solutions contained 20 ml of 95% ethanol per liter. The *A. griseum* cuttings were soaked in a 3-cm depth of the treatment solutions in beakers on a mist bench for 24 hr. Cuttings were then inserted into wooden flats containing a steam-pasteurized medium of peat moss and perlite (1:1, v:v). The daylength was extended to 16 hr by 100W incandescent light bulbs placed 60 cm above the plant canopy at 50-cm intervals from 6 to 11 pm. The experiment was a completely randomized design with 5 replicates per treatment. The number of roots and root quality were determined after 63 days.

A 24-hr treatment of stem tip cuttings of *A. griseum* with 1.1×10^{-3} M IAA in combination with 4.5×10^{-3} M catechol resulted in 100% rooting (Table 4). All other treatments gave lower rooting percentages. Treatment of *A. griseum* cuttings with a combination of 1.1×10^{-3} M IAA and 9.1×10^{-4} M catechol resulted in production of a mean of 13 roots per cutting with 80% rooting. Treatment with all other combinations of IAA and catechol resulted in the formation of fewer roots per cutting. Roots which did form were brittle and difficult to transplant.

The 100% rooting of *A. griseum* cuttings treated with a combination of catechol and IAA represents an improvement over rooting percentages of 30% (3) and less than 1% (4) reported by other workers. Fordham (6) reported 100% rooting of *A. griseum* cuttings taken from a 6-year-old-plant; however, cuttings taken from younger plants the same day showed only 46% rooting. Fordham offered no explanation for these differences.

These experiments demonstrate that treatment of cuttings with catechol in combination with IAA can be of value in the propagation of woody plants. Additional experiments should be carried out to assess the use of catechol and auxins to stimulate root initiation in cuttings of other difficult-to-root species.

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Distance Measuring and Signaling Device for a Mechanical Tree Planter

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Abstract. **Depending on soil-surface conditions, an electronic pick-up and counting device to signal within-row tree distances using a mechanical tree planter produced planting distances as accurate or more accurate than those obtained with traditional planting techniques.**

Traditionally, orchards have been laid out by measuring and staking 2 outside rows and 2 or more rows perpendicular to the outside rows. The remainder of the planting sites were established by "sighting-in" on the previously staked rows. A 2nd method commonly used was to measure and stake the outside rows of the orchard and then, by sighting on these outside stakes and with the aid of a sub-soiler, from a grid pattern to locate tree position. Trees were then planted in a hole dug by a tractor-mounted auger at the intersection of the layout lines. Both methods (2, 3) of staking out and planting an orchard required considerable time and labor. To reduce planting costs and to increase planting efficiency in high-density orchards, a continuous mechanical tree planter was developed by the U.S. Department of Agriculture (4). Recent studies have shown that shoot growth and anchorage of mechanically planted trees are superior to trees planted with a conventional auger (1).

In addition to traditional orchard layout techniques described, other options are available for use with the mechanical planter. All methods required staking the ends of the row to establish the spacing between the rows. To establish the spacing within the row, the first row was usually staked using a measuring tape to mark the planting distance between individual trees. Succeeding within-row spacing was determined by a person walking beside the planter and sighting-in adjacent rows and signaling the person planting trees when to plant. The person on the planter also could sight-in the planting location. Staking every 3rd or 4th row often increased accuracy. Another way to establish within-row distance was to have a cable trailing the planter that was the distance of the spacing required; a tree was planted when the tip of the cable passed the previously planted tree. Both methods often resulted in less-than-desired accuracy for within-row spacing. At the 1981 West Virginia State Horticultural Convention, held in Martinsburg in January, K.C. Elliott et al. described a proposed ground-driven measuring wheel attached to a tree planter and an electronic counting device for determining within-row planting distance. Field testing and results were not reported.

The objective of the present study was to develop tractor- and planter-mounted equipment which would determine within-row tree spacing accurately and provide a signal as to when to plant. Flexibility to allow rapid adjustment for different tree-spacing distances was considered an essential design feature.

An inductive proximity switch sensing on a 50-tooth, 10-pitch gear mounted to a hub on one of the front tires of the tractor (Fig. 1) was used to gauge distance traveled. Each passing of a spur-gear tooth by the proximity switch corresponded to 1/50 of the rolling

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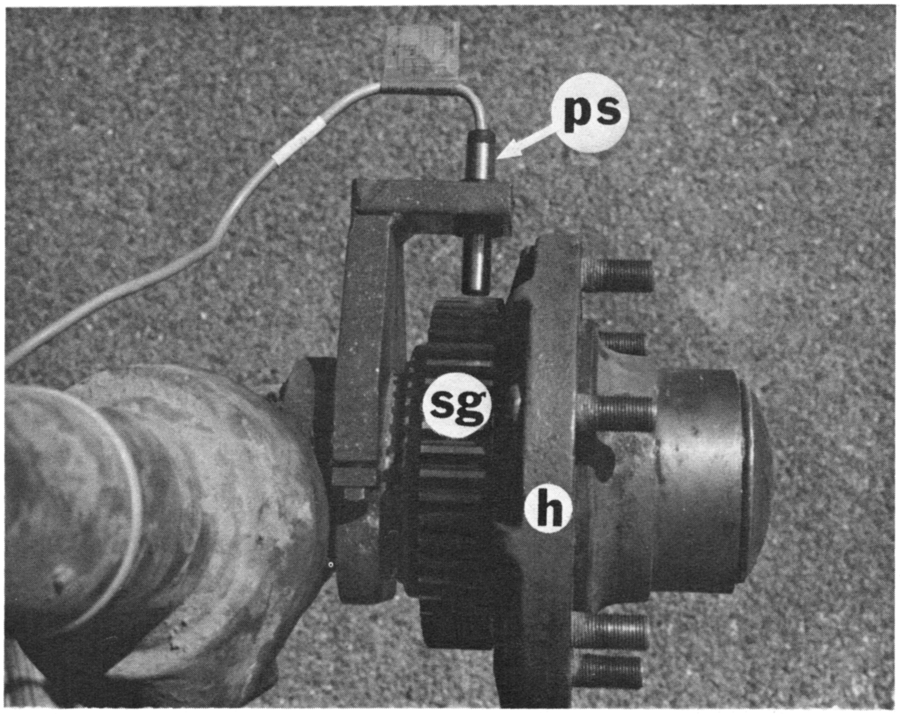

Fig. 1. Spur gear (sg) and proximity switch sensor (ps) mounted on the front hub (h) of a standard farm tractor. Tractor tire and wheel removed for clarity.

circumference of the front tire. A hole was machined in the spur gear and the gear press fitted to a mating machined surface on the hub of the front wheel. The mounting bracket of the proximity switch was attached to the front axle. This mounting arrangement did not interfere with any of the tractor's steering linkage.

Several locations for mounting the spur gear were considered. The packing wheels on the planter were considered but careful field observation showed that they often lose contact with the ground and would give an inaccurate measurement of distance traveled. A trailing ground-driven wheel was considered but potential problems with slippage, poor ground contact, and damage to the wheel during transport of the planter ruled out this option. The rear drive wheel of the tractor was also ruled out because of slippage.

The signal from the proximity switch was fed into a predetermining counter (Fig. 2 and 3) and recorded on an LED display. The predetermined level at which a normally open output contact would be closed momentarily was set by a series of thumbwheel switches which, when calibrated, corresponded to a desired planting distance. Since the output power of the predetermining counter was less than that required to operate a horn, a relay was added to energize the horn.

Calibration of the counter was necessary since the rolling circumference of the front wheel was unknown. Three test runs of the mounted electronic indicator over an average distance of 37.56 m produced a mean of 655 counts (gear teeth) or an average of 0.0546 m per count. From these data a calibration table was developed. Desired planting distance could then be established by setting the counter thumbwheels to the desired number of counts.

Tests were conducted on 3 different ground surfaces using the electronic indicator to determine within-row spacing. Tractor speed was about 2 km/hr for all tests. Each treatment was replicated 4 times (rows) with 25 subsamples/replication (distance between trees within the row). Treatment 1 was conducted with the tractor moving in a straight line on a paved surface. A person sitting in the planter seat simulated planting by making a mark on the pavement when the horn sounded. This treatment served as a check since tire slippage would be at a minimum. Treatment 2 was conducted with the tractor operating in a well-established 2-month old sod; stakes were used to simulate trees being planted. The third treatment was conducted in a soft, tilled soil. Apple trees were planted at this site to establish an orchard. The predetermining counter was set to 110 to give a theoretical spacing distance of 6 m for all 3 treatments.

To compare the accuracy of the electronic spacing indicator with traditional planting methods, in-row distance measurements were taken in 4 established orchards, each of which had been planted with a mechanical tree planter. In each orchard, sampling consisted of randomly selecting 4 rows and measuring the spacing between 26 consecutive trees. The first traditional planting method, treatment 4, consisted of cross-hatching the field in a perpendicular fashion using a single row plow. Planting sites existed where the plow crossed. The person planting the trees sighted on the cross furrows to determine when to plant. Treatment 5 had every 4th row staked using a measuring tape. The person doing the planting sighted on the initial staked row or the previously planted row to make a decision when to plant. Treatment 6 also had every 3rd or 4th row measured and staked. In this case, an assistant walking beside the planter spotted the planting sight using the staked row and signalled to the person on the planter when to plant. Treatment 7 had only the initial row measured and staked. All subsequent rows were planted by having the person on the planter sight on a previously planted row and make the decision when to plant.

The proximity switch, predetermining counter, and signaling circuit operated as de-

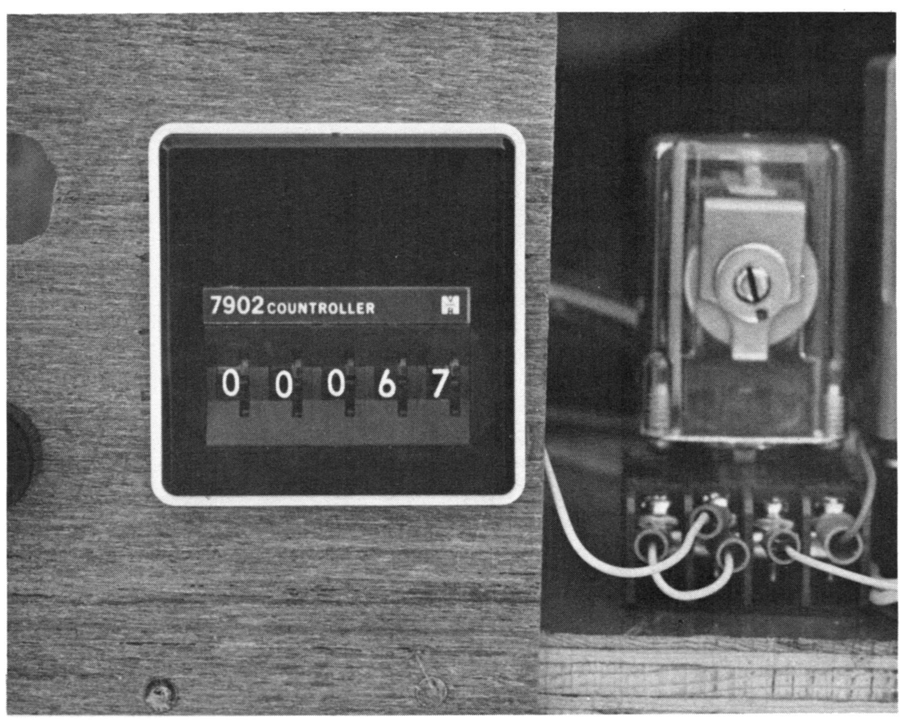

Fig. 2. Predetermining counter and relay for obtaining desired tree spacing signal with a mechanical tree planter.

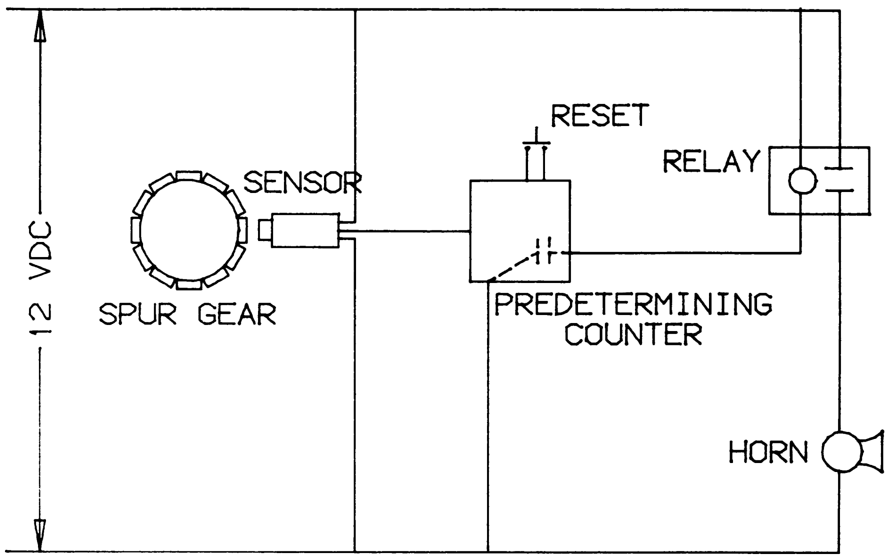

Fig. 3. Circuit diagram for proximity switch sensor, predetermining counter, and horn relay for mechanical tree-planting signaling device.

signed. Preliminary testing showed that if the speed of the tractor exceeded 18 km/hr the counter malfunctioned because the teeth of the spur gear pass the proximity switch at a rate too fast to generate the proper pulse. Actual planting speed ranged from 1.5 to 2 km/hr, well below the level that caused the counter to malfunction. The proximity switch and spur gear did not interfere with normal steering or operation of the front tractor tire. Ground conditions that caused the rear tractor tires to slip did not have an adverse affect on the distance-measuring tire.

The accuracy of the different planting techniques is shown in Table 1. The precision of each planting treatment is best shown by comparing the mean SD. The smaller the value of the SD, the more precise the planting technique. There was no significant difference between treatments 1 (paved surface) and 2 (established sod). The average spacing distance was very close to the desired value of 6.00 m. However, for treatment 3 (tilled soil), the mean SD was significantly different from those of treatments 1 and 2. The 6.36 m average-spacing distance was considerably more than the desired 6.00 m. Observations in the field showed that the distance-measuring wheel experienced considerable slippage when rolling over the soft tilled soil. Because of the slippage problem, trees of adjacent rows could be out of alignment by as much as 2 to 3 m at the end of a long row. The electronic space indicator was as accurate as when the planter made the decision based on cross-hatching or every 4th row staked.

These 3 methods were more accurate than machine-planting with an assistant determining tree location or having only the first row staked. Traditional methods showed a wide range in spacing variation within the tree row. Visually, a traditional orchard may look planted more precisely because of constant eye compensation to keep adjacent trees in line. While the electronic sensor and indicator does not allow for eye compensation, it may result in an orchard planted more precisely. Additional design and testing are needed to avoid the inconsistent spacing problem when operating on tilled soil.

Table 1. Accuracy of various tree-planting techniques with a mechanical tree planter.

Treatment number	Treatment[z]	Space indicator[y]	Desired spacing (m)	Actual mean spacing (m)	Mean SD
1	Check	Electronic	6.00	6.01	0812 d[x]
2	Established sod	Electronic	6.00	6.02	.0912 d
3	Tilled soil	Electronic	6.00	6.36	.2322 c
4	Cross-hatched	Planter	4.88	4.87	.1945 c
5	4th row staked	Planter	3.00	3.03	.1980 c
6	4th row staked	Asst. planter	4.88	4.88	.3282 b
7	1st row staked	Planter	5.49	5.56	.5167 a

[z]Refer to text for detailed description of treatments.
[y]Planter refers to the person sitting on the tree planter physically planting the tree. Assistant planter refers to a person walking beside the tree planter.
[x]Mean separation, Duncan's multiple range test, 5% level.

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