The Duff Hygrometer
as an Aid to Fire Weather Research.

By
H.W. Beall.

The problem of accurately determining and predicting, by a study of the weather conditions, the degree of fire hazard which exists at any given time is one that has received an increasing amount of attention from foresters and meteorologists during the past three or four years. The relationship existing between the relative humidity of the air and the occurrence of forest fires has long been noted, particularly in the western States, and considerable research work has been carried out along these lines in both the United States and Canada. It has been found, however, that atmospheric humidity alone is, at best, a somewhat uncertain indication of fire-hazard, and in recent years attempts have been made to measure the moisture content of forest materials under varying weather conditions, and to interpret this moisture content in terms of inflammability.

Undoubtedly, the majority of forest fires which are caused by human agencies originate in the duff, and, in consequence, particular attention has been devoted to this material. It has been satisfactorily determined that, when the uppermost layer of duff contains more than 25 per cent moisture (by weight), the danger of ignition and spread of fire is non-existent. As the duff moisture content decreases from this point, the fire hazard proportionately increases; thus, from 25 per cent to about 18 per cent, the hazard, while very low, is increasing. Duff moisture contents between 0 per cent and about 7 per cent indicate extreme fire-hazard.

The problem of interpreting duff moisture content in terms of inflammability has thus been quite accurately settled, but the actual measuring of the moisture content has proved rather a more difficult task. Several instruments have been devised for this purpose, but the duff hygrometer, the invention of an officer of the United States Forest Products Laboratories, appears to be the most satisfactory device yet produced. During the past summer, three duff hygrometers were in operation at the Dominion Forest Experiment Station on the Petawawa Reserve at Chalk River, Ontario, and a brief summary of the results obtained with them is contained herein.

It might, perhaps, be as well to give a short description of the hygrometer itself. The "movement", or actuating part of the instrument consists of a strip of rattan about twelve inches long and 1/10 inch in diameter which expands when subjected to moisture, and contracts when dried. This strip is enclosed in a perforated nickel tube, pointed at one end, to which end the rattan is attached. The free end of the rattan is fastened to an indicating arm, which moves over a dial, and the indicator and dial are, in turn, enclosed in a metal case with hinged lid, to keep out rain and insects. In operation, the tube is inserted horizontally just under the top layer of duff. The dial is calibrated to read in both per cent moisture content and inflammability, and it is, of course, essential to the operation of the instrument that this should be as accurately done as possible. In the case of the instruments in question, the calibration was performed from samples of the duff in which they were to be inserted, in the Physical Testing Laboratories, Topographical Survey, Department of the Interior, Ottawa.

In the field, representative hardwood, mixedwood, and softwood stands were selected, in which the respective hygrometers were placed. A depth of about one quarter inch below the surface of the duff was first tried, but this was soon found to give erroneously high fire hazard readings after three or four consecutive days of dry weather. (For the purpose of checking the instruments fire tests were frequently made by placing lighted matches on the duff, and noting the extent and rapidity of the combustion). It was thus seen that, in order to obtain satisfactory results, an accurate adjustment of the depth would be necessary. Unfortunately, owing to the uniformly wet weather which prevailed throughout the season, it was found impossible to check the hygrometers for the higher fire hazards. For low inflammabilities, however, a depth of one inch appeared to be entirely suitable for the softwood hygrometer. The other two instruments registered 'no inflammability' throughout almost the entire season, so that little information could be obtained concerning them. The probability is that they should be placed slightly nearer the surface.

In any event, the readings of the duff hygrometer at the high fire hazards, where its usefulness is greatest, can be depended upon only when the instrument has been checked by actual fire tests under just such conditions. The dial requires re-calibration at the end of each year, as the characteristics of the rattan strip are gradually changed by constant expansion and contraction. Further, a certain

irregularity in returning from a high humidity reading to a lower one has been noticed, probably due to the fact that the outer layer of the rattan dries out more rapidly than the core. Again, the rattan reaches its maximum point of saturation when the duff humidity is about 45 per cent, and consequently the indicator never rises above this reading, though the moisture content of the duff frequently exceeds 200 per cent.

In favour of the duff hygrometer, it may be said that the instrument is compact, strong, and not unduly subject to mechanical faults. (No difficulties of this nature were experienced during the entire season, with the exception of the inherent defects of the rattan, mentioned above). Provided that the instrument has been properly calibrated and placed at the correct depth, it may be expected to give fairly accurate results, under most conditions, for all duff moisture contents at which fire hazard is present. Recently, however, investigations have been made towards the perfection of an instrument which would measure duff moisture content directly by weight, rather than indirectly by the relative humidity of the air within the duff, as is the case with the duff hygrometer. Such an instrument should eliminate many of the defects of the latter.

The main purpose of the studies conducted at the Petawawa Reserve has been to ascertain the rate of drying of the forest litter under varying conditions of precipitation, temperature, wind, and relative humidity. When the precise effect of the varying meteorological conditions upon those materials in the forest in which fires start or spread is better understood, forest authorities will be in a better position to intelligently interpret and apply weather forecasts supplied by the Weather Bureau. Fire weather research is, indeed, a virtually unexplored field, but, with the increasing interest that is everywhere being manifested in this important phase of forest work, very definite progress may be expected within the next few years.