Mist Box Construction for Rooting of Cuttings in Hawaii

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INTRODUCTION

The relative merits of the mist box method of propagating cuttings and some of the results obtained for several difficult-to-root species of plants were discussed in a previous publication (*1*). A brief discussion was also devoted to the description of the mist box and the materials necessary to construct it.

Subsequent investigations conducted on a large variety of plants and on several variations of the original mist box have demonstrated the desirability of such a method in commercial horticultural establishments. During the course of the experiments numerous propagators and growers have made inquiries on the construction and use of the mist system.

Because of the widespread interest by growers, the authors felt the need to describe the construction and use of the mist box in greater detail, and make available several plans, along with the necessary materials and costs.

MATERIALS AND METHODS

Materials

The quantity of materials required and the ultimate cost of the misting system depend entirely upon the type of construction and prevailing prices of these materials. Cost of materials fluctuates and the costs quoted herein are averages of retail prices quoted by several local firms in Honolulu.

Minute Timers

(1) *Pulse Timer.* This is the timer which controls the intermittent misting schedule. It runs on a 60-second cycle, preset at 4 seconds misting time. If one 4-second misting per minute is desired, the dial is set at 60 seconds. This will allow one 4-second misting with 56 seconds off. If the dial is set at 30 seconds, there will be two 4-second mistings per minute. Thus, by adjusting the dial, a number of 4-second misting periods may be obtained within a minute. This timer is shown on the right in figure 5. Locally, the list price is approximately $70.00, purchased through the local dealers.

(2) *Process Timer.* This is another minute timer which controls the on-and-off periods on a percentage basis within a 60-second cycle, e.g., 5 seconds on, 55 seconds off; 10 seconds on, 50 seconds off; 30 seconds on, 30 seconds off; etc. It may be purchased locally at a list price of approximately $25.00. It is a versatile clock and quite adaptable to the mist box.

24-Hour Timers

(1) *Day and Night Timer.* This timer, shown in figure 5, left, operates on a 24-hour basis and activates either one of the above minute timers by turning the misting system on in the morning and off in the evening at any desired hour. It is a convenient piece of equipment for the misting system, but not entirely necessary, especially if an operator is available even on weekends and holidays to operate the minute timer. In most instances it would be convenient to have one installed. This timer is available locally at a list price of approximately $33.00.

(2) *General Purpose Time Switch.* A versatile 24-hour timer is one adapted with trippers to give as many as 12 on-off operations within a 24-hour period. It may be used like the above timer to activate and inactivate the minute timer or be used separately for hardening off the rooted cuttings. By attaching the adjustable trippers to the dial with thumb screws, it could lengthen the misting and the intervals between misting. Its minimum misting period is 1 hour. It is available locally at a list price of approximately $12.00.

Solenoid Valve

This ⅜-inch solenoid valve shown in figure 6 is activated by the minute timer and opens and closes the water line feeding the mist nozzles. One ⅜-inch solenoid valve can control several mist boxes or benches. A valve of a larger capacity will obviously service more boxes. Solenoid valves are available locally through equipment and plumbing companies at a list price of approximately $16.00.

Nozzles

The type of nozzle to use will depend upon the misting system to be constructed. Figure 7 shows two types. On the left is the hollow cone jet nozzle, No. 2, used in systems as illustrated in figures 1 and 2. It produces a very fine mist and its discharge rate is approximately 1.2 gallons of water per nozzle per 8-hour day set at one 4-second mist per minute with 40 pounds pressure at the tips. The flat cone nozzle may work equally well if the nozzle is adjusted to give a horizontal ejection. These nozzles cost approximately $1.86 apiece and may be purchased through a number of firms dealing with plumbing and spraying equipment.

The nozzle on the right in figure 7 is a bafflehead mist nozzle used in systems illustrated in figure 3. The mode of mist emission necessitates the use of this type in an overhead position. The mist produced by this nozzle is not as fine as that produced from the jet nozzle but the area covered is much wider. Its discharge rate is approximately 9.25 gallons per nozzle, per 8-hour day, set at one 4-second mist per minute with 40 pounds pressure at the tips. This is considerably more than the discharge rate of the finer jet type nozzle. The amount of dripping after the solenoid valve closes is also considerable. The baffle nozzle is priced locally at approximately $1.60 apiece and may be purchased locally through equipment firms.

Lumber

The mist box, when continuously used, will be constantly wet and for this reason any degree of permanence can be achieved only through the use of weather- and termite-resistant lumber. The mist boxes shown in figure 4 are constructed of 2-inch × 12-inch redwood, rough construction grade material. The quantity of lumber required and its cost will be discussed later.

Pipes

The quantity, sizes, and cost of pipes and fittings will also be given in the discussion for each plan separately.

Construction

Plan A

In figure 1 is illustrated the original mist box constructed at the University of Hawaii in 1955. The actual box in operation is shown on the top in figure 4. The dimensions of this box are 4 ft. wide × 2 ft. high × 16 ft. long, divided into four equal compartments. It has a capacity of approximately 2,300 cuttings placed 2 inches × 2 inches. These compartments were made especially to carry on separate propagation experiments and are not necessary for commercial use.

The 2-foot depth was designed so that even after a 6-inch layer of crushed rocks or black sand is placed in the bottom for drainage and an 8-inch layer of rooting medium is laid over the rocks, there will still remain 10 inches of wall space surrounding the cuttings to act as a windbreak. This additional wall space serves to keep the wind out and also keeps the mist swirling within the box.

The 4-foot width is the maximum width which can be misted efficiently with the number and placement of nozzles for this box. Furthermore, the propagator can reach the center of the box from both sides, making it convenient to place or remove the cuttings from the box.

The length of the box may be extended for greater capacity without reducing efficiency.

The ½-inch pipeline comes from the solenoid valve and runs along the top of the walls with the jet nozzle placed so as to have one nozzle at each wall, each diagonally opposite the other, as shown in figure 4, top. This arrangement requires the use of more nozzles but the mist coverage is complete, eliminating any dead space within the box.

The lumber used for the construction of this mist box is 2-inch × 12-inch redwood. This size accords durability and freedom from

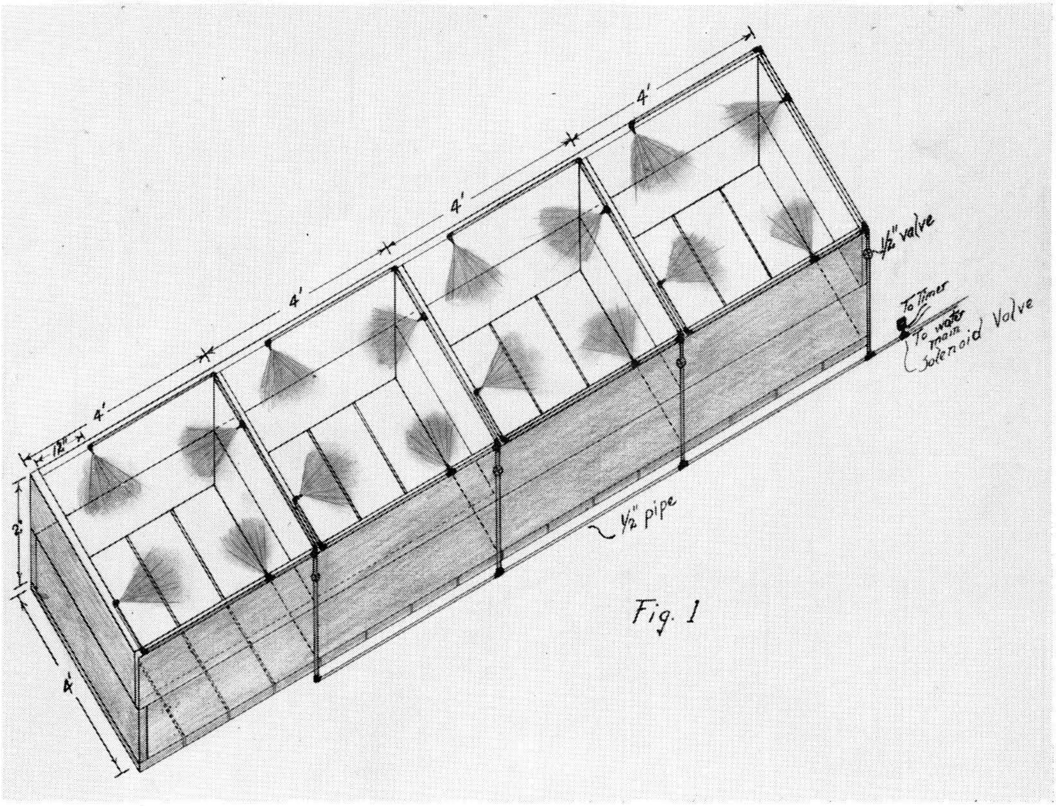

Fig. 1. Plan A type mist box showing dimensions, pipe and nozzle arrangements. The four separate sections were designed for propagation experiments.

warping. The use of 1-inch × 12-inch redwood will reduce the cost of the lumber requirement but additional braces must be provided to prevent warping.

In constructing the flooring of the box a space of approximately ½ inch is allowed between boards for drainage. No additional holes are necessary for drainage.

Materials required and the approximate cost of this plan are given in table 1.

Plan B

This plan, illustrated in figure 2, represents only a slight deviation from plan A. The actual boxes in operation are shown in figure 4, bottom. Plan B differs from plan A by having only two sections instead of four. The center partition is necessary to prevent the sidings from warping. The dimensions are 4 ft. wide × 1½ ft. high × 16 ft. long, the height being 6 inches lower than in plan A.

TABLE 1. Materials required to construct plan A type of mist box with average retail prices in Honolulu*

QUANTITY	MATERIAL	UNIT	UNIT COST	TOTAL COST
2	½″ × ⅜″ reducers	Ea.	$ .204	$ .41
2	⅜″ × 2″ nipples	Ea.	.26	.52
4 lengths	½″ pipe (84′)	100 ft.	15.80	13.27
4	½″ side outlet T	Ea.	.90	3.60
8	½″ × ¼″ T	Ea.	.34	2.72
4	½″ valves	Ea.	2.00	8.00
2	½″ union	Ea.	.59	1.18
1	⅜″ solenoid valve	Ea.		16.00
16	hollow cone jet nozzles	Ea.	1.86	29.76
10 pcs. 1 pc.	2″ × 12″ × 16′ redwood 2″ × 12″ × 8′ redwood	1000 bd. ft.	242.00	81.31
	Cost of box and fixtures			158.74
	Electrical timers			103.00
			TOTAL COST	$261.74

*This table does not include labor or the cost of crushed rocks and medium. The cost of the lumber could be reduced by approximately one-half if 1-inch × 12-inch material is used instead of the 2-inch × 12-inch size.

Another change is the arrangement of the nozzles. The ½-inch pipeline coming from the solenoid valve runs along the top of the sides with the jet nozzles placed 2 feet apart and arranged alternately from the opposite side (fig. 2). This allows eight nozzles on one side and six nozzles on the other. This number and arrangement of nozzles are adequate to give complete coverage only when protected from the wind. Experiments using this box have indicated that the addition of two more nozzles, making eight nozzles on both sides, each opposite the other, gives better coverage and prevents dead spaces in the corners. The construction materials are the same as for plan A. In table 2 are listed the requirements of material and the approximate costs.

As in plan A, cost of lumber may be reduced to approximately half by using 1-inch ×12-inch material. This box can also accommodate approximately 2,300 cuttings.

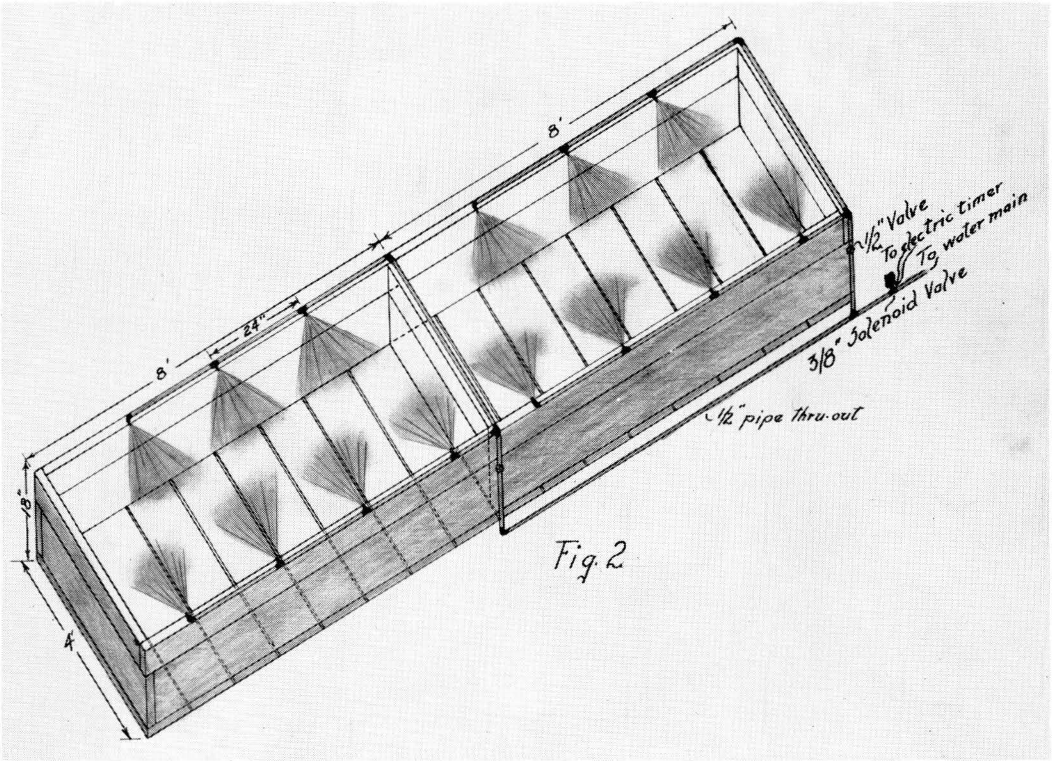

FIG. 2. Plan B type mist box showing dimensions, pipe and nozzle arrangements. There are only two compartments. Nozzles are placed along the sides.

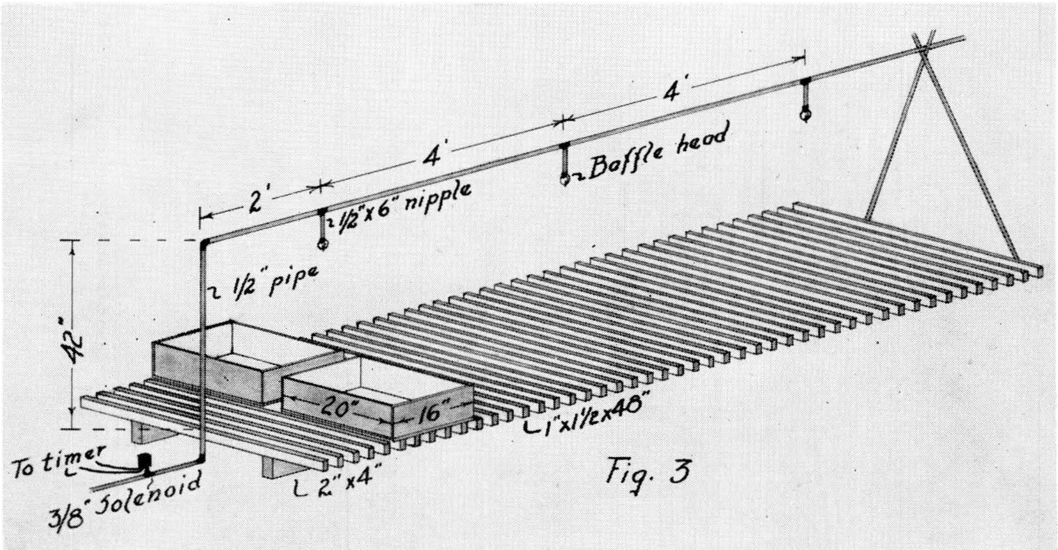

FIG. 3. Plan C type mist bench with central overhead misting. Two planting flats are shown, end to end, as they would be placed on the bench. Note the space provided between the two flats for drippings from nozzles.

TABLE 2. Materials required to construct plan B mist box with average retail prices in Honolulu

QUANTITY	MATERIAL	UNIT	UNIT COST	TOTAL COST
2	½″ × ⅜″ reducers	Ea.	$ .204	$ .41
2	⅜″ × 2″ nipples	Ea.	.26	.52
4	½″ × 2″ nipples	Ea.	.22	.88
2½ lengths	½″ pipe (84′)	100 ft.	15.80	8.22
2	½″ side outlet T	Ea.	.90	1.80
10	½″ × ¼″ T	Ea.	.34	3.40
4	½″ × ¼″ elbows	Ea.	.246	.98
2	½″ valves	Ea.	2.00	4.00
2	½″ unions	Ea.	.59	1.18
1	⅜″ solenoid valve	Ea.		16.00
14	jet nozzles	Ea.	1.86	26.04
8 pcs. 1 pc.	2″ × 12″ × 16′ redwood 2″ × 6″ × 4′ redwood	1000 bd. ft.	242.00	62.92
	Cost of box and fixtures			126.35
	Electrical timers			103.00
			TOTAL COST	$229.35

Plan C

The third plan illustrated in figure 3 is a drastic modification of the original mist box. This plan follows the general idea first presented by Snyder and Hess (2) using overhead misting. The box is entirely replaced by a slatted bench upon which individual cutting boxes are placed in two rows with the pipeline elevated and running through the middle. The mist nozzles used here are the bafflehead type.

The actual dimensions of this slatted bench depend upon the size of the flats and the number of flats desired. The dimensions of the bench illustrated in figure 3 are 4 ft. wide × 12 ft. long. Although the bafflehead nozzle has the capacity of covering an area 4 feet wide, the wind factor must be considered in determining the width of the bench. A bench width of 4 feet will be adequately covered with the mist on a calm day, but with moderate winds, the windward side may not receive the mist. For this reason, the bench width should be approximately 3 feet, unless good windbreaks can be provided around the benches.

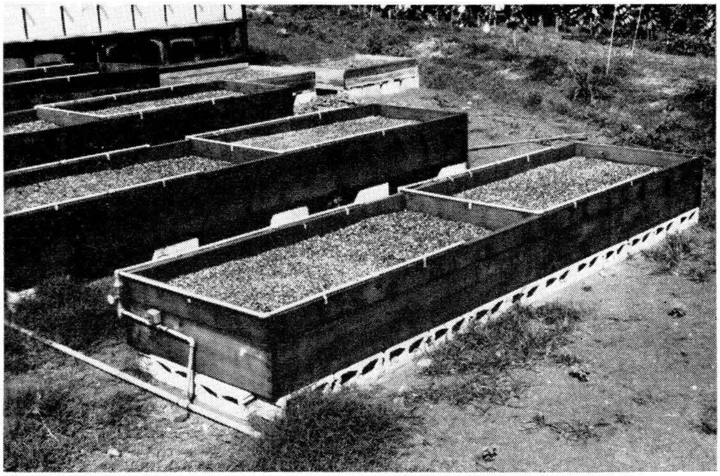

FIG. 4. Top photo shows plan A mist box in operation. Bottom photo shows plan B mist boxes.

The length of the bench may be of any desired length within reason. Lengths of 16 to 24 feet would be ideal.

Dimensions of the flats should be such as to fit the required number of flats evenly on the bench. In the illustration in figure 3, the flats are placed with the long dimension at right angles to the length of the bench. It is emphasized here that the length of the flats should be at least 2 inches less than half the width of the bench. This would allow a space of 4 inches in the middle, between the two rows of flats. This space is necessary to allow for nozzle dripping, since the bafflehead nozzles have a tendency of dripping even after the solenoid valve closes the water line.

To avoid dripping into the flats and to obtain complete mist coverage, a slight deviation of plan C may be used. In place of a single central misting system, the pipeline carrying the nozzle may be divided into two lines, each running along edges of the bench. The nozzles used are the jet type facing down at an angle towards the center.

TABLE 3. Materials required to construct plan C mist bench (16-ft. length) with average retail prices in Honolulu

QUANTITY	MATERIAL	UNIT	UNIT COST	TOTAL COST
1 length	½″ pipe	100 ft.	$15.80	$ 2.32
4	½″ T	Ea.	.28	1.12
1	½″ cap	Ea.	.15	.15
2	½″ elbow	Ea.	.22	.44
2	½″ × ⅜″ reducer	Ea.	.204	.41
2	⅜″ × 2″ nipples	Ea.	.26	.52
1	½″ valve	Ea.	2.00	2.00
4	bafflehead nozzles	Ea.	1.60	6.40
1	⅜″ solenoid valve	Ea.		16.00
2 pcs. 1 pc.	2″ × 4″ × 16′ redwood* 1″ × 12″ × 16′ redwood*			10.67
	Cost of bench and fixtures			40.03
	Electrical timers			103.00
			TOTAL COST	$143.03

*The 1-inch × 12-inch redwood is ripped to 1-inch × 1½-inch × 48-inch pieces for the bench slats. These slats are nailed crosswise on two pieces of 2-inch × 4-inch × 16-foot redwood base. The 2-inch × 4-inch bases are supported on tiles, elevating the bench to a convenient height.

This double line system gives efficient coverage, although more costly than the single pipeline methods.

Plan C is the simplest and the cheapest of the three principal types discussed here. Materials required and the cost figures are listed in table 3.

Electrical Control System

Intermittent misting has been shown to be more desirable than continuous misting. Experiments conducted at Cornell indicate that continuous mist lowered the temperature of the rooting medium below the optimum level and also caused deterioration of foliage *(2)*. It was also shown that oxygen levels were lowered to the point of injury, especially when accompanied by poor drainage. Another advantage of intermittent misting is the use of less water per day.

To attain these advantages of intermittent misting, various electrical devices such as clocks, humidistats, and electronic leaves are used (2). Time clocks provide the most dependable control of misting, although their strict regularity despite weather changes could impose harmful effects. Also, mist systems with electrical timers are set to operate only during daylight hours and leave the cuttings exposed to occasional windy or dry nights. However, in Hawaii where humidity is relatively high throughout the year, no adverse effects of non-misting at night have been observed in the 4 years this system has been in operation. It is suggested, therefore, that the electrical timers of the type shown in figure 5 be used in Hawaii.

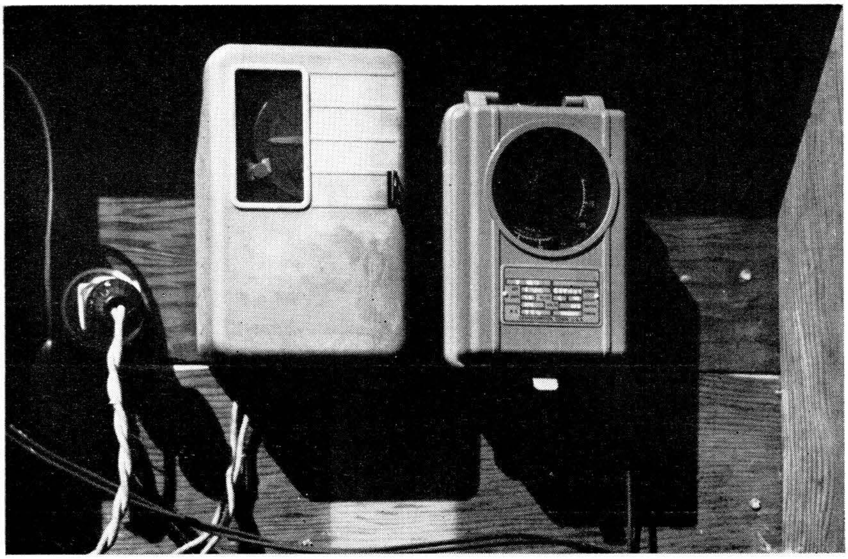

Fig. 5. Electrical timers placed in weatherproof box. The timer on the left is the 24-hour timer and the timer on the right is the minute timer.

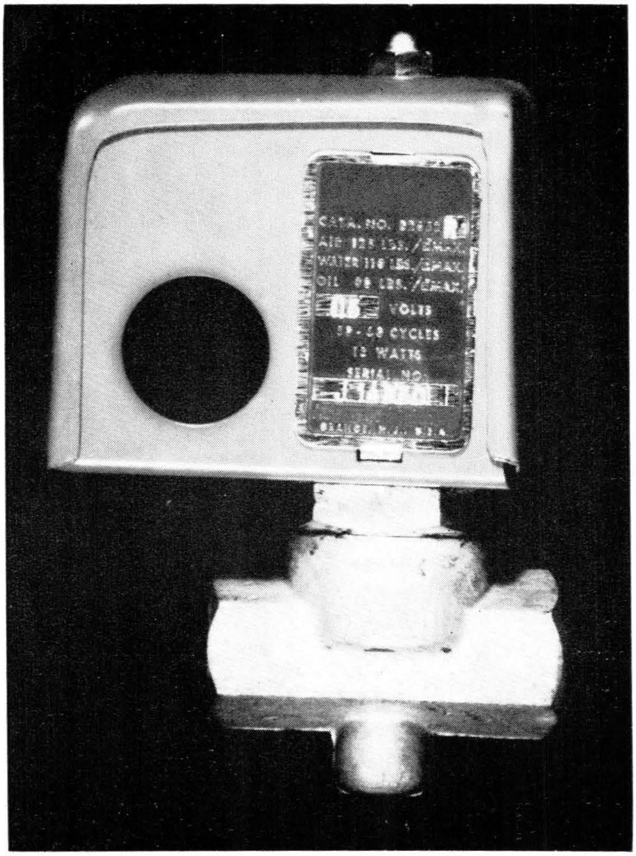

FIG. 6. 3/8-inch solenoid valve used in the systems discussed in this circular.

The wiring scheme using both the minute timer and the 24-hour timer is shown in figure 8. The 120-V power line is connected to the 24-hour timer. From a pair of terminals in the 24-hour timer, the wiring is connected to the terminals in the minute timer. Wires are now connected from the minute timer to the solenoid valve. The solenoid valve controls the water line feeding the mist nozzles. The 24-hour timer activates the minute timer in the morning and inactivates it in the evening. Once the minute timer is activated in the morning, it regulates the opening and closing of the solenoid valve, giving intermittent misting. The number of 4-second mistings per minute may be regulated by adjusting the dial on the minute timer.

To insure protection and long service, the clocks should be placed in a weatherproof box. A gallon can or some other weatherproof material should also be placed over the solenoid valve to protect it from the mist

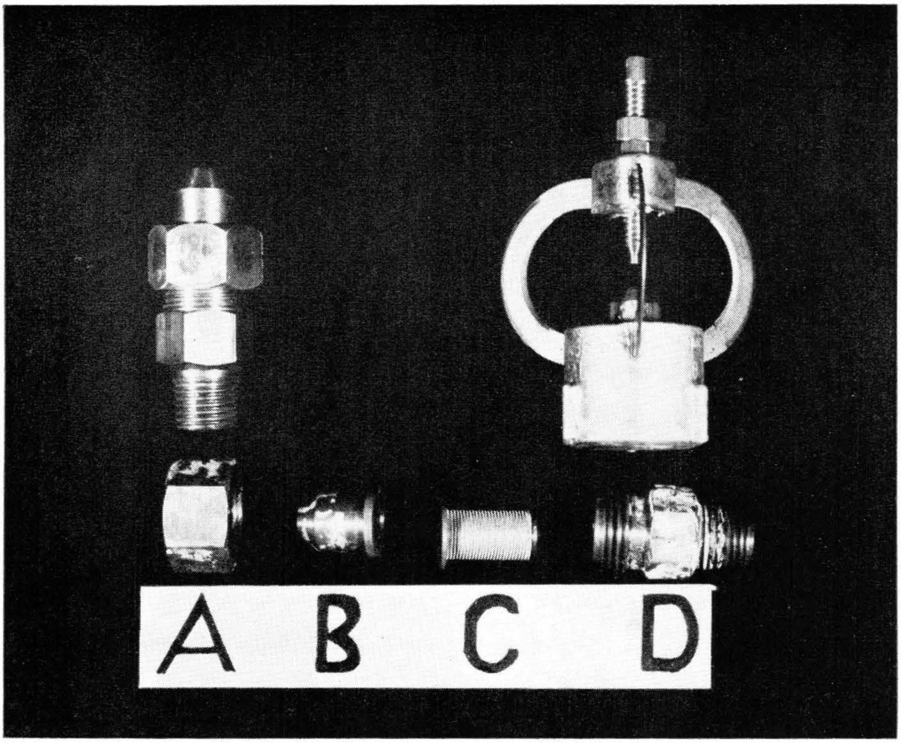

FIG. 7. *Left*: **jet nozzles (No. 2).** *Right*: **bafflehead nozzle.** *Bottom*: **jet nozzle disassembled to show the various parts. A=nut; B=jet; C=screen; D=housing.**

and rain. The solenoid valve in particular is subject to rather rapid rusting and would tend to short circuit, if unprotected.

Tables 1 to 3 give the approximate costs of individual units, together with the timers. This unit cost may be reduced by constructing longer boxes or benches or by constructing several boxes. These additional boxes or benches may be operated on the same clocks and solenoid valve. One solenoid valve will operate two units without loss of efficiency. One set of clocks will operate a large number of units. Excessively long benches or boxes exceeding 24 feet increase the difference in pressure between the first and last heads with consequent difference in the rate of discharge.

INSTRUCTIONS FOR OPERATION

Location of Mist Boxes

The location of mist boxes or benches is an important factor. The 4-second misting per minute appears to be excessive when these units are operated under shade as in greenhouses. Soft rots and defoliation have been observed under these conditions. Excessive growth of mosses, lichens, and sooty molds on stems and leaves has also been noted. Maximum

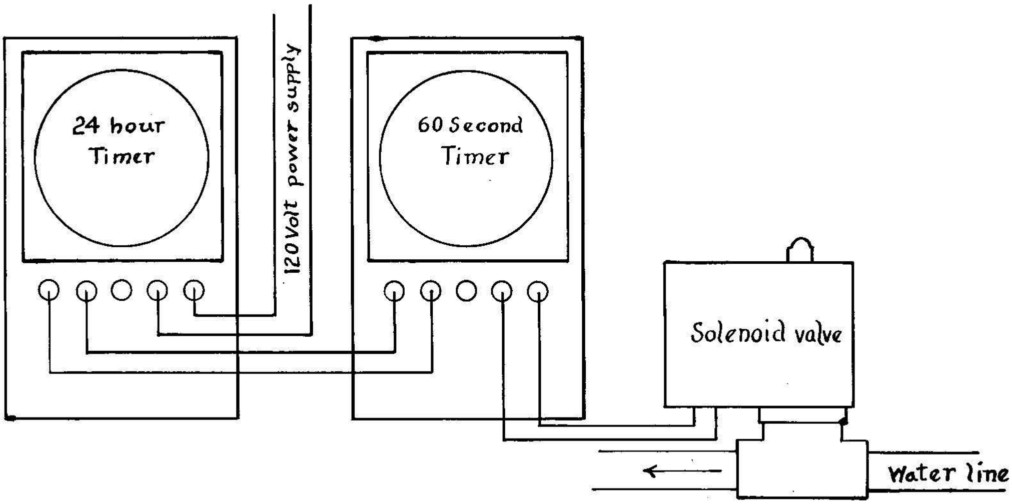

Fig. 8. **Diagram illustrating electrical wiring system for the timers. (See text for detailed description of wiring.)**

efficiency may be obtained by placing the mist units in direct sunlight with no overhead shade. The mist ejected over the cuttings is sufficient to prevent rapid evaporation and burning of leaves. Maximum sunlight also allows the turgid leaves to continue photosynthetic activities and reduce disease problems.

Another important factor to consider in locating the mist units is windbreak. Hawaii is blessed with gentle tradewinds, but for mist propagation, even this gentle breeze is enough to blow the mist away and leave dead spots in the boxes or benches. For this reason, these units should be protected from the winds. Windbreaks may be constructed around the units with neutral polyethylene materials. This material will break the wind and yet admit enough sunlight. Hedge planting or a lath fence around the propagation area are also effective as windbreaks.

Misting Time

The number of 4-second mist periods per minute can be controlled by setting the dial in the timing device. Approximately 4 years of operational experience has shown that during the warm, dry months from April to October or even November on the Manoa Campus, two 4-second mistings per minute gave excellent results. During cloudy and rainy periods from November to March, only one misting per minute was found to be adequate. These statements, however, cover general situations. It is well known that in Hawaii, weather conditions are quite variable with cloudy and rainy days in the midst of summer and many sunny days in the winter. Therefore, adjustment of the minute timer is largely a matter of good judgment on the part of the operator. The automatic electrical devices are not sensitive to weather changes and must be adjusted by the operator. During prolonged periods of rain, the automatic device may be turned off completely and the misting operated manually several times a day.

Media

Media such as wood shavings, vermiculite, perlite, and mixtures of these have been tested and the results obtained indicate that vermiculite of the rough grade (No. 1) and perlite (Spong-Rok) gave the best rooting. Vermiculite particles, although light, will become saturated with water and have a tendency to pack. The large size and irregular shape of the particles afford greater amount of air space around the basal portions of the cuttings than the finer grade vermiculite under normal compaction. Perlite also gives adequate aeration and does not seem to pack as much as vermiculite.

Another beneficial feature of vermiculite and perlite is the ease with which rooted cuttings may be removed. The rooted cuttings may be loosened by lifting with a wooden label or some thin piece of wood along the side of the row of cuttings and pried up gently. In this way, the cuttings may be removed without any damage to the roots.

Vermiculite and perlite may be used repeatedly until the particles begin to disintegrate and pack tightly. At this point the old material may be removed and the boxes cleaned and washed with a good fungicide before replacing with new medium.

Drainage

To obtain good drainage in plan A and B types of boxes, a 4- to 6-inch layer of crushed rocks or coarse black sand is placed in the bottom of the box. Since there is ample drainage in the flooring, there is no danger of water accumulating in the box. An 8-inch layer of medium is placed over the layer of rocks.

Types of Cuttings

In rooting experiments conducted on the Manoa Campus, mature tip cuttings were found to be most responsive for most plants. Guava (*Psidium guajava*), mock orange (*Murraya exotica*), macadamia, and others, showed progressively poorer rooting of cuttings away from the tip. In other plants such as the acerola (*Malpighia punicifolia*) and passion fruit (*Passiflora edulis*, var. *flavicarpa*) the older growth immediately below the terminal cutting rooted equally well. Older wood with rough bark was highly undesirable in all cases.

Retention of some leaves on cuttings is also an important factor to consider. Misting allows the cuttings to retain their leaves in a turgid condition and keeps the stomates open longer for maximum gas exchange necessary in photosynthesis. Leaves may also contribute substances beneficial to rooting. Leafless cuttings of guava, mock orange, acerola, and passion fruit have given very poor rooting percentages, even with the use of root-inducing substances.

The number of leaves to be retained on cuttings varies with the species of plants. At the present time, it is largely determined by convenience. For large-leafed cuttings, only two or three leaves may be left on the cuttings and these leaves may be further reduced by cutting half of each leaf. For guava and passion fruit cuttings, retaining two half leaves only has given good results. For species with small leaves such as acerola and mock orange, as many as 10 to 15 leaves may be retained.

Hardening of Cuttings

Very few species of plants can withstand direct field transplanting from the mist boxes. Carnation cuttings were rooted and transplanted into field beds without loss. In most instances, however, rooted cuttings should be transplanted into individual containers and kept in shaded lath houses until new growth occurs. When the new growths are well on their way, the plants may be moved into more sunlight. The use of the 24-hour timer adapted with trippers will enable the propagator to harden-off the rooted cuttings in place, provided only one type of cutting is grown in a box. With this timer, the interval of misting can be adjusted so that misting can be removed gradually. The hardening-off process should not be neglected because a high rate of mortality can occur when cuttings are removed from the mist boxes.

Maintenance of Nozzles

Regardless of type of nozzles used, they should be inspected periodically since dust particles and mineral deposits in the water tend to accumulate and clog the holes. Clogging occurs frequently in the jet nozzles even though a fine screen is provided. The bottom row in figure 7 illustrates a nozzle with all its parts removed. C is a screening device which fits into D. B is the jet which fits over the screen when placed into D. A is a large nut which is screwed over D to keep B and C in place. To clean, merely remove the nozzle and take it apart as shown in the figure, wash the parts thoroughly, and put them back in place.

SUMMARY

Excellent results obtained in rooting of cuttings by the mist system and the growing interest shown by growers have created a need to present more information regarding the construction and uses of this system. Several plans have been shown and discussed, indicating the advantages and disadvantages of each plan. Each of these plans is not the ultimate in design but provides a point from which one can deviate and add improvements. The variable climatic conditions in the Hawaiian Islands may call for different designs and mist adjustments for each location.

The electrical timers mentioned herein are not the only devices to give intermittent misting, but these have been proven to give reliable control of misting.

The requirements of material, the approximate average costs, and methods of construction have been discussed in detail. A change in design or size of these units will obviously change the cost.

Instructions for operating these units are discussed fully. The value of complete mist coverage throughout the entire box or bench cannot be overemphasized. This is accomplished in two ways: (1) by adding a nozzle or two to the present setup, thereby reducing the distance between nozzles, and (2) by constructing adequate windbreaks around the propagating units.

The types of cuttings best suited for mist propagation are also discussed. Success in rooting depends to a great extent upon the age of the cuttings and the presence of leaves on them.

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