NEEDLE ELECTRODE DRIVER FOR TREE VIGOR DETERMINATIONS

by B. Allen Dunn and James A. Rowland

Reduced tree vigor can occur from either man-induced impacts, such as construction and trampling, or by naturally occurring disease and insect attack. Various techniques have been developed to measure these losses of vigor, and one of the most recent is the Shigometer.

The Shigometer (Shigo and Shigo, 1974) is a battery operated, field instrument which assesses tree vigor by determining the electrical resistance of bark, cambium, and outer xylem. Needle electrodes are inserted through the bark into the sapwood, and resistance to a pulsed electric current is measured.

Vigorous trees exhibit characteristic readings to a pulsed electric current that differ from stressed or damaged trees. Healthy, dominant trees have lower resistance readings than intermediates, which in turn have lower resistance than those which are suppressed. Also, trees with full, dense crowns have lower resistance readings than those with sparse crowns (Wargo and Skutt, 1975).

Resistance patterns are also present when decay develops in wounded or pathogen infected trees (Tattar and Blanchard, 1977). As wood tissues decay, concentrations of potassium, calcium, manganese, and magnesium cations increase, and as these cation concentrations increase resistance to a pulsed current decreases. The magnitude of the decrease in resistance indicates the degree of tissue deterioration (Shigo and Shigo, 1974).

The electrodes used in resistance measurements are two stainless steel needles embedded in a nylon insulated handle. The needles are inserted by an oscillating action which frequently results in the bending and ultimate breakage of needles.

In order to overcome this problem, a handle driver has been developed to insert and extract the needles. This paper describes construction and operation of the driver. The driver decreases measuring time and eliminates needle breakage.

The Driver

The driver has an overall length of 12.5 inches (31.25 cm) and can be used with 1 or 1.5-inch (2.5 and 3.75 cm) standard needles (Figure 1). Its total weight is 33 ounces (924 grams) with the hammer alone weighing 14.5 ounces (406 grams). The hammer is a sliding weight which is pulled back, then slammed forward, driving the needles into the wood with no bending stress. Figure 2 illustrates driver components, and Table 1 identifies each component part. Figures 3 through 6 illustrate Parts B, C, D, E, and F. To control rust all metal parts should be zinc plated.

The driver can be constructed for approximately $350.00.

A study of the driver's performance found that measuring time and needle bending were reduced and needle breakage eliminated. Insertion methods were compared by conducting penetration tests of 40 hardwood and conifer species. For each species ten tests were made using the conventional insertion method, and ten with the driver. Each test utilized a pair of needles and was made at breast height (135 cm). Needle bending, which was determined by the perpendicular displacement of needles from the face of the probe, was assessed after each test.

Table 2 lists tested species and a comparison of mean time and percent of needle bending for conventional and driver insertion methods. Measuring time was found to have been reduced 51 percent for hardwoods, and by 40 percent for conifers. Utilizing conventional insertion techniques, the needle bending rate was 52 percent for hardwoods and 31 percent for conifers, and the rate of breakage was 1 percent for hardwoods and no breakage occurred for conifers. In driver tests no needles were broken, and the rate of bending was 5 percent for both hardwoods and conifers. No charge in measurement accuracy was found when the driver was used.

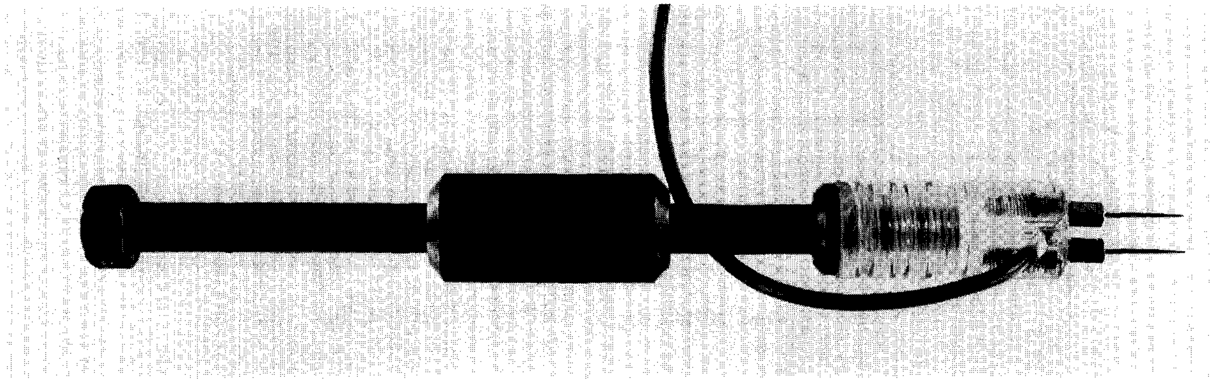

Figure 1. Needle electrode driver.

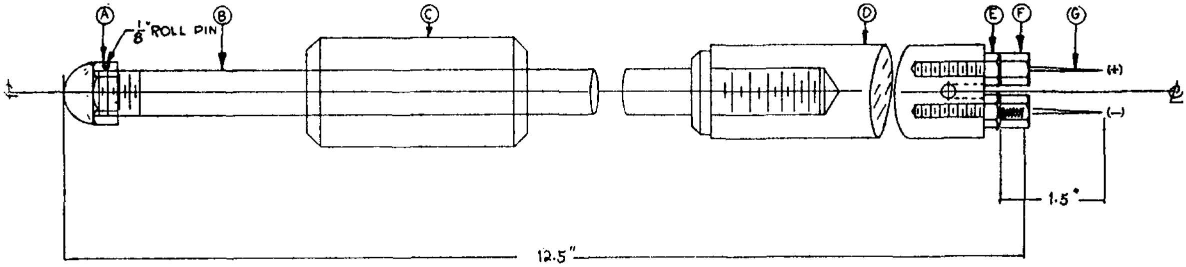

Figure 2. Components of the needle electrode driver.

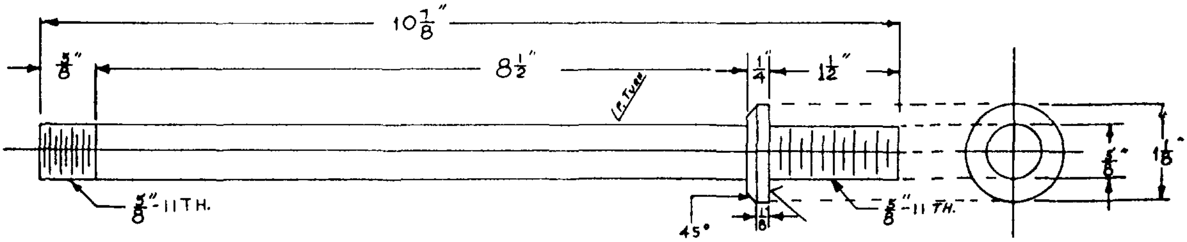

Figure 3. Sliding hammer bar (Part B).

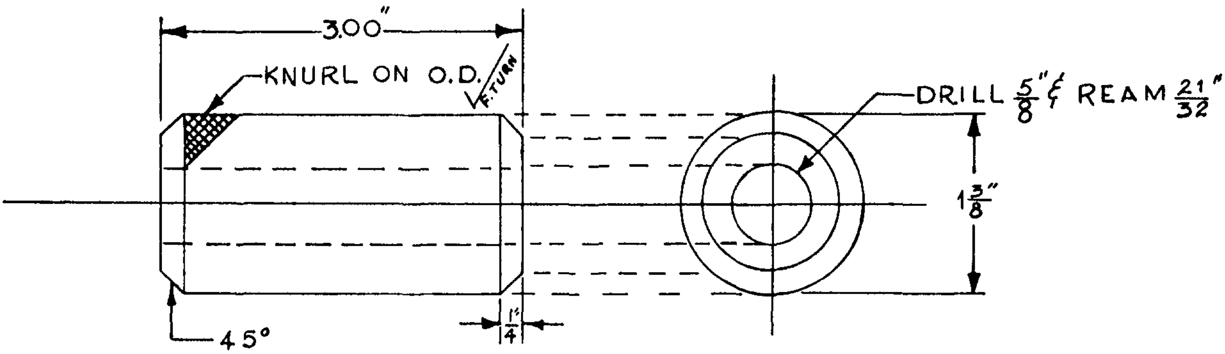

Figure 4. Sliding hammer (Part C).

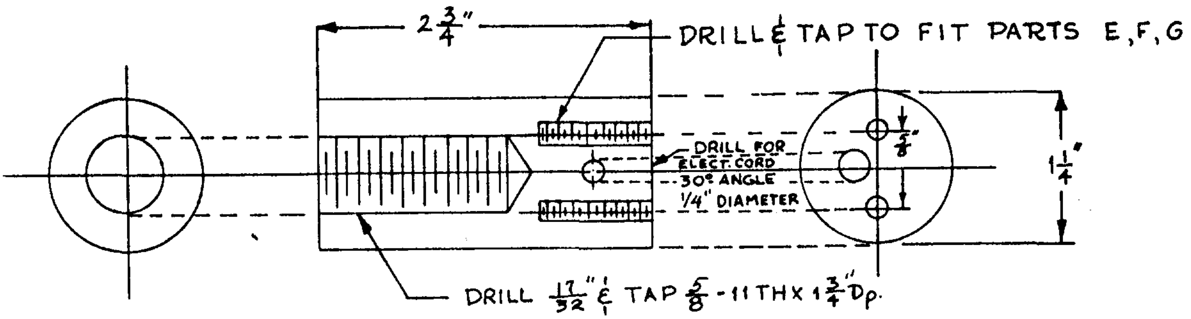

Figure 5. Nylon insulator (Part D).

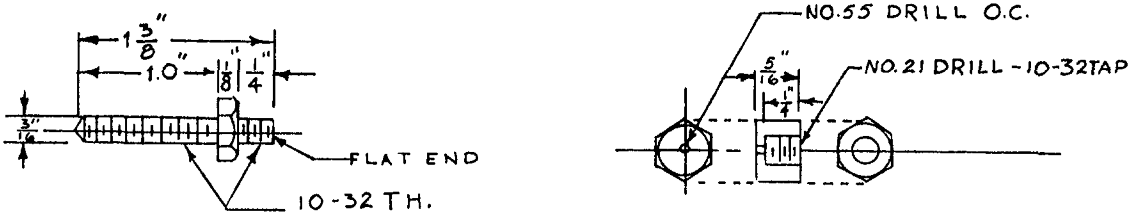

Figure 6. Electrodes crew (Part E) and the electrode holder nut (Part F).

Table 1. Needle electrode driver component list

Component	*Name*	*Material*	*Size*	*No. Reqd.*
A	Acorn nut	Steel	5/8-11 N.C.	1
B	Sliding hammer bar	C1212-Steel round bar	1-1/8 X 12	1
C	Sliding hammer	C1212 Steel round bar	1½ X 3-1/8	1
D	Nylon I insulator	Nylon 6/6, E.P. Grade 275	1¼ X 2¾	1
E	Electrode screw	5/16 HEX-C1212, Steel	3/16 X 1-3/8	2
F	Electrode holder nut	5/16 HEX-C1212, Steel	5/16 X 5/16	2
G	Wire brad electrode	Steel	18 ga X 1½	2
MISC.	Roll pin	Spring steel	1/8 X 7/8	1
	Electric cord		RG 58A/U	4 ft.

Literature Cited

1. Shigo, A. L. and Alex Shigo. 1974. Detection of Discoloration and Decay in Living Trees and Utility Poles. USDA Forest Service Research Paper, NE-294, 11 pp.
2. Tattar, T. A. and R. O. Blanchard. 1977. *Electrical techniques for disease diagnosis.* J. Arboric. 3:21-24.
3. Wargo, P. M. and H. R. Skutt. 1975. *Resistance to pulsed electric current: an indication of stress in forest trees.* Can. J. For. Res. 5:557-561.

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Table 2. Comparison of time and percent bent needles for conventional and driver electrode insertion methods by species.

		Electrode insertion method					
		Conventional		*Driver*		*Differential**	
Scientific name	*Common name*	*Time (Sec)*	*Needles bent (%)*	*Time (Sec)*	*Needles bent (%)*	*Time (Sec)*	*Needles bent (%)*
Hardwoods							
Acer rubrum	Red maple	3.38	52.6	1.20	0.0	2.18	52.6
Betula nigra	River birch	2.84	46.6	1.48	0.0	1.36	46.6
Carya glabra	Pignut hickory	3.73	82.7	1.78	7.5	1.95	75.2
Carya tomentosa	Mockernut hickory	4.68	85.3	2.11	15.1	2.57	70.2
Castanea dentata	American chestnut	1.25	15.0	1.07	0.0	.18	15.0
Catalpa bignonioides	Catalpa	1.40	17.5	.80	5.5	.60	12.0
Celtis occidentalis	Hackberry	3.68	45.2	2.01	0.0	1.67	45.2
Cercis canadensis	Eastern redbud	1.88	22.6	1.48	7.4	.40	15.2
Cornus florida	Dogwood	3.58	82.6	1.47	7.4	2.11	75.2
Fagus grandifolia	American beech	3.02	32.6	1.45	0.0	1.57	32.6
Fraxinus pennsylvanica	Green ash	3.34	78.7	1.40	7.4	1.94	71.3
Ilex opaca	American holly	2.74	45.2	1.72	15.0	1.02	30.2
Juglans nigra	Black walnut	2.25	45.3	1.46	0.0	.79	45.3
Liquidambar styraciflua	Sweetgum	3.08	37.6	1.54	7.6	1.54	30.0
Liriodendron tulipifera	Yellow poplar	2.14	41.0	1.04	2.5	1.10	38.5
Nyssa sylvatica	Black tupelo	2.50	37.5	1.35	7.3	1.15	30.2
Ostrya virginiana	Eastern hophornbeam	3.80	77.7	1.79	5.5	2.01	72.7
Oxydendrum arboreum	Sourwood	2.64	52.6	1.16	7.3	1.48	45.3
Plantanus occidentalis	Sycamore	3.16	45.0	1.66	0.0	1.50	45.0
Populus deltoides	Eastern cottonwood	1.39	27.6	1.07	0.0	.32	27.6
Prunus serotina	Black cherry	2.71	52.6	1.47	0.0	1.24	52.6
Quercus alba	White oak	2.78	65.0	1.10	5.0	1.68	60.0
Quercus coccinea	Scarlet oak	3.59	62.0	1.57	7.1	2.02	54.9
Quercus falcata	Southern red oak	4.89	71.2	1.39	5.2	3.50	66.0
Quercus marilandica	Blackjack oak	2.02	57.6	1.15	7.2	.87	50.4
Quercus nigra	Water oak	3.98	65.2	1.88	15.1	2.10	50.1
Quercus prinus	Chestnut oak	2.26	61.0	1.24	9.8	1.02	51.2
Quercus stellata	Post oak	2.54	52.6	1.14	0.0	1.40	52.6
Quercus velutina	Black oak	4.99	73.1	1.63	12.6	3.36	60.5
Robinia pseudoacacia	Black locust	2.18	42.6	1.47	0.0	.71	42.6
Ulmus americana	American elm	2.20	35.1	.89	0.0	1.31	35.1
Average		2.92	51.9	1.42	5.1	1.50	46.8
Conifers							
Juniperus virginiana	Eastern redcedar	2.11	62.7	1.38	17.5	.73	45.2
Pinus echinata	Shortleaf pine	2.01	32.6	.99	0.0	1.02	32.6
Pinus elliottii	Slash pine	1.52	17.5	.96	0.0	.56	17.5
Pinus palustris	Longleaf pine	2.11	22.6	1.24	7.6	.87	15.0
Pinus strobus	White pine	1.67	27.6	1.26	0.0	.41	27.6
Pinus taeda	Loblolly pine	1.90	31.8	.98	3.2	.92	28.6
Pinus virginiana	Virginia pine	2.33	47.6	1.21	12.5	1.12	35.1
Taxodium distichum	Baldcypress	1.56	25.2	.99	0.0	.57	25.2
Tsuga canadensis	Eastern hemlock	1.87	12.3	1.23	7.0	.64	5.3
Average		1.90	31.1	1.14	5.3	.76	25.7
Overall Average		2.69	47.2	1.36	5.2	1.34	42.1

*Differential is defined as conventional minus driver values.