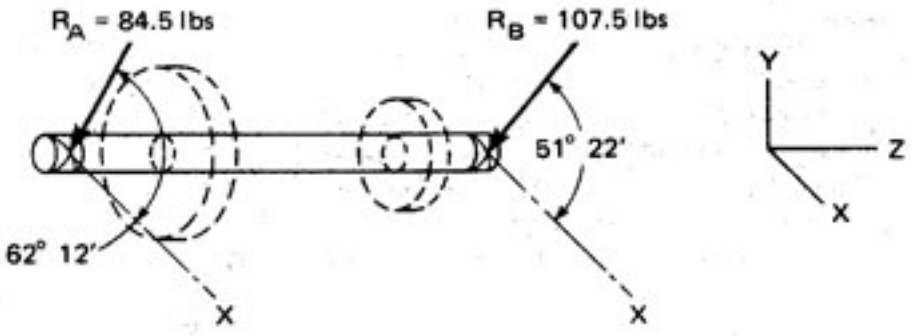

Figure 20 Resultant Bearing Reactions

5.0 SIZING BALL BEARINGS

(a) Basic Definitions

In the course of many years of experience with bait bearings and extensive testing, it has been found that the prediction of the load capacity of a ball bearing is a statistical event related to the fatigue life of the bearing. This makes the sizing of ball bearings more difficult than that of many other machine elements.

A basic phenomenon in ball bearings is that ball bearing life has been found to be inversely proportional to the cube of the bearing load. This means that when the load is doubled the life expectancy of the bearing is reduced by a factor of eight. This phenomenon has been studied extensively and has led to the adoption of an industry-wide national standard for rating ball bearings pioneered by the AFBMA (Anti-Friction Bearing Manufacturers Association, 1235 Jefferson Davis Highway, Arlington, Virginia, 22202). The following represents a summary of the load rating of ball bearings less than one inch in diameter, according to ANSI-AFBME Standard 9, 1978: “Load Rating and Fatigue Life for Ball Bearings” — reprinted with the permission of the American National Standards Institute Inc., 1430 Broadway, New York, N.Y., 10018:

"*Life Criterion*. Even if ball bearings are properly mounted, adequately lubricated, protected from foreign matter, and are not subjected to extreme operating conditions, they can ultimately fatigue. Under ideal conditions, the repeated stresses developed in the contact areas between the balls and the raceways eventually can result in fatigue of the material which manifests itself as spelling of the load carrying surfaces. In most applications the fatigue life is the maximum useful life of a bearing. This fatigue Is the criterion of life used as the basis for the first part of this standard.”

The material in the standard which follows assumes bearings having non-truncated contact area, hardened good quality steel as the bearing material, adequate lubrication, proper ring support and alignment, nominal internal clearances, and adequate groove radii. In addition certain high-speed effects such as ball centrifugal forces and gyroscopic moments are not considered. We now continue with the standard.

"Life. The "life” of an individual ball bearing is the number of revolutions (or hours at some given constant speed) which the bearing runs before the first evidence of fatigue develops in the material of either ring (or washer) or of any of the rolling elements.”

"Rating life. The “RATING LIFE”, L_{10}, of a group of apparently identical ball bearings is the life n millions of revolutions that 90 per cent of the group will complete or exceed. For a single bearing,

L_{10} also refers to the life associated with 90% reliability. As presently determined, the life which 50 percent of the group of ball bearings will complete or exceed ("median life". L_{50} is usually not greater than five times the RATING LIFE."

"*Basic Load Rating*. The "basic load rating", C, for a radial or angular contact ball bearing is that calculated, constant, radial load which a group of apparently identical bearings with stationary outer ring can theoretically endure for a RATING LIFE of one million revolutions of the inner ring. For a thrust ball bearing it is that calculated, constant, centric, thrust load which a group of apparently identical bearings can theoretically endure for a RATING LIFE of one million revolutions of one of the bearing washers. The basic load rating is a reference value only, the base value of one million revolu. tions RATING LIFE having been chosen for ease of calculation. Since applied loading as great as the basic load rating tends to cause local plastic deformation of the rolling surfaces, It is not anticipated that such heavy loading would normally be applied."

(b) Determination of Basic Load Rating.

Based on the preceding definitions the standard lists the equations required for the determination of the basic load rating:

"Calculation of Basic Load Rating. The magnitude of the basic load rating, C, for radial and angular contact ball bearings with balls not larger than 25.4 mm (1 inch) in diameter is:

$$C = f_C (i \cos \alpha)^{0.7} Z^{2/3} D^{1.8}" \quad (27)$$

where
- C = basic load rating, lbs.
- i = number of rows of balls in the bearing
- α = nominal contact angle, degrees ("nominal angle between the line of action of the ball load and a plane perpendicular to the bearing axis")
- Z = "the number of balls per row in a radial or angular contact ball bearing or the number of balls in a single row, single direction, thrust ball bearing"
- D = ball diameter, in.
- f_c = "a factor which depends on the geometry of the bearing components, the accuracy to which the various bearing parts are made and the material"

"Values of f_c are obtained from the appropriate column of Table" 2.

"Calculation of RATING LIFE. The magnitude of the RATING LIFE, L_{10}, in millions of revolutions, for a ball bearing application is

$$L_{10} = (C/P)^3" \quad (28)$$

(c) Illustration

Consider an ABEC 3 single row, radial ball bearing having 10 balls of 1/16" diameter, 0.330" inner race diameter and 0.452* outer race diameter in a single shield configuration.

$\alpha = 0°$ (radial bearing)
Z = 10 (number of balls)
D = 1/16" (ball diameter)

and dm = 1/2 (0.330 + 0.452") = 0.391" (pitch diameter of ball races).

This gives (D cos α) / dm = 0.16. With this value we turn to Table 2, third column and find f_c = 4530. Substituting these values into Equation (27) we obtain

C = 143 lbs.