable to rats by adding attractants such as edible oil, peanut butter, and sugar. Test bait samples should be selected from the 3 classes of foods suitable for baits, as follows: cereals (cornmeal, bread, oatmeal, poultry mash, etc.), proteins and fats (meats, fish, waste cooking grease, peanut butter, etc.), and fruits and

vegetables (melons, sweet potatoes, bananas, etc.). It is important to use freshly prepared baits in each case, since rodents will reject stale or spoiled foodstuffs. Rat infestation in areas where water is scarce often may be controlled by using poisoned water. A water-soluble anticoagulant rodenticide is to be made available from standard supply for use in such cases. Label instructions should be followed in using this item.

(*b*) *Other rodenticides.*—Zinc phosphide is surpassed in safety and effectiveness by warfarin and other anticoagulant rodenticides, but can be used effectively, by prebaiting, if preferred anticoagulant rodenticides are unavailable. Prebaiting (offering unpoisoned bait) prior to poisoning is essential for success with zinc phosphide rodenticide. When rats are well-fed and not especially hungry, prebaiting 6 to 8 days will give better control than shorter periods of prebaiting. Warfarin and other anticoagulant rodenticides are self-prebaiting, making unnecessary such a change between unpoisoned and poisoned bait. Mix zinc phosphide at the rate of 1/5 ounce to 1 pound of bait material.

(*2*) *Trapping.*—It is frequently necessary or desirable to supplement poisoning with trapping. The placement and operation of traps require skill and persistance. The ordinary wood-base spring trap is probably the most effective type, and should be used in numbers. Traps should be tied to overhead pipes, beams or wires, nailed to rafters, or otherwise secured wherever black greasy marks indicate runways. On the ground they should be set at right angles to the runways with trigger pans toward the bulkhead, since rats normally run close to walls. Boxes and crates should be placed so as to create passageways where rats cannot pass without going over the traps. Traps should be so placed in a space as not to be visible from the entrance. Although unbaited traps (with the trigger pan enlarged with a piece of cardboard or lightweight metal) may be used in narrow runways, trapping is usually more effective when accomplished with baited triggers. Preferred baits vary with the area and with the species of rodents involved, but include bacon rind, nuts, fresh coconut, peanut butter, raw vegetables, and bread or oatmeal dipped in bacon grease. All traps should be serviced regularly.

(*3*) *Fumigation.*—Fumigation will destroy effectively rat populations in burrows and other harborages. Where the gas can be confined, this method of control in burrows and other enclosures also will kill fleas infesting the rats. Hydrocyanic acid gas applied as calcium cyanide dust is very effective for gassing rats in burrows. This dust should be applied with a foot-pump duster. The nozzle of the hose should be inserted into the burrow opening and the dust forced by the foot pump into the burrow. A less effective method for small-scale gassing is to throw 1 tablespoonful of the dust into the entrance of the burrow. After the dust is applied by either method, the burrow openings should be tamped shut with earth. Fumigation for rat control should be conducted only by appropriately trained personnel. Calcium cyanide dust should not be used indoors where a high concentration of gas may accumulate. The foot-pump duster should be filled out of doors with the operator standing to windward.

Section IV. INSECT AND RODENT CONTROL ON VESSELS

9–31. Insect Control

(1) *General.*—Insect control on vessels has 3 basic phases; namely, the prevention of all entry by insects, the elimination of suitable harborages and breeding areas through the observance of sanitary practices, and the extermination of existing infestations. Scheduled shipboard pest control training programs are available at the two Disease Vector Control Centers, and the Preventive Medicine Units having entomologists on their staffs. Shipboard control operations normally will be accomplished by trained ship's personnel with non-controlled standard stock items under technical supervision of senior medical department representatives. Operations shall be in accordance with current Bureau of Medicine and Surgery Instructions and Notices of the 6250 series. Strict adherance must be maintained to directives regarding

personal safety and shipboard hazards in the handling of pesticides. All pesticides shall be properly stored under lock in prescribed areas to prevent access by unauthorized personnel.

(2) *Prevention of entry.*—Exclusion of insects from vessels is perhaps the most basic form of shipboard insect control and should be vigorously practiced throughout all stays in the vicinity of land. Such a program should contain at least the following measures:

(a) Maintain screens on all structural openings from the open air which lead to food servicing and personnel occupying spaces.

(b) Inspect all incoming consignments of dry and fresh food materials to insure that they are insect free. Materials showing evidence of insect contamination should not be accepted. Broken containers, torn bags, and any spilled foodstuffs should be removed at once.

(c) Apply an approved insecticide solution, emulsion, or wettable powder as a preventive residual spray to all bulkheads and decks of dry food storage spaces. The timing of reapplications should be based on frequent inspections for the presence of insects which infest stored products.

(3) *Sanitary control.*—To maintain insect-free spaces requires unceasing sanitation. Simple cleanliness with frequent and abundant use of plain soap and hot water is necessary. While there are many excellent insecticides now available, efficient insect control still demands cleanup work. The neglect of routine measures of sanitary disposal of garbage and trash will seriously limit the benefits to be obtained from the use of insecticides. In particular:

(a) Eliminate spaces in which trash, food particles, and dirt may accumulate.

(b) Clean living quarters and spaces where food is stored, prepared, or served and where utensils are washed. Special attention should be given to secluded portions of these areas.

(c) Properly store and dispose of trash and garbage.

(4) *Chemical control.*—Where infestation of insects already exists, suitable insecticides should be applied as described below.

(5) Special features relating to insect and rodent control on board vessels are:

(a) Fumigation solely for the control of insects will not be undertaken on shipboard. Infested dry foodstuffs are to be returned to supply activities ashore for fumigation by specialists, or if beyond salvage, to be surveyed in accordance with *Navy Regulations*. Storerooms that are insect infested should be thoroughly cleaned when emptied and given a standard residual treatment with insecticides. Submarines are currently exempted from the above restriction in that fumigation with carboxide gas is permitted for the control of extreme cases of cockroach infestations. However, every effort should first be made to eliminate the infestation by residual applications of suitable insecticides.

(b) Personnel responsible for the mixing, application, and storage of insecticides aboard vessels should be thoroughly familiar with the precautions and restrictions outlined in chapter 11 of this manual. Storage and use of kerosene-based insecticides aboard Navy vessels is permitted, provided pertinent regulations of the Bureau of Ships are complied with. Specifically, all kerosene-based insecticides should be stored in the paint and flammable liquid storeroom. When kerosene solutions of insecticides are to be used as residual sprays by trained personnel, open flames or highly heated surfaces must be avoided. Tests have shown that no explosion hazard will then exist. Recommended fire prevention practices should be observed at all times.

(c) The most successful methods of insecticide application aboard ship are residual and space sprays. A residual spray is applied directly to surfaces. When the solvent evaporates, a fine film of poisonous material is left. Such an insecticide as DDT, when so applied, is toxic to contacting insects over considerable periods of time. Space sprays are quick killing insecticide-bearing mists or aerosols which are dispersed into the air of a space for the purpose of contacting and killing all exposed insects therein. As commonly used, space sprays do not contain enough insecticide to give a satisfactory surface residue. On the other hand, residual sprays are too concentrated to be safely sprayed into the air. Usually, a material is added to space sprays which is irritating to the insect and causes it to move about and so become more accessible to the air-floated particles.

9–32. Cockroaches

(1) *Relation to man.*—Although cockroaches are not normally associated with the transmission of human disease organisms, they can under some circumstances mechanically spread certain causative agents of diarrhea and dysentery. Because of this, and because of the mechanical contamination of food and food-handling areas which their activities cause, they should be controlled whenever found in areas and spaces occupied by man.

(2) *Characteristics.*—There are several different kinds of habitation-infesting cockroaches, but all are generally similar in appearance, habits, and methods required for their control. They breed rapidly in the presence of food and warmth, shun the light, and are most active at night. During the day they hide in cracks and other places of concealment. Their eggs are laid in small brown cases. Growth occurs as a simple increase in size, interspersed by an occasional shedding of the skin to allow for increased size. In most species, wings are fully developed by the final or adult stage. The species most commonly found on ships is the Ger-

man cockroach. It is rather small, ⅝ inch or less in length, and may be recognized by the two longitudinal dark lines on the area immediately behind the head. The female carries the egg case at the tip of the body until almost hatching time. Another cockroach which may be found on ships is the American cockroach. This is a much larger species, being approximately 1½ inches long when full grown, and is reddish brown in color with yellowish markings on the area behind the head. This cockroach carries the egg case for only a few days, following which the case is dropped or glued to some surface. Several other species of cockroaches infest human habitations and may occasionally be found on ships. However, their habits do not materially differ from those described above. Development from egg to adult takes 2 to 5 months for the German cockroach, and from 6 to 18 months for the American cockroach. In general, the female cockroach produces about 150 young during the average lifetime of 7 months for the German cockroach and 15 months for the American cockroach.

(3) *Control.*

(a) *General.*—Clean ships usually have few roaches. Medical inspections reveal that ships maintaining high sanitation standards are seldom troubled with roaches. Roaches require very little food—a few crumbs or a small accumulation of grease will support a large population. Sanitation from the cockroach-control point of view requires the removal of all possible food sources from these insects. This means meticulous prevention of food particles and grease accumulations throughout food service spaces. Special attention should be directed beneath bread boxes, toasters, food slicers, tables, benches, transoms, and cabinet drawers. Likewise, food residues on rolling pins, bread and pastry boards, cutting boards, utensils, and in the baked goods storage areas and coke machines provide a good source of food for cockroaches and must be eliminated if insect control is to be established. Other potential food source areas are the decks in food service spaces, particularly under ranges and ovens. No opened food packages, particularly sugar, cornstarch, and condiments in the galley or wardroom pantry should be left lying about. Remember, the presence of cockroaches is usually an indication of poor housekeeping. Inspections are important for the early detection and elimination of infestations, as well as for the maintenance of a high level of sanitation. Cockroaches consistently avoid light or exposure. Consequently, the best time for making inspections is at night when sudden illumination will usually reveal any roaches present as they forage for food. Fecal pellets or egg cases also may indicate their presence.

(b) The first requirement for successful cockroach control is the utilization of every feasible means to prevent the insects' access to foods. This includes the maximum degree of cleanliness in food preparation, serving, and storage areas. The keeping of food in other areas should be prohibited, unless it is stored in tighly-closed containers. Complete recovery of all food scraps from messing spaces and galleys after each meal is essential. Spaces which exist behind or between fixed equipment and which cannot be cleaned properly should be sealed or shielded to prevent food particles from falling into them. When sanitary measures have been adequately applied, insecticides are then effective in the elimination of existing infestations or the prevention of new ones. Residual application of insecticide sprays, that is, application of long-lasting insecticides to the hiding places and habitual runways, destroys the adult roaches and the young as they are hatched from the eggs. Fumigation and space spraying are not recommended, except when immediate kill is essential, because these methods neither destroy the eggs nor leave a permanent toxic residual to kill the young, with the result that immediate reinfestation or development of new colonies from the eggs is likely.

(c) *Insecticides.—Blatella germanica,* the German cockroach, has developed resistance to chlordane in the majority of cases. Insecticides of the organic phosphate group are used where roaches have been confirmed as resistant to the chlorinated hydrocarbon insecticides. Three percent malathion is effective against cockroaches, but does not have a long residual action. Diazinon dust, 2.0 percent, has given excellent results for as long as 3 months. Combination dust and spray treatments of 2.0 percent Diazinon dust with either 3.0 percent malathion emulsion or 0.5 percent Diazinon solution gives results superior to those achieved with dusts or sprays alone. Diazinon is effective longer on wood or wallboard than on glass or linoleum. Wall paper and plaster may become stained with organic phosphorus toxicants. Asphalt or vinyl tile floors should not be sprayed with oil-base solutions because of softening and surface-marring.

Where German and other species of cockroaches are still susceptible, a 2.0 percent emulsion or solution of chlordane or a 0.5 percent solution or 1.0 percent dieldrin dust will control them.

Pyrethrum aerosol bombs are used during inspections to "flush out" cockroaches from hidden spaces to establish the size and location of the infestations.

(d) *Application.*—Start at one corner of the space to be treated and work carefully around the compartment injecting the insecticide solution into *all* cracks, crevices, and hidden spaces where roaches may find shelter. Inaccessible spaces may be treated with a pump-type oiler, or with a Luer 20 or 30 cc. syringe with a No. 19 needle which will force a pin stream for a considerable distance into minute cracks. Exposed surfaces where roaches

frequently rest, such as under surfaces and supports of tables and fixed equipment, shelves, drawers, lockers, and backs of pictures or bulletin boards, may be treated with a coarse spray or with a brush to the point of wetting without runoff. Storerooms should be given special attention before stores are taken aboard, and bulkheads, decks, pallets, shelving, and racks should be thoroughly treated at that time.

9–33. Control of Cockroaches on Submarines

(1) *General.*—The exclusion and sanitation measures detailed above for the control of cockroaches on surface vessels apply equally well for submarines. However, the eradication of an established infestation presents a special problem, since repeated residual treatments with insecticides may produce an undesirable air contamination. In addition, residual treatments are generally difficult to apply aboard submarines. For some time it has been customary to disinfest submarines during yard overhaul periods by fumigation with carboxide gas. This measure is adequate for the control of all free moving forms but not for the egg stage, and accordingly must sometimes be repeated within a relatively short time. Fumigation will not be attempted without the approval of the Bureau of Medicine and Surgery. The need for fumigation should be established in each case by a preventive medicine officer or experienced entomologist prior to requesting BUMED approval.

(2) Carboxide is a mixture of 10.0 percent ethylene oxide (the fumigant gas) and 90.0 percent carbon dioxide, which is added to reduce the fire and explosion hazard. In addition, the carbon dioxide stimulates respiration and increases absorption of the ethylene oxide. Both of the gases in the mixture are about 1.5 times as heavy as air and therefore tend to collect in pockets if not agitated. Carboxide gas has a faint but distinct ether-like odor, easily recognized in the concentration set up for fumigation. It escapes from the cylinder as a liquid which breaks down to a fine mist and vaporizes readily. The vapor is noninjurious to clothing, furniture, or food products, but stains may be caused by the liquid or mist.

(3) Carboxide is available in steel cylinders holding 30 or 60 pounds under a pressure of 725 pounds per square inch at 70° F. when filled.

(4) The recommended concentration for the control of insects is 6 pounds per 1,000 cubic feet for an exposure period of 4 hours. A heavier dosage may be required in some cases.

(5) The following instructions for submarine fumigation with carboxide gas should be adhered to:

(a) Open wide all interior doors, drawers, and cabinets.

(b) Seal all exterior openings which might permit the escape of gas.

(c) Secure all open flame heaters, exposed element heaters, or similar devices during the fumigation period since high temperatures may cause a chemical breakdown of the ethylene oxide to free oxygen and result in explosion or fire. This hazard is not involved, however, when electrical circulating fans or other similar electrical circuits are in use.

(d) All cylinders should be securely lashed in the upright position and grounded before discharging gas.

(e) Send all personnel from the area and check to make completely sure this has been accomplished.

(f) When all preparation is complete and all openings closed except the exit, open wide the valves of the cylinders, beginning with the unit farthest from the point of exit and with the nozzle directed away from the operator. Place the cylinders so that the gas does not directly strike any surface within 5 feet. Creating air turbulence within the ship and within each space is very important in obtaining adequate distribution of the gas. To this end, it is desirable to have all bracket fans operating, the battery ventilation blowers going at low speed, the general ventilation lined up to recirculate, and any special air circulation device turned on.

(g) Open the area of fumigation at the end of 4 hours. Personnel wearing oxygen-rescue-breathing apparatus (OBA) should be detailed to open all airports, and to re-establish supply and exhaust ventilation. The Dwyer CO_2 analyzer should be used to determine carboxide concentrations remaining in pockets during ventilation.

(h) The most effective procedure for accomplishing exhaust of the fumigant is to idle the engines. During this operation the main induction remains closed and a suction is taken through the ship by cycling the opening of the several deck hatches. Efforts should be made to create turbulence within each compartment so the gas there will be forced into contact with the stream of air blowing down the passageway. This may be accomplished by operating the bracket fans and blowers in the ventilating systems at high speeds. Portable blowers should be set in place beforehand in any spaces known to be poorly ventilated and they should be turned on during the clearing process. Since there is relatively poor ventilation in the engine room bilges, both engine rooms should be used alternately. After 30 minutes of this type of ventilation a man with an OBA should make CO_2 determinations in each of the larger spaces. When the CO_2 in a space is less than 0.2 percent, the concentration of ethylene oxide can be expected to be 0.02 percent, the maximum allowable concentration for several hours exposure without serious symptoms developing. After a period of general ventilation, CO_2 determinations and the sense of smell (concentrations of 0.2 percent or more are irritating to nose and eyes) may be used to determine whether the

ship has been cleared. If CO_2 is found in the slightest measurable amount or the irritating effect is noted, further ventilation is required.

(6) Carboxide gas shall not be carried on board naval vessels as a regular allowance item. When required, it shall be obtained by requisition. Need for the material should be anticipated as far in advance of actual use as possible.

(7) As compared with that of other commonly used fumigants, the hazard to man of the concentration of carboxide set up for fumigation is comparatively slight. Nonetheless, a man remaining in a space under fumigation or entering such a space unprotected would quickly succumb and even light exposure to the gas may result in headache, nausea, and vomiting. Preconceived ideas should not lead one to neglect using the CO_2 analyzer, nor one's sense of smell for verifying the adequacy of ventilation in each space before permitting its general occupancy.

(8) Two insecticides are authorized for use on submarines (BUMED Instruction 6250.9).

(a) Synergized pyrethrum, low pressure aerosol-type liquid mixture in dispensable beer can type container, non-refillable (stock item). This material induces sudden and intense excitement a short time after application causing the insects to leave their hiding places. It is useful to determine the extent of cockroach infestation.

(b) Malathion emulsifiable concentrate to be diluted to 3.0 percent with water (stock item). This is a controlled item requiring approval of the nearest medical or district public works entomologist prior to issue.

(c) The following instructions regarding use of these insecticides should be adhered to:

(1) They shall be used only when the ship is in port and is not expected to submerge for a period of 24 hours.

(2) The ship's exhaust air must either be discharged overboard or used by the ship's engines for a period of 24 hours following application.

(3) Insecticides must not be transported or stored on submarines.

(4) Extensive areas must not be covered with these insecticides. They shall not be sprayed indiscriminately over bulkheads or overheads. No more than 10 to 15 percent of the total square feet of bulkhead and deck area shall be covered in any compartment.

(5) Insecticides must not be sprayed on foods or containers in which food will be stored.

(6) Personnel responsible for the mixing, application, and storage of the materials shall be certified pest control operators approved by the local area entomologist. They shall be familiar with the precautions outlined in the applicable Bureau of Medicine and Surgery Instructions of the 6250 series.

9–34. Bed Bugs

(1) *Relation to man.*—The species of bed bugs that commonly attack man are not known to transmit diseases. However, the annoyance caused to humans by their attacks is severe, and control is indicated whenever an infestation is found to occur.

(2) *Characteristics.*

(a) *Appearance.*—The mature bed bug is a brown, wingless insect. Its size depends upon the amount of blood that it has taken. An unfed specimen is ¼- to ⅜-inch long. When engorged with blood, the body becomes elongated and swollen and the color changes from brown to dull red. Bed bug eggs are white, and about 1/32-inch long. The newly hatched bugs are translucent and nearly colorless. The young bugs are similar in shape to the adults. During their period of growth, they shed their skins several times to allow for increases in size. After each molt they are pale in color, normally becoming brown within a matter of hours.

(b) *Feeding habits.*—Bed bugs do almost all their feeding at night by biting people who are asleep. The bites are usually painless when inflicted. When bed bugs bite, they inject into the skin a fluid that assists them in obtaining blood. Often this fluid causes the skin to become irritated and inflamed, welts develop, and there is much itching. If very hungry, and if the light is dim, the bugs will feed during the day. If undisturbed, a mature bed bug will engorge with blood within 3 to 5 minutes. It then crawls to its hiding place, where it remains for several days digesting its meal. Newly hatched bed bugs may live without feeding for several weeks during warm weather, and for several months during cool weather. If given an opportunity for an occasional blood meal, they may live about 10 months. Even without food, mature bugs may survive for months under ideal conditions of temperature and shelter.

(c) *Development.*—Under favorable conditions, the mature female bed bug may lay as many as 200 eggs. When opportunities for regular feeding occur, eggs are laid at an average rate of 3 or 4 a day. Maximum egg laying occurs when the temperature is above 70° F. and no eggs are laid at temperatures lower than 50° F. At temperatures above 70° F., hatching occurs in 6 to 17 days. Under such conditions, growth requires from 4 to 6 weeks. There is considerable variation in the period of development, even among bugs hatching at the same time. As a result, bed bugs in all stages of development are present at all seasons of the year, except in unheated rooms in winter, when only adults may be present.

(d) *Hiding places.*—Habitual hiding places are usually made evident by black or brown spots that stain surfaces on which the bugs rest. These spots are the dried excrement of the bugs. Bed bug eggs (glued to surfaces), eggshells, and cast skins also

may be seen near these places. Hiding places include the seams of mattresses, the joints and springs of beds, upholstered furniture, lockers, crevices of walls and floors, and behind all items close to walls. Bed bug infestation is not necessarily associated with unclean situations. Because of their ability to cling to clothing and baggage, they are easily introduced into even the cleanest of places.

(3) *Control.*—Bed bugs are effectively controlled by the resldual application of insecticidal sprays, i.e., application of long-lasting insecticides to infested surfaces. Neither fumigation nor space spraying should be used. The eggs are not destroyed by residual sprays, but the newly hatched bugs are. Infested bedding should not be destroyed because subsequent cleaning is all that is necessary to make it reusable.

(a) *Insecticides.*

(*1*) DDT, 5.0 percent, in kerosene is the insecticide of choice. One treatment with this material will protect spaces against reinfestation for 6 months or longer.

(*2*) If DDT-resistant bed bugs are encountered, the use of either lindane, 0.5 percent; malathion, 0.5 to 1.0 percent; or ronnel, 1.0 percent, should be effective.

(*3*) Aqueous emulsions of DDT, lindane, malathion, and ronnel may be used where an extreme fire hazard exists or around materials that would be stained or otherwise damaged by oil. However, aqueous sprays sometimes do not give satisfactory control of bed bugs.

(b) *Equipment.*

(*1*) Select a sprayer that produces rather coarse spray particles. For limited operations, the ordinary "flit type" sprayer, 1-quart size, may be used. Delivery is slow with this equipment. For faster work, use a blowtorch-type hand sprayer or the standard 2-gallon compressed-air sprayer; both should be equipped with a coarse fanspray nozzle. The former is more convenient in the small crowded compartments of most ships.

(c) *Preparation of quarters.*

(*1*) Cover, or remove from the areas to be treated, all rubber materials, and other objects which must be protected from applications of oils. However, be certain that such items do not contain bugs.

(*2*) Set all movable items far enough away from bulkheads to permit the spraying of bulkhead surfaces and the backs of furniture.

(*3*) Remove all seabags and contents of lockers to another location so that spraying work will not be hindered.

(*4*) Fold mattresses over once and place in the center of each bunk at a 45° angle. Where compartments are small and a large number of mattresses are to be treated, it is usually better to stack them on an open deck where the ends and sides may be treated in one operation.

(d) *Application.*

(*1*) Begin at one end of the space and work around the compartment spraying all likely bed bug hiding places. Wet surfaces just to the point of runoff. This should include the backs and bottoms of all furniture and the under surfaces of cushions of upholstered furniture. It is unnecessary to spray the entire bulkhead or overhead because bed bugs are killed by crossing a 12- to 18-inch band of treated surface.

(*2*) Proceed along a row of bunks spraying one end of each bunk (principally springs, bunk corners, and canvas bottoms and grommets where encountered) and one folded edge of each mattress. Return up the other side, spraying the other end of each bunk and mattress. Usually it is not necessary to treat the flat surfaces of the mattresses. As pointed out above, under some circumstances the treatment of mattresses is best accomplished on deck. Fabric items should show a covering of minute droplets but should not be soaked.

9–35. Insect Pests of Drystores

(1) Shipboard surveys have shown at least half of all ships visited to have insect infestation of drystores. It is probable that the majority of these infestations existed in the materials when taken aboard. However, this does not exempt shipboard personnel from the responsibility of applying regular preventive treatments to storerooms and routinely separating infested and uninfested materials in order that a buildup of insect populations and spread to other bulk materials may be prevented.

(2) The detection, identification, life histories, and the currently recommended control measures for stored-products pests are adequately treated in NAVDOCKS TP–MO–310 and in the *Joint Manual on Storage and Materials Handling* (ch. 3), therefore, will not be repeated here.

(3) Infested drystores are to be returned to supply activities ashore for fumigation by specialists, or if beyond salvage, to be surveyed in accordance with *Navy Regulations*. Fumigation for the control of insects will not be undertaken on shipboard unless recommended by Navy entomologists and accomplished by specially trained personnel.

(4) Inspect all incoming consignments of dry and fresh food materials to insure that they are insect free. Keep all storerooms clean, dry, and treated residually with insecticides. For storeroom treatment, a 5.0 percent water suspension made from 75.0 percent DDT wettable powder is recommended for application with a hand sprayer equipped with a coarse atomizing nozzle to all surfaces except the overhead. The 5.0 percent DDT solution used for bed bug control also may be used for treatment of storeroom bulkheads if care is taken not to saturate cartons of foodstuffs. Treatments should be scheduled when stocks are low and storerooms can be emptied, cleaned, and treated.

9–36. Miscellaneous Insect Pests

(1) Flies and mosquitoes are sometimes a problem on board ship when in port. Control of these insects can be obtained by the use of aerosols in the living and messing compartments. The necessity for regular treatments against these insects in large spaces, i.e., holds, would be exceptional. There will be occasional need for repellents by personnel on deck or by shore parties when the ship is in infested areas. For further information on the control of these insects see articles 9–21 and 9–22.

(2) Lice, primarily crab lice, are sometimes found infesting personnel on board ships. Control involves the treatment of infested personnel with 10.0 percent DDT dust. (See art. 9–23.)

(3) Other obnoxious or dangerous insects have been reported so rarely aboard ships that special instructions are not required here. However, the standard aerosol and residual sprays will be reasonably effective against almost any insect which may occasionally appear.

9–37. Rodents

(1) *General.*—As with insect control, rodent control involves the prevention of all entry by rodents; the elimination of suitable harborages through the accomplishment of basic sanitary procedures; and the use of traps and rodenticides to eliminate established infestation.

(2) *Prevention of entry.*—No rodent problem will exist if this method is fully utilized.

(a) Whenever in port, rat guards (36-inch outside diameter) must be placed on all ships to shore lines. These guards must be placed with care to prevent rats from by-passing them in any way. All unguarded ship to shore connections must be illuminated at night. No unprotected means of access to shore should be permitted.

(b) *Rat proofing.*—The rat-proof construction of a vessel is accomplished by so designing and building it as to eliminate, or to render inaccessible to rats, every space which might afford them harborage or food. Open-type construction, which eliminates enclosed spaces, is preferable to "protective" rat proofing. The control of rat infestation on vessels is concerned also with preventing the passage of rats from one section of a vessel to another. Most new ships are built rat proof. However, if required, detailed information on the subject can be secured from the *Handbook on Sanitation of Vessel Construction* issued by the U.S. Public Health Service, U.S. Department of Health, Education, and Welfare.

(3) *Sanitary control.*—Rodents will not remain on vessels if denied shelter, food, and water.

(a) Rodents require undisturbed shelters for breeding. Shifting and restowing cargo will often strongly interfere with their activities.

(b) Rodents cannot thrive if deprived of access to food and water. Accordingly, keep all food securely stored and eliminate open accumulations of water. Collect garbage and trash in screened or metal containers and dispose of it promptly and efficiently.

(4) *Extermination.*—Poisoning is the method of choice. However, in many situations it will be necessary to supplement this with the use of traps. Instructions for these procedures are detailed in article 9–30. Where rodent infestation exists that is a serous threat to human health, or where regulations of the Public Health Service so require, fumigation with hydrocyanic acid gas is authorized. However, this work must be accomplished by personnel of the Public Health Service. Instructions for securing this service are contained in the *Bureau of Supplies and Accounts Manual*, paragraphs 33860, 36850, 81298.8, and 81393.

9–38. Quarantine Procedures

(1) Quarantine procedures in the Navy embrace measures designed to prevent the dissemination of human, animal, or plant diseases from place to place. Basic regulations and detailed instructions concerning such procedures are published in the *General Orders*.

(2) By international convention, a "certificate of deratization" or a "deratization exemption certificate" is required of vessels entering most foreign ports, if detention for fumigation is to be avoided. A certificate to be valid must be issued by the Public Health Service or by its duly appointed representatives. Details for the accomplishment of this procedure are presented in the *Manual of the Medical Department*.

Section V. INSECT AND RODENT CONTROL ON AIRCRAFT

9–41. General

(1) Although insects do not normally become permanently established on aircraft, they are very commonly accidental visitors and passengers. Because of the potential importation and establishment of alien economic and public health pests and vectors by this means, it is necessary to maintain effective preventive and control measures on all

aircraft moving between major geographical areas. Rodents cannot be disregarded in this respect, since reports have been made of their presence on aircraft. However, they do not constitute a problem of any importance.

9–42. Control Procedures

(1) Measures designed to prevent the importation of exotic pests by air traffic comprise the categories of prevention, extermination, and surveillance.

(2) *Prevention of entry.*—Measures to prevent the entry of insects into aircraft should be taken. These would include the adequate inspection of onloading passengers and cargo, and the insect or rodent proofing of aircraft, including the maintenance of adequate closure of standing aircraft.

(3) *Extermination.*—Since present measures designed to prevent the entry of insects onto aircraft are considered to be inadequate, it is mandatory that insect extermination measures be automatically carried out on aircraft moving from one major area to another.

(a) *Disinsection.*—All aircraft operated by or under the jurisdiction of the Armed Forces shall be disinsected:

(*1*) Immediately before the last takeoff prior to landing at an airport in the United States, its territories, commonwealths, or possessions, if they depart from or touch at any point that is outside thereof and between 45° north and 45° south latitude; provided that disinsecting is not required during the period 1 October through 31 March for aircraft landing north of 35° north latitude except when an aircraft is to proceed immediately from an airport north of 35° north latitude to an airport south of that latitude or when the responsible Armed Forces officer deems disinsecting essential because of a special problem involving arthropod-borne diseases.

(2) On any flight when required by the U.S. Department of Agriculture or the U.S. Public Health Service.

(3) When required by regulations promulgated in accordance with *General Order 20.*

(*4*) Before entering a foreign area according to the requirements of the country concerned.

(b) *Method.*—The method of disinsecting shall be as specified in AFR 160–71, Bureau of Medicine and Surgery Instructions 6250 series, or other methods as required by an agency of the United States or a foreign country.

(c) *Area insect control.*—Where known possibilities exist for the transport of dangerous insects, the space and residual insecticide treatment of airfield loading areas should be accomplished. Procedures to be used for such treatment would depend upon the insect species involved and should be determined through consultation with the area entomologist.

(*4*) *Surveillance.*—Entomological surveillance is required on and around Navy airfields receiving aircraft from abroad or from other quarantinable zones. This measure, which is designed to detect promptly any incipient establishment of exotic insects, is extremely important. Specific surveillance requirements will differ widely from area to area, and should be determined through consultation with the appropriate area entomologist.

9–43. Quarantine

(1) The basic regulations and detailed instructions governing quarantine procedures for Navy aircraft are detailed in *General Order 20.*

Section VI. COLLECTION AND PREPARATION OF SPECIMENS FOR SHIPMENT TO MEDICAL LABORATORIES

9–51. General

(1) Insects, other arthropods, and mammals of medical importance will be collected whenever possible, in order that control measures can be adapted to the species concerned and that representative collections may become available from all geographical areas where naval personnel are stationed. The importance of accurate identification of arthropod and animal species associated with disease transmission or nuisance abatement cannot be overemphasized.

9–52. Procedures

(1) *Mosquitoes.*

(a) *Mosquito larvae.*—Either in the field or in the laboratory, concentrate all of the larvae from a single collection (do not mix collections from different days or from different breeding areas) in one inch of water in a small test tube. Heat with a match or burner until bubbles begin to reach the surface. Pour into a small open container. Pick up the larvae on the point of a needle and drop into 70.0 percent ethyl alcohol in a novacaine tube (ob-

tainable from dental facilities). Push a small loosely compacted piece of cotton into the tube to a point just above the larvae and well below the surface of the alcohol. Write the collection data with a lead pencil on a bond paper label and push it into the tube above the cotton. Insert the top novacaine tube stopper using a needle to release the compressed air. Make certain that no bubble exists in the section of the tube holding the larvae. One week following preservation re-examine the tubes. If bubbles have formed, remove the top stopper and with a long needle release the trapped air. Wrap the tubes carefully in cotton or other soft packing material for mailing.

(b) *Mosquito adults.*—Mosquito adults are very delicate and must be handled carefully to avoid loss of scales or appendages essential to their proper identification. Moisture will cause scales to lose their natural color. Condensation of moisture on the inside of a chloroform collecting tube occurs quickly if the tube is left in the sun or a heated place. Consequently, mosquitoes should be removed from killing tubes as soon as killed. Reared specimens should be kept alive at least 12 hours to allow them to harden. Adult mosquitoes should be packed in pill boxes. Prepare the pill boxes for receipt of specimens by cutting 2 slips of fine paper tissue, lens paper preferably, the size of the lid. Place a thin, very light wisp of cotton in the bottom of the box. Insert 1 paper slip over the cotton. Its dimensions will be larger than the box and the tucked edges will hold it firmly. Pour in the mosquitoes from the collection. Then tuck in the other paper slip until it just contacts the mosquitoes. Be sure this covering slip will not become subsequently dislodged. Over the top paper slip, place a wisp of cotton of sufficient dimension to barely engage the lid when closed. Do not, under any circumstances, pack mosquito adults between layers of cotton, cellucotton, or similar fibrous and heavy materials. Write the collection data on the top of the box.

(2) *Flies.*—Delicate flies, such as sand flies, culicoid biting flies, eye gnats, and black flies, may be tubed in 70.0 percent ethyl alcohol as described for mosquito larvae. Domestic flies and related types should be preserved dry in pill boxes as detailed above for mosquito adults, except that heavier cotton layers will be needed in proportion to the greater weight of the specimens involved.

(3) *Ectoparasites.*—Particular effort should be made to collect ectoparasites from wild rodents suspected of being reservoirs of disease. Since fleas leave the animal after death, it is best to capture the animal alive and kill it with chloroform in a container from which the detached insects can be collected. At this time, the fur also should be brushed with cotton moistened with ether or chloroform and the anesthetized fleas combed onto white paper. Tube specimens in 70.0 percent ethyl alcohol as described for mosquito larvae. Parasitic mites may be collected by scraping the skin or, in the case of dead animals, portions of diseased skin may be removed and preserved in alcohol. Ticks may be collected from their host by examination of all parts of the animal. Care must be taken in removing ticks in order that the mouthparts do not break off in the skin of the host. Ticks also may be collected from the habitats of their host. Place specimens in alcohol as for fleas. Lice may be picked from clothing and bedding with forceps or combed from hair with a fine-tooth comb and placed in alcohol. Bed bugs may be similarly preserved.

(4) *Miscellaneous arthropods.*—Spiders, scorpions, centipedes, millipedes, maggots, and other soft-bodied forms may be preserved in vials of 70.0 percent ethyl alcohol. Where corks are used to close vials, it is well to paraffin them in order to prevent loss of fluid through evaporation. If a small amount of glycerin is added to each vial, the specimens will not become dry and shrunken should the alcohol be lost accidentally. Larger, hard-bodied insects such as reduviid bugs and cockroaches should normally be preserved dry in pill boxes but also can be placed in tubes of alcohol.

(5) *Mammals.*—Specimens of mammals should be collected whenever the question of the proper identification of species is involved. Detailed instructions for the accomplishment of the collection and preservation of such specimens can be obtained from *A Field Collector's Manual in Natural History*, available from the Smithsonian Institution, Washington, D.C. Packages of mammal specimens should be marked "Skins of Mammals" and should clearly show the name and address of the shipper and addressee, together with such other endorsement, if any, as may be required by the laws of the State, territory, or district in which specimens are mailed. Parcels must be wrapped so as to prevent grease soaking through the package and damaging other mail matter.

9–53. Disposition of Collections

(1) Collections of specimens will be sent to the appropriate preventive medicine unit or disease vector control center for identification. Specimens which cannot be identified by the unit or center involved, or which are considered of sufficient significance for museum use, will be forwarded to the United States Naval Medical School, National Naval Medical Center, Bethesda, Maryland for further study and disposition. Complete data for each lot of specimens including date, locality, elevation, host, habitat, and name of collector will accompany the shipments. An appropriate request for services and any questions for which answers are specifically required by the shipper should be contained in a letter to accompany each shipment.

Section VII. SUMMARY TABLE OF RECOMMENDATIONS FOR VECTOR CONTROL WITH INSECTICIDES

9–61. General

(1) The recommendations contained in this chapter for insect vector control with insecticides are summarized in table form in the following articles. When using the summary table, reference should be made to the appropriate portion of the text whenever additional details are required. Formulation symbols used are to be interpreted as follows: E=emulsion, aqueous; D=dust, G=granular; OS=oil solution; and WP=wettable powder. Formulations marked with an asterisk (*) are for use by *certified* personnel *only* where resistance to chlorinated hydrocarbons has been demonstrated. Formulations so marked are not necessarily standard supply items.

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Insect	Type of application	Insecticide	Mode of application	Formulation (% and form)	Dosage	Miscellaneous
Art. 9–62 House Flies Larvae	Ground	DDT	Spraying	2.5% E	Point of saturation	
		Chlordane	Spraying	1.0% E	Point of saturation	
		Dieldrin	Spraying	0.5% E	Point of saturation	
		Diazinon	Spraying	0.25% E*	Point of saturation	
		Malathion	Spraying	1.0% E*	Point of saturatiou	Add sugar at rate of 2½ parts per part of toxicant.
		PDB	Sprinkling	Crystals	2 oz/latrine hole	
Adults Outdoors	Space	DDT	Misting	5.0% E	12 gals/mile	
		Dimethoate	Misting	E*	20 gals/mile	Follow label directions.
		BHC	Misting	2.0% gamma OS	12 gals/mile	
		Naled (Dibrom)	Misting	E*	15–20 gals/mile	Follow label directions.
		Malathion	Misting	12.5% E*	12 gals/mile	
		DDVP	Misting	E*	15 gals/mile	Follow label directions.
	Residual	DDT	Spraying	5.0% E, WP	To point of runoff	Plus 2.0% pine rosin.
		Chlordane	Spraying	5.0% E	To point of runoff	
		Dieldrin	Spraying	1.0% E	To point of runoff	
		BHC	Spraying	2.0% gamma OS	To point of runoff	Do not use on valuable plants.
		Dimethoate	Spraying	E*	To point of runoff	Follow label directions.
		Diazinon	Spraying	1.0% E*	To point of runoff	Spot treatment only.
		Naled (Dibrom)	Spraying	E*	To point of runoff	Follow label directions.

		Malathion	Spraying	3.0% E*	To point of runoff	Add sugar at rate of 2½ parts per part of toxicant.
		Ronnel	Spraying	E*	To point of runoff	Follow label directions.
	Baits	Malathion	Liquid	2.0% E*	1 gal/1000 sq. ft.	
			Dry	2.0% E*	2–4 oz/1000 sq. ft.	Plus 10% sugar.
		DDVP	Liquid	1.0% E*	Follow label directions.	In a 12.5% sugar solution.
Indoors	Space	As for mosquitoes				
	Residual	DDT	Spraying	5.0% OS	To point of runoff	
		Lindane	Spraying	0.5% E	To point of runoff	Spot treatment only.
		Ronnel	Spraying	E*	To point of runoff	Follow label directions.
		Dieldrin	Spraying	0.5% E	To point of runoff	Spot treatment only.
		Naled (Dibrom)	Spraying	E*	To point of runoff	Follow label directions.
		Malathion	Spraying	3.0% E, OS*	To point of runoff	Spot treatment only.
		Diazinon	Spraying	E*	To point of runoff	Follow label directions.
	Residual (Fly cords)	Malathion Ronnel Diazinon	30 linear feet of cord per 100 sq. ft. of floor area (3/16 inch cord)			Obtain from commercial sources. *Do Not Use Parathion-Treated Cords.*
Art. 9–63 Stable Flies	Ground	As for house flies				
	Space	As for house flies				

Insect	Type of application	Insecticide	Mode of application	Formulation (% and form)	Dosage	Miscellaneous
Art. 9-64 Culicoid Biting Flies	Ground	Dieldrin	Spraying	E	1.25 lbs/acre	Causes rapid development of resistance. Destructive to many forms of aquatic life.
Larvae		BHC	Spraying	E	1 lb gamma/acre	
		Chlordane	Spraying	E	2 lbs/acre	
Adults	As for mosquitoes. Also, treat screens with 0.1% lindane or 5.0% DDT solutions.					
Art. 9-65 Sand Flies (*Phlebotomus*)						
Adults	As for mosquitoes					
Art. 9-66 Black Flies Larvae	Ground	DDT	Point introduction into streams	5.0% OS	0.1 parts/million for 30 minutes.	
	Aerial	DDT	Spraying	OS	0.2 lb/acre	
Adults	As for mosquitoes, except increase DDT dosage for aerial applictaion to 0.25 lb/acre.					
Art. 9-67 Mosquitoes Larvae	Ground	DDT	Spraying or Dusting	OS, E, WP, D	0.2 lb/acre	Apply 3.0 lbs/acre for residual effects. This dosage harmful to fish and wildlife.
		BHC	Spraying	OS	0.1 lb gamma/acre	Apply 1.0 lb gamma/acre for residual effects. This dosage harmful to fish and wildlife.

		Dieldrin	Spraying	E	0.1 lb/acre	Apply 1.0 lb/acre for residual effects. This dosage harmful to fish and wildlife.
		Malathion	Spraying	E*	0.4 lb/acre	
	Aerial	DDT	Spraying	OS	0.2-0.4 lb/acre	
		BHC	Spraying	OS	0.125 lb gamma/acre	
		Malathion	Spraying	OS*	0.5 lb/acre	
	Ground or Aerial	Paris green	(Special equipment)	5.0% granules	15 lbs/acre	May be used where organic phosphorus compounds and chlorinated hydrocarbons are ineffective.
		Other materials are formulated as granules. Excellent to penetrate heavy vegetation cover.				
Adults Outdoors	Space	DDT	Fogging	8.0% OS	8 gals/miles	
			Misting	5.0% E	12 gals/mile	
		Malathion	Misting	5.0% E*	12 gals/mile	
			Fogging	6.0% E*	0.1 lb/acre (7.0 gals/mile	
	Residual	DDT	Spraying	5.0% E, WP	5 lb/acre	
Indoors	Residual	DDT	Spraying	5.0% OS, E, WP	To point of runoff	
		Malathion	Spraying	3.0% E, OS*	To point of runoff	
	Space	Standard Navy Insecticide	Spraying	1.0% DDT plus thiocyanates	By observation	
		Aerosol Dispenser	Aerosoling	Synergized pyrethrins	6 secs/1000 cu. ft.	

Insect	Type of application	Insecticide	Mode of application	Formulation (% and form)	Dosage	Miscellaneous
Art. 9-68 Lice Adults	Residual	Malathion	Dusting	1.0% D		
		DDT	Dusting	10.0% D	1 oz/person	
		Lindane	Dusting	1.0% D	1 oz/person	
Art. 9-69 Bed Bugs All life stages except eggs.	Residual	DDT	Spraying	5.0% OS	To point of runoff	
		Malathion	Spraying	0.5-1. 0% E*	Light application to mattresses	
		Ronnel	Spraying	1.0% E*	Light application to mattresses	
		Lindane	Spraying	0.5% OS	To point of runoff	Prepare just before use from the emulsifiable concentrate with deodorized kerosene.
Art. 9-70 Cockroaches All life stages except eggs. Indoors	Residual	Chlordane	Spraying or Painting	2.0% E	To point of runoff	Spot treatment only. Most German roach populations now resistant.
		Dieldrin	Spraying or Painting	0.5% OS	To point of runoff	Spot treatment only. Most German roach populations now resistant.
		Malathion	Spraying or Painting	3.0% OS*	To point of runoff	Spot treatment only.
		Diazinon	Spraying or Painting	0.5% E, OS*	To point of runoff	Spot treatment only.
			Dust	2.0% D		Spot treatment only.
Outdoors	Residual	Chlordane	Dust	5.0% D		

Art. 9–71 Mites All life stages	Residual	Chlordane	Spraying	E	2 lbs/acre	Consider fish and wildlife hazards. Follow label directions.
		Dieldrin	Spraying	E	1 lb/acre	
		Lindane	Spraying	E	0.5 lb/acre	
Art. 9–72 Ticks All life stages Outdoors	Residual	DDT	Spraying or Dusting.	E, D	2 lbs/acre	Consider fish and wildlife hazards.
		BHC	Spraying	E	½ lb/acre	
		Dieldrin	Spraying	E	1 lb/acre	
		Chlordane	Spraying or Dusting.	E, D	2 lbs/acre	
Indoors	Residual	Lindane	Spraying	0.5% OS, E	To point of runoff	Spot treatment only.
		DDT	Spraying	5.0% OS	To point of runoff	
		Diazinon	Spraying	0.5% E	To point of runoff	Spot treatment only.
		Malathion	Spraying	1.0% OS	To point of runoff	Spot treatment only.
Art. 9–73 Fleas All life stages	Rat runs and burrows.	DDT	Dusting	10.0% D		
Indoors	Residual	DDT	Spraying	5.0% OS, E	1 gal/1000 sq. ft.	Double dosage for earthen floors.
		Malathion	Spraying	2.5% OS, E*	1 gal/1000 sq. ft.	

Fleas—Con.

Insect	Type of application	Insecticide	Mode of application	Formulation (% and form)	Dosage	Miscellaneous
Art 9-73 Outdoors	Residual	DDT	Spraying	5.0% E	2 gals/1000 sq. ft.	
		Malathion	Spraying	2.5% E*	2 gals/1000 sq. ft.	
	On Dogs	Malathion	Dusting	3.0-5.0% D		
		Sevin	Dusting	2.0% D		
		Lindane	Dusting	1.0% D		
		Rotenone	Dusting	1.0% D		
		Chlordane	Dusting	2.0-4.0% D		
Art. 9-74 Mosquitoes Mites Ticks	Repellent—Personal application.	Diethyltoluamide.	Apply lightly to exposed parts of body.	75% (in 2 oz bottles).	Follow label directions.	
	Repellent—Clothing application.	Diethyltoluamide.	Apply to clothing.	75% in 1 gal cans.	Follow label directions.	
				75% in 6 oz pressurized cans.	Follow label directions.	

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CHAPTER 10

INSECTICIDES AND DISPERSAL METHODS

DEPARTMENT OF THE NAVY

BUREAU OF MEDICINE AND SURGERY

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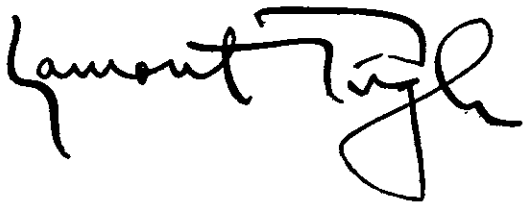

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Chapter 10

INSECTICIDES AND DISPERSAL METHODS

Section I. LIMITATIONS OF INSECTICIDES

10–1. The Role of Insecticides

(1) The development of numerous insecticides and dispersal methods during and since World War II has brought about a high degree of specialization in the field of insect control. Mosquito control by chemical methods once involved merely the application of light oils to breeding areas by simple hand sprayers and the release of pyrethrum sprays from "flit guns." Today there is a great variety of insecticides and dispersal methods, from which a choice of the most efficient chemical control program must be made. The problem is further complicated by differences in effectiveness against specific insect vectors, development of resistance, and the toxic hazards of some of the new insecticides, such as chlordane, lindane, dieldrin, and several others.

(2) A tendency to regard DDT and the newer synthetic insecticides as cure-alls which would remove all insect problems with little effort has been a very serious detriment to their proper use. The neglect of routine measures, such as adequate disposal of human waste, garbage, and trash, results in failure to attain permanent sanitary control; the use of insecticides should augment, not replace, the standard methods of sanitation. Labor is still required to spray, paint, and dust these new materials, and the men using them require more skill and training than when only the old, less complicated insecticides were available.

10–2. Special Requirements

(1) DDT continues to be the most useful all-purpose insecticide although there are numerous older as well as newer materials which are superior for certain specific insects or uses. Concentrated solutions of the new and highly toxic insecticides will not be made available for general issue, but some of the more useful formulations have been standardized and listed in the General Stores Section, Catalog of Navy Material, as carrying point items for limited issue in those cases where resistance to DDT has been conclusively demonstrated or where special problems exist. Requisitions for these items should be submitted to the Supply Officer, Naval Supply Center, Norfolk, Virginia, or Naval Supply Center, Oakland, California, via the Bureau of Medicine and Surgery, or a district or area activity designated by the Bureau, for approval. Requisitions for restricted items should indicate the titles and qualifications of the personnel who will be responsible for the use of the material.

(2) Many naval activities, particularly ships and small stations, will not have personnel adequately trained in the use of all pesticides. Several items which are designated in this Manual as general-use items are available from the Catalog of Navy Material and are suitable for use by locally indoctrinated personnel under medical-department supervision. Most other items require special handling, formulation, or safety equipment and should be used only by highly qualified pest-control operators. When general-use items will not provide satisfactory control and there is any doubt that personnel available are qualified to supervise the use of other materials, medical officers should request, through district or other command channels, the assistance of specialists. Services of medical-department entomologists and vector-control specialists or pest-control divisions (Code DD/600) of district public works offices should be requested to outline control programs and to train or evaluate competence of local personnel as required. See BUMED Instruction 6250.3 and BUDOCKS Technical Publication Tp–Pu–2, Pest Control.

(3) The tendency to change from DDT to a different insecticide with every variation in effective-

ness observed should be resisted. Many factors other than resistance may be the cause of less satisfactory control, such as faulty equipment or techniques, increased breeding or infiltration rates, or inadequate sanitation. Furthermore, the use of several insecticides may increase over-all resistance rapidly to the point where none of the new-type materials will give practical control.

10–3. Toxic Hazards

(1) A serious limitation to the use of many of the new insecticides is the potential toxic hazard to humans and animals. Considerable misinformation has been disseminated concerning the safety or danger of various products. The dangers of DDT have been exaggerated in certain instances to the point where its use has been prohibited altogether, while the "safety" of pyrethrum has led others to conclude that any pyrethrum formulation may be used with no precautions whatsoever. All insecticide preparations should be considered as harmful to humans in some degree, and for this reason certain basic precautions must be observed. It should be standard procedure to protect foods and cooking utensils and to avoid continued exposure to fogs, sprays, or dusts in unventilated areas, no matter what material is used. Basic precautions which are applicable for any insecticide-solvent combination are discussed in detail under article 10–41. Additional precautions listed under specific insecticides conform in most cases to the current recommendations and regulations of the Food and Drug Administration; U. S. Public Health Service; and the Insecticide Division, Production and Marketing Administration, of the U. S. Department of Agriculture, which is charged with the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act. Appropriate revisions will be made as new information and recommendations become available.

(There are no arts. 10–4 through 10–10.)

Section II. DDT

10–11. General Characteristics of DDT

(1) DDT (dichloro-diphenyl-trichloroethane) is a complex organic chemical first synthesized by a German chemist in 1874. In November 1942, the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, began a series of extensive tests to determine the effectiveness of DDT in the control of various insect pests and disease vectors affecting military personnel. This chemical proved to be most valuable, and large amounts of it were available for use against the vectors of typhus, malaria, dengue, filariasis, and other pests common to the tropics. DDT in its purified form is a white crystalline substance with a melting point of 108° C. to 109° C. The physical properties of this insecticide are such that it can be dispersed in oil solutions, emulsions, water dispersions, diluted dusts, aerosols or fogs. The prolonged residual effectiveness of DDT against insects constitutes its main advantage over previously used insecticides. Furthermore, minute doses produce lethal action on most insects. Ingestion of DDT by insects is not required since absorption takes place from the surface of the insect's body and its extremities. The discovery of the value of DDT in controlling insects of medical importance during the last war has been considered by many as one of the major scientific achievements in the field of preventive medicine. Although it has been supplemented by newer chlorinated hydrocarbons and other insecticides for some purposes, particularly where resistance has developed, DDT is still one of the most useful chemicals for insect control.

(2) Since DDT is slow in affecting insects, observations to determine kill should not be made too soon after treatments are applied. This delay will vary with the type of dosage, method of application, species of insects, and the stage of their development. In addition, it is important to understand that insects may be "knocked down" some time before they die. This effect is much slower than that obtained by the use of pyrethrum, but the final kill is much more certain than with previously known insecticides.

10–12. Forms in Which Supplied

(1) General Stores Section, Catalog of Navy Material stock numbers are as follows:

(*a*) Insecticide, DDT (solution, 20-percent) (airplane spray)—Stock No. G51–I–157–138.

(*b*) DDT powder, technical-grade, concentrated—Stock No. G51–I–157–5 and G51–I–157–25.

(*c*) Delousing powder, DDT (10-percent), 2-ounce can—Stock No. G51–I–171; and insecticide powder (10-percent), 5-pound can—Stock No. G51–I–157–600. For dusting only.[1]

(*d*) DDT emulsifiable concentrate (25-percent DDT, emulsifier and suitable solvent), flash point 140° F. 5-gallon pail—Stock No. G51–I–156–55.[1]

[1] General-use items. (See art. 10–2.)

(*e*) Liquid insecticide (thiocyanates and DDT)—Stock No. G51–I–165.[1]

(*f*) DDT-type aerosol gas and cylinder—Stock No. G51–G–120–31 (gas stock number) and Stock No. G51–C–2031–10 (1-pound cylinder).[1] Requisitions for this item should indicate quantities under each stock number.

(*g*) Insecticide, DDT, 75-percent water-dispersible powder—Stock No. G51–I–157–75.

10–13. Uses of Each Form

(1) *The DDT 20-percent concentrate solution* is a useful item because it may be diluted to desired strength with diesel oil or kerosene and eliminates the great amount of work required to obtain satisfactory solutions in the field. For many purposes it is therefore more desirable than the technical DDT (undiluted) powder described in paragraph (2) of this article. Solutions of DDT at from 10- to 20-percent strength are commonly used for aerial spraying. This item may also be used for preparation of fogging formulations in accordance with the directions given in article 10–56 (5) (*d*). Details of dosage and formulations are given under sections on dispersal equipment. For mosquito larviciding with hand sprayers, from 0.5- to 1-percent solutions are used, depending on the output rate of the sprayer. Lubricating oils are not recommended because they have a viscosity too high for use in hand sprayers and they do not spread well on water surfaces. The addition of 0.5 percent of a spreader (such as Triton B1956 or Ethofat 142/20) increases greatly the efficiency of oil solutions as larvicides.

(2) *DDT powder, technical-grade, concentrated*

(*a*) This powder must never be used until dissolved in oils or organic solvents. It is undiluted DDT, and its physical form is much too coarse to be applied as a powder. It presents some practical advantages in shipping and offers the user some choice as to solvents. However, since all the solvents must be shipped, often in oil drums, there is no saving in shipping space as compared with the prepared solutions. Some time and trouble are required to prepare a 5-percent DDT solution in kerosene or diesel oil No. 2 in the field due to the low solvent power of these carriers. The development of alkylated naphthalene solvents such as Sovacide F, Sovacide 544C, and Velsicol NR70, which will dissolve up to 20 or 30 percent of DDT without the toxic or explosive hazards of older auxiliary solvents such as xylene, simplifies the problem. The amount of work required for the field preparation of DDT solutions is much less with availability of the concentrated solution described in paragraph (1) of this article; therefore this item will ordinarily be required only by special control units. When 25-percent emulsifiable concentrate, 20-percent concentrate solution, or auxiliary solvents are not available, 5-percent solutions of the technical-grade DDT powder in diesel oil or kerosene should be made up several days before expected use. A solution sufficiently close to 5 percent for practical use may be prepared by adding 2 pounds of DDT to each 5 gallons of oil. Twenty pounds to a 55-gallon oil drum, short by 5 or 6 gallons, is a useful proportion. Concentrations higher than those recommended should not be attempted or the DDT may crystallize out at low temperatures, clogging the equipment. Mechanical mixers, large mixing tanks, and pumps are efficient for large-scale operations; these will dissolve the DDT in 8 to 20 minutes, depending on the concentration, the type of oil, and the efficiency of the mixer.

(*b*) A 5-percent solution of DDT in kerosene is the best of the oil-type preparations for residual treatments in buildings or on cloth surfaces such as bed nets and mattresses. Kerosene dries rapidly, makes finer crystals, catches less dust, and is less likely to cause damage on treated surfaces. One quart of 5-percent solution applied as a semicoarse spray is adequate for about 250 square feet. The kerosene solution may also be used as a fine spray against adult insects. Care must be taken that oil solutions are not used near open flames, and smoking should be prohibited for several hours in rooms where oil solutions have been applied.

(3) *Delousing powder, 10-percent DDT (2-ounce cans) and insecticide powder, 10-percent (5-pound cans).*—These preparations are ready to use and can be applied rapidly and with safety directly on the human body. Local pharmacies should procure the 10-percent powder and should not attempt to prepare this material from the technical DDT described in article 10–13 (2). Special grinding machinery is necessary to produce a satisfactory dusting powder. About 1 ounce is necessary for each person and his clothes. These preparations are particularly adapted for louse control by the individual dusting of personnel. They are rapidly dispersed and readily absorbed by insects. The 10-percent strength is required for use against lice and fleas. The 10-percent DDT dust is also useful for control of rodent ectoparasites by dusting burrows and runways. Where DDT-resistant lice occur, as in Korea, a 1-percent lindane dust has been used with good results. This item may be obtained through Army Quartermaster channels. (See art. 10–23 (2).)

(4) *DDT emulsifiable concentrate (25-percent DDT).*—The emulsifiable concentrate requires less total shipping space than most other forms and can be used as a larvicide, an insecticidal spray, of a residual spray for buildings and vegetation. This preparation is added to water in the desired ratio, an advantage where the supply of oil is limited. The new preparation replaces the xylene with a high-

[1] General-use items. (See art. 10–2.)

flash solvent to reduce the fire and explosion hazard. The great advantage of the emulsifiable concentrate is that any clean water, including rain, river, sea, or brackish water, may be employed in the preparation. For residual applications, a 5-percent spray can be prepared by adding one part of the concentrate to four parts of water. This may be applied at a rate of approximately 1 gallon to every 900 square feet of surface. A water-dispersible powder formulation or kerosene solution should be used on tentage since emulsions may cause leaking during heavy rains. If the emulsion is to be used as a larvicide, a concentration of 0.5 to 1 percent should be prepared, depending on the output rate of the sprayer, to give a distribution of 0.05 to 0.4 pound of DDT per acre. Any spraying apparatus must be thoroughly washed, rinsed, and oiled after use to prevent corrosion of the metal parts; if the emulsion is used in aerial spraying special care of all equipment is essential because of this corrosive action. A creamy layer may sometimes form at the surface of an emulsion; when this occurs the emulsion has been broken, and it should be stirred thoroughly before being poured into the sprayers for use. Since the effectiveness of the diluted emulsion begins to decrease after preparation, only the amount required for immediate use should be mixed at one time. This item is not designed for dilution with diesel oil or kerosene, although some lots may be used in this way. If such use is contemplated a sample solution should be prepared and observed after several hours to determine compatibility.

(5) *Liquid insecticide (containing thiocyanates and DDT)* is ready for immediate use. This is a general-purpose spray, commonly known as standard Navy insecticide (SNI), which may be used in the ordinary "flit" gun or in power sprayers and is recommended for all general space spraying and for disinsection of ships, at a dosage of up to 3 ounces per 1,000 cubic feet. Smaller dosages are sufficient when used in mechanical aerosol generators such as the Microsol 202. It is safe to use for all purposes when the basic precautions (art. 10–14) are observed.

(6) *DDT-pyrethrins aerosol dispenser.*—This DDT aerosol replaces the old formula, which contained only pyrethrins as an insecticidal agent. It is designed for adult mosquito and fly control in closed spaces. Six seconds (approximately 1 gram per second) of spraying time per 1,000 cubic feet of space is sufficient for most purposes, and fulfills the requirements for U. S. Public Health Service quarantine regulations for disinsection of aircraft. Aerosol dispensers should not be used outdoors or for cockroach control.

(7) *Insecticide, 75-percent DDT, water-dispersible powder.*—The water-dispersible powder requires less shipping space and may be used as a residual or larvicide but may give an unsightly white appearance on some surfaces. A wettable DDT may be indicated where residuals are to be applied to tentage (art. 10–13 (4)) or to adobe or mud-plaster walls, which are common in many parts of the world. Emulsions or oil solutions may be absorbed into the mud and clay; hence much more effective and lasting residuals are obtained with the water-dispersible powder. A 5-percent dilution is prepared by adding 1 pound of this item to about 1¾ gallons of water. A smooth paste should be prepared first and the remainder of the water may then be added. Agitation is essential during spraying to assure good dispersion and to prevent settlement of the powder and clogging of equipment.

10–14. Precautions in the Use of DDT

(1) Although DDT is a toxic substance, it is not dangerous to man when the proper precautions (art. 10–41) are taken. DDT in oil solutions is readily absorbed through the skin and should be handled with care; preparations in dusts or aerosols are considered to be entirely safe when the basic precautions are observed.

(2) Oil solutions can be used with safety only if they are not allowed to contact large areas of the skin or if repeated and prolonged contacts are avoided. If the hands must be exposed to oil solutions, rubber gloves should be used. Leaking sprayers may give excessive exposure. Personnel applying dusts or sprays for long periods within buildings should wear appropriate respirators as indicated in article 10–46. This precaution is not necessary out of doors if the materials are delivered leeward.

(There are no arts. 10–15 through 10–20.)

Section III. OTHER INSECTICIDES

10–21. Resistance to Insecticides

(1) The development of resistance to most of the chlorinated hydrocarbons by several insects has been demonstrated in many parts of the world. DDT, lindane, benzene hexachloride, dieldrin, and methoxychlor are examples of chlorinated hydrocarbons. The use of DDT and lindane for as little as one season to control houseflies in dairies or native villages has resulted in the development of strains which could not be controlled with practical dosages of these materials during the following year. In the laboratory flies have been developed which will live and reproduce in cages heavily coated with pure DDT. Rapid development of resistance to the newer insecticides, chlordane and dieldrin, has also been demonstrated in the field and the laboratory. Mosquitoes and other insects of medical importance are beginning to show resistance to DDT in some places; and in the case of pestiferous mosquitoes, resistance has developed to a serious degree in many areas. Housefly strains resistant to DDT and lindane have been controlled for limited periods with chlordane and dieldrin, and DDT-resistant mosquitoes have been controlled with lindane. However, it has been shown in several areas that houseflies soon may become resistant to all of the chlorinated hydrocarbon insecticides. Resistance has become a serious problem in the control of disease vectors in the case of lice in Korea as well as of houseflies in many countries. Consideration must be given to the use of alternative insecticides, but more important, there must be greater emphasis on nonchemical control measures.

(2) The question as to whether a resistant strain will revert to a susceptible status when not exposed to the insecticide for a period of time has not been completely answered. The consensus among researchers on this problem at present is that while reversion will probably occur eventually if there is no further exposure to the same or related insecticides, the time required will depend on the magnitude of the resistance developed. Under practical conditions in the field in the case of houseflies, it is likely that some exposure to insecticides would continue even where organized chemical fly-control operations are suspended, because there would be widespread use of chlorinated hydrocarbons for agricultural purposes and by individuals. Therefore, where a deep-seated resistance has been developed, reversion within a practical period of time would not be expected.

(3) Fly resistance has occurred for the most part in dairies, dumps, or native villages and in warm climates where the population densities of flies and numbers of generations have been high. Few complaints have been received from military posts maintaining high sanitation standards where the fly population is normally at a low level. Several authorities believe that resistance may not become a problem where fly breeding is kept at a minimum and insecticides are used only to augment standard sanitary procedures. It is also likely that resistance will be much less where space sprays or even residuals are used only within screened areas so that fewer flies will be selected by sublethal exposures to escape and breed. Applications of DDT residuals to inside surfaces may often be inadequate for continued fly control unless augmented by space sprays and other approved control measures.

(4) It must be emphasized continually that change to a new insecticide should be considered only when all other methods have been shown to be inadequate and there is conclusive proof that unsatisfactory results are due to resistance and not to faulty techniques, equipment, poor sanitation, or unusually large insect populations. A change from DDT to other chlorinated hydrocarbons will accelerate the development of resistance to all these materials. Resistance to standard Navy insecticide (art. 10–13 (5)) has not been reported, and this item should be used more generally as a space spray.

10–22. Chlordane

(1) *General.*—Chlordane is another synthetic organic insecticide which has displaced DDT for some purposes. Although its residual effect is not as long

lasting as that of DDT, it is more toxic to most insects and acts to a considerable degree as a fumigant. A 2-percent chlordane formulation is particularly recommended for roach and ant control and may also be used outdoors against fleas, houseflies, sand flies, and mosquitoes. A 10-percent chlordane dust is recommended as a soil application to control cat and dog fleas. Chlordane may be used for area control of mites and ticks outdoors if benzene hexachloride is not available. Cockroaches resistant to chlordane occur in the area around Corpus Christi, Texas, and may be found in other areas. Where satisfactory control cannot be obtained with chlorinated hydrocarbon insecticides or general-use sprays it may be necessary to use a sodium fluoride dust (art. 10–33).

(2) *Forms in which supplied*

(*a*) Chlordane, liquid, containing 2-percent chlordane (for residual roach and ant control) is available under General Stores Stock Nos. G51–I–155–375 (1-gallon container) and G51–I–155–385 (5-gallon container). This is a general-use item for unrestricted issue. (See art. 10–2.)

(*b*) Chlordane concentrate (46-percent), emulsifiable, is listed under Stock No. G51–I–155–355 (5-gallon pail) and is for use only under supervision of highly trained personnel; it will be issued only after approval of requisitions by the Bureau of Medicine and Surgery or a district or area activity designated by the Bureau.

(3) *Directions for use*

(*a*) The 2-percent chlordane liquid is a solution in kerosene oil and is recommended for use in control of roaches and ants indoors and for ant- and fly-breeding areas outdoors. For the control of roaches, application of chlordane liquid should be made at the approximate rate of 1 pint per 125 linear feet as a spot residual application only. The best way to gauge the proper amount of chlordane (2-percent formulation) is to spray until surfaces are wet without run-off. The spray should be applied freely to cracks, crevices, niches, and spaces in bulkheads and equipment where roaches seek shelter. For this type of application the one-pump oiler (Stock No. G42–0–35–115, oiler, one-pump, 2-pint capacity with ejection-tip hole reduced to 1/64-inch diameter) has been found very useful. One application is usually effective for several months and must not be applied within living quarters more often than at 2-month intervals, unless deposits are removed by frequent washing. In living areas spot applications shall not cover more than 15 percent of the total square feet of wall area. For ants indoors, the solution should be applied to areas frequented by ants, particularly to wall cavities from which ants emerge. Their runways and nests should be sprayed outside and beneath the buildings. Oil solution applied at the rate of from 1 tablespoon to 1 pint poured directly on the anthills, or better, with a probe or soil auger, is effective against subterranean species. Oil solutions should not be sprayed near open flames or directly on vegetation because of their tendency to burn plants. Carpenter ants may be eradicated with chlordane if their galleries are treated. For the control of flies out of doors, where sanitary control is not possible, their breeding and resting places should be sprayed thoroughly. A dosage of 100 milligrams of chlordane per square foot (1 gallon to 700 square feet) applied to the surface of fly-breeding media should give good control of larvae present at the time of treatment unless resistant strains are present. The development of resistant strains must be expected if this procedure is used routinely.

(*b*) The chlordane concentrate, a restricted item, must be diluted with water before use. A spray containing 2-percent chlordane is prepared by adding 22 parts of water to 1 part concentrate. It may be used in the same way as the chlordane liquid described in subparagraph (3) (*a*) of this article. Dilutions of from 1 to 5 percent may be used as outdoor residuals in local areas for mosquito, fly, and sand-fly control when recommended and supervised by qualified personnel. Chlordane concentrate should not be selected for routine use as long as DDT is effective and nonchemical methods are feasible.

(c) For use as an outdoor mist or fog a dilution containing about 2½-percent chlordane should be prepared. For temporary control of mosquitoes, flies, and sand flies around camp sites and bivouac areas, apply a 1- to 2-percent dilution lightly to vegetation, tree trunks, and other surfaces at the rate of 5 to 10 gallons per acre, depending on the amount of vegetation or other surface to be treated. For control of mites and ticks the 1-percent dilution is applied to ground litter and low vegetation at the rate of 10 to 20 gallons per acre. Indoor fogging with chlordane is approved only under the restrictions given in article 10–56 (6).

(*d*) All equipment in which chlordane emulsion has been used should be carefully cleaned, dried, and treated with an antirust agent before storage.

(4) *Precautions.*—In addition to the basic precautions (art. 10–41) the following should be observed: Chlordane should not be used as an interior space spray, i.e., to spray the air in a room for flying insects, or as a fog where personnel are present (art. 10–56 (6)). Personnel should not remain for long periods in unventilated areas after chlordane has been applied. In rooms such as bedrooms, nurseries, etc., regularly occupied by children under 2 years of age, chlordane should not be used because young animals are more susceptible than adults to the vapors which are given off for an extended period of time. Do not spray chlordane solutions directly on packaged foodstuffs. Regu-

lations of the Food and Drug Administration forbid the use of chlordane as a residual spray for fly control in dairy barns. In case of spillage on skin, immediate washing with soap and water is necessary. This is particularly important in the case of concentrates of the technical material. Operators should wear appropriate protective clothing (such as overalls and waterproof, xylene-resistant gloves) which can be changed after spraying operations.

10–23. Lindane

(1) *General*

(*a*) Lindane is the gamma isomer of benzene hexachloride, another chlorinated hydrocarbon insecticide which has been utilized extensively since World War II. The major objection to even more widespread use of benzene hexachloride has been a strong, persistent odor. This objection has been eliminated with the development of lindane, which is essentially the pure gamma isomer without the less effective and more odorous isomers. Lindane is expensive even though it is used in much smaller amounts, so that for outdoor applications where the odor is not a factor it is more economical to use a benzene hexachloride formulation (art. 10–24).

(*b*) Lindane is effective as a residual spray against flies, mosquitoes, roaches, and other household pests; as a space spray against adult flies and mosquitoes; as a larvicide for the control of fly and mosquito larvae; and as a dust or spray against ticks, mites, fleas, and lice. Its effectiveness as a residual spray is limited by a high degree of volatility.

(2) *Forms supplied.*—A lindane (20-percent) emulsifiable concentrate is available from the Catalog of Navy Material (Stock No. G51–I–167–133). This item will be issued only after approval of requisitions by the Bureau of Medicine and Surgery or a district or area activity designated by the Bureau. Requisitions should bear the titles and qualifications of the personnel who will be responsible for the use of the material. A 1-percent dust for use against DDT-resistant lice is available through Army Quartermaster supply channels in the Far East. No more than 60 grams may be applied to an individual, including clothing, nor more often than once in 60 days.

(3) *Directions and uses*

(*a*) Lindane is indicated for interior use and BHC for outside use where adult-mosquito resistance to DDT has been confirmed. This situation has been demonstrated for salt-marsh and floodwater *Aedes* in some areas along the east coast and in parts of California, and further development of this problem should be anticipated. It has also been shown that lindane is more effective than DDT against *Anopheles gambiae* and *minimus*. Lindane may be useful for roach and fly control where chemical controls are essential and DDT resistance has been confirmed. It must be remembered that resistance will also develop in a short time if lindane is used widely as a residual.

(*b*) For residual applications in buildings other than living quarters, the lindane emulsifiable concentrate should be diluted (1 part concentrate, 39 parts water) to make a spray containing about 0.5-percent lindane. Apply thoroughly to surfaces just short of run-off. One gallon of finished spray will treat 750 square feet or deposit about 25 milligrams of lindane per square foot of surface area. If satisfactory control is not obtained, this dosage may be increased to a maximum of 50 milligrams per square foot by using a 1-percent dilution. Residual applications of lindane in living quarters will be limited to spot applications with the 0.5-percent concentration until more information on the toxicity of lindane vapors is available. Spot applications in living quarters shall not cover more than 15 percent of the total square feet of wall area. The continuous release of lindane vapors by devices employing heat shall not be permitted except under the restrictions listed in paragraph (4) of this article. Procurement of lindane vaporizers will not be approved until more information on the efficiency and safety of such devices is available. Recent evidence indicates that in many areas effective housefly control may be obtained for only one season.

(*c*) After use with lindane emulsion, all equipment should be carefully cleaned, dried, treated with antirust agent, and stored so as to avoid corrosion.

(4) *Precautions.*—In addition to the basic precautions (art. 10–41) the following should be observed: Lindane should not be used repeatedly as a general space spray indoors at concentrations greater than 0.1 percent. It should not be applied as a fog where personnel are present or in living areas at a rate greater than 1 gallon of 2-percent solution per 50,000 cubic feet or more often than once in 30 days. If lindane vaporizers are used, the method and rate of dispersal must conform to the recommendations of the Interdepartmental Committee on Pest Control,[2] which are as follows:

(*a*) The insecticide should be continually released over a 24-hour period at a rate not to exceed 1 gram per 15,000 cubic feet per 24 hours. The dispensing rate per hour should not vary more than 25 percent. Devices should be so constructed that output in excess of that recommended is impossible.

(*b*) Installation shall be made only on commercial or industrial premises and similar locations where human exposure shall be on a working-day basis, not continuous.

[2] Composed of representatives of the Departments of Agriculture, Interior, Army, Navy, Air Force, and Health Education and Welfare.

(c) The devices should not be used in homes or sleeping quarters.

(d) Unless it can be demonstrated that contamination does not occur, the Committee recommends against the use of insecticide vaporizers in rooms where food is served, processed, or stored. This is to be interpreted at naval ships and stations to mean that such devices may not be used where food is served, prepared, or stored. (See SECNAV Instruction 6250.2.)

(e) The Interdepartmental Committee has no evidence that other insecticides, when used in vaporizers in space occupied by humans or where food is present, are effective or safe.

10–24. Benzene Hexachloride

(1) *General.*—Technical grades of benzene hexachloride are available commercially which contain approximately from 11- to 60-percent gamma isomer. The essentially pure gamma isomer (at least 99 percent pure) is known as lindane and is discussed in article 10–23. The uses for benzene hexachloride (often referred to as BHC) are essentially the same as for lindane, and its chief advantage is in lower cost for treatments where the odor is not a limiting factor. Formulations may be prepared and applied so that the amount of gamma isomer dispersed is approximately the same as when lindane is used.

(2) *Forms supplied.*—A benzene hexachloride emulsifiable concentrate (11-percent gamma isomer) will be made available as a standard item for outdoor applications. Pending standardization, requisitions for open purchase of benzene hexachloride should be submitted via the Bureau of Medicine and Surgery for approval and recommendation of an approved purchase description.

(3) *Directions and uses*

(a) As an outdoor spray against mosquitoes, flies, and sandflies the BHC emulsifiable concentrate should be diluted (1 part of an 11-percent gamma concentrate to 21 parts water), to make an emulsion containing approximately 0.5-percent gamma isomer.

(b) Apply this 0.5-percent emulsion lightly to vegetation, tree trunks, and other surfaces at the rate of 5 to 10 gallons per acre. To control mosquito larvae, apply as a fine mist at the rate of 0.5 to 3 gallons per acre of water surface. For control of mites, ticks, and fleas, apply as a spray to ground litter and low vegetation at the rate of 10 to 20 gallons per acre. Where flies are resistant to DDT and chlordane, the spray may be applied to fly-breeding materials at a rate of 1 to 2 gallons per 750 square feet.

(c) For airplane application against mosquitoes not satisfactorily controlled with DDT, a 2½- to 5-percent gamma solution is used, depending upon the discharge rate of equipment. The standard 11-percent emulsifiable concentrate is suitable for dilution with diesel oil. Apply to areas where adult mosquitoes occur, at a rate of 1 quart of 5-percent or 2 quarts of 2½-percent gamma solution per acre. (See art. 10–57 on aerial dispersal.)

(4) *Precautions.*—The same precautions as are given for lindane in article 10–23 (4) should be observed for benzene hexachloride.

10–25. Dieldrin

(1) *Uses*

(a) Dieldrin is one of the most effective new insecticides but is also one of the most toxic to mammals. In the lower dilutions (0.3 to 0.5 percent) normally applied, it is probably no more dangerous than related insecticides, but there is a great hazard to personnel handling the concentrated preparations and to animals and humans when stronger formulations are utilized. It is particularly dangerous by skin absorption, and there is but little warning of the development of toxic levels. Therefore, dieldrin will be approved only for experimental use under the direct supervision of highly qualified vector-control specialists and will be issued only after approval of requisitions by the Bureau of Medicine and Surgery or a district or area activity designated by the Bureau. It is currently listed as a restricted item in the Catalog of Navy Material as insecticide, dieldrin, emulsifiable concentrate, Stock No. G51–I–157–1625, and contains about 18 percent technical dieldrin.

(b) Dieldrin will not be used for interior applications, but has been found very effective in preventing fly emergence when it is applied to the surface of fly-breeding materials at the rate of 25 to 50 milligrams per square foot. Chlordane, dieldrin, and gamma benzene hexachloride are far superior to the older fly larvicides such as sodium arsenite or paradichlorobenzene. See arts. 10–22, 10–24, 10–31, and 10–32.) The probable development of resistance, however, may eventually limit the usefulness of these materials as fly larvicides. Dieldrin is also recommended as a residual mosquito larvicide in shallow, landlocked, and freshwater ponds where *fish and other aquatic organisms are of no significance.* Tests by the U. S. Public Health Service have indicated that an emulsion of dieldrin applied at the rate of 1 pound of dieldrin per acre gives effective control for from 1 to 2 years of *Aedes, Culex,* and *Anopheles* mosquitoes breeding in ponds.

(2) *Precautions.*—Investigations indicate that dieldrin is much more toxic to man and animals than DDT, lindane, or chlordane. Users should exercise extreme care in handling it. Waterproof, xylene-resistant gloves and other protective clothing should be worn by workers handling technical dieldrin or dieldrin concentrates. Respirators should be worn when handling technical dieldrin,

dieldrin dusts, or wettable dieldrin powders, and by operators of application equipment in any situation where they are exposed to appreciable contamination during spraying or dusting operations (art. 10–46). Every feasible precaution should be taken to avoid the breathing of dieldrin fumes, dusts, or sprays and to avoid skin contamination with dieldrin in any form. Contaminated skin areas should be washed immediately with soap and water, and contaminated clothing should not be worn.

10–26. Pyrethrum and Allethrin With Synergists

(1) Pyrethrum is a natural product which has been widely used for years as an insecticide due to its relative safety to humans and rapid paralytic action against insects. It is normally formulated in combination with other insecticides because of the tendency for many insects to recover after initial knock-down by pyrethrum. At present its high cost and status as a critical material are limiting factors in the use of pyrethrum, although the use of recently developed synergists such as piperonyl butoxide increases its efficiency. Pyrethrum is currently used by the Navy in combination with DDT in the aerosol-bomb formula. Pyrethrum is particularly useful for large-scale treatment of grains and foods which cannot be adequately protected from contamination.

(2) Allethrin is a synthetic preparation of the allyl homolog of cinerin I, one of the most active components of pyrethrum. For some purposes this compound is as effective as natural pyrethrum, and as production increases it probably will be widely used if costs are not too high.

10–27. Thiocyanates

(1) The thiocyanates (Lethane, Thanite) were among the first synthetic insecticides developed. They are used in the standard Navy space-spray formula with DDT. (See art. 10–12 (1) (*e*).) Sprays formulated with these materials are not dangerous to humans when the basic precautions are observed, and they have been found to be an excellent cheap substitute for pyrethrum as an ingredient of space sprays. A formula containing Lethane and DDT has also been found effective when used in airplane or fogging formulations for adult-mosquito control. Also resistance to the standard space spray has not been reported.

10–28. Methoxychlor

(1) Methoxychlor is an analog of DDT that is less poisonous to mammals and is recommended for use in dairies or in food-processing plants and similar locations where protection of foods and utensils during spraying is not possible. It is a residual insecticide and has been used effectively against DDT-resistant flies, but resistance will also build up to the methoxychlor.

10–29. Organic Phosphorus Compounds

(1) Several organic phosphorus compounds such as parathion and tetraethyl pyrophosphate have been developed recently which are very effective insecticides, especially for agricultural use. Their toxicity to man and other mammals is so great, however, that these materials have not been authorized for use by naval personnel or at naval activities. Current research indicates that they may eventually have a place in the control of resistant insects.

10–30. Dilan

(1) Dilan is another new synthetic insecticide that has been effective against DDT-resistant flies and appears to be less toxic to animals than DDT. However, resistance may be expected to develop where it is used continuously, and it will not be standardized unless further research indicates that it could replace other items.

10–31. Sodium Arsenite

(1) Sodium arsenite has been recommended for many years as a soil poison for termite control and for the prevention of fly breeding in dead bodies or other fly-breeding materials. Sodium arsenite (54-percent solution) is listed in the Catalog of Navy Material under Stock No. G51–S–2333, 30-gallon drum. The new materials chlordane, lindane, and dieldrin are more effective as fly larvicides and require much less shipping space, but the development of resistance to the chlorinated hydrocarbons in some areas may again bring about a requirement for sodium arsenite. When sodium arsenite is used as a fly larvicide, the 54-percent concentrate should be diluted (1 part to 53 parts water) to make a 1-percent solution, and the surfaces of breeding materials (corpses, garbage, greasy earth, etc.) should be thoroughly wetted. Sodium arsenite is a poison and will burn plants and shrubbery, so it must be used with care. If arsenicals are used as a soil poison for termite control at naval activities, it is a responsibility of the medical officer to see that adequate precautions are observed to prevent accidental ingestion or contact by personnel, particularly children, and that only qualified operators are employed.

10–32. Paradichlorobenzene

(1) Paradichlorobenzene, a crystalline, volatile material, has also been used for control of fly larvae. The vapor kills fly larvae and repels adult flies from the breeding points. When deposited in straddle trenches or boxed-in pits, it slowly vaporizes, and the heavy vapor remains in the pit. Use 1 pound for each seat, with one-fourth pound twice weekly

subsequent to initial application. Seats should be kept free of PDB condensation to avoid possible skin burns. Two ounces of paradichlorobenzene per garbage can have controlled fly breeding for 1 to 2 weeks in field tests. Vaporization does not occur if paradichlorobenzene is covered by water or feces. This item is also useful for moth control in tight chests or closets. Paradichlorobenzene is listed in the Catalog of Navy Material under Stock Nos. G51–D–190, 1-pound can, and G51–D–192, 100-pound drums.[1]

10–33. Sodium Fluoride

(1) The use of sodium fluoride is indicated only where roaches are resistant to chlordane and lindane and where general-use sprays or dusts do not give satisfactory control. The sodium fluoride dust should be colored and must not be stored in food establishments or galleys. It is a dangerous poison, and every precaution must be observed to prevent contamination of food or accidental ingestion. It should be applied only by trained and responsible operators.

(There are no arts. 10–34 through 10–40.)

Section IV. TOXICITY OF INSECTICIDES TO HUMAN BEINGS

10–41. Basic Precautions

(1) The possibility of danger from insecticides, as with other chemicals, will usually depend as much on the method and conditions of use as on the inherent toxicities of the insecticides. Any material which is insecticidally effective is, with few exceptions, toxic in some degree to humans. Therefore, the basic precautions recommended should always be observed. Usually the toxic properties of the solvent or carrier as well as those of the insecticides must be considered. An insecticide-solvent combination that is effective against most insects, completely safe for all types of uses, and economically acceptable as well, has yet to be discovered. The basic precautions contained in this section should be observed in the use of insecticide-solvent combinations no matter what material is used or what safety features may be claimed. Additional precautions are required as indicated for specific insecticides in section III.

(*a*) Protect food and eating utensils from contamination.

(*b*) Limit exposure of personnel to liquids and vapors as far as practical.

(*c*) Avoid inhalation, swallowing, and skin contact with liquids. In case of spillage on the skin, washing with soap and water is necessary.

(*d*) Maintain good ventilation during application, and where prolonged contact is necessary respirators and protective clothing should be worn (art. 10–46).

(*e*) Do not use in the presence of open flames or very high temperatures. Containers should be plainly labeled and kept covered or closed as much as possible. Waste material soaked with solvents should be discarded in covered safety cans.

(*f*) Safe and orderly storage of pesticides under the supervision of qualified and responsible personnel should be a routine precaution. All containers should be stored away from open flame and strongly oxidizing materials. Do not store in mess halls or near foods.

10–42. Toxicity of DDT

(1) *Relative safety.*—When employed only in the effective recommended dosages, DDT is less toxic to man than paris green, sodium fluoride, nicotine, or most of the other chlorinated hydrocarbon insecticides. The extensive experience with use of DDT throughout the world since its introduction during World War II is the best evidence of its relative safety. The main danger from DDT, aside from accidental ingestion of large doses, is now considered to lie in the possible accumulation of residues in the fatty tissues and possible liver damage, since this does occur in small animals when there has been continuous exposure to small amounts in their food. In order to provide a wide safety margin, DDT is no longer approved for use where repeated contamination of food cannot be prevented, as in dairies (or on cows), food-processing plants, flour mills, and similar areas, even though there has been no evidence that the low levels accumulated are harmful to human beings. In brief, recent studies indicate the need for greater realization of the potential hazards of DDT residues in foods but do not show any need for restriction of the use of DDT if presently recommended precautions are observed and repeated contamination of food and milk is prevented.

(2) *Action on skin.*—Experiments with animals

[1] General-use items. (See art. 10–2.).

have shown that there is no absorption of dry DDT powder from the skin, but oily solutions are absorbed; large doses cause hyperexcitability, tremors, clonic convulsions, and liver damage. Men engaged in mixing or spraying the oily solutions of DDT should take all necessary precautions to prevent the material from spilling on or coming in contact with the skin. Occasional contact is apparently not dangerous, but repeated or prolonged contact must be avoided. If it is accidentally spilled on the skin, wash immediately with soap and water.

(3) *Parenteral absorption.*—In animals, dry DDT is not readily absorbed when injected intramuscularly or subcutaneously. In oils, however, it acts in the same manner as when absorbed in oily solution from the skin.

(4) *Effect on the nervous system.*—The acute toxic manifestations in animals consist of anorexia, irritability, tremors, convulsions, and paralysis. The effect on the nerve tissues is apparently purely functional, there being no demonstrable pathological lesions in the brain, spinal cord, or peripheral nerves.

(5) *Effect on the respiratory tract.*—No toxic symptoms occurred in dogs and rats exposed in an atmosphere containing many times the recommended insecticidal concentration of DDT in aerosol. Daily exposure of monkeys and men for 1 hour to heavy concentrations of DDT in dust caused no ill effects. The talc or pyrophyllite contained in 10-percent DDT powder offers no apparent threat of silicosis under normal use conditions; this danger is present, however, among men constantly exposed, week after week, to heavy concentrations. A respirator should always be worn when applying any insecticidal dust within closed spaces. The toxicity from inhalation of heavy concentrations of DDT smokes has not been definitely determined, but it is probably no greater than that of similar exposure to sprays.

(6) *Effect on the gastrointestinal tract.*—The fatal oral dose of DDT for man is not known, although it is thought to be about 1 ounce of technical DDT for the average person. Deaths attributed to DDT have been reported, but in practically all cases there was concurrent ingestion of large quantities of solvents which are often capable of producing similar toxic effects. Symptoms of DDT intoxication include tremors, convulsions, inco-ordination, prolonged prothrombin time, toxic necrosis of the liver, and a terminal nephritic picture. A dose of 20 grams has proved highly dangerous though not fatal to man. Experimental ingestion of 1 to 5 grams resulted in great discomfort and moderate neurological changes. Vomiting followed only after 11 hours, and recovery was complete on the following day. Such dosages are many times that which an individual would obtain when carefully dispersing the recommended insecticidal quantities of DDT. Chronic DDT poisoning may result from the ingestion of small amounts of the material over a long time. The Federal Food and Drug Administration has tentatively set a tolerance of five parts per million as the upper limit on any single item containing DDT residues for human consumption and less than one part per million if all the food consumed is contaminated. The occasional ingestion of water that has been treated for larviciding is apparently not harmful, but this must be avoided wherever possible.

10–43. Toxicity of Lindane and Benzene Hexachloride

(1) Lindane is rated at one-fourth the toxicity of DDT from the standpoint of continued ingestion, but it does accumulate in body tissues to some degree, particularly in the fat. However, its acute toxicity from ingestion, inhalation, or skin absorption is reported as considerably greater than DDT. Since much lower concentrations are ordinarily used, this would be of practical importance only in the handling of concentrates. At the present time there is not sufficient information on the possible danger from continued exposure over a period of months or years to lindane vapors, whether such vapors are evolved from heavy residual deposits in closed areas or from heating devices. Therefore, unlimited exposure to such vapors must be avoided. (See art. 10–23 (4).)

10–44. Toxicity of Chlordane

(1) Chlordane is a poison which, from the acute standpoint, affects mainly the central nervous system. The fatal dose for man is unknown but is estimated at from ⅛ of an ounce to 2 ounces. In animals after repeated exposure, clinical manifestations noted were liver damage, inanition, ataxia, convulsions, collapse, and sudden death. Its chronic toxicity by dermal application through multiple exposures is approximately four times greater than that of DDT, with moderate irritation to the skin and evidence of systemic absorption. Skin areas contaminated with chlordane sprays or concentrates of the technical material should be washed immediately with soap and water, and contaminated clothing should not be worn. Millions of pounds of chlordane have been used with no apparent ill effects to users; however, one human death has resulted from accidental skin application of a 25-percent solution amounting to a little over 30 grams of technical chlordane—clear evidence that this material must be handled with caution. Much smaller amounts (2 to 4 grams) may be fatal to individuals with chronic liver damage. It has been reported that the acute oral toxicity of chlordane to rats is one-half that of DDT, while its chronic toxicity is at least three times that of DDT. In actual use, as a 2-percent chlordane solution, its toxicity would be about equal to a 5-percent DDT

solution. However, due to its vapor-producing quality, this material is not approved for residual applications over entire inside surfaces in living quarters and mess halls, and spot applications are limited to 15 percent of the total square feet of wall area. (See art. 10–22 (4).)

10–45. Toxicity of Other Important Insecticides

(1) *Dieldrin.*—The acute dose in man is not known. Oral LD50 for rats is about 87 milligrams per kilogram, indicating an acute toxicity roughly five times that of DDT. The acute dermal toxicity for rats is only slightly less (60 milligrams per kilogram for the female), so that particular care must be observed in handling both solutions and concentrates. Nothing is known about chronic toxicity specifically in man. Experimental animals show a wide species variation in their susceptibility to dieldrin. Repeated skin application of 10 milligrams or even 20 milligrams per kilogram are tolerated by rats, whereas rabbits are killed by both of these dosages. Dieldrin is one of the most toxic of the chlorinated hydrocarbons, and every precaution must be observed to avoid skin contamination or breathing of dieldrin in any form.

(2) *Thiocyanates.*—Thiocyanates can be toxic but are not dangerous in the concentrations normally applied. Lethane has an acute oral toxicity somewhat less than that of DDT, but its toxicity by skin application is much greater. It has been estimated that applications to the skin of about 600 milliliters of a 5-percent solution of Lethane in a single exposure, or 150 milliliters in daily exposures, would be dangerous to man. Normal precautions required in the handling of any insecticide should prevent exposure of this magnitude, and widespread use of Lethane since 1936 has produced no reports of serious toxic effects.

(3) *Organic phosphorus compounds.*—Death has followed splashing of the body and clothing of one worker with technical parathion. The amount was sufficiently small that the worker was not soaked or at any rate did not follow the simple instructions for changing clothes and bathing. Two operators have died after rather extensive skin contact with agricultural sprays and inhalation of dust from 25-percent wettable powder. Others have died after what was apparently almost entirely respiratory exposure to 25-percent dust.

10–46. Protective Devices and Clothing

(1) *Respirators*

(*a*) The use of respirators is advised for protection from dusts or mists during field handling of, and open-field exposures to, insecticides. *Their use is not a substitute for other essential precautions.* For protection against field exposures to insecticidal dusts, the respirator listed in paragraph (3) (*a*) of this article is recommended. For protection against mists and low-vapor concentrations of chlordane, BHC, lindane, and dieldrin, the respirator listed in paragraph (3) (*b*) of this article is recommended.

(*b*) Respirators do not provide adequate protection from inhalation of insecticide dusts, mists, and vapors for use by those formulating or mixing insecticides or applying insecticides continuously in closed spaces. Under such conditions of severe exposures, full-face gas masks equipped with tested canisters or air-line masks should be worn. Universal-type canister masks, Type N, Bureau of Mines approved, NAVEXOS, P–422, page 40, or a full-face air-line mask is recommended. (See par. (3) (*c*) of this article.)

(2) *Protective clothing.*—Waterproof, xylene-resistant gloves and other protective clothing such as overalls should be worn by operators who handle concentrates or who are continuously exposed to insecticide formulations. Contaminated clothing should not be worn, and all clothing should be changed after spraying or mixing operations.

(3) *Standard items.*—The following items are listed in the Catalog of Navy Material, General Stores Section, Class 37:

(*a*) Mechanical filter pad, half-mask, Type C—Stock No. G37–M–315. Class-1 filter pads for Type C (red, for dusts)—Stock No. G37–R–97.

(*b*) Twin-chemical-cartridge, half-mask, Type B–2—Stock No. G37–M–314. Filter cartridge for Type B–2—Stock No. G37–R–96.

(*c*) Air-line mask, full-facepiece—Stock No. G37–M–57–50.

(*d*) Solvent-resistant gloves—Stock No. G37–G–2593 (sizes 9 to 11).

(*e*) Coveralls—Stock No. G37–C–2572 (medium and large).

(There are no arts. 10–47 through 10–50.)