THE MICROSCOPE IN ENGINEERING WORK.

By ROBERT GRIMSHAW.[A paper read at the Stated Meeting of the Franklin Institute, June 21, 1882.]

The specimens shown are intended to outline a method of using the microscope as an aid to the testing machine in estimating the value of structural materials.

While it is not intended to suggest that the microscope will determine definitely the elastic limit, nor even the breaking strain of structural materials, it is designed to convey very distinctly the idea that the microscope may be used for preliminary investigations which will determine whether or not the material is good enough to warrant its being tried on the testing machine. If the microscope condemns the material, it is not worth while going to the expense of having it tested by more expensive methods. If the microscope fail to reveal any flaw, then the material may be sent to the testing machine to be further proved. The larger the specimens that would be required for testing in the machine, the more marked the advantages of the microscope in saving, in the case of specimens readily determined to be bad, the expense of further testing, and the risk of using it in construction. The samples shown this evening are of bridge timbers, and the lesson they are intended to convey is that had this method of examination been followed, the material which was proved to be faulty after being built into the bridge, would have been promptly thrown out.

The samples shown were photographed by Mr. W. E. Partridge of New York, a professional engineer who is an enthusiastic amateur photographer, and to whom I am indebted for the particulars concerning them.

"The timber from which the poor specimens were taken came in the form of a chip broken off when a highway bridge was wrecked in 1879-80. The timber formed a portion of the sill of a draw-bridge, which consisted of two twelve-inch sticks, lying one on the other. The turn-table casting having been somewhat too small, this twenty-four-inch timber had to support one of the A frames of the bridge at a distance of twelve inches outside of the bed-plate. After a few days of service, while an empty truck was passing over, the strain became so

great that the A frame sheared the twenty-four inch sill, wrecking the whole bridge. The timber was so exceedingly poor that upon mounting it on the microscope the porous and weak nature of its structure was at once discovered. Its annular rings are something like three times the distance apart which would be found in a piece of thoroughly good wood of a similar character. The medullary rays are few in number and short in length, while in good wood they are of considerable length, and so numerous that the tangential sections appear like a series of tubes seen endwise or a number of parallel chains. After once seeing and comparing two samples of wood it is very easy to recognize their characteristic features by the use of a pocket magnifying glass."

The trunks and limbs of exogenous trees are built up of concentric rings or layers of woody fibre, which are held together by radial plates acting like the trenails of a wooden vessel, or the "bonds" in a brick or stone wall. The rings or layers, representing successive years' growths, are composed of tubes, the interstices between which are also filled with cellulose. The slower the growth of a tree, the thinner these yearly layers, and the denser and harder the wood,—other things being equal. This is true as between one kind of tree and another, and also as between different individuals of the same kind.

Not only is the closeness of the growth an indication of the hardness and strength of the timber, but the size, frequency, and regularity of distribution of the radial plates which bind the layers together may be taken as a very close illustration or sign of the character of the wood and its ability to resist strain, especially that from crushing stress.

The micro-photographs of the sections of good and bad timber show that in the strong specimens the concentric rings are close in texture and of slight width; and the radial plates frequent, wide, long, and thick, while in the poor material, the reverse characteristics are shown.

The lesson to be learned from these micro-photographs is that having proper views of transverse and radial lengthwise sections, and of sections perpendicular to a radius, of a standard piece of timber resisting certain standard or minimum strains,—all timber having fewer rings per inch of tree diameter, fewer fibres, and fewer and shorter radial plates per square inch of section, should be rejected as not up to the standard, and applied for other purposes or used with a greater factor of safety.

This method has the advantage of enabling every stick of timber in a bridge to be inspected and judged, and is offered as an interesting and valuable aid to the breaking tests made by the machine.

In this connection, I may offer as the parallel in metal work two portions of pure Lake copper; one an ingot as ordinarily found, in which the grain is coarse and crystalline, the color dark-red, and the mass full of blow-holes; this is an average sample of copper casting. The other is run from the same pig, at the same heat, and in a similar mould, but with proper precautions to prevent oxidization; in consequence, there are no blow-holes, the grain is close and fine like that of the best bronzes, and the color is *salmon*, which is the true copper color. The "deoxidized" casting weighs 25 per cent. more than the ordinary casting from the same pattern, calipering the same. For these I am indebted to the Philadelphia Smelting works, Twelfth and Noble sts.

Tests made of the deoxidized copper rolled into sheets .035 inch thick showed on strips 2 inches wide a tensile strength of 33,760 pounds per square inch, ordinary fine copper in sheets being quoted by Trautwine at 30,000 pounds. This would show 12.5 per cent. superiority in the metal having the fine fracture.

No. 20 "deoxidized" wire shows a calculated tensile strength of 45,000 pounds per square inch, and still later tests of wire of the same thickness showed a calculated tensile strength of 41,056 pounds per square inch for the ordinary, and 47,552 pounds for the deoxidized,* a striking confirmation of the indications of the microscope.

Transmission of Force to Great Distances.—Emile Lacoine shows that the distance to which a dynamo machine can transmit any given fraction of its energy is inversely proportional to the square of the section of the enrolled wire, and the temperature of the conductor is raised much less in proportion as the distance increases.—*L'Electricien*. C.

* Actual breaking strength of the wires, 39½ and 39½ pounds for two samples of the "commercial," and 44½ and 47 pounds for the "deoxidized." It must be remembered that the larger the specimens tested the lower the tensile strength per square inch of section, and the finer the wire is drawn the greater its tensile strength per square inch, and the less the superiority of the metal which was close-grained in the ingot.