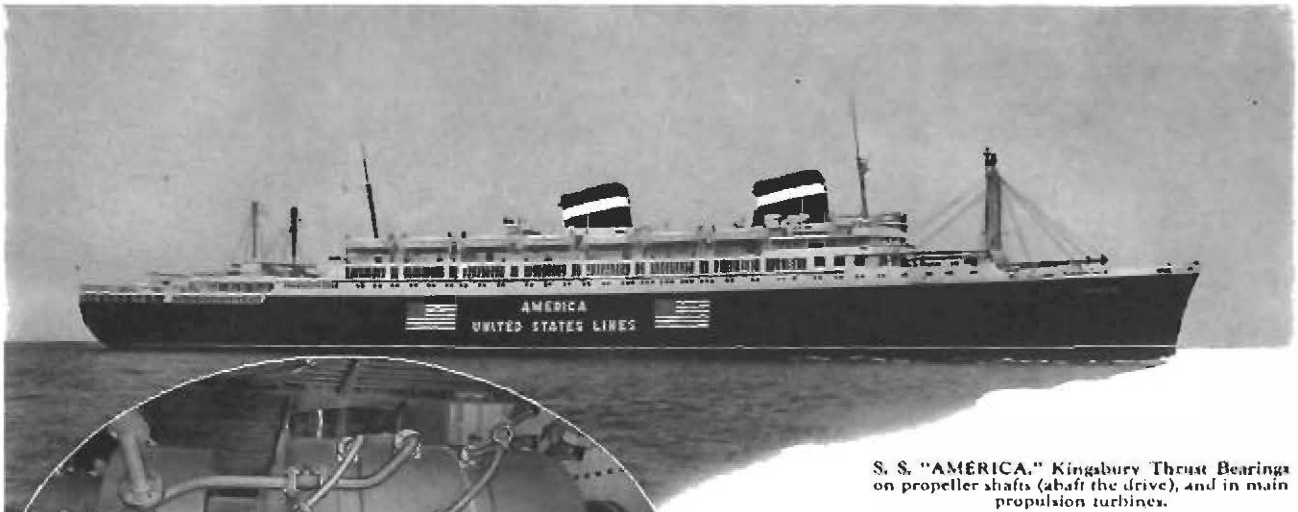
THE KINGSBURY GUIDE BOOK

Principles, designs
and applications of
Kingsbury Thrust Bearings
And Journal Bearings

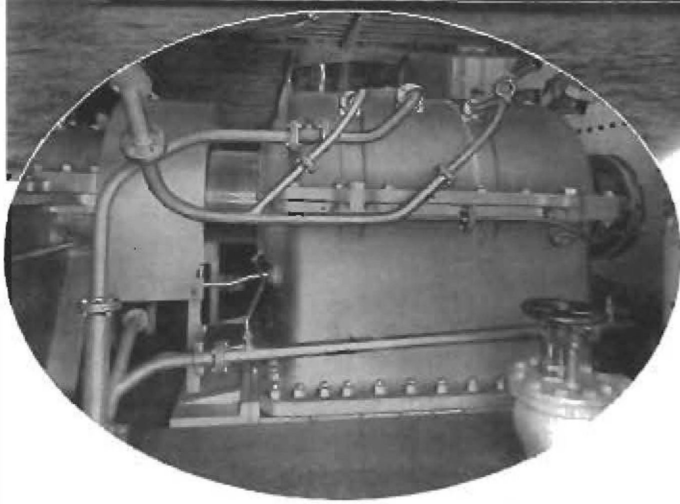
Catalog KG

KINGSBURY

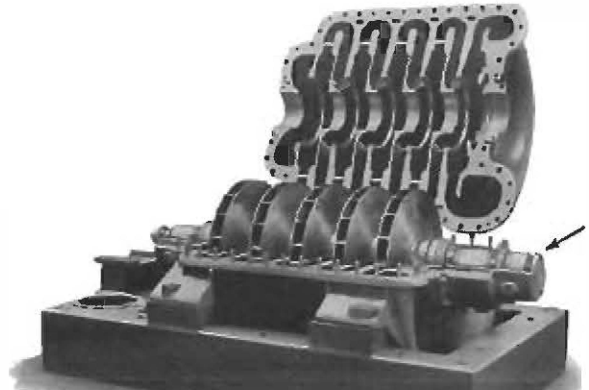


S. S. "AMERICA." Kingsbury Thrust Bearings on propeller shafts (abaft the drive), and in main propulsion turbines.

Newport News Shipbuilding & Dry Dock Co., builders

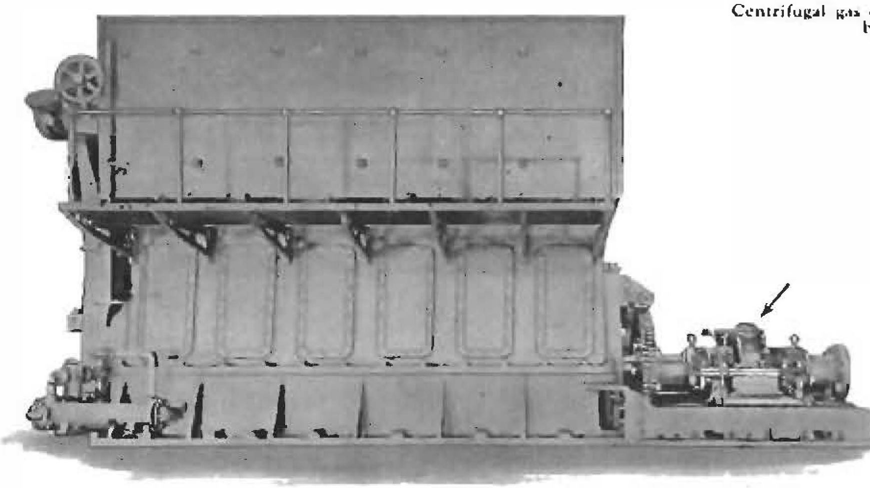


One propeller thrust bearing of S. S. "AMERICA": six-shoe type, size 45 in.



Centrifugal gas compressor. Kingsbury Thrust Bearing built into right-hand end.

Courtesy De Laval Steam Turbine Co.



Marine-type steam engine, with Kingsbury Thrust Bearing, 2-shoe type, and outside cooler for dredge pump service.

Courtesy Skinner Engine Co.

THE KINGSBURY GUIDE BOOK

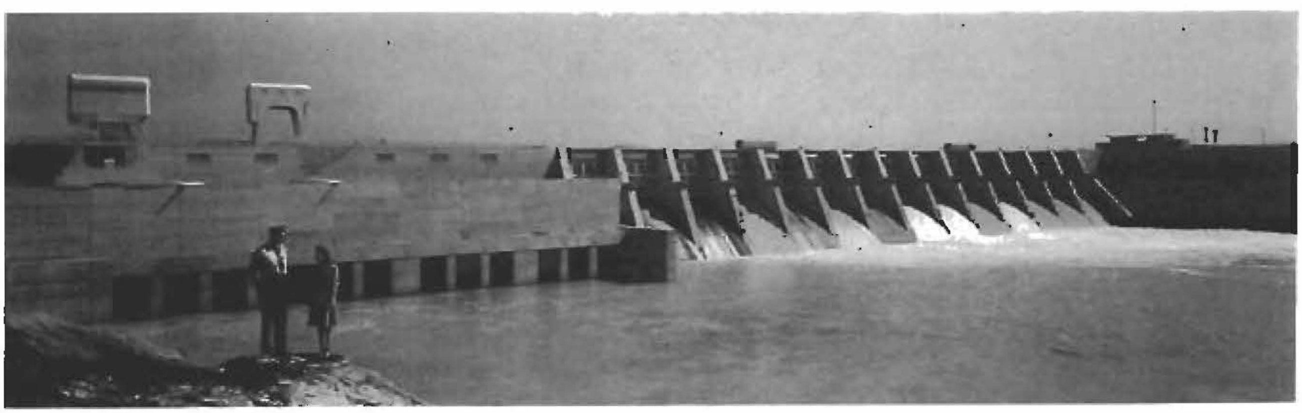
Principles, Types and Designs, Chief Applications of
KINGSBURY THRUST BEARINGS
AND JOURNAL BEARINGS

CATALOG KG

KINGSBURY MACHINE WORKS, INC.
Main Office and Works
FRANKFORD, PHILADELPHIA 24, PA.

Printed in U. S. A.
1948, 10M

CONTENTS



Fort Loudoun Dam, TVA System. Four Allis-Chalmers generators, 35,555 k.v.a. each, with 93-inch Kingsbury Thrust Bearings. Load, 1,800,000 lbs. Speed 105.8 r.p.m.

FOREWORD

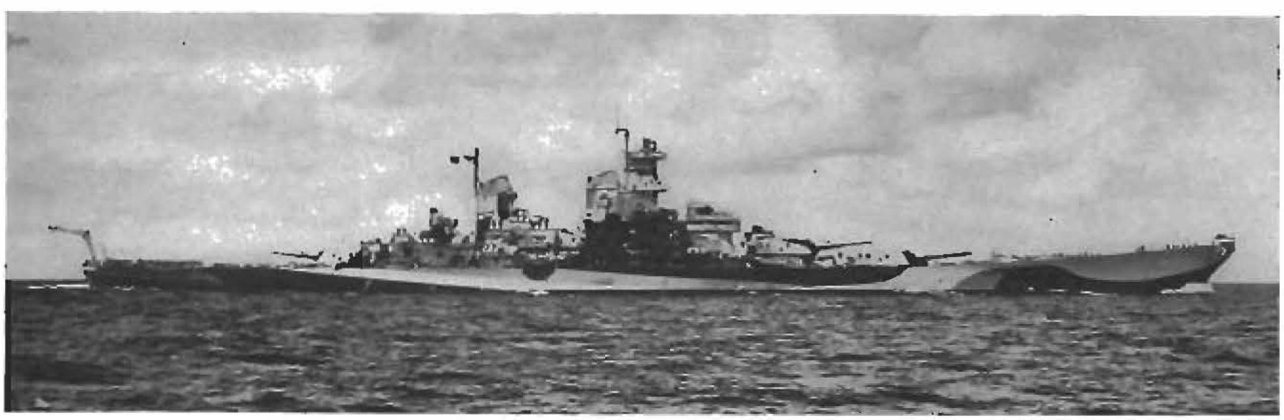
This booklet outlines the principles and construction of Kingsbury Bearings, and indicates their chief present fields of use. It is a "guide" for two main groups of readers: (1) those who seek general information about the bearings and their uses, and (2) those who are familiar with the bearings in some particular field, but wish a broader view of the product and of its remarkable adaptability to many kinds of machinery. With designers reaching after ever higher standards of load, speed and endurance, the unique capabilities of Kingsbury Thrust Bearings are of growing interest.

Following a brief statement of the Kingsbury principle of wedge-shaped oil films, and a suggestion of its scope in machinery design, the main features of the bearings, encountered in all applications, are described. These include the distinction between "adjustable" and "equalizing" types, which covers both horizontal and vertical (shaft) applications and is fundamental to an understanding of them.

In subsequent pages, the various bearing forms are grouped, first by the number of shoes, then by the intended use. Since the machine designer is interested primarily in his own product, the classification is functional as far as possible.

To assist those with past Kingsbury experience, a "finding list" is included, pages 14 to 17. It includes all the principal styles of two-, three- and six-shoe bearings, with identifying symbols, and indicates the main features of construction by diagrams and explanatory notes.

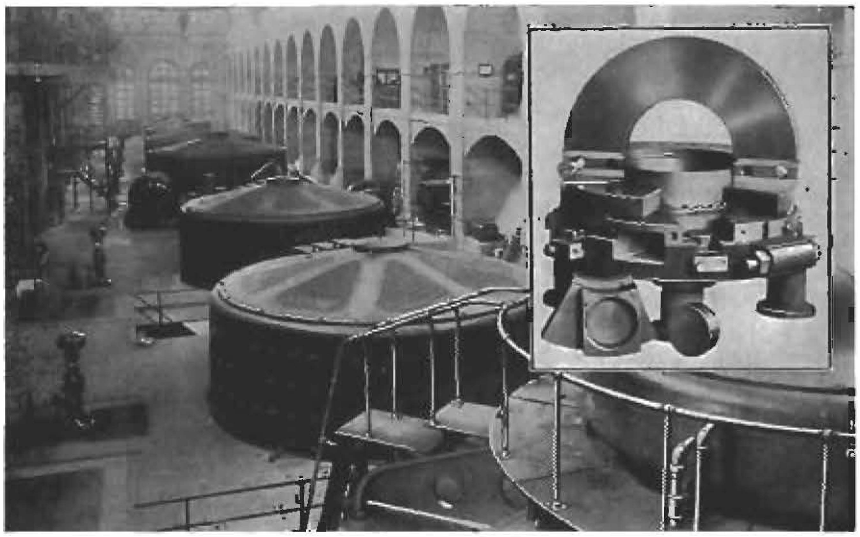
For fuller information on specific uses (marine, pump, hydroelectric, etc.), and for data on dimensions and capacities, the reader is referred to separate material, which will be sent on request.



U.S.S. "MISSOURI." Displacement 45,000 tons. Each of the five battleships of this class is equipped with thirty-six Kingsbury Thrust Bearings. Four of these, of size 49 inches, are on the propeller shafts.

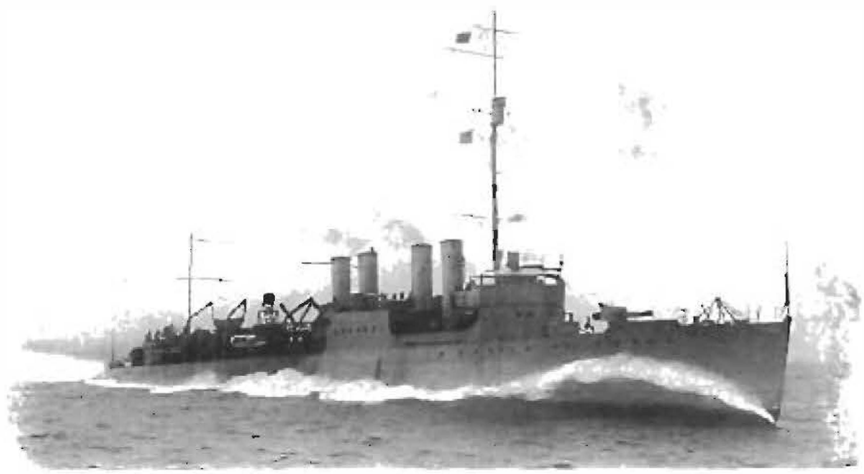
Official U. S. Navy photo

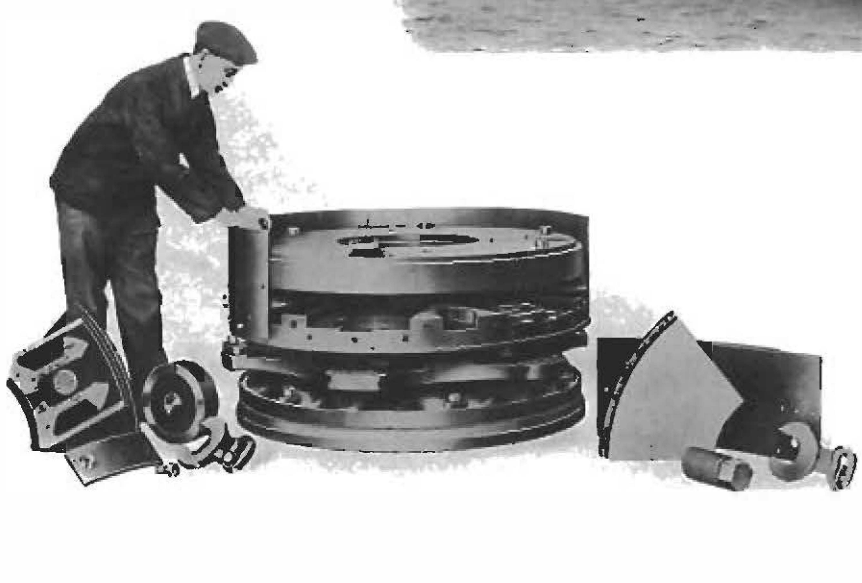
Early Kingsbury Mileposts



Holtwood Station of the Pennsylvania Water & Power Company. Kingsbury Thrust Bearings are 48 and 56 inches diameter. They are of the adjustable (not equalizing) type. One of them is shown in the inset, with one shoe removed and one-half of split runner turned up on edge. Installed 1912 to 1924.

Four-stack destroyer, one of 260 built in World War I for U. S. Navy. Kingsbury Thrust Bearings were used in the turbines, also in the reduction gears to take the propeller thrust.





Vertical 49-inch Kingsbury Thrust Bearing, adjustable type. One of three built in 1919 for the 32,000 kv.a. units of the Niagara Falls Power Co., Cliff Extension.

The Growth of an Idea

The idea that heavy running thrust loads could be "floated" on films of oil grew out of physical experiments made, in England and this country, in the 1880's. In this country the experimenter was Albert Kingsbury, then a student at Cornell University, later a professor at Worcester Polytechnic Institute. He knew that, to renew itself automatically under load, an oil film must be tapered, whether for a journal bearing or for flat surfaces. From his study and experiments, he conceived the idea of dividing the stationary bearing surface into pivoted segments, merely immersed in oil. He reasoned that, if the segments were free to tilt, the oil adhering to the moving collar would be continuously drawn in at the entering edges, and would build up films of substantial carrying capacity. With the oil films thus constantly renewed, there would be no metal-to-metal contact, no friction except that of the oil itself, and no wear.

Albert Kingsbury, 1862-1943. Inventor of the Kingsbury Thrust Bearing. Founder and late President of Kingsbury Machine Works, Inc.

Kingsbury tried his idea and found that it worked. When sure that he had mastered the principle, he boldly proposed to furnish thrust bearings for the most difficult of all applications at that time—namely, vertical hydroelectric generators, with running loads of hundred of tons. Till then, no form of thrust bearing had proved adequate for those monsters, and further increase in generator size seemed impossible. But Kingsbury's first hydro installation—in the Holtwood Station of the Pennsylvania Water and Power Co., on the Susquehanna River—was a complete success. It carried a running load of 405,000 lbs. on a 48-in. thrust collar, replacing a roller bearing.

That was in 1912. Other installations quickly followed, among them the famous Niagara power plants. And generator sizes, released from their former limitations, grew steadily till recent Kingsbury Bearings at the TVA plants carry over two million pounds running load.

Soon after the Kingsbury principle had been proved in hydroelectric generators, the First World War broke out. The United States Navy adopted Kingsbury Bearings for all its major ships then building, down to and including the four-stack destroyers, which then, and twenty-five years later, did such effective service against submarine attacks.

After that war Kingsbury Thrusts were rapidly adopted, both for passenger and cargo ships and for applications ashore in centrifugal pumps, dredge pumps, steam turbines and many miscellaneous services.

In World War II, Kingsburys carried the propeller thrusts on virtually all the Navy's combat ships and most of the auxiliaries down to harbor tugs. They were used extensively for the main thrusts of the new merchant marine which had to be built up under pressure, and in many other shipboard applications such as main and auxiliary turbines, boiler feed and condenser pumps, etc. They were used also in small high-speed turbines of lighting sets running at 10,000 r.p.m. In applications to high-speed turbo-compressors, especially in airplanes, even that speed has been largely exceeded.

An important contribution of Kingsbury Thrust Bearings to machine design has been in releasing the designer from former limitations as to speed and load. Kingsbury Thrust Bearings are supplemented by journal bearings which likewise carry unusual loads. Both the thrust and journal bearings are self-aligning when needed, and are otherwise designed to carry exceptional loads per square inch. This permits the designer to use heavily-burdened alloy steel shafts with relatively small bearing areas, and yet to enjoy complete dependability of performance.

The Kingsbury Principle

A rotating collar and stationary pivoted segments or "shoes" are the vital elements of the Kingsbury Thrust Bearing. As they run in a bath of oil, not under pressure, the oil clings tenaciously to the collar surface, and is drawn between the collar and shoes, forming separating films of remarkable load-carrying capacity. This is possible only because the shoes are pivoted and free to tilt microscopically, thus permitting the formation of wedge-shaped films, with the thick end on the entering side. (A running journal naturally takes a position which allows a tapered film to form. The diagrams below show how the same result is reached with pivoted shoes in Kingsbury Thrust Bearings.) The oil films are continuously renewed, due merely to the rotation of the oil-flooded collar; and the working surfaces never touch each other as long as the shaft turns. Consequently the loads carried may be far in excess of those possible with any bearing that lacks the pivoted segment feature; and the friction is far less.

Since the loads are so concentrated and speeds are often high, the oil becomes heated by its own "shearing" friction. To remove the heat, the oil is cooled either by radiation or by an oil cooler, which may be in the housing or outside. It is circulated, either by automatic devices within the housing or by an outside pump. Kingsbury Bearings might indeed be described as being built around circulating oil films, on which the load is "floated" by the motion of the collar and the viscosity of the oil.

The loads carried per square inch of shoe area depend on shoe size, oil viscosity and speed. The higher the speed, the greater the load capacity. No definite limits to speed or load have yet been found. We have never known a Kingsbury-built Thrust to wear out in normal service.

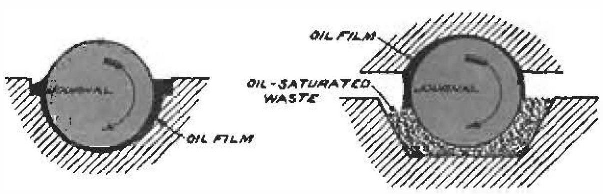


Figure 1
The wedge film in journal bearings.

These diagrams show (much exaggerated) what happens when a loaded surface, bathed in oil, is set in motion on a smooth supporting surface. A loaded journal takes a slightly eccentric position, allowing the entering oil to form a wedge. A loaded plate tilts slightly. A loaded plate (like a thrust collar), bearing against supporting shoes free to tilt, draws wedge-shaped films of oil between itself and the shoes.

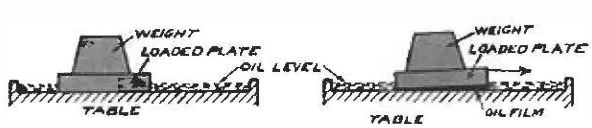


Figure 2
Action of loaded, moving plate in an oil bath.

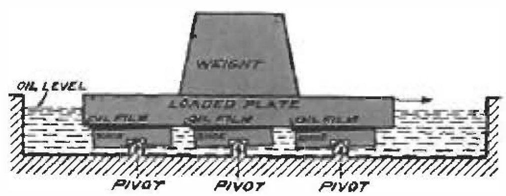


Figure 3
Action of pivoted shoes, supporting a loaded, moving plate in an oil bath.

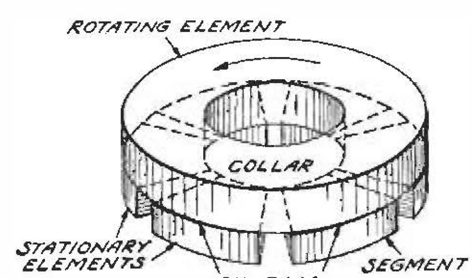


Figure 4
Rotating thrust collar, supported by pivoted shoes. (Oil bath is assumed.)

Advantages of Kingsbury Bearings

(*1*) ***Durability*** . . —No wear and indefinitely long life, because wedge-shaped oil films keep bearing surfaces apart. Original scraper marks remain visible after years of service.

(*2*) ***High Capacity*** . —Oil films carry tremendous pressures. Loads exceeding 2,000,000 pounds are easily and safely carried in hydroelectric generators. There is no known upper limit.

(*3*) ***No Speed Limits*** . —Perfect lubrication maintained at highest designed shaft speeds, also lowest. Present range of experience 3 r.p.m. up to 30,000.

(*4*) ***Low Friction*** . . —Coefficients of .001 to .005 for most conditions. Power loss results solely from oil film shear: there is no metallic rubbing.

(*5*) ***Low Maintenance***—Run year after year with no need for repairs or renewals. Only attention required is to keep oil clean and properly cooled.

(*6*) ***Radial Accessibility*** . . —Easy to provide for routine inspection of bearing surfaces, without removing any parts over end of shaft.

These points add up to a lifetime of dependable and economical service, under almost any conditions of load and speed.

Typical Fields of Use

As already indicated, Kingsbury Bearings may be applied to either horizontal or vertical shafts. The arrangements for oil circulation are necessarily different in the two cases; other details of construction must also be adapted to meet the requirements of various types of installation. Many of the designs shown in the following pages have been thoroughly standardized and are widely used.

Some of the commonest applications are:—

Marine propeller thrust service
Hydroelectric generators
Hydraulic turbines (horizontal and vertical)
Steam turbines (horizontal and vertical)
Dredge pumps
Boiler feed pumps (horizontal and vertical)
High speed blowers
Centrifugal compressors
Vertical electric motors
Deep well pumps
Oil pumps (pipeline and refinery)

For each kind of service, specialized information will be supplied on request, including recommendations on appropriate bearing types. For some of these applications, pages 18 to 31 contain further data.

The Kingsbury principle—often in standard Kingsbury designs—is readily applicable to a wide variety of other machinery, with no sharp limits to load or speed, and inherent freedom from wear. We are always glad to hear from machinery designers and to discuss their bearing problems. Of especial interest are the new applications arising in new and difficult types of machinery.

Basic Elements

The basic elements of a Kingsbury Thrust Bearing are:

(1) The stationary pivoted ***Shoes.***

(2) The ***Thrust Collar*** which rotates with the shaft, and applies the load to the shoes. (Called ***Runner*** in vertical bearings).

(3) The ***Base Ring,*** or other means of supporting the shoes and equalizing the shoe loads.

(4) The ***Housing*** or mounting, which contains and supports the internal bearing elements.

(5) The ***Lubricating System,*** which continuously floods the collar and shoes with oil.

(6) The ***Cooling System*** for removing the heat due to oil friction.

Every thrust bearing installation involves all of these elements in one form or another. Designs may be classified as horizontal or vertical; as having "adjustable" or "equalizing" thrust elements; and also according to the number of shoes. Some designs are furnished as complete units including housings, with or without self-contained lubrication, and with water cooling equipment where needed.

The Shoes and Their Backing

Before passing to the various embodiments of the above elements in particular types of bearings, the general form of the shoes should be noted; also the different methods of supporting them and dividing the load among them.

The Shoes

The shoes are segmental. Standard bearings have from two to eight shoes according to type, arranged as diagrammed in Figure 6.

Every shoe has a pivoted "shoe support." Usually the support is set into the back of the shoe, and has a hardened, slightly rounded pivot which contacts a hardened backing surface. A small shoe and its support are shown at the left in Figure 5.

In large vertical hydroelectric bearings the shoe supports are separate pieces, so shaped as to minimize flexure of the shoe under load.

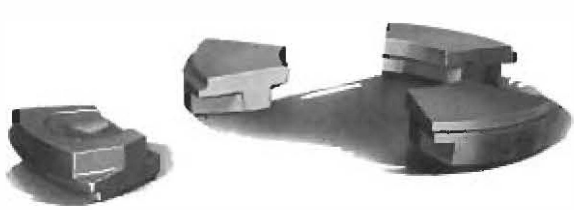


Figure 5
Three pivoted shoes (a fourth is inverted to show the hardened steel "shoe support" set into its base).

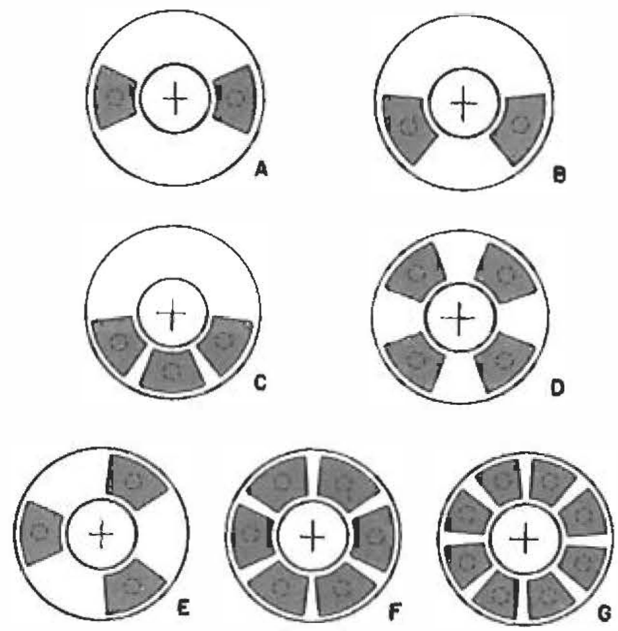


Figure 6
Diagram of shoe arrangements in Kingsbury Thrust Bearings.

A — Two-shoe equalizing arrangement; Figure 20, page 13.
B — Standard arrangement for two-shoe adjustable thrust bearings, marine and industrial; pages 18 to 20.
C — Three shoes, equalizing (special marine arrangement).
D — Four shoes, equalizing, for small bearings.
E — Three shoes for standard equalization by leveling washers Figures 12 to 14, page 12.
F — Six shoes in standard equalizing bearings, horizontal or vertical. Also in vertical six shoe adjustable hydroelectric bearings.
G — In special cases, equalizing bearings may use eight instead of six shoes. Large hydroelectric bearings use eight shoes, either adjustable or equalizing.

The Backing

Loads are transmitted from shoes to housing by devices which either do, or do not, *automatically* equalize the load among the shoes.

When the loads are equalized by manual adjustment, the bearing is called "*Adjustable.*" When the action is automatic, the bearing is called "*Equalizing.*" Every equalizing bearing is also self-aligning.

The Spherical Bearing (page 29) is self-aligning, although not equalizing. There are also a few special designs, mostly small, which depend for equal load distribution on precise grinding of the pivoted supports. They have flat collars and are not self-aligning.

"Adjustable" Bearings

In two large groups of bearings the load is divided by manual adjustment of massive "jack screws" which transmit the thrust to the housing. These are the two-shoe marine-type bearing, illustrated in Figures 9 and 10, and described on pages 16 to 18, and the six- or eight-shoe vertical adjustable hydroelectric thrust bearing, shown in Figures 7 and 8, and described on page 29.

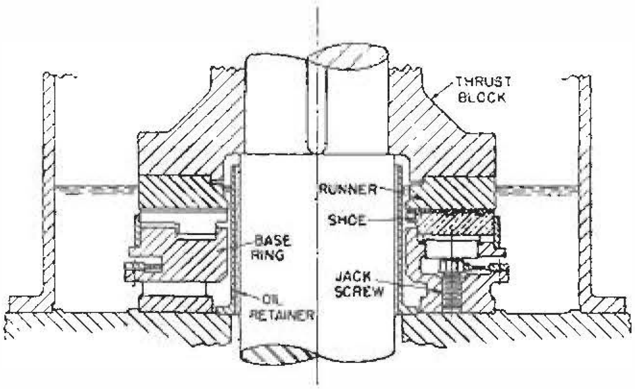


Figure 7
Elements of vertical adjustable thrust bearing.

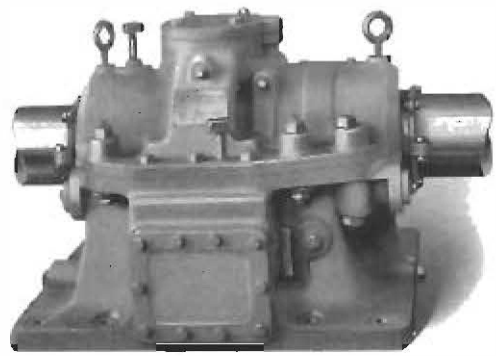


Figure 9
Small two-shoe adjustable thrust bearing with housing.

Figure 8
Vertical 69-inch adjustable thrust bearing, as furnished in 1921 for four 45,000 k.v.a. units of the Queenston, Ont., plant of the Ontario Hydro Commission, and in 1923 for three 62,000 k.v.a. units of the Niagara Falls Power Co., Cliff No. 3-C plant.

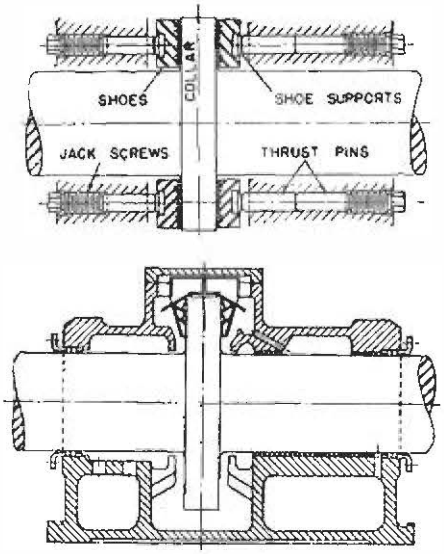


Figure 10
Elements of two-shoe adjustable thrust bearing; plan and vertical sections.

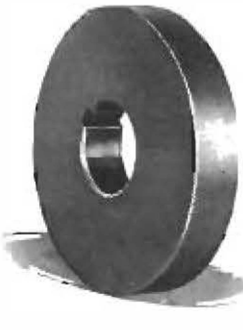


Figure 11
Standard (removable) collar for bearings with horizontal shaft.

"Equalizing" Bearings

Two principal methods of equalization are used. They are illustrated in Figures 12 to 17.

For the three-shoe bearings shown by Figure 13, the equalizing means consist of a "solid" (i.e., one-piece) spherical-seated "base ring" and solid "leveling washer," shown in the left side of Figure 15. These three-shoe bearings are used only in small to medium sizes. They may be either horizontal or vertical.

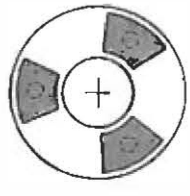


Figure 12
Standard three-shoe equalizing bearing (Style N) with shoes removed, showing hardened steel support plugs in shoe cage.

Figure 13
Three-shoe bearing, Style N. For vertical or horizontal shaft.

Figure 14
Style NV for vertical shaft. (Style N with runner added). Arrows show direction of oil flow.

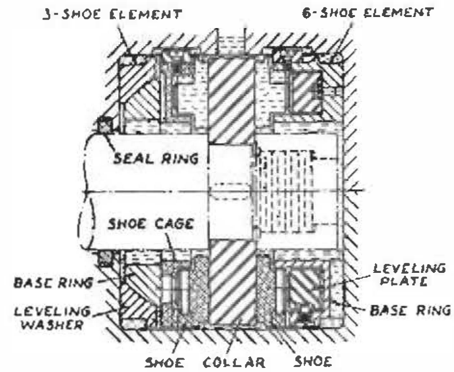


Figure 15
Three-shoe and six-shoe double horizontal thrust bearing elements.

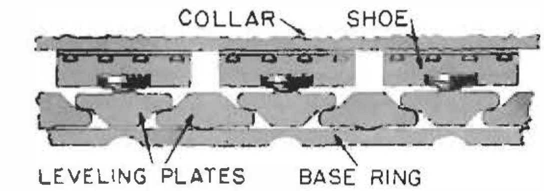


Figure 16
Developed diagram showing principle of equalized support of shoes by use of leveling plates.

For six-shoe bearings, and the occasional four- and eight-, the loads are equalized by a series of interlocking levers or "leveling plates," as shown in Figures 16 and 17. The shoes bear against the "upper" plates. The "lower" plates rock very slightly, on radial ribs formed

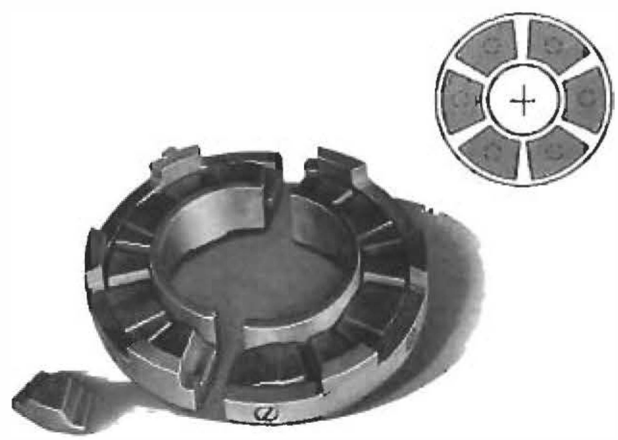


Figure 17
Split base ring and leveling plates of small (Style J) six-shoe bearing. A "lower" leveling plate is shown separately.

on their under sides, until every shoe takes an equal share of the load.

The leveling plates are loosely held in a "base ring," which may be in one piece, for assembling over the end of the shaft, or split (as in Figure 17) for radial assembling. The whole assembly (Figures 18, 19, 22) of base ring, leveling plates and shoes, with collar or runner, is mounted in a housing, and the lubricating and cooling systems are designed to suit either a horizontal or a vertical shaft,

Figure 20
Small two-shoe equalizing bearing for light loads. The split base ring rocks on a blunt knife-edge at right angles to the shoes.

Figure 18
Style J bearing assembly. (Shoes added to Fig. 17 parts). For vertical or horizontal shaft.

Figure 19
Style JV (6-shoe) thrust bearing for vertical shaft. (Runner added to Style J bearing). Arrows show direction of oil flow, inward at bottom of base ring, outward between shoes.

as required. The bearing may be "single," for one-direction load, or "double" for two-direction loads; or a six-shoe bearing for the main load may be combined with a three-shoe bearing for a lighter reverse load or simply to limit the end play. (See Figure 15.)

For light loads an equalizing type of two-shoe bearing has been developed: see Figure 20. It is often used on the unloaded side in six-shoe dredge pump thrusts; also in small sizes for compressors. Being split, it can be assembled over a shaft with integral collar, which cannot be done with the three-shoe type, Figure 21.

For vertical use the arrangements shown in Figures 21 and 22 are often convenient. In them a raised flange, forming part of the three-shoe leveling washer or the six-shoe base ring, holds the shoes radially in place, making it unnecessary to include such a flange in the housing design.

In large six- and eight-shoe hydroelectric units, equalization has given strikingly good results, as it eliminates the need of manual adjustment and is also unlikely to be put out of alignment by settling of the power house foundations, such as may occur in the mountainous regions where large hydro plants are most often built. It is referred to on page 29.

Left—Figure 21
Style LV (3-shoe) thrust bearing for vertical shaft. Runner is shown in phantom. For vertical uses this is often the most convenient form of three-shoe bearing, as it does not require a separate shoe-retaining flange.

Right—Figure 22
Style KV (6-shoe) thrust bearing for vertical shaft. Runner is shown in phantom. The base ring is in one piece and has a raised shoe-retaining flange. Styles LV and KV have interchangeable dimensions.

Symbols for Standardized Designs

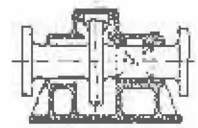
Kingsbury Thrust Bearings are built in a great variety of types and sizes. They may be regarded as a unique system of elements built around moving films of oil, rather than as specific articles of manufacture. Certain standardized components are used in various groupings, with lubrication and housing to suit.

Designs, past or present, sufficiently established to carry symbols are here listed. Current standards should be used wherever possible.

Bearings in Standard Housings

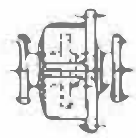
NOTE: The "size" of a thrust bearing is the outside diameter of the shoe face. The "size" of a journal bearing housing is merely a nominal figure. It is *not* the shaft diameter, which may range from 40% to 70% of the housing "size", depending on the style of bearing.

Horizontal Adjustable Two-Shoe Thrust Bearings, with Journal Bearing and Housing. Automatic Lubrication.



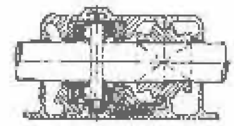
GK Bearing

Bearing Symbol	Usual Size Range	Description
GK	21-45	Journal bearing has lower half shell.
GH	9-19	Journal bearing has no shell.
GF	12-45	Journal bearing has full shell.
GC	9-27	See Fig. 27, page 20.



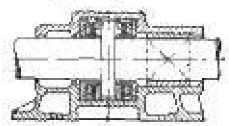
GC Bearing

Horizontal, Equalizing and Self-Aligning, Six-Shoe Thrust Bearings, with Journal Bearing and Housing. Also separate Self-Aligning Journal Bearings.



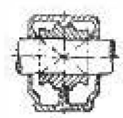
LG Bearing

Bearing Symbol	Usual Size Range	Description
LG	12-33	Self-oiling; water cooled. See Fig. 41, page 24.
FF	12-45	Has one journal shell. Not self-oiled.
FTF	12-45	Has two journal shells, not self-oiled. See Fig. 36, page 22.
L	12-33	Journal bearing only. Not self-oiled. See Fig. 53, page 31.
LD	12-33	Journal bearing with automatic disc lubrication. See Fig. 55, page 31.

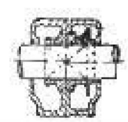


FF Bearing

Horizontal Equalizing Thrust Bearings in Housings, with Self-Aligning Journal Bearing. Also separate Self-Aligning Journal Bearing.

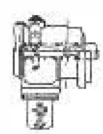


L



LD

Bearing Symbol	No. of Shoes	Usual Size Range	Description
CH	6 x 6	4-9	Self-oiling. See Fig. 37, page 23.
SH	6 x 3	5-9	Old type, resembling CH but less compact. Obsolete. (SH, SJH, SNH)
SJH	6 x 6	5-9	
SNH	3 x 3	5-9	
C	None	4-9	Journal bearing only. Fig. 39.
S	None	5-9	Like C, but bearing shell same as in SH.



CH

C

NOTE: The letter "S," added at the end of any bearing symbol, means that some special feature is used, though the design is otherwise standard. E.g., a "GHS" bearing might have high supporting flanges instead of the usual pedestal base.

Symbols for Standardized Designs

Housings Furnished by Purchaser

Vertical Six-Shoe Adjustable Types

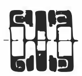
Bearing Symbol	Usual Size Range	Description
DV	19-73	See Figure 7. Shoes bored 43% of O. D.
DVM	19-73	Like DV, but shoes bored 50% of O. D.
DVL	19-73	Like DV, but shoes bored 56% of O. D.

Equalizing Types, Horizontal and Vertical

Elements Only

NOTE: "H" as part of symbol means that separate collar (Figure 11) is furnished by us. "6" or "3" means shoes on one side only of collar. "6 x 6," etc., means shoes on both sides. "J" and "B" base rings are usually split: "N" base rings are always solid.

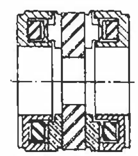
Bearing Symbol (*See Note*)	Horiz. or Vert. Shaft	No. of Shoes (*See Note*)	Usual Size Range	Description
JHJ	H	6 x 6	5-17	
JH	H	6	5-17	
JJ	H	6 x 6	5-17	
J	H	6	5-17	
BHB	H	6 x 6	5-45	
BH	H	6	5-45	
BB	H	6 x 6	5-45	
B	H	6	5-45	B base is same as for J series except thinner. See Fig. 31.
NHN	H	3 x 3	5-17	
NH	H	3	5-17	
NN	H	3 x 3	5-17	
N	H	3	5-17	


JHJ

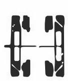

JJ


JH


J

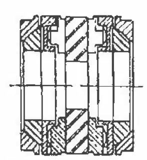

JHJ Elements
(See Fig. 30, page 21)


NHN


NN


NH


N

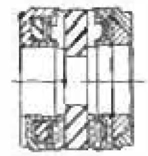

NHN Elements
(Compare JHN)

Symbols for Standardized Designs

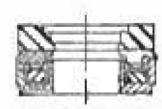
Equalizing Types, Elements Only

(continued)

Bearing Symbol (*See Note*)	Horiz. or Vert. Shaft	No. of Shoes (*See Note*)	Usual Size Range	Description
JHN	H	6 x 3	5-17	 JHN
JN	H	6 x 3	5-17	 JN
BHN	H	6 x 3	5-17	
BN	H	6 x 3	5-17	B base is same as for J series except thinner.
KV	V	6	5-17	 KV See Figure 22
LV	V	3	5-17	LV See Figure 21 
JV	V	6	5-17	 JV See Figure 19
BV	V	6	5-17	BV is like JV but thinner base ring.
NV	V	3	5-17	 NV See Figure 14, page 12.
KBV	V	6	19-45	 KBV Compare illustration page 30.



JHN Elements
(See Fig. 15, page 12)



JV Elements

Symbols for Miscellaneous Designs

Note: A few of these, which are marked *, represent specialized designs, made up only to meet unusual requirements and not considered standard. Some others are obsolete as *symbols* only, and represent designs still standard but now called by other symbols specified: e.g., old DH is now called BHB. Still others represent obsolete *designs* and are so indicated.

Bearing Symbol	Horiz. or Vert. Shaft	Solid or Split Base Ring	No. of Shoes	Usual Size Range	Description
AVS*	V	Solid	6	7-8	Resembles NV but 6 special shoes.
GV*	V	Solid	6	5-17	Adjustable shoes.
DH	H	Split	6 x 6	5-45	Now called BHB.
DNH	H	6 Sh. Split 3 Sh. Solid	6 x 3	5-17	Now called BHN.
DVS	V	Optional	6	19-73	Now called DV.
EH	H	Split	6	5-17	Now called B.

Symbols for Miscellaneous Designs

(continued)

Bearing Symbol	Horiz. or Vert. Shaft	Solid or Split Base Ring	No. of Shoes	Usual Size Range	Description
EV*	V	Solid	2	5-17	Equalizing base.
F*	H		None	12-45	Journal bearing unit: same rigid shell as in GF unit.
FGF*	H		2 x 2	32½	Liberty Ship design. Like GK but 2 journals.
FL	H		None	12-45	Obsolete design. Like F but longer shell.
FLP	H		None	12-45	Obsolete design. Like FL, plus viscosity pump.
FP	H		None	12-45	Obsolete design. Like F, plus viscosity pump.
GG	H	Split	2 x 2	7-27	Obsolete design. Double removable collar, equalizing; journal and housing.
GN	H	Split	2 x 2	7-27	Obsolete design. Resembles GG but integral collars.
GP	H	Split	2 x 2	7-27	Obsolete design. Like GN but pedestal base.
GV	V	Solid	3	5-17	Now called NV.
HH*	H		3 x 3	21-45	Equalizing thrust: otherwise resembles GF.
KH	H	Split	6 x 6	17-29	Obsolete design. Equalizing thrust, rigid shell, automatic lubrication.
KPH	H	Split	6 x 2	17-29	Obsolete design. Like KH but has 6 x 2 shoes.
LGL*	H	Split	6 x 2	21-33	Like LG but two journals.
LH	H	6 Sh. Split 3 Sh. Solid	6 x 3	5-17	Obsolete design. Like SH but low pedestal mounting; no cooler.
LL	H	Split	6 x 2	5-17	Obsolete design. Like LH, but through shaft with integral collar, 6 x 2 shoes.
LP	H		None	12-33	Obsolete design. Same as L, plus viscosity pump. Replaced by LD
MJV*	V	Split	6	5-17	Equalizing thrust and journal unit with housing.
MNV*	V	Solid	3	5-17	Equalizing thrust and journal unit with housing.
PH*	H		2 x 2	9-45	Adjustable bearing elements with horseshoe-shaped base ring.
PSV*	V	Solid	6	9-45	Spherical bearing.
SP	H		None	5-17	Obsolete design. Same as S plus viscosity pump.
SS	H	Split	6 x 2	5-17	Obsolete design. Like SH, but through shaft with integral collar, 6 x 2 shoes.
VML*	V	6 Sh. Split 3 Sh. Solid	6 or 3	5-17	Equalizing thrust and journal unit with housing.
Y	H		None	5-17	Obsolete design. Like S but high pedestal mounting.
YH	H	6 Sh. Split 3 Sh. Solid	6 x 3	5-17	Obsolete design. Like SH but high pedestal mounting.
YP	H		None	5-17	Obsolete design. Same as Y plus viscosity pump.
YY	H	Split	6 x 2	5-17	Obsolete design. Like YH, but through shaft with integral collar and 6 x 2 shoes.

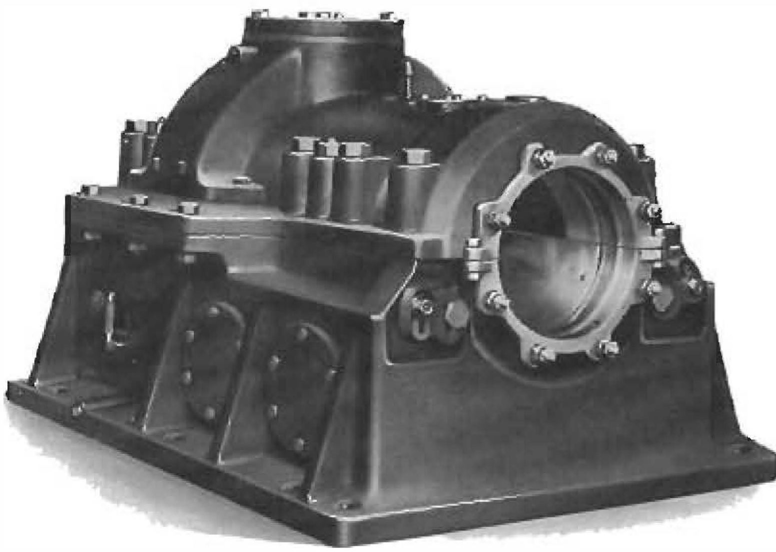
NOTE: A few of these, which are marked *, represent specialized designs, made up only to meet unusual requirements and not considered standard. Some others are obsolete as *symbols* only, and represent designs still standard but now called by other symbols specified: e.g., old DH is now called BHB. Still others represent obsolete *designs* and are so indicated.

Horizontal Thrust Bearings

Two-Shoe Adjustable Unit With Housing for Marine and Industrial Use

This type, examples of which are illustrated in Figures 23 to 29, was originally designed for use on engine-driven ship propeller shafts. Many thousands are in service, from towboats to cargo and passenger ships and tankers. Usually they are mounted just abaft the engine, sometimes on an extension of the bedplate.

So high is the load-carrying capacity of the oil film, that two shoes are usually ample to carry the thrust. The shoes are supported



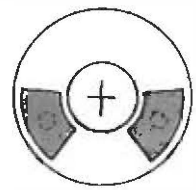


Figure 23
Large two-shoe adjustable thrust bearing. Shaft (with integral collar) omitted.

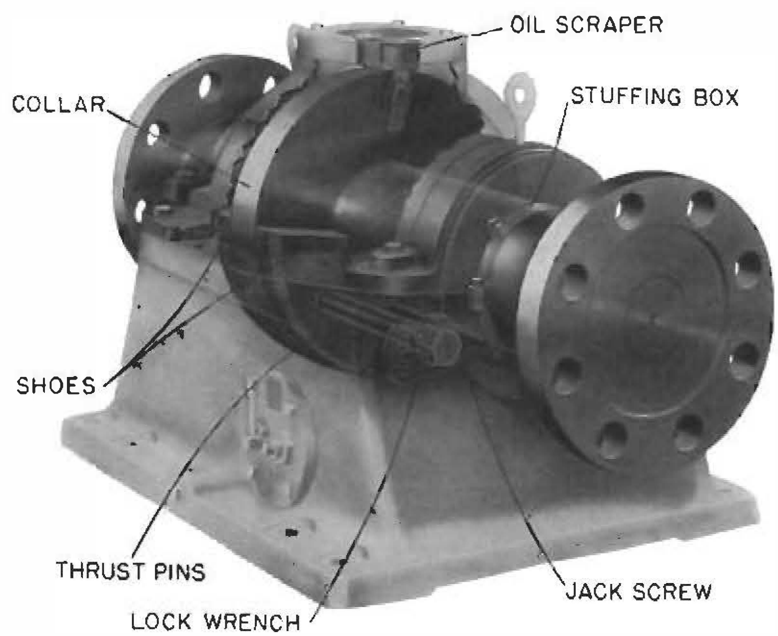


Figure 24
Medium-size two-shoe adjustable thrust bearing. Part of housing is broken away; part is in phantom, to show internal parts.

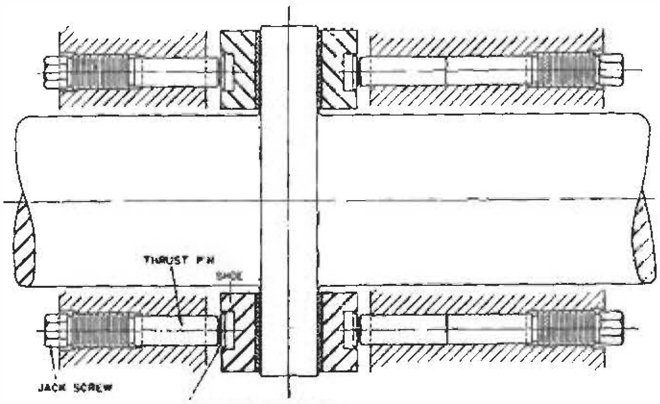


Figure 25
Plan section, showing thrust collar and shaft, shoes and jack screws.

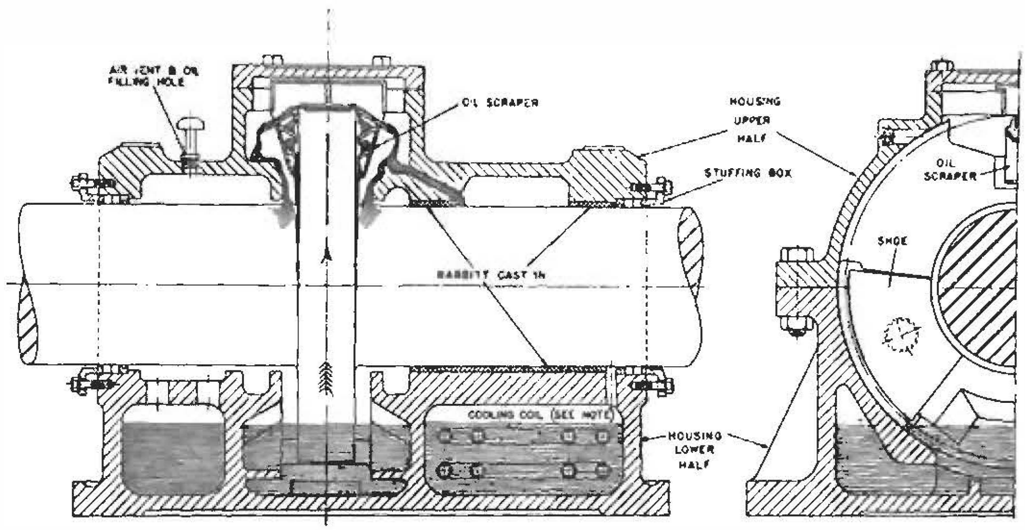


Figure 26
Vertical section, showing oil picked up by thrust collar and distributed to collar faces and journal bearing. The coil is used when the operating speed requires it.

loosely in the lower half of the housing, where they are backed by adjustable jack screws a little below the shaft center. Each shoe has a hardened, rounded insert in its back, which permits the characteristic slight tilting of the shoes.

The thrust collar is forged integral with a short section of the propeller shaft. Its diameter is approximately twice that of the shaft. In standard designs, a journal bearing is located close to the collar in the same housing.

In order to take the astern thrust and also to limit the end play, a second set of shoes and jack screws is provided, working against the after face of the thrust collar.

Lubrication is automatic. The bottom of the collar dips in an oil bath; and the oil adhering to it is taken off by a bronze scraper riding on top of the collar, and delivered in ample streams to both faces of the collar and to a large pocket over the journal bearing.

At the moderate shaft speeds usual in commercial vessels, the heat due to oil shear is carried away by the surrounding air and the foundation. This is called "air-cooled" operation. At higher speeds, a small water cooling coil may be added to absorb the surplus heat. Another method sometimes used is to supply cooled oil from an external lubricating system, with return overflow at the usual oil level.

Besides their use in ships, these two-shoe thrusts are much used in dredge pumps, unless the load and speed require the six-shoe type of thrust bearing. For dredges, the two-shoe construction is valuable for following-up of pump wear. Both two-shoe and six-shoe types can supply oil through pipes for lubricating the separate journal bearing near the pump impeller.

These bearings are used also, at still higher speeds and with special lubricating and cooling arrangements, for horizontal water turbines.

Various modifications of the standard design may be had to meet special conditions. Particulars will be given on request. The type is suitable for many industrial uses.

A modified form of two-shoe thrust bearing is shown in Figure 27. It is intended to be bolted over a circular opening made to receive it in the after end of a marine Diesel engine crankcase. Besides the thrust elements, it contains a journal bearing adequate to support the flywheel.

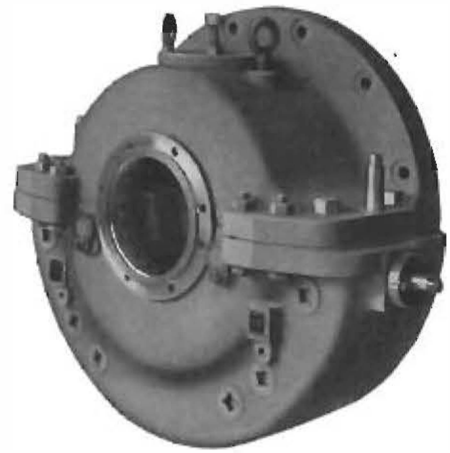


Figure 27
Compact two-shoe bearing for bolting to after end of Diesel engine crankcase.

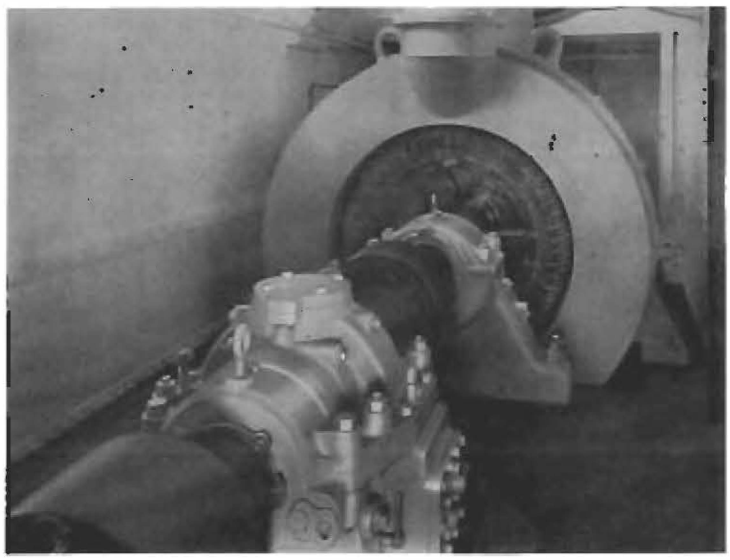


Figure 28
Two-shoe thrust bearing on propeller shaft of Diesel-electric hopper dredge, U.S. Army Engineers.

Photo by Trinity Court Studios

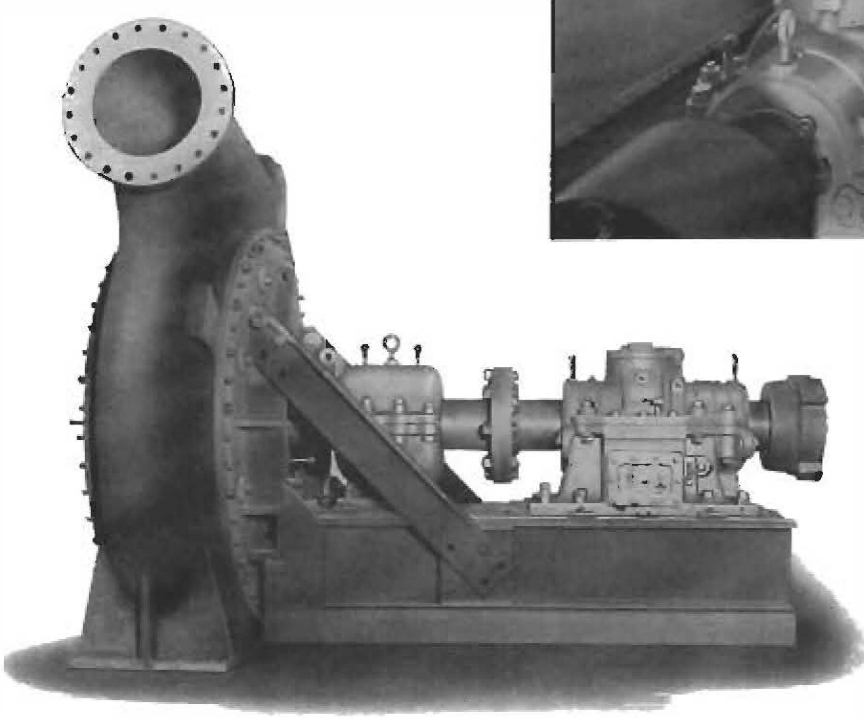


Figure 29
Kingsbury Thrust Bearing (two-shoe) and Journal Bearing used on dredge pump.

Courtesy Bucyrus-Erie Co.

Six-Shoe Equalizing Bearing

In these bearings, the load is equalized between the shoes by a series of interlocking levers or "leveling plates," illustrated in the photograph, Figure 17, and diagrammatically in Figure 16. By rocking slightly, they assure that every shoe gets its share of load and no more.

The six-shoe equalizing bearing consists of collar, shoes, leveling plates, and base ring, with provision for passing a stream of cooled and filtered oil through the thrust cavity. These elements are assembled in a housing which may be supplied by the machinery builder or by us. Though only horizontal applications are shown here, the same standard

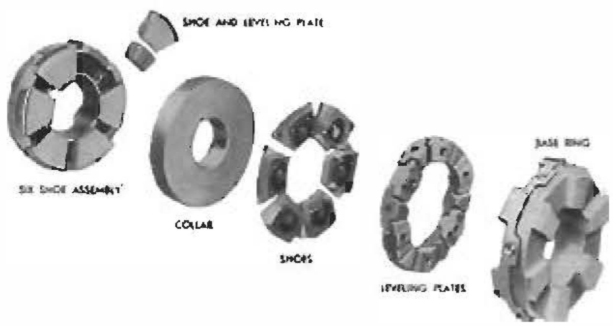


Figure 30
Small double (two-way) six-shoe thrust bearing. Near-side elements "exploded;" far-side elements assembled.

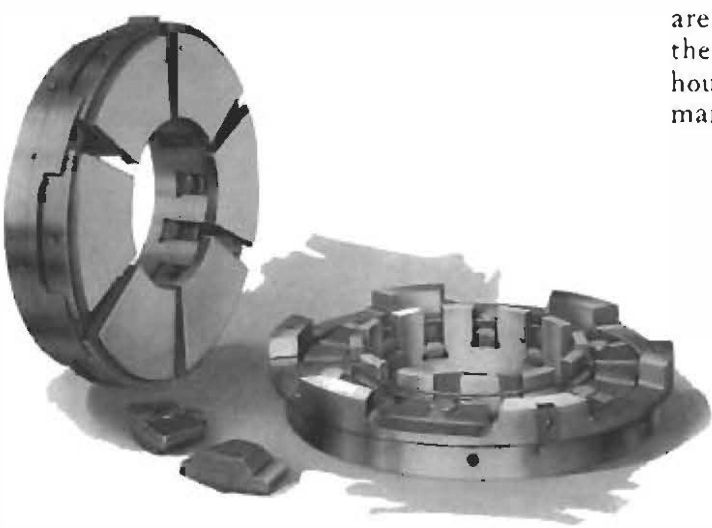


Figure 31
Large double six-shoe bearing, without collar. Base rings solid. Shoes of nearer set are omitted to show leveling plates. Two leveling plates (upper and lower) shown separately.

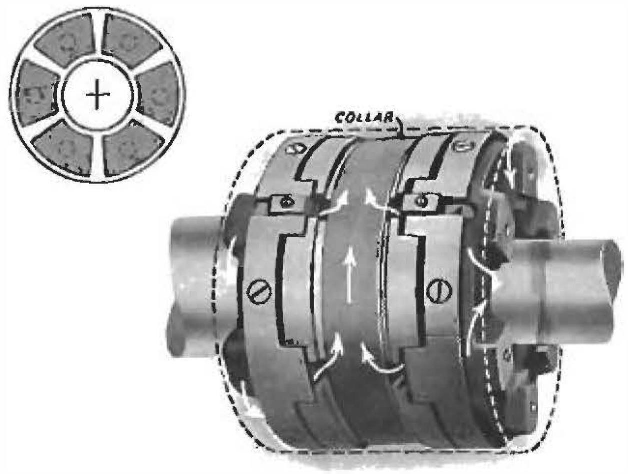


Figure 32
Small double six-shoe bearing assembled. Arrows show direction of oil flow.

elements are used in the vertical equalizing bearings shown on pages 12 (left side) and 13.

Usually the elements are alike on both sides of the collar (compare Figures 30 and 32), thus providing for two-way thrust, and also for limiting the end play. When the thrust is moderate, three or even two shoes may be used instead of six: the equalizing arrangements of these latter types are illustrated in Figures 15 (left side) and 33.

In the following pages, six-shoe bearings are shown assembled in housings designed for the commonest specific uses. In appropriate housings, the same bearings are suitable for many other uses.

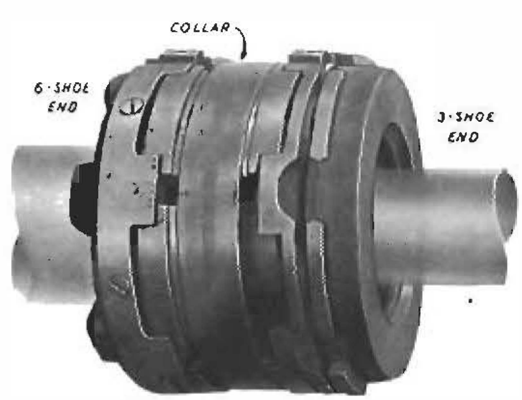


Figure 33
Small six-shoe and three-shoe bearing assembled with collar. Compare sectional drawing, Figure 15.

Marine Thrusts (Six-Shoe)

The equalizing thrust elements are very often built into the machinery housing. A typical example is the six-shoe double thrust bearing in a marine main reduction gear housing for turbine drive, Figure 34. A similar arrangement is shown in vertical section in Figure 35, with arrows indicating the oil flow. Stated generally, the method of lubrication is to introduce the oil under nominal pressure. It flows toward the shaft, past the leveling plates. On meeting the collar it flows outward between the shoes, and escapes at the top, carrying away the heat due to oil friction.

With six shoes instead of two to carry the load, the diameter of a six-shoe bearing can be much less than that of a two-shoe bearing for a given thrust. Since the bearing in Figures 34 and 35 is at the forward end of the propeller shaft, the shaft size at that point can be reduced to fit the bore of a six-shoe collar of appropriate size. This again favors incorporation of the Kingsbury Thrust into the gear housing.

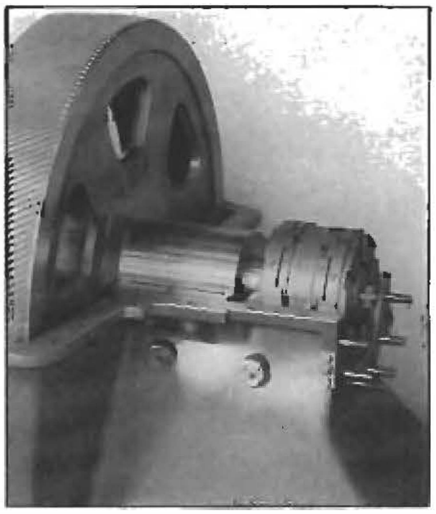


Figure 34
Double six-shoe bearing built into forward end of marine reduction gear case.
Courtesy Westinghouse Electric Corp.

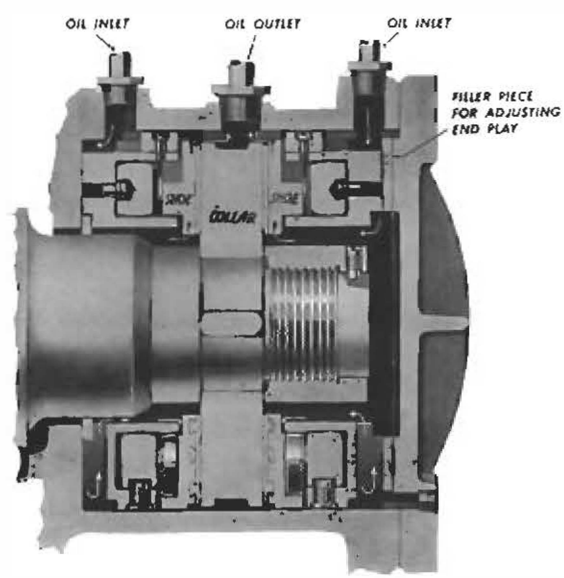


Figure 35
Vertical section of double six-shoe bearing in housing. Arrows show direction of oil flow.

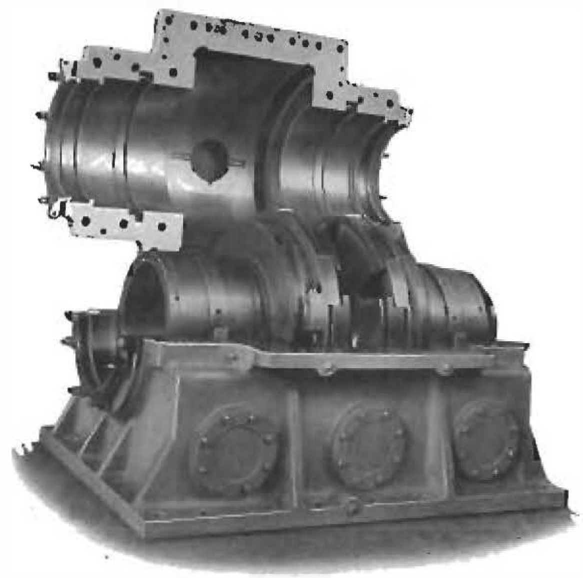


Figure 36
Large double six-shoe thrust bearing, Style FTF, for use in shaft tunnel of twin-screw ship. Collar (not shown) is forged integral with thrust shaft.

In medium to large sizes, these built-in Kingsbury Thrusts are used in the main reduction gears of many turbine-driven U. S. Navy vessels, and many U. S. turbine-driven liners and cargo vessels. Figure 31 shows such a bearing, larger than that in Figure 32 and partly disassembled to show the leveling plates.

In large, multiple-screw ships the six-shoe separately-housed type of thrust bearing, shown in Figure 36, is sometimes used, with thrust collar forming part of a section of the propeller shafting.

Boiler Feed Pump Thrusts

Most horizontal multi-stage centrifugal pumps, especially for boiler feeding, develop considerable end thrust. The problem is also important in fire, oil pipeline and refinery hot oil pumps. In view of the very responsible nature of their duty, completely dependable thrust bearings for these pumps contribute materially to the uninterrupted functioning of the entire installation.

Figures 37 to 39 show a type of self-contained, self-lubricating thrust bearing developed for either end of a centrifugal pump. The same mounting contains a compact, highly efficient, self-aligning journal bearing. Both are lubricated by oil from an oil-circulating ring surrounding the thrust collar, similar in principle to the oil circulator forming part of the standard six-shoe dredge pump thrust bearing (page 24).

Immediately on starting, oil from the circulator fills the restricted space around the thrust elements, between the seal rings, and also flows under pressure to the journal bearing. From those it passes to the cooler (attached under the housing) and thence back to the bath. The journal bearing is so grooved as to minimize foaming and facilitate cooling by the oil stream; and the self-aligning feature assures even distribution of the load.

Frequently, the inboard end of the pump carries a journal bearing duplicating the features of the journal bearing built into the thrust mounting. When that is done, suitable supply and return piping connects the two bearings, and the thrust "oil circulator" supplies both.

For pumps so designed that the standard bearing unit here shown cannot be attached to the pump housing, we can furnish the 6-shoe or 3-shoe elements shown in Figures 32 and 33, for use in housings built to receive them.

Figure 38
Oil circulator as used in boiler feed pumps.

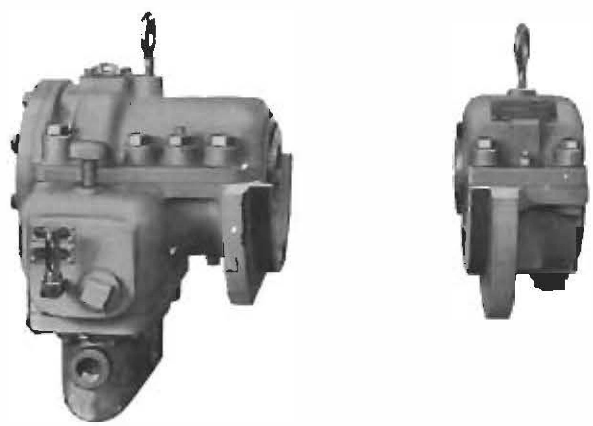


Figure 39
Standard Style CH thrust bearing, with built-in journal bearing, and separate Style C journal bearing for inboard or drive end of pump.

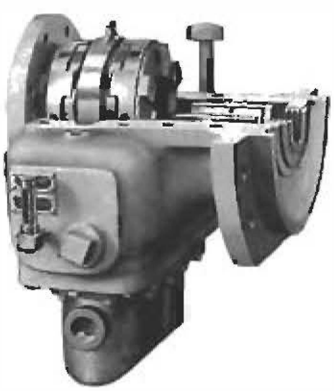


Figure 37
Standard Style CH thrust bearing, with built-in journal bearing and attached cooler, for boiler feed pumps. Oil circulator surrounds thrust collar.

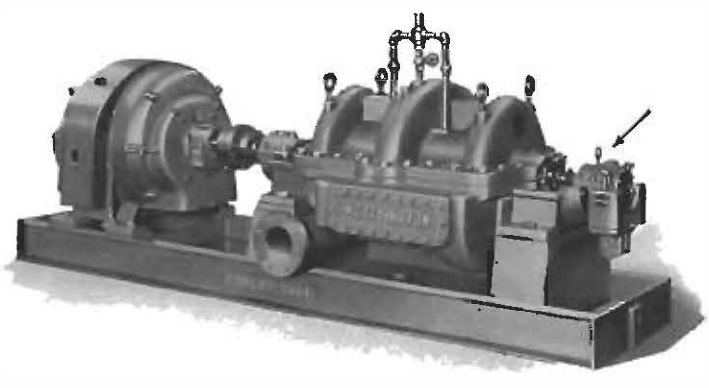


Figure 40
Small (4-inch) Style CH thrust bearing on outboard end of centrifugal pump.

Courtesy Worthington Pump & Mchy. Corp.

Dredge Pump Thrusts (Six-Shoe)

A heavy-duty dredge pump requires a massive journal bearing, located as close as possible to the pump impeller, and a combined thrust and journal bearing at the drive end of the pump shaft. A suitable form of journal bearing is shown on page 31. It receives oil circulated from the thrust bearing by pumping action generated in the latter, as described below.

The equalizing elements of these thrust bearings—shoes, leveling plates and base rings—are identical with those of the six-shoe marine thrust bearings already described. Since the thrust is normally one way, a two-shoe bearing on the unloaded side is sufficient to restrict the end play. The thrust collar is usually forged on the shaft.

The heavy loads and high speeds of dredge pump operation require use of an oil cooler. To circulate the oil, use is made of the cling of the oil to the collar rim. The collar runs inside a stationary bronze ring called the "oil circulator" or "pumping ring," as wide as the collar rim and internally grooved. Oil taken from the bath builds up a pressure in the ring groove, by which it is forced into the thrust cavity on each side of the collar, and also to the built-in and separate journal bearings. As there are no moving parts except the collar itself, the chance of failure in a separate pump is eliminated. (See the similar device used with boiler feed pump thrusts, Figure 38.)

Steam Turbine Thrusts

At the high speeds of small turbines it is desirable to move the oil through the thrust bearing with the least possible churning and resultant power loss. This is accomplished by

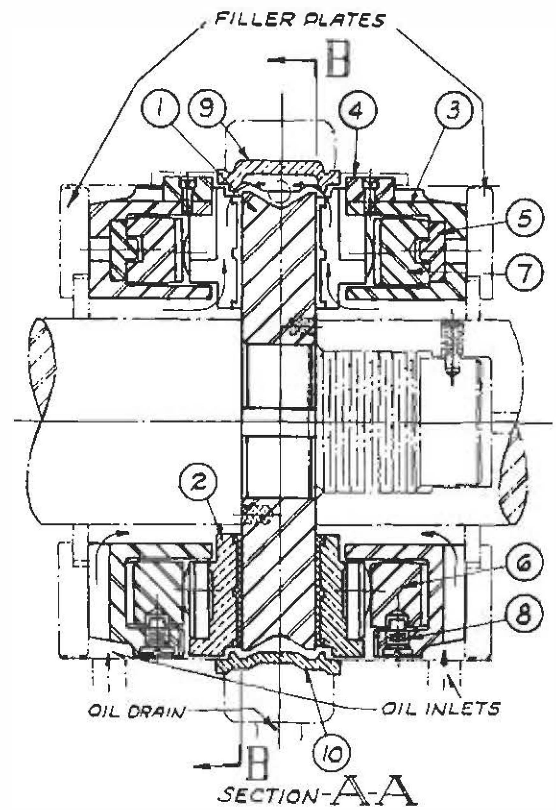


Figure 42
Double six-shoe bearing with oil control ring for high speeds. (Three-shoe bearings may be used instead of six-shoe.)

(1) Collar; (2) Shoe Assembly; (3) Base Ring (split); (4) Base Ring Key; (5) Leveling Plate Support; (6) Upper Leveling Plate; (7) Lower Leveling Plate; (8) Leveling Plate Set Screw; (9) (10) Oil Control Ring (in halves).

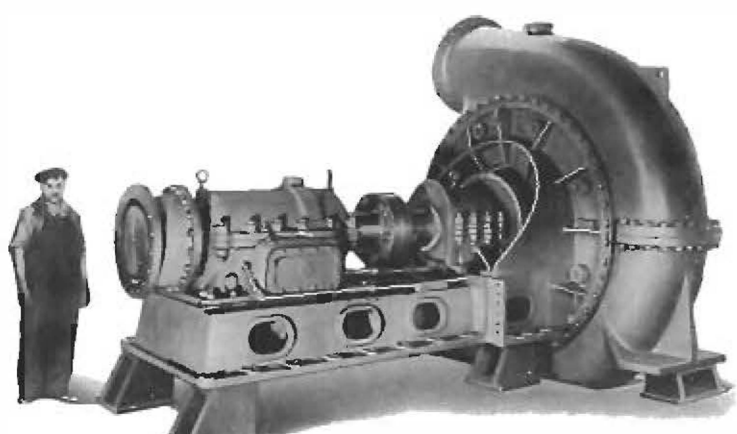


Figure 41
Combined journal and six-shoe thrust bearing, and separate journal bearing, for heavy-duty dredge pump. Dredge "GULF STREAM."
Courtesy McWilliams Dredging Co.

Figure 43
Oil Control Ring for high-speed steam turbine thrusts.

the addition of an "oil control ring," which surrounds the collar but does not move. The collar (otherwise standard) has a grooved rim, making in effect a low flange at each edge. The control ring is internally grooved to match the flanges, and each groove has a tangential outlet at the top. See Figures 42 and 43. Thus oil thrown off by the flanges is carried around the grooves and expelled horizontally at the top, as if from the discharge outlet of a centrifugal pump. Unlike most Kingsbury horizontal equalizing bearings, these steam turbine thrusts have no definite oil level: when running, oil reaching the shoes and collar is promptly expelled before it can recirculate and become heated by churning.

Either six shoes (with leveling plates), or three shoes (with leveling washers), may be used in most cases. For the three-shoe bearing, see next paragraphs.

Three-Shoe Equalizing Elements

When the thrust load (e.g., of a pump or turbine) is low for the shaft size, the standard three-shoe instead of six-shoe elements may be used. See Figure 13, page 12. They afford some saving in the power loss due to oil shear, which is considerable at higher speeds. The shoes are like those of most six-shoe bearings; but their "solid" (i.e., one-piece) spherical-seated base ring and solid leveling washer must be assembled over the end of the shaft. The shoes are held in a "cage" so shaped as to receive and direct the flow of oil, substantially as is done by the six-shoe base rings already described.

These three-shoe elements are interchangeable as to size with the standard six-shoe elements. They are standardized only in sizes up to 17 inches diameter of collar.

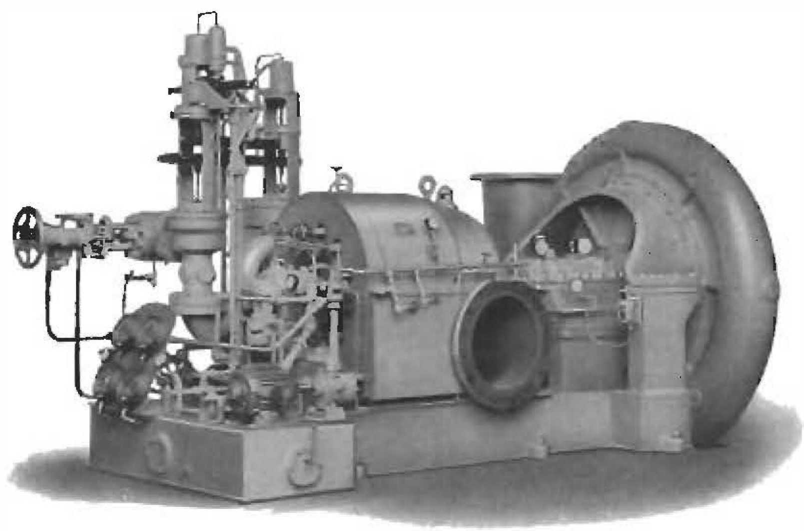


Figure 44
Steam turbine driving centrifugal blower. Kingsbury Thrust Bearing is built into the journal housing between turbine and blower.

Courtesy Roots-Connersville Blower Corp

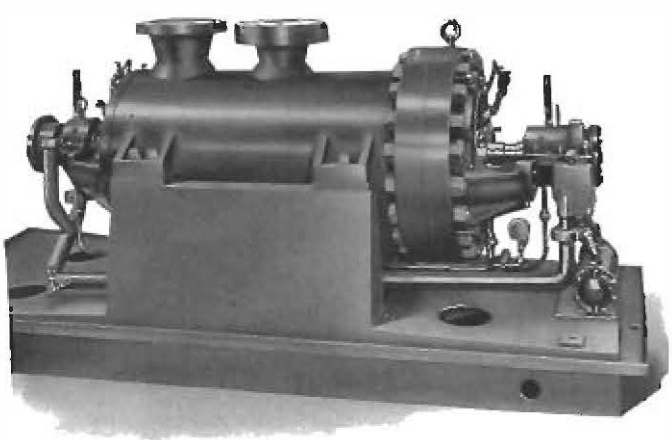
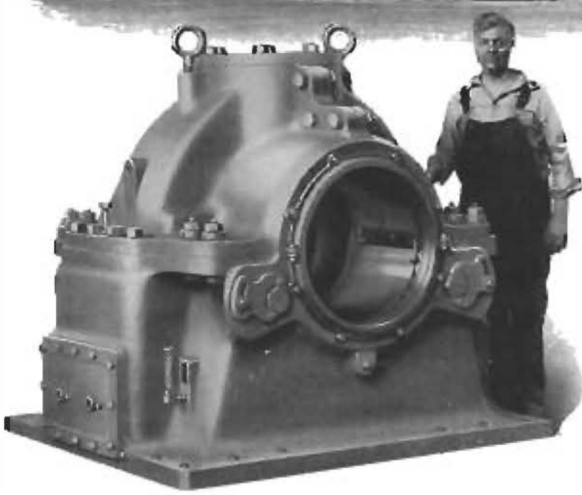


Figure 45
Seven-stage boiler feed pump fitted with Kingsbury combined Thrust and Journal Bearing, also separate (inboard) Journal Bearing.

Courtesy Byron Jackson Co

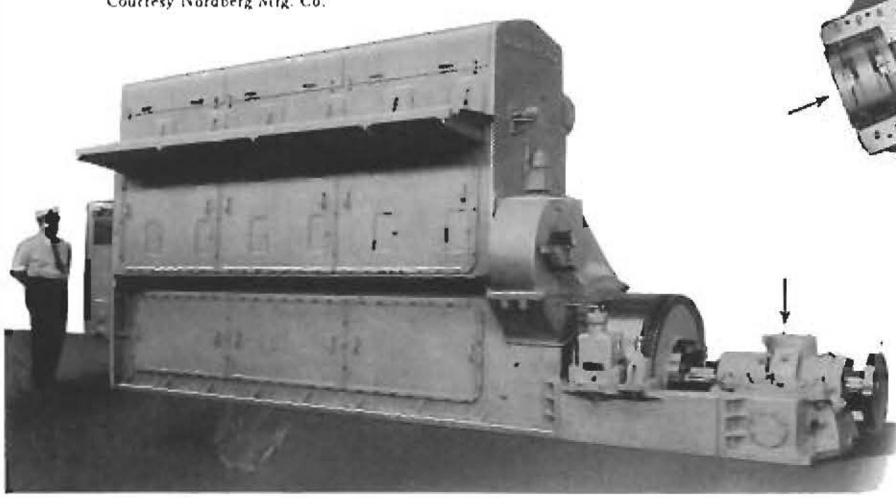
Oil tanker propelled by Sun-Doxford engine. One of many Kingsbury-equipped motor tankers built for Sun Oil Co.

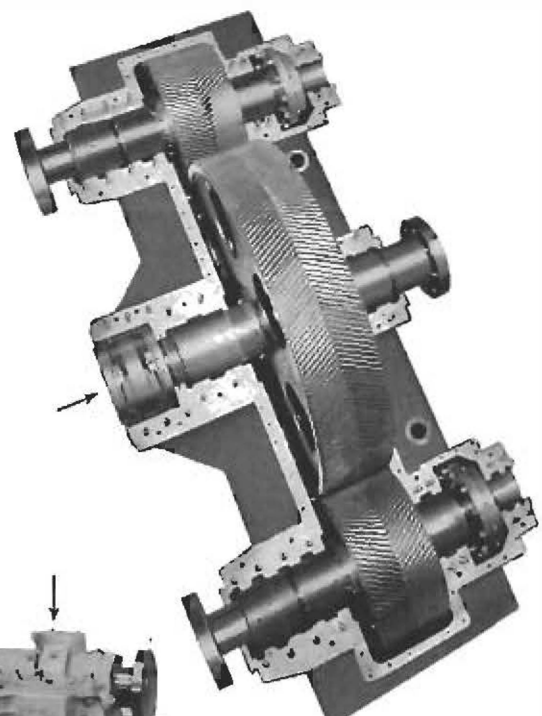


Two-shoe thrust bearing for Sun-Doxford Diesel engine.

Marine Diesel engine, rated 750 h.p., with Kingsbury 21-in. two-shoe thrust bearing. Installed on Socony-Vacuum tanker on Great Lakes.

Courtesy Nordberg Mfg. Co.





Reduction gear set for marine Diesel engine, with Kingsbury six-shoe thrust bearing.

Courtesy Farrel-Birmingham Co.

Special-Purpose Thrusts

The Kingsbury principle can be applied to many special conditions. An example is the wood pulp refiner shown in Figure 48. The thrust is heavy, the space available limited, and the speed—although moderate—is high enough to be destructive to the anti-friction bearings which were first tried. Standard Kingsbury Thrusts have met the requirements easily.

Still more unusual is the rubber plasticator shown in Figure 47. This machine, operating somewhat like a huge sausage machine, masticates the rubber stock and forces it out under tremendous pressure through a constricted opening. The shoes are carried on the shaft and revolve with it. The collar is stationary, hollow, and cooled by a stream of water running through it.

This rubber plasticator runs slowly—about 25 r.p.m.—and uses heavy oil. At the opposite extreme in speed and service is the 3¼ in. three-shoe bearing shown in Figure 46. Destined for an airplane supercharger, it is designed to carry 1000 lbs. load at 30,000 r.p.m.

Figure 46
Small one-way three-shoe thrust bearing for airplane supercharger. Load, 1000 lbs.; speed 30,000 r.p.m.

Between and even beyond the extremes above cited, wherever a Kingsbury Bearing can be properly mounted and supplied with circulating oil, the machinery designer can be sure of getting indefinitely long life, low friction and nominal maintenance, by availing himself of the Kingsbury principle and the experience of the Kingsbury organization.

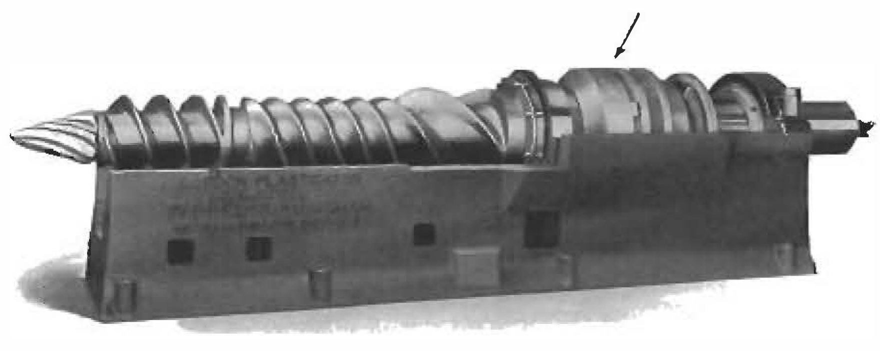


Figure 47
Kingsbury special 6 x 4-shoe Thrust Bearing built into rubber plasticator.

Courtesy Farrel-Birmingham Co.

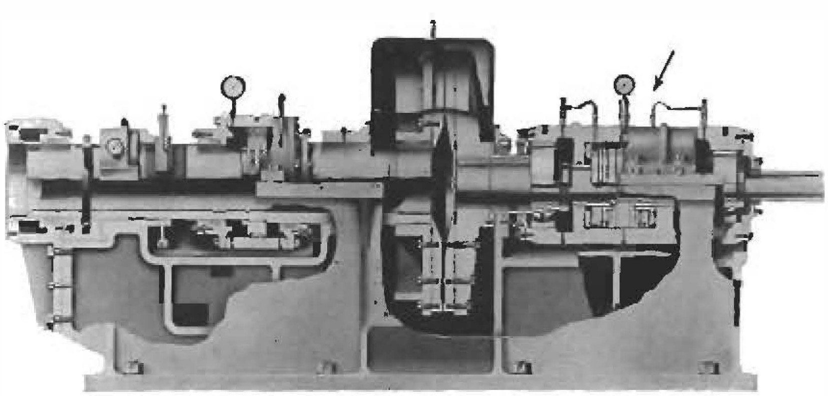


Figure 48
Kingsbury 6 x 3-shoe Thrust Bearing, built into wood pulp refiner.

Courtesy Sutherland Refiner Corp.

Vertical Thrust Bearings

Equalizing Types

Vertical equalizing bearings of three-shoe and six-shoe types, in all but the very largest sizes, employ the same arrangements of shoes, leveling washers or leveling plates, and base rings that are standard for horizontal bearings of equalizing types. (See pages 12 and 13, also 21.)

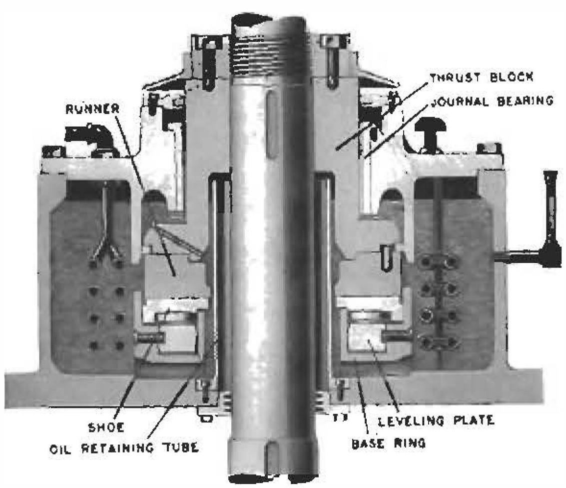


Figure 49
Vertical equalizing thrust bearing, using Style KV elements in housing with guide bearing and cooling coil.

Below hydroelectric sizes, these vertical equalizing bearings are extensively used in vertical pumps for deep wells, condenser circulation, unwatering dry docks, etc., and with vertical electric motors for any purpose. In small sizes, they are used in vertical turbines, driving condenser pumps and for similar services.

Although the standard arrangement of shoes, etc., is the same in vertical as in horizontal equalizing bearings, the lubrication is much simpler. In a horizontal bearing it is necessary to provide against escape of oil at the bearing ends. But in a vertical bearing the shoes and lower face of the runner can be submerged in the oil bath, which is kept from running down the shaft by a fixed retaining tube, loosely surrounding the shaft and rising above the bath level. This is shown in Figure 49. The cooling coil, if one is needed, is immersed in the bath. If the oil is clean and protected from contamination, it may be used indefinitely with only periodic checking against impurities, and make-up for evaporation.

Circulation is induced by the motion of the runner. A guide bearing located above the thrust bearing can be lubricated from the thrust bath by using either the centrifugal or the viscosity principle to lift the oil, without separate moving parts.

In moderate sizes, the thrust bearing is usually located at the top of the shaft. In hydroelectric sizes, the thrust may be located either at the top or between the generator and the water turbine, as is most convenient.

Figure 49 shows a common form of combined thrust and guide bearings, designed for electric motor drive of vertical pumps, etc. For electric motor speeds, oil is lifted from the bath to the guide bearing by using centrifugal force, going by way of a radial hole drilled in the flanged lower end of the journal sleeve, which also acts as the "thrust block," transmitting the thrust load from the shaft to the thrust bearing runner. A seal ring confines the oil and forces it upward.

Figure 50 shows a similar thrust bearing, but without guide bearing.

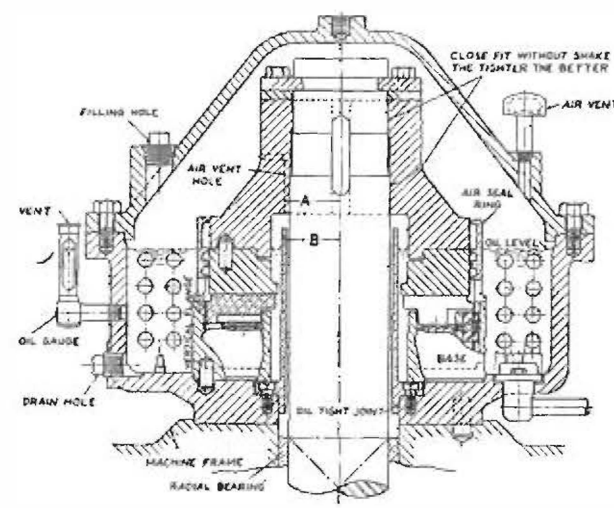


Figure 50
Simple vertical mounting with cooling coil and air seal ring. Thrust bearing may be Style LV or KV.

Adjustable Type (Hydroelectric)

This is the best-known hydroelectric type, of which the historic first Holtwood bearing was the ancestor. The runner is a cast iron disc, several feet in diameter, sometimes divided into segments to facilitate assembling, and bolted to the under face of a massive steel "thrust block" keyed to the shaft. In the larger sizes, there are eight shoes instead of six. They are so shaped and supported as to ensure their remaining flat when loaded—an important point with loads which may run well over 500 pounds per square inch. The massive "shoe supports" are separate pieces, each containing a hardened pivotal insert which rests on the hardened face of a jack screw.

Figure 51
Eight-shoe adjustable thrust bearing; one of three at Guntersville Dam, TVA System. Size 87 in.; load 2,000,000 lbs. Speed 69.2 r.p.m.

The runner faces are finished and joined with the utmost care; and corresponding care is needed in finishing the thrust block face, that it shall be precisely square with the bore and true to a straightedge throughout.

Equal distribution of the load among the shoes is accomplished by a special procedure of careful sledging of the jack screw wrenches. The same procedure may sometimes be used to plumb the shaft and center the rotating elements of the generator or turbine, or both.

These hydroelectric thrusts run in an oil bath similar to that of the smaller equalizing bearings above described, with a cooling coil.

For protection against stray currents, it is usual to insulate the thrust elements from the housing base.

Occasionally a sample of oil should be drawn from the bottom of the bath, to check for possible contamination, and oil is added as needed to make up for evaporation. Good oil, kept clean, lasts for many years.

Unlike most horizontal thrusts, a hydroelectric bearing starts and stops fully loaded. However, experience has shown that enough oil adheres to the working faces, even after a shutdown, to make special provision for starting unnecessary if the bearing was properly installed and the jack screws carefully adjusted.

In case settling of the power house foundation is to be anticipated, the safest precaution is to use the equalizing type of thrust bearing, for which a special hydroelectric design has been developed. (See illustration, page 30.)

Spherical Type

This is, in effect, a self-aligning bearing, in which that feature is obtained by the use of a spherical-faced runner, bearing on six spherical-faced shoes supported in a solid base ring. It combines in a single set of elements, the functions of a thrust bearing and a guide bearing. The shaft center is always held exactly at the center of the spherical surface.

A feature of the spherical bearing which is sometimes valuable is the absence of any side play, such as may occur in the conventional guide bearing owing to the necessary allowance for running clearance. Under all conditions for which a spherical bearing is designed, its side play is zero.

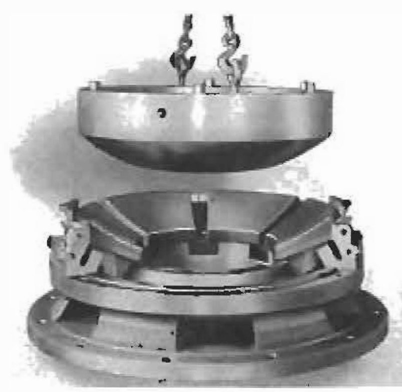
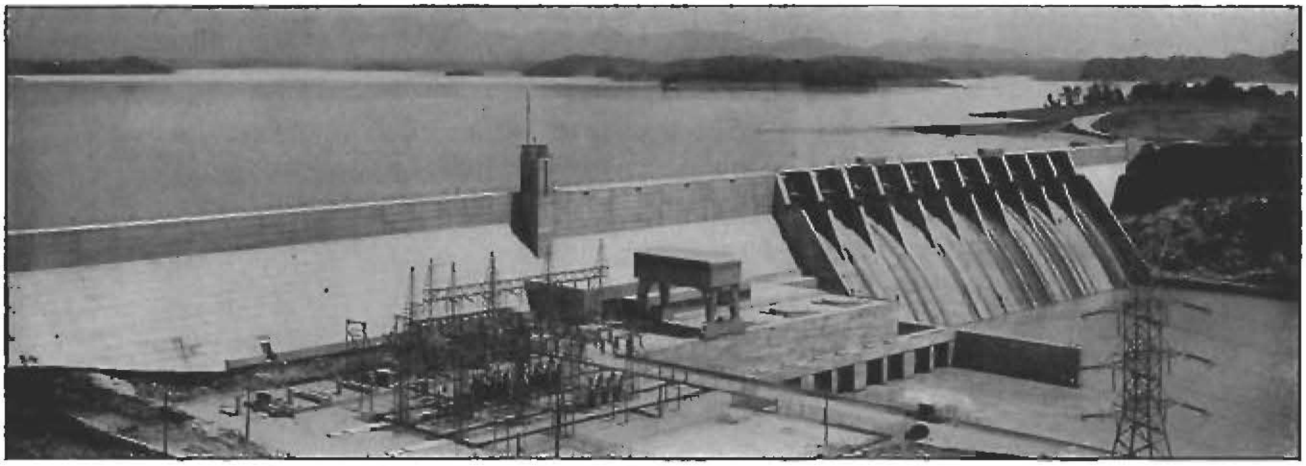


Figure 52
Six-shoe spherical thrust bearing, Rosetilla Hydro-electric Development, Mexico. Size 45 in. Load 300,000 lbs. Speed 128 r.p.m.

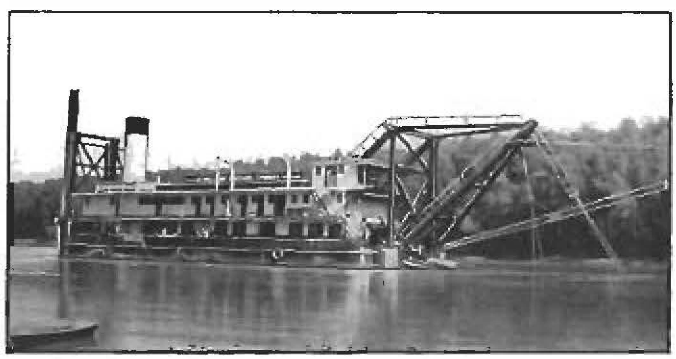


Douglas Dam, TVA System. General Electric Co. generators with 89-in. Kingsbury adjustable bearings.

Hydroelectric thrust bearing, equalizing type. For Elliott generator, All-American Canal, California. Size 53 in. Load 555,000 lbs. Speed 150 r.p.m.

Chickamauga Dam power station, TVA System. Allis-Chalmers generators with Kingsbury 93-in. adjustable bearings. Load 2,075,000 lbs. Speed 75 r.p.m.

Dredge "GULF STREAM"; McWilliams Dredging Co. Kingsbury Thrust Bearing and Journal Bearing on dredge pump shaft.



Kingsbury Journal Bearings

Kingsbury Journal Bearings are designed to utilize the same laws of oil film behavior which are so strikingly exemplified in Kingsbury Thrust Bearings. All employ flooded lubrication to carry away the heat of oil shear. All shells are so grooved as to carry the oil stream to every part of the loaded area, and also to prevent loss of load support at the ends due to foaming. Bearings with self-aligning shells assure uniform film thickness from end to end. Thus maximum use is made of the theoretical load-bearing capacity. When properly installed, suitably loaded and kept supplied with oil, they should—like the thrust bearings—last indefinitely without repairs.

The journal bearings built into self-contained mountings for thrust bearings have already been briefly mentioned; also the separate journal bearings for the inboard ends of centrifugal pumps. Besides those, there are two principal types of heavy journal bearings, shown in Figures 53 and 55. There is also a special design, Figure 54, which eliminates shaft vibration due to oil whirl at very high speeds, and is also strikingly compact.

Line Shaft Bearing
(Marine Propulsion)

This bearing, Figure 55, is wholly self-contained, since it generates its own oil circulation. A disc, spring-clamped on the shaft, picks up oil from the bath, and delivers it to a bronze scraper bearing against the face at the top of the shell. The shell is self-aligning: unlike the shell in Figure 53, it is intended only for downward loads. This bearing is particularly suitable for use in shaft tunnels, as it runs for long periods without attention.

Figure 53
Heavy journal bearing with self-aligning shell, for dredge pumps.

Dredge Pump Bearing
(Heavy Duty, Self-Aligning)

This bearing, Figure 53, is designed primarily for the impeller end of dredge pump shafts. It is self-aligning, and is so lubricated as to withstand the severe test imposed by a rock whirled in the impeller. It is customarily used in connection with a Kingsbury combined thrust and journal bearing at the drive end, and receives oil from the latter's built-in "oil circulator" or "scraper." (See pages 20 *top* and 24 *left column* regarding this.)

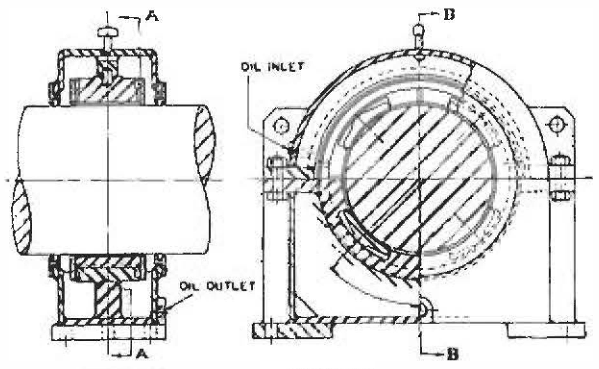


Figure 54
Journal bearing with rocking shoes, for very high speeds.

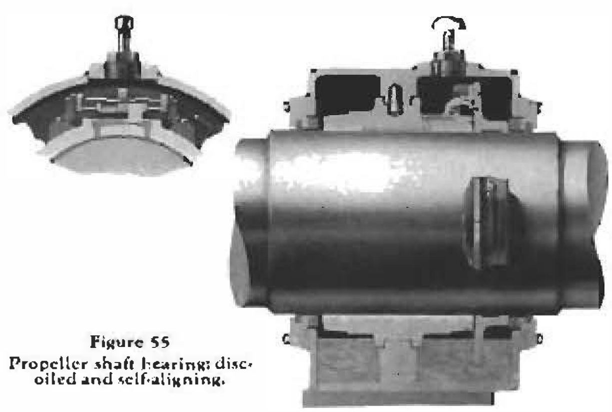


Figure 55
Propeller shaft bearing: disc-oiled and self-aligning.

Lubrication and Cooling

The basic principles of Kingsbury lubrication are: (1) to flood the bearing surfaces with oil, thus giving full opportunity for the oil films to assume the wedge form; (2) to circulate the oil rapidly enough to remove the heat due to shearing of the films; (3) to suit the viscosity to the load and speed. The methods of doing these things depend on conditions. Most of them have been indicated in the preceding pages.

If, as in a central station, a horizontal bearing can be tied into a general oil circulating system, the simplest plan may be to feed cooled and filtered oil under system pressure to the thrust cavity and discharge it at the top. This plan is used also with thrust bearings built into turbine-driven marine reduction gears, as in Figures 34 and 35. For such bearings, the oil rate is influenced very largely by the speed.

However, it is often preferable or necessary that the thrust bearing shall be completely self-contained, with its own devices for circulating and cooling the oil. Most two-shoe horizontal adjustable bearings, Figures 24 and 26, are in this class. The oil is circulated by the thrust collar, dipping into the bath of oil.

When the speed is high enough to require water-cooling, a copper coil is installed in the oil bath, or an oil cooler is mounted alongside the housing. At moderate speeds the bearing operates air-cooled. Air in motion is considerably more effective than still air. Wood foundations are inferior to steel for dispersing heat.

Centrifugal pumps, using mostly compact six-shoe bearings, require compact circulating and cooling arrangements. For boiler feeding and similar service, the need is met by the built-in oil circulator and small attached cooler shown in Figures 38 and 37: for special conditions other cooling arrangements may be used. Oil under pressure from the circulator is frequently piped to the inboard pump bearing, and then returned to the thrust housing.

On an enlarged scale a similar lubricating and cooling arrangement is used for dredge pump thrusts, with oil similarly piped to, and returned from, the journal bearing next to the impeller.

Using an extension of the same principle, isolated journal bearings anywhere can be lubricated by attaching a "pumping disc" to the shaft to circulate the oil. Compare the Line Shaft Bearing, Figure 55, page 31. If the shaft speed permits, the centrifugal principle may be used in a similar way.

With vertical bearings, lubrication of the thrust elements is simple (see Figures 49 and 50). Usually a cooling coil can be placed in the bath if needed; or oil from the bath can be circulated through an outside cooler. The adjacent guide bearing can be lubricated without additional moving parts, by using the centrifugal principle if the speed permits. If the speed is too low for that, the viscosity principle may be invoked, somewhat as it is used in the "oil circulator" of pump thrust bearings. A shallow-grooved stationary ring, facing against one of the submerged rotating elements, takes oil from the bath and delivers it to the oil space leading to the guide bearing just above. Oil issuing at the top of the guide bearing drains back to the bath.

The power loss due to oil shear under given running conditions can be calculated definitely. When using an external oil circulating and cooling system, the rate of oil flow can be stated for any desired temperature rise, usually from 10° F. to 25° F. When using an internal water cooling coil, or an attached oil cooler, the required rate of water supply can likewise be figured. For any new set of conditions, we should always be consulted regarding oil or water rates, and also regarding viscosity.

Load Ratings: What They Mean

We have found no definite speed limits for Kingsbury Thrust Bearings. Because the shoes are free to tilt, increasing speeds tend to draw more oil between shoes and collar, thereby adding to the load capacity; and this fact is taken into account in the rating tables. The main point to be watched, at high speeds, is to avoid churning and consequent heating of the oil. This is the reason for the Oil Control Ring type, described on page 24.

Stated accurately, the load capacity cannot be expressed in "pounds per square inch:" it depends on the thickness of the films of oil. And the film thickness depends not only on load and speed but on the size and proportions of the shoes and on the operating viscosity. Viscosity, in turn, depends on grade and temperature. With load and speed specified, size, oil viscosity and general design must be made to suit. In all cases, provision must be made for removing the heat of oil friction. These facts explain why we should have full particulars regarding intended use.

Our rating tables specify load capacity for given size and number of shoes, of given bores to suit shaft diameter, at given speeds, with oil of "standard" viscosity. Other things being equal, the load capacity is roughly proportional to the viscosity at bath temperature; but this is limited by the unsuitability of heavy oil for high speeds. The following examples are taken from the standard rating tables:

Typical Ratings, Two-Shoe Adjustable Bearings

Loads in Pounds

Bearing Size	Bearing Area Sq. In.	100 r.p.m.	200 r.p.m.	400 r.p.m.	800 r.p.m.
9	16	3,000	3,400	3,800	4,300
15	44	10,000	11,000	12,500	13,800
21	87	23,000	26,000	29,000	......
27	142	41,000	46,000	52,000	......
37	267	90,000	100,000	......	......
45	394	140,000	156,000	......	......

Typical Ratings, Six-Shoe Equalizing Bearings

Loads in Pounds

Bearing Size	Bearing Area Sq. In.	100 r.p.m.	400 r.p.m.	1,200 r.p.m.	4,000 r.p.m.	10,000 r.p.m.
5	12.5	....	2,370	2,850	3,500	4,010
9	40.5	....	10,800	13,000	15,800	18,400
15	112.5	30,500	38,500	46,000	56,000	......
23	264	86,500	109,000	130,000	......	......
31	480	179,000	225,000	......	......	......
45	1012	440,000	555,000	......	......	......
65	2111	960,000	......	......	......	......
93	4330	2,250,000	......	......	......	......

In these tables, "bearing size" is the outside diameter of the bearing surface of the shoes; the collar is a little larger. Numerous other sizes are omitted. For two-shoe bearings, the ratings given are averaged between those for the smallest and largest shoe bores to accommodate various shaft diameters.

The ratings assume that the cooling system (air, water, or oil circulation) and the choice of oil will result in a bath viscosity of 150 to 200 Saybolt, *at the actual operating temperature.* In marine service, loadings should be more conservative, and oils somewhat heavier, than for land work. We should always be consulted regarding the final choice of bearing size and design for a new application.

Low Frictional Power Loss

Though the loss due to oil film shear in a Kingsbury Thrust Bearing is a calculable quantity to be provided for, it is very small. As previously stated, it represents a frictional coefficient of from .001 to .005 at the running speeds of marine propeller shafts and hydroelectric generators. It is believed to be the lowest friction obtainable with comparable security against failure.

As compared with less durable bearing types, such as might be used on towboats, fishing boats and other small vessels, investment in a Kingsbury is to be regarded as insurance against loss of earning time necessitated by repairs to the thrust bearing. The same comparison applies to various types of industrial machinery. For hydroelectric generators, for example, the saving in power loss may be capitalized as part of the cost of the entire power plant, since part of that cost is neutralized by whatever power loss exists, necessitating the construction of a larger plant to deliver the rated output. In addition, the lower friction of the Kingsbury Bearing indicates that the oil films are thicker, and the insurance against failure correspondingly greater.

Standard *vs.* Special Designs

The internal parts of both horizontal and vertical equalizing bearings (shoes, collar when removable, six-shoe leveling plates and base ring, three-shoe cage and leveling washer, and oil control rings) have been thoroughly standardized on the basis of long experience, and cover a broad range of sizes. These standards should be strictly followed.

Similarly, the various two-shoe adjustable bearing units have been standardized, to meet the usual requirements of marine service. For dredge pumps and water turbines certain standard options are available, chiefly in the details of the journal bearings, and in the lubrication and cooling systems. For any specific application, we shall of course make complete recommendations.

Again, we have standardized the self-contained thrust and journal bearing units for centrifugal pumps, and their companion inboard journal bearings. See Figure 39, page 23. Various shaft diameters are standard for each size. Several oil cooler sizes are used, according to speed and other conditions.

It is obvious that departure from the standardized parts and complete units will increase costs, and in ordinary circumstances will delay deliveries.

In general, it is best to think of special bearings and mountings as something to be used for machines requiring departures from established practice, and where the quantities expected are sufficient to warrant the extra cost of development and machine work. Naturally, no rule can be laid down regarding this: the benefits to be gained by using a Kingsbury Bearing in a given case may be enough to overcome the cost even of a quite special design. This has often happened, in our experience, when we have been asked to replace a bearing of different type which could not be depended on to carry its load.

Standard Guarantee

Any bearing or part furnished by us, which shall prove defective in design, material or workmanship, within one year after installation and test, will be replaced without charge f.o.b. Philadelphia, if returned to our factory. No allowance will be made for labor or other expense in connection therewith unless authorized in writing by an officer of the Company.

For oil coolers and cooling coils, in accordance with usual trade practice, there is no specific guarantee period.

Spare Parts

A Kingsbury Bearing correctly chosen and installed, and properly supplied with oil, will run indefinitely without sensible wear. If failure occurs, it is usually due to lack of oil. Resultant damage is usually limited to the shoes on the loaded side, which should be sent back to us for rebabbitting. Sometimes the collar must be refinished: this may be done either by us, or in the field if our instructions are carefully followed. Hardly ever is it necessary to replace other parts. This may be contrasted with the fact that, with ball or roller bearings, the entire bearing must be replaced if failure occurs.

Accordingly, our standard proposals for spares include only one set of shoes, plus collar (if separate) for very responsible service. For journal bearings, the usual spare is the lower half of a split shell where that part is removable. Spares for marine use are governed by the American Bureau of Shipping or other applicable regulations.

Data Needed With Inquiries and Orders

In order to advise regarding the selection and mounting of a Kingsbury Bearing for a new application, we should have the fullest information regarding conditions of use. This always includes:

Thrust load;
Shaft diameter through bearing;
Revolutions per minute;
Is shaft horizontal or vertical?

In addition, the kind of service should be stated, and the general arrangement of the machine should be sketched or described, with space limitations indicated. Journal bearing loads, when applicable, should be given. It is helpful to know whether water cooling, or an external oil circulating and cooling system, is available; also whether the water (if used) is fresh or salt, clean or dirty.

Kingsbury Experience

Since its beginning, the experience and research of the Kingsbury organization have been devoted solely to the development of oil-film thrust and journal bearings. Such bearings may be found today on the propeller shafts of thousands of ships of the U. S. Navy and merchant marine. They are in land and marine turbines developing millions of horsepower. The same type of bearing is used in thousands of centrifugal pumps and similar rotary machines.

Out of that specialization have come various patents, issued and pending. Some of those patents, now expired, have contributed to the enrichment of machinery design. Others, including a number on recent developments and special uses, are still active. But beyond any question of patents is the matter of specialized experience. That is often the difference between the bearing which works well on paper and the bearing which works well in the power station or in the anxious tryout of some newly-contrived machine. The machinery builders who go to the originators of a precision-built component—whether a machine tool or a thrust bearing—do so for much the same reason that jewelry manufacturers go to diamond cutters for precious stones. They know that there is something in long experience which cannot be expressed in blueprints. That indefinable something—call it what you will—may help to explain the strikingly successful performance record of Kingsbury Bearings built by Kingsbury.