2nd. Edition

PATENT SPECIFICATION

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Specification Accepted: Sept. 1, 1943.

PROVISIONAL SPECIFICATION
No. 555 A.D. 1942.

Improvements in or relating to Cylinder Liners for Internal Combustion Engines, Compressors and the like

We, FRANK METCALF ASPIN, a British subject, of Walmer Place, 149, Walmersley Road, Bury, Lancashire, and FREDERICK ELLINGHOUSE, a British subject, of 39, Ashley Road, Solihull, Birmingham, do hereby declare the nature of this invention to be as follows:—

This invention relates to cylinder liners 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 liner in the cylinder body of an internal combustion engine, compressor or the like wherein the liner has a relatively lower coefficient of expansion than the cylinder body which comprises forming the cylinder and liner of such metals and making the complementary engaging surfaces relatively slightly tapered and of such diameter as to provide a relative interference fit giving a pressure gradient.

The invention also includes the method wherein the liner is assembled in the cylinder body by creating a temporary substantial temperature difference such that the relative contraction of the liner and expansion of the body exceeds the interference fit, including the slight taper where necessary.

According to the invention a liner for the cylinder of an internal combustion engine, compressor or the like wherein the liner is of a metal having a relatively lower coefficient of expansion than the metal of the cylinder body is characterised in that the complementary engaging surfaces are relatively slightly tapered and of such diameter as to provide a relative interference fit giving a pressure gradient.

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 a cylinder of an internal combustion engine, compressor or the like having a liner as aforesaid is characterised in that the cylinder bore is machine finished to give slight surface undulation.

Such an assembly may be further characterised in that the undulations in the cylinder bore cross with those on the surface of the liner or in that the cylinder is slightly tapered complementary to the taper of the liner.

In the accompanying drawings,

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 a 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 *e*.

In all the forms shown herein, the internal bore of the cylinder body is originally 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 expanson 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.

Dated this 1st day of January, 1942.
For the Applicants:
WILSON, GUNN & ELLIS,
Chartered Patent Agents,
54/56, Market Street, Manchester, 1.

PROVISIONAL SPECIFICATION
No. 2502 A.D. 1943.

Improvements in or relating to Lined Housings having Preformed Liner Inserts

We, FRANK METCALF ASPIN, a British subject, of Walmer Place, 149, Walmersley Road, Bury, Lancashire, and FREDERICK ELLINGHOUSE, a British subject, of 39, Ashley Road, Solihull, Birmingham, do hereby declare the nature of this invention to be as follows:—

This invention relates to lined housings having preformed liner inserts and is an extension of or development of the inven-

tion described in our earlier Application for Patent No. 555/42.

In such earlier Application the invention was described as applied to the securing of cylinder liners for internal combustion engines, compressors and like machines embodying a piston and cylinder which normally operate at considerably elevated temperatures.

It has now been found that the invention described in such earlier Application for Patent is applicable also to bushed bearings, such as for main bearings or big ends of internal combustion engines and to other lined housings generally, whether or not subjected particularly to elevated temperatures and irrespective of their relative co-efficients of expansion.

Accordingly the invention comprises the method of securing a preformed liner in a preformed housing 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 present invention includes all the subsidiary features and the constructional details described in the said earlier specification as if the same were read to apply to any lined housing other than a cylinder as therein referred to and irrespective of relative co-efficients of expansion of the liner and its housing.

Dated this 9th day of February, 1943.

For the Applicants:
WILSON, GUNN & ELLIS,
54/56, Market Street, Manchester, 1.

COMPLETE SPECIFICATION

Improvements in or relating to Lined Housings having Preformed Liner Inserts

We, FRANK METCALF ASPIN, a British subject, of Walmer Place, 149, Walmersley Road, Bury, Lancashire, and FREDERICK ELLINGHOUSE, a British subject, of 39, Ashley Road, Solihull, Birmingham, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to lined housings having preformed liner inserts, such as cylinder liners for internal combustion engines, compressors and like machines embodying a piston and cylinder which normally operate at considerably elevated temperatures, as well as bushed bearings for example for main bearings or big ends of internal combustion engines and to other lined housings generally, whether or not subjected particularly to elevated temperatures and irrespective of their relative co-efficients of expansion.

There are many known advantages in the use of light alloys, such as magnesium and aluminium alloys, in the manufacture of 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 for example as a cylinder 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 requires effective contact between the liner and housing 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 housing.

Accordingly, the invention comprises the method of securing a preformed liner in a preformed housing 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 liner and housing will generally be of different metals.

According to one embodiment the invention comprises the method of securing a liner in the cylinder body of an internal combustion engine, compressor or the like wherein the liner has a relatively lower co-efficient of expansion than the cylinder body, which comprises forming the cylinder and liner of such metals and making the complementary engaging surfaces relatively slightly tapered and of such diameter as to provide a relative interference fit giving a pressure gradient.

The invention also includes the method

wherein the liner is assembled in the cylinder body or other housing by creating a temporary substantial temperature difference such that the relative contraction of the liner and expansion of the housing exceeds the maximum interference fit.

According to the invention a construction embodying a preformed liner and preformed housing in which the liner is secured by providing an interference fit between complementary engaging surfaces is characterised in that the said complementary engaging surfaces are relatively slightly tapered in both directions axially and of such diameters as to provide an interference fit having pressures which are in a gradient in both directions axially.

According to one embodiment of the invention a liner for the cylinder of an internal combustion engine, compressor or the like wherein the liner is of a metal having a relatively lower coefficient of expansion than the metal of the cylinder body is characterised in that the complementary engaging surfaces are relatively slightly tapered and of such diameter as to provide a relative interference fit giving a pressure gradient.

Obviously, either the bore of the housing or the outer periphery of the liner itself may be cylindrical or both parts may be tapered either in the same or opposite directions the essential feature being the relativity of the shape of the parts to provide the slight relative taper for giving the pressure gradient. The tapering may be such that for example the line is either barrel or waisted shape for fitting a cylindrical bore in the housing. The finish of the complementary engaging faces may be relatively different, for example the exterior surface of a cylinder liner may be rough ground or the bore of the housing or the outer periphery of the liner may be finished to provide slight surface undulation and where both parts have such undulations they may cross relatively when in position.

In the drawings accompanying the Provisional Specification No. 555/42:—

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 a 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 *e*.

In all forms shown herein, the internal bore of the cylinder body is originally 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 lnies, 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.

Although described above with particular reference to the liner for a cylinder of an internal combustion engine the drawings are clearly diagrammatic and may be taken equally as illustrative of the application of the invention to journal bearings of any kind, such as for big end bearings. Also, as already indicated at the beginning of this Specification the invention is not necessarily limited as regards the relative differences of co-expansion of the metals, which may, and probably will in some cases be the reverse of those described for a cylinder liner.

The invention is obviously not limited to all the details of the examples above described. For example 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. The same of course obtains as regards the application of the invention to preformed housings and liners other than cylinder liners of the internal combustion engines and the like. The liner may be of bi-metal construction of which one may be the same metal as the housing.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. The method of securing a preformed liner in a preformed housing 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.

2. The method of securing a liner in a housing according to Claim 1, including the further step wherein the liner is assembled in the housing by creating a temporary substantial difference of temperature such that the said interference fit is temporarily removed.

3. The method of securing a liner in a housing according to Claim 1 or 2, including the further step wherein the exterior surface of the liner and/or the internal surface of the housing is or are also finished to provide slight relative surface undulations.

4. The combination of a preformed liner and preformed housing characterised in that the liner and housing are preformed 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.

5. The combination according to Claim 4 further characterised in that the liner is of a metal having a relatively lower coefficient of expansion than the metal of the housing.

6. The combination of a liner and a housing according to Claim 4 or 5, further characterised in that the liner is slightly tapered to a barrel or waisted shape, whilst the bore of the housing is cylindrical.

7. The combination of a liner and a housing according to Claim 4 or 5, further characterised in that the housing is slightly tapered to a barrel or waisted shape, whilst the liner is cylindrical.

8. The combination of a liner and a housing according to Claim 4 or 5, further characterised in that the liner and the bore of the housing are both tapered.

9. The combination of a liner and a housing according to Claims 4, 5, 6, 7 or 8, further characterised in that the exterior surface of the liner is rough ground to provide slight surface undulation.

10. The combination of a liner and housing according to any of the preceding Claims 4, 5, 6, 7, 8 or 9, further characterised in that the housing bore is machine finished to give a smooth surface with slight undulations.

11. The combination according to Claim 9 and 10 combined, further characterised in that the undulations in the cylinder body bore cross with those on the surface of the liner.

12. The combination of a housing and liner constructed and arranged substantially as herein described with reference to and as illustrated in any of the several figures of the accompanying drawings.

13. The combination of a cylinder liner in a cylinder body characterised according to any of the preceding Claims 4 to 12.

14. The combination of a bearing liner

in a housing, characterised according to any of the preceding Claims 4 to 12.

15. The method according to any of the preceding Claims 1 to 3 wherein also a thin layer of another metal is applied to the complementary engaging face of either or both parts, before their engagement.

16. The combination according to any of the preceding Claims 4 to 14, further characterised by a thin layer of a different metal applied to either or both the complementary engaging surfaces before their engagement.

17. The combination of housing and liner for the cylinder of an internal combustion engine or the like or a journal bearing, constructed substantially as herein described with reference to and as illustrated in the several figures of the drawings accompanying the Provisional Specification No. 555/42.

Dated this 11th day of February, 1943.

For the Applicants:
WILSON, GUNN & ELLIS,
Chartered Patent Agents,
54/56, Market Street, Manchester, 1.

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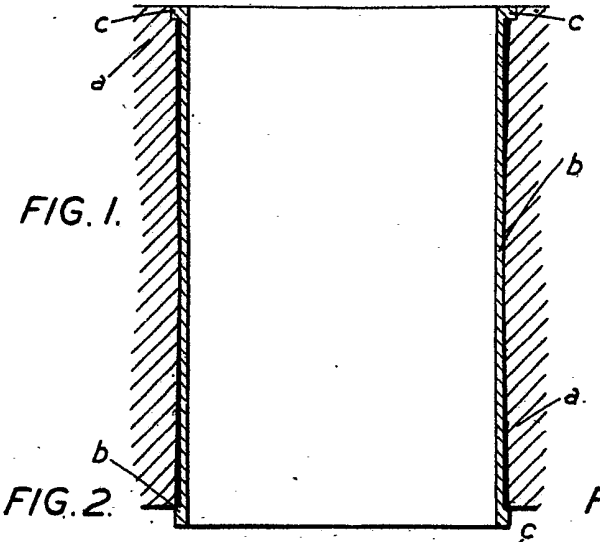


FIG. 1.

FIG. 2.

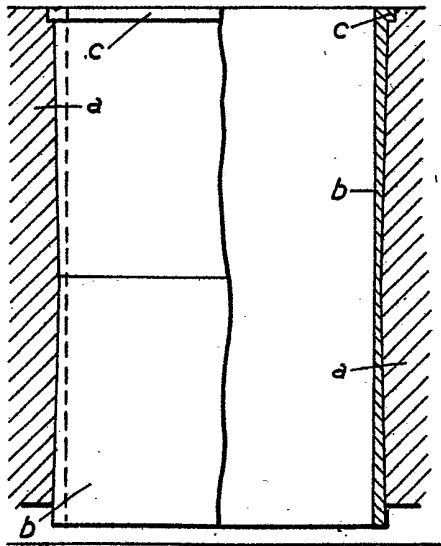
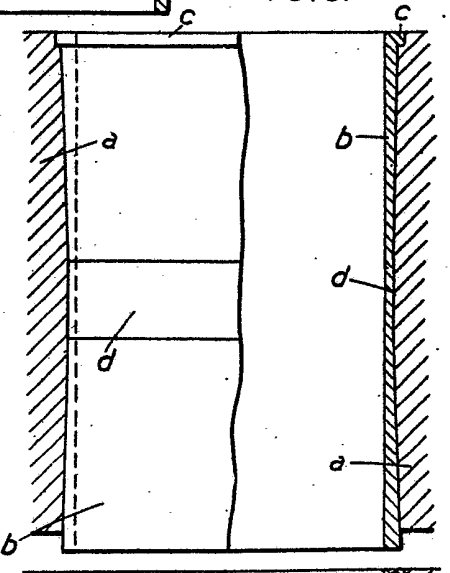


FIG. 3.



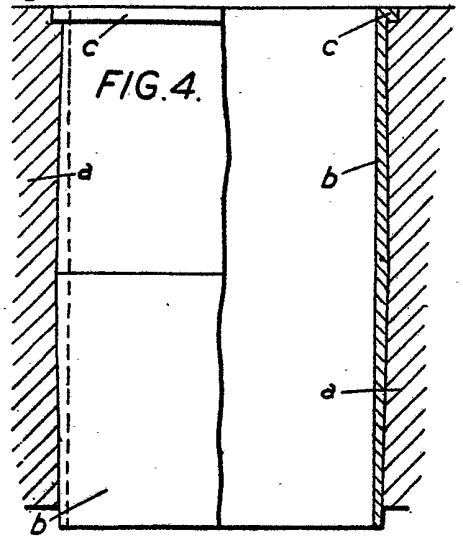


FIG. 4.

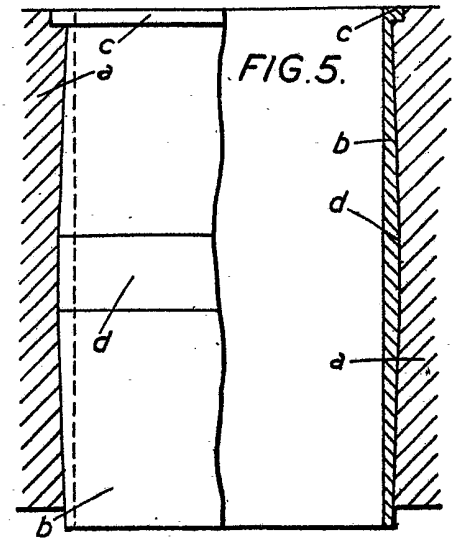


FIG. 5.

M.M.P. Ltd.