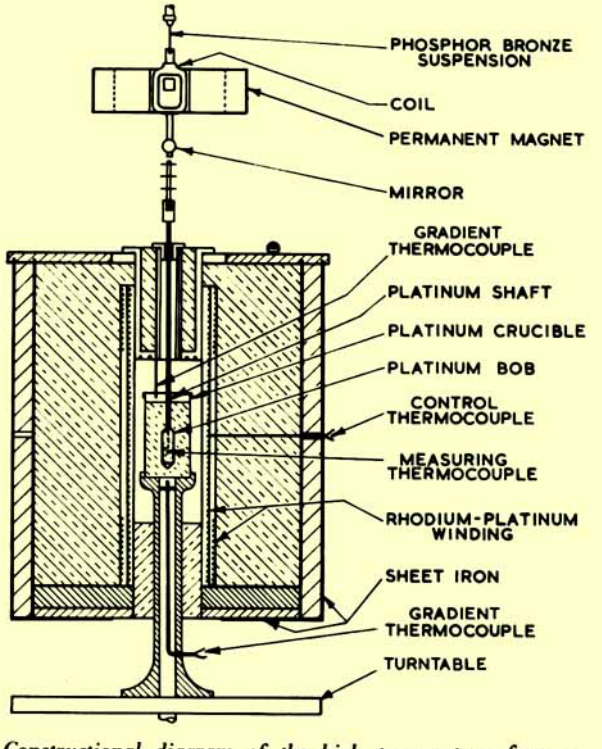
The Viscosity of Molten Glass

PLATINUM APPARATUS FOR DETERMINATIONS BY THE ROTATING CYLINDER METHOD

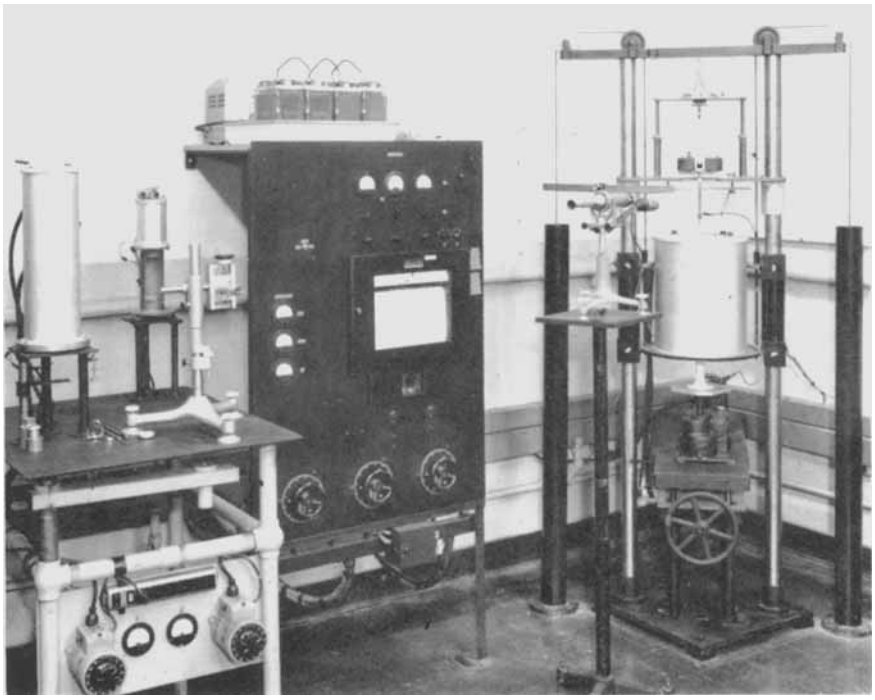
The viscosity of glass has a considerable effect on its other physical properties such as its melting and crystallisation characteristics and the temperature and pressure ranges within which the glass can be worked. When high speed mass production techniques are employed the glass must conform closely to viscosity tolerances so that products will have uniformity of thickness, shape and strength. Therefore there is a need for standard samples of glass of known viscosity against which process samples can be compared.

While at work on this problem for the U.S. National Bureau of Standards A. Napolitano and E. G. Hawkes, assisted by other laboratories co-operating in the project, have adapted the rotating cylinder method (1) to the determination of the viscosity of glass above its softening temperature. This method, originally devised by Margules, consists of measuring the viscous drag or torque on the inner of two concentric cylinders when the outer cylinder holding the molten glass is rotated at constant velocity. A similar type of apparatus has been used in the past for glass studies by other investigators.

A high temperature furnace, shown here schematically, was designed for this work and constructed with graded high temperature refractories. The outer concentric cylinder, 5 cm diameter and 10 cm high, is fabricated from 1 mm platinum sheet and acts as the sample crucible. The inner cylinder is in the form of a bob, 1.25 cm diameter and 3.75 cm long with 45° tapered ends. It is suspended within the crucible by a hollow spindle 29.5 cm long and 0.635 inch diameter. Both bob and spindle are made from 10 per cent rhodium-platinum alloy. The bore of the spindle is 0.3175 cm and extends to the centre of the bob to accommodate a platinum : 10 per cent rhodium-platinum thermocouple for checking temperatures before and after viscosity measurements, since slight temperature gradients within the glass affect the accuracy of determinations. The furnace element was



Constructional diagram of the high temperature furnace designed by the National Bureau of Standards for determining the viscosity of molten glass



The laboratory equipment for viscosity determination. On the right is the rotating cylinder apparatus; on the left the furnace for determining the viscosity of glass fibres

wound with 20 per cent rhodium-platinum wire, 0.032 inch diameter. All metal used in the fabrication of the crucible, bob, spindle and windings was of the highly refined grade specifically for glass melting or physical property measurements on molten glass.

To calibrate the apparatus, measurements were made at 25°C and 40°C using NBS standard oils of known viscosities between less than one and 500 poises. The viscosities of the glass measured over temperatures between 800°C and 1450°C covered the range 10^2 to 10^6 poises.

To measure the viscosity below the softening point, a fibre elongation method was used down to 575°C. Each fibre is drawn from the parent glass sample and is subjected to a load. The viscosity can then be determined as a function of the load and the elongation rate, provided that the fibre dimensions are known and that the temperature remains constant.

The Bureau methods can thus be used for samples of glass above 575°C, whether molten or not, and can act in conjunction with the standard samples as a much-improved control on the quality of glass production.

The Bureau recently announced (2) that the first of these standard samples is now available for use in calibrating commercial glass viscometers. It is known as Standard Sample No. 710, a soda-lime-silica glass whose softening point is about 724°C, and a certificate of viscosity values is issued with each sample. Next will be a standard lead-silica glass and the Bureau also plans to determine the surface tensions of both these standard samples.

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References

1 H. R. Lillie, *J. Amer. Ceram. Soc.*, 1929, **12**, (8), 516 – 529

2 *NBS Tech. News Bulletin*, 1962, **46**, (11), 174 – 175