AD 684045

FTD-HT-23-934-68

FOREIGN TECHNOLOGY DIVISION

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EDITED TRANSLATION

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English pages: 5

SOURCE: AN SSSR. Ural'skiy Filial. Institut Khimii. Trudy (Academy of Sciences of the USSR. Ural Branch. Institute of Chemistry. Transactions), No. 12, 1966, pp. 132-134.

Translated by: D. Koolbeck/TDBRO-2

PREPARED BY:

TRANSLATION DIVISION
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

DATA HANDLING PAGE

01-ACCESSION NO.: TT8001879

98-DOCUMENT LOC:

39-TOPIC TAGS: gallium base alloy, friction loss, corrosion resistant metal, metal surface

09-TITLE: THE APPLICATION OF GALLIUM ALLOYS IN LIQUID SLIDING CONTACTS

47-SUBJECT AREA: 11

42-AUTHOR/CO-AUTHORS: YATSENKO, S. P.; 16-KONONENKO, V. I.; 16-DANILIN, V. N.; 16-DRUZHININA, Ye. P.

10-DATE OF INFO: -----66

43-SOURCE: AN SSSR. URAL'SKIY FILIAL. INSTITUT KHIMII. TRUDY (RUSSIAN)

68-DOCUMENT NO.: FTD-HT-23-934-68

69-PROJECT NO.: 72301-78

63-SECURITY AND DOWNGRADING INFORMATION: UNCL, O

64-CONTROL MARKINGS: NONE

97-HEADER CLASN: UNCL

76-REEL/FRAME NO.: 1887 0531

77-SUPERSEDES:

78-CHANGES:

40-GEOGRAPHICAL AREA: UR

NO. OF PAGES: 5

CONTRACT NO.:

X REF ACC. NO.: 65-BC8012605

PUBLISHING DATE: 94-00

TYPE PRODUCT: Translation

REVISION FREQ: NONE

STEP NO.: 02-UR/2768/66/000/012/0132/0134

ACCESSION NO.:

ABSTRACT: The Hg and Na-K usually used in liquid sliding contacts have serious drawbacks. Hg is heavy and toxic and Na-K alloys are very reactive. In this connection low-melting alloys at a Ga base are of prospective interest. The Ga alloys were found to have considerable advantages with respect to Hg or Na-K contacts. The tested Ga alloy has a wide temp. range of liquid state, a low elec. resistance (2/7 as low as Hg and 3/4 as low as Na-K). It is stable in air up to 500° and has a low vapor pressure. The friction losses are considerably lower than those in Hg sliding contacts, but 4.5 times higher than in Na-K contacts. The contact potential drop is lower than both in the Hg and Na-K contacts.

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Mercury and sodium-potassium alloys have found practical application as contact liquids in liquid sliding contacts (LSC), used for the most part in acyclic machines on large currents [64, 103, 126]. Since sodium-potassium alloys possess relatively low melting temperature (-11°C) and small specific gravity (0.87 g/cm^3) it is possible to achieve high speed of motion of the contact surfaces without excessive mechanical losses. A basic deficiency of these alloys is their exceptionally great chemical activity with respect to the ambient medium; this is manifested in violent interaction with the oxygen in the air and with water vapor, creating fire and explosion hazards. This makes careful hermetization of machines necessary; in practice the accomplishment of this airtight sealing is fraught with severe difficulties.

Mercury is heavier by far (16 times) than sodium-potassium alloys and therefore can be used where limited speed of motion of contacts is permissible. Essential deficiencies of mercury are its strong toxicity and its high vapor pressure, significantly complicating the problem of protection of service personnel and giving rise to certain undesireable phenomena.

In connection with these deficiencies of mercury and Na-K alloys, in the course of searching for another contact liquid for LSC we investigated low-melting alloys based on gallium. The studies included the plotting of pyrometric curves of cooling and heating, density, electrical resistance, and viscosity, and also investigation of other properties in laboratory conditions and on special experimental installations which simulated the work of LSC (see Communications 1 and 17).

As a result of the studies it was established that gallium alloys have significant advantages over mercury and Na-K alloys and can be effectively applied in LSC. A comparison of one of the variants of gallium alloys with other examined low-melting metals and alloys is presented in Table 2 (see Comm. 1). As can be seen, the gallium alloy is in the liquid state in a wide range of temperatures and has a completely acceptable melting temperature (and also is inclined to supercooling), comparatively low electrical resistance (3.5 times lower than mercury, 1.3 times lower than Na-K alloys), and also possesses certain other positive properties. It is relatively stable in air (a film is formed on the surface of the alloy which protects it from further oxidation up to a temperature of approximately 500°C) and it has a low vapor pressure. It should be noted that in LSC for large currents there is a danger of expulsion of the contact liquid due to the electrodynamic force of the current, which can be balanced by centrifugal forces; in this case the light Na-K alloys turn out to be inapplicable, while gallium alloys, possessing a density on the order of 6.7×10^3 kg/m^3, ensure the required magnitude of centrifugal force and simultaneously reduce friction losses in the contact as compared to those with mercury.

Among the basic problems in the use of gallium alloys in LSC is that of selecting structural materials for the contacts which will be corrosion-resistant with respect to the given alloys. Special studies on isothermic corrosion of a number of structural materials in gallium alloys showed that the problem of selection of the required materials can be solved successfully. It is also important to clarify the magnitude of friction losses in LSC. Tests of LSC on the experimental installation showed that, other conditions being equal, the friction losses with gallium alloys are several times lower than those with mercury (for example, at a relative speed of motion of the contact surfaces of 45 m/s the losses in a contact with a gallium alloy were 6 times less than those with mercury, but 4.5 times greater than with Na-K alloy).

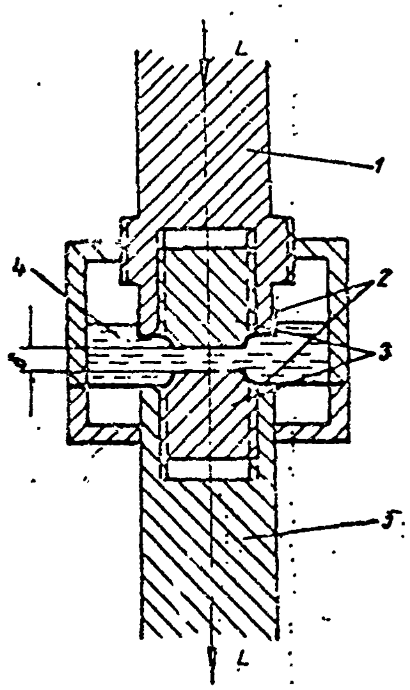

Fig. 74. Diagram of experimental installation for measuring voltage drop in LSC.
1 - upper conductor; 2 - electrical insulation; 3 - removable contacts (δ — gap between contact surfaces); 4 - contact liquid; 5 - lower conductor; L - current between contact devices.

An important factor in the evaluation of contact liquids is the magnitude of ΔU, the voltage drop in the contact during current flow; for reduction of overall losses in LSC this parameter must be minimum. The transient drop was determined on a special experimental installation (Fig. 74) with different materials in the contact surfaces and for different gaps δ, filled with contact liquid, between the contact surfaces. Voltage was measured on dc current directly between the contact surfaces. In this way the transient drop between the contact surface of one pole and the contact liquid (directly on the layer of contact liquid) and also that between the liquid and the contact surface of the opposite pole were taken into account.

Determination of voltage drop at high current densities, which can be tolerated in powerful acyclic pulse generators, was accomplished by measurement in the process of brief passage of current (for 2-3 s), during which voltage and current were oscillographed (appropriate means were used to compensate the emf of the measuring circuit voltage which might be induced in the process of changing the current and the magnetic flux connected with it). The tests gave results (Fig. 75) which permitted comparison of gallium alloys with materials of other composition.

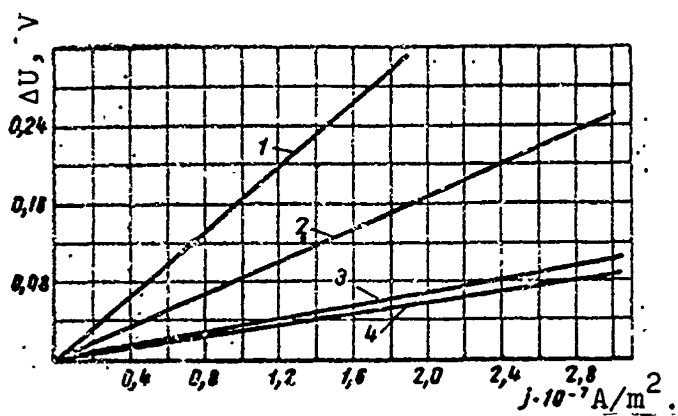

Fig. 75. Dependence of voltage drop in LSC on current density in the contact.
1 - mercury, contact of steel 40Kh; 2, 3, 4 - alloys of Ga, In, and Sn, with contacts of steel EI-69, steel 40Kh, and beryllium bronze, respectively.

The magnitude of the transient voltage drop depends in large measure on the material of the contact surface and is sharply reduced in those cases where the given material is not corrosion-resistant with respect to the contact liquid (Fig. 75, curves 3 and 4). It is obvious that comparison of contact liquids should be made only on the basis of data from tests with corrosion-resistant materials (Fig. 75, curves 1 and 2). As is evident, the transient voltage drop in the contact with gallium alloy is two times less than in the case of mercury. It is known [104] that the transient voltage drop between a steel ring and an Na-K alloy is, on the average, greater than that when mercury is used.

Thus gallium alloys prove to be more effective in LSC than mercury and Na-K alloys.