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MATERIALS REPORT NO. 30

FINAL REPORT OF TEFLON BEARING PROJECT
(TASK NOPI-Res-1-77-51)

by

J. G. Weir



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INDIANAPOLIS, INDIANA

MATERIALS REPORT
NO. 30

RESEARCH AND TEST DEPARTMENT
MATERIALS DIVISION

FINAL REPORT OF TEFLON BEARING PROJECT
(TASK NOPI-Re8-1-TV-51)

Prepared by: J. G. Weir

Approved by:

Carl Ferguson, Head, Materials Division
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J. C. Wagner, Head, Metallurgical Branch

SUBJECT: Final Report of Teflon Bearing Project, Task NOPI-Re8-1-77-51

REFERENCE: (a) Progress Report of Teflon Bearing Project (Task NOPI-Re8-1-77-51) Materials Report No. 18, of 20 June 1951
(b) Progress reports of 21 December 1951; 25 June 1952; and 25 December 1952
(c) NOPI Memorandum for File 10-51-N(M) Report of Conference with W. B. Ensinger at NOPI, 10 October 1951
(d) BuOrd ltr Re8f-WMM:kas to CO NOPI of 2 June 1952, reporting conference between J. G. Weir and W. B. Ensinger

PURPOSE:

The purpose of the subject project has been set forth in reference (a) which, with this report, constitutes a complete report of the work done and results obtained.

SUMMARY:

Continued work has supported and finalized the findings reported in reference (a). Analyses of current literature reporting success with Teflon bearings has always revealed that the report did not apply to instrument bearing applications which carry stringent requirements of low torque, wide temperature range of operation, and minute radial clearances. Indications that continued investigations could lead to success through long range basic research have been noted. In that this entire program has been predicated on a direct application basis, such long range programs are precluded. Sapphire bearings proved unsatisfactory because of chipping and fretting corrosion.

CONCLUSIONS AND RECOMMENDATIONS:

1. Teflon bearings are not suitable for instrument bearing applications in their present state of development.
2. Sapphire bearings, as sketched in reference (a), are subject to friction oxidation of the shaft and chipping of the sapphire where vibration is present, and should not be used as a ball bearing substitute.
3. For bearing life above 200 hours, diametrical clearance should be in the order of 0.0015 to 0.0030 inches, continuous operating speed should be less than 1000 RPM, bearing load should be under 10 psi on the projected area, and permissible torque should be over 15 gram centimeters.
4. Any continuation of this program should be preceded with basic research on the impregnation of porous metal matrices with Teflon. Such a program should start with the development of a suitable matrix which has the following properties or characteristics: (1) A coefficient of thermal expansion which equals that of the shaft material on which the bearing is to operate. (2) Porosity so controlled that the final bearing

surface will be comprised of 40 to 60 percent Teflon, balance metal.

(3) Mechanical strength sufficient to carry the required bearing load.

(4) High thermal conductivity. Once a suitable matrix has been developed, then considerable research related to impregnation will be required to develop a technique that will completely fill the voids with Teflon interlocked sufficiently to retain it in the "pockets" and still exposed sufficiently to effect lubrication. This phase would become quite involved in various dispersing mediums, wetting agents, baking conditions, characteristics of the suspended Teflon, etc. These phases should then be followed with machining research to develop the technique to machine the heterogeneous mixture of soft plastic and hard metal.

5. Further work on vacuum deposited and subsequently oxidized metal films is also of a long range and basic research nature. This technique could be well worth consideration in many fields of its own. As applied to Teflon bearings, its most evident value stems from the possibility of using a vacuum deposited film as an oxidation preventative or possibly an anti seize treatment to be applied to the porous metal matrix.

DETAILS:

1. Continued review of current commercial literature has revealed several notes or reports of successful application of Teflon bearings. Careful study of these notations always shows that the application was less stringent than for instrument usage. In general the torque limitations were higher and almost universally the temperature range of operation was very narrow. A distinct advantage listed was the freedom from seizure or galling.

2. Sapphire bearings as sketched in reference (a) were constructed, mounted in a size 1 synchro, and tested by operating the synchro electrically. In that tests on a dynamometer had shown hard chromium plated shafts were superior to other materials, adapter sleeves were so constructed. Chipping of the sapphire and friction oxidation of the chromium shaft surface were so pronounced in a short time that it was deemed inadvisable to continue this line of investigation.

3. Several sets of composite metal-Teflon bearings were made to fit a solid metal mock-up of a small 400 cycle synchro which was mechanically driven at 1500 RPM for test. Repeated failures from excessive radial shake (over 0.0004 inches) in less than 100 hours of running was considered sufficient reason to discontinue the testing. From these failures without a single success, the theory of impregnated porous metal was conceived.

4. Work done on impregnated porous metal bearings has been described in reference (a). Analyses of the failures of those attempts have indicated

that there is a possibility of success if and when techniques for impregnation and machining set forth in Conclusions and Recommendations are developed.

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