

C O P Y .

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LLOYD'S REGISTER OF BRITISH & FOREIGN SHIPPING,

71, Fenchurch Street, LONDON, E.C.

May 25th 1909.

Dear Mr. Kerr,

I now give you some particulars as to the practice of fitting liners on shafts as carried out every day by seven of the most successful Engineering Firms in this country.

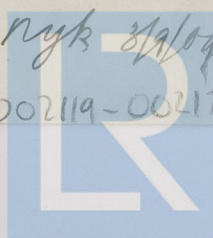
In every case the liners are made to fit tight the whole length of the bearings at both ends. In some cases the liner is made not to be tight between the bearings, but when this is the case the space between the liner and shaft is filled with white lead, putty or red lead putty pumped in by pressure not less than 30 lbs per square inch. In some cases the liners are shrunk on, in others they are forced on by hydraulic pressure cold, but if there is a tendency to stick fast when they are being forced on they are quickly heated in place by large gas jets acting all round. The hydraulic pressure required to force a liner on is reckoned to be from  $1\frac{3}{4}$  to 2 tons per inch of circumference and if the pressure is seen to be unduly increasing as the liner is pushed on then the gas jet comes in use to slightly expand the liner.

When the liner is shrunk on, after it is in the correct position it is cooled by water jets commencing at one end, this end being cooled and fixed while the other end is expanded and free. By gradually cooling along the length, the lengthways contraction takes place towards one end and the finished liner is left with very little longitudinal strain in it. If it is attempted to cool the liner all over at once it seizes at both ends and the longitudinal contraction has been known to cause circumferential fracture. It must be remembered that there is more proportionate contraction and therefore more stress lengthways if both ends are fixed than there is circum-

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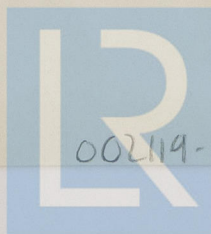
ferentially because the expansion is considerably more than the difference of diameter<sup>s</sup>, and part of the circumferential contraction takes place before there is any real stress put on the metal.

In putting on these long liners, it is a vital point to keep them absolutely straight whether they are shrunk on or forced on cold. For this it is essential that they should be so fixed before **boring** as to be without strain. Then after boring they may be considered to be straight also.

When heating them for shrinking on it is essential that they should be uniformly heated all round. If not the part most heated expands unduly and the liner ceases to be straight and will not go in place properly.

The amount of allowance for shrinking or for tightness is the same whether the liner is shrunk on or forced on by hydraulic pressure. Most usually it is  $\frac{1}{1000}$  of the diameter, but occasionally as little as  $\frac{1}{1500}$  of the diameter has been used. The  $\frac{1}{1000}$  was adopted many years ago by Sir Joseph Whitworth and is now almost universal. The heating of the liner, when this is done, is effected by gas jets on the Bunsen principle, that is a mixture of gas and air is used giving a hot smokeless flame. The liner is turned round continuously all the time it is being heated so as to ensure the uniformity of temperature and straightness.

In a long liner steps in size are requisite. In this respect there are differences of practice. The steps of course are made so that as little as possible **traverse** has to take place over the fitting portions. Where the shaft is stepped great care is taken to leave no mark in the shaft, that is to say the step in the shaft is tapered thus;-  and care must be taken that the step in the liner accurately corresponds with that in the shaft and that the error, if any, is such that the liner





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will not override the step in the shaft. That is to say an error like this  is better than one like this .

There is a difference of opinion and practice as to pinning the liners. Some firms use no pins, others always use pins, some only fit them when they are specified.

As shafts do well without pins and as there are some risks with their use, I personally think they had better be omitted. They cause a weak spot in what would otherwise be a homogeneous shaft. If by any means they work out they cut up the lignum vitae, and I am sure they will never make a loose liner into a tight one.

Another point of importance is the metal. I see the sketch you send says Bronze 88 x 12. I take it this means 88% copper 12% Tin. This is probably a good metal. It approximates to what we call Admiralty Gun Metal which is 88% copper 10% Tin 2% Zinc. The 2% Zinc is put in because without it molten copper dissolves oxide of copper, whereas the Zinc has such an affinity for Oxygen that the oxidation which takes place in melting is solely oxide of zinc, not oxide of copper, and the oxide of zinc remains on the surface and does not get into the metal. Some of our Engineers put in as much as 4% of Zinc but keep 10% of Tin. Some again have the idea that 2% of Lead is useful, this, however, is not generally believed and the Admiralty object to it.

I have tabulated the particulars of the practices of the various firms.

In the case where the shrinking is done vertically they have a deep pit. The liner, after boring, is placed on end in the pit and heated by Bunsen gas (coal gas and air) both internally and externally. The shaft is suspended from a crane and lowered vertically into the liner, its weight forcing it down.

I think I have dealt with every point requiring attention.



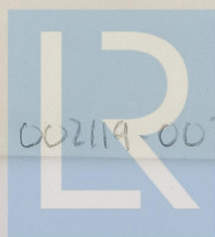
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Yours truly,

(Signed) J.T.Milton.

P.S:- I see I have omitted to state that for the part between the bearings it is desirable that the reduction of thickness should be on the outside, to facilitate the drawing of the shaft for examination, as scale forms on the part not working in the bearings and renders the withdrawal difficult unless the diameter is reduced at this part.

(Initialled) J.T.M.



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