NATURE

50 Years Ago

Learned behaviour is reported to be transmitted by injecting into untrained animals fractions or homogenates, containing RNA, from the cerebral hemispheres of trained rats … The transfer problem is very important for the understanding of memory and learning, and we have carried out a series of experiments with rats … Each recipient was given intraperitoneally 1 ml. of a solution containing total brain RNA extract from one donor … A general trend is revealed … which shows that injectees which received extracts of trained donors performed better than recipients of control brain extracts … Our findings do not, of course, indicate whether they concern the transfer of some specific memory mechanism or simply of a certain kind of excitatory state.
From *Nature* 14 October 1967

100 Years Ago

Meteors of the largest type exhibit a propensity to appear in the twilight of early evening. On Monday, October 1, at 6.37 p.m., a splendid object of this class presented itself, moving slowly along an extended flight in a south to north direction … descriptions have been received from places so wide apart as Weston-super-Mare, Somerset, and the extreme North of England … The Rev. J. Dunn, of Weston-super-Mare, describes the fireball as very brilliant, passing just above Capella. It was visible for five seconds; the head was some ten minutes of arc in diameter, and it threw off a short, reddish tail of sparks … Mr. T. J. Moore reports from Doncaster … that about one minute after the object had passed a very loud explosion was heard … Spectators agree as to the remarkable brilliancy of the object, and state that it aroused apprehension in cases where its nature was not understood.
From *Nature* 11 October 1917

ENGINEERING

Liquid metal pumped at a record temperature

Although liquid metals are effective fluids for heat transfer, pumping them at high temperatures is limited by their corrosiveness to solid metals. A clever pump design addresses this challenge using only ceramics. SEE ARTICLE P.199

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Every energy-conversion process produces heat as a product or by-product. Thermal energy is therefore one of the most abundant forms of energy in the industrial world. The conversion of this heat to more-useful forms of energy would dramatically improve the efficiency of many industrial processes and has been the focus of intensive research. Thermal energy is most valuable when it's transported, stored or converted at high temperatures (greater than 1,300 kelvin[1]). However, few materials can ensure reliable heat transfer at such temperatures without either melting, losing their load-bearing capacity or corroding. On page 199, Amy *et al.*[2] use a careful engineering design to bypass the inherent weaknesses of ceramic materials[3], such as brittleness, and construct an all-ceramic pump system that is capable of circulating liquid tin at temperatures of up to 1,673 K.

Liquid metals, if pumped at high temperatures, have many appealing properties[4] that could enable extremely efficient heat transfer and storage. Such properties include low viscosity above the metal's melting point and high thermal conductivity. However, the use and circulation of liquid metals at high temperatures has hitherto been limited by the inherent corrosiveness of these fluids to metallic structural materials[5]. Amy *et al.* report that their all-ceramic device can pump liquid tin for 72 hours at 1,473 K, with peak temperatures of up to 1,673 K. The successful demonstration of their proof-of-concept pump shows how clever design can lead to important technological advances.

Liquid-metal pumps need to operate in challenging conditions that involve dynamic and tensile loads, large thermal gradients and contact with a highly corrosive liquid metal. Instrumental to the performance of Amy and co-workers' pump are the ingenious design of the pump system, the correct choice of structural materials and the precise fabrication of the pump's components. The authors use a pump system that brings only ceramic materials in contact with the liquid tin to mitigate undesirable corrosion effects: they use graphite for the liquid-metal reservoir, piping, joints and seals, and a nitride-based ceramic known as Shapal Hi-M Soft as the primary pump material (Fig. 1a).

Because both graphite and Shapal can be easily shaped using machines, Amy *et al.* could precisely fabricate pump components that have a complex geometry, such as the teeth of the pump's gears. Moreover, the authors could exploit the fact that graphite expands laterally under compression to achieve dynamic sealing — a key requirement for pumping liquid metals at high temperatures, whereby the pump system guarantees fluid containment in the presence of moving parts.

Amy and co-workers' pump system also accounts for misalignments caused by thermal expansion and large thermal gradients across the system during operation. For instance, the pump's temperature is about 1,500 K, whereas the temperature of the motor driving the pump is about 300 K. The authors purposefully offset the pump and motor in the vertical direction at room temperature, so as to correct for misalignments that occur when the pump is in operation (Fig. 1b).

The authors' pump operated without mechanical failure of any of its components during testing. However, the short duration of the test (72 hours) cannot provide concrete evidence of the transferability of this technology to an industrial scale. After testing, Amy *et al.* reported appreciable wear on the gear teeth, which invites improvement in the choice of structural material and the use of elastohydrodynamic lubrication — in which the perfectly polished gear teeth are separated by a thin film of liquid metal. Additionally, the authors suggest that Shapal could be replaced by fine-grained, durable aluminium oxide to decrease abrasive wear at the points of contact between interlocking gear teeth.

Amy and co-workers indicate that the pump design allows for flexibility in the choice of structural materials to improve performance or reduce cost. For instance, graphite could be replaced by other sealing materials that have a hexagonal crystal structure, such as boron nitride. Other candidate hexagonal ceramics not suggested by the authors are the structurally layered carbides and nitrides known as the MAX phases[6]. Such ceramics can be easily shaped into components that have a