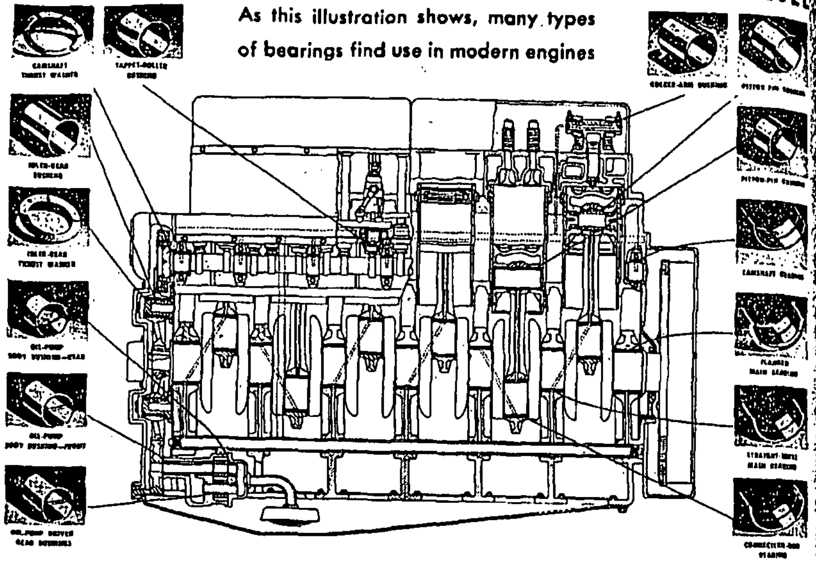
TYPICAL BEARING AND BUSHING APPLICATIONS IN A DIESEL

As this illustration shows, many types of bearings find use in modern engines



SERVICE CONDITIONS AND MATERIALS OF DIESEL BEARINGS

The following information regarding *bearing applications* in diesel applications will serve as a guide in selecting materials.

MAIN AND CONNECTING-ROD BEARINGS

In main and connecting-rod bearings, the journal is rotating and in almost all cases lubrication is sufficient so material selection depends largely on bearing loads. Within their load-carrying capacity, lead- or tin-base babbitts are preferred. As loads increase, higher-duty materials come into the picture. High-lead copper alloys have been used, but in such cases it is necessary to keep shaft hardness up to about *400 brinell*. This reduces shaft wear substantially, particularly under abrasive conditions. With trimetal bearings—consisting of an intermediate layer of copper-lead, and a surface layer of precision-plated white metal—and aluminum bearings, it is found that such shaft hardness is not needed. This makes it possible to use *high-duty bearing materials* on large diesel shafts where heat treatment is not always economical.

ROCKER-ARM BUSHINGS

Although oscillating motion is inherent in rocker-arm bushings it has been found that tin- or lead-base babbitts are satisfactory for light loads. For medium loads, a 25% leaded bronze is often used, requiring a hard shaft. In highly loaded applications and in large diesels, it becomes necessary to revert to higher duty materials, such as 80% copper, 10% lead and 10% tin, with shafts of about 60 Rockwell C hardness.

PISTON-PIN BUSHINGS

High impact loading and, in many cases, limited lubrication have made it necessary to incorporate extremely hard piston pins as well as hard and high-load-carrying bearing material. Split steel-backed bushings lined with 80% copper, 10% lead, and 10% tin have almost entirely eliminated difficulty in these applications. In some cases, an alloy of copper, with 4% each of lead, tin, and zinc, is used as an alternate, particularly in smaller diesels.

STARTER-MOTOR BUSHINGS

Because of intermittent operations and the possibility of improper lubrication, 25% copper-lead graphited split bushings have found wide use in starter-bushing applications.

OIL-PUMP BUSHINGS

Lubrication usually proves satisfactory in oil-pump body and driven-gear applications, and tin- or lead-base babbitts, along with aluminum bearing alloys, find use.

CAMSHAFT AND GENERATOR BUSHINGS

Because of rotating motion, light loads and ample lubrication, it is advantageous to employ the tin- or lead-base babbitts and aluminum alloys, although copper-lead alloys are sometimes being used.

Modern Bearing Materials Meet Tough Demands of Diesel Service Conditions

As new alloys and combinations of metals come into use, selection requires better knowledge of bearing requirements and properties of materials. Here are practical pointers on both*

▶ As ENGINE SPEEDS INCREASE and bearing loads grow heavier, lining materials face ever more severe requirements. To meet these demands, original babbitts have been improved and new alloys developed. While the new materials are, in general, superior to babbitts in load-carrying ability, they are apt to be less tolerant of departures from sound design, accurate construction and good operation. Thus selection of lining materials is today an exacting job, requiring thorough understanding of what is required of a bearing in a given application and of the properties of bearing alloys.

Bearing Requirements. To prove suitable for bearing service an alloy must display: (1) adequate fatigue strength (2) good embedability and conformability (3) resistance to seizure (4) resistance to corrosion, and (5) if used as a lining, bondability. Let's look at each of these characteristics to grasp its meaning and assess its importance.

Fatigue Strength. Many rate fatigue strength as the most important of bearing-alloy characteristics. "Failure from fatigue usually starts with cracks at the surface, which work downward well into the metal and frequently turn sidewards before reaching the bond. Such cracking finally results in detachment of pieces of the lining, known as spalling or "shelling-out." This in turn causes progressive failure of the bearing due to increased friction and overheating, resulting from disruption of the surface and consequent faulty flow of lubricating oil. The photos of fatigue failure on p 76 illustrate this.

It is hard to obtain a true picture of the relative fatigue strength of alloys because of the difficulty of duplicating service conditions. There is little similarity between the ordinary fatigue tests and actual bearing operating conditions. The closest approach to actuality would be a test by *flexing—opening* and closing the bearing—causing alternating tension and compression stress in the metal. Unfortunately for clear understanding, flexing of the bearing shell is not always the major cause of failure. It is, however, a contributing cause and sometimes the sole cause.

The tension stresses required, in addition to the normal compressive stresses, may result from the difference in rate of thermal expansion between the lining and the back. In a steel-backed tin-base babbitt-lined bearing a rise of 130 F can produce over 13,000-psi stress, higher than the yield point of any ordinary babbitt. Such tension stresses, plus the normal compression, may open cracks in the surface.

Stress in lining material after casting on the backing is high and of the order of magnitude of the lining's yield point. When the bearing is subsequently heated to 150 F, stress drops to a small value because the high rate of creep relieves it. Cooling down to room temperature causes stress to return to a high value. Examination of operating conditions shows that during starting and initial running before the bearing warms up, tensile stresses will be high but they become small when the bearing runs warm.

It has also been shown that cracks indicating incipient fatigue failure can be produced by alternate heating and cooling of a portion of the lining surface through relatively few cycles. In early fatigue failure, the bearings often show signs of excessive localized heating of the surface.

Today's clearer picture of fatigue-failure causes has influenced the trend to thinner linings. Reducing thickness of the lining does not prevent the stresses but it does decrease their size.

Embedability. Inevitable presence of dirt in diesel engines demands that bearings display embedability. Requirements vary greatly from engine to engine, and with geographical and climatic conditions. Where oil and air filtration are employed, the variation is less and tends to depend mostly on filtration effectiveness.

When dirt enters the bearing clearance space, it must embed in the bearing material or cut a groove around shaft or bearing. This should not be confused with the scoring resulting from insufficient anti-seizure characteristics. Confusion may be avoided by reserving the term "scoring" for the case just mentioned and using the term "cut" or "dirt-cut" to refer to bearings grooved by dirt and foreign matter.

Conformability. If it were possible to construct engines with complete accuracy and alignment, and if no distortions occurred in operation, the conformability of a bearing material would have little or no importance. Actually, of course, firing loads and other oper-

---

* At the 19th National Oil and Gas Power Conference of the Oil and Gas Power Division, ASME, four comprehensive papers on bearings were presented by B Crankshaw and G W LaPier, Cleveland Graphite Bronze Co; H J Kearey, National Bearing Division, American Brake Shoe Co; W E Thill, Federal-Mogul Corp; and D B Wood, Aluminum Co of America. This article and a preceding one (Jan, pp 84-87) is a condensation and free adaptation of these papers.