SOLAR/WIND ENERGY TO COOL TOBACCO STORAGES FOR INSECT CONTROL

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It may be said, with confidence, the cigarette beetle *Lasioderma serricorne* (F.) is not a cold hardy insect. According to Runner (1), it was first described from America by Fabricius in 1792 as attacking "American dried plants" found in warm or tropical parts of the country. In this bulletin, Runner states that there had been a noticeable increase and spread of beetles in tobacco factories as heating of factories was improved with the use of steam. This occurred around 1900 indicating that until manufacturing plants were heated well the cigarette beetle was a pest of stored tobacco only in factories located in the southern portion of the U.S. The cigarette beetle is not a pest in products stored in unheated buildings located north of about the 42nd latitude. Over a period of 200 or more years it has not become cold tolerant although it has been exposed in the northern or colder climates to situations that are favorable for development of genetic strains adapted to survival at low temperature.

A literature review of the cigarette beetle prepared in 1957 by Howe (2) lists work by several investigators giving low temperature and exposures which cause mortality of all insect stages. This work, with some reported by Childs et al. (3) is shown in Figure 1. In these tests the insects were not protected from the cold by more than a thin layer of media. The resistance to temperature of 5°C and lower was similar for all stages. At -10°C it appears an exposure of 2 days will kill all stages except the larval and this stage is killed in about 2-1/2 days. The larval stage appeared to be somewhat more tolerant of the cold than the other stages. At 0°C the insects were killed in 12 to 14 days and at 4.5°C larvae were killed in 20 days. At 10°C nearly 35 days of exposure were needed to kill the eggs and larvae.

Tobacco packed in a hogshead, ca. 450 Kg/1.43 m^3, adjusts slowly to change of temperature in the surrounding atmosphere. Childs et al. (4) reported an infested hogshead with tobacco at an initial temperature of ca. 26°C required an exposure of 56 days in a constant temperature room of 4.4°C before the cold killed all stages of the cigarette beetle (Figure 2). This exposure was more than twice the time period needed to kill unprotected insects subjected to a similar temperature. At ca. 10°C

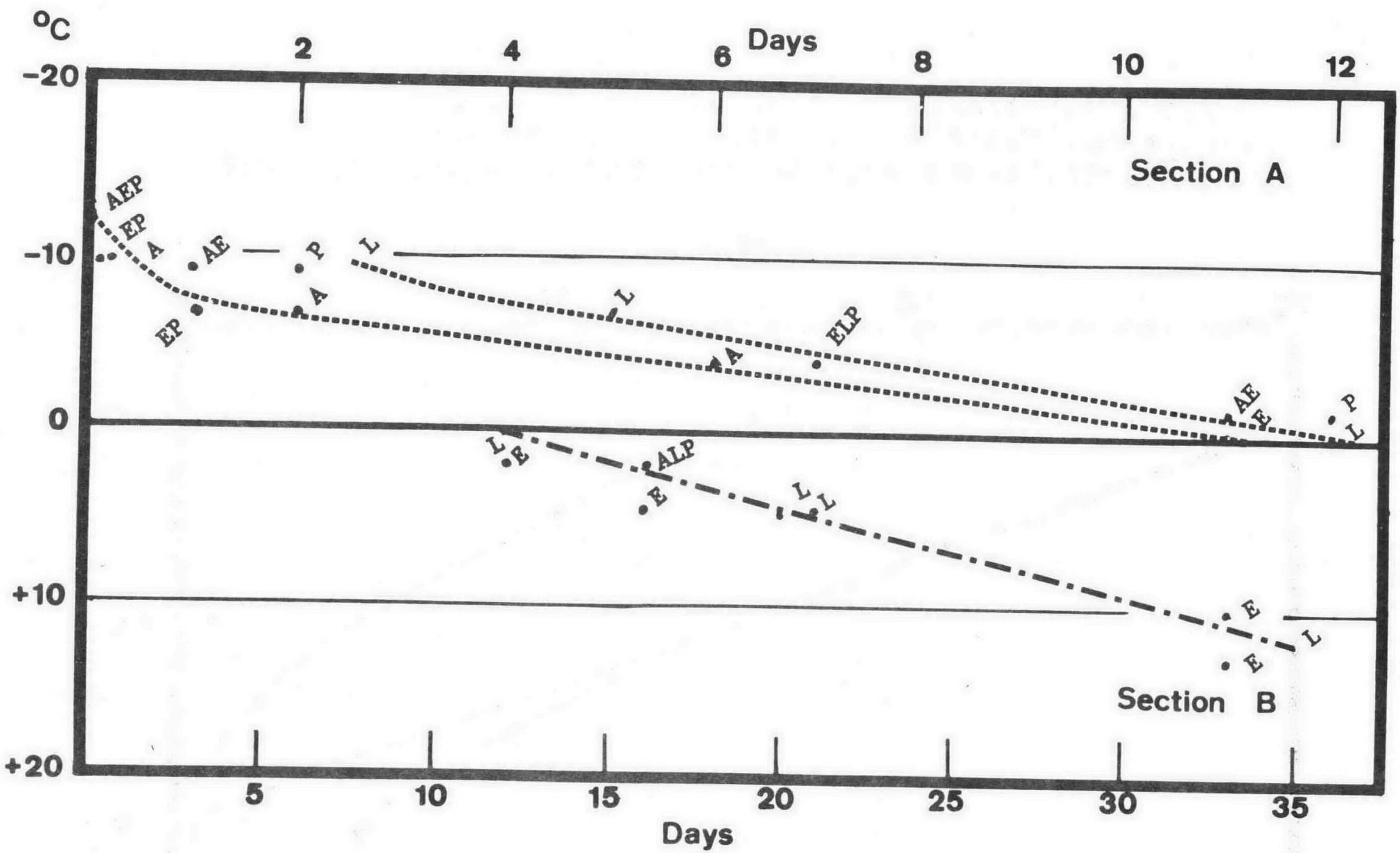


Figure 1.--Number of days required to kill Adults, Eggs, Larvae, and Pupae of the cigarette beetle exposed unprotected to low temperature.

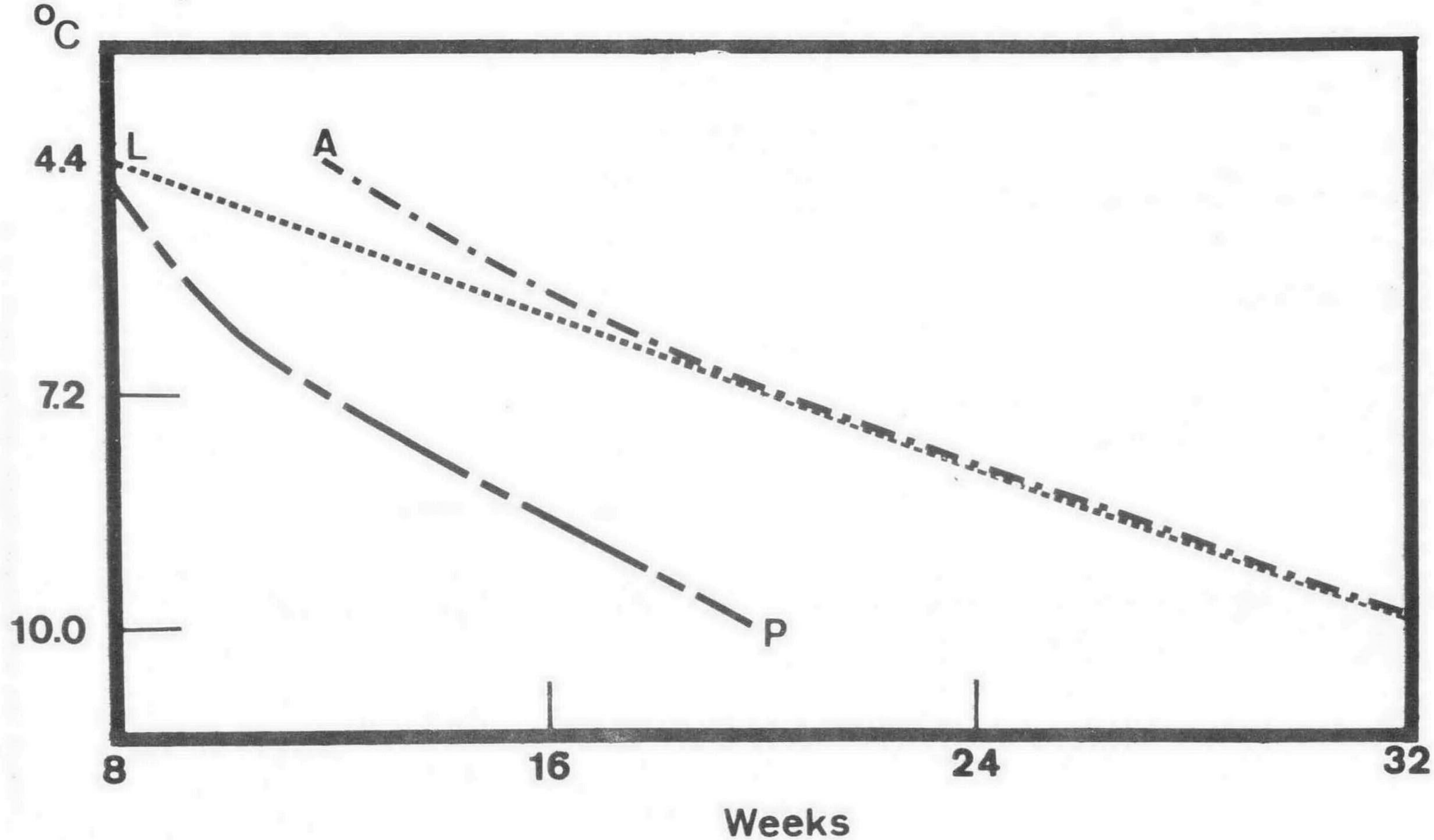


Figure 2.--Weeks of exposure of flue-cured tobacco hogshead to low temperature required for kill of cigarette beetle Adults, Larvae and Pupae.

unprotected insects were killed in 35 days whereas insect infestations in hogsheads lived for more than 200 days. These data indicate to control the cigarette beetle in tobacco hogsheads during the win er season, the tobacco temperature should not exceed 4.4°C over a period of not less than 8 weeks.

Fletcher et al. (5) found that tobacco stored in a fan ventilated warehouse located in Durham, N.C. (36 latitude) from November through April of 1969-70 encountered 91-93 days when its temperature was 4.4°C or lower. Samples of tobacco removed from 3 exposed hogsheads were free of living insects although found in the samples were several hundred dead cigarette beetle adults and larvae and a few dead pupae. Fletcher's work indicated winter kill of the cigarette beetle can be achieved in tobacco hogsheads with expenditure of some electrical energy for cooling the storages during the winter season.

Economics is the factor that will determine whether the cigarette beetle can be controlled in commercial storages by mechanically chilling air inside the storages during the winter season. Because of the cost of electrical energy generated at power stations, this study is to define (1) energy required to cool tobacco packed in a hogshead to 4.4°C or less over an 8-week period during the winter season in a warehouse located at Fuquay-Varina, N. C. (latitude ca 35°30'), (2) the harmonization between insulation and ventilization of a tobacco storage to use efficiently energy from solar and/or wind sources to cool the storage, and (3) type and cost of solar or wind mechanical equipment needed to cool the storage.

We are re-examining the time needed to cool tobacco packed in hogsheads. When the tobacco was at a steady state temperature of ca. 32.2°C (90°F), hogsheads were moved to a cold room controlled to 4.4°C (40°F). Data given in Figure 3 show quick response to temperature change at the hogshead stave, but change of temperature in tobacco was slower and the quickness of change was related to the depth of tobacco monitored. A hogshead stacked vertically had less openly exposed area than a hogshead stacked on its side. Response to temperature change was slower in the vertically stacked hogsheads but was sufficiently rapid to be considered stable after 20 days.

To determine the thermal conductivity of flue-cured tobacco the engineers designed a guarded hot-plate type apparatus shown in Figure 4. Steady one-dimensional heat transfer vertically through the 1-foot cube (0.028 m^3) of tobacco was designed by providing a constant voltage to the electrically heated hot-plate under the tobacco and by providing cold controlled ambient temperatures to the top of the tobacco cube. Independently operated heat tapes on the exterior sides and on the bottom of the 1-foot (30.5 cm) thick styrofoam insulation slabs were used as guarded hot-plates to assure one dimensional heat flow through the tobacco. Results of analysis from sets of three test

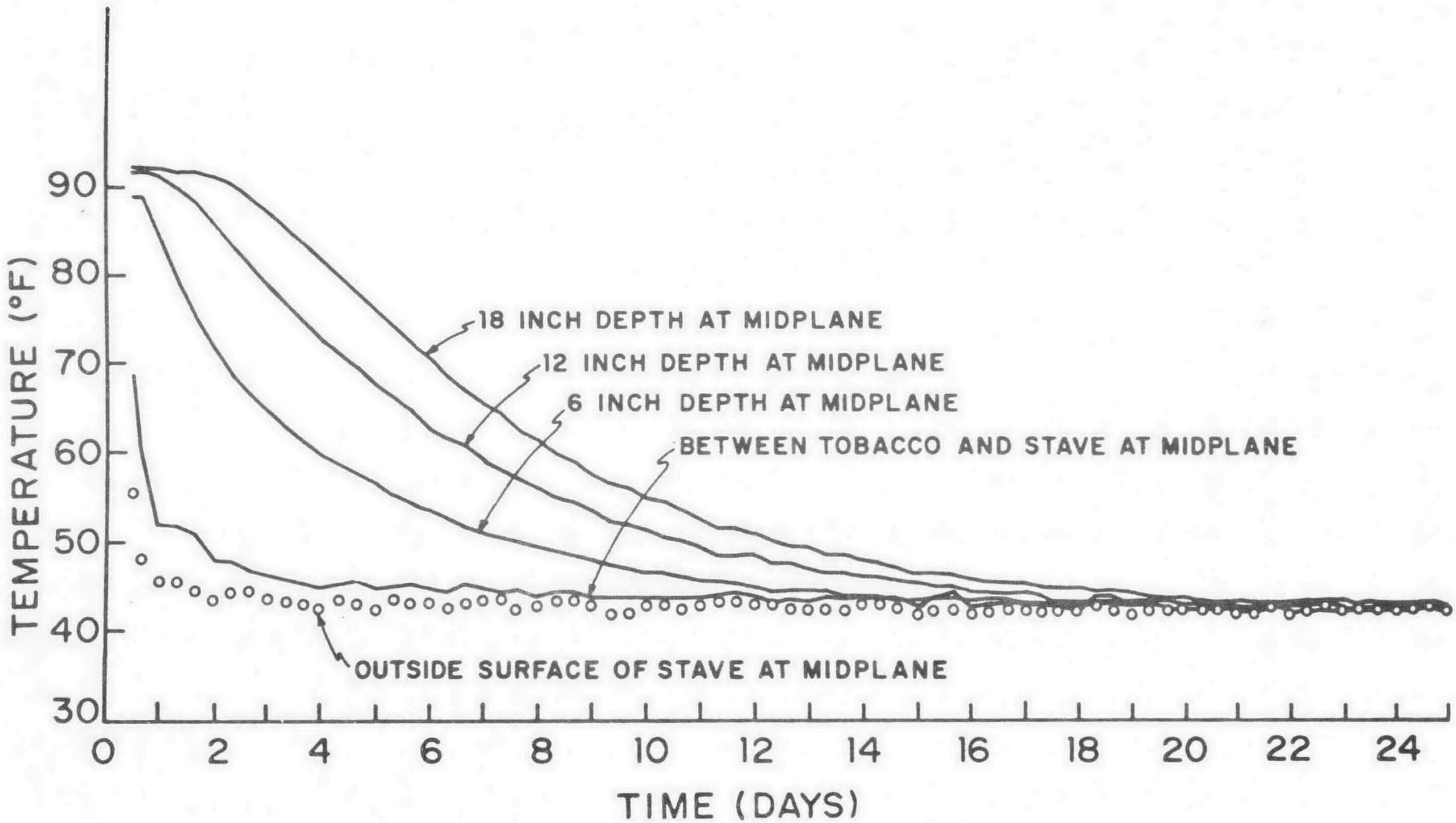


Figure 3, Cool-down temperatures, vertical hogshead

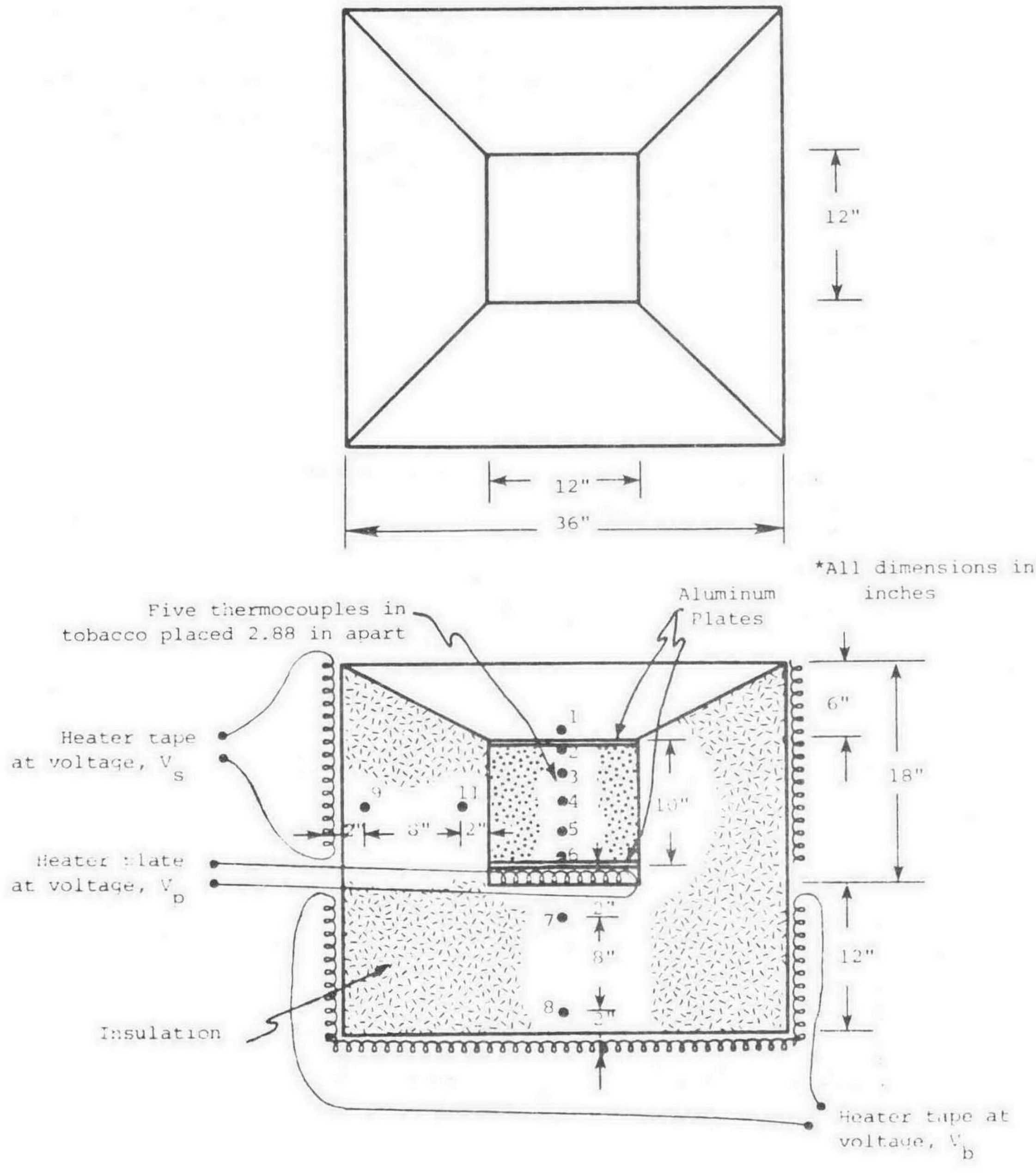
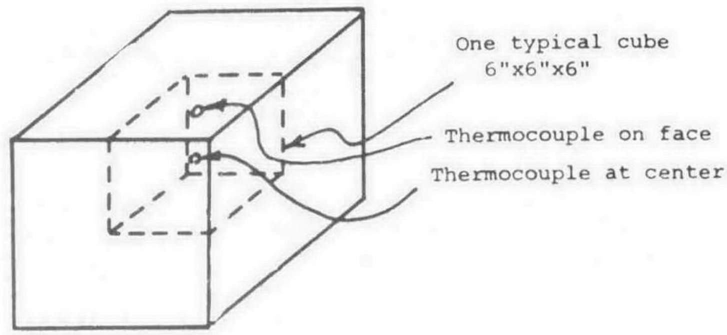


Figure 4. Schematic of Apparatus for Determing Thermal Conductivity



*All dimensions in inches

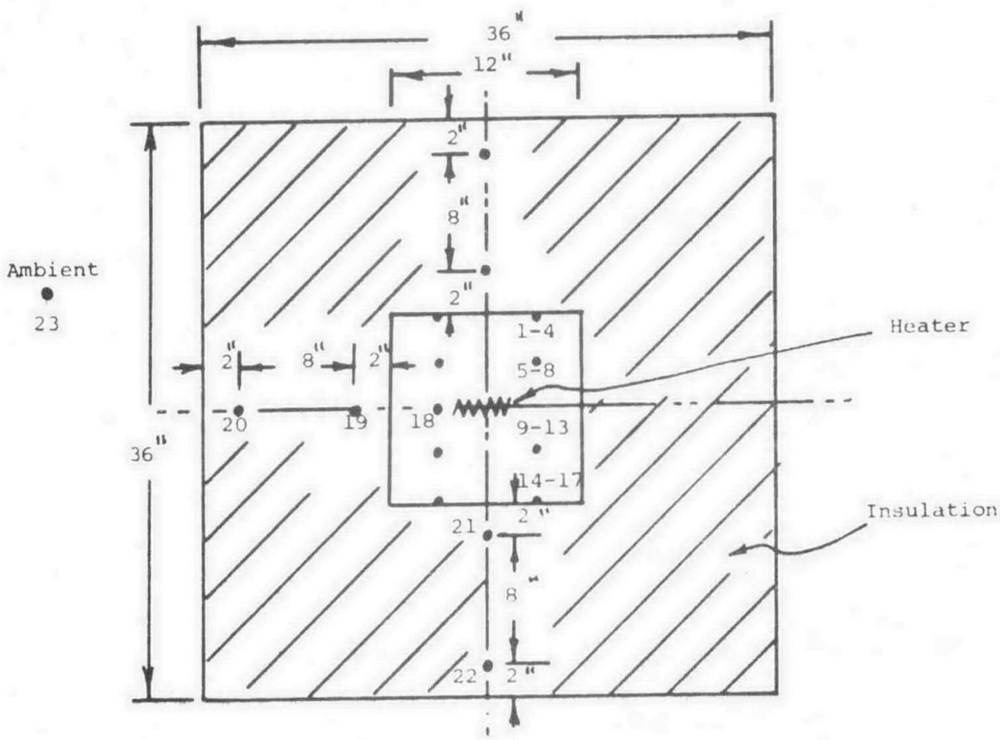


Figure 5. Schematic of Apparatus for Determing Specific Heat Apparatus