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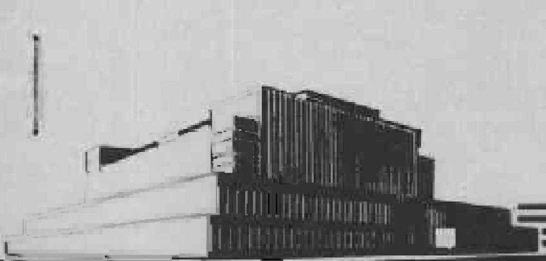
April 1959

No. 2147



FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

USING A RESISTANCE-TYPE WOOD MOISTURE METER TO APPRAISE DECAY HAZARD

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Summary

Moisture content measurements on green white oak specimens dried to various moisture contents were made with a commercial moisture meter of the resistance type. Interpretation of these measurements, coupled with related information gained from field use of the meter, leads to the following principal conclusions: (1) The meter is a valuable tool for ascertaining whether wood has a moisture content above the fiber-saturation level, and thus is subject to decay; (2) meter readings in the range above the fiber saturation point, although quantitatively highly inaccurate, are nevertheless capable of showing whether the general moisture level is comparatively low, intermediate, or high; (3) by driving the contactor points at about the same place each time, the meter can be used to discern small changes in the moisture content of a given zone of wood and, therefore, to indicate changes in decay hazard; and (4) the response of the meter may be more closely correlated with the amount of moisture in a specified volume of wood than with the amount in a given weight of dry wood.

Introduction

Electrical moisture meters generally are designed and used to determine the moisture content of wood in the 7 to 25 percent range. For this they are

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

reasonably accurate and very convenient. For the moisture content range above fiber saturation, however, less attention has been paid to attaining meter accuracy, and great accuracy is not normally required. Only when special utilization problems are involved does accuracy become important enough to warrant examining closely some of the factors influencing the response of a meter in this range.

In dealing with the decay of wood and wood products, it is often important to know the current moisture conditions with respect to decay hazard -- especially, to be able to compare them with subsequent values as quantatively as possible. Decay hazard may exist in buildings, ships, bridges, and other permanent structures where the method of moisture determination must be nondestructive, rapid, and capable of reproducing results that will be reasonably meaningful. A specific need for a great many moisture determinations arose, for example, when it became necessary to find levels of and seasonal changes in the moisture contents of wood members in the crawl spaces of basementless houses. Another extensive application of the measurement of moisture for evidence of decay hazard was made on the wood flight decking of aircraft carriers of the "mothball" fleet.

For limited studies, it is possible to ascertain moisture content by securing increment-borer, or larger, samples of the wood, and ovendrying them. If applicable the most practical device for evaluating wood moisture where large numbers of determinations are involved is the moisture meter. Thus, some exploratory work on the response of the meter at higher moisture contents appears justified. The commercial moisture meters have inherently reliable circuits and construction. Consequently, variable readings obtained with them presumably are attributable mainly to differences associated with the wood rather than with the apparatus.

A study of meter response in wet wood was started in 1943, using a Kaydel Moisture Gauge Type L-4102[2] with a 4-point contactor; the indicated moisture range of this instrument was from 6 to 102 percent. Work was continued intermittently since that time and the principal findings are summarized in this report. It should be emphasized that this was not a critical study of the moisture meter but more of an attempt to interpret some of the responses derived from a series of measurements with an unmodified, commercial instrument made for the particular purpose of learning more about the applicability of the meter for diagnosing decay hazard.

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[2] No longer available, but essentially the same as resistance types currently on the market.

Wood Samples

Since it was felt that the natural occurence of moisture in green samples would eliminate much of the nonuniformity of distribution that characterizes wood that is dried and rewet, material from freshly felled trees was obtained for the study. The species was white oak (Quercus alba).

Sections of trunks about 2 feet long, cut from five trees at Bent Creek Experimental Station, Asheville, N. C., during the week of April 5, 1943, were paraffined at the cut ends and shipped to Madison, Wis.[3] At the Forest Products Laboratory the heartwood of these cross sections was split into billets about 2-1/2 inches square. Approximate locations of the billets, by radial zones, are shown in cross section in figure 1.

For further handling, the billets were planed down to 2 by 2 inches in cross section. Three inches were then removed from each end of the billets and as many 6-inch samples as possible were cut from the remainder. The ends of the samples were promptly paraffined to retard drying. Each 6-inch piece was next divided by a line into two parts each 3 inches long, which were numbered so that they could be identified according to billet and position in the billet. The samples were then stored at 80° F. and 65 percent relative humidity until various approximate moisture levels were attained.

Making Moisture Meter Readings

In order to have a suitable distribution and range of moisture contents, samples were selected for desired moisture levels during the course of drying on the basis of their weight and an exploratory reading with the moisture meter. Each sample was then cut into two 3-inch specimens, which had previously been marked out and labeled. The succeeding manipulation of the specimens was as illustrated in figure 2. A 13/16-inch slab was sawed off the tangential face of one specimen, the contactor centered on this newly exposed face, and a meter reading taken. Immediately, another slab, 5/16 by 5/8 by 5/16 inches (thickness), was sawed out and weighed to two decimal places. This slab occupied exactly the zone of wood delineated by the spacing of the contactor needles and the depth of wood penetrated by them. The other 3-inch specimen of the pair was dealt with in the same way except that the slabs were removed from a radial instead of a tangential face. Samples or faces with obvious defects such as knots and checks were not used.

[3] The sections were provided by Dr. George Hepting and associates of the Southeastern Forest Experiment Station.

Observations

Response of the Meter to Differences in Ovendry Moisture Content

When ovendry moisture contents of classified specimens from one of the trees were plotted against meter readings onthe same specimens, the result was as illustrated in figure 3. The relations shown are typical of those indicated in previous, exploratory observations. A correlation between the moisture determinations made in the two ways is clearly evident, but it is also apparent that the variation in meter readings was large, especially with the larger moisture contents. This, of course, is in line with the background of general experience that has discouraged the use of the meter for appraising moistures above the fiber-saturation point.

From the point of view of wood pathologists, however, the diagram reveals elements of usefulness. The meter apparently will rarely fail to indicate wood with a moisture content greater than 30 percent -- the nominal fiber saturation point and widely regarded as the lower limit of dangerous wetness -- by reading 30 percent or more. Also, it apparently would not often read "wet" if the ovendry moisture content is 25 to 30 percent or less. Moreover, it appears from the diagram that even though the meter reading may be too variable to denote with acceptable quantitative precision the moisture content of wet wood, it can show whether the general moisture level is comparatively low, intermediate, or high. This information is often sufficient.

The foregoing expectations have actually been experienced in moisture sampling of buildings and Douglas-fir ship decks. In the latter, for example, a comparison of a sizeable number of resistance-type meter readings with the ovendry moistures of 5/8-inch plugs extracted from the same deck positions as were checked by the meter showed that the readings were rarely less than 30 percent where the true wood moisture was 30 percent or more. If anything, there was a tendency for the meter to sometime indicate wet wood when the moisture content did not exceed 30 percent. This was observed with about 17 percent of the "wet" readings, though in such cases the meter values typically were not far above 30. A moderate error in this direction can be tolerated, whereas a similar error in the opposite direction -- tending to conceal wet wood -- would be serious.

It also was brought out in the field investigations, though not looked for in the laboratory study, that the meter is sensitive to small differences in moisture provided the differences are measured at the same place or nearly so. This may seem strange in view of the variability of readings depicted in figure 3. The explanation lies in the fact that by keeping to about the same position with the contactor, moisture becomes the most significant variable affecting the meter. Thus the meter can be very useful for answering questions about decay hazard not only by indicating whether the wood is wet enough for decay -- and if so what the general moisture level may be -- but also by indicating the magnitude and direction of changes in moisture that occur over a period of time. Such information is of particular interest when measures have been instituted to correct an adverse moisture condition.

Response of Meter to Differences in Moisture Content Per Unit Volume of Wood

One of the more interesting and perhaps potentially useful findings in the laboratory study on green oak specimens was a markedly better correlation between meter reading and moisture content if the latter is expressed in terms of amount of water per unit volume rather than unit weight of wood. The evidence of this is given in the diagrams of figures 4 and 5. These data suggest that the electrical resistance of wood with free moisture is determined largely by the absolute amount of water between electrodes. From this it would follow that how the water is distributed between the cell walls and cell cavities does not make a great deal of difference in the meter reading. In making these comparisons, volumes were measured in a Breuil-Mercury Volume Meter, Type VM.

The moisture meter could, of course, be calibrated to read directly in terms of some weight of water per specified volume of wood. The advantage of reading in such terms would seem to be largely for ascertaining total weights or volumes of water in a given wood member or structure. This kind of information could be useful in estimating the duration of decay hazard, especially where the volume of wood can be more readily or accurately appraised than the weight (a knowledge of the wood density would, of course, be necessary in order to compute absolute amounts of water from conventional meter readings). It is unlikely, however, that readings in terms of unit volume would be helpful in deciding simply whether or not a given item of wood is wet enough to decay. That is because the lower moisture limit for important decay is determined by the amount of water in relation to the weight of the wood, which, as already noted, is normally about 30 percent of the ovendry weight.

Sources of Error in Meter Readings

The error in meter readings such as revealed by figure 1 is attributable to a number of factors. The basic trouble is that in wet wood differences in electrical conductivity created by variable moisture are not especially large compared with differences arising from other factors. One of the more influential of these other factors seemed to be the density of the wood. But the influence of density apparently may be more a reflection of the manner of expressing the true moisture content than anything real. For if we eliminate the weight (or density) of the wood from the expression of its moisture content the unexplainable variation of meter readings is, as already noted in figure 4, materially reduced.

Other extraneous factors that seemed to be tied in, in some degree, with variation in meter readings were radial position of the wood in the trunk (located by zones as illustrated in figure 1), contact of the electrodes through radial versus tangential faces of the specimens, and the number of growth rings per inch.

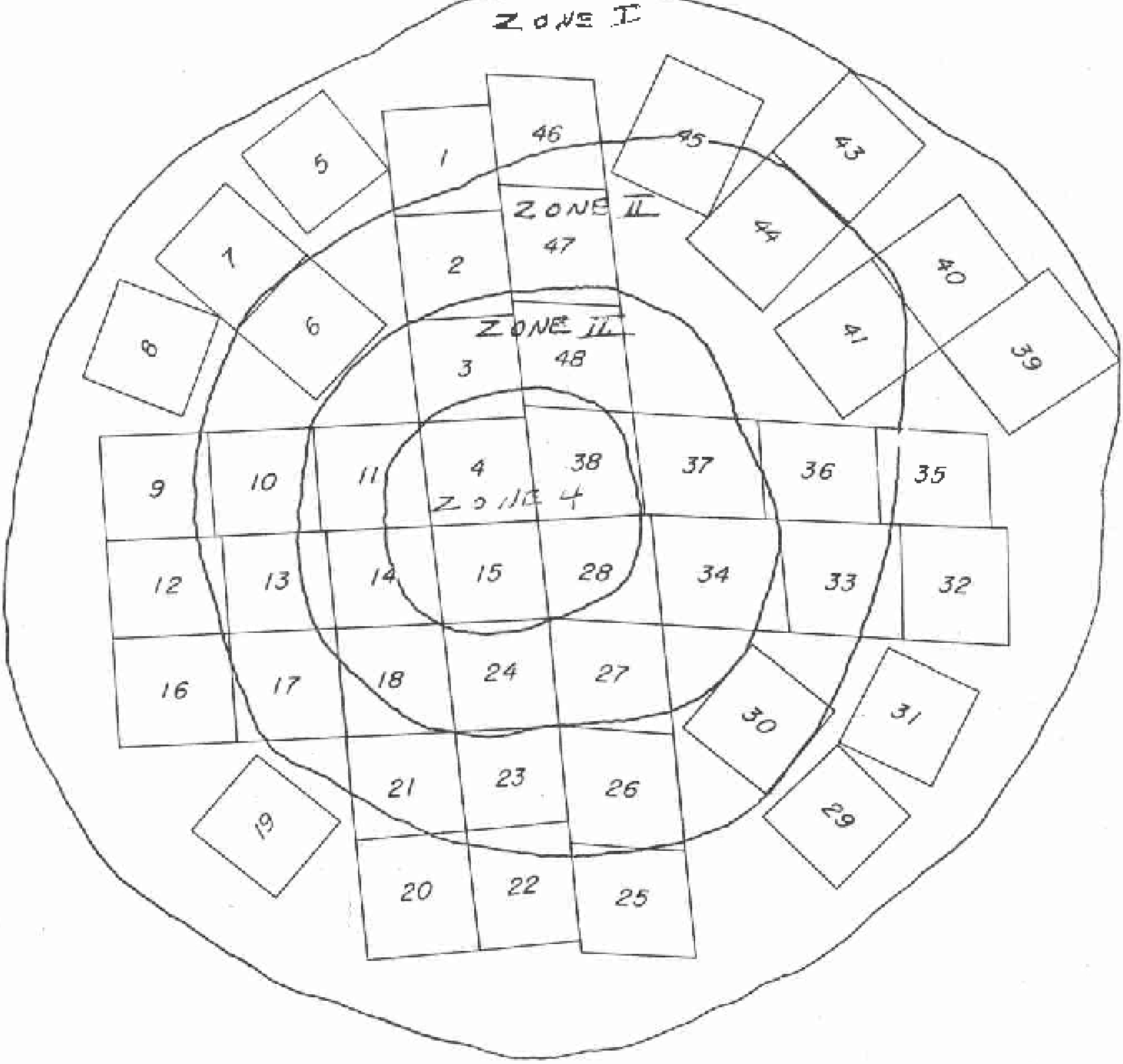

Figure 1. --Manner of recording the location of billets in the tree cross section.

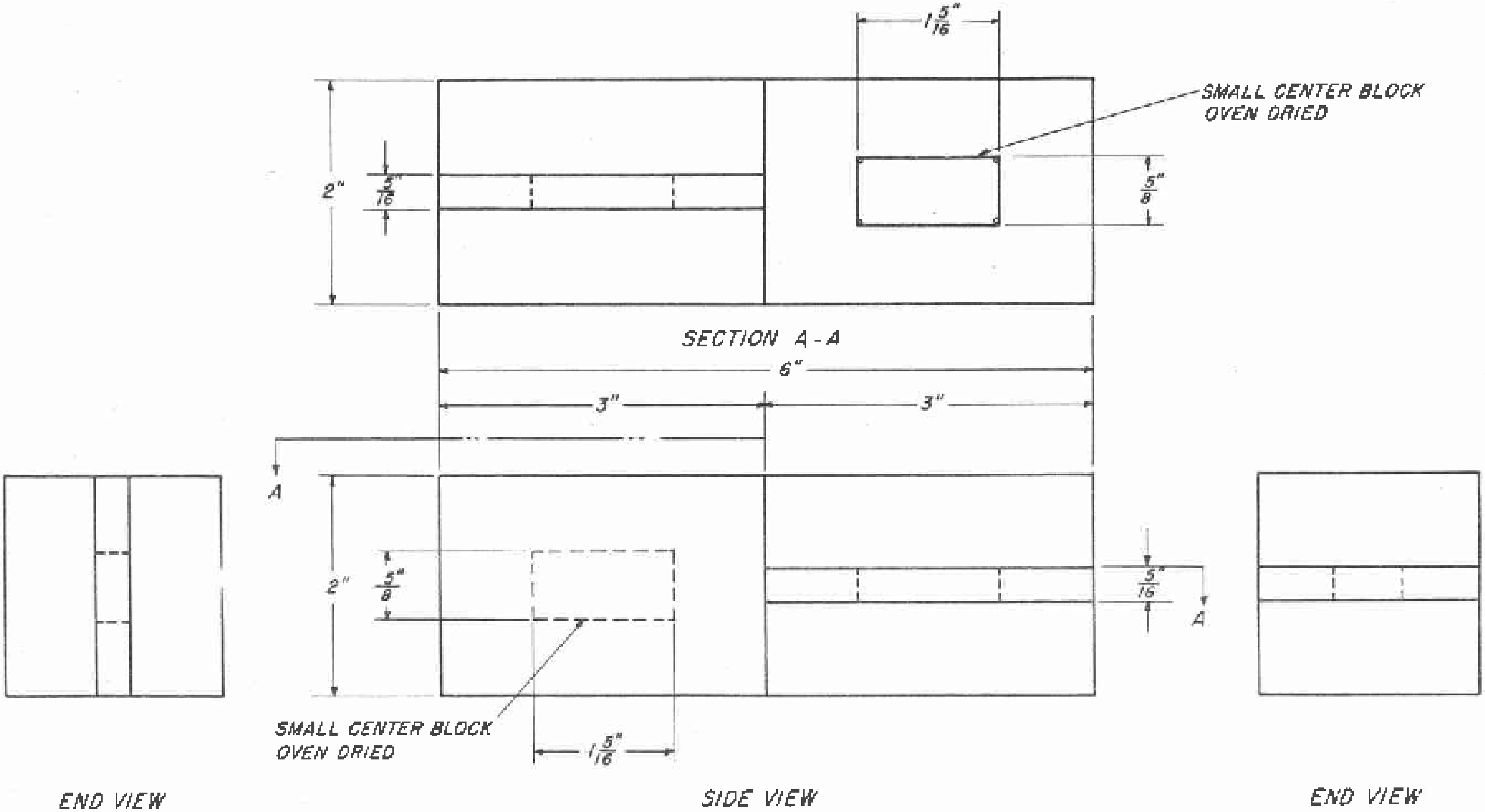

Figure 2. --Location of small center blocks used for moisture determinations.

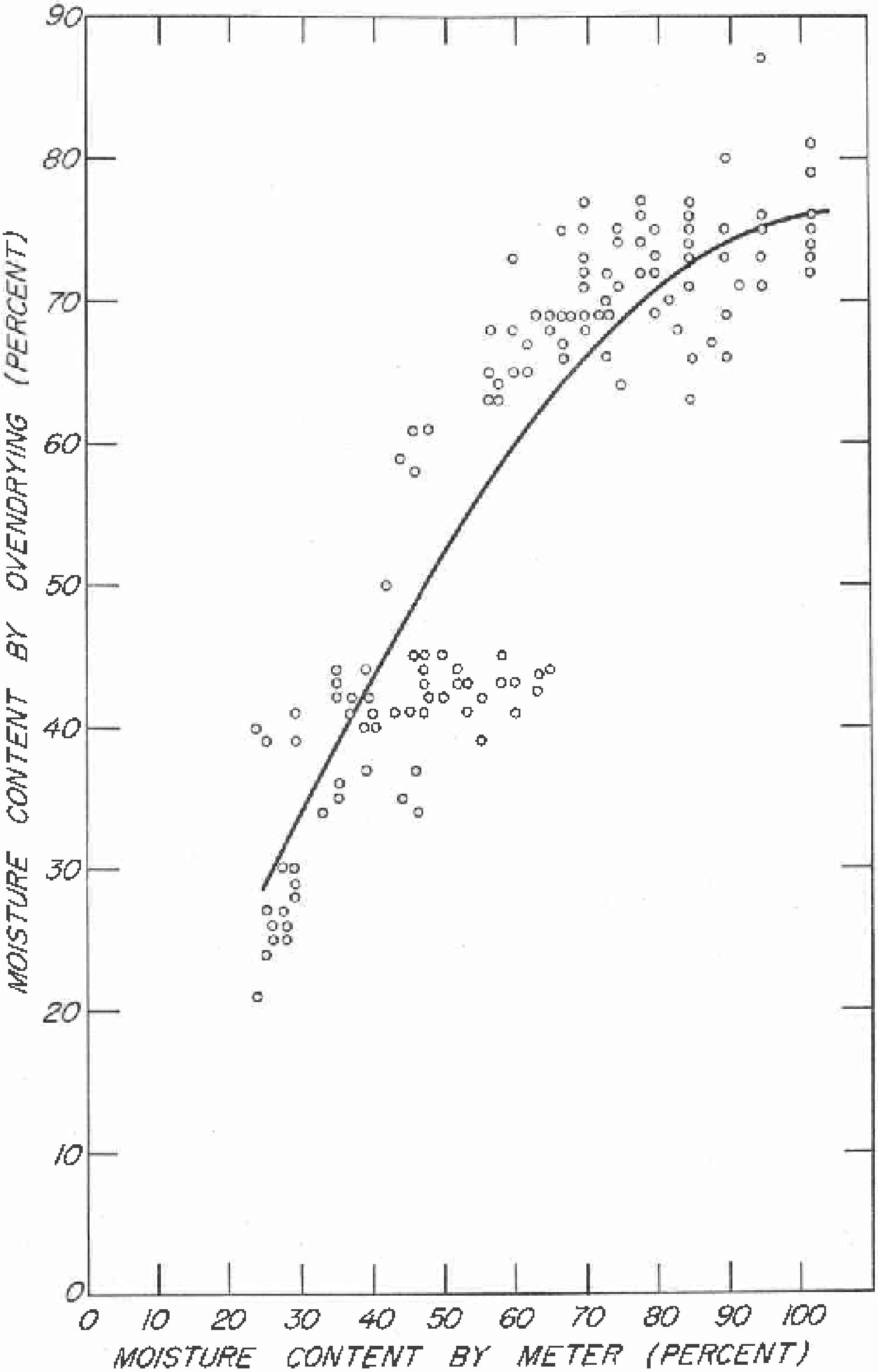

Figure 3. --Percentage moisture content, as determined by ovendrying of unclassified white oak specimens, versus moisture meter readings.

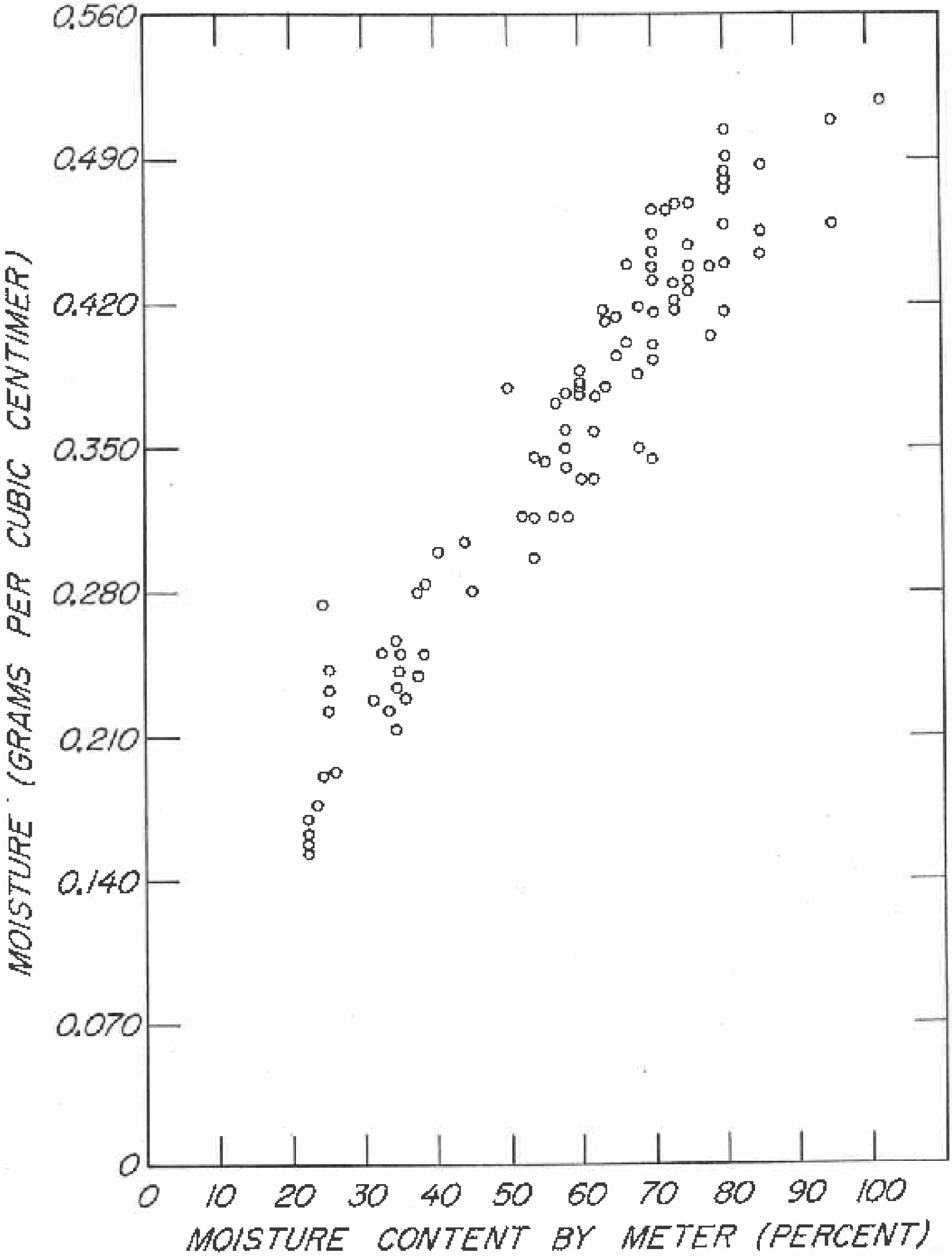

Figure 4. --Plot of moisture content per unit of volume of white oak, as determined by ovendrying against moisture meter readings.

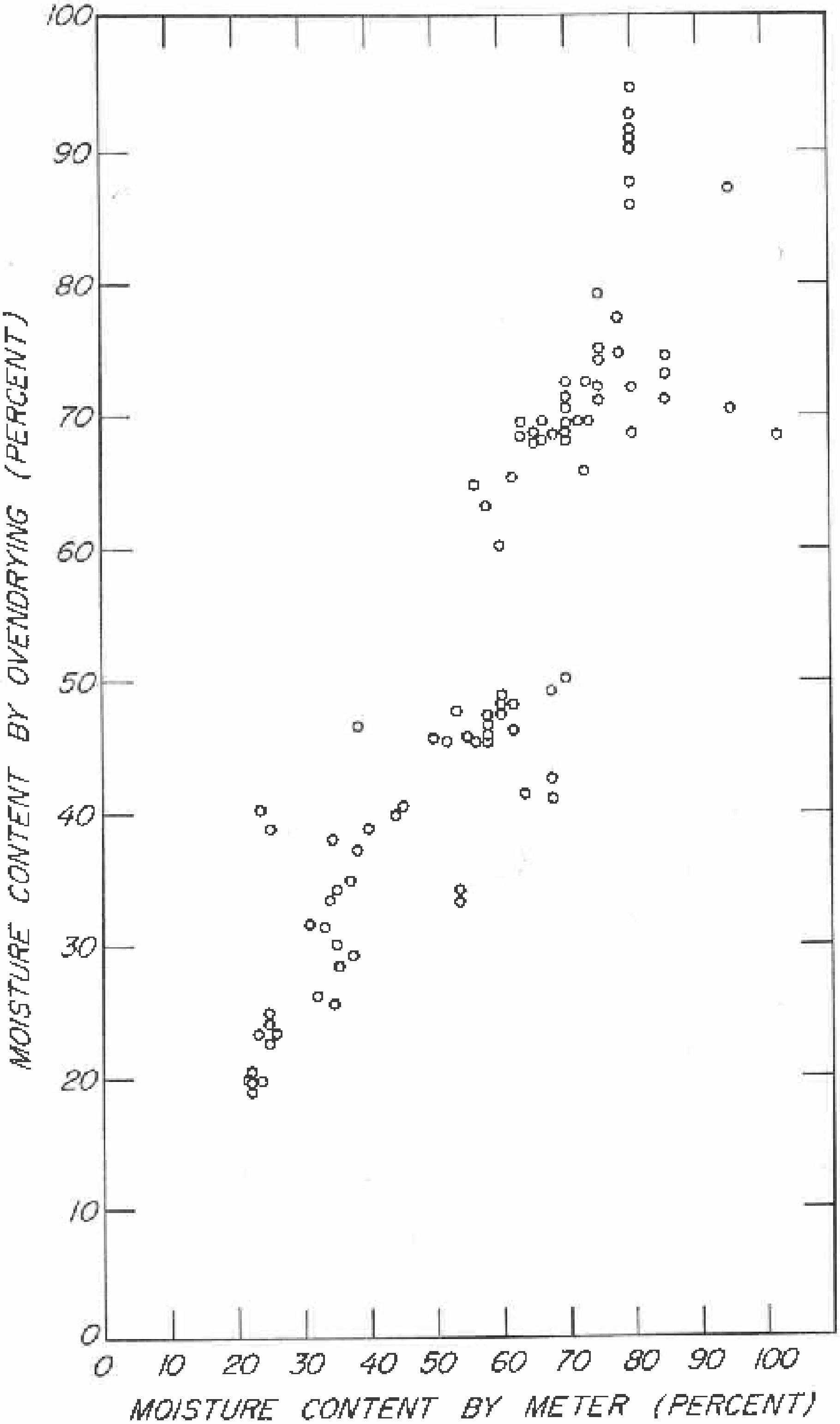

Figure 5. --Plot of percentage moisture content, as determined by ovendrying of white oak (same specimens as represented in figure 4) against moisture meter readings.

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