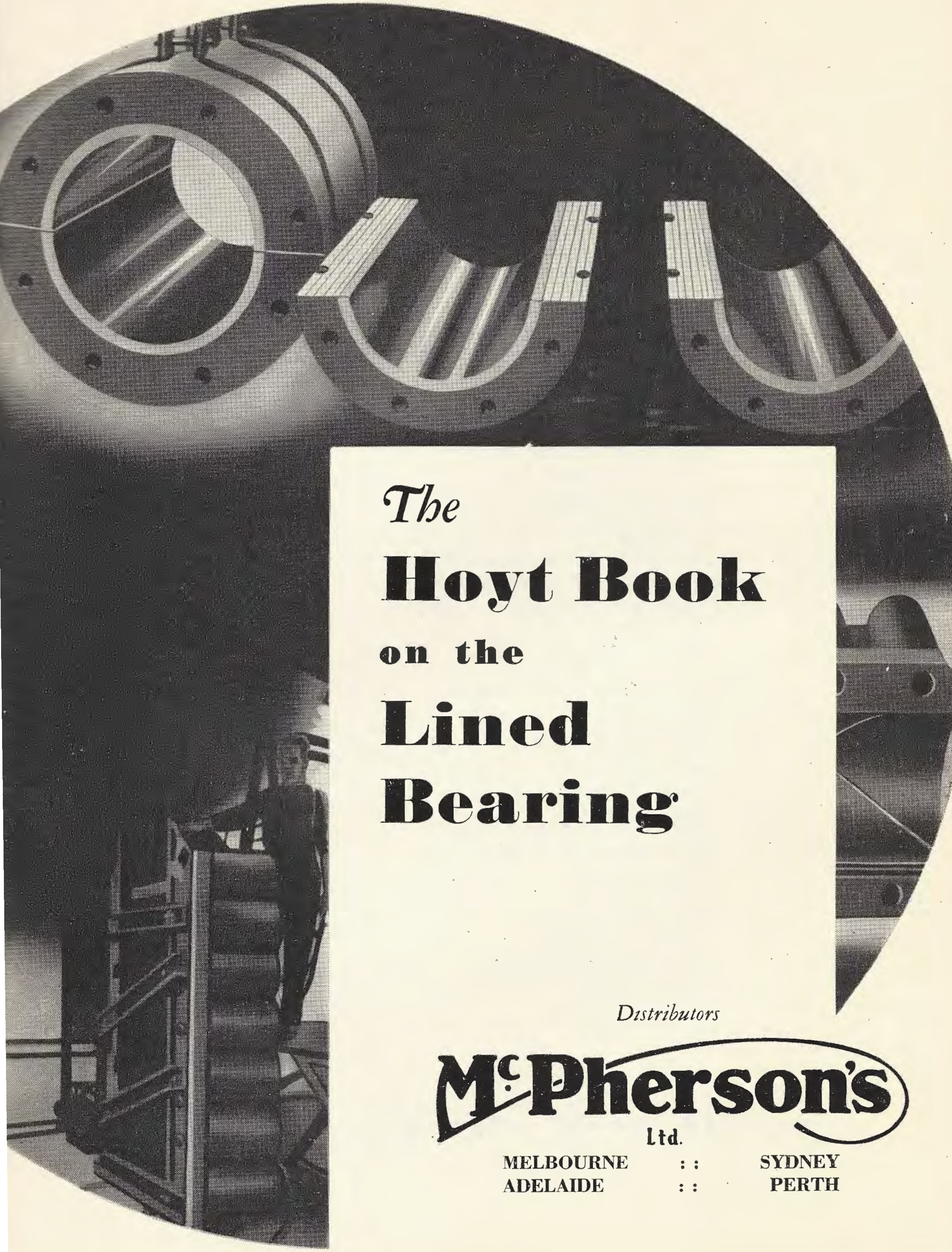
HOYT BOOK on the LINED BEARING

McPherson's
LTD



The Hoyt Book on the Lined Bearing

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FOREWORD

Familiarity
Breeds
CONTENT!

The object of this book is to promote a familiarity of the advantages and economies of the various Hoyt Bearing Metals.

Once a product has proved itself under working conditions and under prolonged tests, sales follow automatically.

It is in pursuance of this policy that we confidently recommend Hoyt Metals to the trade. For many years in many parts of the World, Hoyt Bearing Metals have been recognised outstanding quality and performance.

It only remains to see that users are properly advised when introduced to Hoyt Metal and that, primarily, is the purpose of this book. However, many problems may arise in which the information in these pages is not adequate. In all such cases Hoyt specialists will be pleased to give every possible assistance and advice.

Specify Hoyt Always

HOYT METALS

give improved Bearing Service with Economy

Any two white metal compositions may be alike in the sense that each consists of like percentages of the various metals employed, but according to the ability and experience of their respective makers, and the quality of the ingredient materials employed, so may their performances differ. In an exacting duty, such as the bearings of a modern high-speed compression ignition engine, the one composition might perform the allotted task well and give no trouble; and the second prove a source of constant misgiving to the user.

In deciding, therefore, between two alloys with similar claims, and known (or assumed) to be approximately equal in chemical composition, the purchaser must place his confidence in the reputation of the brand and its maker. The reputation of Hoyt Metals is both world-wide and of many years' standing, and there will be few engineers without some experience of their merits. For the benefit of any without experience, however, we may state that the Hoyt Co. have *specialised* in the manufacture of anti-frictional alloys for more than eighty years.

Hoyt Metals are made from selected virgin metals of the highest commercial purity. All metal mixing and casting is under scientific control, closely supervised by a well-equipped laboratory under the personal direction of a highly experienced metallurgist.

World-wide Reputation

An Invitation
to put our Claims to the Test

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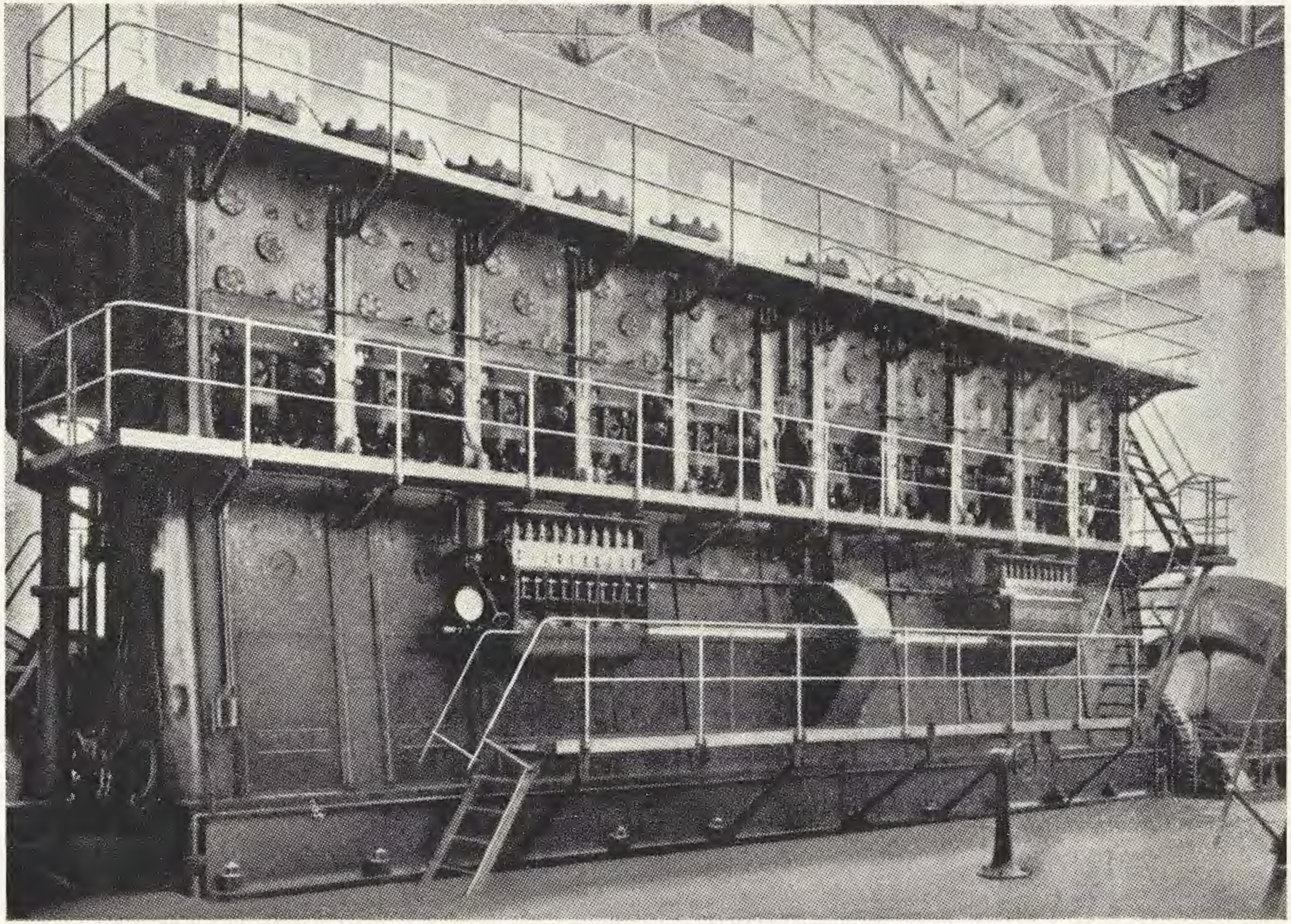
If you are unfamiliar with Hoyt Metals we cordially invite you to put our claims to the test, and to make a trial. If you will write us stating the types of bearings for which material is required, we shall be pleased to recommend a suitable Hoyt grade.

If you are in difficulty with the lining of bearings (large or small), or their lubrication, or if you have any difficult bearings to deal with, a Hoyt technical adviser will be glad to advise.

M.A.N. Diesel Engine — 11,700 b.h.p. at 215 r.p.m.



Bearings — NUMBER ELEVEN Metal.

NUMBER ELEVEN

Scientifically produced from Finest Virgin Materials . . .

The Hoyt Brand "NUMBER ELEVEN," for more than half-a-century, and in the minds of many thousands of engineers, has been symbolized with "THE BEST" in tin-base white bearing metals.

The original alloy contained slightly over 92 per cent. of tin, in combination with copper and antimony. At that time the tin content of a bearing metal was accepted as the "yard-stick" by which quality might be determined and performance in service anticipated. To-day, the tin content of a bearing metal serves only as a *general* guide to intrinsic worth: improved types of our NUMBER ELEVEN are provided, which contain slightly *less* tin than the original.

THE WORLD'S TOUGHEST AND MOST DURABLE ANTI-FRICTION METAL

Sample bar of NUMBER ELEVEN Metal, bent, twisted and hammered cold, demonstrating its exceptional toughness.

The original Hoyt NUMBER ELEVEN METAL possessed extremely high anti-frictional properties, combined with exceptional toughness and ductility. In all efforts at improvement, the full retention of these three desirable features has always been insisted upon.

During the past quarter of a century research and development have been largely aimed at producing alloys with greater load-carrying capacity; and particularly the ability to sustain such loads at elevated temperatures.

We will gladly advise users as to the most suitable alloy upon receipt of details as to dimensions of bearings, pressures, speeds, etc.

The research and development work undertaken by the Hoyt organization in this connection has resulted in the production of Hoyt NUMBER ELEVEN "D," AND NUMBER ELEVEN "R," etc.

Again we would emphasize that in producing these alloys it has been a fundamental condition that the HIGH ANTI-FRICTIONAL PROPERTIES and EXCEPTIONAL TOUGHNESS and DUCTILITY, for which the original brand was famous, *must* be retained.

Tin-base White Metals. Alloys composed mainly of tin, with the addition of copper and antimony (and sometimes lead*) have a long and successful record of performance in engine

* Lead in the 80 to 90 per cent. tin range can be regarded as an undesirable impurity, although 0.25 per cent. or more may be frequently encountered. Hoyt NUMBER ELEVEN Metal is *lead-free.*

bearings. These alloys can be employed with crank journals of almost any degree of hardness. Tin-base white metals also possess great ductility; high anti-frictional properties; are non-scoring, and resist corrosion. These are vital advantages which cannot be ignored.

Although Hoyt NUMBER ELEVEN is classified as a tin-base metal, readers are asked to regard our NUMBER ELEVEN as being in a class apart. As a result of research, the use of special and selected component materials, combined with our own special processes of manufacture, the physical properties and resultant performance of NUMBER ELEVEN have been raised considerably above that of the "average" white metal. We can quote actual examples in support of this.

It is an interesting and important fact that a large percentage of British aircraft engines built during the war were fitted with white metal bearings, and that a large proportion of those were lined with Hoyt NUMBER ELEVEN Metal. The demand for increased performance and a reduction in the weight per h.p. was ever present, but designers adhered to the use of white metal, much of that, as we have stated, being Hoyt NUMBER ELEVEN — a fact which speaks for itself.

NUMBER ELEVEN is less liable than any other anti-friction metal to break-up under pounding or conditions of extreme loading. Engineers know from experience that the very disturbing possibility of a serious period of trouble is reduced to an almost negligible quantity where NUMBER ELEVEN is employed. The exceptional ductility of the material is of especial value where the bearing shells are of cast-iron or steel. All shells in heavy duty should, of course, be tinned before being lined (to provide adhesion), but, in the case of large bearings, the quality of such tinning (due to the absence of proper facilities) is often very weak, and looseness of the linings is therefore common. As a result, most white metals, being of a brittle character, tend readily to break up; the inherent toughness of NUMBER ELEVEN, however, enables it to resist this tendency to a greater extent, and to render increased and all-round better service in consequence.

The Anti-Frictional Qualities of Number Eleven *considerably exceed* those of any other white metal, and result in a cool-running, power-saving bearing. It is recognized that anti-frictional alloys in bearings that unavoidably have a high working temperature, thereby have their strength (resistance to pressure) materially reduced, which assists any tendency to crack, and leads the way to the troubles that inevitably follow.

Number Eleven Metal shows the lowest temperature rise under applied load, and over-heating is much lessened by its use; and in many acute and troublesome cases has been completely overcome. The vital importance of this reduction of heat cannot be over-estimated; for every degree of heat lower is additional strength to the liner, and helps to maintain the proper viscosity of the oil, the advantages of which are obvious. NUMBER ELEVEN will not injure any shaft.

PHYSICAL PROPERTIES
OF THE
NUMBER ELEVEN GROUP OF ALLOYS

HARDNESS (BRINELL).

	At air	At 100°C.
NUMBER ELEVEN (STANDARD) "D"	26.5	12.5
NUMBER ELEVEN "R"	33	14.3

TENSILE TEST

	Elastic Limit	Ultimate Stress
NUMBER ELEVEN (STANDARD) "D"	2.3 per sq. in.	4.9 tons per sq. in.
NUMBER ELEVEN "R"	2.5 ,,	6.48 ,, ,,

COMPRESSION TEST

	Yield Point	Crushing Load at air Temperature	
		Max. Stress	Comp. Strain
	Tons per sq. in.	Tons per sq. in.	per cent.
NUMBER ELEVEN (STANDARD) "D" ..	3.8	10	37.5
NUMBER ELEVEN "R"	5.4	12	38.5
		Crushing Load at 100°C.	
NUMBER ELEVEN (STANDARD) "D" ..	2.5	5.8	41.5
NUMBER ELEVEN "R"	3	6.2	41.5

TEMPERATURE (°C.)

	First melting point	Complete liquid point	Av. Pouring temperature
NUMBER ELEVEN (STANDARD) "D" ..	234	329	385
NUMBER ELEVEN "R"	232	344	385

THE STANDARD NUMBER ELEVEN "D" IS ALWAYS SUPPLIED UNLESS OTHERWISE SPECIFIED.

Number ELEVEN Metal is made in Two Grades–

Number ELEVEN R
and
Number ELEVEN D

For the various uses of Number ELEVEN R and Number ELEVEN D see page 15, headed "WHAT QUALITY SHOULD I USE?"

How Hoyt Number ELEVEN Metal successfully meets the needs of the Diesel Engineer

Oil Penetration One Cause of Failure in Diesel Engine Bearings

Extended observation goes to show that lubricating oil penetrating between the bearing shell and the white metal liner does much to shorten the life of Diesel engine bearings, and is the primary cause of many early failures.

The coefficient of heat conductivity of oil is about 1/200th that of white metal or iron, and, therefore, when large areas of the white metal liner have an insulating oil film behind them, normal conduction of frictional heat is hampered, and the temperature of the bearing can readily rise. In some instances, overheating may occur to an extent sufficient to bring about a complete breakdown.

Oil penetration commences in two ways: either (1) directly through fine cracks in the bearing liner itself — which rapidly extend under pressure of the shaft; or (2) by a creeping-in of the oil between the shell and the liner at the butt faces.

Taking the first-mentioned: to obviate premature cracking, the white metal should possess the maximum of toughness, and have high anti-frictional qualities; and therefore be less subject to a rise of temperature under load. Obviously, the higher working temperature, the greater the tendency to crack. An excessively hard, and therefore unavoidably *brittle*, metal, with necessarily reduced anti-frictional qualities, cannot be expected to give the best results.

In the case of oil penetration at the butt faces, the best course is clearly to ensure that the adhesion of the white metal ALL OVER is as perfect as it can be, special attention being paid to the faces referred to. ALL shells should, of course, be tinned before filling, to provide such adhesion; but in the case of most large bearings, the quality of such tinning, due usually to the absence of proper facilities, is often very doubtful, and looseness of the linings is therefore common.

From the foregoing it will be apparent that the bearing conditions in the Diesel Engine are met best by a white metal that is sufficiently hard, so as *not* to yield to the high working loads encountered (especially in cross-heads), yet one that is, at the same time, exceptionally tough, to minimize the possibility of cracking.

Hoyt NUMBER ELEVEN is correctly balanced and stands apart as meeting requirements to a much greater degree than any other white metal.

In actual service on many important motor ships, and also in Power Stations, where previously fractures of the white metal linings had persistently occurred at an early stage, or where for some other reason the life of the lining has been short, our material is consistently proving its superiority.

Where there has been no acute trouble, however, the very long wear given by NUMBER ELEVEN metal; the increased confidence in the bearings; and the additional safeguard provided, are advantages to which Engineers should give their earnest consideration.

NUMBER ELEVEN Metal is used by Shipping Companies, Electric Light and Power Stations, and other Diesel engine users in every part of the Empire, for every type of engine, and the results are in every case better than those obtainable with any other white metal.

General Purpose Metals

I. C. E. Metal

Developed from the original Hoyt "Copper Hardened" formula.

A Hoyt brand of exceptional merit, in large and world-wide use for a variety of severe and high-speed duties.

For bearings of Automobiles, Gas and Petrol Engines of all types, every type of Steam Engine, Locomotives, Steam Pumps, Marine Engines, Textile Machinery, High-speed Mining Machinery, High-speed Woodworking Plant, Centrifugal Drying Machines, Winding Engines, Rolling Mills, Saw Mills, Electrical Converters, Dynamos and Motors of the largest size, etc.

I.C.E. BRAND is a high-grade, tin-base composition of proved high efficiency, and one to be relied upon always for a full measure of long and care-free service.

Brinell Hardness: At air 32-3 3, at 130°C. 9-10.
Tensile Test: Yield Point: 5.2 tons per sq. in.
Compression Test: Proof stress of 0.1 per cent., 2,950 lb. per sq. in.
Elongation 1.2 per cent. Ultimate stress: 5.3 tons per sq. in.

Arrow

A very superior anti-friction alloy for heavy pressure and high-speed.

ARROW is a dense-grained, tough composition, suitably hardened with Copper and Antimony.

No. 1

A very good anti-frictional metal for heavy pressure and medium speed, or medium pressure and high speed.

A tenacious, tough metal, carrying a large percentage of tin.

Star Brand

The Hoyt standard quality for all general engineering work.

In common with all Hoyt brands, STAR Brand is made from selected grades of *virgin material.* Its composition and quality are therefore at all times uniform, and users are assured a *full* measure of satisfaction from every ingot. STAR Metal gives lasting wear in Agricultural Machinery, Axleboxes (all types), Brick Making Machinery, Bakery Machinery, Boot and Shoe Machinery, Colliery Plant, Cement Making Machinery, Concrete Mixers, Flour and Rice Mills, Fans, Lifts, Laundry Machinery, Mining Machinery, Mill Shafting, etc., Paper Machinery, Plummer Blocks, Railway Axleboxes, Stone Crushers (Jaw), Textile Machinery, Threshing Machines, Tramcar Bearings, Tube Mills, Winches, etc., etc.

No. 3 M

Equal to or better than the numerous metals claimed to be of the "Magnolia Type."

Can be used for most of the purposes for which STAR is especially recommended.

No. 4a and 4

Close-grained and well-proportioned metals. For light pressure and medium speed, or medium pressure and slow speed.

The best of all low-priced Babbitts.

No. 175

For Gyratory and Heavy Duty Crushers, Rolling Mills, etc.

Highly recommended for eccentric bearings of gyratory crushers, locomotive bearings, pumps, tube mills, and in those cases where additional hardness in the babbitt is desired.

Physical Characteristics:

Brinell No. 38-40

Compression yield — lbs. per sq. inch to produce 2 per cent. reduction in height of sample .. .. 17,500 lbs. (approx.)

First melting point .. .. .. 238°C. (460°F.)

Liquid point .. .. 399°C. (750°F.)

Average pouring temperature 430°C. - 480°C. (800-900°F.)

No. 400

Corrosion-Resisting Metal for Under-Water Bearings

This material represents the latest development in connection with bearing metals designed for operating in salt water. It is almost equi-potential with steel in aerated sea-water, and offers a high intrinsic resistance to corrosion. It is also shown to possess superior anti-frictional properties, especially when running in sea-water without oil lubrication.

Tensile Strength .. .. .. 7.4 tons per sq. in.

Brinell Hardness No. 35.7

Pouring Temperature .. .. 310°C. (590°F.)

No. 7 Metal

A copper-free metal for bearings of anhydrous ammonia machinery, and enclosed type of compressors.

Specific Gravity and Weight Per Cu. In.

	S.G.	Wt. cu. in. lb.
NUMBER ELEVEN "D"	7.297	.2634
NUMBER ELEVEN "R"	7.304	.2637
No. 38	7.378	.2663
No. 175	7.51	.2711
No. 7	7.694	.2778
I.C.E.	7.918	.2858
Arrow	8.93	.3225
No. 1	9.55	.345
STAR	10.324	.3727
No. 3M	10.501	.3791
No. 4A	10.48	.3783
No. 4	10.685	.3857

John I.
THORNYCROFT
Productions

Top: "Steadfast" oil-engined vehicles.

Right: 45 ft. harbour tender for the Chilian Government. Power 280 b.h.p., speed 19½ knots.

Below: Coastal Motor Boat and 200 ton Motor Yacht "GULZAR."

(Messrs. John I. Thornycroft & Co. Ltd. are consistent users of Hoyt NUMBER ELEVEN METAL.)

MATRIX METAL (No. 19a)

Melting point, 248°F. (120°C.). Pouring temperature, 446°F. (230°C.) upwards.

The main application of this metal is as a matrix for locating and holding punch and die parts in drive fits, etc. In connection with die-making position and for securing machine parts without the use of this alloy obviates the need for complicated holding devices. This metal expands slightly upon cooling.

TUBE BENDING METAL (No. 5a)

Melting point, 160°F. (71°C.).

This alloy replaces resin, sand, pitch, lead, etc., as a filler to prevent bursting, flattening or rupture of the tube wall during bending. Hoyt's Tube Bending Metal expands slightly upon cooling and consequently fits snugly to the inside of the tubing and the latter can be bent as though it were a solid bar. Rapid chilling of the metal is desirable (see instructions); this gives a fine-grained structure and renders the metal very ductile.

The method described has been successfully applied to the bending of duralumin, copper, brass, plain and stainless steel, also plated tubes. The alloy can also be used for tubes of irregular section, also in the forming of rolled or extended sections.

Directions for Using Hoyt Tube Bending Metal No. 5a

Preparation: All tubing should be in the fully annealed condition and with any scale or foreign matter removed from the bore.

Tightly plug one end of the tube, using a plug of hardwood or other suitable material. (The plug should have a slight taper and fit the tube snugly.) Then fill the tube with a light grade oil. Pour off the oil from the tube with the exception of a small amount to be left in the bottom. *The use of oil is recommended to prevent "tinning" of the tube.*

Melting the bending alloy: Hoyt No. 5A melts at 160°F. (71°C.) and can be melted by suspending the ladle in hot water; or a welded container, made from stainless steel and jacketed with hot water, can be employed.

Filling the tube: The metal should be poured in a steady stream and allowed to flow down the side of the tube. If it is slopped in air pockets will result. When filling small-bore tubes it is an advantage to stand them in boiling water during the process. When the tubing is of too small a diameter ($\frac{1}{4}$ in. diameter or less) to permit of pouring, the alloy can be drawn into it by suction.

Quenching: Immediately the tube has been filled lower it into a cold water quenching tank. RAPID QUENCHING IS ESSENTIAL. Allow it to remain there for fifteen to twenty minutes, *or until completely cooled.*

After quenching, remove the plug and *re-warm the tube to room temperature before attempting to bend.*

Bending: *A steady and uniform pressure should be applied.* The tube may be bent over a forming block or in any type of bending equipment. The bends should be made slowly, at uniform speed and uniform loading.

Removing the bending metal: The tube, after bending, should be plunged into boiling water and the metal allowed to run out; shaking the tube will assist. (The use of a stainless steel tank for containing the water is recommended; galvanized iron and other metals may lead to contamination of the bending alloy.)

Whilst the tube is still hot immerse it in cold water for about two minutes.

Finally, flush out with a cold grease solvent and finish-clean with the pull-through.

WHAT QUALITY SHOULD I USE?

Aero Engines	*
Agricultural Machinery (all types excepting prime movers).	STAR
Ammonia Compressors (enclosed type).	No. 7
Automobile Engines	NUMBER ELEVEN "D" or "R"
Axleboxes of:	
Railway coaches	STAR
Railway locomotives	No. 175 or I.C.E.
Railway waggons	STAR or No. 3M
Road Rollers	ARROW
Tramcars	STAR or No. 3M
Air Compressors	I.C.E.
Blowers	STAR
Bobbin Making Machinery	NUMBER ELEVEN "D"
Boot and Shoe Machinery	STAR
Brick Making Machinery:	
Rollers	I.C.E.
General Plant	STAR or No. 3M
Conveyors	No. 3M
Cement Mills	ARROW
Compression Ignition Engines	NUMBER ELEVEN "R"
Centrifugal Machinery:	
Pedestal Bearings	I.C.E.
Other Bearings	STAR
Pumps	I.C.E.
Compressors:	
Heavy Duty and/or high speed	I.C.E.
Other types	I.C.E.
Crushers:	
Gyratory	No. 175
Jaw type	No. 3M
Converters, Rotary	I.C.E.
Colliery Plant:	
Prime movers	(*See* Engines.)
Rope Capping	4A
Pumps	I.C.E.
Tube mills	No. 4
Fans	No. 175
Packing Metal	*
Diesel Engines:	
High speed	NUMBER ELEVEN "R"
Heavy stationary types	NUMBER ELEVEN "D" or "R"
Marine	NUMBER ELEVEN "R"
Electrical Machinery:	
Stationary motors and generators	I.C.E.
Converters	I.C.E.
Small, or slow-speed motors	ARROW
Engines:	
Aviation	*
Automobile	NUMBER ELEVEN "D"
Diesel (heavy stationary type)	NUMBER ELEVEN "D" or "R"
Diesel (road vehicles)	NUMBER ELEVEN "R"
Gas	I.C.E.
Oil (other than c.i. type)	I.C.E.
Marine Diesel	NUMBER ELEVEN "R"
Marine Steam	I.C.E.
Steam	I.C.E.
Fans:	
Large or where exhausting hot gases	No. 175
Small and medium size	STAR
Flour and Rice Mills	STAR
Ford Cylinder Blocks (lined without preheating)	No. 38.
Gas Engines	I.C.E.
Gear Boxes:	
Machine Tool	STAR
Road Vehicle Gear Boxes	STAR
Reduction Gears:	
Turbine	NUMBER ELEVEN "D"
Other types	I.C.E.
General Plant and Machinery:	
For bearings running at 1,000 and/or with loads of 100 lb. sq. in. and upwards	STAR
Other types	No. 3M

Grinding Machine (high speed):	I.C.E. or No. 175
Jaw-Type Crushers (including backing of jaws)	No. 4
Laundry Machinery:	
Prime Movers	(*See* Engines)
Hydro Extractors	I.C.E.
Other types	STAR
Lathes	I.C.E. or No. 175
Machine Tools:	
Lathes	I.C.E. or No. 175
Grinding Machines	I.C.E. or No. 175
Other types	I.C.E. or No. 175
Mill Shafting	STAR or No. 3M
Mining Machinery	(*See* Collieries)
Motor Boats: Stern Tubes and "A" Brackets	No. 400
Michell Thrust Bearings	NUMBER ELEVEN "D"
Oil Well Boring Machinery	No. 4
Oil Engines (not Diesel)	I.C.E.
Power Station Plant:	
Diesel Engines (heavy stationary types)	NUMBER ELEVEN "D" or "R"
Gas, Petrol and small Oil Engines	NUMBER ELEVEN "D" or I.C.E.
Steam Engines	I.C.E.
Compressors	NUMBER ELEVEN "D" or I.C.E.
Turbines	NUMBER ELEVEN "D"
Electrical Generators and Motors	I.C.E.
Pumps	I.C.E.
Paper Machinery	STAR or No. 3M
Paraffin Engine	NUMBER ELEVEN "D" or I.C.E.
Pulverizers	No. 175
Plummer Blocks	STAR or No. 3M
Pumps (reciprocating and centrifugal)	I.C.E.
Petrol Engines	NUMBER ELEVEN "D"
Quarry Machinery:	
Prime Movers	(*See* Power Station Plant)
Crushers, Gyratory	No. 175
Crushers, Jaw Type	STAR or No. 3M
Jaw backings	No. 4
Tube Mills	No. 175
Rolling Mills	No. 175 or I.C.E.
Road Roller Axle Bearings	ARROW
Rope Capping	No. 4A
Railway Bearings:	
Locomotive	NUMBER ELEVEN "D"
Carriage Bearings	STAR
Wagon Bearings	No. 3M
Reduction Gears:	
Turbine	NUMBER ELEVEN "D"
Other types	I.C.E.
Steering Engines	I.C.E.
Stone Crushers	(*See* Quarry Machinery)
Semi-Diesel Engines	I.C.E. or No. 38
Steam Engines	I.C.E.
Sugar Rolls	No. 175
Saw Mills	I.C.E.
Saw, Circular	I.C.E.
Stern Tubes	No. 400
Tramcar Bearings:	
Suspension Bearings	I.C.E.
Axle Bearings	STAR
Textile Machinery	STAR
Turbines	NUMBER ELEVEN "D"
Tube Mills	No. 175
Under-water Bearings	No. 400
Winches	STAR
Woodworking Machinery:	
High-speed	NUMBER ELEVEN "D"
Medium	I.C.E.
Circular Saws	I.C.E.

*** Special recommendations will be made upon receipt of details of engine.**

USEFUL CALCULATOR to SAVE TIME and METAL

For estimating quantity of Hoyt Number Eleven Metal (*) required to fill a bearing.

Diameter of core or mandrel in inches	Thickness of Lining to be Cast, i.e., Distance between Mandrel and Inside of Bearing Shell or Housing. Weight (in Lbs.) per Inch of Length Metal Hoyt Number Eleven							
	1/8″	1/4″	3/8″	1/2″	5/8″	3/4″	7/8″	1″
1	.1166	.2592	.4277	.6222	.8425	1.0888	1.3610	1.6592
1 1/16	.1231	.2721	.4471	.6481	.8749	1.1277	1.4063	1.7110
1 1/8	.1296	.2851	.4666	.6741	.9073	1.1666	1.4517	1.7629
1 3/16	.1361	.2980	.4860	.7000	.9397	1.2055	1.4970	1.8147
1 1/4	.1425	.3111	.5055	.7259	.9721	1.2444	1.5425	1.8666
1 5/16	.1490	.3240	.5249	.7519	1.0045	1.2833	1.5879	1.9184
1 3/8	.1555	.3370	.5444	.7778	1.0369	1.3222	1.6332	1.9703
1 7/16	.1620	.3499	.5638	.8038	1.0693	1.3611	1.6786	2.0221
1 1/2	.1685	.3629	.5833	.8296	1.1018	1.4000	1.7240	2.0740
1 5/8	.1814	.3888	.6222	.8814	1.1666	1.4778	1.8147	2.1777
1 3/4	.1944	.4147	.6611	.9333	1.2314	1.5556	1.9054	2.2813
1 7/8	.2073	.4406	.7000	.9851	1.2962	1.6334	1.9961	2.3850
2	.2203	.4666	.7388	1.0370	1.3610	1.7110	2.0869	2.4888
2 1/8	.2332	.4925	.7777	1.0888	1.4258	1.7888	2.1776	2.5924
2 1/4	.2462	.5184	.8166	1.1407	1.4906	1.8666	2.2684	2.6961
2 3/8	.2591	.5443	.8555	1.1925	1.5554	1.9444	2.3591	2.7998
2 1/2	.2722	.5703	.8944	1.2444	1.6203	2.0221	2.4499	2.9036
2 5/8	.2851	.5961	.9333	1.2962	1.6851	2.0999	2.5406	3.0072
2 3/4	.2981	.6221	.9722	1.3481	1.7499	2.1777	2.6313	3.1109
2 7/8	.3110	.6480	1.0111	1.3999	1.8147	2.2555	2.7221	3.2146
3	.3240	.6740	1.0500	1.4518	1.8790	2.3332	2.8128	3.3184
3 1/4	.3500	.7259	1.1277	1.5555	2.0087	2.4888	2.9942	3.5258
3 1/2	.3760	.7777	1.2055	1.6592	2.1385	2.6444	3.1757	3.7332
3 3/4	.4019	.8296	1.2832	1.7629	2.2682	2.8000	3.3572	3.9406
4	.4277	.8814	1.3610	1.8666	2.3980	2.9554	3.5387	4.1480
4 1/4	.4536	.9332	1.4387	1.9307	2.5276	3.1111	3.7202	4.3554
4 1/2	.4795	.9850	1.5165	2.0740	2.6572	3.2666	3.9016	4.5628
4 3/4	.5054	1.0369	1.5942	2.1777	2.7868	3.4221	4.0831	4.7702
5	.5314	1.0888	1.6721	2.2814	2.9165	3.5776	4.2646	4.9776
5 1/4	.5573	1.1406	1.7498	2.3855	3.0461	3.7332	4.4461	5 1850
5 1/2	.5833	1.1925	1.8276	2.4888	3.1757	3.8887	4.6275	5.3924
5 3/4	.6092	1.2443	1.9054	2.5925	3.3054	4.0442	4.8090	5.5988
6	.6351	1.2962	1.9832	2.6962	3.4350	4.1998	4.9905	5.8072
6 1/4	—	1.3480	2.0609	2.7999	3.5646	4.3554	5.1720	6.0146
6 1/2	—	1.3999	2.1387	2.9036	3.6942	4.5109	5.3534	6.2220
6 3/4	—	1.4517	2.2164	3.0073	3.8239	4.6664	5.5349	6.4294
7	—	1.5036	2.2943	3.1110	3.9535	4.8220	5.7164	6.6368
7 1/4	—	1.5554	2.3720	3.2147	4.0831	4.9775	5.8979	6.8442
7 1/2	—	1.6073	2.4498	3.3184	4.2127	5.1331	6.0793	7.0516
7 3/4	—	1.6591	2.5276	3.4221	4.3424	5.2886	6.2610	7.2590
8	—	1.7110	2.6054	3.5258	4.4720	5.4442	6.4423	7.4664
8 1/4	—	1.7629	2.6831	3.6295	4.6016	5.5997	6.6238	7.6738
8 1/2	—	1.8147	2.7609	3.7332	4.7312	5.7553	6.8052	7.8812
8 3/4	—	1.8664	2.8387	3.8369	4.8609	5.9108	6.9867	8.0886
9	—	1.9184	2.9165	3.9406	4.9905	6.0664	7.1682	8.2960
9 1/2	—	2.0222	3.0720	4.1480	5.2498	6.3775	7.5312	8.7108
10	—	2.1259	3.2276	4.3554	5.5090	6.8886	7.8941	9.1256
10 1/2	—	2.2296	3.3831	4.5628	5.7683	6.9997	8.2571	9.5404
11	—	2.3332	3.5387	4.7702	6.0275	7.3108	8.6200	9.9552
11 1/2	—	2.4369	3.6942	4.9776	6.2868	7.6219	8.9829	10.3700
12	—	2.5406	3.8498	5.1850	6.5461	7.9330	9.3459	10.7848

How to Apply the Table

Example. — What quantity of NUMBER ELEVEN Metal would be needed to line a pair of bearing shells to a thickness of 5/8 in., assuming them to be 6 1/4 in. inside diameter (without white metal) by 8 in. long?

The mandrel or core would have a diameter of 5 in. Looking down the table, the weight per inch of length of 5/8 in. thickness of metal surrounding a mandrel of 5 in. diameter is 2.9165 lbs.

∴ 2.9165 by 8 (length of bearing in inches) = 23.3320 lbs., the quantity of metal required.

The weight in any other Hoyt grade can now be ascertained by multiplying this result by the corrective figure shown below.

NOTE.—The weight arrived at is the amount in a pair of half-bearing shells or one bush.

* When it is desired to know the weight in a Hoyt Metal other than Number Eleven, the ascertained total weight in Number Eleven Metal should be multiplied as under:—

Weight wanted in	Same weight as Number Eleven
No. 175	× by 1.0417
I.C.E. Metal	× „ 1.088
Arrow „	× „ 1.222
No. 1 „	× „ 1.307
Star „	× „ 1.374
3M „	× „ 1.382
4A „	× „ 1.421
No. 4 „	× „ 1.430

In above table nothing has been allowed for spills or for the building-up of the metal on the ends of the bearing. A little more metal than the indicated amount is desirable.

SECTION "A"

Dealing with the Lining of Automobile, Tractor and similar bearings up to say 6 ins. diameter

Tinning

Thoroughness in cleansing essential: Bearings to be tinned should be thoroughly cleansed from grease, dirt, rust, etc., especial attention being paid to any anchorage holes or grooves.

Treatment of greasy bearings: When a number of greasy bearings is to be done, it is worth while placing them in caustic soda solution (about 3 per cent. of soda in water) for about thirty minutes, keeping the liquid near boiling point, and afterwards washing them in clean, running water.

Preparation for Tinning: Run out the old white metal by immersing the bearing in a pot of old white metal heated to 730-750°F. (390-400°C.). Alternatively an air/gas blowpipe or a spirit blowlamp can be employed, care being taken to see that the flame is kept clean. Then scrub the shell with a wire brush to remove all traces of old metal and as much as possible of the old tinning. The bearing shell must be *really* hot so that the whole of the surface is "free" (molten). Do not overlook the cleansing of the joint faces and flanges.

TINNING OF BEARING SHELLS OF BRONZE OR BRASS.

In the case of bronze and similar bearings the old white metal is best run out with the air/gas blowpipe or spirit blowlamp. The surface should then be thoroughly gone over with a wire brush. **It is important that as much as possible of the previous tinning is removed.**

***The Tinning Bath:** Prepare a pot, or bath, of pure tin heated to a temperature *not exceeding* 480°F. (250°C.). The size and capacity of the bath will, of course, depend upon the sizes of the bearings being handled.

Flux: Make a saturated solution of Hoyt Powder Flux using a little more powder than the water will dissolve.

Commencing the Tinning: After thoroughly cleansing and making-ready the bearing as described above, grip it with a pair of tongs and immerse it in the bath, allowing just sufficient time for it to become heated. Then withdraw it and go all over the inner surface, as quickly as possible, with liquid flux, using a *clean* bristle brush. Immerse again (lowering it gently), at the same time giving it a rocking motion; hold it there for a few seconds; then withdraw it and go over the surface again with the flux. This second fluxing, followed by a further immersion in the tinning bath, is strongly recommended.

The bearing shells should not remain in the bath a moment longer than is necessary in order to obtain a bright, free-running tinned surface.

When the bearing is finally removed from the tinning bath it should be given another coating of flux, after which it can be quenched and stood aside until the lining jig is ready. Much time, however, may be saved by placing it on the jig (previously heated ready) and babbitting it immediately; and in that event a final coating with flux is not required.

Any surplus tin on the surface of the bearing should be allowed to remain; in other words, leave a good, thick layer of tin in the bore of the bearing.

IMPORTANT: Bearings made from bronze, gunmetal or brass **MUST NOT REMAIN IMMERSED** in the tinning bath, or pot of old white metal, for any length of time. Steel bearing shells, however, benefit by "soaking."

* One tinning bath only is needed for bronze shells.

TINNING OF BEARING SHELLS OF STEEL (including connecting-rods where the white metal is lined directly into the rod):

Run out the old white metal by immersing the bearing in a pot of old white metal heated to about 730-750°F. (390-400°C.). Then brush the bearing well out with a *wire* brush, which should remove all traces of the old lining.

Fluxing: Make a saturated solution of Hoyt Powder Flux in clean, cold water — use a little more of the powder than the water will dissolve. Dip a *fibre* brush in the flux solution, and, whilst the bearing is still hot, go thoroughly over the surfaces to be tinned.

The Tinning Bath: Prepare a bath or pot of pure tin heated to a temperature of 750°F. (400°C.) maximum.

First Tinning: After fluxing, immerse the bearing in the bath, at the same time giving it a rocking motion. When the tinning on the surface is running freely, *i.e.*, it appears to be thoroughly "wet," remove the bearing and quench it in cold water. If inspection reveals any black specks (or dirt) the bearing should be fluxed again and re-immersed in the bath.

An alternative method: Take the steel shell or connecting-rod (which will have previously been heated by immersing it in the tinning bath) and sprinkle a few crystals of Hoyt *Powder* Flux upon the surface to be tinned. There should be sufficient heat present to melt the crystals of flux. Then take an old hacksaw blade or wire brush (the former is preferred) and scrub the whole of the surface vigorously. Immediately this has been done, immerse the bearing in the tinning bath, at the same time giving the bearing a rocking motion.

Second Tinning: For this operation a second bath containing tin at a temperature of 480°F. (250°C.) maximum is needed. Heat the bearing by immersing it in this second bath; withdraw it and go all over the tinned surface, as quickly as possible, applying the *liquid* flux, already described, with a *clean* bristle brush. Immerse again (lowering it gently), at the same time giving it a rocking motion. Hold it there for a few seconds; then withdraw it and go over the surface again with the liquid flux. Finally, replace the bearing in the tinning bath until the jig is ready.

A wash to prevent tin adhering to backs of shells can be prepared from any one of the washable distempers (oil-bound water paint). The colour is obviously unimportant, although a light colour such as cream or buff is preferred. The distemper is thinned by adding a solution of clean water and silicate of soda (water glass) in the proportion of 50 per cent. water to 50 per cent. silicate of soda by measurement. It is usually sufficient to add 50 per cent. of the above solution to 50 per cent. of the water-paint. The silicate of soda forms a binder and prevents the paint flaking.

Heating the Metal

Great Care should be taken not to overheat the white metal in the melting pot. The use of a thermometer is advised.

Pouring temperatures of Hoyt Metals: NUMBER ELEVEN Metal ("D" and "R") pours at 725°F. (385°C.) **upwards** according to the size and nature of the work — maximum 800°F. (430°C.). **I.C.E. Metal** at about 700°F. (370°C.).

If a metal is accidentally made a little too hot, cool at once by the addition of new (cold) metal.

Pouring temperature — use of discretion: The foregoing temperatures must be regarded only as a general guide. The actual pouring temperature of the metal will depend upon the size of the bearing and thickness of the lining to be cast, etc. For very thin linings, the metal may need to be hotter than for thick ones. *The minimum, rather than the maximum, temperature should be aimed at,* but the metal must always be hot enough to prevent its cooling too rapidly, *i.e.*, the metal must remain in a fluid state until the bearing is full up to the top, in order that the operation of "venting" (described later) may be carried out properly.

Turn gas down when metal in pot is molten: When the metal in the pot has become molten, the gas should be turned down low, with just sufficient heat to maintain the metal in the pot at the correct temperature. A bluish ash (oxide) forming on the surface indicates that the metal is being burnt. If the metal has been overheated accidentally, it should be cooled at once by the addition of new (cold) metal.

Don't forget to stir the metal! It is extremely important that ALL anti-friction metals be WELL AND FREQUENTLY STIRRED from the bottom. (*Statements that certain metals do not need stirring are wrong and misleading — ALL metals must be stirred frequently.*)

Pot with enclosed burner best: A pot providing for the gas ring to be enclosed is especially recommended for melting white metals, as it ensures a more even distribution of heat. Where a pot of the enclosed type is not readily procurable, however, a casing may be fashioned out of sheet iron.

Filling pot and pouring off: Always have a fair quantity of metal in the pot, and sufficient for the amount of work in hand. In order that the metal may retain its original condition it should not be allowed to cool down in the pot at the end of the day, or when a batch of lining work is complete, but be well stirred from the bottom, poured off, and cooled as quickly as possible. This is especially necessary with high-grade tin-base metals. It is an advantage to "chill" it if suitable rough moulds are available. A piece of channel-iron, divided into sections with clay, forms a good rough mould. Clean the pot well before re-filling. All metal pots should be thoroughly cleaned out once a fortnight and given a coat of distemper on the inside.

Re-melting of Metal: Provided Hoyt Metals are not overheated they may be re-melted, with the periodical addition of new metal, without injury, but the fewer times the better. To revive, add three parts of new metal to one of old.

Never mix different makes or qualities of white metal. Do not use old metal from bearings.

Pouring the Metal

Pre-heating the jig: The metalling jig and mandrel or core should be assembled and both heated to the same temperature as that of the white metal being poured, an air/gas blowpipe or a spirit blowlamp being used for this purpose.

A preferred method, however, is to place the jig and mandrel in a pot of old white metal at the same temperature as that of the new lining metal. If only the mandrel is placed in the pot of old metal the jig will, of course, have to be heated separately.

Where a *horizontal-type jig* is employed the end plates and core-piece are heated by placing them in a pot of old white metal at 730-750°F. (390-400°C.).

Should the bearing shell have been stood aside whilst the jig has been prepared, bring the former up to the required temperature by re-dipping it in the tinning bath immediately before placing it on the jig.

IMPORTANT: It is essential that the tinning on the inner surface of the bearing be JUST FLUID when the white metal is poured in.

Where an air/gas blowpipe or spirit blowlamp is employed care must be taken not to allow the flame to play upon any tinned surface.

Jigs of modern type, designed for quickness in operating, should not require stopping-off.

Commencing to Pour: As a preliminary to pouring skim the top of the pot by drawing the film of dross to one side. Insert ladle and STIR THE METAL WELL and FROM THE BOTTOM. Take a ladleful of the metal, and, resting the lip of the ladle on the top of the bearing shell (observing that the tinning on the shell is still molten), proceed to pour. Pour gently at first, continuing until the bearing is full right to the top. DO NOT THROW THE METAL IN, but hold the ladle near the job, *at one place,* and gently tilt it so as to obtain a steady flow. With large bearings, more than one ladleful of metal may be needed; and the job should be "puddled" as each ladleful is added.

The top of the casting must NOT be allowed to "chill" before more metal is added; the metal at the top must be kept fluid by means of a gentle heat from the blowpipe. Keep the pot fed with new (cold) ingot metal as required.

"Venting" or "puddling" the metal in vertical jigs. To ensure smooth castings and to obviate blowholes: immediately the bearing is full, take a stainless steel wire and dip it *continuously and rapidly* in and out, all round, lightly and without forcing it. At the same time prevent the metal at the top from setting by means of a gentle heat from the blowpipe. It is also an advantage to "sweep" round the mandrel with the puddling wire. The metal at the bottom MUST solidify first, and the cooling proceed until the bearing is solid up to the top. Care should be taken to see that metal that is thickening (cooling off) is not pierced with the "venting" wire; otherwise you will find cavities in the metal when the bearing is bored out. During this operation of "venting" (which takes, say, two or more minutes, according to size of bearing), the metal may sink down from the top; if it does, a little more should be poured in.

Cool as quickly as possible: *Cool the bottom of the bearing* with cold air from the blowpipe *as quickly as possible.* If cold air is not available, a wet sponge or cloth may be pressed against the lower part of the bearing; or a fine water spray may be played on the back of the bearing shell. Care must be taken so that damp or water does not reach the molten white metal inside the bearing.

Adhesion between the white metal and the shell or housing is greatly improved by rapid quenching. Quenching, however, must be progressive, *e.g.*, from the bearing shell into the molten metal. In the case of bearings lined vertically, quench from the bottom upwards, and from the shell into the molten metal as far as that is possible. The reason for this technique is that the shell and the anti-friction metal (which have differing rates of contraction) are being cooled simultaneously. If the anti-friction metal is cooled incorrectly, that is from the inside or by way of the mandrel, this sets up stresses tending to pull the white metal away from the housing and so weaken the bonding. Correct cooling of the bearing, as by the impingement of water on the outside of the shell, results in a progressive yielding of the anti-friction metal while still in the plastic state, and no undesirable stresses are introduced.

Bearings filled in a horizontal position: With certain types of jigs, the bearing shells are mounted horizontally for filling, and "venting" or "puddling" may be dispensed with.

Should the white metal appear not to fill right up to the extreme edges and into the corners, it can be tempted right over the edge with the puddling wire. A perfect union should result, with the white metal snug up to the edge of the bearing; and when it is finally machined, there should be nothing to indicate the union except a change of colour.

DIRECT LINING.

Reference has been made to the method of tinning bearings by immersion. When a batch of bearings has been tinned in this manner, they may be quenched and subsequently re-heated for babbitting, one at a time; or they can be transferred individually, and immediately after the final tinning, to suitable jigs and metalled straight away. If the latter is done, it is essential to see that the part is mounted on the jig and filled (babbitted) before the tinning has had time to "chill." In the absence of the necessary jigs and facilities, it would be better to re-heat them individually as required, and to white metal them one at a time. Where a number of bearing shells or connecting-rods of similar type are being dealt with, however, much time is saved by placing them on the jig and lining them immediately they are removed from the second tinning bath.

It cannot be over-emphasized that there should be as little delay as possible between the time the bearing actually leaves the bath until the white metal is poured in; otherwise the tinning will "chill" and poor adhesion of the babbitt will result. Thicker shells will naturally allow more latitude than thinner ones.

The lining jigs employed must be of the quick-operating type, and several of these will be needed.

SECTION "B"

Re-metalling of Diesel Engine and other large bearings with bores of 6 ins. upwards

Tinning

Exceptions are admitted, but, speaking generally, it can be said with certainty that ALL bearings are the better for being tinned.

Apart from lessening the likelihood of oil penetrating between the white metal and the shell, thus hampering the conduction of heat generated, tinning ensures that the white metal rests snugly against the surface of the bearing shell. In the absence of good bonding, the white metal (with an air space behind it, as it were) will have a tendency to flex at each reversal of stress, and consequently to fracture.

Types of bearings to be tinned, with some exceptions: All bearing shells in high-class work, high-speed service, and, in particular, *engine* bearings generally, should be thoroughly tinned before being filled. At the discretion of the engineer, certain cast-iron bearings (which are generally furnished with anchorage holes or grooves), and bearings in medium and light services may, however, be left untinned; but *all* bearings are capable of giving better service where good adhesion of the white metal has been assured by sound tinning.

Thoroughness in cleansing essential: Bearings to be tinned should be thoroughly cleansed from grease, dirt, rust, etc., especial attention being paid to any anchorage holes or grooves.

Treatment of greasy bearings: When a number of greasy bearings is to be done, it is worth while placing them in caustic soda solution (about 3 per cent. of soda in water) for about thirty minutes, keeping the liquid near boiling point, and afterwards washing them in clean, running water.

Preparation for Tinning: Run out the old white metal with the air/gas blowpipe, or, if the size of the bearing permits it, by immersing it in a pot of old white metal heated to 730-750°F. (390-400°C.). Or a spirit blowlamp can be employed, care being taken to see that the flame is kept clean. Then scrub the shell with a wire brush to remove all traces of old metal and as much as possible of the old tinning. The bearing shell must be *really* hot so that the whole of the surface is "free" (molten). Do not overlook the cleansing of the joint faces and flanges.

TINNING OF BEARING SHELLS OF BRONZE OR BRASS.

In the case of bronze and similar bearings the old white metal is best run out with the air/gas blowpipe or spirit blowlamp. The surface should then be thoroughly gone over with a wire brush. **It is important that as much as possible of the previous tinning is removed.**

The Tinning Bath: Prepare a pot, or bath, of pure tin heated to a temperature *not exceeding* 480°F. (250°C.). The size and capacity of the bath will, of course, depend upon the sizes of the bearings being handled.

Flux: Make a saturated solution of Hoyt Powder Flux using a little more powder than the water can dissolve.

Commencing the Tinning: After thoroughly cleansing the bearing as described above, immerse it in the bath, allowing just sufficient time for it to become heated. Then withdraw it and go all over the inner surface, as quickly as possible, with liquid flux, using a *clean* bristle brush. Immerse (again lowering it gently), at the same time giving it a rocking motion; hold it there for a few seconds; then withdraw it and go over the surface again with the flux. This second fluxing, followed by a further immersion in the tinning bath, is strongly recommended.

The bearing shells should not remain in the bath a moment longer than is necessary in order to obtain a bright, free-running tinned surface.

When the bearing is finally removed from the tinning bath it should be given another coating of flux, after which it can be quenched and stood aside until the lining jig is ready. Much time, however, may be saved by placing it on the jig (previously heated ready) and babbitting it immediately; and in that event a final coating with flux is not required.

Any surplus tin on the surface of the bearing should be allowed to remain; in other words, leave a good thick layer of tin in the bore of the bearing.

IMPORTANT: Bearings made from bronze, gunmetal or brass **MUST NOT REMAIN IMMERSED** in the tinning bath, or pot of old white metal, for any length of time. Steel bearing shells, however, benefit by "soaking."

TINNING OF BEARING SHELLS OF STEEL (including connecting-rods where the white metal is lined directly into the rod):

Run out the old white metal with the air/gas blowpipe or by immersing the bearing in a pot of old white metal heated to about 730-750°F. (390-400°C.). Then brush the bearing well out with a *wire* brush, which should remove all traces of the old lining.

The Tinning Bath: Prepare a bath or pot of pure tin heated to a temperature of 750°F. (400°C.) maximum.

First Tinning: Take the steel shell or connecting-rod (which will have previously been heated by immersing it in the tinning bath) and sprinkle a few crystals of Hoyt *Powder* Flux upon the surface to be tinned. There should be sufficient heat present to melt the crystals of flux. Then take an old hacksaw blade or wire brush (the former is preferred) and scrub the whole of the surface vigorously. Immediately this has been done, immerse the bearing in the tinning bath, at the same time giving the bearing a rocking motion. When the tinning on the surface is running freely, *i.e.*, it appears to be thoroughly "wet," remove the bearing and quench it in cold water. If inspection reveals any black specks (or dirt) the bearing should be fluxed again and re-immersed in the bath.

AN ALTERNATIVE METHOD OF FLUXING is to use a saturated solution of Hoyt Powder Flux applied with a bristle brush.

Second Tinning: For this operation a second bath containing tin at a temperature of 480°F. (250°C.) maximum is needed. Heat the rod by immersing it in this second bath; withdraw it and go all over the tinned surface, as quickly as possible, using the *liquid* flux already described and a *clean* bristle brush. Immerse again (lowering it gently), at the same time giving it a rocking motion. Hold it there for a few seconds; then withdraw it and go over the surface again with the liquid flux. Finally, replace the bearing in the tinning bath until the jig is ready.

TINNING OF CAST IRON SHELLS.

The results from tinned iron shells show almost as many variations as there are qualities of iron. Iron shells which have been in use and are inclined to be at all porous are particularly troublesome; some irons of a spongy nature, even when new, give trouble.

The degree of adhesion between white metal and cast iron is almost equally uncertain, as in the case of tin and cast iron, and the best result is not to be compared to the bonding to be obtained with bronze and anti-friction metal, or steel and anti-friction metal. It would not be strictly accurate to say that adhesion between anti-friction metal and cast iron can be successfully obtained. What actually happens is that according to the quality of the tinned surface on the iron so is the anti-friction metal made to lie up closer to the shell, and thus far the tinning is of value, but the actual strength of the adhesion, as such, is generally poor in character. In attempting to tin iron it is essential to reduce to a minimum the chances of oxidation during the tinning process. The chief difficulty in tinning cast iron arises from the presence of graphitic carbon, which prevents the molecular contact between the tinning alloy and the iron, thus making it extremely difficult to produce the "wet" surface familiar with bronze and steel.

Fused alkaline salt baths have been tried for the surface treatment of cast iron, as a preliminary to the tinning, but whilst these baths may adequately cleanse and prepare the surface, they cannot affect the size and distribution of the graphite crystals in the iron, which latter are a most important factor.

Tinning by immersion: The double-tinning method, as described for steel shells, is recommended, with the first bath at 610°F. (320°C.) and the second bath at a temperature not exceeding 480°F. (250°C.). This will be found to produce a coat of tin on the surface of the iron, which to the eye will appear rather like a number of bits hanging on. This surface can then be brought up by scrubbing it with a stiff wire brush, and at the same time sprinkling it with Hoyt Powder Flux.

Oil should be burnt out: If an iron shell has previously been in service in an engine; after the old metal has been run out of the shell, it should be kept heated for a time sufficient to burn out all the oil from the pores of the old casting. The burning-out can be done by means of an ordinary oven or by other means, raising the shell to such a temperature that the oil exudes from the pores and catches fire (say 752°F. (400°C.)). This may have to be carried out for quite a long time before oil ceases to exude. Afterwards the shell should be boiled in caustic soda solution (about 3 per cent. of soda in water). Keep the liquid near boiling point for about thirty minutes and then wash in clean cold water.

Pickling: If it is desired to pickle the casting, this can be done by placing it in a sulphuric acid solution (contained in either a lead-lined or porcelain vat), and at the strength of 16° Beaume (cold), say, one part of sulphuric acid in six parts of water. *(CAUTION.—Add the acid to the water; IT IS DANGEROUS to put the water in the acid.)*

It should be pickled long enough to take on a dull grey colour, then thoroughly washed in hot caustic soda solution (6 per cent.) and afterwards put through a bath of cold running water for about 30 minutes.

It is important to thoroughly remove all traces of the acid or acid salts, as the smallest quantity remaining is likely to promote corrosion. Dry the bearing thoroughly.

When the best possible result has been obtained, the shell should be partially quenched until ready to set up on the lining jig. We repeat, however, that the results depend largely on the quality of iron; if one encounters a particularly bad quality it may prove troublesome. The tinning should be as thorough as possible, but should not occupy too long a time, otherwise the surface will get into a "gummy" condition, which is difficult to remove.

It is not suggested that the Hoyt Powder Flux recommended here is a universal panacea for the troubles of tinning cast iron, but it is a great help and is certainly more effective than all other fluxes we have tried.

Gas-heated muffle best: In the absence of a bath a gas-heated muffle, made from sheet iron and lined with asbestos sheet, in which the bearings can be heated, is very useful. In the case of large bearings (say, for 6 in. shafts and upwards) the use of a muffle is particularly recommended, it being practically impossible to heat a large shell all over with a blow-lamp and at the same time maintain an even temperature.

Treatment of new bearing shells prior to tinning: When new shells are received in the lining shop they will generally be clean, with the bores machined ready for tinning; the following notes, however, are included for reference as needed.

Removal of sand: When loose sand is present, this should, of course, be removed. "Tumbling" can be employed in the case of the smaller shells.

Removal of scale: Pickling may be necessary to remove scale. There are several baths in common use, but probably the best consists of one part of commercial sulphuric acid in ten parts of water. The bath should be maintained at about 120°F. When the bearings have been immersed, wash in clean, hot water, or hot caustic soda solution.

A wash to prevent tin adhering to backs of shells can be prepared from any one of the washable distempers (oil-bound water paint). The colour is obviously unimportant, although a light colour, such as cream or buff, is preferred. The distemper is thinned by adding a solution of clean water and silicate of soda (water glass) in the proportion of 50 per cent. water to 50 per cent. silicate of soda by measurement. It is usually sufficient to add 50 per cent. of the above solution to 50 per cent. of the water-paint. The silicate of soda forms a binder and prevents the paint flaking.

Heating the Metal

Great care should be taken not to overheat the white metal in the melting pot. The use of a thermometer is advised.

POURING TEMPERATURES OF HOYT METALS.

Number Eleven Metal "D" and "R" pours at 725°F. (385°C.) upwards according to the size and nature of the work — maximum 800°F. (430°C.).

No. 175 Metal, 850°F. (454°C.).

No. 38, 800°F. (430°C.), excepting when used for Ford cylinder blocks, when it should be heated until the surface appears "cherry red," say, 1,500°F. (620°C.).

I.C.E. Metal, 700°F. (370°C.).

Star Brand, No. 3M, No. 4A, and No. 4, 620°F. (325°C.).

If a metal is accidentally made a little too hot, cool at once by the addition of new (cold) metal.

Pouring temperature — use of discretion: The foregoing temperatures must be regarded only as a general guide. The actual pouring temperature of the metal will depend upon the size of the bearing and thickness of the lining to be cast, etc. For very thin linings, the metal may need to be hotter than for thick ones. *The minimum, rather than the maximum, temperature should be aimed at,* but the metal must always be hot enough to prevent its cooling too rapidly, *i.e.*, the metal must remain in a fluid state until the bearing is full up to the top, in order that the operation of "venting" (described later) may be carried out properly.

Turn gas down when metal in pot is molten: When the metal in the pot has become molten, the gas should be turned down low, with just sufficient heat to maintain the metal in the pot at the correct temperature. A bluish ash (oxide) forming on the surface indicates that the metal is being burnt. If the metal has been overheated accidentally, it should be cooled at once by the addition of new (cold) metal.

Don't forget to stir the metal! It is extremely important that ALL anti-friction metals be WELL AND FREQUENTLY STIRRED from the bottom. *(Statements that certain metals do not need stirring are wrong and misleading — ALL metals must be stirred frequently.)*

Pot with enclosed burner best: A pot providing for the gas ring to be enclosed is especially recommended for melting white metals, as it ensures a more even distribution of heat. Where a pot of the enclosed type is not readily procurable, however, a casing may be fashioned out of sheet iron.

White metal can be melted over a smith's forge but that method is not recommended where gas heating is available.

Filling pot and pouring off: Always have a fair quantity of metal in the pot, and sufficient for the amount of work in hand. In order that the metal may retain its original condition it should not be allowed to cool down in the pot at the end of the day, or when a batch of lining work is complete, but be well stirred from the bottom, poured off, and cooled as quickly as possible. This is especially necessary with high-grade tin-base metals. It is an advantage to "chill" it if suitable rough moulds are available. A piece of channel-iron, divided into sections with clay, forms a good rough mould. Clean the pot well before re-filling. All metal pots should be thoroughly cleaned out once a fortnight and given a coat of distemper on the inside.

Re-melting of Metal: Provided Hoyt Metals are not overheated they may be re-melted, with the periodical addition of new metal, without injury, but the fewer times the better. To revive, add three parts of new metal to one of old.

Never mix different makes or qualities of white metal. Do not use old metal from bearings.

Pouring the Metal

Pre-heating the jig: The metalling jig and mandrel or core should be assembled and both heated to the same temperature as that of the white metal being poured, an air/gas blowpipe or a spirit blowlamp being used for this purpose. A preferred method, however, is to place the jig and mandrel in a pot of old white metal at the same temperature as that of the new lining metal. If only the mandrel is placed in the pot of old metal the jig will, of course, have to be heated separately.

Should the bearing shell have been stood aside whilst the jig has been prepared, bring the former up to the required temperature by re-dipping it in the tinning bath immediately before placing it on the jig.

IMPORTANT: It is essential that the tinning on the inner surface of the bearing be JUST FLUID when the white metal is poured in.

Where an air/gas blowpipe or spirit blowlamp is employed care must be taken not to allow the flame to play upon any tinned surface.

Jigs of modern type, designed for quickness in operating, should not require stopping-off.

Commencing to pour: As a preliminary to pouring skim the top of the pot by drawing the film of dross to one side. Insert ladle and STIR THE METAL WELL and FROM THE BOTTOM. Take a ladleful of the metal, and, resting the lip of the ladle on the top of the bearing shell (observing that the tinning on the shell is still molten), proceed to pour. Pour gently at first, continuing until the bearing is full right to the top. DO NOT THROW THE METAL IN, but hold the ladle near the job, *at one place,* and gently tilt it so as to obtain a steady flow. With large bearings, more than one ladleful of metal may be needed; and the job should be "puddled" as each ladleful is added. The top of the casting must NOT be allowed to "chill" before more metal is added; the metal at the top must be kept fluid by means of a gentle heat from the blowpipe. Keep the pot fed with new (cold) ingot metal as required.

"Venting" or "puddling" the metal is recommended: To ensure smooth castings and to obviate blowholes: immediately the bearing is full, take a stainless steel wire and dip it *continuously and rapidly* in and out, all round, lightly and without forcing it. At the same time prevent the metal at the top from setting by means of a gentle heat from the blowpipe. It is also an advantage to "sweep" round the mandrel with the puddling wire. The metal at the bottom MUST solidify first, and the cooling proceed until the bearing is solid up to the top. Care should be taken to see that metal that is thickening (cooling off) is not pierced with the "venting" wire; otherwise you will find cavities in the metal when the bearing is bored out. During this operation of "venting" (which takes, say, two or more minutes, according to size of bearing), the metal may sink down from the top; if it does, a little more should be poured in.

Cool as quickly as possible: *Cool the bottom of the bearing* with cold air from the blowpipe *as quickly as possible.* If cold air is not available, a wet sponge or cloth may be pressed against the lower part of the bearing; or a fine water spray may be played on the back of the bearing shell. Care must be taken so that damp or water does not reach the molten white metal inside the bearing.

Adhesion between the white metal and the shell or housing is greatly improved by rapid quenching. Quenching, however, must be progressive, *e.g.,* from the bearing shell into the molten metal. In the case of bearings lined vertically, quench from the bottom upwards, and from the shell into the molten metal as far as that is possible. The reason for this technique is that the shell and the anti-friction metal (which have differing rates of contraction) are being cooled simultaneously. If the anti-friction metal is cooled incorrectly, that is from the inside or by way of the mandrel, this sets up stresses tending to pull the white metal away from the housing and so weaken the bonding. Correct cooling of the bearing, as by the impingement of water on the outside of the shell, results in a progressive yielding of the anti-friction metal while still in the plastic state, and no undesirable stresses are introduced.

SECTION "C"

Handling of Crusher and other special types of bearings

For details of Tinning, Heating of Metal, Pouring, etc., see preceding Section "B"

Owing to their weight, and the fact that the crushers are frequently working in remote places, the re-metalling of such parts sometimes taxes the ingenuity of the engineer.

The following is an outline of the procedure usually to be followed; but the methods suggested are, of course, subject to modification, according to the situation in which the work is being carried out and the tackle available.

A jig will be needed. This will consist of a mandrel for forming the bore; and where white metal is to be cast on the outside of the piece, as well as on the inside (as in a gyratory crusher), a suitable outer part, or sleeve, is necessary.

This equipment is usually provided by the makers of the machine. The parts are usually of cast iron, and are split; there being an arrangement for slightly opening the outer part, and a somewhat similar arrangement for slightly closing the inner part or mandrel. This adjustment is effected by means of short, hexagon-headed set screws. It will be readily understood that the clearance which this operation provides, facilitates the separation of the casting and jig after babbitting; otherwise it might prove difficult, if not impossible, to separate them. We are, of course, dealing with something which is rather exceptional as regards both size and weight.

Where such appliances have not been provided with the machine, it is usually because they are not necessary, and the work is then generally of such a character that the engineer can make up the appliances he needs from sheet iron of suitable gauge, or sheets of asbestos can be wrapped round the parts. Where the proper equipment is available and used the bearings are, of course, babbitted dead to size, and the need for machining is obviated.

The first operation is to remove the old white metal and to prepare the casting for re-babbitting. All grit and oil should be removed, and the job made as clean as possible.

Next, fix the cover and mandrel in position; and it will be found an advantage to first coat these with a mixture of blacklead and water; this will facilitate their removal later on.

The job should next be stopped off with wet pulp asbestos. In carrying out this part of the work, some regard must be paid to the weight of the molten metal to be held in the bearing; keeping in mind, however, that the metal at the foot will usually have commenced to chill before the whole casting is full; nevertheless, the pressure may be considerable.

It is necessary that the whole of the parts—consisting of sleeve, eccentric and mandrel—be heated before pouring the white metal, but *only just sufficient* to drive out any moisture present and likely to cause "spitting." An excess of heat, particularly when bearings are being cast to size, is liable to cause shrinks. To conserve heat, some sort of cover might be considered, although this is not an essential. A gas-heated muffle (which can readily be made from sheet iron) is recommended.

If the casting is not an over-large one, an alternative to gas would be two or three large blow-lamps; but if the bearing to be heated is a very large one, in the absence of gas, the best method of heating would be a wood or coke fire set around the job, the work necessarily being done out-of-doors. A separate coke fire will be needed for the heating of the white metal. It is much better, of course, if the parts can be removed to the workshop, where they can (if the appliances are available) be handled to better advantage.

The need for handling the casting during the various operations is to be avoided, and it will usually be heated (standing vertically) in the position where it will be required for filling. When sufficiently heated, the fire can be raked off, leaving the job ready for the next operation. Tinning is almost out of the question for these large parts, unless one is very specially equipped; so that, generally speaking, this operation is omitted. Where tinning is carried out, however (as it might be in the case of some of the smaller types), it is all to the good. Tinning the housing prior to babbitting is always an advantage, and is calculated to prolong the life of any white metal bearing. Apart from strengthening the liner as a whole, it facilitates conduction of frictional heat, which is always beneficial.

Having heated the casting sufficiently, together with the outer part of the jig and mandrel, next proceed with the pouring of the babbitt. The latter, in the absence of gas, will have been heated on a coke fire. Our general recommendation is that the white metal should not be heated to excess; in the case of work such as that now being dealt with, however, it is an advantage to raise the temperature 150°/100°F. higher than normal, depending upon the thickness of the lining being cast. This will assist materially in heating the job as a whole, and in producing a satisfactory result.

The pot employed for melting (and pouring) the white metal is preferably one fitted with a cock or valve; and it must be arranged so that it can be lifted from the fire, and brought into position over the casting for pouring. Further, it is an advantage to have it slung in such a way that it can readily be moved to and fro around the job as the filling proceeds. Have ample metal in the pot, and more than is actually required for the filling, to allow for possible loss due to leaks, etc. Check the temperature of the metal immediately before commencing to pour.

When pouring is commenced, the metal may break through the stopping somewhere and stream out. This can be checked by the application of wet rags, or wet pulp asbestos. This method will cause solidification of metal at the leak, and a consequent seal.

The weight of metal in these large bearings is usually sufficient to squeeze out any air that may have become trapped, and "puddling" or "venting" can be dispensed with until the metal nears the top of the casting.

It is desirable to "chill" the bearing, commencing at the bottom and working upwards. A good method is to apply wet rags, or old sacks saturated with water, or a small jet of water from a hose can be used. Do not allow the water or steam to come into contact with the white metal inside the work.

The pouring of the metal should be continuous from start to finish, and the whole casting should be filled as quickly as possible.

When pouring, if, as the metal is nearing the top, feeling with the "venting" wire indicates that the metal is chilling more rapidly at one side than the other, this can be checked by moving the pot round and continuing the pouring from that point. This will have the tendency to prevent further cooling here, and enable the metal at the other side to cool off.

If, when the bearing is full, the metal sinks down a little (as it probably will) more should be added. It is always an advantage to cast a "header" to take care of shrinks. This can be smoothed off afterwards by means of a gas blow-pipe, a large blow-lamp, or a bar of iron heated red in the fire.

Be sure that the white metal has "chilled" throughout, *i.e.*, in the centre as well as at the ends, before attempting to remove the cover and mandrel.

Where large castings, similar to those just dealt with, are being handled, several operators are necessary. Even in the case of a small casting, which it is possible for a man to handle single-handed, it is often much better dealt with if he has plenty of help; the job is done more quickly, with greater certainty, and there are not so many chances of failure.

POURING BEARINGS IN POSITION.

Another job that has sometimes to be performed and one which, we think, comes within the scope of the present notes, is where a bearing has to be filled in position; that is to say, the old white metal has to be removed from its housing and replaced with new without dismantling the machine.

The journal will firstly have to be supported and the old metal removed. Next the job will have to be cleansed, the journal centred, the necessary stopping-off carried out, and the whole made ready for heating. As to how the heating is best accomplished will depend upon the situation of the job and the means available, and much we have written earlier in these notes will apply in this case also.

The heat may have to be localized to prevent damage to other parts of the machine, and consequently the use of a wood fire will be out of the question. Therefore, in the absence of gas, the only other means of heating available will be a powerful blowlamp or two. Where such a job has to be carried out in the open, screen it as much as possible to conserve heat.

In some cases it may not be possible to pre-heat the housing, and a "chill" casting will have to be made. For this purpose, the white metal should be made a little hotter than usual, and the pouring of it should be both quick and continuous.

Before pouring the white metal, the journals should be given a liberal coating of graphite to prevent the babbitt adhering to them.

In wood-stave moulding machines excellent results have been obtained by "smoking" the spindles with a heavy coating of carbon from a welding blowpipe, using only acetylene leaving the pipe with sufficient velocity to force the flame away from the tip about ¼ in. The operation only takes a few seconds, and the spindles leave the metal cleanly. The only fitting necessary is a small amount of scraping.

Miscellaneous Notes

TESTING STRENGTH OF ADHESION.

We have frequently emphasized the value of securing good adhesion of the liner by, firstly, seeing that the housing (shell or connecting-rod as the case may be) is *well and thoroughly tinned;* and, secondly, that the white metal, when poured, really unites with the tinning.

The methods of determining whether the adhesion of the white metal is good, or otherwise, are:—(1) "Ringing," *i.e.,* tapping each shell after filling; (2) taking a bearing at random from each batch filled, and chipping out the white metal with a hammer and chisel; (3) the hot paraffin test.

The ringing test is the one in most general use. Where bearings are being repaired, as distinct from production, it is the only test that can reasonably be applied, since in knocking out the white metal the bearing is destroyed.

All shells should be rung *before filling,* when any found to be cracked can be rejected; and any that are sound but do not ring well suitably marked. It will be found that shells impregnated with oil will frequently ring badly, or not at all. Holes and grooves may also contribute to a bad "ring," but not to the same extent.

The ringing of bearings naturally calls for a good deal of discretion on the part of the operator, but a man who has accustomed himself to the operation and has a well-trained ear will readily determine whether the white metal is properly bonded. Since, however, the rejection or passing for use of a casting is dependent upon his individual judgment, however skilled, care should be taken to ensure that all castings sent forward for inspection shall be sound.

Having arranged for the initial ringing of the shells, to ensure that only sound ones are passed to the white-metalling bench, it next follows to see that in the tinning and metalling the work is properly carried out. Provided the bearings are properly cleaned and thoroughly tinned with pure tin or good quality solder, and heated until the tinning just runs before the white metal is poured (the latter at the correct temperature), unsatisfactory castings should never occur.

For the purpose of ringing, the bearings should after cooling off, be placed face upwards on a smooth wooden bench or table, and lightly tapped with a small *wooden* mallet, or light object of like material. An ordinary pencil answers very well in the case of most bearings. Ringing with a metallic object is likely to prove misleading.

The bearings should ring with a high note, the higher the better. All bearings will not ring alike, and some will not ring with such a high note as others; but any that ring with a decided low note — especially in a batch of shells that as a whole have a high ring — should be put aside for further examination and possible re-metalling

A bearing may sometimes ring with a fairly good note when the white metal is adhering everywhere, but not as strongly as it should be; or even when the adhesion, although good in some places (such as at the edges) may be poor indeed in other parts of the bearing. As there is not, therefore, any *absolutely certain proof* that the metal is adhering perfectly and strongly everywhere, it is all the more necessary that the lining methods should be careful all through. This is particularly the case with connecting-rods (metal lined direct on to the steel) which cannot usually be tested satisfactorily by ringing. The "ring" of the cap, however, is some guide to the other half when the two have been lined together.

Many experienced testers take the view that ringing is in the long run better than the knocking out of the white metal with a hammer and chisel, for the reason that, in the case of the former test, every single piece has to be passed; whilst, with the latter, only a very small percentage of each batch can be examined, which might conceivably be the only good ones in a large number. A good compromise when examining a comparatively large number of bearings, as in the production of new shells, for instance, is to subject all doubtful cases from the ringing test to that of the knocking out of the white metal. In this way, one test provides a useful check upon the other.

Lastly, there is the paraffin test, which is almost too well known to need description; however, a few words on this test will serve to complete these notes. After metalling, the bearing shells are placed in a bath of hot paraffin for a matter of thirty minutes; taken out, wiped, allowed to cool, and then sprinkled with French chalk. Should the adhesion of the white metal have been poor, the paraffin will have penetrated between it and the shell, to emerge again when the shell is re-heated, and become absorbed by the French chalk and staining it. The degree of absorption will serve to show the quality of the bonding.

The weakness of this test rests in the fact that any small recess or aperture at the butt faces or on the ends (itself entirely harmless) may retain the oil, and, giving it up again, lead one to suppose the adhesion of the liner is weak and that the paraffin has penetrated beneath it.

A very common cause of poor adhesion is that the shells are not made hot enough for the tinning to run and unite with the white metal when the latter is poured. The shells may be properly tinned, but unless the white metal is able to unite with the tinning, the liner will quickly become loosened. This fault is probably a worse one than having the white metal uniting with the tinning, but adhesion between the tin coating and the housing itself being poor.

CAUSES OF NON-ADHESION OF WHITE METAL.

If the metal does not adhere to a shell after careful tinning, there are no other reasons than the following:—(1) the flame has reached the tinned surface and oxidized it; (2) the shell has been made too hot and the surface oxidized in this way; or (3) the shell has not been made hot enough to cause the tinned surface to just run. Non-adhesion may also be present in bearings filled solid (*i.e.*, without use of a mandrel) due to the metal having shrunk away from the shell on cooling. Cores or mandrels made from aluminium are not recommended.

Non-adhesion can also result from failure to remove any signs of burnishing due to the surface of the housing having been in actual contact with the journal.

BLOWHOLES AND SHRINKS IN WHITE METAL LININGS.

Blowholes are generally due to the following causes:—(1) White metal not hot enough; (2) mandrel or inside of bearing damp with oil or water; (3) some of the flux used in tinning has been left in the bearing; (4) air has been trapped in some way; (5) metal has caved-in owing to leaks; (6) moisture from the luting has got in; or (7) the ladle has not been held steady and in one place during pouring.

Some white-metallers have a tendency to throw the metal into the bearing. Others move the ladle round the job, pouring the metal in several places. Both methods are wrong, and are frequently the cause of blowholes.
Shrinks appearing in the casting will probably be due to having the white metal too hot.

CLEANING OF MANDRELS.

It is an advantage to rub the mandrels smooth with emery-cloth occasionally, and to smoke them to prevent the metal sticking. The mandrels should be removed from the lining bench for cleaning, and carefully wiped before being replaced. Particles of emery must under no circumstances be allowed to come into contact with the white metal or equipment.

PRESERVATION AND USE OF TURNINGS.

It is essential that white metal turnings should be kept clean and free from any foreign matter including particles of aluminium, bronze, brass, steel, etc. There should be a suitable box or other receptacle in which they can be kept until ready for running down. This box should be fitted with a lid to ensure that no odd pieces of other metals, dirt, etc., find their way in.

Turnings may be re-melted, provided the metal from which they come has not been over-heated or re-melted more than *twice* at the most; and provided they are free from impurities.

The clean and good turnings should be beaten into small cakes, dried carefully, and melted down, using tallow as a flux. Commence by forming a pool of metal, molten at, say, 750°-800°F. (400°-427°C.) in a pot or ladle, and add the cakes one by one, pushing them well down into the metal already molten. Pour off into a small ingot mould and cool as quickly as possible. A chilled mould is best. Any dross or scum rising to the top of the pot as the cakes are melted should be skimmed off.

Metal recovered from turnings may be used with new ingot metal in the proportion of 1 part of turnings to 3 parts new metal.

CASTING OF WHITE METAL BY THE CENTRIFUGAL PROCESS.

This process cannot very well be applied to the repair of bearings, unless large quantities of one particular size or type of bearing have to be dealt with.

The apparatus for the centrifugal casting of white metal is quite simple, consisting of two spring-loaded circular plates mounted on the end of a hollow spindle, which is belt-driven between two self-aligning ball-bearing blocks.

The bearing shell to be babbitted (which must obviously be in the form of a bush) is accurately located between the two plates, which are then revolved and the white metal poured into a hole of suitable size in the centre of the front plate.

When molten metal is "spun" the heavier components of the alloy will always tend to be thrown farthest and to concentrate nearest the housing. For that reason the amount of metal to be cast in and the speed at which it is to be "spun" are factors which have to be taken into account to ensure that the alloy which is to form the surface of the bearing, after it has been finally machined, is of the correct composition.

PEINING OF BEARINGS.

The hammering or peining of bearings after babbitting needs to be carried out with discretion and then only for the purpose of correcting any slight distortion, such as closing-in of the bearing shell, that may have taken place during the operation of babbitting. A ball hammer is employed for the peining and this should be used sparingly. Heavy hammering or flogging of the lined surface is unnecessary and is detrimental to the crystal-structure of the white metal. A series of comparatively light blows, located so as to give the necessary correction to the shell, is all that is required.

PICKLE FOR SMALL CONNECTING-RODS.

Steel Rods. Run out the old white metal from the rods, and wipe them perfectly clean. Next, boil them in a 5 per cent. solution of caustic soda (½ lb. to a gallon of water). Rinse well in clean water. Then make up a solution of sulphuric acid to the strength of 30 Beaume (equal to a S.G. of 1.714); and immerse the heads of the rods, also the caps, in this for ten minutes. Again rinse well in clean water. (A container of porcelain or other suitable material will be required for the acid solution.)

SOME SPECIAL TYPES OF BEARINGS WITH SUGGESTIONS AS TO HANDLING

STRIP AND THIN-WALL BEARINGS.

Big-ends of Connecting-Rods: Where possible we advise tinning the connecting-rod and/or cap, and lining the white metal directly into it, thus dispensing with the steel shells.

Main Bearings: Main bearings of this (strip) type can, however, be tinned and re-babbitted.

The following are the chief points to be borne in mind:—

1. Always use Hoyt NUMBER ELEVEN "R" METAL.

2. Adhere to the instructions as laid down in the "Hoyt Operational Sheet."

3. The lining jig should be heated up to 850°F. (454°C.), or approximately 100°F. (55°C.) hotter than the temperature of the white metal.

4. It is essential to cool immediately after lining either by air or water, preferably by the latter which is more efficient.

5. Take care to re-set the shell to original outside diameter before machining.

6. Always support the back of the bearing in a cradle or housing when machining. The back of the bearing must fit the cradle accurately.

7. When fitting shells to Con-Rods or Mains in their housings, pay particular attention to the fit at the back. This will avoid "fretting" and overheating in service. Be careful not to remove any steel from the butt faces or to leave any white metal on them.

8. In the case of lead-bronze bearings (copper-lead), skim out sufficient lead-bronze to give a white-metal thickness between 0.010 in. minimum and 0.030 in. maximum. Should the lead-bronze be in a bad condition, *i.e.,* flaked or worn through to the shell, it will be necessary to machine out completely.

DURALUMIN CONNECTING-RODS AND CAPS.

(White metal lined directly into the rods.) Before metalling, tin the parts with pure tin, using a shallow vessel containing sufficient molten tin to cover them. Burnish the molten tin on the surface of the bearing with an old *clean* half-round file or wire brush, keeping the part submerged in the tin bath as much as possible. Do NOT use any flux. The tin in the bath must not be too hot — 480°F. (250°C.) is sufficient. The bearing should be babbitted immediately it has been tinned, and not quenched or stood aside.

The bath in which duralumin rods are tinned should NOT be employed for any other purpose.

AVIATION CONNECTING-RODS AND MAIN BEARINGS.

Especial care *must* be taken with aviation engine bearings, mains and connecting-rods. In some details the methods described in the foregoing "Hints" *cannot* be applied to these bearings. Melted-down turnings must *not* be used; it is best that the metal be heated *once* only; great care must be taken not to overheat the steel of the connecting-rod (and so lower the temper); the adhesion to the steel must be absolutely perfect all over, including right up to and *over* the edges — in fact, not a spot must be missed; and a high standard of craftsmanship is required. Before attempting this work, in the absence of previous experience, we invite you to write us for pouring temperatures, etc., stating types of bearings to be handled. We are always pleased to assist all bona fide enquirers.

FORD CYLINDER BLOCKS.

When babbitting cylinder blocks which cannot be pre-heated, it is necessary to employ a special type of white metal (Hoyt No. 38), and to heat this until it appears "cherry red." When everything is ready and the mandrel is in position, take a ladle, filled with white metal, in each hand and pour it in from both sides simultaneously. The two streams of metal should meet and form a perfect bearing; if it "chills" before this takes place it has not been made hot enough.

OPERATIONAL SHEET

Covering the Re-Metalling of Connecting Rods and Bearing Shells with Hoyt's Number Eleven ("D" or "R") Alloy

1. Before commencing work, check temperatures of melting pots with the thermometer:
    - (*a*) Pot containing old white metal: 730-750°F. (390-400°C.).
    - (*b*) First (hot tinning) pot or bath: containing pure tin: 750°F. (400°C.) maximum.
    - (*c*) Second (cold tinning) pot: containing pure tin: 480°F. (250°C.).
    - (*d*) Pot containing Hoyt NUMBER ELEVEN Metal: 725-800°F. (385-430°C.). (725°F. is a good average pouring temperature for NUMBER ELEVEN "D" or "R" metal, but for casting exceptionally thin linings the metal may be heated to a maximum of 800°F.)

N.B. For the tinning of bearing shells of bronze or brass ONE BATH ONLY, of pure tin, is required, having a temperature of 480°F. (250°C.). (See page 17.)

2. **REMOVAL OF OLD WHITE METAL:** Immerse the bearing shell or head of the connecting-rod in the pot containing old (molten) metal; or, alternatively, the old metal can be run out by means of a gas/air blowpipe. Remove all traces of the old metal with a *wire* brush.

3. **FLUXING:** Make a saturated solution of Hoyt Powder Flux in clean, cold water — use a little more of the powder than the water will dissolve. Dip a *fibre* brush in the flux solution, and, while the bearing is still hot, go thoroughly over the surfaces to be tinned.

4. **FIRST TINNING:** After fluxing, immerse the bearing in the bath (b) at the same time giving the bearing a rocking motion.

5. **INSPECTION:** Carefully examine the bearing to ensure that the tinning has taken all over. Should the bearing not appear "wet" all over, repeat operations 3 and 4. Finally, quench by plunging into cold water.

6. **SECOND TINNING:** Re-heat the bearing by immersing it in the second tinning bath (c). Remove and go over the surface with liquid flux, using a fibre brush as before. Re-immerse the bearing in the bath, holding it there for a few seconds, then remove and reflux. Finally, replace the bearing in the second bath until the jig is ready.

   IMPORTANT: Bearing shells made from bronze, gunmetal or brass MUST NOT REMAIN IMMERSED in the tinning baths or pot of old metal. Steel bearing shells, however, benefit by "soaking."

7. **PRE-HEATING THE JIG:** The white-metalling jig, together with the mandrel or core, should be heated to the same temperature as the white metal being poured.

8. **POURING OF THE WHITE METAL:** First of all skim the pot by drawing the film of dross to one side. Insert ladle and STIR THE METAL WELL, raising it from the bottom of the pot.

   When filling the bearing, the metal should be made to flow in a steady stream. Do NOT throw the metal in.

9. **PUDDLING OR VENTING:** (Small bearings) Where bearings are lined vertically (not horizontally, as in certain jigs) as soon as the bearing is full, take a stainless steel wire and dip it, continuously and rapidly, in and out, all round; lightly and without forcing the wire into the metal solidifying at the bottom. (Large bearings) Commence puddling when, say, about a quarter of the white metal has been poured into the bearing. Finally, smooth off the top of the casting with the blowpipe and puddling wire.

10. **CHILLING THE CASTING:** Cool the bearing as quickly as possible, commencing at the bottom, using cold air from the blowpipe; or better, chill it by means of a fine jet of water allowed to play on the back of the bearing itself. Do NOT cool off the mandrel or core.

11. **TESTING FOR ADHESION OF WHITE METAL TO THE SHELL:** Make two parallel cuts lengthwise through the white metal, about $\frac{3}{8}$ in. to $\frac{1}{2}$ an inch apart and strip off the white metal with hammer and chisel.

12. **GENERAL:** The pot containing the NUMBER ELEVEN Metal should be emptied each night. All pots should be thoroughly cleaned out once a fortnight and given a coat of distemper on the inside.