LETTERS TO THE EDITORS

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Creep of Metals and Recrystallization

THERE has been a certain amount of dispute as to the fundamental laws of creep of polycrystalline metals[1]. I have advanced the view that the normal creep of a rod extending longitudinally under constant stress can always be represented fairly closely by the formula

$$l = l_0(1 + \beta t^{1/3})e^{kt},$$

where l is the length at time t, l_0 is approximately the initial length and β and k are constants. This gives a final rate of extension per unit length which tends to become approximately constant. On the other hand, it has been contended that there is a final state of accelerated creep, called[2] by some metallurgists Stage 4. When the total extension is of some per cent, this stage is often obtained in tests at constant load and can then, on my view, be attributed to increasing stress, consequent upon the thinning of the specimen. As argument against this, it has been pointed out that the increasing rate of creep has been obtained with extensions of less than 1 per cent in the case of certain steels at high temperature (see Fig. 1)[3]. This I have, however, attributed to recrystallization during the process of creep, recrystallization having been shown to produce increased rate of flow in certain cases[4].

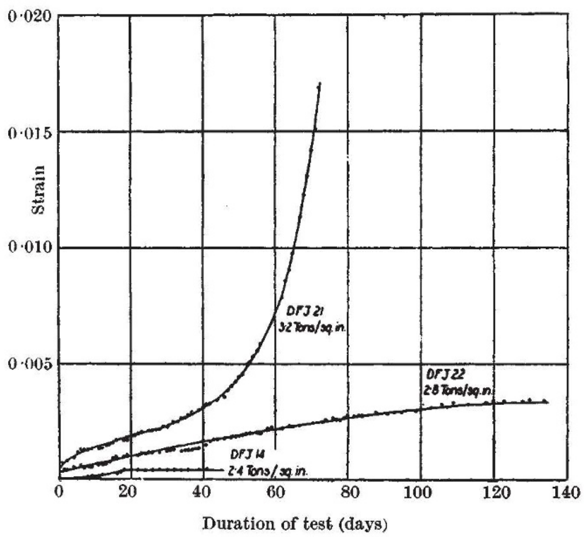

Fig. 1. Creep of a high-nickel–high-chromium steel at 800° C.

Certain experiments which Miss Charmian Sinclair has been carrying out with me on the flow of metals under constant stress throw light on this point. The metal in question is a pure lead (Tadanac virgin lead, of purity approximately 99·99 per cent) which was prepared by extrusion at 100° C. and kindly supplied to me by Mr. G. L. Bailey, director of the British Non-Ferrous Metals Research Association. It turns out that this metal, although normally stable at atmospheric temperature, recrystallizes under stress, the crystals increasing in size from about 0·05 mm. up to about 0·3 mm. linear dimensions.

Fig. 2 shows length against time for a range of stresses, each stress being maintained constant during flow by an Andrade–Chalmers constant stress bar[5]. It will be seen that the form differs markedly from that obtained with normal metals, which is represented by the broken line, obtained with normal lead extended at about the same temperature at constant stress. For the recrystallizing lead there is a stage of accelerated creep during the first ten minutes which is followed by a final creep at an approximately constant rate. The form of creep curve during the first ten minutes resembles closely that for the steels at high temperature. Whether the steels would, at like extension, ultimately creep at constant rate, cannot be said, but the 2·8 tons/sq. in. curve suggests that it may be possible.

It is clear, in any case, that recrystallization during creep has a fundamental effect on the form of creep curves. So far we have examined the wires microscopically only before and after creep, and noted the very marked recrystallization that has taken place. We are about to examine the state of crystallization at different stages of creep, with the object of connecting the rate of creep with the process of recrystallization.

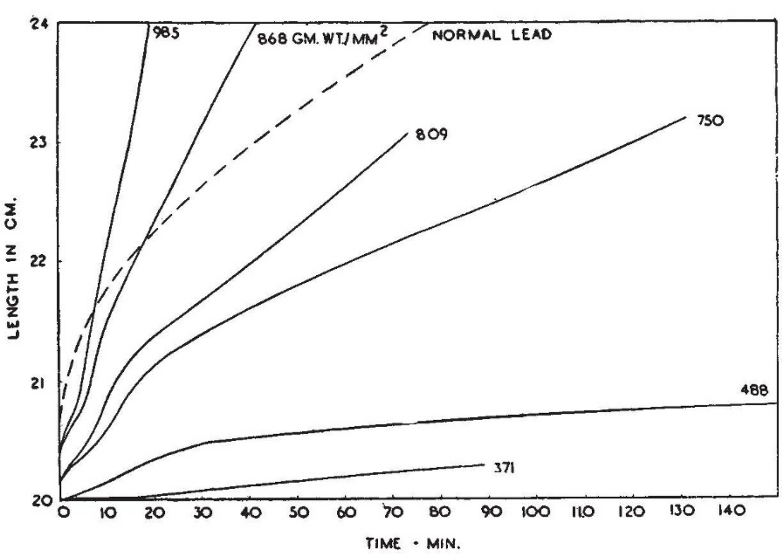

Fig. 2. Creep of a very pure lead which recrystallizes under stress

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[1] For example, *Nature*, **157**, 469 (1946).

[2] Hanson, D., Amer. Inst. Mining and Met. Eng. Tech. Pub. No. 1071.

[3] Tapsell, H. J., and Remfry, J., D.S.I.R. Engineering Research Special Report No. 15 (1929).

[4] For example, Bristol Conference Report, Physical Society (in the press).

[5] Andrade, E. N. da C., and Chalmers, B., *Proc. Roy. Soc.*, A, **133**, 348 (1932).