an easy matter to estimate the discharge by each main. For example, say a 30-inch main is 10,000 feet long and a 26-inch main is 12,000 feet long, what will be the hydraulic grade to deliver a total of 15 c.f.s. and what will each main discharge? First, assume a grade for the 30-inch main, say, 0.10 per cent., then, according to the table, the discharge is 13.16 c.f.s. The assumed grade for the 26-inch main will be $\frac{10,000 \times 0.1}{12,000} = 0.083$ per cent. and with this grade the discharge is 8.18 c.f.s. The total will be 21.34 c.f.s. The next step is to ascertain the proportional discharge to give an aggregate of 15 c.f.s. — $\frac{13.16 \times 15}{21.34} = 9.25$ c.f.s. for the 30-inch and $\frac{8.18 \times 15}{21.34} = 5.75$ c.f.s. for the 26-inch, which is a part of the answer. The grades to give these discharges can be ascertained by example 6 given in the previous letter. $S = \left(\frac{9.25}{41.04}\right)^2 = 049$ per cent. grade for the 30-inch main and $\left(\frac{5.75}{28.27}\right)^2 = 043$ per cent. grade for the 26-inch main.

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SOME EXPERIMENTS ON THE PLASTIC ELONGATION OF WIRE.*

By A. V. de Forest.

IN the course of tension tests on wire, using a dead-load method, it was observed that brass wire stretched very differently from copper, aluminum, nickel, soft iron and German silver. These latter stretched in fairly uniform manner, that is, the stress-deformation diagram showed an apparently smooth curve, while that for brass was an irregular one. Turning to the literature it was found that this phenomenon is clearly shown in Dalby's autographic stress-deformation diagrams, and is evidently the same effect as the well-known "self-hardening" of bronze, and certain aluminum alloys when tested in the usual manner. The amorphous cement theory, advanced by Beilby and extended by Rosenhain, seems to offer a simple explanation of this matter, and further experimental work was undertaken to support the theoretical reasoning.

As is universally known, the amorphous theory accounts for the hardening effect of cold work by assuming that a layer of amorphous material, sub-microscopic in thickness, is formed on the cleavage planes, and between grains where slip has occurred. This material is assumed to be of the nature of an under-cooled liquid, such as glass, stiff and brittle. The effect of this intergranular layer is to "cement into rigidity" the enclosed blocks of crystallin material. After the metal has been deformed, it may thus be regarded as composed of broken parts of the original grains, in the form of crystallin blocks, surrounded and supported by the amorphous cement. The manner in which the metal yields to a reforming force will then depend on the relative resisting power of the two components.

There is little direct evidence on this point, but what seems a simple idea of the matter will account for the observed facts. At room temperature the cement formed between crystallin blocks of some metals requires a considerable time in which to reach its maximum supporting power. Muir's experiments on mild steel show that several days are required before overstrain tension specimens reach their greatest elastic limit. Howe has likewise shown that iron and mild steel behave in a similar way with respect to hardness. Using a word readily suggested by the term "cement," it would seem that the amorphous layer required a given time in which to set. This time might be expected to be dependent on the temperature, whatever the nature of the setting process; whether or not this process consists in the recrystallization into the adjacent crystallin blocks of the surplus amorphous material, leaving a layer of the same order of magnitude as that filling the original intergranular spaces. In fact, both the above experimenters found the time required for setting was reduced from a few days to a few minutes by heating the metal to 100° C. Whether the properties of the crystallin component are changed by such a small change in temperature is unknown, but it seems reasonable to suppose that the effect of such change on the unstable cement would be greater than that on the stable crystallin matter. Even the unstable forms of hardened steel are apparently little changed by heating to 200° C. As the facts can be readily explained without assuming such a change, it will be omitted for the sake of simplicity in the present case.

The setting process is then probably largely a function of the temperature. It may likewise be supposed that the viscosity of this substance is also affected by smaller changes in temperature than those which sensibly affect the crystallin particles. The rapid elongation under constant or diminishing loads found by many workers at higher temperatures, and the great intergranular brittleness found by Rosenhain at temperatures close to the melting point, indicate a great change in viscosity.

From these considerations it would seem that a metal subjected to a gradually increasing dead load would stretch smoothly and uniformly, when the rate of stretch and the temperature were such that the cement would set comparatively slowly. The blocks of crystallin material moving along the slip planes would be supported by an amorphous layer so viscous that no rapid motion would be possible. The motion of the blocks would be gradually checked by the increasing area of cement, and its increasing stiffness as time was allowed for it to set. The retardation would be gradual and the end of the motion would be imperceptible. Under these conditions the stress-deformation diagram would be a smooth curve, such as is usually obtained from copper.

As the temperature is raised the cement between the blocks of crystallin matter becomes less viscous at its foundation, and therefore the slip becomes more rapid. Also the time required for setting is less, and the relative motion of the blocks is more suddenly arrested. As the deformation increases, slip along new planes begins, only to stop suddenly when the resulting cement stiffens in its turn. A much slower rate of loading might also result in the same form of irregular stress-deformation diagram, for the mobile phase formed by any one slipping movement would have time to yield to a perceptible degree before the load became sufficient to develop slip along new planes.

*Abstracts from paper read before the American Society for Testing Materials.

An arrangement has been completed by Italy with Great Britain for the purpose of obtaining cheaper coal for Italy next winter.