fore grafting. This was touched on by Dr. Dorsman in his paper recently at the International Horticultural Congress. And we, for our part. always so far as possible insure the stocks are as dry as possible at the grafting stage. Temperatures are generally best in the 60 - 65°F. region, but some genera do appear to have a higher temperature requirement and Juglans are quite happy in temperatures up to 80°F. Generally speaking we do not have remarkedly good results by budding, certainly in this part of England at least. I often read with envy some of the successes that you have in the States by budding techniques. Whether the fault is ours or of the climate I do not at this moment really know.

Well now ladies and gentlemen if no one has yet turned me off, I'll close on the next slide which I suppose must be one of the most famous horticultural views in the world — it's of the palm house at Royal Botanic Gardens at Kew and wish you every success for the following lectures in your meeting and thank you very much for listening to me.

CHIKO HARAMAKI: Our next speaker is our program chairman, Stu Nelson, from Saskatoon, Saskatchewan.

THE ROLE OF BOTTOM HEAT IN THE ROOTING OF CUTTINGS

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Bottom heat is a practice of supplying additional heat to the medium and is not limited to the rooting of cuttings as we propagators might think. In fact, it possibly has more use in the forcing of growing plants than in the rooting of cuttings. I suppose that the first use of bottom heat can be traced back before the "Dark Ages" as with most of our horticultural practices, but I have not tried to do this. Rather, I will limit my remarks to the use of bottom heat—mostly electrical—as we know it today. It would seem that the acceptance of electricity, rather than manure, could be dated at around 1930 and in the early 1930's, there were a number of reports from different countries describing the installation and economics of such a procedure (1, 4, 7, 15). The economics of electricity over manure would seem to have been easily proved (5, 23) but I am not sure that I can say the same, without considerable reservation, for the beneficial effects on rooting.

By the way bottom heat is tossed around in conversations at this meeting, one would suspect that it might be the password to success and that the literature would abound in references. Neither would appear to be true. In fact, good experimental comparisons, either in favor or against bottom heat as a tool to aid rooting; are very few. It would be dif-

ficult to say why there are not more references because we cause we all know that bottom heat has been and will continue to be used extensively even though the only benefit reaped may be a psychological effect on the operator.

In this review, I have limited myself to where bottom heat is used during the entire rooting process and I have not included some rather elaborate techniques used for precallusing cuttings in this country, Europe and Russia. Right from the start, bottom heat for the propagation of cuttings has not received wide acclaim. In the early 1930's, there were isolated reports that bottom heat (75-79 degrees F) was necessary for citrus in cool climates [Halma (8)], was beneficial at 60 to 70 degrees F for softwood cuttings of trees and shrubs in outdoor frames in Alberta, [Ure (19)] and was used with softwood cuttings of apple [Stoutmeyer and others (18)]. In the same decade, however, a Russian report (21) summed up that the 600 varieties, including 479 species and 118 genera, did not, for the most part, require bottom heat. Since the 1930's there have been further isolated reports. Crossley (6) reported that bottom heat did not seem to be necessary for *Ilex aquifolium* where a greenhouse was available but that it might be of benefit in outdoor frames covered with glass or plastic. According to Bergh (2) soil heating (65 degrees F) greatly enhanced the callus formation, root development and rooting quality on cuttings of shy-rooting rhododendron varieties. Electricity or some other means of heating the cutting beds is necessary for Mulberry in Japan (9) and in the United States bottom heat at 70 degrees F profitably increased the rooting of blueberry cuttings in March but was not needed in June (17). There was a further report (13) of a three-year study on a commercial nursery in Texas which indicated that the time required to root and grow nursery stock to a suitable size might be reduced by 12 to 24 months with the use of electrical soil heating cable and that greater yields of sturdier, more uniform plants could be obtained.

Although temperatures around 70 degrees F have been mentioned above, a few other references were found. In Europe, Jacobs and others (11) reported that begonia rooted well at 72.5 degrees but most cuttings at 77 degrees F had scorched rootlets. Both, however, were better than the 65 degree control, that *Aeropanax reticulata* rooted well at 77 degrees but 82 degrees F was too high and that *Ficus decora* rooted better at 88 degrees than at 82 or 77 degrees F.

In trials at Wooster (12), bottom heat at 70 degrees F was generally best but this report showed that air temperature in combination with bottom heat was very important. Air temperatures of 50 degrees was better than 60 or 70 degrees F.

The combination of moisture with bottom heat is also an important consideration. Riehl (16) emphasized the importance of maintaining the proper levels of light and moisture

when propagating at high temperatures. He found that rooting in a moist medium at 61 degrees was quicker than rooting in a dry medium at 73 degrees F. Working with rhododendrons, Bergh and others (3) found that better rooting occurred in propagation frames heated with hot water than with electricity because the rooting medium was damper, and Wells (22) suggested that bottom heat (75-85 degrees F) was desirable for holly provided a high humidity was obtained; intermittent mist provided excellent conditions.

Mist propagation has become very popular and bottom heat has been used. Henrada (10) reported that, with the exception of *Chamaecyparis lawsoniana,* 77 degrees was better than 86 degrees F with the fifteen succulent. herbaceous and woody plants tested. Piringer (14) reported that 70 degrees gave more main roots on *Buxus* than 80 degrees F but with interrupted light during the night to yield more branching, 80 degrees F was better for *Buxus* and 70 degrees F for *Ilex.* Van Doesberg and Ravensberg (20) reported that in some cases the rooting of rhododendron cuttings was improved by soil warming with mist.

Summary of Work at Ottawa

Over a five-year period, work with intermittent mist, with and without bottom heat, was conducted in the greenhouse and out-of-doors. In the early part of this period many comparisons of the effect of bottom heat was made but later, these comparisons are less frequent because it was already apparent to me that bottom heat played a minor role. Facilities were used more and more in the testing of other propagation techniques. Although some 200 taxa were tested over this period, only 88 are included in this summary. With some taxa tested, no comparisons were made and in many areas, the use of bottom heat and no bottom heat was not tested over a wide enough range of hormone treatments to be included.

A summary of this work is included under the following five classifications:

1. Bottom heat beneficial in all treatments tested.
2. Bottom heat beneficial only in check treatments and equal results, in general, obtained with hormones.
3. Bottom heat beneficial only in combinations with hormones.
4. No beneficial effects of bottom heat.
5. Bottom heat detrimental in practically all treatments.

The propagation methods have been coded as follows:

IMI—intermittent mist in the greenhouse
IMO—intermittent mist outdoors
CTI—cheesecloth over greenhouse benches—no mist
PTI—plastic tent over greenhouse benches—no mist
* Denotes better results in some other propagation bed
/—before name denotes 50-60 percent rooting only
//—before name denotes very poor rooting, 30 percent or less

Although these classifications will be published in full, there is not time to itemize them all in this talk. In classsification 1 there are only six items listed where bottom heat was of benefit in the respective propagation beds and in four instances, better rooting was obtained elsewhere without the aid of bottom heat. There are seven entries under classification 2 and one entry had better results in another type of propagation bed without bottom heat. It was interesting to note that there are no plants to be found in classification 3 which covers beneficial effects of hormone and bottom heat together.

The majority of the taxa fall into the group showing no beneficial effects, ie, classification 4. There are 65 entries in this group. There are 14 entries (the second largest group) in classification 5 which indicated detrimental effects at practically all hormone levels.

From the above classification of plant material, there is little evidence to support the use of bottom heat of most plant materials. I think, however, that one must admit that its use can speed up rooting and possibly give increased rooting percentages under adverse conditions. Hormones applications can achieve the same effects in an easier manner and there is no evidence that the effects of bottom heat and hormone treatments compliment each other.

As mentioned previously, some of the plants in the various classifications are indicated as having better results in another propagation bed than listed herein. Without exception, this was a polyethylene tent with intermittent mist but no bottom heat outdoors (PTO). It is also interesting to note that the deciduous material seemed to prefer this hot humid atmosphere while the coniferous plant material performed equally or slightly poorer in this atmosphere.

Appended to the paper is a further list, including another 70 taxa not included above, where 80 to 100 percent rooting was easily obtained without bottom heat but could not be classified above because no comparison with bottom heat was made.

Classification 1 Bottom heat beneficial in all treatments tested

Berberis piorettii (IMO)*
Chaenomeles japonica (IMO)
Juniperus sabina (IMI)*
Malus robusta 5 (IMI)*
Taxus baccata repandens (IMO)
Thuja occidentalis filiformis (IMI)

Classification 2 Bottom heat beneficial only in check treatments and equal results in general, obtained with hormones

Juniperus chinensis pfitzeriana aurea (CTI) (IMI) (IMO)
Juniperus sabina tamariscifolia (IMI)

Lonicera tatarica "Carleton" (IMO)*
Taxus baccata repandens (IMI)
Thuja occidentalis lutea (*elegantissima*) (IMI) (IMO)
Thuja occidentalis saundersii (IMO)

Classification 3 Bottom heat beneficial only in combination with hormones

NIL

Classification 4 No beneficial effects of bottom heat

Buxus microphylla koreana (IMO)
Cornus stolonifera flaviramea (IMO)
Chamaecyparis pisifera plumosa argentea (IMO)
Chamaecyparis pisifera plumosa aurea (IMO)
Chamaecyparis pisifera plumosa squarrosa (IMO)
Daphne burkwoodii (IMO)
Forsythia ovata (IMI) (IMO)
Genista pilosa (IMO)
Genista tinctoria (IMO)
Ginkgo biloba (IMO)
Hydrangea arborescens (IMI) (IMO)
Hydrangea paniculata (IMI) (IMO)
Juniperus chinensis blauwii (IMI)
Juniperus chinensis hetzii (IMI)
Junperus chinensis keteleeri (IMO)
Juniperus chinensis pfitzeriana aurea (PTI)
Juniperus communis depressa aurea-spica (IMO)
Juniperus horizontalis douglasii (IMI) (IMO)
Juniperus horizontalis plumosa (IMO)
Juniperus sabina (IMO)
Juniperus sabina tamariscifolia (IMO)
Juniperus scopulorum (IMO)
Kerria japonica (IMO)
Ligustrum vulgare (IMO)
Ligustrum vulgare pyramidale (IMO)
Lonicera prolifera (IMO)
Malus baccata (2 selections) (IMO)*
Philadelphus coronarius aureus (IMO)
Philadelphus lemoinei "Dame Blanche" (IMO)
Philadelphus virginalis "Minnesota Snowflake" (IMO)
Philadelphus virginalis "Silvia" (IMO)
Physocarpus opulifolius aureus (IMO)
Polygonum reynoutri (IMO)
Prunus fruticosa (2 selections) (IMO)
Prunus tenella (IMO)
Prunus triloba (IMO)
Rhamnus dahurica (IMO)*
Rhamnus frangula (IMO)*
Ribes grossularia (2 selections) (IMO)
Ribes nigrum "Consort" (IMO)
Ribes rubrum "Red Lake" (IMO)
Rosa multiflora (IMO)

Rubus henryi (CTI) (IMI)
Spiraea media (IMO)
Spiraea trichocarpa (IMO)
Spiraea vanhouttei (IMO)
//*Tamarix pentandra* (IMO)
Thuja occidentalis "Columbia" (IMO)
Thuja occidentalis ellwangeriana (IMI) (IMO)
Thuja occidentalis fastigiata (pyramidalis) (IMI) (IMO)
Thuja occidentalis globosa (IMI)
Thuja occidentalis hoveyi (IMO)
Thuja occidentalis "Little Gem" (IMI) (IMO)
Thuja occidentalis "Patmore" (IMI) (IMO)
Thuja occidentalis "Rheingold" (IMO)
Thuja occidentalis saundersii (IMI)
//*Ulmus americana* (IMO)
Ulmus pumila (IMO)
Viburnum lantana (IMO)

Classification 5 Bottom heat detrimental in practically all treatments

Berberis thunbergii artopurpurea (IMO)*
Betula pendula delecarlica (IMO)
Cotinus coggygria (IMO)*
Cotoneaster acutifolia (IMO)*
Euonymus alatus (IMO)
Lavendula officinalis (IMO)
Picea abies maxwellii (IMO)
Picea abies ohlendorffii (IMO) (IMI)
Prunus tomentosa (2 selections) (IMO)
Malus robusta 5 (IMO)*
Spiraea arguta (IMI) (IMO)
Thuja occidentalis hollandica (IMO)
Viburnum prunifolium (IMO)*
Vinca minor (IMO)

Classification 6 No comparison with bottom heat but 80-100 per cent easily obtained without bottom heat

Acer ginnala (PTO)
Acer tatarica (IMO)
Caragana arborescens (IMO)
Caragana frutex (IMO)
Cornus alba spaethii (IMO)
Kolkwitzia amabilis (PTO)
Pachistima canbyi (IMO)
Pachysandra terminalis (IMO) (PTO)
Philadelphus burfondensis (IMO)
Philadelphus burkwoodii (IMO)
Philadelphus cordifolius (IMO)
Philadelphus coronarius multiflorus plenus (IMO)
Philadelphus cymosus "Atlas" (IMO)

Philadelphus cymosus "Voie Lactae" (IMO)
Philadelphus falconeri (IMO)
Philadelphus grandiflorus (IMO)
Philadelphus insignis "Souvenir de Billiard" (IMO)
Philadelphus laxus (IMO)
Philadelphus lemoinei "Avalanche" (IMO)
Philadelphus lemoinei "Enchantment" (IMO)
Philadelphus lemoinei erectus (IMO)
Philadelphus lemoinei "Fleur de Lis" (IMO)
Philadelphus lemoinei "Frosty Morn" (IMO)
Philadelphus lemoinei "Innocence" (IMO)
Philadelphus lemoinei "Manteau d'ermine" (PTO)
Philadelphus lemoinei "Mont Blanc" (IMO)
Philadelphus lemoinei ochroleucus (IMO)
Philadelphus lewisii "Waterton" (IMO)
Philadelphus nepalensis (IMO)
Philadelphus nivalis (IMO)
Philadelphus pekinensis chachybotyris (IMO)
Philadelphus polyanthus "Favorite" (IMO)
Philadelphus polyanthus "Pavillion Blanc" (IMO)
Philadelphus satsumanus (IMO)
Philadelphus scbrenkii (IMO)
Philadelphus speciosus (IMO)
Philadelphus virginalis "Albatre" (IMO)
Philadelphus virginalis "Argentine" (IMO)
Philadelphus virginalis "Glacier" (IMO)
Philadelphus virginalis "Mrs. Thompson" (IMO)
Philadelphus virginalis "Patricia" (IMO)
Philadelphus virginalis "Purity" (IMO)
Philadelphus virginalis "Thelma" (IMO)
Prunus dropmoreana (IMO)
Syringa hyacinthiflora "Necker" (IMO)
Syringa lovaniensis "De Louvain" (IMO)
Syringa prestoniae "Alice" (IMO)
Syringa prestoniae "Audrey" (IMO)
Syringa prestoniae "Calpurina" (IMO)
Syringa prestoniae "Celia" (IMO)
Syringa prestoniae "Elinor" (IMO)
Syringa prestoniae "Ethel M. Webster" (IMO)
Syringa prestoniae "Jessica" ((IMO)
Syringa prestoniae "Ursula" (IMO)
Syringa perstoniae "Virgilia" (IMO)
Syringa swegiflexa x *S. reflexa* "Fountain" (IMO)
Syringa vulgaris "Geheimrat Singlemann" (IMO)
Syringa vulgaris "Mme. Lemoine" (IMO)
Syringa vulgaris "Mare Micheli" (IMO)
Syringa vulgaris "Montaigne" (IMO)
Syringa vulgaris "Paul Thirion" (IMO)
Syringa vulgaris "Perle Von Stuttgart" (IMO)
Syringa vulgaris "Pres. Lincoln" (IMO)
Syringa vulgaris "Ronsard" (IMO)
Syringa vulgaris "Victor Lemoine" (IMO)

Viburnum juddii (PTO)
Weigela florida (IMO)
Weigela wagneri "Bristol Ruby" (IMO)
Weigela wagneri "Eva Rathke" (IMO)
Weigela wagneri "Stelzneri" (PTO)

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CHIKO HARAMAKI: Thank you, Stu. I am sure your comments will stimulate some heated discussion. Our next speaker here is Mr. Harvey Gray.