dual purpose frame which requires little or no maintenance when constructed from redwood. One of the most outstanding features of this method is the lack of leaching of nutrients; such leaching may be one of the prime disadvantages of propagation under most mist systems.

Disadvantages of poly tents. I find one of the most frustrating drawbacks of propagation under poly tents is the fact that the cuttings cannot be readily observed. This may be merely a personal idiosyncrasy but I always prefer to have access to cuttings while they are in the rooting media. Closely allied to this first disadvantage is the fact that we have no convenient control of fungus infection which may develop during the rooting process. Since we have high humidity, no air circulation, and cuttings closely spaced in these frames, a fungus infection could cause a complete crop loss. We use no soil sterilants or fungicides on the soil prior to sticking cuttings and to date we have been fortunate. Another disadvantage is relative to weather conditions, since a prolonged period of cloudy, cool weather can delay rooting; in Newport, we often experience such prolonged periods of foggy, cool, weather during mid-August.

Summary. I would like to state, without reservation, that the advantages of propagation under poly tents more than outweigh the disadvantages. The cost of production per unit is substantially less than with most mist systems and no elaborate structures are required at any point during the operation. Presently, half of our entire softwood production is carried out under poly tents and we find this method completely satisfactory.

MODERATOR CESARINI: Thank you very much, Larry, for a very well presented paper. Sometimes I wonder what the nursery industry did before they invented polyethylene films. Our next speaker has been the propagator for the D. Hill Nursery Co. for over 4 years. At this point I introduce to you Mr. Peter Orum.

A PRACTICAL SYSTEM OF COLD-FRAME PROPAGATION

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Cold-frame propagation of ornamental woody plants has always been an accepted method. It has worked poorly and it has worked well, but seldom has it been very practical.

I once visited a large nursery in Germany. It was said to have several thousand glass-sashes in its propagation area. The amount of people needed to take care of this and carry sashes around ran almost into the hundreds.

Some years ago my close associate, John Wilde, and I started out with the goal of developing a practical system for

propagation in outdoor frames. Our three main premises were: (1) it had to be well adapted to the ornamentals we desired to grow; (2) it had to be economical; and (3) it had to be suited for large scale production. Through modification of methods used by other propagators and some new developments of our own we have come a long way toward this goal.

To paint the clearest picture for you, I have divided my subject into three subgroups:

I. Frame Construction
II. Propagation in the Frame
III. Adaptability

Frame Construction. This is of paramount importance. If we just looked at the plant propagator's side of the case, we would be satisfied as long as we built a frame in which the cuttings had a perfect environment. But since we, in the commercial part of this group, are managers too, we must look with an equally strong eye to the economic side. We must make money on our propagation, otherwise we will cease to exist as commercial propagators.

In the selection of an area, two things, especially, should be considered: drainage and wind protection. Although it is possible to prepare and build on almost any area, the cost will vary greatly.

To accomplish this type of propagation with an automatic mist system it is necessary to apply an excess of water at certain times. Also, since in most areas, there is an excess of rainfall during certain periods, — and cuttings, rooted or unrooted, standing with "wet feet" for any length of time will die, it is of utmost importance to provide good drainage.

The safest procedure is to lay a line of drain-tile down the middle of each frame then fill the trench with gravel. However, other methods will work, such as building the frames on a slope or on very sandy soil. It should be noted that these other methods need closer attention by the propagator. Since the mist is applied on the top of the cloth — up in the air — it is subject to drift. Overlapping of the water system takes care of part of this but real strong winds will take the mist away from the intended place. An area enclosed by natural windbreaks would be ideal, but snow-fence will do a fairly good job.

The basic layout consists of two frames separated by a waterline with risers for the nozzles. This mistline then covers the two frames.

An area can be layed out in two basic ways. Where space is available there should be a drive-way between each double-frame. This greatly facilitates transportation. Fork lifts and shelf-pallets can be used to transport plants to and from the frames. Hardly any walking is necessary and cost is cut substantially. If space is limited, a multiple frame system can be used. One frame is next to the other and there are no drive-ways in between — only alleys. In this case the frames should not be over 60 feet long and there should be a drive-way at each

end. There would then be 30 feet walking distance from the middle. But the cost of this would have to be weighed against the better useage of the land.

Many different materials can be used for the frames: wood, steel, cement blocks or poured concrete — and for the water pipe: steel, aluminum or plastic. Again, the type of material to be used should be weighed against the length of life and the labor saved during construction and use.

Through several experiments we have developed a frame which we feel is very close to the ideal. We describe it as "Cement block—Frame Model 1965." This frame is built with cement blocks used in the building industry sold under the name of, "twelve-inch off-set cornerblock." A single row makes up the two outsides of the double-frame. A double row makes the center and works as an alley as well. The blocks are laid in a few inches of sand. Every three feet a steel ground-anchor is placed in the row so that the eye is just above the block. This is for fastening the tobacco-cloth in the summer and winter-covering in the fall.

Peagravel is filled in if the frames are to be used for cuttings in flats or trays. This is leveled to about two inches above the bottom of the blocks. If the cuttings are to be stuck directly, the frame is filled with a sterile rooting medium to about six inches above the bottom of the blocks. A sand-peat mix is satisfactory but some perlite mixed in might help in wet periods. The rooting medium is then dressed with a two-inch layer of coarse sand.

The water system consists of a water line lying in one side of the alley between the two frames. Every ten feet there is a two-foot high riser. We are using a rotary nozzle. This, of course, does not give an even water distribution, but it is even enough to produce a frame full of uniform cuttings and that is what counts. It is important that the mist line be level; otherwise, there will be a backflow of water to one end of the frame after the value is shut off.

On each mist line there is as electric valve. These are connected to time-clocks on a central control panel. Each electric valve is controlled by a 10-minute timer. A whole section, or group of sections, is controlled by a "day and night clock." It is advisable to use a 24-volt system as this saves quite a bit in cost of underground cable.

For covering of the frames a heavy galvanized arched wire is used — stuck down in the sides by the concrete blocks. This provides for very easy covering, be it with tobacco-cloth for propagation, or plastic for winter protection.

Propagation in the Frame. Through observation and experimentation we developed a simple theory for this undertaking. If cuttings are kept under moist cloth, which lets enough light through, they will have a favorable environment for rooting. Applying the water on the top of the cloth and not on the cuttings directly will cut down the leaching from

the cuttings during the rooting period. This leaves the cuttings in better condition to root.

Some air movement is almost a necessity to keep down fungus diseases. Covering the cuttings with the light cotton material called "tobacco-cloth" provides for this. In a climate with a lot of bright sun in the summertime, a light shade is favorable, especially for rooting certain ground-covers and most variegated material. This, the tobacco-cloth provides for, too. Last, and sometimes most important, the tobacco-cloth gives some protection against failure. If the mist system fails because of human or technical error, the cloth gives a one to two hour tolerance, while uncovered new cuttings possibly would have only 20 to 30 minutes.

Propagation is started as early as material is available which will be, in our area, about the end of May. All cuttings are made in the field and brought to the frames for sticking without delay. They are stuck at the spacing found to work best with the particular variety. Spacing boards have been designed for this purpose. When stuck, the cuttings are soaked and covered with the tobacco-cloth. If the cuttings are to be in flats or trays they are normally stuck in a working shed, then transported from there to the frame.

The following two months is the critical time — the time when the propagator really has to be on the ball. In order to keep the cloth moist at all times the "day and night clock" must be set to turn on and off at the right times. And the 10-minute timers must be set to apply the right amount of water. This can be anywhere from two minutes on a real bright day to less than half a minute on a darker day. The 10-minute timer works so that the mist can be on or off for any length of time in the ten minute cycle, for instance, *on* for two minutes, then *off* for eight.

You will see that a judgment and calculation of the weather, the condition of the cuttings, and the setting of the clocks, is made by the propagator. We do not feel that time is ripe to make this much more automatic under general nursery conditions. There are too many variables that we do not yet control.

For a short period of rain, like a shower, there is no need to reset the clocks. But if prolonged periods of rain and cloudy weather occur, it is often advisable to cut the mist off completely. When the majority of the cuttings are rooted, a hardening-off is started. This is done partly by cutting down the amount of water applied and partly by opening up the cloth on the sides to give more air. This gives the propagator a lot of room in which to play things according to the need of the specific varieties. At the time the cuttings are well rooted, the mist is cut off completely. Shortly after, the cloth is removed from everything but certain groundcovers and variegated plants. From this point on the cuttings are treated as any other growing plants. Through the mist system they are

irrigated when necessary, with fertilizer injected at all times.

Some kind of winter protection is needed in northern areas. This can be as simple as a thin layer of hay or straw on the more hardy plants. On less hardy plants it is advisable to cover with polyethylene. The covering is done fast and easily on our standard frame. Polyethylene is rolled out over the arched wire. On the sides, this is squeezed down between the wire and the concrete block, using a 1 x 2 inch wooden strip. Then, chicken netting is rolled on the top and tied to the ground anchors on the side. No wind, except maybe the hurricane "Camille" will move this.

The following spring most of the rooted cuttings are lifted and canned — or sold, in the case of groundcovers. Slower growing varieties are kept in the frame for a second growing season.

Obviously, cuttings with very different requirements should not be bunched together in the same set of frames. This could be labeled as a liability. Rather, I think, it is an asset, since it forces better planning, cuts labor costs and provides for better economy.

Adaptability. It would not do much good to design a system that, though it might be good, was not adaptable.

We have found, under our conditions, that many species of junipers and certain spruce clones, including 'Hilli' and as well as 'Glauca Koster' lend themselves to this method of propagation as well as nearly all ornamental deciduous shrubs and broadleaved groundcovers.

Not only must a system of propagation fit the plants to be propagated but it must, too, fit the overall operation of the nursery. For production of deciduous shrubs in June, and groundcovers from June to September, this system has worked extremely well. In increasing numbers, we are now producing junipers and spruce this way with equally good results. It is far more economical to produce cutting-grown understocks for juniper grafting by this method.

The system will not eliminate greenhouse propagation. Only 3 to 4 months are suited for propagation in outdoor frames in our climate. Because of availability of labor and cutting material it is not possible for a large nursery to do all its propagation in these few months. To even out the production, especially through the winter months, greenhouses are needed.

The cost and economy factor of the system is very favorable. It is, I dare to say, its real merit. Comparable costs, in production per unit and in overall costs, show a considerable advantage over operations in greenhouse bench areas. Total direct labor cost per rooted cutting has been brought down to 0.96 minute or 2.5c. This includes bench preparation, making the cutting, cultural care all the way through, plus lifting and grading. In comparison a 'Hetz' juniper for understock, cutting-made in the greenhouse, eats up 2.3 minutes of direct labor, or 7.3c.

Besides this distinct advantage in production economy, the system has the advantage of much lower initial investment than a greenhouse. The cost of construction is about one dollar per square foot of frame space. This includes everything, from grading of the land to the electric controls. I would guess that bench space in a greenhouse would cost about four times as much. The investment is less fixed, as it can be written off in a short time. The frames can be moved or even abandoned without great loss. These things are often advantages.

It is increasingly obvious that labor cost in propagation tends to make propagation of many ornamentals unprofitable. This is especially the case near industrial areas in the United States. Reduction of cost by propagating the best adapted varieties in outdoor frames seems to be one of the possibilities best suited to fit into the propagation operations in our area; that is, to produce liners at competitive and profitable prices.

At this time I wish to express my great appreciation to my tireless co-worker, John Wilde; also to the management of the D. Hill Nursery, who never shied away from exploring into the unknown, here especially remembering the late Jack Hill.

MODERATOR CESARINI: Thank you very much, Peter. We now have time for questions.

JIM WELLS: I'd like to ask Larry Carville why he sticks his cuttings with a dibble. Have you tried dispensing with the dibble?

LARRY CARVILLE: The only reason we are still using the dibble is that my men have very short fingers and by using the dibble they can get the cuttings properly inserted to the proper depth in the medium. We don't use a board, hammer or a slat. My predecessor used the dibble and I like it too; however, students today aren't being trained in the proper use of the dibble and we will no doubt have to change in the future, but at the present time it works very well for us.

HANS HESS: I'd like to ask Mr. Bailey why he puts *Euonymus alata* and *E. alata* 'Compacta' cuttings in the greenhouse and doesn't do these outside like the other softwood shrubs?

VINCE BAILEY: We have to put something in the greenhouse, Hans; but really it's because they are a little more difficult to root than some of the other things and we save the greenhouse space for those species we find to be a little more difficult to root.

ARIE RADDER: Mr. Orum, when are your junipers stuck in the frames?

PETER ORUM: From the first of June to about August 15; they shouldn't be stuck much later than this in our area.

CASE HOOGENDOORN: Do they still root if you stick them the 15th of August?

PETER ORUM: Yes, but that's not rooted by fall, that's rooted by next spring because they're covered with polyethylene during the winter.

JOHN ZELANKA: Mr. Orum, of the juniper cuttings which you stick, do varieties such as 'Maneyi' and other hard-to-root varieties root in one sticking or do you have to restick these in the greenhouse to finish them off?

PETER ORUM: We are still working with 'Maneyi" and do have some rather good results with our system, although the last couple of years we have had better results sticking 'Maneyi' in the greenhouse about the first of September.

MODERATOR CESARINI: That's all the time we have now; any other questions will have to go in the Question Box. I want to thank all the speakers again and you the audience, you've both been wonderful. Thank you very much.

CHARLEY HESS: The second half of this afternoon's program will be moderated by Mr. John Newhouse. It's a pleasure to have John take over the rest of this afternoon's program, John!

MODERATOR NEWHOUSE: We have a very good program for you on nutrition and plant growth but I ask that you hold all questions till the end of the program. Our first speaker is Martin Meyer from the University of Illinois.

EXTERNAL AND INTERNAL NUTRITION AND SPRING GROWTH OF WOODY ORNAMENTAL PLANTS

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The exact response of woody ornamental plants to fertilizer applications is often difficult to measure. This is because of the nature of the growth of these plants. The growth to be considered here and of concern to ornamental horticulturists is shoot growth or, specifically, growth of terminal meristems of the shoots of woody plants. This growth controls the form of the plant, produces leaves and flowers, and gives interest and environmental modification to the landscape. The nature of this shoot growth and response of this growth to fertilizer applications at various times will be considered.

What is the nature of growth of woody plants in temperate regions? Woody plants break buds and initiate growth from preformed parts in the spring. This may constitute the total height growth for the season in some plants; however, in other plants it may not. The growth of woody plants can be divided into two basic patterns. The first of these patterns can be referred to as homophyllous which refers to one type of leaf being formed. This is the situation when spring growth is the total elongation of the shoot for the year. This growth con-