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H. FORD
CYLINDER LINER
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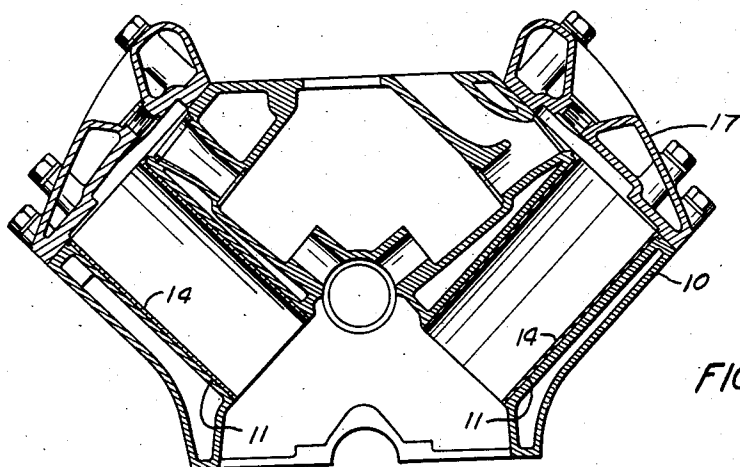


FIG. 1

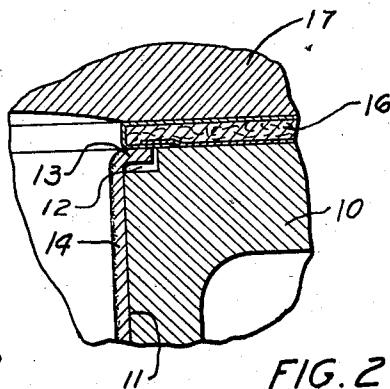


FIG. 2

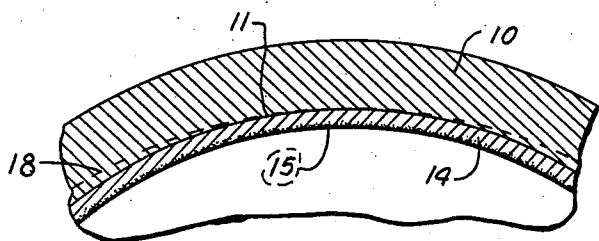


FIG. 3

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CYLINDER LINER

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Application March 27, 1939, Serial No. 264,315

4 Claims. (Cl. 309—3)

This invention relates to cylinder liners and has for its object to provide a new and improved construction of a liner or shell particularly adapted for, but not limited to, use in the cylinders of an internal combustion engine.

Many proposals have heretofore been made to provide the cylinders of an internal combustion engine block with liners, or sleeves, of different metals or compositions, that would give better and longer wearing surfaces than the cast iron material usually employed for the fabrication of such cylinder blocks, but to date no form of cylinder liner has gone into extensive commercial use although the advantages of this type of cylinder construction have long been recognized.

The principal reason why the lined cylinder type of construction has not gone into more general use is apparently because heretofore the problem of providing a liner that would function efficiently yet be capable of manufacture at a low production cost, had not been satisfactorily solved. Therefore lined cylinders have been found only in higher priced engines. One of the major difficulties encountered is that of cooling the liner, or insuring uniform heat transfer between the liner and the surrounding cylinder walls. Simply expressed, a solution of this difficulty involves but one condition,—an intimate contact between cylinder wall and liner along the entire area of their mating surfaces. If this contact is not maintained in any localized area, an insulating air space will be formed or exist between the liner and cylinder block; heat transfer will be retarded, and the liner will develop a hot spot at that point which will not only produce very unsatisfactory operating conditions within the cylinder, but which may possibly result in the destruction of the liner. The general types of construction that have been used in the past to obtain the required degree of heat transfer relationship between cylinder wall and liner, are a water jacketed liner or, as it is termed, a "wet sleeve" construction, and a tight press fitted liner. Of these the press fit type is perhaps the simplest and the improved liner of the present invention falls generally within this category.

However, where former press fitted liners have relied solely upon the overlapping in dimensions between the outside diameter of the liner and the diameter of the cylinder to provide a tight press fit and thereby attain the required intimacy of contact, the liner of the present invention depends principally upon the characteristics of the metal of which it is constructed and the

heat treatment of this metal before insertion within the cylinder to achieve the desired result. The principal objection to former press fitted liners aside from their high initial cost of production is that they have not been capable of retaining the required snug relationship between the outer surface area of the liner and the cylinder walls over a long period of engine operation, and this is due to the fact that operation of an engine causes appreciable general and localized distortional effects upon its cylinder walls. Bell mouth, or increase in diameter, takes place at the head ends of the cylinders because of the high combustion temperatures and pressures developed in that region, while temperature differentials, unevenly tightened cylinder heads, etc., have other distortional effects and therefore the liner to be effective must either be of sufficient cross sectional wall thickness to resist the localized effects or of such a nature as to be capable of following the changing contours of the cylinder walls. Such pliability to be effective, must be an inherent property of the liner alone so that the liner will not be materially influenced by the manner in which it is fitted within the cylinder. Apparently the necessity for the liner being inherently pliable had not heretofore either been fully appreciated or it had not been thought to be possible of achievement with available methods of heat treatment.

The principal object of the present invention is to provide a new and improved construction of a cylinder liner or shell which will have sufficient flexibility to be capable of automatically adjusting itself, not only to any inequalities due to machining inaccuracies between the cylinder bore and liner as the latter is pressed into the block, but also to any subsequent changes in contour of the cylinder bore during the operation of the engine.

Another object is to construct a cylinder liner or shell of a low carbon steel of high ductility capable of being fabricated from a flat blank of sheet steel by the well known relatively low cost drawing operations into a finished tubular sleeve or liner of the requisite accuracy of finished size without necessitating any of the more costly machining operations.

A further object is to provide a liner or shell construction for cylinders which when inserted into the cylinder block will be securely retained therein against accidental longitudinal movement but which may be readily removed from the block for replacement.

Another object is to provide a cylinder liner

or shell in which the inner wearing surface is subjected to a hardening process to secure a hardened corrosion resistant surface or skin, the penetration of which is of a limited extent while the outer peripheral surface and the major part of the cross sectional thickness of the liner wall will remain unhardened.

A further object is to provide the outer peripheral wall thereof with a corrosion resistant coating such as a tin, or chromium plating which in turn has three main purposes; namely to prevent destructive oxidizing effects after the liner has been placed in position and during operation of the engine, to serve to form a protective coating to limit the penetration of the hardening effects to the inner wearing surface of the liner and the cross section of the wall immediately adjacent thereto, and to form a film which will aid in providing and maintaining intimate contact between the surface of the liner and the cylinder wall and thus insure that said surfaces will be kept in the required degree of heat transfer relationship throughout the period of operation of the engine.

A still further object of this invention is to improve upon the construction disclosed in my application, Serial No. 212,724, filed June 9, 1938, of which this application, is, as to certain features, a continuation in part.

The above and other objects of the invention will appear more fully from the following more detailed description and by reference to the accompanying drawing in which

Fig. 1 shows a vertical section through a V-type of motor, showing the improved liner inserted in place within the cylinder block;

Fig. 2 is an enlarged sectional detail showing the interengagement between the cylinder liner and block to prevent longitudinal displacement of the liner, and

Fig. 3 is an enlarged horizontal sectional view through a portion of the liner and cylinder block and showing on an enlarged and somewhat distorted scale the manner in which the flexibility of the liner permits it to conform to any inequalities in the cylinder block.

As shown in the drawing the numeral 10 indicates the cylinder block of a V-type motor provided with cylinder bores 11, the upper end of each bore being countersunk to provide a recess 12 to accommodate a horizontally outwardly projecting flange 13 of the liner 14. Although the liner is shown as inserted in the cylinder bores of a V-type combustion engine, it will be understood that the invention is not limited to any particular type of engine, but that it is equally applicable for use in any case where it is desired to line a cylinder with a more wear and corrosive resistant surface than provided by the metal of which the cylinder is constructed.

The liner is preferably constructed as a tubular shell drawn from flat stock of from three and one half to six hundredths of an inch in thickness, preferably of sufficient ductility to be drawn by well known drawing operations into the desired tubular shape and size and of low carbon steel containing, for example, not over 0.10% carbon. Steel of such a low carbon content is ordinarily incapable of being case hardened or nitrided in a short time by the usual methods heretofore employed. It has been found, however, after extensive experiment, that a surface hardening of such steels may be effected to produce an extremely hard corrosion resistant skin which provides a highly efficient wear resistant

surface, and also that the penetration of the hardening may be limited to but a few thousandths of an inch, thereby retaining in the remainder of the cross-sectional thickness of the material all of the physical properties of low carbon steels. This hardening process, which forms no part of the present invention but is made the basis of a separate application, is effected by applying a coating of a strong alkali such as sodium carbonate, to first passivate the surface to be hardened and immediately thereafter placing the liner in a furnace where it is subjected to a temperature of 1250° F. to 1400° F. in an atmosphere of ammonia gas and carbon monoxide NH₃ and CO. After the liners are subjected to this heating process they are then air cooled in a reducing atmosphere down to a temperature of about 400° F. Before subjecting the liner to the nitriding treatment however, the outer peripheral surface thereof is given a plating of tin, chromium or other material which is resistant to nitrogen penetration, in order to prevent nitriding thereof and consequent growth.

As a result of the above treatment the liner is provided with a hardened inner skin which is indicated by the reference character 15 in Fig. 3. Since the outer surface is plated with either tin or chromium before the nitriding takes place, the remainder of the cross-sectional thickness of the wall of the liner has the well known soft and ductile properties of low carbon steel. After the liner has been hardened and cooled, as above described, it may then be inserted into the cylinder block. The cylinder bores provided in the cylinder block are approximately one thousandth of an inch smaller in diameter for a bore of 3½ inches than the outer diameter of the liner, and the liner is press fitted into the cylinder bore. Due to the fact that the cross-sectional thickness of the wall of the liner is exceedingly thin and as the soft ductile properties of a low carbon steel is maintained in nearly the entire cross-sectional thickness of the liner wall except for the relatively thin case hardened inner surface which extends only to a depth of approximately six thousandth of an inch, the liner has such flexibility to be automatically self-conforming to any slight inequalities or inaccuracies resulting from the machining or subsequent distortion of the bore of the cylinder. It is desirable to machine the bore with a fairly high grade of accuracy and to maintain dimensions within a tolerance of one thousandth of an inch so that any warping of the liner to adjust itself to inaccuracies will not exceed a maximum of one-half thousandth of an inch. As the liner is but slightly larger in diameter than the bore of the cylinder in which it is to be inserted, no great amount of pressure is required to force it into the cylinder bore to a point where the upper surface of the horizontal flange 13 at the top end of the liner lies in the same plane with the surrounding surface of the cylinder block. After the liner has been inserted into position it is then lapped to the exact finished dimension, leaving a case hardened skin of about two and one-half thousandths of an inch in thickness to provide a wearing surface. Because of the fact that the liner is but a very slight amount over size and is forced into the cylinder bore with but a relatively small amount of pressure, no difficulty is experienced in removing a liner should it become necessary or desirable to do so, and replacing the same with a new liner.

It will be noted by referring to Fig. 2 of the

drawing that the cylinder gasket 16 is so proportioned as to extend over and cover most of the horizontal flange 13 of the liner, thereby sealing any possible annular space that may exist between the liner and the cylinder block from the combustion chamber and after the cylinder head 17 is attached to the cylinder block, the liner is firmly held against movement longitudinally of the bore by the inter-locking engagement of the flange 13 between the shoulder 12 and gasket 16.

I have indicated in Fig. 3, by the dotted line showing, the manner in which the flexibility of the liner permits it to adjust itself to any inequalities of the bore, the dotted line 18 being intended to depict, in a greatly exaggerated degree, the normal cylindrical form of the liner and the full line showing being intended to represent a departure from the true cylindrical form that might possibly occur due to inaccuracies in machining operations. It is to be understood, however, that it is necessary to keep the machining of the parts within fairly close limits so that when the liner is lapped, the amount of material removed will not be so great as to go below the case hardened inner skin or surface. Due to the fact that the liners are not heated to a very high temperature to perform the hardening of the inner skin thereof, no measurable or appreciable distortion of the liner results from the hardening process, and as the dimensions of the liner may be held within great accuracy in fabricating the same by a drawing operation, the liner may be produced in large quantities by mass production methods and held within very close tolerance while at the same time the production costs are kept to a minimum.

By the use of the present invention it now becomes possible to provide an internal combustion engine for automobiles or other uses in which all of the surfaces subjected to wear may be readily replaced whenever it becomes necessary so to do and consequently the cylinder block which is one of the most expensive parts of such engines may be used practically indefinitely as all of the other parts of the motor such as valve seats, bearings, pistons, connecting rods, etc., have for some years been made detachable from the block for replacement or servicing.

In addition to providing a cylinder wall surface which is more resistant to the frictional wear produced by movement of the piston, the liner of the present invention also affords marked protection against deterioration caused by corrosion, which frequently is a greater contributing factor in causing cylinder and bore failure than frictional wear thereof. As a nitriding process in addition to producing a more wear resistant surface also produces a surface which has very high corrosion resisting properties, the liner of the present invention has its entire exposed surface made more corrosive resistant by the nitriding of the inner wall and the plating of the outer wall. The use of a cylinder wall surface having the above properties, has another important advantage from the standpoint of engine operation in that it permits greater control over oil consumption, since increased pressure between the piston rings and the cylinder wall surface becomes possible owing to the improved wearing qualities of the latter, and thus the seal between the combustion chamber and the crank case is more positive.

The high inherent flexibility and ductility of the liner of the present invention is also a distinct advance over prior constructions as these

properties permit repeated distortions of localized areas of the liner without cracking or failure of the material, which would not be possible with the cast iron liners heretofore used. These localized distortions of the present liner, as for example, in compensating for bell mouth, are to be distinguished from an overall change of shape to compensate for out of roundness. The relatively thick walled cast iron liners of the prior art were capable of such overall distortions to a limited extent but were incapable of any increase of their area to compensate for localized distortions.

Moreover, it has been found that the thin film of plating given to the outer surface of the liner possesses to a certain degree flowing or conforming properties independent of any actual change of contour in the material of the liner itself, and thus this film is capable of eliminating any possible minute spaces between the liner and the cylinder wall due to minor machining imperfections or small distortional effects which would otherwise not be material enough to cause a change in contour of the liner. This property of the outer surface plating when added to the aforesaid properties of the liner proper results in a complete structure having the inherent capacity to cling to the cylinder wall thruout any distortions found in normal engine construction and operation, and as previously stated, this is the principle requirement for satisfactory lined cylinders of any type.

While I have shown and described a construction of a liner which has proved highly satisfactory in actual practice, it will be understood that many variations, changes and modifications may be resorted to without departing from the principle of the invention.

I claim:

1. The combination with a cylinder of a preformed replaceable one-piece cylindrical liner constructed of low carbon steel and having an extremely thin uninterrupted side wall, said liner being pressed into a bore of said cylinder, the inner surface of said liner being nitrided to produce a wear-resistant surface of great hardness, the major portion of the radial thickness of said liner being left unhardened so that said liner retains such flexibility as to be automatically self-conforming to any slight inequalities existing between the outer periphery of said liner and the bore of said cylinder, and a film of metal forming the exterior surface of said liner, said film being of less hardness than said inner surface and being sufficiently soft to establish an intimate contact for heat transfer from the exterior surface of said liner to the adjacent surface of said bore.

2. A liner for use in an internal combustion engine cylinder comprising a one-piece preformed circumferentially continuous cylindrical shell of low carbon sheet steel of extremely thin cross-section, the inner surface of said shell being nitrided to provide a hard wear-surface, the depth of penetration of said nitriding being limited to but a minor portion of the radial thickness of said shell and the remaining portion of said radial thickness having preserved therein the inherent flexing qualities of said low carbon steel so that said shell can readily flex to conform to slight inequalities of a cylinder bore when inserted therein, and a layer of relatively soft metal on the outer peripheral surface of said shell adapted to provide intimate contact of the

shell with the wall of the bore of said cylinder when said shell is pressed into said bore.

3. A liner for use in an internal combustion engine cylinder comprising, a one-piece, pre-formed circumferentially continuous cylindrical shell of low carbon sheet steel having a radial thickness of approximately three and one-half to six hundredths of an inch, the inner surface of said shell being nitrided to provide a hard wear-surface, the depth of penetration of said nitriding being limited to but a minor portion of the radial thickness of said shell and the remaining portion of said radial thickness having preserved therein the inherent flexing qualities of said low carbon steel so that said shell can readily flex to conform to slight inequalities of a cylinder bore when inserted therein, and a layer of metal on the outer peripheral surface of said shell adapted to provide intimate contact

of the shell with the wall of the bore of said cylinder when said shell is pressed into said bore.

4. A liner for use in an internal combustion engine cylinder comprising, a drawn low carbon steel cylindrical shell having an uninterrupted side wall of a radial thickness of approximately three and one-half to six hundredths of an inch, the inner surface of said shell being nitrided to provide a hard wear-surface, the depth of penetration of said nitriding not being in excess of approximately six thousandths of an inch so that said shell can readily flex to conform to slight inequalities of a cylinder bore without cracking when inserted into said bore, and a layer of metal on the outer peripheral surface of said shell adapted to assure intimate contact of the shell with the wall of the bore of said cylinder when said shell is pressed therein.

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