minations are to be found in *Bulletin* No. 18, while the tannin in the bark of a few of the most promising trees is found in *Bulletin* No. 24.

A *Bulletin* shortly to be published is to give the deflections under various loads of the woods tested in this manner, and the weight under which they failed, together with the force necessary to crush in the direction of the fibre pieces, whose length was equal to eight diameters. In addition to the tables published in the *Bulletins*, the final report will give the force necessary to indent the wood.

This series of tests is felt to be incomplete in many ways, and with the experience that has been gained in the work could doubtless be improved. A brief description of the methods used may be of interest.

Each specimen as soon as received was given a number, and this number has been constantly repeated in all the work done on that specimen, it is designated in the report as the office number, and wherever met with always refers to the same tree.

After numbering, the sticks were at once sawed into bars five centimeters square. These pieces were then seasoned by air-drying. During the first winter they were kept in a room warmed by a stove to about 70° F. After that they were removed to a timber-loft at Watertown Arsenal, where they were kept until they were dressed for the final tests.

Two blocks of fifteen centimeters in length were taken from each specimen and dried rapidly with steam-heat until they had lost most of their moisture. From these pieces blocks of exactly 11 centimeters in length and about thirty-five millimeters square, were dressed out. These were then placed in an oven which was maintained at a constant temperature of 100° until the blocks were perfectly dry. After they had ceased to lose weight, they were carefully measured with a micrometer caliper and then weighed. From the measurement and weight it was easy to calculate the specific gravity.

The ends removed from these blocks were used for determining the ash. They weighed from 10 to 20 grammes and thus gave quite appreciable amounts of ashes. The ash was determined by drying the wood in the same manner as the specific gravity blocks, then carefully burning in a platinum dish in a muffle-furnace heated by gas. The heat was so regulated as to burn the ash perfectly white without melting it. In most cases the ash was left in the exact shape that it occupied in the wood. It was judged best to report the ash exactly as found, and not to attempt to make any correction, on account of carbon dioxide that might have been lost from the calcic carbonate present.

From these results, the approximate fuel-value was calculated, assuming that equal weights of all woods have the same fuel-value. This value is supposed to be given more correctly by taking as the weight of the wood, not the specific gravity, but the weight of a cubic decimeter, minus the ash contained in it. The ash evidently adds nothing to the fuel-value, while it does add to the weight. This assumption, which is the one which is generally made, is not strictly true, but it is near enough for all practical purposes. It is founded on experiments made by Count Rumford and Marcus Bull.

The carbon and hydrogen determinations were made by burning fine sawdust in a platinum boat in a current of oxygen and collecting the products in the usual way. These analyses were calculated on the dry wood. The determinations may be conveniently divided into two classes—those of the coniferous woods and the non-coniferous.

The coniferous woods examined, with two exceptions, gave larger amounts of carbon than the hard woods. These two exceptions were the common white cedar or *arbor vitæ* of the north, and the black spruce or *picea alba*, neither of which would be selected as valuable fuel. The average composition of twenty-nine specimen of coniferous woods examined was carbon, 53.21; hydrogen, 6.45; ash, .32; specific gravity, .5624. Fuel-value by weight, 4488.3; by volume, 2524.2.

For the non-coniferous woods the average results were carbon, 49.53; hydrogen, 6 33; Ash, .66; specific gravity, .6951. Fuel values by weight, 3993.9; by volume, 2776.1. These latter values agree very closely with those given in the books, as the results of the analyses of European woods. It is rather singular that with the exception of fir, no coniferous woods have been reported on in Europe.

Forty-one determinations of non-coniferous woods were made. After the long sticks of wood had become thoroughly seasoned they were dressed out to the exact size of four centimeters square, and were sawed as near as possible to the length of 11 decimeters. They were then tested on the Watertown machine. In testing, the stick was placed in a perpendicular position resting on supports that were exactly one meter apart. The force was then applied at the centre of the length by means of an iron bearing, which had a length a little greater than the width of the stick and a radius of 12.5 millimeters. The weights were slowly applied, 50 kilograms at a time, after each weight was added, the deflection was noted. After 200 kilograms had been added, the weights were removed and the set read; the weights were again applied, the reading again taken at 200 kilograms, and then at every 50 kilograms until the stick was broken, the breaking weight being noted. In making the *report, the coefficients of elasticity for the weights, 50 and 100,* have been calculated; also the modulus of rupture.

So far I can only give the most general results in regard to these tests. In the first place we have not been able to establish any general law in regard to the direction in which a stick is the strongest, that is, parallel or perpendicular to the annual rings.

The results have shown, however, that it is by no means necessary to break two sticks to show which is the strongest, provided they are of the same kind of wood. The weak stick will show the largest deflections from the start. The strongest stick found was a specimen of locust, but following closely after it were specimens of hickory and southern pine. Ash was found to stand well up to a certain point, and then it gave away suddenly and without warning, generally shattering badly. The California red-wood was another that shattered very much. White oak was found to be inferior in strength to several other oaks, and to Southern pine, the average breaking weight of 40 specimens being 386 kilograms, while the average breaking weight of 8 specimens of *quercus prinoides* or the cow oak of the South was 528 kilograms.

The average of 27 specimens of *pinus australis* was 490 kilograms. The average of 36 specimens of the Douglas fir from the Pacific coast was 374 kilograms, and of six specimens of the Western larch was 523 kilograms.

13 specimens of white pine (*pinus strobus*) gave 274 kilograms.

11 specimens of beech gave an average of 454 kilograms.

16 specimens of *carya sulcata* averaged 464 kilograms.

20 specimens of *carya alba* averaged 512 kilograms.

24 specimens of white ash averaged 378 kilograms.

8 specimens of locust averaged 513 kilograms.

The next series of tests which were made, consisted in taking specimens of the same size, square as before, and 32 centimeter long, and compressing them in the direction of their fibres. Here again both locust and the Southern pine stood up well.

9 specimen of locust stood an average weight of 11,206 kilograms.

5 specimens of the Western larch stood an average of 10,660 kilograms.

35 specimens of white oak stood an average of 8183 kilograms.

24 specimens of *pinus australis* stood an average of 10,498 kilograms.

The third series of tests was to find the force necessary to indent the wood at right angles to the grain. These tests are not finished yet, and I have made no examination of the results.

They are made on blocks 4 centimeters square and 16 centimeters long, the bearing of such a size that it makes an impression on the block which extends from side to side of the block and is the same length; or, in other words, is 4 centimeters square.

In closing this paper I wish to express my thanks to Col. Laidley for valuable suggestions made during the progress of the work, and to Mr. Howard for the able manner in which he has executed the tests. These tests have been made at the joint expense of the War Department and the Census Bureau, the machine having been put at our service by order of the Secretary of War.

The tests will all probably be published in the annual report of the testing machine, calculated in feet and pounds.

DISCOVERY OF A PLANET.—Another small planet (No. 233) was discovered by M. Borrelly at Marseilles on May the 11th, and observed by M. Bigourdan at the Paris Observatory on the following night. It was of the eleventh magnitude.