Can the theory of the proximity effect explain the variations of current in a super-normal-super sandwich? And how complete is the likeness between the sandwich and a Josephson junction? Comparisons between experiment and the first principles calculation of P. de Gennes have been no more than perfunctory, and tend to bring out the difficulties in handling mean free path variations and self-field effects. A simplified version of the theory, however, can be used to describe the temperature variation of the critical current with fair accuracy except where self-field limiting is expected to occur near the critical temperature. A major difference from the Josephson junction is seen to exist at very low temperatures, the latter tending to a finite critical current and the sandwich to an infinite critical current.

There are several other distinctions between the lead-copper-lead sandwich and a Josephson junction. The copper barrier is typically about 5000 Ångströms thick compared with about 20 Ångströms for the insulator; the resistance of the insulator is typically 1 ohm, compared with about 10^{-7} ohms for the copper slice. Nevertheless the other similarities between the two types of junctions will arouse or stimulate the interest of those with a keen eye for this year's model of this decade's phenomenon.

TRIBOLOGY

Troublesome Lubrication

from a Correspondent

A SYMPOSIUM on lubrication in hostile environments, sponsored by the Joint British Committee for Vacuum Science and Technology and the Tribology and Process Engineering Groups of the Institution of Mechanical Engineers, was held on January 15–16 at the Institution of Mechanical Engineers. Opening the symposium Dr H. Kronberger, who has direct experience of lubrication problems in atomic energy, outlined the conditions in which bearings and sliding mechanisms must often operate—extremes of temperatures and environments that are active, compatible or non-existent (such as outer space). Lubrication can be provided by (1) sealing the lubricated surfaces from the environment; (2) using materials which are self-lubricating in compatible environments; and (3) using a non-hostile environment as a lubricant; for example, water and gas bearings and sodium in reactor pumps.

Problems of lubrication for supersonic transports and gas turbine engines between -55°C to 315°C were dealt with by B. T. Fowler (Esso). At low temperatures it is not possible to use the familiar technique of lowering the viscosity of a lubricating oil by adding petrol which evaporates when the engine is hot. Fortunately ester fluids have better viscosity characteristics, lower volatility and better load-bearing properties than mineral oils. In 20 years a bulk oil/system operating temperature of 90° – 310°C for the mineral oils has risen to 200° – 450°C for the polyphenyl esters. The latter under high load bearing had a life of 18 hours at 475°C .

Lubricating cryogenic apparatus and pumps distributing pure gases is complicated by gas contamination, combustion hazards and failure of conventional lubricants at low temperature or in active gases. D. H. Tantam (British Oxygen Co.) reported that metal to

metal bearing surfaces under light loads and at low rubbing speeds undergo less wear in liquid oxygen than in liquid nitrogen or argon because of surface oxidation.

The self-lubricating properties of two-phase composites such as Ni/CaF₂ at 400°C in dry CO₂ were described by J. Houghton and L. A. Mitchell (Central Electricity Generating Board). Their model, which explains the wear of composites, has indicated that the best bearing performance is obtained with a soft matrix with a high specific wear rate. The high wear rates of these materials, however, limit their application. A PTFE-filled porous metal is an example of a valuable composite bearing material. (Unfortunately it begins to dissociate at 180°C .)

C. L. Harris and M. G. Warwick (Elliott Automation) discussed lubrication of bearings and gears at gas pressures of 10^{-7} – 10^{-10} torr by low vapour pressure oils and greases, lamellar solids, soft metals and composites. A dry plastic gear combination ('Nylatron' against 'Delrin') had a life of 3,600 hours, and lead films were effective in lubricating miniature ball bearings under light loads for 3–4 years at 3,000 revs/minute. Harris and D. W. Wyn-Roberts (Elliott Automation) found that lead films did not lubricate steel when exposed to oxidizing atmospheres.

Low vapour pressure lubricating fluids may have abnormally high evaporation rates because of volatile impurities or the formation of volatile components by thermal or catalytic degradation during rubbing. Using mass spectrometry and gas-liquid chromatography, L. Lawrenson, L. Holland and M. A. Baker (Edwards High Vacuum) have analysed the residues and condensates from mineral oil lubricants used in a vacuum. With a fluid of uniform molecular weight they observed molecular breakdown in friction conditions. Whether a mineral (or silicone) fluid had a medium or low vapour pressure (10^{-5} – 10^{-9} torr), the effective vapour pressure was increased to about 10^{-3} torr by friction degradation.

The frictional properties of dry and liquid lubricants and of metal surfaces are critically dependent on the presence of reactive gases and their level in the environment. When metals are heated to a high temperature they can release by desorption and surface reaction H₂, H₂O, CO, CO₂ and CH₄ and so on. Leaks from air can contribute, for example O₂ and N₂. Low partial pressures of oxidizing or reducing gases in the presence of rubbing materials can have pronounced effects on wear and frictional properties. Undoubtedly, if more precise information is to be obtained about such surface reactions it will be necessary to use techniques such as mass spectrometry for determining the nature of gas atmospheres.

ANTARCTICA

Made by the Birds

MUMIYO, a waxy substance of unknown origin found on rocks in Asia and Antarctica, was formerly thought to have healing properties, and has recently aroused considerable interest in the Soviet Union as a possible medicine. Writing in *Arbok 1967*, just published by the Norwegian Polar Institute at Oslo, Dr T. S. Winsnes reports that he has seen snow petrels in the mountains of Dronning Maud Land spitting out a thick pink substance that looks very much like mumiyo.

Although in the early Middle Ages the name mumiyo