others. Of those we grow, *Abies concolor* trees seems to be most affected by frost damage but they recover readily.

MODERATOR DOUGLASS: We have one more presentation in this session. John Walters is the Director of the University of British Columbia Research Forest, Haney, B. C. John, we understand you have developed an ingenious gun for literally "shooting" planting stock into the ground. It will be our pleasure to have you explain this to us. John Walters:

CONTAINER PLANTING IN FORESTRY

JOHN WALTERS

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Forest tree planting began about 400 years ago. Since that time the methods of tree planting have changed only slightly while the principles have changed not at all. Although 1½ billion seedlings are planted each year in North America we rely still on the same techniques which were developed for much smaller quantities of planting stock at a time when labour costs were insignificant. Forestry in the Pacific Northwest currently relies on manual methods to plant two-year-old bare root Douglas fir seedlings. About 500 trees per man-day are planted with this technique, currently in wide use in the Pacific Northwest.

Today, we are faced with the problem of accomplishing a monotonous, tedious job with a labour force which is rapidly diminishing in terms of quantity and quality. In some regions an attempt has been made to mechanize this operation by borrowing techniques from agricultural practice and by modifying agricultural equipment such as the broccoli planter. These tractor-drawn implements do not operate well on sandy and rocky soils, nor do they do a good job of planting on rolling terrain. Moreover, much of the terrain of the Pacific Northwest is inaccessible to this type of furrow-making planter. Besides the steep slopes broken by granitic outcrops, the areas are littered with large volumes of heavy logging debris.

However, regardless of the topographic conditions of the planting site, present day reliance on bare-root seedlings limits the development and introduction of new planting methods. Bare-root seedlings, having dimensions and succulence which vary from seedling to seedling, have obliged all modern tree-planting machines to rely heavily on manual aids both during the insertion of seedlings into the furrows and also, subsequent to planting, follow-up operations to improve the job done by the machine. Moreover, critical requirements of seedling physiology must be protected during the planting operation. The accommodation of these requirements imposes stringent demands upon the planting process and it is safe to say that bare-root planting requires more accommodation than any other method, whether machine or manual.

From the biological point of view the best method is the one which provides for the least disturbance of the root system. This requires that the seedling be moved from nursery to planting site with its roots still in the soil in which it germinated. In horticultural practice this has been accomplished best by ball-root planting, and, increasingly, by container planting. The overriding advantages of container planting are: firstly, that it requires least accommodation in terms of protecting seedling condition and, secondly that it permits the fixing or stabilizing of seedling dimensions so that seedlings can be metered mechanically throughout nursery, transportation, and planting processes. In the face of these crucial advantages it is incredible that container planting in forestry was almost completely ignored until after the Second World War. The reason for this neglect is not clear but recently forestry has made several attempts to catch up. Paper bags treated with asphalt have been tested in Europe. Containers made of tin, concrete, galvanized iron pipe, palm leaves, banana bast, sunflower stems, bamboo, and wood veneer have been used extensively, specially in the tropics. Polyethylene bags are used in the semi-arid areas of Africa and in Taiwan. By far the most popular is the peat pot common to horticulture. This year the Swedish government and industry are spending nearly 1 million dollars in an attempt to develop a mechanical planting system using peat pots. The main disadvantage to this type of container is associated with its lack of rigidity and its rapid deterioration, resulting in high labour costs. Synthetic rooting media are also being tested. One of these is a polyurethane foam, containing nutrients, developed by Dow Chemical Co. which is being tested at U. B. C. Research Forest.

Increasingly, forestry is turning to plastic tubes of various kinds. In Alberta, government and industry have cooperated to test several types made of vacuum-formed polyethylene or extruded polyethylene; 18 million polyethylene tubes were planted in Ontario last year and the program in 1967 calls for 37 million. In all of these containers, the growing medium, usually soil, or sand and peat, is poured in and the seed inserted using various semi-mechanical aids. The crucial disadvantage of this type of semi-flexible container is, however, that its composition and design limit its suitability for total mechanization in any of the nursery, transportation. and planting processes.

In an attempt at the University of British Columbia to develop a new planting method which could be totally mechanized, old principles were joined to new techniques and this method has been under development and test in B. C. since 1950. The devices described here are called the planting gun and bullet (Figures 1 and 2).

Although the objective of the project was to mechanize planting, the conditions under which reforestation are carried out in much of the Pacific Northwest dictate that the machinery must be manually transported over the planting sites. This fact strictly limits the weight and method of operation of machinery. The planting gun[1] weighing seventeen pounds, is sufficiently light and convenient to be portable over logging debris on steep and rocky slopes. It also became evident early in this project that mechanical metering of large numbers of seedlings under rugged field conditions required that the dimensions of the seedlings should be constant and that this could be accomplished, within narrow tolerances, only by

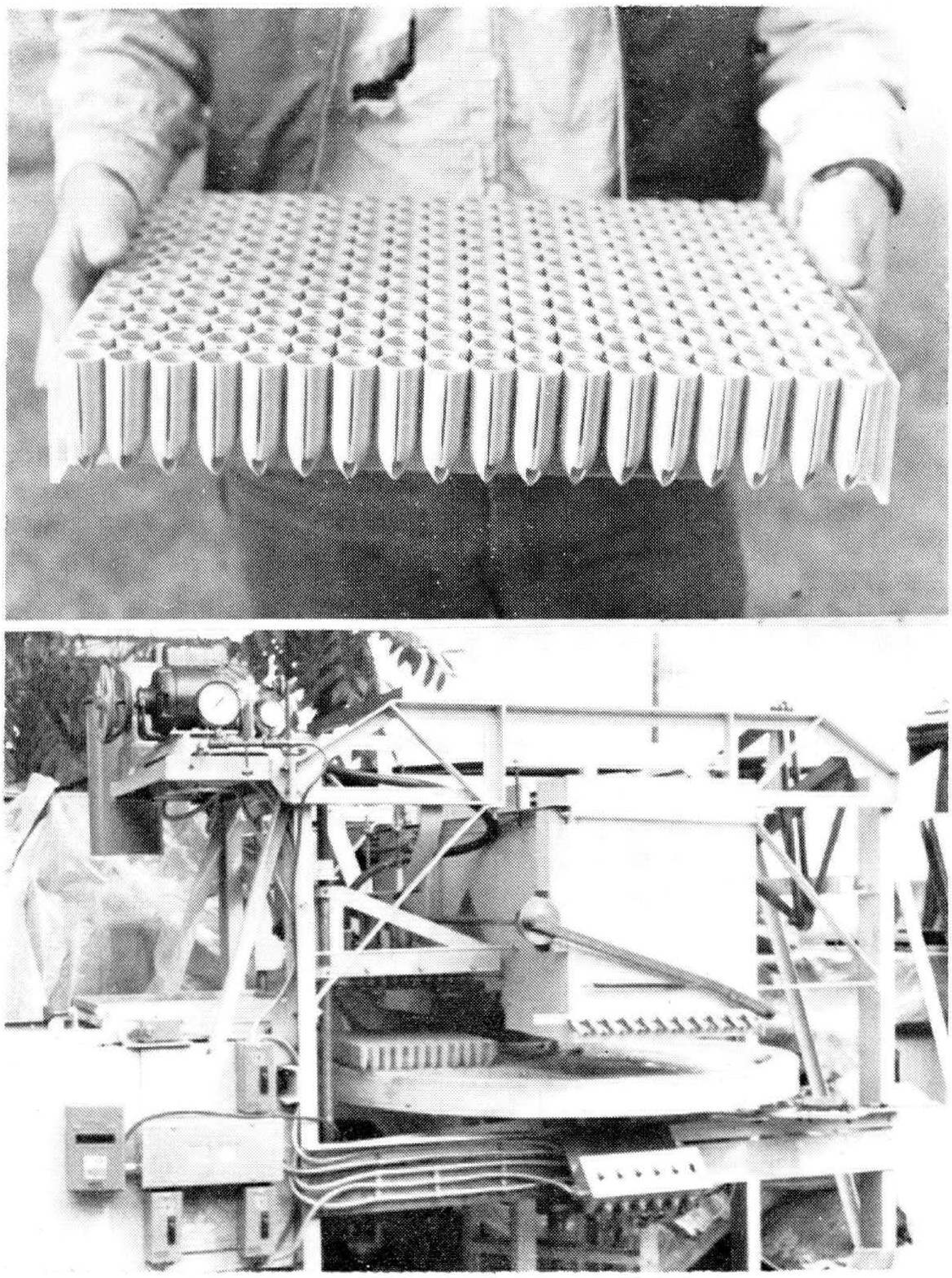

Figure 1. *Above.* One-half inch "bullets" in strip of 12 (216 bullets) in tray. *Below.* Prototype of "Lazy Susan" seeding machine.

[1]Mfg. by: Columbia Plastics, 2155 W. 10th Ave., Vancouver 10, B. C., Canada

growing seedlings in containers of fixed dimensions. For this reason a rigid container was designed which could be pro-

Figure 2. Planting "gun". *Above*. Single-shot gun in use. *Below*. 24-shot planting gun.

duced from a relatively inexpensive material. Styrene plastic was chosen to fill the latter requirement and the needs of mass production met by injection molding. The bullets[1] are 2½ in., 3½ in., 4½ in., and 5½ in. in length, are ⅞ in. in outside diameter, and have walls 1/16 in. in thickness. The wall of each bullet is weakened by a slit which is 1/16 in. wide and which extends longitudinally from the rim to a hole near the point of each bullet. The hole is ¼ in. wide and ½ in. long, and is offset from the point to permit passage of the roots while preserving the essential profile and strength of the bullet. A longitudinal groove, 1/32 in. deep, and diametrically opposing the slit further weakens the bullet and acts as a fulcrum for the unfolding bullet as root growth widens the slit. The bullets are molded in strips of twelves and received from the factory in disposable plastic racks.

Bullets are filled with University of California Soil Mix C (Fertilizer I) and seeded mechanically. The machine weighs 1,000 pounds. A ¾ HP compressor actuates a turntable which completes one revolution per minute in four equal stages controlled by a solenoid. The compressor also operates soil-metering grids on diametrically opposed soil hoppers, a tracked seed-pan, a seeder, and a soil-tamper. The machine is adjustable to accommodate bullets ranging in length from 2½ in. to 5½ in. Plastic trays containing 18 strips of bullets, are placed below the main soil hopper which fills the 216 bullets simultaneously with soil mix. A quarter turn of the table carries the tray to the second position where the soil is mechanically tamped. The transfer of the tray to the tampers clears the first position for the insertion of a second tray of bullets. Another quarter-turn carries the first tray to a second hopper which refills the tamped bullets. Finally, in the fourth position, the wheeled seed pan rolls under, and lifts up to, 216 vacuum-operated nozzles each of which picks up one seed. When the seed-pan rolls back, the nozzles are lowered to meet the incoming tray of bullets. The operation is synchronized to release the vacuum when the nozzles are submerged ¼ in. below the rim of the bullets. The tray, filled with soil mix and seed returns to the first position where it is removed and placed in the lath shed. Completed in one minute each revolution of the turntable fills 864 bullets.

Trays of seeded bullets are placed in troughs and sub-irrigated. When ready for planting, seedlings in the plastic trays are transported to the planting site and transferred to the pack-boards of the planting gun operators.

The planting gun is a tubular device, which inserts the bullet-shaped plant-pots, each containing a tree seedling, into the ground when a downward force is applied manually to the gun handle. When the downward force is discontinued, a coil spring extends the gun to actuate blades which cut one bullet from the strip of bullets in the magazine. The bullet then drops to the muzzle of the gun where it is held ready for planting. Tests carried out since 1957 at the University of British Columbia Research Forest prove that the bullets are shattered by root growth after three or four growing seasons, depending on site quality and rate of growth.

Some of the containers described here were introduced with the sole purpose of improving survival and subsequent growth. This worthy objective is no longer adequate and must be supplemented by mechanical aids. It is already apparent that for biological and mechanical reasons each phase of a container program has important implications for other phases. Because of this, revolutionary techniques of sowing, growing, transporting, and planting will be developed in the very near future. It seems certain that many of these techniques will have applications in agriculture and horticulture as well as forestry and that each of these three sciences will benefit by learning and borrowing from the others.

VICE-PRESIDENT TICKNOR: The moderator for our second session this morning, which is on "Chemicals and Plant Growth", is Dr. J. W. Neill. Dr. Neill is in the faculty of the Division of Plant Science, University of British Columbia, Vancouver. Dr. Neill:

MODERATOR NEILL: I am most happy to be here and to give you my own word of welcome to British Columbia. The subject matter for this session is a very fundamental and important one to all of us — "Chemicals and Plant Growth." Our first speaker is Dr. Dennis Lavender, from the Forest Research Laboratory, Oregon State University, Corvallis. Dr. Lavender has spent some 20 years in forest research in the Pacific Northwest. He is going to discuss the role of growth regulators in the physiology of Douglas fir seedlings. Dr. Lavender:

THE ROLE OF GROWTH REGULATORY SUBSTANCES IN THE PHYSIOLOGY OF DOUGLAS FIR (*Pseudotsuga menziesii* [Mirb.] Franco) SEEDLINGS

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Douglas fir, in common with most conifers, is characterized by extremely slow seedling growth and by very heterogenous populations. Obviously it does not recommend itself as an experimental organism to physiologists studying basic processes in plant growth. It is not surprising, then, that there are little data describing chemical growth regulation of this species nor that the great majority of the existing information is derived from highly empirical trials. Unfortunately, while