Oct. 30, 1945. F. M. ASPIN ET AL 2,387,971

CYLINDER LINER AND CYLINDER

Filed Jan. 11, 1943

Fig.1.

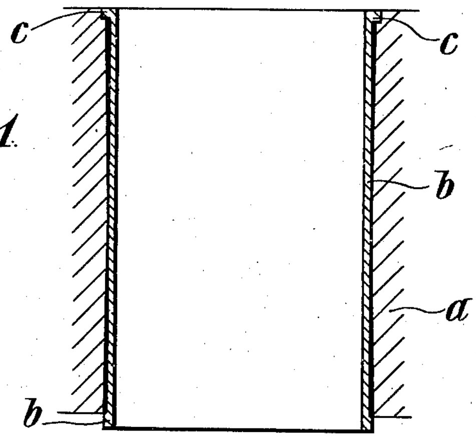


Fig.2.

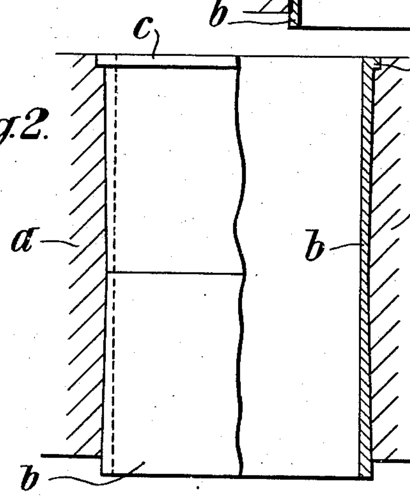


Fig.3.

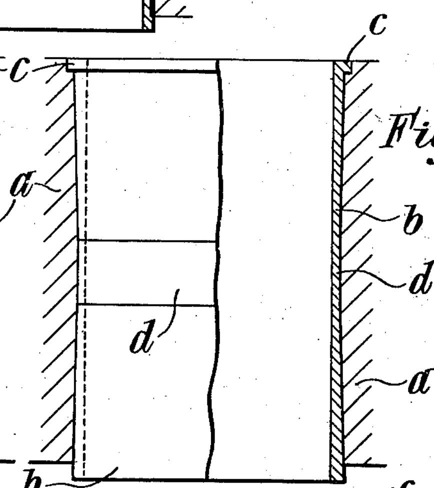


Fig.4.

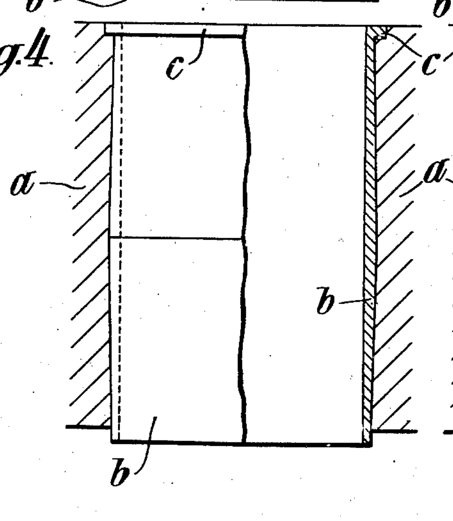
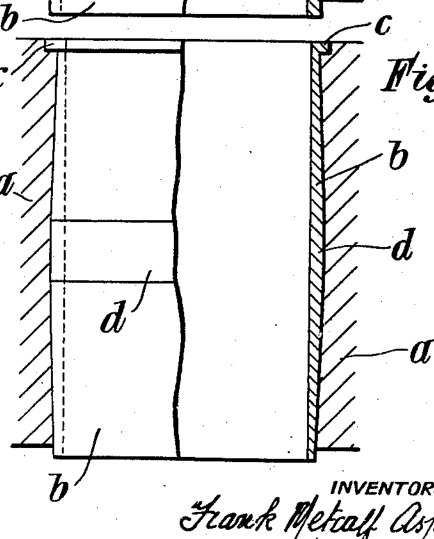


Fig.5.



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CYLINDER LINER AND CYLINDER

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10 Claims. (Cl. 309—3)

This invention relates to cylinder liners and cylinders for internal combustion engines, compressors and like machines embodying a piston and cylinder which normally operate at considerably elevated temperatures.

There are many known advantages in the use of light alloys, such as magnesium and aluminium alloys, in the manufacture of such machines, but there are also known disadvantages of which perhaps the most important are the general unsuitability of such metals to provide the wearing surface of the cylinder. There is the consequent necessity of fitting a liner and the very real difficulty of securing such liner owing to the fact that the light alloys in general have a higher coefficient of expansion and lower tensile strength than the usual cylinder metals such as iron including special cast irons. There is also the factor of heat interchange which where the cooling medium does not itself contact the liner requires effective contact between the liner and body of the cylinder in spite of the different rates of expansion in order that the heat of the liner may be dissipated. Cylinder liners have under such conditions been fitted so as to have a uniform interference fit throughout the length of their engagement, but this of itself has been found to be only partially successful.

The object of the invention is an improved method of fixing and complementary construction of liner and cylinder body.

The invention comprises the method of securing a preformed liner of one metal in a preformed housing of another metal such as a steel liner in an aluminium cylinder body of an internal combustion engine, wherein the liner metal has a relatively lower co-efficient of expansion than the housing metal, which includes the step of forming the housing and liner with complementary engaging surfaces relatively slightly tapered in both directions axially and of such diameters as to provide a relative interference fit having pressures which are in a gradient in both directions axially.

The invention also includes the further step wherein the liner is assembled in the housing by creating a temporary substantial temperature difference such that the said interference fit is temporarily removed.

According to the invention the combination of a liner and housing such as a steel liner in an aluminium cylinder of an internal combustion engine, wherein the liner is of a metal having a relatively lower co-efficient of expansion than the metal of the housing, characterised in that the liner and housing are preformed so that their complementary engaging surfaces are relatively slightly tapered in both directions axially and of such diameters as to provide a relative interference fit having pressures which are in a gradient in both directions axially.

The liner may also be characterised in that the exterior surface is rough ground to provide slight surface undulation and may be further characterised in that the slight taper of the liner provides a barrel or waisted shape.

According to a further feature of the invention the housing having a liner as aforesaid is characterised in that the bore is machine finished to give slight surface undulation.

Such an assembly may be further characterised in that the undulations in the bore cross with those on the surface of the liner or in that the bore is slightly tapered complementary to the taper of the liner. Such taper may be in the same or the opposite sense relative to that of the liner so long as it is complementary, i. e. such as to provide the required relative taper for an interference fit which will give pressure gradients within practical proportions relative to the materials used.

In the accompanying drawing:

Fig. 1 is a diagrammatic section of a cylinder of an internal combustion engine having a bore fitted with a liner according to one example of the invention.

Fig. 2 is an exaggerated section of the construction of Fig. 1.

Figs. 3, 4 and 5 show modified forms of the invention.

As illustrated in Fig. 1 the cylinder body *a* which is made of cast magnesium alloy having a coefficient of expansion of .00026 per degree C., is machined with a cylindrical bore. The liner *b* of cast iron having a coefficient of expansion of .000011 per degree C., is machined externally with a slight taper or waist and is flanged at *c* at one end. The external diameter and taper are such that at the centre the interference fit, before assembly, is .001'' per inch diameter, whilst at the ends the interference fit is .002'' per inch diameter, at normal room temperature. The tapered interference fit, giving a pressure gradient, is represented diagrammatically in section by the wedge-shaped line. The mean interference fit is therefore .0015'' per inch diameter.

As shown in Fig. 3, the liner *b* has a waist taper with an enlarged cylindrical waist portion *d*.

As shown in Figs. 4 and 5, the liner *b* has a barrel-shaped taper, whilst in Fig. 5 there is a central cylindrical portion *d*.

In all the forms shown herein, the internal bore of the cylinder is cylindrical, i. e. without taper.

The internal bore of the liner will be finished after assembly to eliminate any cylinder distortion.

In machining the parts, the cylinder bore is preferably honed, so as to provide relatively microscopic undulations in cross lines, whilst the outer surface of the liner is relatively rough ground.

The method of assembly is to freeze the liner and heat the cylinder until the contraction of the one and the expansion of the other exceeds the interference, including the effect of the taper, when the liner is slipped into the bore of the cylinder body. As the parts assume an equal temperature the interference is established, the liner expanding and the body contracting until the complementary surfaces come together, expelling air between the surfaces. Any air trapped between the surfaces appears ultimately to be dispersed through the pores of the metal. The pressure of the interference fit is such that the slight undulations or roughness formed by the machine finish of the liner and cylinder body, and the grain thereof are forced one into the other, according to whichever yields first providing partial compacting of the surfaces and intimate, almost bonded, contact. This result produces an increased contact area and provides for efficient heat interchange. The slight relative taper produces a pressure gradient because the interference throughout the length of contact is a progressive graduation.

Obviously the metals must be carefully selected for their essential properties of expansion coefficient and strength as well as for their suitability for the other required known characteristics and the degree of interference fit must be such that at the low temperature limit of normal working, the pressures due to difference of expansion coefficient will not cause fracture or exceed the elastic limit so as to crush either metal with the effect of loosening the liner before the high temperature limit is reached at which there must still remain some degree of interference fit.

The invention is obviously not limited to all the details of the examples above described, for instance other metals than those specified could be used for the cylinder body and liner. Also the receiving bore in the cylinder body could be made tapered as well as or instead of the taper of the liner before insertion of the liner whilst still providing a slight relative taper so that there will be a progressive range of interference pressure as will naturally occur in the case of Fig. 1. Moreover, if desired an intermediate metal may be applied say in a thin layer, to either the liner or cylinder bore where such will provide better bonding to the contacting surfaces of the metals which are selected for the cylinder body and liner respectively.

What we claim is:

1. The method of securing a preformed liner of one metal in a preformed housing of another metal such as a steel liner in an aluminum cylinder body of an internal combustion engine wherein the liner metal has a relatively lower coefficient of expansion than the metal of the housing which includes the step of slightly tapering the housing and liner axially in two directions and of such diameters to provide complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in two directions axially.

2. The method of securing a preformed liner of one metal in a preformed housing of another metal such as a steel liner in an aluminum cylinder body of an internal combustion engine wherein the liner metal has a relatively lower coefficient of expansion than the housing metal which includes the step of slightly tapering the housing and liner axially in two directions and of such diameters as to provide complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in both directions axially and including the further step of creating a temporary substantial difference of temperature sufficient to temporarily remove said interference fit whereby the liner is secured in the housing by shrinkage.

3. The method of securing a preformed liner of one metal in a preformed housing of another metal such as a steel liner in an aluminum cylinder body of an internal combustion engine wherein the liner metal has a relatively lower coefficient of expansion than the housing metal which includes the step of slightly tapering the housing and liner axially in two directions and of such diameters as to provide complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in both directions axially including forming in the complementary engaging surfaces of the housing and liner slight and relatively crossing undulations.

4. The combination of an aluminum cylinder of an internal combustion engine, and a steel liner having a relatively lower coefficient of expansion than the cylinder, the liner and the cylinder being preformed and slightly tapered axially in two directions forming complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in two directions axially.

5. The combination of an aluminum cylinder of an internal combustion engine, and a steel liner having a relatively lower coefficient of expansion than the cylinder, the liner and the cylinder being preformed and slightly tapered axially in two directions forming complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in two directions axially, one of said complementary engaging surfaces being smooth and provided with undulations.

6. The combination of an aluminum cylinder of an internal combustion engine, and a steel liner having a relatively lower coefficient of expansion than the cylinder, the liner and the cylinder being preformed and slightly tapered axially in two directions forming complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in two directions axially, one of said complementary engaging surfaces being smooth and provided with undulations, and the other of said complementary surfaces being relatively rough.

7. A liner for a cylinder of an internal combustion engine, having a relatively lower coefficient of expansion than the cylinder, the liner being preformed and having on its exterior cylinder engaging surfaces an intermediate cylindrical portion and tapered axially from the intermediate cylindrical portion in two directions, the intermediate cylindrical portion and the tapered portion having diameters adapted to form with the cylinder walls a relative interference

fit having pressures which are in a gradient in two directions axially.

8. The combination of a cylinder of an internal combustion engine, and a liner having a relatively lower co-efficient of expansion than the cylinder, the liner and cylinder being pre-formed and slightly tapered in two directions, forming complementary engaging surfaces having a relative interference fit having pressures which are in a gradient in two directions axially.

9. For use with an aluminum pre-formed internal combustion engine cylinder slightly tapered axially in two directions, a pre-formed steel liner having a relatively lower co-efficient of expansion than the cylinder and slightly tapered axially in two directions and sized and shaped to have an interference fit in the cylinder and having pressures which are in a gradient in two directions axially when the cylinder is shrunk on the liner.

10. For use with a pre-formed steel liner slightly tapered axially in two directions, a pre-formed aluminum internal combustion engine cylinder having a relatively higher co-efficient of expansion than the liner and slightly tapered axially in two directions and sized and shaped to have an interference fit with the liner and having pressures which are in a gradient in two directions axially when the cylinder is shrunk on the liner.

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