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THE COLLEGE OF AERONAUTICS

DEPARTMENT OF MATERIALS

Characteristics of the high temperature mechanism of creep and recovery in graphite

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Cranfield, Bletchley,
Buckinghamshire, England.

1. Statement of work carried out

An experimental material has been obtained from the Morganite Carbon Company. It consists of ground petroleum coke in a pitch binder with 10% ground artificial graphite added for ease of manufacture. The extruded rods were carbonised at 1200°C and rods in this form are referred to as 'ungraphitised' in this report. Part of the batch was subsequently heat treated for $\frac{1}{2}$ hour at 2500°C and these are referred to as 'graphitised'. Considerable difficulties have been encountered in the experimental work on this material, mainly caused by longitudinal cracks in the rod. These are invisible before testing, and in many cases they opened up during the test, and the results were consequently discarded. Some creep and recovery curves have, however, been obtained on apparently uncracked material and these are given in figures 1 and 2 respectively. The usual trends in the creep behaviour can be noted; these are:

1) The amount of creep strain in a given time increases with temperature for the graphitised material.

2) Ungraphitised material tested above 2000°C has a high creep rate when compared to the graphitised material.

On recovery from a constant creep strain of approximately 0.010, the temperature and the state of graphitisation do not appear to exert large effects. All curves have fairly similar gradients and after 1000 seconds the amount of recovery is within the range 56 - 82% of the initial strain. During loading to the creep stress the load/deformation curves were plotted on an XY recorder, with the results seen in figure 3. The effect of a change in temperature from 2300°C - 2500°C is very small. Work is in progress to determine the effect of temperature over the range 1500 - 2700°C on the torsional modulus of this graphite.

The results on this experimental graphite are somewhat limited and therefore an analysis to determine the activation energy for creep is not justified. Additional tests are being carried out to provide sufficient data.

A supply of A.T.J. graphite has been obtained from the Jet Propulsion Laboratory, Passadena, California, by courtesy of Dr.W. Kotlensky. Our results both in tension and torsion will be compared with their published results.

During the period covered by this report a high temperature tensile creep apparatus has been constructed. The solid tensile specimen is screwed into carbon grips and the assembly heated by a concentric carbon resistance tube. Carbon black is used as an insulator around the heating tube and the whole chamber is maintained with a positive pressure of argon to prevent oxidation. The temperature control system and power source are shared with the torsional creep apparatus. Dead loading with weights via a 10:1 lever system is employed. This equipment will enable tensile and

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torsion tests to be carried out on the same bars of material. From such tests the Young's and shear moduli can be derived, and hence the Poisson ratio.

2. Research plans

Three principle lines of investigation are being pursued:

a) On the experimental petroleum coke/pitch graphite, additional torsional and tensile data are being gathered to give sufficient material for activation energy analysis and for the comparison of torsional and tensile properties.

b) The A.T.J. graphite will be tested.

c) The possibility of obtaining pyrolitic specimens is being examined.

3. Personnel, administrative actions, conferences, etc.

The personnel engaged on this work remain the same. About 70 man-hours were contributed by the departmental workshops.

A written contribution to the Institute of Mechanical Engineering (in collaboration with A.S.M.E. and A.S.T.M.) International Conference on Creep, New York and London, August - September 1963 has been made. This discussion relates to statements made on the high temperature mechanisms of creep in graphite by Williamson and Jenkins.

4. Utilisation of funds

These have been utilised, with some money being retained for the proposed purchase of pyrolitic graphite.

5. Important property acquired

None.

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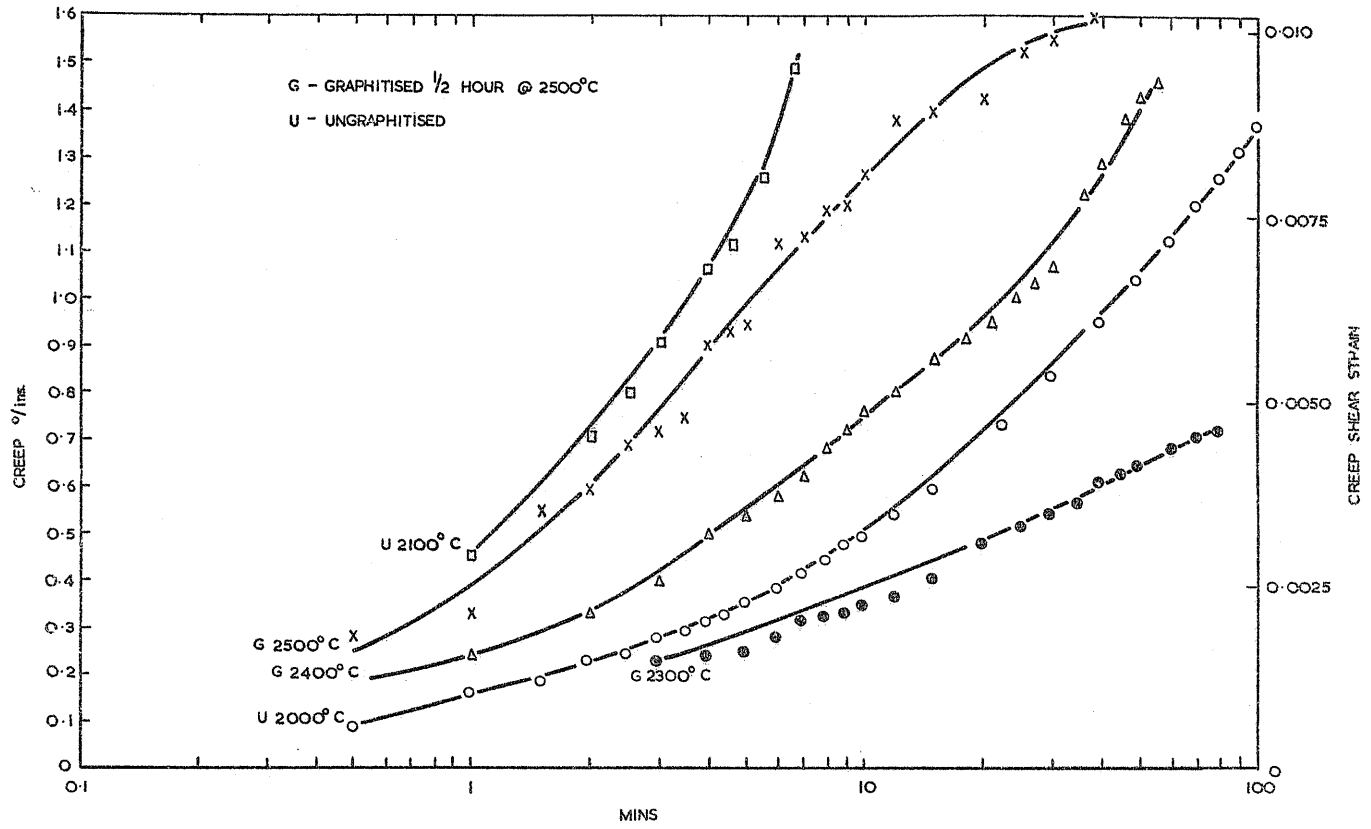

FIG. 1 PETROLEUM COKE - PITCH MATERIAL (+ 10% ARTIFICIAL GRAPHITE)
TORSIONAL CREEP CURVES FOR A LOAD OF 2000 PSI AT A RANGE OF TEMPERATURES

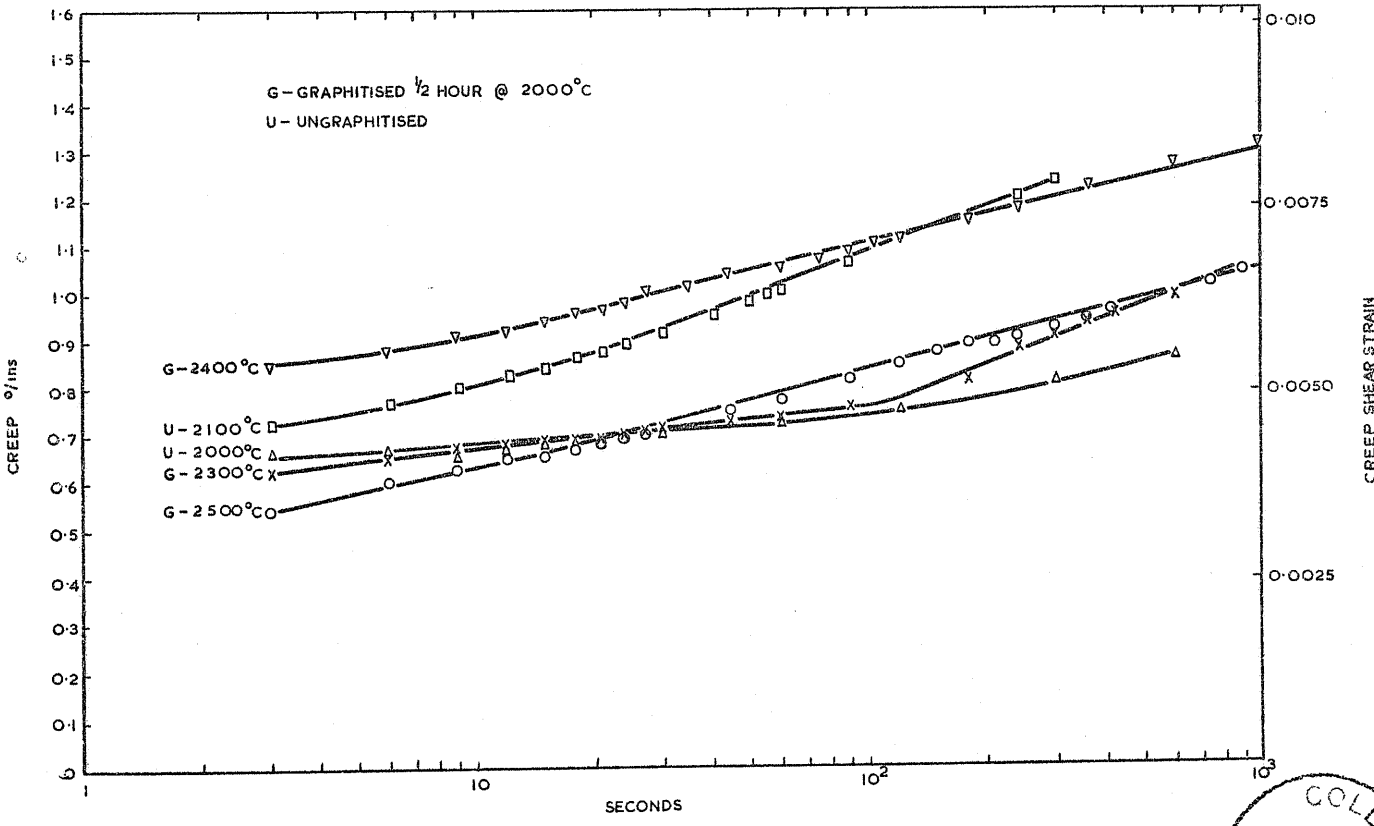

FIG. 2 PETROLEUM COKE - PITCH MATERIAL (+ 10% ARTIFICIAL GRAPHITE)
TORSIONAL RECOVERY WITH TIME OVER A RANGE OF TEMPERATURES AFTER BEING CREPT TO A STRAIN OF 0.010 AT THE RECOVERY TEMPERATURE

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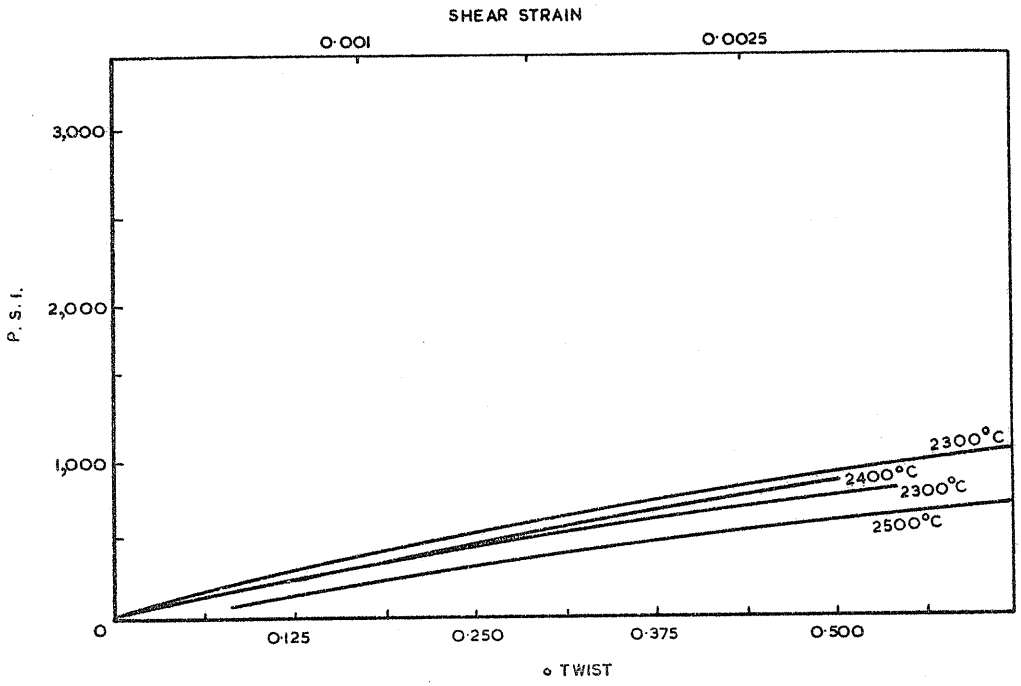

FIG. 3 PETROLEUM COKE - PITCH MATERIAL (+ 10% ARTIFICIAL GRAPHITE) LOAD/TWIST CURVES AT A RANGE OF TEMPERATURES