THE U.S. ARMY MINIATURE SOLID STATE MOSQUITO LIGHT TRAP[1]

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ABSTRACT. A new portable Army miniature solid-state mosquito light trap (AMSS trap) has been developed at the U.S. Army Medical Bioengineering Research and Development Laboratory. The AMSS trap has the unique features of once-a-day tending and the capability of being effectively operated by any 6 volt DC source.

A new portable Army miniature solid-state mosquito light trap (AMSS trap) (Fig. 1) has been developed at the U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, Frederick, MD. The AMSS trap has the unique features of once-a-day tending and the capability of being effectively operated by D-cell batteries, adapted 110 AC line current or any 6-volt storage battery. Components used in fabrication of the AMSS trap were those identified as most satisfactory when subjected to engineering analysis with regard to durability, efficiency, and cost. Evaluations addressed various aspects of mechanical, electrical, and human engineering with respect to operational conditions and designs.

Conclusions of the analyses and components used in the final fabrication are as follows:

a. The Mabuchi® RF510T series, 6 volt DC motor was the motor of choice. It provided the optimum fan speed in revolutions per min (rpm) over a wide range of operating voltages. This motor also had the highest rating in terms of rpm per milliampere of current used and life expectancy. The cost of the Mabuchi motor is only about one-fourth the cost of the motor commonly used in most miniature light traps.

b. The 4-bladed, 3 in. diameter, plastic Thorgen® fan was vastly superior to any other fan considered. It delivered the air velocities necessary to collect and retain mosquitoes in the trap. Since the fan is a true airfoil instead of a fabricated aluminum blade, specimen damage from passing through the fan is lessened.

c. The Chicago Miniature Lamp Number 503 was selected as the primary lamp. It had a long life and relatively high candlepower output with low current consumption. The Chicago Miniature Lamp Number 1490 was considered an acceptable alternative.

d. The Globe Union Gel-Cell®, 6-volt, 7.5 amp. hr rechargeable battery (GC680) was selected as the primary battery power supply. This battery is self-contained with a high energy to weight ratio. The gel-cell eliminates the use and handling of battery acid and the associated problems created by use of wet-cell lead-acid batteries. The discharge characteristics of this battery provide a relatively constant operating voltage over a sustained period of time. This is not the case with either standard D-cells or lantern batteries in which the operating voltages are significantly lowered after a few hours of use.

e. A 14-in. diameter aluminum pizza pan was used as the rain shield for the trap. Since the pan is flat, it also can easily serve as a convenient surface for sorting mosquitoes.

f. The standard catch net available

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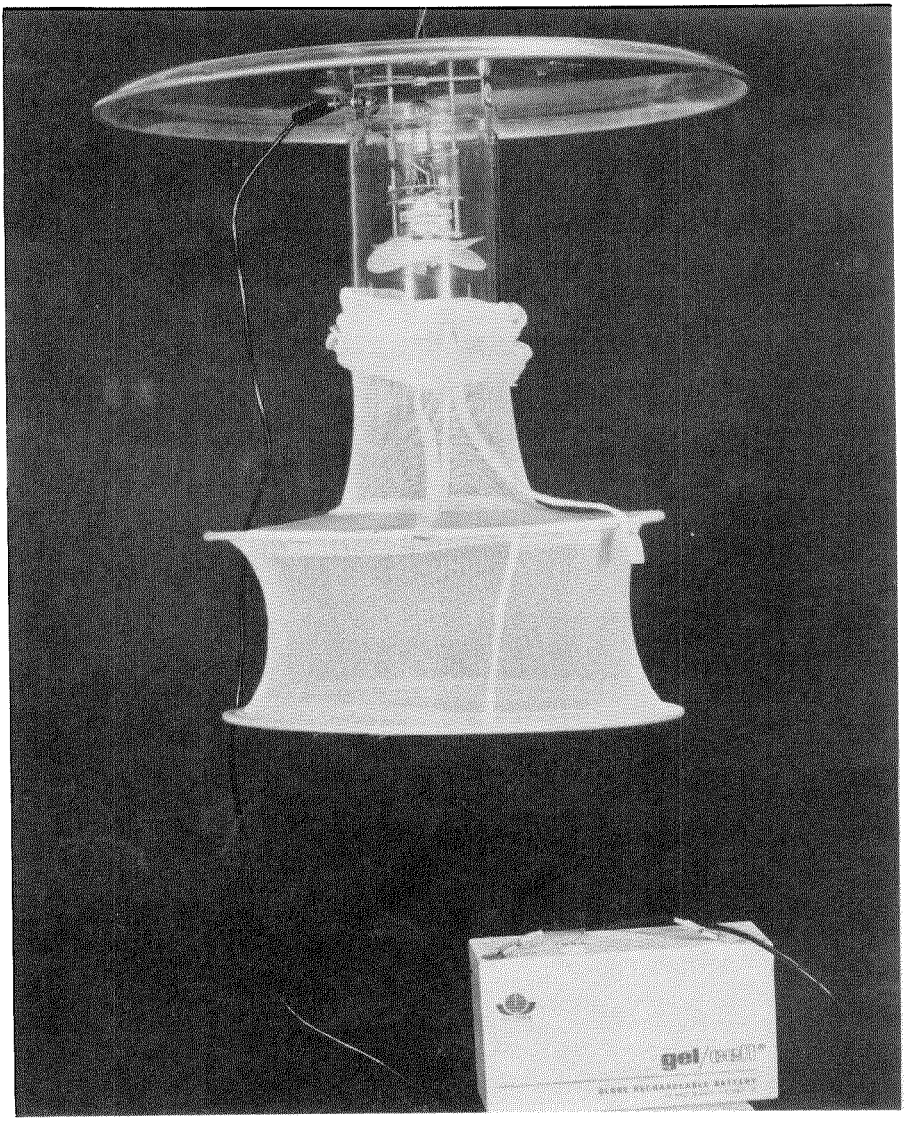

Figure 1. The AMSS trap.

from most suppliers was also modified. To facilitate mounting of the net and its recovery the next day, a durable elastic band was sewn into the netting mesh above the tie-string.

g. The circuitry (Fig. 2) is designed so that the trap will not operate if battery polarity is reversed. A single polarized input plug is utilized to eliminate the possibility of reversing polarity when plugging the battery pack lead into the trap. The circuitry was developed so that, when 6 volts are applied to the trap, the motor will operate at 5¼ volts and the lamp at 4¼ volts.

The primary advantage of the circuitry is that it allows the trap to be set out any time during the day. The trap is auto-activated at dusk in response to decreasing ambient light conditions. Once activated, the motor and lamp operate continuously until dawn. At dawn the increasing ambient light shuts off the lamp. The motor continues to run until the power supply is disconnected. Thus, specimens are held in the collection net until time of collection.

The engineering design provides sufficient reserve power so that the AMSS trap does not lose a trap-night even if the system is inadvertently activated prior to the proper time. If the system were fully activated, the primary power source would have sufficient power to run the trap at peak efficiency (battery voltage 5.75 or greater, lamp voltage 4.0 or greater) for more than 24 hr prior to battery failure. If the lamp, the primary power consumer, were not activated, the primary power source could operate the motor for up to 75 hr before the air velocity from the fan would drop below the level needed to retain the mosquitoes in the net.

Field evaluations of the AMSS trap were conducted at Pocomoke, Maryland, and Wallops Island, Virginia, in separate field tests during 1977, and in Panama during 1978. The 1977 tests compared operating voltage, trap type, and power source. The tests in Panama were conducted to compare different lamps and effectiveness of the AMSS trap for *Culicoides* collection.

In 1977, a paired test was conducted with the AMSS trap to determine the effect operating lamp voltage had on catch. Six identical AMSS traps were used in this test. Voltages of 3 of the traps were adjusted to give an operating lamp voltage of 4¼ volts while the voltages of 3 other traps were adjusted to 2½ volts. These voltages were selected because they simulated the characteristic operating lamp voltage of the AMSS trap and the standard CDC trap with 4 D-cell batteries, 2 hr after activation. At 3 sites, 10 m apart, paired traps with lamps set to operate at 4¼ and 2½ volts were hung on fabricated stands. Stands were 2 m in height and each had two 1-m arms. To ensure a relatively constant lamp voltage through the night a 6-volt gel-cell battery was used in this evaluation.

Two other evaluations, a trap type study and a battery type study were set out in a similar manner. However, 3-pronged, 2-m stands were used in these tests. The trap type study was conducted at 3 sites 10 m apart while only a single site was used in the battery type study. The trap type study evaluated 2 traps: the AMSS trap, powered by 5 D-cell batteries in series, and the CDC-4 trap powered by 4 D-cell batteries. In the battery type study, 3 AMSS traps were set to have an operating lamp voltage of 4¼ volts when 6 volts were applied to the trap. Each trap was operated with 1 of the following battery configurations: 4 D-cell batteries in series, 5 D-cell batteries in series and one 6-volt gel-cell rechargeable battery.

Batteries in each of the evaluations were changed daily. D-cells were discarded and the gel-cells were recharged and returned to the evaluation.

Trap positions in these 3 studies were assigned on a random basis. To minimize positional differences, each trap was moved 1 position clockwise for each successive night of operation. The CDC-4 was tended twice daily, while the AMSS trap was tended once per day. All mosquitoes in the battery and trap-type

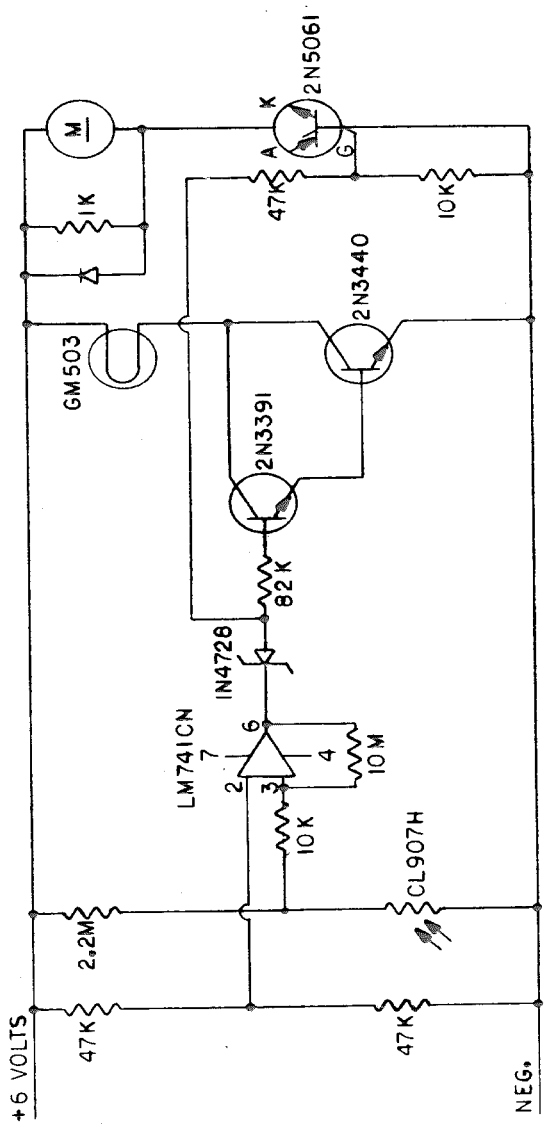

Figure 2. Electronic circuitry for AMSS trap.

studies were counted and identified to species. In the lamp voltage study, only total number of specimens was determined. An analysis of variance was conducted and an "F" value determined.

In 1978, tests were conducted at 3 locales in Panama to determine which of 2 satisfactory lamps (Chicago Miniature 503 and 1490) was best and to determine effectiveness of the trap for *Culicoides* collection. Six AMSS traps were used at each test site. These were paired on T-shaped stands previously described. The traps were accurately calibrated to deliver identical operating lamp voltage (4.25 volts).

To compensate for possible positional effects, stands were rotated 180 degrees after each night. Stands and traps were positioned in a variety of environments from jungle islands to mangrove swamps. To survey for *Culicoides*, 6 traps at one site were equipped with alcohol jars instead of catch-nets. At another site, traps were compared to a man-baited trap. The traps were emptied daily and supplied with fresh gel-cell batteries. After being used 1 night, batteries were placed on a charger overnight to prepare for their subsequent re-use.

In a total of 36 trap-nights of operation the AMSS trap with the operating lamp voltage set at 4¼ volts caught 3.46 times more mosquitoes than it did when set at 2½ volts (Table 1). The trap catch index is a normalized value determined by dividing the total mosquitoes trapped by each trap by the least productive trap in the test. The level of significance in this study was determined to be .999.

Table 1. Comparison of mosquito catch for Army Miniature Solid State (AMSS) mosquito light trap system with CM-1490 lamps operated at 2.50 and 4.25 volts.

Voltage	Trap-Nights	Total Mosquito Specimens Trapped	Catch per Trap-Night	Trap Catch Index
4.25	18	785	43.6	3.46*
2.50	18	227	12.6	1.00*

* Level of significance >.999.

In a total of 36 trap-nights of operation, the AMSS trap caught 3.48 times more mosquitoes than the CDC-4 trap (Table 2). In addition, the AMSS trap caught twice as many species per trap-night than did the CDC trap. The level of significance between the AMSS trap and the CDC trap was calculated to be .999.

For 12 combined trap-nights the AMSS trap powered by the 6-volt rechargeable gel-cell battery captured 6.63 times more mosquitoes than the 4 and 5 D-cell powered traps (Table 3). The level of significance was determined to be .950. Additionally, the gel-cell powered trap caught 1.80 times more mosquito species per trap night than did the other two traps. Due to the limited number of operational trap-nights, no significance could be attributed to the 2.48 times more specimens caught by the 5 battery trap when compared to the 4 battery trap. However, the trend is felt to be most noteworthy.

Results of the lamp study are summarized in Tables 4 and 5. In a total of 40 trap-nights of operation the AMSS trap with the 503 lamp caught slightly more mosquitoes than did the AMSS trap equipped with the 1490 lamp. In a total of 22 trap-nights of operation, the AMSS trap with the 503 lamp also caught slightly more *Culicoides* than did the trap equipped with the 1490 lamp. Either lamp would be satisfactory, although the 503 lamp was selected as the primary lamp due to slightly longer life expectancy.

Results of the comparison of the AMSS trap and a man-baited trap are summarized in Tables 6 and 7. When compared directly to a man-baited trap, the AMSS trap was a poor second. The man-baited trap averaged almost three times the number of mosquitoes as the AMSS trap. However, the results in Table 6 are skewed due to the presence of large numbers of *Anopheles albimanus* in the area. This species, which is highly anthropophilic, but poorly attracted to light

traps, represented a signficant portion of the catch of the man-baited trap. If this species is eliminated as in Table 7, both AMSS and man-baited traps are equally effective in collecting total number of specimens. Similar to results in Tables 2 and 3, the AMSS trap collections in Panama represented a greater diversity of species than the man-baited trap. With the addition of a CO_2 source, the AMSS trap probably could be equally effective as the man-baited trap for collection of anthrophilic species.

The AMSS trap is a substantially better trap than the CDC trap in the aspects of total mosquitoes caught, total mosquito

Table 2. Comparison of mosquito catches for AMSS and CDC traps using number of D-cell batteries designed for each trap.

Trap	No. D-Cell Batteries	Trap-Nights	Mean Number Species	Total Specimens Trapped	Catch per Trap-night	Trap Catch Index
AMSS	5	18	8	233	12.9	3.48*
CDC	4	18	4	67	3.7	1.00*

* Level of significance >.999.

Table 3. Comparison of mosquito catches from AMSS traps operated with three different power sources.

Power Supply	Trap-Nights	Mean Number Species	Total Specimens Trapped	Catch Per Trap-Night	Trap Catch Index
1—6-volt gel-cell	4	5	179	44.8	6.63*
5—1.5 volt D-cell	4	3	67	16.8	2.48*
4—1.5 volt D-cell	4	3	27	6.8	1.00*

* Level of significance >.999.

Table 4. Comparison of mosquito catches from AMSS traps operated with two different lamps from two different sites.

Lamp	Trap-Nights	Total Specimens Trapped	Catch per Trap-Night	Catch Index
1490	20	361	18.1	1.00
503	20	418	20.9	1.15

Table 5. Comparison of *Culicoides* catches from AMSS traps operated with two different lamps.

Lamp	Trap-Nights	Total Specimens Trapped	Catch per Trap-Night	Catch Index
1490	11	2768	251.6	1.00
503	11	3010	273.6	1.09

Table 6. Comparison of mosquito catches from AMSS traps with a man-baited trap.

Lamp	Trap-Nights	Total Specimens Trapped	Catch per Trap-Night	Catch Index
AMSS	22	629	28.6	1.00
Man-Baited	2	171	85.5	2.99

Table 7. Comparison of mosquito catches from AMSS trap with a man-baited trap less anthrophilic *Anopheles albimanus*.

Lamp	Trap-Nights	Total Specimens Trapped	Catch per Trap-Night	Catch Index
AMSS	22	614	27.9	1.03
Man-Baited	2	54	27.0	1.00

species caught per trap-night and in economy of manpower expended to tend the traps. The AMSS trap is also better than an animal-baited trap in respect to total number of mosquito species caught per trap night and in economy of manpower. The once-a-day tending system which will retain live specimens in the trap throughout the day has proven to be a useful and effective system for efficient utilization of manpower.

THE U.S. ARMY PORTABLE INSECT SURVEY SET[1]

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ABSTRACT. A new portable insect survey set has been developed at the U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, Frederick, MD 21701. The basic component is the Army Miniature Solid State Mosquito Light Trap (AMSS trap). The set is equipped with a variety of both AC and DC power sources and all ancillary items needed for continuous operation.

A new portable insect survey set has been developed and evaluated at the U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, Frederick, Maryland. The trap used in this set is the Army Miniature Solid State Mosquito Light Trap (AMSS trap) (Driggers et al. 1980). Unlike the current set which it will replace, this new self-contained insect survey set utilizes a variety of both AC and DC power sources.

The old miniature trap and trap set had many deficiencies including mechanical defects and a requirement for tending twice a day. The old trap set consisted of a 3.2 cubic ft. medical chest which contained 4 miniature traps, 5 wet-cell, lead-acid batteries, a single battery charger, 8 catch-nets and 4 kill-jars. The wet cell batteries had the typical problems associated with handling battery acid and maintenance during the winter. To solve the problem of the wet-cell batteries, a CDC trap using 4 D-cell batteries was adopted. This trap still had the mechanical and tending problems of the old trap. Additionally, a large electrical load was placed on the D-cell batteries with the potential for the motor to stop prior to tending in the morning. Also, the cost of replacing 4 D-cell batteries daily was greater than the cost of the wet-cell battery. These deficiencies led to the development of the AMSS trap and insect survey set (Fig. 1) which have the unique features of once-a-day tending and the capability of being effectively operated by any 6-volt power source.

The basic component of the new insect survey set is the AMSS trap. This trap and its advantages have been described by Driggers et al. (1980). The new trap set will have 6 AMSS traps, while the old set had only 4 traps.

The insect survey set will be provided with 3 power sources: gelled electrolyte batteries, AC/DC converters, and D-cell battery holders.

[1] Opinions, assertions, and product names contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views or endorsements of the Department of the Army or the Department of Defense. This paper was presented at the Washington meeting of AMCA, April, 1979.

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