DISCUSSION

Erwin V. Zaretsky[1] *(written discussion)*—The technical content of the author's paper is excellent. However, the discusser has reservations with regard to the authors' results as related to rolling-element bearings. While it may be possible to study the relationship of inclusions and fatigue life using rotating beam specimens, it is not possible to quantify these effects to rolling-element bearings. Results published by ASTM in 1959 by Sachs, Sell, and Brown[2] and in 1960 by William J. Anderson and the discusser[3] failed to show a relation between rolling-element fatigue life (Type II failure mode) with standard testing methods used to evaluate standard (nonrolling) fatigue life (Type I fatigue mode). This lack of correlation can be explained by the fact that classical rolling-element fatigue is subsurface originated while, as example, rotating beam (R. R. Moore) is of surface origin. Specimen preparation, surface condition, and environment significantly affect the resultant life. Specifically high-hardness brittle materials such as bearing steels will generally be more sensitive to surface imperfections than the softer more ductile materials. As a result, there is no reasonable substitute for rolling-element fatigue bench testing. Furthermore, it is the discusser's experience that most researchers using rotating beam specimens do not obtain a sufficient number of failures to reach statistically significant results, much less relate the results to rolling-element fatigue.

Jacques Monnot, Bernard Heritier, and Jean Y. Cogne (authors' closure)—The reason for the correlation and its limits between RCF (rolling contact fatigue on bearings) and RBF (rotating bending fatigue on Moore Specimens) are explained in our first publication.[4]

Concerning crack initiation on the RBF Moore Specimen, we used a special surface preparation with diamond polishing which gave us practically no surface crack initiation sites. On the contrary, we observed that these crack initiation sites are subsurface nonmetallic discontinuities and more often subsurface nonmetallic inclusions.

Rolling-contact fatigue is a very complex phenomenon where numerous parameters are involved. Many of these parameters are related to the bearing manufacturing, heat treatment, geometrical parameters, surface finish, lubrication, etc. Others are related to usage conditions such as stress conditions, speed, and temperature. Our research and tests on finished bearings show that under certain usage or test conditions, the steel manufacturing parameters appear more clearly to have an influence on the bearing life. As a result, it can be concluded that the correlation between rolling contact fatigue and rotating bending fatigue does exist, but only for the steel manufacturing parameters and under specific conditions.

[1]National Aeronautics and Space Administration-Lewis Research Center, Cleveland, OH.

[2]Sachs, G., Sell, R., and Baum, W. F., Jr., "Tension, Compression, and Fatigue Properties of Several Steels for Aircraft Bearing Applications," *Transactions*, American Society for Testing and Materials, Philadelphia, Vol. 59, 1959, pp. 635–657.

[3]Zaretsky, E. V. and Anderson, W. J., "Relation Between Rolling-Contact Fatigue and Mechanical Properties for Several Aircraft Bearing Steels," *Transactions*, American Society for Testing and Materials, Philadelphia, Vol. 60, 1960, pp. 627–649.

[4]Monnot, J., Tricot, R., and Gueussier, A., *Revue de Métallurgie*, Vol. 67, July 1970, pp. 619–638.