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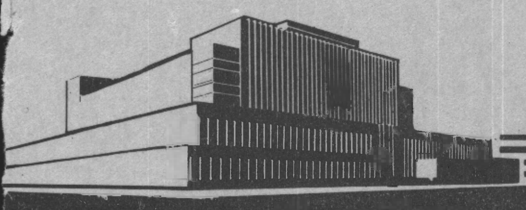

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

METHOD OF DETERMINING SPECIFIC GRAVITY OF WOOD CHIPS

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Summary

A weight-volume method has been developed at the U.S. Forest Products Laboratory for determining the specific gravity of green wood chips. Essentially, the method is based on the weights of a quantity of chips in air and under water. It thus is the same as that used to determine the green or soaked volume of larger wood samples[2] by the buoyancy method.

Introduction

According to Archimedes, an object held submerged in water is buoyed up by a force that is equal to the weight of the water displaced by the object. Since, in the metric system, 1 gram of water occupies 1 cubic centimeter, the buoyancy of an object determined in grams is numerically equivalent to its volume in cubic centimeters. To determine the buoyancy, and thus the volume, of an object, two metric weights are required: (1) the weight of the object in air, and (2) the weight of the object when held submerged in water. If the object tends to sink, its volume (in cubic centimeters) is determined from the difference in the two weights. If the object tends to float, its volume is determined from the sum of the two weights.

The possible sources of error in determining the volume of a green or soaked wood sample by this method are related to the surface area involved. Thus, the weight in air will be affected by any surplus moisture and that in water by any air bubbles adhering to the surface of the sample. When a solid piece of wood is chipped, its overall surface area is increased enormously, and the possibility of obtaining an incorrect value for the overall volume of the chips is therby greatly magnified. The procedure and technique described in this report indicate how these possible sources of error can be kept at a minimum.

Material and Methods

Herbarium bags 5 by 8 inches in size and made of a coarse muslin with a strong woven nylon drawstring at the top are suitable containers for 50-gram samples of air-dry wood chips. The bags when new have a starchy dressing that must first be removed by boiling them in water with soap or detergent. If the starch is not removed, the weight of the bag will decrease during the course of the experiment as the dressing is dissolved out. The bags can be numbered directly with indelible pencil. Half a dozen glass marbles placed in each bag provide the additional weight necessary to ensure that the bag, with or without chips, tends to sink when held submerged in water. These marbles remain in the bag throughout the entire procedure.

To determine the specific gravity of a quantity of chips on the basis of dry weight and green or soaked volume, the following weights must be obtained:

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Heinrichs, J. Frank. Rapid Specific Gravity Determinations. Journal of the Forest Products Research Society, Vol. IV, No. 1, p. 68. 1954.

(1) Weight of the bag when saturated and held submerged in water with marbles.

(2) Weight in air of the saturated bag with marbles.

(3) Weight of the dry bag with marbles.

(4) Weight of the bag and marbles, plus wood chips when saturated and held submerged in water.

(5) Weight in air of the saturated bag and marbles, plus wood chips.

(6) Weight of the dry bag and marbles, plus wood chips.

From these weights the overall specific gravity of the chips is calculated according to the formula for objects that sink:

$$\text{Specific Gravity} = \frac{(6) - (3)}{[(5)-(2)] - [(4)-(1)]}$$

The procedures for steps (4), (5), and (6) are a repetition of the procedures for steps (1), (2), and (3), hence steps (1) and (4), (2) and (5), and (3) and (6) are discussed together. Once the weights for the bags alone have been established (steps (1), (2), and (3)), the bags need not be weighed again.

Steps (1) and (4)

Bags with or without air-dry wood chips are placed in a large vacuum desiccator and weighted down with a perforated plate. For 2 hours, a high vacuum pump is run to evacuate air from the desiccator. By means of a 3-way stopcock, water is introduced into the desiccator while the vacuum is maintained. The desiccator is then attached to a water pump with a mechanism for pressure cycling (fig. 1), and an intermittent vacuum on a 4-minute cycle is pulled on the system for 1 hour to dislodge any air bubbles that might form. The bags are kept submerged in water during transfer to the container in which they will be weighed (fig. 2). The neck of each bag should be opened while submerged and the contents shaken slightly to release any trapped air. The balance is then zeroed and each bag weighed in turn to the nearest 0.1 gram (fig. 2). To maintain the zero point, all bags should be kept in the container until weighing is completed.

Steps (2) and (5)

The bags are taken out of the container, and the bulk of the surplus water is drained off. By means of the drawstrings they are tied to the loops of a centrifuge (fig. 3) and spun at a speed of 325 revolutions per minute, empty ones for 2 minutes and chip-filled bags for 6 minutes, to remove the surplus moisture adhering to the surfaces. Weights are obtained to the nearest 0.1 gram.

Steps (3) and (6)

The bags, empty or full of chips, are dried on a rack in a forced-draft oven at 105° C. for 6 hours and weighed to the nearest 0.1 gram while still hot.

Discussion of Method

The reliability with which the weights can be determined in steps (1) and (4) depends upon the degree to which all air bubbles adhering to the surfaces of the bag and chips can be removed. Stamm[3] has shown that initial evacuation of air from a wood sample prior to immersion in water followed by an intermittent vacuum applied to the surface of the liquid is the most efficient means of saturating wood. The time limits recommended in this paper are based on previous experiments and include an ample safety factor. If the above equipment is not available, the bags, empty or full of chips, can be alternately boiled in water and cooled to remove all air bubbles adhering to them or the chips. This method has been found to give reproducible values but is not generally recommended, since boiling may dissolve out some of the soluble material in the wood and moreover the application of heat may cause additional swelling of the saturated chips.

The reliability with which the weights can be determined in steps (2) and (5) depends upon the degree to which all superficial water is removed from the bag and the chips before weighing. A centrifuge was found to be the most efficient means of uniformly removing excess surface moisture from particles of all sizes. Care must be taken in using the centrifuge not to rotate the samples too fast or too long, since there is always the danger of removing internal moisture from the samples by evaporation. Conversely, by rotating the samples too slowly or for too short a time, there is always the danger that too much moisture will remain on the surfaces.

A speed no greater than 350 revolutions per minute was used because of the difficulty of attaining adequate balance with such a bulky load. The time limits prescribed are based on the pattern of moisture emission from the rotating samples. The rate of emission decreased rapidly at first and then tended to level off at about 1 drop every 2 seconds on a sheet of 4- by 6-inch paper held 2 inches from the periphery of rotation. Because there is no definite point at which the sample remains completely saturated and the surface water only is removed, it was arbitrarily decided to use 350 revolutions per minute and 2 or 6 minutes of rotation. The resulting weights were found to be reproducible within 1 percent. Although the estimated volumes may be slightly over or under the true volumes, they will provide specific gravity values that are comparable.

Steps (3) and (6) do not involve any special problems.

Application of the Method

This technique has been used at the Forest Products Laboratory to evaluate the specific gravity of chips from 4-foot dog boards of southern pine. The particle size was limited to chips retained on 1/8- and 3/16-inch screens. The reproducibility of the technique was determined from three repetitions of steps (4) and (5) for each 50-gram sample of chips. These repeated weights, obtained for 14 different samples, varied up to 1 percent (table 1). Specific gravity values calculated from these repeated weights (table 1) varied from 0.2 to 1.4 percent.

Solid samples from planks 2-1/2 inches thick cut from three of these dog boards provide an estimate of the accuracy of the technique. The specific gravity values obtained for the whole samples were determined by the buoyancy method[2] and are shown in table 2, together with the specific gravity values of samples of chips representing these entire dog boards. Although the specific gravity results obtained in this way cannot be analyzed statistically, the data in table 2 show that they provide reliable estimates of the overall specific gravity of the boards.

[3]Stamm, Alfred J. Diffusion and Penetration Mechanism of Liquids into Wood. Pulp and Paper Magazine of Canada 54 (2):54:63. February 1953.

Table 1.--Means and coefficients of variation for weights of saturated chips in air and when submerged in water together with the specific gravity values calculated from these weights for three replications of each of 14 samples.

Sample No.	Weight in air		Weight in water		Specific gravity	
	Mean	Coefficient of variation	Mean	Coefficient of variation	Mean	Coefficient of variation
	Grams	Percent	Grams	Percent		Percent
1	173.6	0.2	52.0	0.1	0.540	0.4
2	160.0	.1	49.4	0.	.541	.2
3	196.4	.1	52.7	.1	.493	.2
4	189.0	.1	52.9	.2	.498	.3
5	182.1	.2	53.7	.2	.547	.5
6	171.7	.1	51.4	.2	.541	.2
7	159.3	.3	50.6	.1	.557	.5
8	147.5	.4	48.3	.3	.564	.8
9	154.5	1.0	47.6	.2	.539	1.4
10	165.8	1.0	50.6	.1	.542	1.4
11	159.0	.2	47.7	0.	.501	.4
12	172.8	.3	50.9	.2	.501	.5
13	168.9	.3	51.0	.3	.511	.5
14	176.9	.4	51.6	.3	.514	.6

Table 2.--Specific gravity values of solid wood samples and chips from three dog boards.

Dog board number	Solid wood			Chips		
	Sample No.	Specific gravity		Sample No.	Specific gravity	
		Sample	Mean		Sample	Mean
1	1	0.561	0.561	9	0.561	0.561
2	2	.516				
	3	.529		10	.540	
	4	.534	.531	11	.501	.520
	5	.544				
3	6	.521				
	7	.491	.515	12	.512	.512
	8	.533				

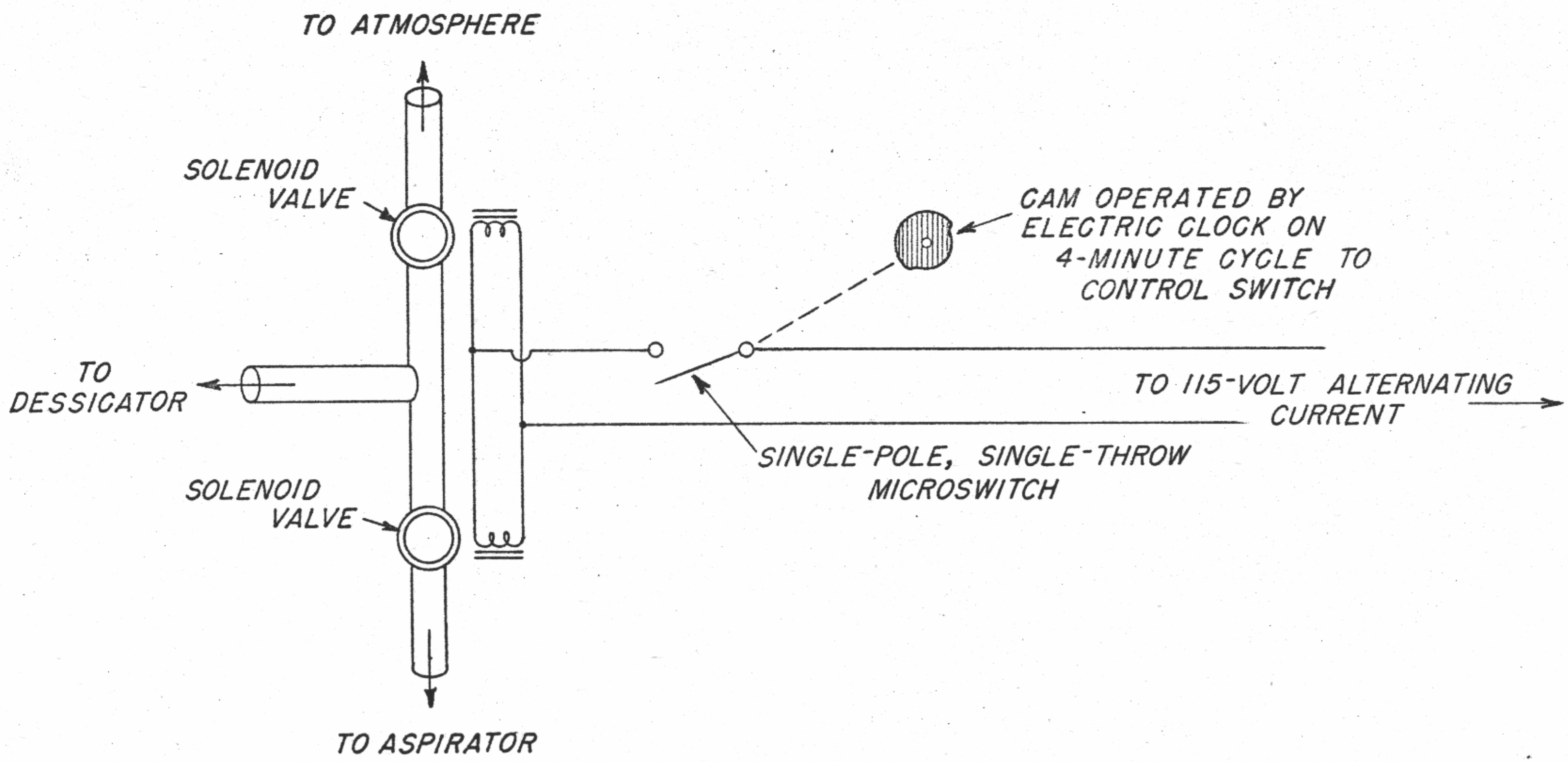

Figure 1. --Mechanism for pressure cycling where one solenoid valve is normally open and the other normally closed. If both values are normally open or both normally closed, a double-pole, single-throw switch is used with the solenoid valves in series.

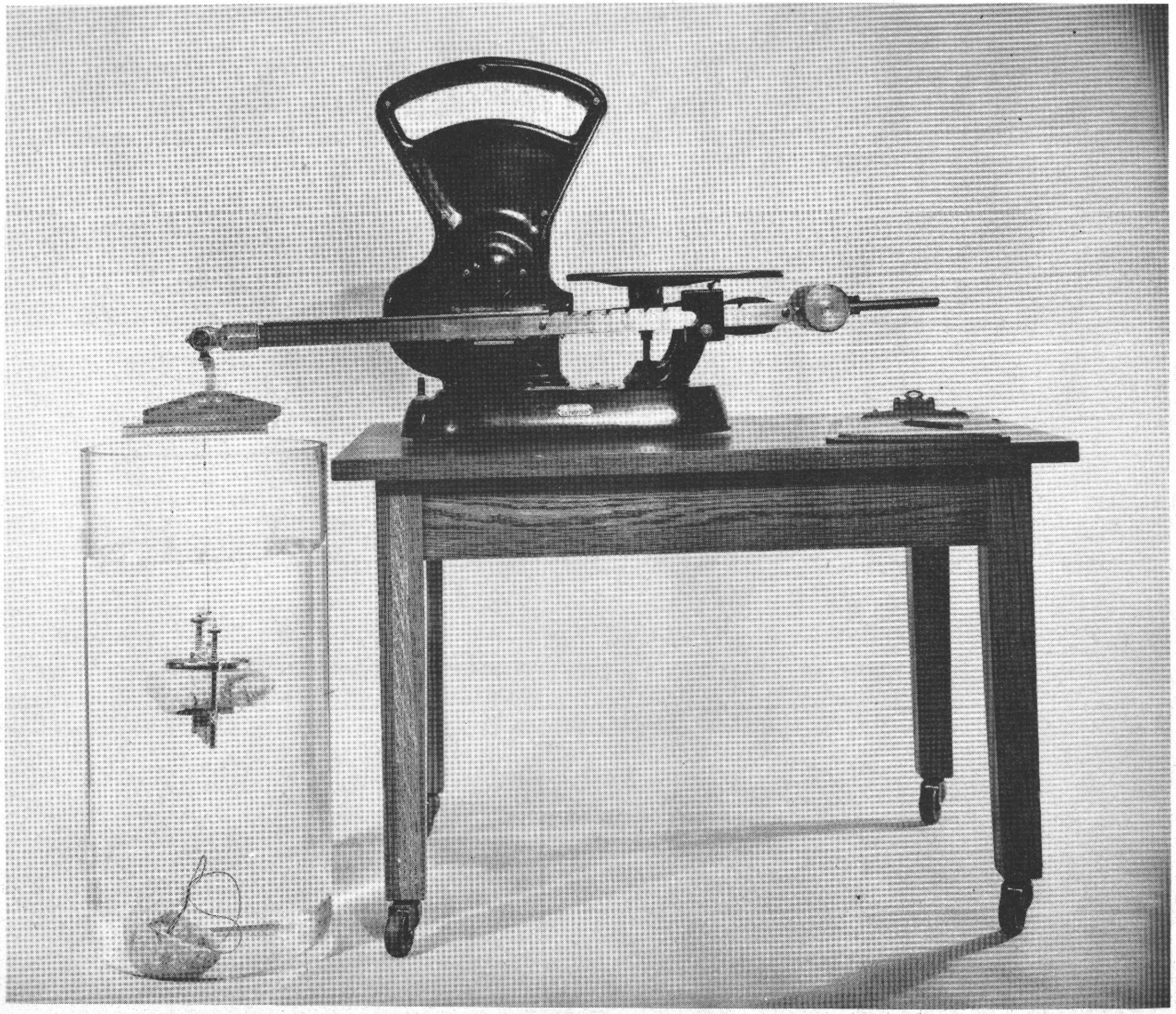

Figure 2. --Balance and container used for obtaining the weight of wood chips submerged in water.

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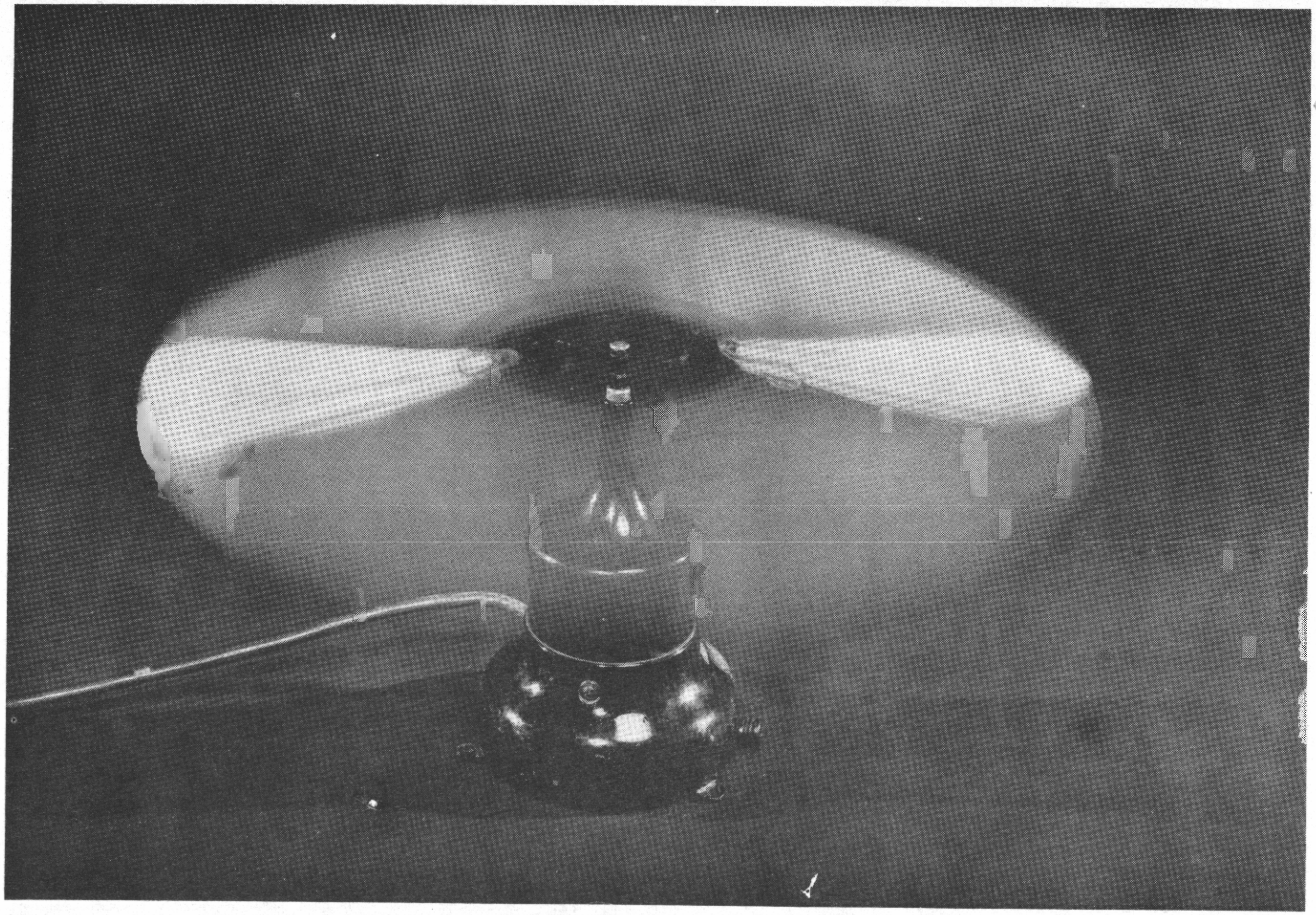

Figure 3. --Centrifuge removing surplus water from bags containing wood chips.

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