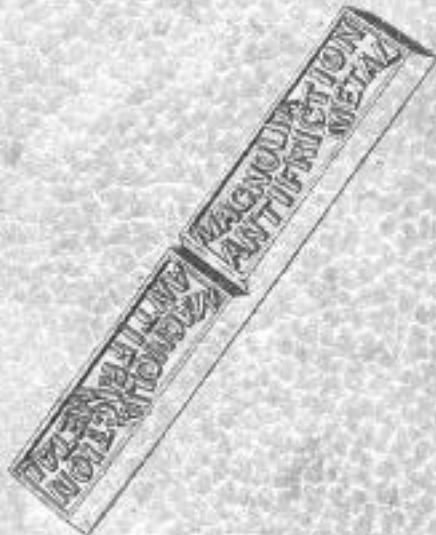


THE
MAGNOLIA METAL
BEARING BOOK



THE MAGNOLIA METAL BEARING BOOK

SECOND EDITION



A discussion of Magnolia Anti-friction Metal, together with simple, practical instructions for the making and operation of lined bearings for highly efficient and economical service.

PRICE \$1.00

MAGNOLIA METAL COMPANY

Main Office

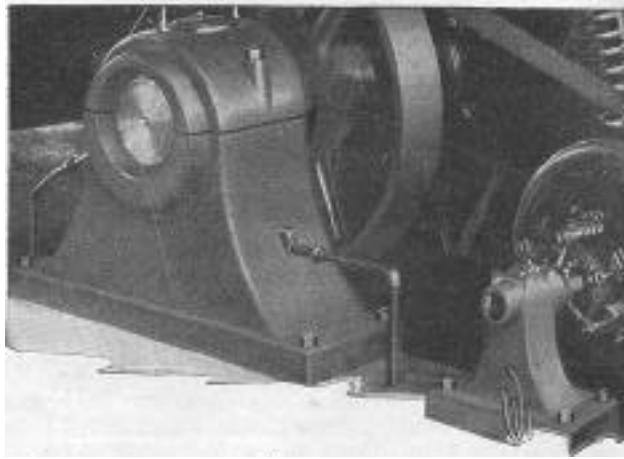
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Introductory

The selection, working and care of the contact metal in lined bearings, although very important, are seldom more than mentioned in engineering text books and hand-books, and to the best of our knowledge, no book of information confined to these subjects has hitherto existed.

The following pages are therefore intended to, and we believe do, contain more simple practical information along these lines than can be found anywhere else between two covers.

The advice given should enable any man of ordinary intelligence to make lined bearings that will transmit power care-free and uninterrupted, with high efficiency and at low initial and maintenance expense.

Our unique experience in developing, compounding, smelting and marketing bearing metals and in keeping Magnolia Anti-friction Metal the recognized leader for 42 years, during which others have come and -gone like mushrooms, enables us to speak with authority on bearing subjects.

Further advice on problems not covered in the following pages, or concerning details which do not appear to be entirely clear, will be given gladly and promptly, if inquiry is accompanied by the necessary data.

MAGNOLIA METAL COMPANY

Guarantee

WE GUARANTEE that Magnolia Anti-friction Metal, applied and used in accordance with our instructions, will assure the lowest frictional coefficient, coolest running temperature and longest life possible from bearings of the lined type.

We further guarantee an unvarying purity and uniformity of every batch within the closest limits obtainable with approved manufacturing methods, strict supervision, 42 years experience, and sincere desire to give every customer the utmost for his investment.

We further guarantee that Magnolia Anti-friction Metal, when properly handled, will pour as freely as water, will make a clean close-fitting casting free from scum, dross, blow-holes and excessive shrinkage, and that the casting will prime and finish perfectly.

The Magnolia Metal Co. is a "Golden Rule" house, believing in doing unto others as you would have done unto you. All we ask is the opportunity to make good. If fair trial on one or more bearings does not produce results entirely in accord with the above statement, a reasonable quantity of metal purchased in the United States or Canada for such test may be returned within 60 days without payment for that used or that returned or for freight either way.

Further specific guarantees in writing will be made if desired and these in connection with our financial standing and long-time reputation for fair dealing, are virtually as good as a bond.

MAGNOLIA METAL COMPANY

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Part 1. Bearing-metal alloys and their characteristics

Babbitt Metal

WHITE-METAL alloy as a lining for bearings was first proposed in 1839 by Isaac Babbitt who recommended a mixture composed of about

Tin	50 parts	(89.28 per cent)
Antimony	5 parts	(8.93 per cent)
Copper	1 part	(1.79 per cent)

To distinguish this composition from the numerous others that were introduced later for white bearing metals, the original has been designated the world over as "genuine babbitt".

Mr. Babbitt by using the qualifying word "about" indicated that he was not sure that his formula was the best. He did, however, demonstrate that a bearing metal softer than brass or bronze was entirely safe and practical.

The Origin of Magnolia Metal

AMONG the many who attempted to produce white AL bearing metals that would possess better anti-frictional qualities and be cheaper, Samuel Singley, a rolling mill superintendent, in 1866 started a 20-year series of exhaustive experiments and tests on various compositions of his own.

He succeeded in producing an alloy that was greatly superior to anything he had been able to purchase.

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Mr. Singley's alloy consisted of a small quantity of tin, a relatively larger quantity of lead with hardening metals and graphite incorporated by a special process to keep it uniformly distributed throughout the mass. After the fame of this had spread locally, it was put on the market in 1886 and has now become known the world over as Magnolia Anti-friction Metal.

Despite an enormous amount of subsequent research by scientists and practical bearing experts, no other bearing metals showing improvement upon genuine babbitt and Magnolia Metal have been produced, hence genuine babbitt and later Magnolia Anti-friction Metal have stood supreme as the standard white bearing metals of the world.

Beware of imitations of Magnolia Metal

OTHER makers of babbitt metals have analyzed Magnolia Metal and stated that they could furnish the same metal at lower cost. *Also, many engineering test and reference books give an analysis of Magnolia Metal. Some are absurdly incorrect, and never yet have we seen one that is absolutely right.

*My deceased father was a chemist and manufacturer of babbitt, and I also have been similarly engaged for about eight years.

We tried to make Magnolia, but did not succeed in making such a good quality, and shall make no further efforts.

Both bad and ordinary babbitt can equal the quality of an imitation of Magnolia Metal, but there is no babbitt better than genuine Magnolia. — E. LIPINSKY, Leningrad, Russia.

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Even with the correct formula, Magnolia Anti-friction Metal can be produced only with our introduction of graphite and with our special foundry treatment.

The difference between Magnolia Metal made by ourselves and an imitation made from the same formula, but without our special treatment, was strikingly proven in what were probably the most exhaustive bearing metal tests that the United States Government has ever made. (Pages 37 to 39.) These tests proved that the coefficient of friction of the imitation was *over three times* that of genuine Magnolia Metal. It is this difference which prevents the temperature of a Magnolia bearing from reaching a destructive point. If for instance the oil holes become choked, the belt tightens or any one of a number of things happen, a Magnolia-lined bearing will run along in good shape, where other metal would fail.

A favorite ruse of imitators is to offer a metal "practically and chemically the same as Magnolia, within 1 per cent." A far smaller margin can make an imitation practically worthless, just the same as with metals for other purposes. Take for instance steel: 1/30 of 1 per cent of phosphorus ruins steel for cutting tools, while a difference of 2/10 of 1 per cent in carbon can prevent hardening. In copper, 1/10 of 1 per cent bismuth ruins the electrical conductivity, and as Sir Henry Vivian, a prominent British authority, says: "One-thousandth part of antimony will convert best selected copper into the worst conceivable."

Your best interests therefore demand that you specify

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Magnolia Metal and see that you get the genuine, which bears the name "Magnolia Anti-friction Metal" cast into the top, and the flower trade mark stamped into the bottom of each ingot.

**A few words about the ingredients
of bearing metal alloys**

DETERMINATION of the value of a bearing metal or distinguishing one brand from another by physical appearance is practically impossible.

Experienced users can of course detect the presence of large quantities of tin or copper and determine the degree of hardness and ductility by hammering and cutting, but, after all, these tests really prove nothing. A babbitt made so hard that it is brittle, may wear faster and squash more readily from frictional heat than will a softer metal that has anti-friction qualities.

An additional quantity of tin does not necessarily improve a babbitt as too much tin in a lead-base metal or the admixture of lead in a tin-base metal may prove detrimental in reducing the fusing point.

For instance, take six parts of tin and one of lead; the mean arithmetic fusing point is 470 deg. fahr., but the actual fusing point is 380 deg. fahr. With two parts of tin to one of lead the actual fusing point will be 340 deg. fahr. In both cases the fusing point is much under that of the lowest constituent in the mass and yet both mixtures would show excellent physical tests for hardness, ductility, etc.

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Even the knowledge of the composition of a metal is no guarantee of its value, as the ingredients may be individually of the highest purity, or if the metal is sold at a close price, they may consist of poorly recovered drosses or scrap from impure or burned out materials.

“The best virgin materials” is an argument to which some makers give special prominence, although as a matter of fact ores are seldom found pure in nature and subsequent purity depends upon skill and honesty in smelting.

The problem is much the same as with water, which in its cleanest state still requires distillation for absolute purity, and which even when dirtiest, can still be made perfectly pure.

Unless the purchaser makes his own tests of each individual batch of metal, a proceeding which is practical only with the largest quantity buyers, he has no means of detecting poor quality until after the use of the metal has caused trouble and waste.

Selection of metal therefore hinges very largely upon faith or reputation, which means that metal bearing a trade mark, known to stand for absolute reliability and uniformity of every batch, is far the safest to purchase.

Those who have purchased Magnolia Anti-friction Metal on the basis of past performances of the metal itself and upon the makers' sworn assurances as to purity and uniformity, have realized the protection of buying in one safe place.

Those who like to make more or less of a physical in-

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spection in comparing bearing metals will find that Magnolia has certain outward characteristics, which distinguish it from other metals of like character.

Magnolia, examined from the bottom of a bar, has a smooth, satiny, oily finish and feeling to the touch; in fact, the whole bar has a certain distinguishing gloss. The wave lines that show along the sides of Magnolia bars are indications of its cleanliness and free-flowing qualities.

The fine, close grain of Magnolia Metal shows that it has been made at a proper temperature and has not been injured by excessive heat above its normal temperature, as is shown in some metals by the coarse grain. This does not apply to a genuine babbitt, which should have a coarse grain.

Magnolia Metal is hard enough to meet any requirement

DUE to its velvety feeling to the touch and its lesser metallic ring than from genuine babbitt, Magnolia Metal is sometimes characterized as a *soft* metal.

Quite true, Magnolia is not as hard as genuine babbitt, but mere hardness in a bearing metal means little and is misleading.

Any white metal alloy, no matter how hard, or how high its fusing point, will soften and squash if the temperature gets above 300 deg. fahr. Perhaps white brass, a tin and spelter mixture, affords one of the best examples of the

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futility of mere hardness. It is wonderfully hard, ductile and tough when cool, but lacks anti-frictional qualities. It gets hot very easily and then goes to pieces like putty and can be crumbled by a tap from a lead pencil.

Sufficient heat will melt any babbitt, no matter how hard. A metal which keeps down friction and frictional heat is therefore much more desirable than one which is hard.

Magnolia Metal is not really soft, however, as its factor of safety under pressure is far in excess of that required in any properly constructed bearings. It stays cool, won't squash, melt or run and it will outlast even bronze or brass, while giving much better service.

Magnolia Metal is strong under compression

THE importance of good resistance to pressure in bearings, especially those that are heavily loaded, needs no comment.

The weakness of lead and tin alone, and the extent to which their sustaining power is increased by the addition of a little antimony, are easily proven. The following test results were obtained with cylinders 1 3/8 in. in diameter and 3 in. long which were compressed 1/2 in.:

METALS	PRESSURE REQUIRED, LB.	EQUIVALENT IN LB. PER SQ. IN.
Lead	5680	5239
Tin	8080	7481
Genuine babbitt	18710	17324
Magnolia Metal	22300	20648

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These figures also show why alloys are far more apt to squash out of bearings under pressure, where the ingredients of the alloy have been permitted to separate before cooling.

More exhaustive comparative tests between Magnolia and an imitation, which in the following description will be called "Metal B," were made in 1912 by the eminent authority, Robert H. Smith, A.M.I.C.E., M.I.M.E., Professor of Engineering, Mason College, Birmingham, England.

The test blocks were cut from the ingots without melting and lathe-turned to the following dimensions:

Magnolia: Lgth. 1.27 in.; Diam. 0.6245 in.; Sectnl. Area 0.3063 sq. in.
 Metal B: Lgth. 1.25 in.; Diam. 0.6255 in.; Sectnl. Area 0.3073 sq. in.

Each was carefully centered in the compression testing machine and the load gradually increased from 2500 lb. until collapse by diagonal shear occurred. As the collapsing point was approached, the successive increases of load were 100 lb. only, and these were applied at 5-min. intervals. At each applied load the exact length and the diameter at mid-lengths were calipered to 1 mil. The readings near the collapsing points only are quoted.

At 3500 lb. load, Metal B began to buckle slightly and to show skin-wrinkling by a finely patterned surface. At 3800 lb. it still showed no cracks, but shortened and buckled rapidly. Under 3900 lb., after two minutes application, it collapsed with a big diagonal shear crack.

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Magnolia deformed with practically perfect symmetry without buckling and without skin-wrinkling up to 4100 lb. Up to 4600 lb., the skin-wrinkling was so faint as to be perceptible with difficulty; to 5100 lb., there was no buckling and the shortening of length and bulging of diameter increased with regularity and symmetry. Under 5200 lb., after 4-min. application, it gave way by two pairs of parallel diagonal very small, shear cracks, which produced very little slipping.

The most striking difference between Magnolia and Metal B was the remarkable regularity and uniformity of the gradual deformation of Magnolia in contrast to the severe buckling and final rapid total collapse of Metal B.

	Magnolia	Metal B
Final collapsing stress, lb. per sq. in.	16980	12690
Ratio of length contraction near collapsing point-		
Under 1000-lb. load, per cent	6.14	7.78
" 3600-lb. " " " "	28.00
" 5000-lb. " " " "	30.7
Ratio of volumetric compression-		
Under 1000-lb. load, per cent	76	1.53
" 3600-lb " " " "	5.5
" 5000-lb. " " " "	3.8

There was a further marked contrast between the conditions of the crushed blocks.

The high compressive strength of Magnolia, nearly 8 tons per sq. in., is far above the requirement of any properly constructed bearing, even with a low safety factor.

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Low coefficient of friction

MAGNOLIA has the lowest coefficient of friction of any known bearing metal—a statement which has time and again been proven by the highest mechanical authorities and by leading governments.

The United States Government test (see 1888 Annual Report of the Secretary of the Navy).showed the following:

LUBRICATION	PRESSURE	R.P.M.	FRICITIONAL COEFFICIENT
Water	300 lb.	491	0.00080
Oil	550 lb.	495.73	0.001875

The French Government test with oil lubrication, 710 lb. pressure per sq. in. and 6.56 ft. per sec. surface speed showed a frictional coefficient of 0.0012.

In the friction test of Magnolia Metal by the United States Government (see Page 38), using water as a lubricant, the engineer officers ran the bearing ahead and *reverse*. Very few babbitt metals will stand reversing, even with oil lubrication, as they rough up on the reverse test like plush rubbed the wrong way.

The fact that Magnolia will stand this reverse test *with water lubrication* is a wonderful tribute to its anti-frictional and self-lubricating qualities.

The anti-frictional qualities were again typically indicated by A. W. Anderson, Secretary, Lilybank Engine Works, Dundee, Scotland, in his observations concerning a large grindstone for the spindle bearings of which he finally chose Magnolia Metal. This stone was 5 ft. 10 in.

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in diameter by 1 ft. thick and ran at 241 r.p.m. Upon completely stopping the engine, the stone when mounted on Magnolia Metal bearings continued to revolve for 70 min., whereas the nearest approach to this performance with metals previously used under the same conditions was 45 min.

Magnolia Metal having the lowest coefficient of friction and being largely self-lubricated from the graphite which it contains, requires less lubrication than any other bearing metal. Practical experience has shown that under certain conditions, Magnolia will run almost without additional lubrication, and instances frequently come to our attention where Magnolia Metal uses only 10 per cent of the ordinary quantity of oil, besides which, oil of a cheaper grade may safely be used.

This self-lubricating feature is an important protection with Magnolia Metal, for when oil lubrication on a bearing has been neglected, or the oil film has broken down, the shaft rests directly on the bearing with metallic contact. It also frequently happens that the weight of a shaft squeezes out the oil during periods of rest, and on starting the bearing, the shaft is heated and cut before the trouble is discovered.

Keeping bearing metal thoroughly lubricated from outside *at all times* is difficult except with forced or mechanical lubrication. The graphite and high degree of self-lubrication of Magnolia Metal from within itself therefore afford greater safety and longer bearing life.

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It is easy to comprehend that this feature results in a big saving in metal, fuel, oil, wear on machinery, labor for rebabbiting, etc., all of which total enormously in favor of Magnolia Metal, in addition to its reasonable first cost.

"For sixteen years this coming July I have used Magnolia Metal on a high-speed lathe (3500 r.p.m.), also on the counter shaft hangers, and *it is there today*, in A-1 condition. There is also in the shops, a head shaft for a motor drive, which has run much longer, and *has not had a drop of oil or a speck of grease on it in at least six years*, to my personal knowledge (as I have always attended to this part myself), and it runs that freely that even I am in doubt sometimes myself.

"Magnolia is right, and works right,- when worked right." - GEORGE A. DIEMER, NEWBURGH, N. Y.

"We put Magnolia Metal under a Corliss Engine main shaft that had been very badly cut. Heretofore we had been compelled to rebabbit every six weeks, using what was represented as the best of metal. We were compelled to play a 1/2 in. stream of water on this bearing constantly to keep it cool. The Magnolia bearing ran perfectly cool without water and on inspection after seven weeks had not worn 1/8 in. With the metal previously used the wear would have been 1 1/4 in."- COLUMBIA (Pa.) ROLLING MILL Co.

"During the past two -years we have used your 'Magnolia Metal' exclusively in main bearings for our centrifugal pumps and high speed engines, and it has given entire satisfaction. I am pleased to recommend its use for our particular kind of work."- WILLIAM A. DREW, Engineer in Charge, Bureau of Water Supply, Department of Water Supply, Gas & Electricity, Brooklyn, N. Y.

The Manager of a large Steel Works in Lanarkshire writes as follows:

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"I fitted Magnolia Metal to a 34-in. cylinder and 4-ft. stroke engine working at 60 r.p.m. We replaced the brasses on the crank-shaft, main spur gear, etc., with Magnolia. The necks of this shaft are 11 in. diameter and 15 in. long, and the total weight of fly-wheel, main spur driver, and shaft is about 65 tons.

"The week following we found that by the use of Magnolia lining we were enabled to dispense with the use of one of our three 28-ft. by 7-ft. Lancashire boilers. In other words, we were enabled to save one-third of the coal previously used for the same work. I have since fitted Magnolia to about 400 bearings of various sizes throughout our works, including the necks of our heaviest rolling mills.

"I attempted to use on our rolling mills a cheaper metal supplied as 'the same as Magnolia,' but after few weeks' use, it was wearing far more rapidly and had out the roll necks badly. I replaced this with Magnolia Metal and have since had no trouble. The cut parts of the necks completely filled."

Magnolia Metal runs very cool

PROBABLY 90 per cent of all troubles with lined bearings are due to the heat caused -by friction, and practically all white-metal alloys containing tin fuse at about 500 deg. fahr. and begin to soften at temperatures around 300 deg. fahr. It follows, therefore, that bearing metal which does not tend to produce excessive friction and overheat will wear better and last longer in severe service.

Within its proper uses Magnolia Anti-friction Metal always runs at temperatures well below the destructive point.

The temperature of a newly finished Magnolia-lined bearing at first gradually increases and then decreases as

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the journal and bearing become conditioned. After this state is reached, and the bearing surface becomes more and more glassy, the bearing runs at a fixed temperature, not greatly above that of surroundings.

That the temperature of a Magnolia lining can actually decrease while pressure is increasing was proven in the test of a 5-in. bearing by Dr. Herbert Gray Torrey from which the figures in the table are taken. This bearing was found to be in perfect condition after conclusion of the test.

Time in Minutes	Temperature Deg. fahr.	Pressure per sq. in. lb.	R.P.M.	Speed of rubbing surfaces, ft. per min.
0	90	500	1550	2030
10	120	500	1550	2030
20	184	500	1550	2030
30	198	500	1550	2030
40	210	500	1550	2030
50	210	500	1550	2030
60	198	800	1500	1965
70	196	800	1500	1965
80	190	1000	1500	1965
90	186	1000	1500	1965
Metal in perfect condition, not displaced or, abraded.				
0	90	1000	1500	1965
15	226	1400	1500	1965
30	244	1800	1500	1965
45	228	2000	1500	1965
60	210	2000	1500	1965
75	204	2000	1500	1965
90	202	2000	1500	1965
95	202	2000	1500	1965

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Test of Magnolia Bearings by R. & W. Hawthorn at works of Leslie & Co., Ltd., Newcastle-on-Tyne, Eng.

THIS test was made with a 3-in. shaft, with bearings on 16 in. bearing centers and so loaded that the pressure per sq. in. of projected bearing area was 495.12 lb.

The Magnolia Metal bearing was cast on a mandrel and put in place without machining.

For 10 min. before the test proper, 3:50 to 4:00 p.m., oil was used, and then completely shut off during the entire 4-hr. test period.

The number of revolutions totaled 45602, average 182.44 r.p.m., corresponding to a surface speed of 143 ft. per min.

The bearing temperatures recorded were as follows:

Time p.m.	Temp. fahr.	Time p.m.	Temp. fahr.	Time p.m.	Temp. fahr.
3:50	71.6	5:15	93.2	6:40	136.4
3:55	74.3	5:20	95.0	6:45	137.7
4:00	77.0	5:25	102.2	6:50	138.2
4:05	80.6	5:30	104.0	6:55	137.3
4:10	86.0	5:35	111.2	7:00	140.0
4:15	88.7	5:40	130.1	7:05	136.4
4:20	89.6	5:45	125.6	7:10	136.4
4:25	91.4	5:50	123.8	7:15	139.1
4:30	93.2	5:55	123.8	7:20	140.0
4:35	93.2	6:00	140.0	7:25	138.2
4:40	93.2	6:05	145.4	7:30	138.2
4:45	91.4	6:10	138.2	7:35	135.5
4:50	91.4	6:15	138.2	7:40	132.8
4:55	91.4	6:20	138.2	7:45	129.2
5:00	91.4	6:25	138.2	7:50	127.4
5:05	93.2	6:30	138.2	7:55	129.2
5:10	93.2	6:35	137.3	8:00	129.2

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The Magnolia, Metal bearing was found to be in perfect condition at the finish, with weight same as at start.

In explanation of the temperature decrease during the last portion of the run, it should be remembered that, having been put in place rough, the bearing had comparatively little contact surface at first, and at the end of the run, was found not yet to have full contact. Of course, as the total load remained the same throughout, as the bearing surface increased the pressure per square inch was correspondingly reduced, hence decrease in temperature.

In a subsequent series of tests with increasing loads, white brass and three other babbitt mixtures were fused with less than half the load carried by Magnolia, and Magnolia was not fused with any pressure applied.

"The Magnolia Anti-friction Metal forwarded for experiment has given the following results: We had no heating and have found no wear whatever in three engines in which this metal was employed.

"On comparison of this metal with others in use at our works, the best results were given by Magnolia."- COLONEL CHERUBINI, Italian Government Technical Bureau, Terni, Italy.

"I have used much Magnolia Metal and will have no other. A heavily loaded 200 h.p. automatic engine of which I took charge four years ago would not hold babbitt metal in the quarter box or crank brasses. I put Magnolia Metal into both places and have had -no trouble since. These bearings now hardly run warm. I believe Magnolia to be the only metal for engine men who want sure relief from hot-box trouble."-CHAS. BARKLEROAD, Engineer, Mowbray & Robinson Lumber Co., West Irvine, Ky.

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Magnolia Metal works well under heavy pressure and high speed

MOST any white metal bearing liner will sustain the weight of the shaft in a properly designed bearing, but only if possessed of good anti-frictional qualities can the bearing metal be expected to stand the hardships of heavy loading and high speed.

The achievements of Magnolia Metal in successfully sustaining heavy loads where harder metals "go down" are due to its very low coefficient of friction which keeps frictional heat far below the destructive point: The higher the pressure, the better the wearing surface, and even a rough cast unscraped or unfinished liner soon wears down into good contact.

In test made at Yorkshire College, Leeds, England, by John Goodman, A.M.I.C.E., M.I.M.E., Professor of Mechanical and Civil Engineering, a Magnolia bearing ran for some weeks under a pressure of 2 tons per sq. in. at a surface velocity of 250 ft. per min., with the temperature maintained at 130 deg. Fahr. by circulating water through the center of the shaft. The lubrication from an oil pad weighing 0.02 lb. and moistened daily, was very meagre, yet after the run the bearing surface was perfect.

Prof. Goodman in his report commented as follows: Under heavy pressures and high speeds I find Magnolia Anti-friction Metal very materially superior to any other I have ever tested. Under such conditions, the friction is much lower, and the metal never seizes, even when a rough

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cast bearing is used without bedding down on the shaft, My experience distinctly shows that the higher the pressure applied, the better does the bearing surface become

Robt. H. Smith, A.M.I.C.E., M.I.M.E., etc., Professor of Engineering, Mason College, Birmingham, England made between 300 and 400 tests on Magnolia Metal, gun metal and the best quality of babbitt, all in a machine designed to produce as nearly as possible the working conditions of machine bearings. The experiments were made on three diameters of journal, four different lengths, four different speeds and five different pressures. In all instances temperature and friction were carefully measured.

As part of his detailed report Prof. Smith said:

"Magnolia Metal is proved by these tests to be much superior to either babbitt or gun metal. It produces less friction, it keeps the bearing temperature lower, requires less lubrication and possesses greater durability. This characteristic of durability is a most important one. Within the wide limits of condition covered by my tests it would be true to say that the longer the Magnolia Metal bearing is used and the more severe the duty imposed on it, the better becomes its condition.

"The general conclusion at which I have arrived is that Magnolia Metal is a very good material for bearings; that its special good qualities appear more particularly when it is subjected to *intense pressure*, such as could not be borne by other metals without fusing or melting, and that under very trying circumstances, the Magnolia Metal may be trusted to remain cool; that is, at a temperature that does not interfere with good working."

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Thousands of applications have come to our attention where Magnolia Metal has been highly satisfactory under heavy duty and speeds over 5000 r.p.m. A recent report showed thoroughly satisfactory continuous service for over 15 years, on a high-speed woodworking machine. In view of the dusty surroundings, this is a rather severe test.

"We have for six years put Magnolia Metal to the severest test on rip saws, planers and moulding machines, running 5000 r.p.m. and doing heavy work, and have found it much superior in every respect to any other metal on the market. Our mill has not been stopped on account of a hot box in all this time. We highly recommend Magnolia Metal." - C. M. JOHNSON, Supt. of Machinery, White Pine Lumber Co., Milwaukee, Wis.

Rolling mills

AS an example of the heavy pressures which Magnolia Metal bearings will stand, rolling mill service is particularly severe because the loads come on with a bump, and the bearings are subjected to all kinds of grit from the dirty surroundings. The good performance of Magnolia under these adverse conditions is indicated by the following comments:

"Magnolia Metal on the journals of our mill for rolling locomotive tires under a pressure of 5000 lb. per sq. in. has given better satisfaction than anything previously used. Brass bearings in this mill gave endless trouble and Magnolia has proved three times more serviceable, both as to durability and in keeping the journals cool."-JAMES MUNTON, Supt., Chicago Tire and Spring Co.

"Magnolia Metal in main line bearings directly under our rolls has proven more durable than anything else we have

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used. These bearings receive the thrust of each piece of hot pipe as it passes through the rolls." - AMERICAN TUBE AND IRON CO., Middletown, Pa.

"We have used Magnolia in all departments ever since its introduction and find it superior to any other bearing metal we have used. One of our heavy bearings carries a 30-ton fly-wheel, but Magnolia gives entire satisfaction." - J. D. DWYER, Supt., Birmingham (Ala.) Rolling Mill Co.

"Magnolia Anti-friction Metal used all through our mill gives the very best of satisfaction. Our superintendent finds that it lasts one-third longer than our best brasses, and there is less friction than when we used brass."-BRIDGEPORT (Conn.) ROLLING MILL CO.

"Our Steel Works does not hesitate to take out all bearings of any dimensions in bronze, brass or white metal and replace with bearings of Magnolia, which has shown great resistance to wear." - Genl. Mgr., Societé Anonyme de John Cockerill, Seraing, Belgium (one of the largest iron and steel manufacturers in Europe).

Street-car service

Magnolia Metal gives greater mileage and offers less frictional resistance than any other bearing metal, besides effecting a big saving in first cost and important economies in oil, cost of reabbtting, quantity of metal used, etc.

"I have been a constant user of Magnolia Metal for bearings for street cars for many years, after three-year tests while I was General Manager of the Keighley Corporation Street Railway System, York, England.

"These tests with both oil and grease as lubricants were made on cars in daily service, and of the many well known brands of metal, Magnolia came out very well on top. Magnolia always showed a far better service on both bearing and journal. The mileage obtained with Magnolia Metal was 90000 miles, - a life which was often commented upon." - J. W. BAMBER, Peterboro, Ontario.

In the metal line specify Magnolia products

Hoisting sheaves

“We are placing an order for 44800 lb. of Magnolia Metal on the strength of entire satisfaction from the trial lot. We intend to use it for all white-metal bearings in our works.

“At the Kimberley Mine we hoist about 4 _ tons of ground 1800 ft. in 35 seconds. The resultant pressure on the bearings at the 14-ft. sheaves during hoisting is about 66000 lb. and the wear and tear on the bearings has hitherto been very great. Magnolia has greatly reduced maintenance charges here.” - ALPHEUS F. WILLIAMS, Acting General Manager, De Beers Consolidated Mines, Ltd., Kimberley, South Africa.

Power apparatus

“I have used Magnolia Metal on crank pins, main bearings, guides of engines and also on bearings of motors and high-speed fans where other metals failed to hold.

“I had a 36-in. fan that had to be rebabbitted nearly every day. After putting in Magnolia, it held over a year.

“I have used Magnolia in some hard places and know its worth. I keep Magnolia on hand and would not be without it for it has worn without trouble where other metals failed.” - F. N. TITUS, Engineer, Shortsville (N. Y.) Wheel Works.

Bearings subjected to dirt and grit

MMAGNOLIA ANTI-FRICTION METAL is by far the safest and longest lived that can be used in dirty surroundings, where dust and grit cannot be kept out of the bearings. The Magnolia Metal liner under these conditions acts as a matrix. Any hard particles which get between the rubbing surfaces are depressed and seated far enough below the contact face to avoid scoring or

In the metal line specify Magnolia products

severe friction. Magnolia Metal will never cut a shaft, axle or pin, even under most trying conditions.

That this is no mere theory but is actually confirmed in practice can be proven by hundreds of service records, from which the following are taken:

Stone crusher. – “Six months ago we babbitted an eccentric on an Austin Gyrotory Stone Crusher, where we had trouble. The Magnolia Metal bearing is in good condition yet, although metal for which we paid twice as much never lasted more than three months.” - SAML. ALEXANDER, Blanc Stainless Cement Co., Allentown, Pa.

Stone crusher. – “I have used Magnolia Metal extensively and with much satisfaction in rock-crushing machinery of the Honolulu Road Dept., where it had a severe test. Too soft a metal would squeeze out, and if too hard, the strain and jar would crack it to pieces.” - H. G. WOOTEN, Engineer, Honolulu, Hawaii.

Concrete mixer. – “I do not believe any service is harder on bearings than concrete mixing. Yesterday I overhauled a Magnolia Metal bearing on a cement mixer that was used for about a year in the construction of the State Prison. It did not have to be rebabbitted as the wear did not exceed 1/32 in.

“Magnolia Metal used on about every class of bearing and every service that an anti-friction metal can be used for has filled the bill for me in every respect.” - FRED VETT, McAlester, Okla.

Punch and shear. – “We used Magnolia Metal for lining the cam on a large punching and shearing machine, which was a hard test because grit and dirt get into the bearing and there is great difficulty in keeping the parts well oiled. Gun metal, phosphor bronze and steel gave way in a short time, but we are most satisfied with the performance of Magnolia.” - WOODROFFE: & CO., Albion Iron Works, Rugeley, England.

In the metal line specify Magnolia products

How Magnolia Metal acts on a rough shaft

HOWEVER true or smooth a journal may be turned microscopic examination of its surface will show innumerable interstices and sharp cutting edges, which act upon the bearing and increase the frictional resistance until the bearing is "conditioned."

Magnolia Anti-friction Metal above all others has the property of imparting correct running surface and maintaining the surface true throughout bearing life. This advantage is particularly noticeable on rough new, and worn old shafts.

Where Magnolia is used on a rough shaft, the initial material is usefully employed in filling in and smoothening the minute voids on the rough surface. The problem at this stage is somewhat like the clogging experienced when filing a soft metal, but once the equalizing action is completed, both shaft and bearing take a glassy polish and further wear is exceedingly small.

The resistance to wear after preliminary conditioning is indicated by the following performance records under usual conditions -

- On bearing of a log mandrel, over 23 years, and then in good condition when the plant was dismantled.
- On bearing of an ice plant engine, over 16 years night and day, equivalent to 36 years' service.
- On a Corliss engine main bearing, 17 years. On a crank pin, 19 years.
- On a tug-boat engine, 20 years.

A record of ten years without having to reline a single

In the metal line specify Magnolia products

bearing in the whole plant is common for Magnolia, and many individual bearings are known to have run over 20 years without relining.

Magnolia vs. genuine babbitt and other white metal alloys-a competitive test on 29 specimens, including 19 prominent makes.

THE superior anti-frictional qualities of Magnolia have been proven by Dr. Herbert Gray Torrey, Mem., Am. Soc. M. E., and for 30 years Chief Assayer, U. S. Mint, New York City, who made comparative tests with 11 genuine babbitt and 8 other white-metal alloys of the very best obtainable makes and grades.

These tests were made on a 5-in. shaft under various loads up to 2000 lb. per sq. in. and at a shaft speed of 1600 r.p.m., with corresponding surface speed of about 2094 ft. per min. All test bearings were made from stock bought in the open market.

In these tests Magnolia Metal was subjected to a continuous 80-min. run as follows:

10 min.	under pressure of	1000 lb. per sq. in.				
20 "	"	"	"	1200	"	"
10 "	"	"	"	1400	"	"
10 "	"	"	"	1600	"	"
10 "	"	"	"	1800	"	"
20 "	"	"	"	2000	"	"

Upon completion of this run the bearing metal was still in excellent condition, neither displaced nor abraded, whereas all of the "genuine babbitts" and other white-

In the metal line specify Magnolia products

metal alloys softened, squashed or fused at 1400 to 500 lb. per sq. in. and in from 15 to 5 min. In each instance, frictional heat caused destruction of the genuine babbitts at loads comparatively light and far below those at which Magnolia Metal is safe in every day service.

These tests on 29 specimens of every prominent make of white metal, including genuine babbitt, copper babbitt soft, hard, extra hard, nickel, aluminum, and other compositions, subjected all to equal conditions except pressures as follows:

METAL	PRESSURE PER SQ. IN.	RUNNING TIME BEFORE DESTRUCTION		
A	1400 lb.	10 min.		
B	1400	5		
C	1400	3	Fused.	Much friction
D	1200	10		
E	1200	6		
F	1200	5		
G	1200	5		
H	1200	3		
I	1000	15		
J	1000	10		
K	1000	5		
L	1000	2		
M	800	10	Fused	
N	700	12	Fused	
O	600	12		
P	500	40	Fused	
Q	500	30	Fused	
R	500	28		
S	500	25	Temp. 300 deg. fahr.	
T	500	20	Fused	

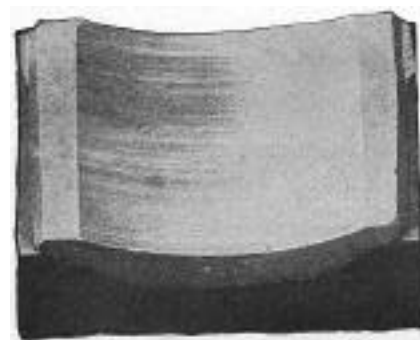
Data for Magnolia Metal and the other eight metals will be found in the captions of illustrations on pages 31 to 35.

In the metal line specify Magnolia products

The photos show typical condition of test blocks of Magnolia after 80 min. and of other material after test to destruction.

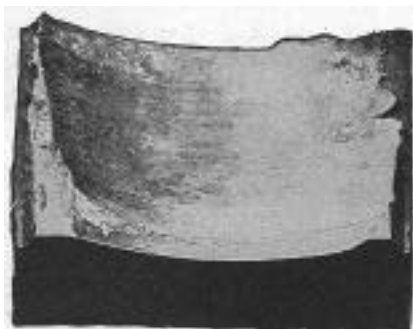
The test results indicate the perfect condition of the Magnolia Metal when subjected to much severer strains than other white metal bearing alloys can stand.

The success of Magnolia Metal is due to its low frictional coefficient and the fact that its temperature can hardly be raised to a destructive point, even without lubrication.



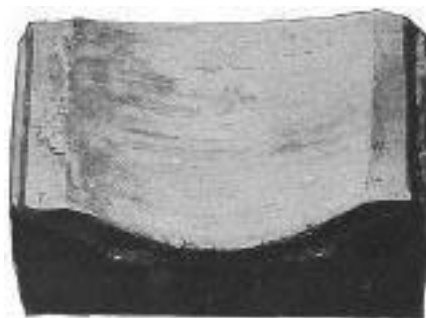
Magnolia Anti-friction Metal. Ran 80 minutes at pressures from 1000 to 2000 lb. per sq. in.. Metal in perfect condition at completion. Surface smooth and highly polished

In the metal line specify Magnolia products



METAL U.

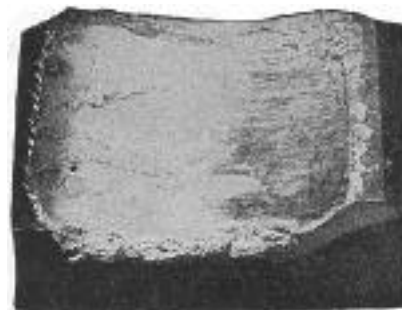
Fused after 34 min. at 1200 lb. per sq. in.



METAL V.

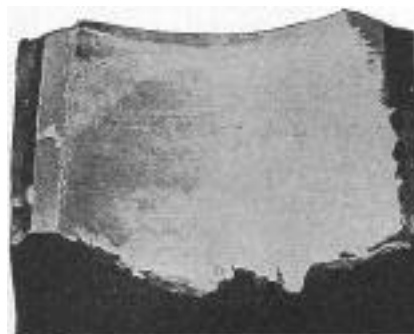
Fused after 40 min. at 1000 lb. per sq. in.

In the metal line specify Magnolia products



METAL W.

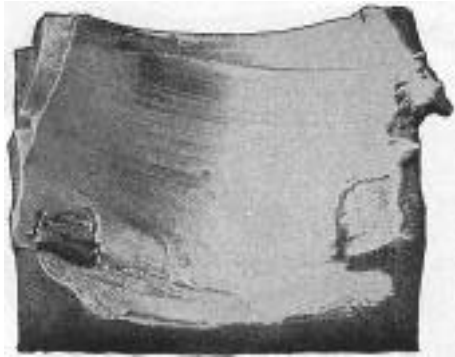
Ran 25 min. at 1000 lb. per sq. in.



METAL X.

Ran 10 min. at 1200 lb. per sq. in.

In the metal line specify Magnolia products

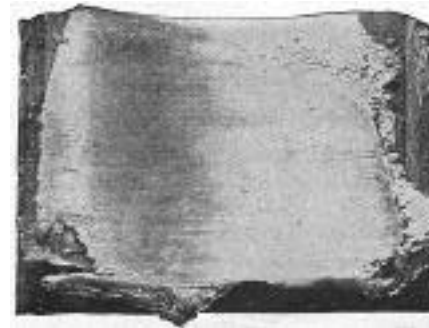


METAL Y.
Fused after 10 min. at 1200 lb. per sq. in.

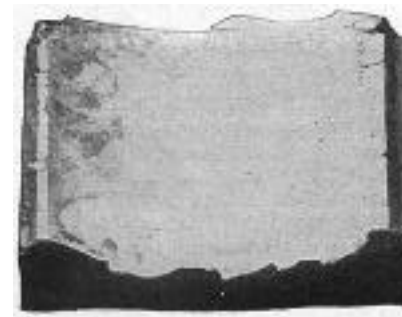


METAL Z.
Ran 22 min. at 1000 lb. per sq. in.

In the metal line specify Magnolia products



METAL AA.
Fused after 15 min. at 1000 lb. per sq. in.



METAL BB.
Stuck to shaft after 15 min. at 1000 lb. per sq. in.

In the metal line specify Magnolia products

**Official Approval of Magnolia Anti-Friction
Metal by the French Government
for use in the French Navy**

The Research Laboratory of the French Government made official test (No. 783) of Magnolia Metal as follows:

- 1st. Determination of coefficient of friction under varying pressures.
- 2nd. Determination of temperature under different velocities: Endurance tests.
- 3rd. Determination of the rate of wear.

The reports of these tests included 14 tabulations and so thoroughly sustained all claims that the following letter was written by order of the Minister of Marine, approving the use of Magnolia Metal by the French Navy.

Translation of Report

The Manager of the Magnolia Co.,
50 Rue Taithout, Paris, IX.

Sir:—By letter on July 10th, 1906, you request permission to be allowed to furnish certain Navy Supplies.

I have the honor to inform you that after examination of the information furnished by the Surveillance Testing Service regarding your method of production, I have decided that you should be allowed to furnish the supplies of Magnolia Anti-friction Metal.

By telegram of this day I transmit this decision to the Administrations of the five ports of Tunis, to the Navy Offices at Indret and Gueriguy and to the Commission of Machines and General Tool Supplies at Paris.

For the Minister and by his order,

The Central Director of Naval Construction.

—A. Dudebout

In the metal line specify Magnolia products

**United States Gov. Test of Magnolia Metal
at the New York Navy Yard**

THE following data are abstracted from the 1888 annual report of the Secretary of the Navy, in which Magnolia Metal was recommended for use in the Steam Engineering Department of the Navy.

The Engineer Officers who made the test were particularly interested in a comparison between Magnolia Metal with white brass (a tin and zinc composition). They also wished to ascertain what difference if any there was between Magnolia Metal and an ordinary commercial imitation of the same basic formula, but not containing graphite nor subjected to our special foundry treatment. This latter metal is designated in the table as “Special No. 2.”

Magnolia Metal, as shown, proved itself far superior to both white brass and ordinary commercial babbitt.

“A” White Brass could be tested up to only 200 lb. per sq. in. as the machine would not turn beyond that weight. The testing machine turned easily up to its limit of 600 lb. per sq. in. with Magnolia Metal. It was not thought necessary to test the “Special No. 2” metal beyond 200 lb. per sq. in.

This water test shows the true value of Magnolia Metal. It also demonstrates that a metal may show relatively the same analysis as Magnolia and yet fall far short of giving equal results; it also shows the destructive effect of frictional heat on even a very hard metal like white brass.

In the metal line specify Magnolia products

Results of combined ahead-and-reverse-for-friction test of Magnolia, Special No. 2 and "A" White Brass

Pressures, 100 lb. per sq. in. to 600 lb. per sq. in. of projected area of bearing surface. Weight increased 100 lb. per sq. in. at each change. Lubricant: Water.

METALS.	Weight Applied in lb. per sq. in.	Time in minutes.	Revolutions		Velocity Of rubbing Surface, ft. per minute.	Coefficient of Friction.	Comparative values As anti-friction metals
			Total.	Per minute.			
1 Magnolia Metal	200	120	58585	488.21	511.25	0.00159375	12.4811
2 Special No. 2	200	120	58835	490.29	513.45	0.0049479	4.0202
3 "A" White Brass	200	120	58170	484.75	507.63	0.0198916	1.0000
4 Magnolia Metal	300	120	59025	491.87	515.09	0.00080208	
5 Magnolia Metal	400	120	59345	494.54	517.83	0.00129166	
6 Magnolia Metal	500	120	58650	488.75	511.82	0.002427	
7 Magnolia Metal	600	120	58870	490.58	513.74	0.00275	

TEMPERATURES IN ABOVE TEST

Metals	Air in room				Water bath				Test metal			
	At Beginning.	Maximum.	Mean.	Mean Increase.	At Beginning.	Maximum.	Mean.	Mean Increase.	At Beginning.	Maximum.	Mean.	Mean Increase.
1	60.0	62.0	60.25	0.25	61.6	90.0	73.0	12.00	60.0	84.0	69.58	9.58
2	62.5	64.0	63.16	0.66	91.0	98.0	95.50	4.50	84.5	94.0	91.58	7.08
3	59.5	66.0	62.66	5.16	85.0	154.0	131.41	46.41	78.0	144.0	123.16	45.16
4	62.5	63.0	61.41	-1.09	59.5	80.0	72.58	13.08	60.0	77.0	69.66	9.66
5	64.5	66.0	65.38	1.08	69.0	90.0	81.24	12.24	68.0	86.0	78.4	10.40
6	72.0	76.0	73.33	1.23	77.5	142.0	105.33	28.83	77.0	130.0	98.58	22.58
7	68.5	71.0	68.25	-0.25	78.0	140.0	97.08	19.08	76.5	124.0	92.60	16.16

In the metal line specify Magnolia products

It will be observed that Magnolia Metal proved to be 1100 per cent superior anti-frictionally to white brass and 200 per cent superior to the "Special" or ordinary commercial grade of babbitt.

Twelve years after, Chief Engineer (retired) C. J. Mc-Connell, U. S. N., who had been one of the Engineer officers in charge of this test, wrote us as follows:

"I have always used 'Magnolia Metal' in preference to any other, as I was firmly convinced of its superiority after the long experiments in N. Y. Navy Yard under my own supervision.

"I went into this trial unbiased; any preference favored the Parsons White Metal, as I had heard a great deal about it, but Magnolia Metal was new to me.

"The results were a surprise, and the report shows Magnolia superior in every way. During the last nine years I had served on the U. S. war vessels 'Mohican,' 'Olympia' and 'Charleston' in the Pacific; 'Lancaster,' in South Atlantic; Flagship 'New York,' in the North Atlantic Squadron, of which I was the Fleet Engineer. Magnolia Metal from the store-rooms of these ships was used when a journal needed rebabbiting or filling with an anti-friction metal; and it always worked successfully.

"I used it more largely about the machinery of the 'Charleston,' and was always able to set up bearings and main journals finer than with ordinary babbitt or other metals. The engines of this ship, on the voyage from Yokohama to San Francisco, worked like clocks, perfectly smooth and finely adjusted, not a hot bearing. I never had trouble with Magnolia Metal, perhaps because I obtained the genuine and was careful in its use.

"For quick-moving engines, such as dynamos and electric motors or torpedo boat engines, I consider it invaluable."

In the metal line specify Magnolia products

Magnolia Metal bearings in marine service

STEAMSHIPS impose upon their larger bearings much the same punishment as in stationary plants and in addition some of the hardest tests to which bearing metal can be put.

While a steamship is rolling about and laboring in a heavy sea, and the engines at times racing while the pro-pellers are out of water, the pressure on the various bear-ings is not evenly distributed. Momentarily one bearing may have to sustain the whole weight, pressure or force of thrust, while its companion scarcely has any duty at all. Slight misalignment, shifting of foundation or a shaft of too small diameter for its work aggravate these conditions.

In the earlier days of steamships there were an absurd number of hot boxes, an abnormal consumption of oil, and the life of bearings was short. Frequently a stream of water kept playing around a bearing to reduce tempera-ture was not effective and stoppage became necessary. The ends of gun metal bearings sometimes fused. The difficulties were lessened by the introduction of lined white metal bearings, but the earlier types of these wore away too rapidly, because the metal would not lubricate properly.

At about this time Magnolia Anti-friction Metal con-taining graphite was introduced and its self-lubricating qualities were immediately recognized as a great advance for better service. Among the first to utilize the benefits

In the metal line specify Magnolia products

from Magnolia Metal in marine service was that great inventor and authority, Captain John Ericsson, who said that Magnolia Metal was a boon and that it would get “more revolutions out of an engine and attain greater speed without drawbacks.”

Practically every large steamship operating company has now used Magnolia Anti-friction Metal, many to the exclusion of all others when Magnolia can be obtained.

Any number of instances can be cited where steamship power and propelling mechanism mounted in Magnolia bearings runs noiselessly and like clockwork, and where a hot bearing has been unknown in 20 years of service.

Magnolia Metal as a metallic packing

THE anti-frictional, self-lubricating and wearing qualities, the ability to “set” gritty particles at a harmless location under the rubbing surface, an ability to fill in and smoothen rough or scored surfaces, which have made Magnolia Anti-friction Metal the best of all white metals for lining bearings, make it equally valuable as a metallic packing.

It may be used in solid machined or plain cast rings, the machined finish seldom being an absolute necessity for tightness. Another method about which some engineers are enthusiastic is to cut the Magnolia ingot into fine particles on a milling machine, fill these particles into cloth sacks and wrap around the rod. Upon initial tightening

In the metal line specify Magnolia products

of the gland on packing so made, the fluid may blow back slightly at the start, but after further tightening during the course of two or three days the packing becomes perfect and will last for many years. This procedure has often been known to give excellent results on bad rods where no other packing could be made to hold.

The following abstracts from letters indicate typical, performances of metallic packing made from Magnolia Metal:

"I was formerly Chief Engineer of the Puget Sound Ocean Tug 'Tatoosh', which is equipped with a 16-in. by 24-in. by 40-in. 28-in. stroke triple-expansion engine. At first we used packing metal of hard fine-grained babbitt composition. The soft rings were cast, machined and scraped by hand when installing but lasted only about 30 days, during which the excessive leakage compelled us to connect the 1/8-in. vent pipes to the condenser.

"A set of Magnolia Metal rings then cast on a mandrel in plaster-Paris molds, and applied without machining or scraping ran two years without trouble."—FRANK H. NEW- HALL, U. S. Local Inspector of Boilers, Juneau, Alaska.

"I tried about all kinds of metal on a piston-rod gland in Abendroth Bros. foundry here, but there was bad leakage, because there was too much clearance around the rod. I turned and bored two solid rings of Magnolia Metal to snug fit around the rod, and together long enough to fill the stuffing box. These two Magnolia rings worked like a charm where six rings of other metal had previously failed. Magnolia is O.K."—ELLIOT E. SMITH, Port Chester, N. Y.

"Three or four different mixtures for metallic packing failed to give as good results as we wanted, so we equipped a switching engine on one side with our regular formula and the other with made rings of Magnolia Metal. Both valve

In the metal line specify Magnolia products

stems were a little out of true, which gave each kind of rings the same chance. We have replaced the rings of our own formula three times but the Magnolia Metal rings have not been touched and we think we have struck the best kind of metal for metallic packing rings."—J. L. LAWRENCE, M. M., Cumberland Valley R. R., Chambersburg, Pa. (Abstracted from Proceedings of Master Mechanics Convention.)

"I had much trouble with high-pressure packing made from different kinds of babbitt metal and used on the main rods of our propelling engines. These engines carry 225-lb. steam pressure and have 3-in. rods traveling at a piston speed of 150 ft. per min. Four or eight beveled pieces constitute the packing for each rod. The packing would melt or burn and crumble so badly that upon renewal I have taken from 30 to 48 pieces at a time out of one stuffing box.

"Since using Magnolia for the rings, I have no trouble whatever and no steam leaks after the rings are conditioned. Today I examined Magnolia rings put in four months ago and found them perfect—hardly any sign of wear and good for years of hard service. I cannot speak too highly of Magnolia Metal."—JOHN OWRE, Steam Engr., U. S. Dredge "Wallowa," Riparia, Wash.

Standard packages of Magnolia Anti-friction Metal



Standard Ingots

MAGNOLIA ingots weigh approximately 5-1/2 lb. each and are packed in boxes containing respective- ly 112 lb., 56 lb. and 28 lb.

In the metal line specify Magnolia products

Dimensions of boxes		
Net contents	Size	Weight of box
112 lb.	12 in. x 8 in. x 8 in.	8 lb.
56 "	12 " x 8 " x 5 "	5 "
28 "	12 " x 8 " x 4 "	4 "

All boxes are printed on sides, ends and tops and contain instructions in English, Spanish, French and German.

Prompt shipment can always be made in any quantity from our factory warehouses in New York, Chicago, San Francisco and Montreal.

Magnolia Metal in cored bars for making bushings



FOR making small bearings, particularly for the crank shafts of small gasoline engines, cored bars of Magnolia Metal save time and the cost of patterns and castings. These bars are very convenient in machine and repair shops. A list of standard sizes appears on Page 45.

As Magnolia Cored Bars consist of first-run metal, direct from the kettles, the mixture is homogeneous, which assures uniform strength and wearing quality at every point in the bearing surface. Bearings made from cored bars fit snugly, will not work loose as poorly cast bearings often do, and are not so apt to cut the shaft as are bearings of bronze.

Magnolia Cored Bars are made in 12-in. lengths and

In the metal line specify Magnolia products

supplied in any number of full length bars of the following sizes :

Diameter of bar	3 in.	2 3/8 in.	2 1/8 in.	2 in.
Diameter of core	1 "	1 "	1 1/8 "	1 "
Weight of bar	22 lb.	15 lb.	14 lb.	13 lb.

Note: Cored bars may be secured also in our other compositions, including Adamant genuine babbitt, and in brands covering every range in quality and price.

We also make other bearing metals

MAGNOLIA Anti-Friction Metal can be used in 90 per cent of all lined bearings, but where ductility and toughness rather than anti-frictional qualities are prime requisites, genuine babbitt is sometimes more desirable. This is particularly true where the bearing metal is not securely fastened to its backing, and with shell bearings, loose-pulley bearings, crushing roll bearings, etc., that are subjected to pounding.

Where for any reason genuine babbitt is preferred, the use of Magnolia Metal for the upper half of the bearing is desirable, in that the Magnolia Metal will quickly condition the bearing and impart its lubricating qualities to the genuine babbitt, thereby greatly increasing bearing efficiency and life.

Genuine Babbitt.—We make two genuine babbitts only. One of these, which we call "Genuine" is made to the original formula of Isaac Babbitt. The other, which has proven able to give better service than the original formula, we call Adamant.

In the metal line specify Magnolia products



Adamant is a super-genuine of -the highest quality and probably the lightest on the market, weighing but 4.24 oz. per cu. in. (specify gravity 7.34). It withstands a pressure of 5,000 lb. per sq. in. with but 0.001 in. deforma- tion, is hard enough to sustain heaviest load possible with babbitt and will not break in severe service.

Adamant flows freely at its pouring temperature, about 800 deg. fahr., produces a clean-cut casting without blowholes, and the elements do not separate. There is no



Adamant can be twisted or bent as shown in these pictures



excess copper to form hard spots which cut the shaft and cause rapid wear, beating and extension of the metal.

Adamant, where a genuine babbitt is required, and Magnolia for all other purposes, would meet all bearing

In the metal line specify Magnolia products

requirements, but for those who demand lower initial cost, we make and recommend the following Brands as affording the Best Service obtainable at their price:



Defender is a very good babbitt—the equal of ninety percent of the brands of other concerns that are offered in competition with Magnolia. We claim that Defender is a cleaner and better metal than these other com- petitive brands and in some instances costs more to produce. Its physical characteristics are very close to Magnolia but it does not possess the same low co-efficient of friction and wearing qualities.



Mystic is very close to Defender Metal and likewise compares with any of the other competitive brands at prices that will meet this competition. The difference under test between Defender and Mystic would not likely be noticeable and they are both made from equally high grade material, carefully refined in the making.

In the metal line specify Magnolia products



Kosmic is a metal of better quality than those usually offered at the same price. It will do good work on slow-moving bearings.

Pyramid is a good cheap metal for slow speeds and light loads.

Power is a superior copper-hardened metal and has been used with much success on rock, stone and granite crushers.

We also manufacture genuine babbitt, white brass, and all the hardware grades from Nos. 1 to 4.

Specification metals

We manufacture specification babbitts, special alloys, etc. Formulae strictly in accord with specifications—the finished products represent the best that can be produced with standard materials and up-to-date equipment. Send your specifications and have us quote on your requirements.

Special brands made to order

FOR those dealers who wish to market their own brand, we will make up ingots to any formula, and bearing a desired trade mark, and we will guarantee strict adherence to specifications.

In the metal line specify Magnolia products

Regular arrivals of ore from our own properties, advantageous arrangements for obtaining all metals, well-equipped smelters and excellent shipping facilities enable us to quote reasonable prices, particularly on yearly contract.

We gladly advise as to prospective market conditions and supply other information regarding metals, whether you place your orders with us or not.

We will quote on long-time contract basis or upon individual lots, and upon request will be pleased to put your name on our mailing list for future quotations.

Die Casting Metal

Our metals for die casting (made to any desirable formula) are compounded with the same skill and care as are our bearing metals, and we will assist if desired, in selecting suitable composition for strength, smooth finish, etc., for each service.

Type metals

Linotype—Electrotype—Monotype—Stereotype

We make all printing metals to standard formulas, from carefully selected materials, thoroughly mixed under our own process, correctly balanced and moulded into the most convenient shapes.

Magnolia type metals can be reworked a great many times with but small loss in re-melting.

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BEARINGS ARE PARASITES; they produce nothing, but unless carefully watched, absorb a large percentage of the valuable product that passes through their territory. So long as money is spent for fuel or purchased power, it is absolutely certain to be wasted by faulty bearings and saved by keeping the bearings in proper condition.

When the man in the front office thinks about the power distribution at all, he is very apt to assume that the motor runs the line shaft and the line shaft runs the machines. He may see nothing wrong in 100 h.p. at the motor dropped to 80 h.p., delivery from the line shaft. What has become of the other 20 h.p.? It is obvious that the motor really runs the machines and the line shaft does nothing but pass the power along.

For this slight service the shaft is entitled to a small wage; but when it grabs 15 to 20 per cent of everything it handles its rapacity ought to be stopped. Think of paying a line shaft system \$25 or more a year for every bearing it possesses—\$2500 for 100 bearings, no discount for quantity—when the bearings themselves are not worth anything like that sum, and the work the whole system does theoretically should cost next to nothing.

For those who find cause for complaint in high taxes, here is a real taxation kick!

Of course it is the pressure the bearings bring to bear on any shaft that causes this unreasonable levy and the obvious way to stop the waste is to keep internal friction in the bearings low.

This same logic applies to every bearing within the individual machine also, as the cumulative toll through a number of more or less neglected bearings here invariably produces a notable power drop between inlet and delivery.

—INDUSTRIAL POWER, Oct. 1922.

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Part 11. Hints for making lined bearings and making them give good service

Lined bearings

BEARINGS that have a removable white-metal lining are considered more desirable in many classes of work because only a small quantity of the more valuable contact metal is required, and this, can be renewed at smaller expense than for a complete new bearing block. Also, the lining metal, by acting something on the same theory as an electrical fuse, gives a sign of distress when overheating occurs, so that the trouble can be remedied before the shaft is ruined.

Shells for lined bearings are usually made from cast iron, malleable iron or bronze, depending upon available space, strength required or surrounding corrosive influence.

Cast iron is the most commonly used material because of its strength and low cost; malleable iron gives greater strength and toughness; and bronze is better and more reliable than either but more expensive. Bronze has more than any other metal the strength to withstand the hammering and effects of vibration to which the bearing is subjected when in use, together with the best possible heat conducting qualities. In cases where a very thin bearing liner is used, a bronze shell will act as a bearing surface temporarily, if through accident, the bearing liner

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melts and runs out. In railway work, for instance, the use of bronze under these conditions usually assures completion of the run.

Cast steel is not a desirable material for the shells on account of the roughness of the casting, and because, when the outer skin is machined off, internal stresses are released and the finished part is apt to warp.

To assure uniformity of grain, wear, and thickness of lining, all bearing shells should be bored before receiving the lining.

The white-metal liner is poured in some instances with the journal and shell in normal operating position but usually not. The former practice is not to be recommended except in emergency cases, because of the difficulty in forming a mould, in uniform pre-heating and in getting to the right place with a sufficiently large ladle of molten metal. The heat conditions tend to spring the shaft, and due to the chilling of the molten metal a poor cast is liable to result.

Main bearings of small engines and rocker shaft bearings of larger ones are sometimes made without provision for taking out the shells, in which instance casting can be done only in place. Under this condition it is preferable to use a mandrel instead of the shaft as part of the mould.

Directions for making a new or renewing an old lined bearing under the conditions most commonly met with in practice are given in detail in the following pages. Close observance of these hints will do much toward assuring care-free bearing service long into the after years.

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Cleaning the shell

THE first step in relining an old bearing is to remove the old lining from and thoroughly clean the shell.

The old lining of an iron or steel shell can be chipped out with hammer and chisel or melted out either by torch or forge or by immersion in a pot of old metal. The shell is free from oil and most of the dirt when smoke ceases, but all traces of scale, rust, dirt and old lining material must still be removed.

Sand should be cleaned off only by blast, tumbling, wire brush or by pickling in a hydrofluoric acid solution composed of 1 gal. commercial hydrofluoric acid to 10 gal. of water (Spec. gr., 1.015 at 16 deg. cent.). This solution should be kept in a wooden container. Muriatic acid or hot soda ash solutions may be substituted.

Scale or rust can be removed by sand blast, wire brush or by pickling in a muriatic acid solution or in a sulphuric acid solution, composed of 1 gal. commercial sulphuric acid to 10 gal. water (Spec. gravity, 1.08 at 68 deg. cent.). This latter solution should be maintained at a temperature of 60 to 80 deg. cent. (105 to 175 deg. fahr.) when in use.

All anchor holes or grooves should be well cleaned out by hand if necessary so that the new metal may flow in to form a secure anchor.

The old lining from bronze shells can be removed by heating, preferably in a pot of scrap babbitt in which the temperature should not exceed 440 deg. cent.

Both iron or bronze shells, after the previous cautions

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have been taken, should have their surfaces scraped with a file or coarse sandpaper as a final precaution, and in the case of a tinned bearing, to give a better surface for bonding of the tin.

Anchorage by tinning

TINNING the liner to its backing bonds the two together strongly, avoids the necessity for peening and permits the liner to wear down very thin without cracking or working loose. It is the approved form of anchorage for bronze shells, and is employed to some extent as the sole method of anchoring in small iron and steel shells, and in connection with anchor holes or grooves in larger shells of these metals.

The tinning mixture, which acts as a fusing medium between the bearing metal and the shell, will adhere only to a surface which has been specially treated. The tin must be made to adhere to the entire contact surface in a thin uniform clean film or the liner is apt to crack or loosen.

After cleaning the shell contact surface as described on preceding page, the bright metallic contact necessary for bonding the tin is best obtained by roughing with sandpaper or an old file.

The parts of the preheated shell which are not to be tinned should then be covered with a thin mixture of graphite and water or red clay and water. The latter mixture should contain only enough clay to produce a red color and should be kept well stirred. As soon as the shell

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is dry it is ready to receive the fluxing mixture, which is a zinc chloride solution consisting of one part of zinc by weight to three parts of commercial hydrochloric (muriatic) acid. This should be swabbed onto the parts to be tinned and the tinning alloy then applied while the shell is hot (see Page 64).

The tinning alloy should be "50-50" solder (half tin and half lead) of high purity. It should be melted in an iron or steel pot in which the temperature is kept between 410 and 440 deg. cent. (770 to 825 deg. fahr.) and in no instance ever permitted to exceed 450 deg., cent. (840 deg. fahr.)

The molten alloy, being a mechanical, rather than a chemical mixture, should always be stirred immediately before use, and at frequent intervals during use in order to keep the lead from settling to the bottom and impairing the uniformity of the mixture. Upon cooling, the metal surface in the pot should be covered with sawdust or charcoal to prevent the formation of dross.

The tinning alloy can be applied in a bar form by rubbing the bar over the surface to be tinned. The bar should melt and flow freely, and a hot soldering iron can be used to assist in covering all the surface with a good coating. Rubbing with a dry rag, a piece of waste or a soft brush will then make the surface even.

A quicker and better method, which lessens the possibility of the shell warping or cracking, is to immerse the shell in the pot of molten solder and keep it there until

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just hot enough for the solder to leave a thin coating when poured off. The shell should then be taken out, the surface on which the coating is to adhere, rubbed with a swab saturated with zinc chloride and the shell dipped again into the tinning mixture to make a better coating and remove all traces of the zinc chloride. As long as any untinned spots can be detected the process should be repeated.

If the shell is to be babbitted immediately, the tinned surface should not be touched after the last removal from the soldering pot. Immediate babbitting without intermediate cooling is preferable for good fusion between babbitt and shell.

In the case of steel or malleable iron shells that must cool after tinning, the shell can be removed from the soldering pot after the first dip, the excess solder brushed or swabbed off and the shell cooled in running water. The outside of the shell should again be covered with red-clay wash, and the shell dipped into the molten solder until it comes to about the same temperature as the latter. Upon removal from the pot, the bore should be swabbed with zinc chloride and the shell again dipped. After last removal from the soldering mixture, the tinned surface should not be touched before pouring the liner.

Anchoring holes and grooves

BRONZE shells properly tinned do not usually require other provision for holding their liners fast, but

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where trouble has been experienced or where double precaution against loose liners is desirable, anchor holes or undercut grooves are added to the shells.

Tinning on ferrous metals, although sometimes done, is not so dependable, as at the temperature of molten solder the bearing shell and the solder cannot be expected to bond strongly. Cast and malleable iron and steel shells are therefore usually provided with anchor holes and slots at the start, or these are added later, where liners that were tinned only have come loose.

Anchor holes or grooves may be employed on both bronze and ferrous metal shells either in connection with tinning or as the sole means of fastening.

Radial holes liberally distributed near the ends and around the bearing windows (where these exist) hold the liner securely at the edges and are an efficient form of anchoring. The holes should be $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter, depending upon the size of the shell, should be at least as deep as the diameter and should have two or three smaller holes drilled at an angle at the bottom to form a root. Another method for added security is to drill only the large holes, but incline them at slight angles in opposite directions. The tops of the holes in all instances should be countersunk slightly to provide for a stronger corner in the liner casting with correspondingly greater resistance to shearing.

Longitudinal or radial slots or a combination of both, with either parallel or cut-under sides, are frequently used

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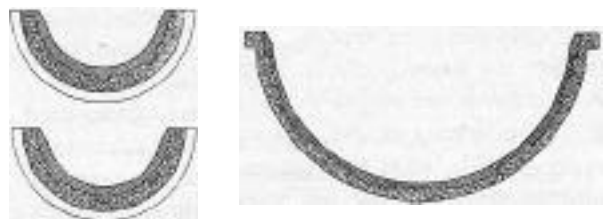


Fig. 1. Typical forms of longitudinal anchor grooves

for anchoring in split bearings. The longitudinal slots are particularly desirable in the bottom halves of high-pressure bearings as they tend to prevent the soft lining metal from squashing out under pressure.



Fig. 2. Longitudinal anchor slots for split bearings

The practice of the Westinghouse Machine Co. in anchoring babbitt bearings is shown in Fig. 2. Except on the smallest bearings where the slots can be shallower, a depth of 5/16 in. is sufficient in bearings of all diameters.

Auxiliary anchors for the thicker liners are sometimes made by countersinking flat-headed screws well below the bearing surface, but as such screws may back up, this practice is not recommend

Mandrels

BEARINGS are sometimes lined, with the journal or shaft in place, but generally this is done only in emergency cases. Better practice substitutes an arbor or

mandrel during the pouring operation as extra metal can then be left for finishing.

Arbors for a single pouring can be made of wood, but metal is preferable, and necessary for large bearings or for repeated use. A good mandrel can be made from a standard rod or a casting, and turning to the most desirable outside diameter costs but a small amount even if done in an outside shop.

The diameter depends upon whether the liner is to be peened and bored, or merely scraped to fit. Liners in which the babbitt is to be peened and bored require a mandrel only enough smaller than the journal to allow for the metal to be removed. If the journal happens to be worn, a further allowance must be made to meet this condition. Less allowance for extra metal should be made to reduce labor in fitting, where the liner is to be merely scraped to finish.

Several methods are employed to keep the molten babbitt from sticking to the arbor. Wrapping with one or two layers of thin paper has been found very satisfactory, and another common practice is to coat the surface with a light coat of oil, chalk, or black lead mixed with cup grease or with a thin clay mixture. The clay mixture is water with only enough clay in suspension to give strong color. It should be kept well stirred and swabbed onto the heated mandrel with a brush or piece of waste. The water evaporates quickly from the heated mandrel without sputtering and leaves a thin layer of fine clay dust. This coating

has been found to be of great help not only in preventing the babbitt from sticking, but in producing smooth, clean cast surfaces free from pinholes and other defects.

A mandrel which is to be used for successive pourings may have to be cooled if the intervening periods are short. This is nicely done by applying the cold clay wash, which prepares the mandrel for the next pour, while at the same time the evaporation takes surplus heat out of the metal.

Forming the mould

DURING the pouring operation all openings other than the inlet hole must be sealed in order that the molten metal cannot run out.

For small bearings, stiff mud, fire clay or putty, if necessary covered on the outside with cloth, insulating tape, etc., can be made into a satisfactory dam for holding in the molten metal.

A good mixture for this purpose is easily made from old pipe coverings, pulverized by pounding with a mallet, sifted to remove the lumps and mixed with cylinder oil to form a stiff paste. This composition will stick better if prepared some little time in advance, and when not in use should be kept in an airtight container. If found to be too dry when wanted again, more oil may be added.

Strips of leather of correct thickness and sufficient length to encircle the arbor may be used as rests and end fillings for the arbor and make good spacers to give a proper depth of babbitt between arbor and bottom of box.

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If an internally lubricated pin or shaft instead of a mandrel is used for the core, the oil holes may be filled by driving in a wooden plug and covering the head with putty. The combination is easily removed with a gimlet after-wards.

Some kind of a stiff backing capable of withstanding pressure due to the weight of the molten metal is necessary with large bearings. A suitable device can often be made from a wide board with circular section cut away so as to fit the shaft with the top of the board above the metal line. A piece of paper placed in front of the board serves well as a gasket and prevents the hot metal from coming in contact with the board. Weights or clamps, if necessary, should be used to hold the parts in proper position.

Where the top shell has a hole for a grease cup, this can be used as a pour hole, and the metal afterwards bored out with a drill.

Liners in removable shells may be poured as shown in Fig. 3, using a form or mandrel clamped with wooden space sticks.

A mould for a bearing that is to be poured around the journal is shown in Fig. 4. The boards at the ends are out to fit the shaft and held together by stay rods. Care must be taken, in this instance, to space the shell evenly from the shaft.

Large engine crank pin, crosshead and main bearings must be poured under such a wide variety of conditions,

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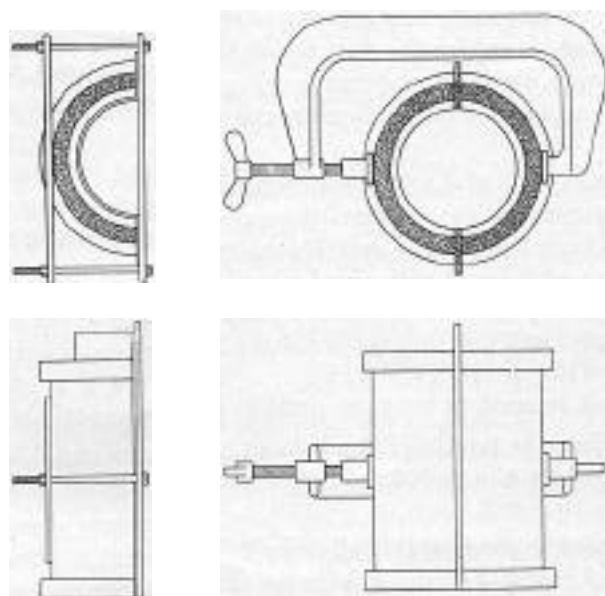


Fig. 3. Good arrangements for pouring liners in removable shells

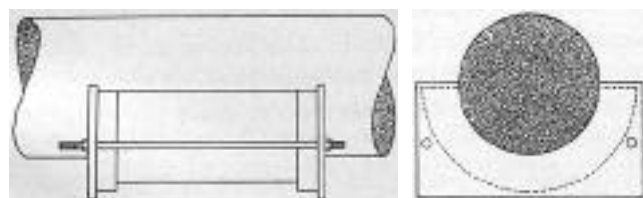


Fig. 4. Mould for a bearing that is to be poured in position

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that detailed arrangements and instructions for each cannot be included in so small a booklet as this.

Where considerable babbitting is to be done on bearings of various sizes, a jig as shown in Fig. 5 can be used.

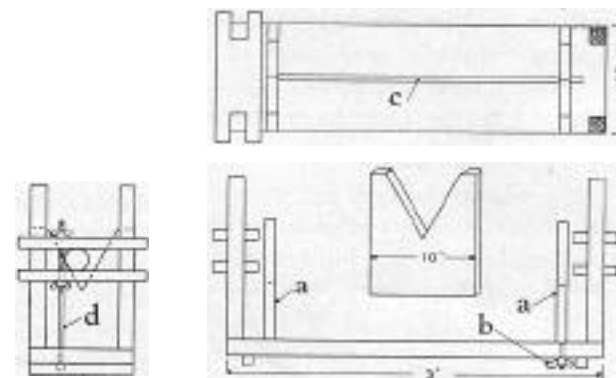


Fig. 5. Jig used in babbitting bearings

A piece of 1 $\frac{1}{2}$ -in. plank, 10 in. wide and 3 ft. long, (sufficient to cover the largest bearing), has two blocks 1 in. high secured at each end to act as feet. A piece of wood, aa, 1 in. thick and 10 in. wide, with a large V-cut in it is fastened near one end of the plank, and another similar piece with a bolt and thumb nut, b, projecting through a slot, c, in the plank can be moved along so as to accommodate a bearing of any length. At each corner of the plank guide posts are fastened, and sliding up and down on these is a clamp, d, having a $\frac{1}{2}$ -in. bolt with long thread and thumb nuts above and below to be used in holding the arbor in place. The bearing is placed on the plank between the V-blocks, the arbor resting on the clamps and adjusted so as to give the right thickness of metal, and the clamps then pulled down onto it to hold it firm.

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Preheating of bearing parts

MOLTEN babbitt coming into contact with cold metal sets and shrinks before properly filling the mould. In order that babbitt and shell establish full contact with each other and shrink together instead of apart, "cold shorts" must be avoided. Unless intimate contact exists between shell and babbitt, the turning force of the shaft may tear the liner loose or cause the surface to slough off in thin flakes.

For this reason the shell and journal or mandrel should be preheated sufficiently at pouring time to permit smooth flow and gradual cooling, but not so much as to cause the heavier babbitt ingredients (lead and antimony) to settle to the bottom of the mould. This segregation would result in soft and hard spots in the bearing surface. Preheating also burns off moisture and grease, which if allowed to remain would form gases and produce blow holes.

The following temperature limits should be carefully observed in preheating:

Bronze shells, solid, tinned,	100 to 125° cent. (212 to 255° fahr.)
“ “ split “	125 to 150° cent. (255 to 300° fahr.)
Iron “ “ or solid	220 to 260° cent. (430 to 500° fahr.)
Steel “ “ “	220 to 260° cent. (430 to 500° fahr.)
Iron or steel shells, tinned	200 to 250° cent. (390 to 480° fahr.)
Mandrels	125 to 150° cent. (255 to 300° fahr.)

Iron or steel shells may be considered sufficiently heated when a stick of "50-50" solder touched to the surface will just melt.

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The mandrel is at the right temperature when water evaporates rapidly from the surface without sputtering

Melting and pouring the babbitt

CASUALLY watching a workman pouring babbitt metal into the bearing shell does not impress the observer as requiring any skill on the part of the operator. Neither does this operation seem to be such as to require any special attention or careful supervision. However, this impression is misleading, for to produce reliable and dependable babbit bearings, many little details, must be thoroughly mastered.

Melting—Babbitting outfits vary from an old kettle heated on the blacksmith forge, to a well-defined department fitted with several gas- and air-heated pots and having a full equipment of jigs and fixtures. A recent type of babbitting pot is heated by electricity and provided with automatic temperature control.

The babbitt should be melted slowly in a clean iron pot or kettle and the temperature of the molten mass maintained uniformly between 460 and 482 deg. cent. (800 to 900 deg. fahr.) In no instance should the temperature exceed 490 deg. cent. (915 deg. fahr.), otherwise some of the tin may become oxidized and the bearing value of the finished liner impaired. Where any extensive amount of babbitting is done, the temperature should be controlled with an automatic regulator and thermocouple or resistance pyrometer.

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Old babbitt from worn bearings should not be mixed with new, nor should an amateur attempt to make the babbitt himself by mixing the base metals together. Mixed or low grade bearing metal is apt to contain impurities which will impair the cast liners, no matter what precautions may be taken. As the compounding of babbitt should be based upon chemical analyses and is really the work of a specialist, it will be found safer to use metal of known composition or time-tried reliable brand. The cost of safe metal is so little more than for "scrap" that the use of the latter cannot be justified.

It should be remembered that babbitt is a mechanical mixture the success of which depends upon perfect diffusion of all ingredients throughout the mass. The molten metal should therefore be kept thoroughly mixed, especially just before pouring, by continually bringing the lower strata up from the bottom of the pot. If permitted to remain quiet while in a liquid state, the mass tends to separate into layers. The lead, being heaviest, sinks to the bottom and the lighter ingredients come to the top. Bearing liners, poured from metal in that state, are bound to make trouble in service. As neither lead nor tin has any special sustaining powers, the lower end of the liner (in pouring) is likely to be lead and is soft and will squash out, while the other end, with too much antimony, a hard, brittle metal, is likely to cut the journal, overheat and crack. In the case of bearing metal containing graphite, the graphite separates from the mass, thereby losing the value of that lubricant.

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Water should not be permitted to drop into the heated pot as it causes the molten metal to fly in all directions with danger of burns to the operator. Dross should be removed from the surface before removing metal for pouring; and upon completion of babbiting operations, the metal, before cooling, should be covered with charcoal or sawdust to retard oxidation and formation of scum.

Pouring—The first precaution in pouring is to have the parts of the mould properly preheated, as described elsewhere, and to see that the cavity is thoroughly clean and perfectly dry. Some put in a little rosin in the belief that this prevents the metal from spattering when coming into contact with too cold a shell or any possible moisture.

Correct temperature of the molten metal must next be assured. Pouring metal that is underheated gives a coarse granular casting, and if overheated, the babbitt partially oxidizes, becomes dirty, shrinks excessively, softens, and has poor anti-frictional qualities. If no indicating and regulating devices are at hand to determine temperature, the molten metal is about right for pouring; when a white pine stick used for stirring, chars but does not ignite. A skilled workman learns to determine the correct pouring temperature by the "feel" in stirring and by the color. The change from a silvery to a yellowish tinge indicates the proper time for checking the heat.

A ladle of the self-skimming type, that is, with welded or riveted sheet-iron bridge as shown in Fig. 6 is preferable for pouring, as it permits the size of the metal stream

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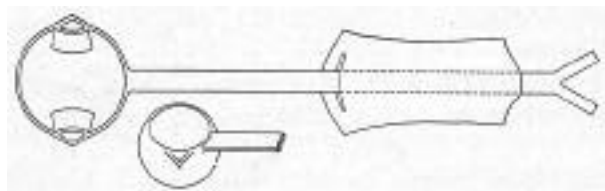


Fig. 6. Self-skimming ladles, showing also leather holders for protecting the hands of the workmen

to be predetermined, prevents splashing and keeps slag at the top of the ladle from getting into the mould. If a plain ladle is used, the lip should be kept clean and free from burrs or other surface irregularities that would interfere with a smooth solid stream, and scum should be kept from entering the mould. This ladle should be held close to the pouring hole to avoid air bubbles or chilling the metal.

The metal should flow steadily and in a way to avoid splashing and pocketing of air. A trifle more metal should be added after the mould is apparently full, in order that any impurities tending to remain after skimming will overflow. The babbitt will shrink a little in cooling, and by continuing to pour after cooling has started, shrinkage in the bottom of the mould will be at least partially compensated.

Best results are obtained by pouring with the shells in a vertical position and directing the stream against the mandrel. Irregular shape of the mandrel may make this impossible, in which instance, the mould may be inclined

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for pouring at the most convenient point. Split shells poured singly at an angle should face downward. They are also sometimes placed in horizontal position on a surface plate, with convex side up over the mandrel, and the babbitt poured through holes put in the casting for that purpose.

Each liner should be poured complete at one operation, so that on large work, a pot of liberal size is desirable. If the ladle is too small, a second ladle should be on hand and ready as soon as the first is empty, in order that, there will be no break in the babbitt.

The kettle of molten metal and the bearing should be kept close together, as carrying a ladle of molten metal any distance is bad practice. Aside from possible danger of spilling, the ladle contents may cool enough to impair smooth flow into the mould.

Finishing the poured bearing

BABBITT is weak while hot, so the poured casting should be handled carefully while cooling, and not removed from the form or mould until after all danger of falling out or disturbing is over, otherwise the anchors may break and the liner become loose.

Cooling should be gradual in order that the size and number of tin-antimony crystals be kept small and brittleness of the matrix in spots prevented.

Small, blow holes, if few in number, should be filled in with babbitt, using a hot soldering iron. If the blow holes

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are large or numerous, or if seams have formed, the lining should be melted out and repoured.

Excess babbitt, metal fins and burrs can be removed with a hot soldering iron, spoke shave or ordinary draw knife. All windows and lubrication holes should be thoroughly cleaned.

In some few instances, or by reason of impossibility, no further finish is given to the bearing surface, which under these conditions is expected to wear down and find its seat.

Better results by far are secured by scraping or preferably boring and then broaching or scraping to final fit.

Scraping is facilitated by covering the bearing surface lightly with Prussian blue, lamp black, red lead or chalk, and putting in and turning the shaft. The coloring rubs off at all points where the shaft touches the babbitt. By repeated scraping of high spots so found, the babbitt can be brought into close contact with the entire journal. Scrapers made for this purpose are readily obtainable, or can be made easily from old half-round files softened and bent to fit and then ground.

Bearings that are to be machine-finished should always be peened with a ball-peen hammer, preferably before entirely cold, as the warm metal yields better to hammer blows and is less apt to crack. The peening compresses the babbitt into a closer fit with its seat.

Bearings that can be handled in a lathe should be turned at moderately high speed with first cuts comparatively coarse and the last or finishing cut fine. If the number of

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bearings of the same size is large enough to justify the expense for special tools, the finished surface obtained by broaching will be found most satisfactory.

For a very good job, scraping of each bearing to final fit is desirable after the machining, as in this way the bearing is brought to the exact contour of the shaft. In the case of a badly worn journal, good fit cannot be obtained in any other way.

Oil grooves for spreading the lubricant

THOROUGH bearing lubrication demands the formation and maintenance of a continuous even film of oil between the frictional surfaces, so that these surfaces will not actually touch each other while the shaft is in motion.

The provision which must be made to get or approximate this result is dependent upon the method of application and the kind of lubricant, the point or points of application, the bearing pressure, the speed of revolution, the direction of rotation and the design and size of the bearing.

To distribute the oil properly in split bearings and at the same time collect that which would otherwise run out at the ends of the bearing and return it to some point where it may again be of some use, all but the very smallest or slowest speed or lowest pressure bearings must be provided with some form of oil grooves. Even in bearings of the lightest duty, though, it has often been found that a bear-

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ing that ran hot without grooves, ran perfectly after grooves had been added. The design of grooves is often based upon the opinion of the man doing the work, but as long as the grooves satisfactorily perform their functions the exact way in which they are cut is of secondary importance.

The bearing edges which are parallel with the shaft should always have their edges beveled or chamfered to keep the oil from being wiped away by these edges. The pocket so formed causes a wedge-shaped body of oil to collect across the bearing, and the revolving journal drags this wedge of oil in between the contact surfaces. It is obvious, however, that the bevel or chamfer should not extend to the ends of the bearing, otherwise the oil would drain off and waste through the openings. Where there is a window in the bearing, the window edges also should be similarly beveled or rounded. Incidentally, these bevels serve another important purpose. There is a metallic contact between journal and bearing when at rest, and unless the edges of the latter are relieved there is a tendency toward slight abrasion at these points at the instant of starting and stopping. Small particles breaking off in this way might get into and harm the useful bearing surface.

Oil grooves, where used in the main surface of the bearing, are generally cut (chipped) by hand or machined into the surface of the liner (except in die-cast bearings) as the liner is usually too thin to permit casting.

Many different layouts of surface grooves seem to give satisfaction, but this does not prove that there may not be a best arrangement in each instance. An analysis of all conditions should be made before deciding how the grooves should be cut, but in all instances the edge of the groove should not make a sharp angle with the journal, but should be eased off. A glance at grooves a and b at the left in Fig. 7, shows that they cannot be as good oil distributors as grooves c and d at the right.

Simplicity is very important for good results. Grooves should be cut only where needed and then only enough to

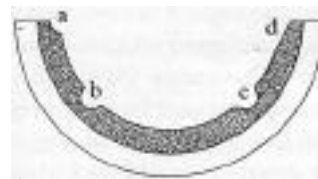


Fig. 7

thoroughly distribute the particular kind of oil that is used. Elaborate grooving systems generally defeat their purpose by breaking up the oil film and conducting the oil away from, rather than leading it to, the important points and enabling it to stay in.

Oil grooves in the bottom half of the bearing are necessary under some conditions but should be employed with the greatest caution when at all. Grooves at this location of greatest bearing pressure reduce the bearing surface, which in some designs is not permissible. They may also

cause the oil to flow into the grooves and out to a region of lesser pressure, which would destroy or impair the oil film.

If bearings heat up, grooves should not be cut in the lower half of the shell as a first remedy, for instead of making matters better, these grooves might make conditions worse. Some other experiment should be tried with the idea of preventing the oil from flowing from a region of high pressure to one of low pressure, and in any event, if the bottom of the box is grooved, the grooves should not meet or cross.

In general, bearings 6 in. wide or less require only a single oil hole in the cap; if wider, two holes should be provided. Mere chamfering of the edges parallel to the axis as before described may give sufficient lubrication, but for the higher speeds and bearing pressures, grooving in the surface of the upper half of the box at least, is necessary. The grooves should be cut to within $\frac{1}{8}$ in. to $\frac{1}{4}$ in. of the end of the box, depending upon the size of the bearing.

Fixed and definite rules for the shape and location of these grooves are impossible because of the wide variation in service requirements. The grooves in all instances should be cut narrow in order not to materially reduce the amount of effective bearing surface, and the grouping should be such as to keep the more generous supply of oil toward the center of the bearing rather than at the edges.

Authorities differ much in their recommendations and it frequently happens that a number of grooving schemes all

give good results under identical conditions. We therefore illustrate a number of layouts which are known to have proven satisfactory, and if the workman observes the hints given in these paragraphs he will have no difficulty in obtaining cool, smooth running.

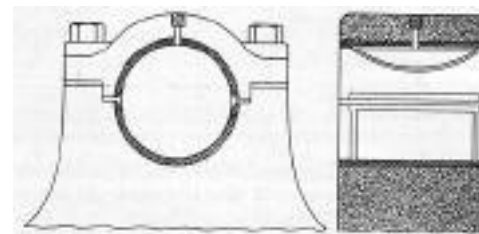


Fig. 8. Outboard bearing with chamfered edges and top and bottom oil grooves

In outboard bearings of large size, where the oil is fed drop by drop through a hole in the cap, the arrangement in Fig. 8 will distribute the oil thoroughly. The lower half of the bearing contains only shallow grooves parallel to the ends of the shell. These intercept oil which would squash out at the ends, and direct it to the beveled recesses where it is again put into circulation.

Grooving developments recommended for single and double ring-oiling bearings are indicated in Figs. 9 to 13, the depth of the grooves varying from $\frac{3}{32}$ in. to $\frac{5}{16}$ in., according to the size of the bearing. Comparatively deep grooves cut near the ends of the shell and parallel to the periphery of the shaft or recesses provided in the housings

and properly drained, to a basin below will prevent the oil creeping along the shaft. To prevent a scraping action

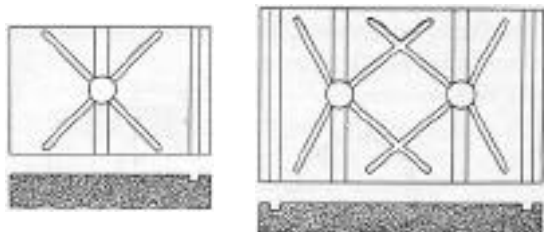


Fig. 9. Grooving layouts for single and double-ring bearings. The groove at the left end should be omitted for bracket bearings, and when the distance between the ring groove and end of the edge chamfers is less than $\frac{3}{4}$ in. both end grooves are omitted

otherwise present, to provide a recess in which surplus oil may gather and as a further means of distribution, the shells should be beveled or chamfered at the horizontal edges, the chamfers extending to within $\frac{1}{8}$ in. to $\frac{1}{4}$ in. of the ends of the bearing.

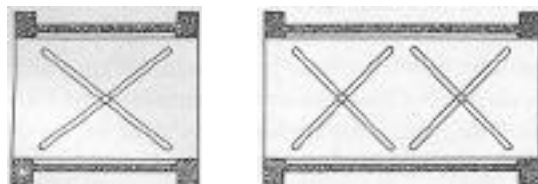


Fig. 10. Crossed grooves for single and double oil holes

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Crank pins are generally oiled through the pin, by means of a duct drilled as shown in Fig. 14. The shallow groove out in the surface of the pin parallel to the axis, reaches almost to the end of the bearing. Grooves may or may



Fig. 11.

Fig. 12

Fig. 11. Two-slot oil groove layout. for crank pin box, which has been found to give excellent results in spreading oil from a central feed hole in the pin

Fig. 12. H-groove for single feed hole

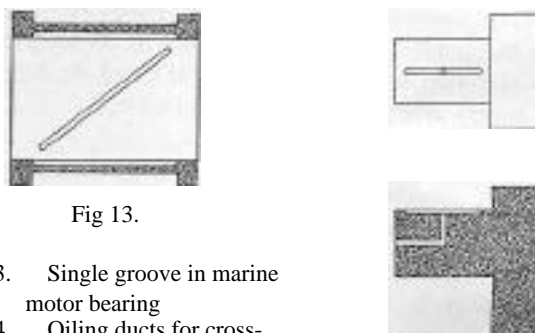


Fig 13.

Fig. 13. Single groove in marine motor bearing

Fig. 14. Oiling ducts for cross-head pin

Fig. 14

not be cut into the bearing liner, but the horizontal edges where top and bottom halves meet should be beveled.

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Crosshead shoes are frequently grooved as shown in Fig. 15. The points of the diamond are from 1 to 2 in. from the ends of the bearing and are connected to the

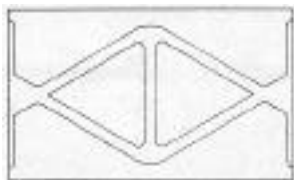


Fig. 15. Grooving layout for crosshead shoe

bevels on the ends. The grooves should be about $\frac{1}{8}$ in. wide and $\frac{3}{16}$ in. deep. With the engine in operation, these open spaces at the ends of the diamond of the lower shoe collect the oil naturally lying on the bottom side, and, due to the travel of the crosshead, force it into the grooves and again out at the other end where the reverse process is repeated in the return stroke. This insures all parts of the slide being served with oil at every stroke, and also to a very great extent prevents splashing.

Clearance between journal and bearing surface

GOOD running fit must provide for a thin film of lubricant between the sliding surfaces, and for expansion of the shaft at the higher temperature of operation. The diameter of the bearing must therefore be slightly larger than that of the journal, the difference increasing with increase of diameter of the journal.

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The exact amount of this clearance is a matter on which no two authorities seem to agree, but for the average horizontal cylindrical bearing, satisfactory results should be obtained within the maxima and minima given in the table below.

A prominent motor manufacturer considers the following as good practice for railway motors using grease, oil or water lubrication:

Up to and not including 3.5 in.	0.006 in. min. to 0.008 in. max.
From 3.5 up to and not including 4 in.	0.008 in. min. to 0.012 in. max.
From 4 in. up to and including 7 in.	0.012 in. min. to 0.016 in. max.

Maximum and minimum clearances for horizontal cylindrical bearings

DIAMETER OF SHAFT	MAXIMUM	MINIMUM
1 in. and under	.002 in.	.001 in.
1 $\frac{1}{8}$ in. to 2 in.	.0035 "	.0015 "
2 $\frac{1}{8}$ " " 3 "	.004 "	.002 "
3 $\frac{1}{8}$ " " 4 "	.005 "	.0025 "
4 $\frac{1}{8}$ " " 5 "	.006 "	.003 "
5 $\frac{1}{8}$ " " 6 "	.008 "	.004 "
6 $\frac{1}{8}$ " " 7 "	.011 "	.0045 "
7 $\frac{1}{8}$ " " 8 "	.012 "	.005 "
8 $\frac{1}{8}$ " " 9 "	.014 "	.006 "
9 $\frac{1}{8}$ " " 10 "	.016 "	.008 "
10 $\frac{1}{8}$ " " 15 "	.019 "	.009 "
15 $\frac{1}{8}$ " " 20 "	.020 "	.015 "

For vertical cylindrical bearings the clearance is from .001 in. to .004 in. less than for horizontal, depending upon the diameter.

Alignment of bearings

SHAFT bearings, either large or small, must be well aligned at the start and kept so or they will certainly

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take too much lubricant, develop excessive friction, heat and wear, and shorten the lives of both themselves and the shaft.

Investigation of many properly made shafts which have fractured, has shown that, in the majority of cases, the edges of the fracture have rubbed together from bending of the shaft due almost invariably to fault in the bearing alignment.

It has been proven by experiments at the University of Illinois that a shaft that is forced to bend at each revolution, as in case of uneven alignment, will run a definite number of revolutions after which it will break. The total number of times before fracture depends upon the metal, the diameter, and the amount of flexure. If these factors are known, the length of shaft life may be predicted with fair accuracy.

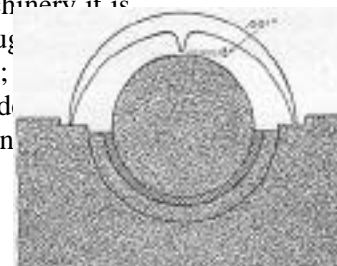
An authority on large oil engine bearings states that the main shaft bearings of a new unit when leaving the test floor should not be out of alignment over 0.001 in., with which the shortening of shaft life is negligible. However, when the discrepancy amounts to 1/32 inch the shaft life is reduced as much as 90 per cent.

Shaft operation often involves conditions under which the bearings cannot be expected to wear equally, and very often the difference is aggravated by difference in the quality of the bearing metal or bad workmanship in making the bearing liners,

It is therefore urgent that methods be found and regu-

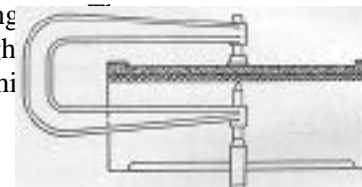
larly employed to check the alignment and wear on all important bearings.

Several good ways are shown: Fig. 16 is a gauge made of sheet steel of say 1/8 in. thickness. The legs rest on the housing and the anvil clears the shaft by 0.001 in. On high grade machinery it is probable that one such gauge similar bearings will suffice; a separate one should be made for each bearing. If a bearing has worn it will ride lower than before and the difference is easily detected.



The micrometer, Fig. 17, offers another method where the babbitt is cast into machine-finished shells.

These shells rest in the housings and are within 0.001 in. of being difference in bearing height exceed 0.002 in. If this thickness the bearing shell were known, then any later wear could be detected by a decrease in the thickness of the bearing shell. A large



gap micrometer may be secured from any gauge maker. This is similar to that shown in Fig. 17. By measuring the bearing shells when an engine is erected, any wear and shaft misalignment can be detected by rolling the shell out and remeasuring the thickness. This should be done at a point about 2 in. from each end of the babbitt liner, and at least once every six months.

The allowable wear varies with different types and sizes of bearings and their distance apart.

Realignment may be done in several ways. Many raise the low bearing point by putting shims under the shell. This must be done very carefully, or the shell may break.

A method of detecting low engine bearings assumes that a low bearing will cause the width between the crank webs (Fig. 18) to change by the deflection of the shaft, when the engine is turned so that this particular crank is at top center and then at bottom center. By measuring between

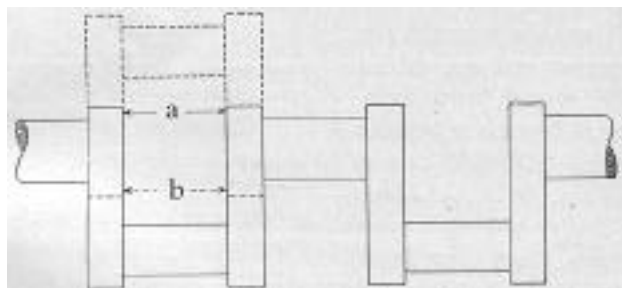


Fig. 18

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the webs by means of an inside micrometer, any change in the width may be detected at once. If the crank to the right of this crank also shows a deflection, it is proof that the bearing between the two cranks is low. On the other hand, if the crank to the left shows a deflection while the one to the right does not, then the left bearing is low. This method is excellent, but the engineer must be careful in taking the measurements. It is necessary in most cases to remove the connecting rods, but if the flywheel overhangs, removing the weight of the rods and pistons will cause the shaft to bend, thus giving incorrect measurements.

Some engines are fitted with micrometer attachments on each of the main bearing caps and when the engine bearings have been properly lined up and the caps securely fastened in place the reading of the micrometer as the screw touches the shaft is noted and recorded and thereafter, at intervals of a couple of weeks, readings are taken to see what wear, if any, has taken place. In this way the bearings can be kept up to position by whatever means of adjustment the engine is provided with. If there is no other means of adjustment, all the bearings must be scraped down to fit the lowest one. Adjustment in some cases is made with shims and in others with wedge blocks. In these cases the bearing shell is set into the adjustable block. It will be found to serve the best purpose, if the engine is partially taken down twice a year so that the bearings can be inspected for alignment.

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Hot weather and its relation to bearing maintenance

BEARING troubles are usually more frequent in summer than in winter, where the number of hours of operation and the loads are the same in both seasons.

The reason is probably because in summer the greater amount of dust blowing around and finding its way into the bearings causes greater friction and the higher surrounding temperatures makes cooling more difficult.

To reduce bearing troubles during hot weather, or in warm surroundings, a generous quantity of reliable well-filtered oil should be used, and the bearing oil grooves inspected more frequently to make sure that they are not clogged. It is well also to see that bearings are given the right chance from the start by making them from only the purest metal and observing every caution in making the liners.

Where dust is excessive, the open ends of the bearing should be provided with felt washers around the shaft and held by metal collars. End protection devices with split collars are readily obtainable and can usually be applied without difficulty.

Babbitt hammers

BABBITT hammers are useful for many purposes and are easily made by moulding and pouring the babbitt on a suitable handle. Any desired weight and shape and size of end are readily obtained by properly proportioning

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the mould. Notches on that part of the handle covered by the babbitt can be employed in place of wedges and will keep the hammer from coming off the handle.

A practical hammer can be made by using a gas pipe handle onto the end of which a T fitting is threaded and its ends filled with babbitt. Any weight of hammer can be made by using different sized fittings. Hammers weighing 2 to 4 lb. meet practically all needs.

Bearing Pressures

WH. SCOTT, in the Engineering Digest, offers a series of formulas based upon the experimental work of Tower, Lasche and Stribeck. These are as follows:

- For main bearings of double-acting engines $p = 750 D \div N$
 - For main bearings of double-acting horizontal engines $p = 660 D^{1/12} \div N$
 - For main bearings of single-acting 4-cycle gas engines $p = 1350 D \div N$
 - For crank-pins of vertical and horizontal double-acting engines $p = 1560 D \div N$
 - For crank-pins; of single-acting 4-cycle gas engines $p = 300 D \div N$
 - For dead loads with ordinary lubrication $p = 400 N$
 - For dead loads with forced lubrication $p = 1600 N$
- p = allowable pressure in lb. per sq. in. of projected area; D = diameter in in.; N = revolutions per min.

F. W. Taylor, Trans. Am. Soc. M. E., as the result of an investigation of line shaft and mill bearings that were running near the limit of durability and heating, yet not dangerously, gives the formula $PV = 400$, where P is the

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pressure in pounds per square inch of projected area and V is the velocity of circumference of journal in feet per second. The formula is applicable to bearings in ordinary shop or mill use, on shafting intended to run with the care and attention which such bearings usually receive, and gives the maximum or most severe duty to which it is safe to subject ordinary chain or oiled ball-and-socket bearings which are babbitted.

ALLOWABLE BEARING PRESSURES—MARKS

	Lb. per sq. in.
Main engine bearings	275 - 400
Main engine crank pins	400 - 500
Steam turbine bearings	85 max.
Horizontal steam turbine bearings	40 - 60
Vertical steam turbine steps	200 - 1000

ELECTRICAL MACHINERY

Generator and motor bearings	30 - 80
Main bearings of engines driving generators	40 - 80

GAS ENGINES

Main bearings (total load)	500 - 1100
Crank pin bearings	1500 - 1800
Crosshead pin bearings	1500 - 2000

Cooling compound for hot bearings

THE following compound is quickly and easily prepared, and usually proves very effective:—To a good quantity of white lead double the quantity of tallow and a very little graphite should be added, after which the mixture should be thinned with enough cylinder oil to make it feed freely into the hot bearing.

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Length-diameter ratios for bearings

TYPE: OF BEARING	LENGTH	DIAM.
Marine Engines		
Main bearings	1	1.5
Crank pin bearings	1	1.5
Stationary Engines		
Main bearings	1.5	2.5
Crank pin bearings	1	1
Wrist pin bearings	1	1.5
Generator and motor bearings	2	3
Ordinary Shafting		
Heavy-fixed bearings	2	3
Light-self-adjusting bearings	3	4

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