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R. M. HEINTZ

1,955,292

METHOD OF MAKING ENGINE CYLINDERS

Filed May 27, 1933

Fig. 3.

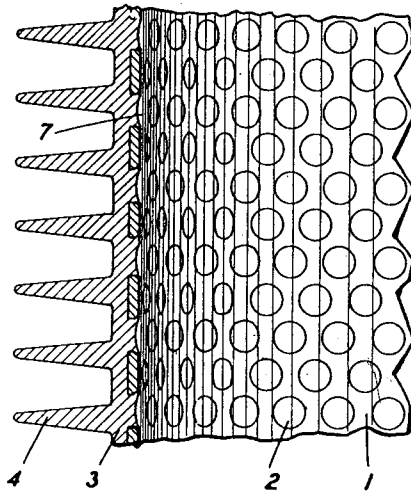


Fig. 2.

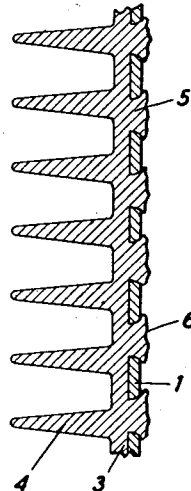


Fig. 7.

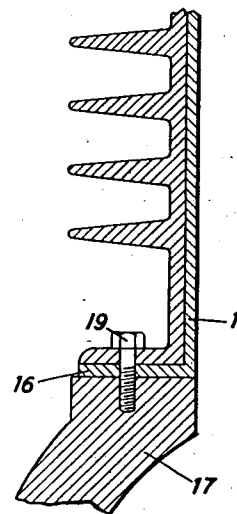


Fig. 4.

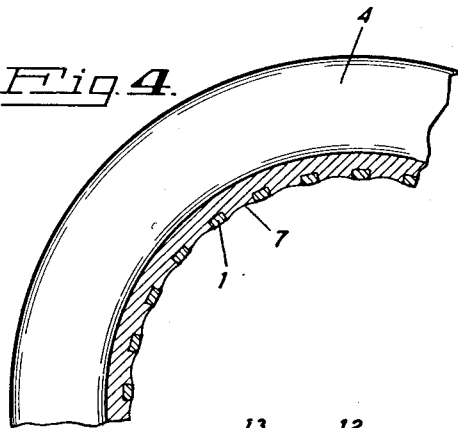


Fig. 1.

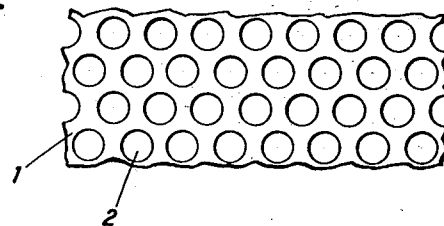


Fig. 5.

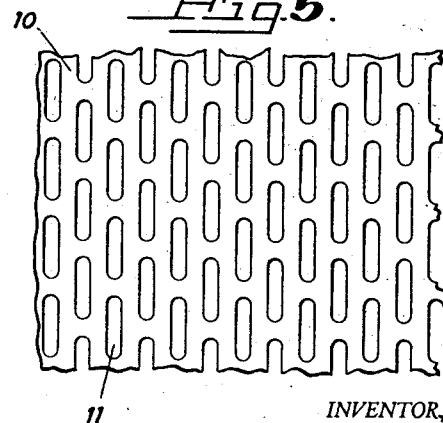
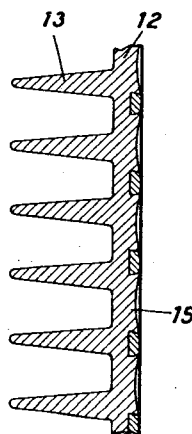


Fig. 6.



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1,955,292

METHOD OF MAKING ENGINE CYLINDERS

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6 Claims. (Cl. 29—156.4)

My invention relates to engine cylinders, and particularly to a method of making lined cylinders for air-cooled internal combustion engines, this application being a continuation in part of my prior application, Serial Number 511,280, filed January 26, 1931, for a Cylinder liner.

Among the objects of my invention are: First, to provide a cylinder liner which will resist wear indefinitely; second, to provide a cylinder liner which is in intimate thermal contact with the body of the cylinder, and which will transfer heat rapidly to the cylinder wall; third, to provide a cylinder liner which will retain lubricants and thus minimize scoring either of the cylinder or of the piston which works within it; fourth, to provide a cylinder liner which will make practical the use of aluminum or aluminum alloy cylinders on engines of relatively large size; fifth, to provide a method of combining a cylinder liner with a cylinder body, having a different coefficient of thermal expansion than the liner, in such a manner that the different rates of expansion of the liner and the cylinder do not affect the heat transfer from liner to cylinder; sixth, to provide a cylinder liner which will expand circumferentially to a greater degree than its apparent coefficient of expansion would predicate; and seventh, to provide a liner of the character described which can be manufactured on an economical basis.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing:

Figure 1 is a fragmentary elevational view of one form of the liner of my invention.

Figure 2 is a vertical sectional view of a portion of a cylinder and liner of my invention, showing the method of assembly.

Figure 3 is a sectional elevation, illustrating the liner in final assembly with the cylinder.

Figure 4 is a sectional view taken in a plane indicated by the line 4—4 of Figure 3.

Figure 5 is a fragmentary elevational view of another form of the liner of my invention.

Figure 6 is a vertical sectional view illustrating the liner of Figure 5 in final assembly with a cylinder.

Figure 7 is a vertical sectional view of a portion of an assembled cylinder and liner of my invention, showing the relationship of the liner and the outer wall at the base, or attachment end of the cylinder.

In an internal combustion engine, particularly in one of the air-cooled type, the material of which the cylinder is constructed should have a hard wear-resisting bearing surface to withstand the friction of the piston. This surface should be readily wetted by the lubricant used, and it should be either integral with the body of the cylinder, or should be in such intimate thermal contact therewith in order to transfer heat rapidly through the cylinder wall and into the air. The cylinder wall, moreover, should be of highly thermal conductive material, in order to facilitate the heat transfer. In engines for automotive and aircraft use, the cylinders should be as light as it is possible to make them and still maintain the necessary strength.

It is almost impossible for cylinders composed of any single metal or alloy to meet these requirements. Aluminum, which has a comparatively high degree of thermal conductivity, does not offer a satisfactory wearing surface, although it is readily wetted by the oil. Cast iron, which is very largely used for the purpose, is deficient in thermal conductivity, and is heavy, but it is easily cast and machined, and presents a wearing surface which is fairly durable. Steel, which can be made to have the hardest possible wearing surface, is oil repellent, of low thermal conductivity, and is difficult and expensive to machine.

When attempts are made to combine materials new difficulties arise. In cylinders of small sizes, cast iron or steel liners have been used within aluminum cylinders. The coefficient of expansion of aluminum is, however, greater than that of the ferric material; and as the cylinder expands it draws away from the liner, leaving a gap which prevents a rapid transmission of heat between liner and cylinder. Carbon collects in this gap, usually in finely divided condition, and thus forms an excellent thermal insulator. Excessive heating of the liner results, which causes rapid deterioration of the lubricant, further frictional heating, and scoring of the cylinder, so that the trouble is cumulative and the cylinder fails. This difficulty is ordinarily exaggerated where steel liners are used, since the oil repellent property of a hard steel surface causes less satisfactory lubrication and greater heating of the cylinder. The trouble may be partly overcome by using cast iron liners and cylinder walls which are stretched almost to the elastic limit when the engine is cold, but this is only effective in cylinders of very small diameter.

Broadly considered, this invention comprises

a liner which is preferably of metal having an extremely hard wearing surface; such as "nitroloy", which is a steel that is nitrided and heat treated to provide an extremely hard wearing surface. Before heat treatment the liner is punched or otherwise perforated, the size and spacing of the perforations preferably being such that approximately one-half of the area of the liner is removed. The cylinder body or jacket is cast about the liner, an aluminum alloy which has a relatively low coefficient of expansion preferably being used, although the coefficient of expansion of the jacket is still greater than that of the liner. This forms a cylinder wall having projections or studs which penetrate the perforations of the liner. In the preferred method of manufacture, the projecting ends of these studs are swaged or riveted so that the studs are upset and form intimate thermal contact with the edges of the holes. The interior of the cylinder is then surfaced, preferably by grinding; and the soft material of the cylinder body cuts away more rapidly than that of the hardened steel liner, leaving the heads of the studs depressed 1/1000th of an inch beneath the wearing surface of the liner.

When the cylinder is in use, the lubricant, although repelled somewhat by the surface of the liner, adheres strongly to the surface of the minute pits formed by the ends of the studs, thus maintaining an oil seal which keeps the cylinder wall lubricated and prevents deterioration from this cause. As the cylinder heats, tending to form a gap between the liner and the cylinder body, the studs themselves expand, so that the thermal contact between the edges of the perforations and the studs becomes better to thus compensate for conditions when contact between the surface of the liner and the surface of the cylinder body becomes worse. The high thermal conductivity between the liner and the cylinder is thus maintained. "Nitroloy" is the preferred material for the liner, first, because it is one of the hardest materials now known, and second, because it maintains the hardness (due to its nitriding and heat treatment) up to the melting temperature of aluminum or any of the alloys thereof which may be used for cylinder body. Cast iron, bronze, or other satisfactory wearing materials, may be substituted for the "nitroloy" without departing from the spirit of this invention.

Describing in detail the preferred method of construction of cylinders embodying this invention, a sheet 1 of "nitroloy" or equivalent material which has, or may be treated to have a hard wearing surface, is formed, in any suitable manner, with holes or perforations, as shown in Figure 1. The holes or perforations 2 are preferably arranged in staggered rows as shown, the size of the perforations being preferably such that the diameter of the holes is approximately four times the thickness of the sheet of material; and the holes being so spaced that their area is approximately the same as that of the surface formed by the material of the sheet. These dimensions are only approximate, since they may be departed from widely without materially affecting the efficacy of the completed cylinder.

The holes are preferably punched, since this operation is not only much less expensive than drilling, but also produces holes which are very slightly conical in form, the orifice on the side of the sheet where the punch is entered being slightly rounded at the edges and also a very

little larger than the orifice on the opposite side of the plate.

The sheet of material thus formed is bent into a cylindrical shape, and the edges welded, the side of the sheet at which the punches entered being on the side of the cylinder. The liner thus formed is then subjected to appropriate nitriding and heat treatment, which with the alloy specified, provides it with a surface which is nearly as hard as sapphire.

Next, the liner is placed in a mold, and is preferably filled with a soft or green sand core, and the cylinder jacket is then cast around it. This jacket comprises a cylindrical body 3, preferably having cooling fins 4 projecting from the body. In the casting process, short studs of metal 5 penetrate the perforations, forcing their way slightly into the soft core to form small mushroom heads 6.

The material used for the cylinder body is preferably one of the aluminum alloys having a somewhat lower coefficient of expansion than the ordinary grades of cast aluminum, although this is not absolutely essential.

It is characteristic of the nitroloy liner, when properly heat treated, that it maintains its hardness even at the melting temperature or aluminum or of the alloys used.

In spite of the relatively low coefficient of expansion of the alloy body, the studs 5, in cooling, shrink more than does the liner, so that their contacts with the edges of the holes might be impaired. To obviate this, the inner surface of the cylinder is preferably swaged, either by rolling or peening, which upsets the studs and brings them into the necessary intimate thermal contact with the liner.

The inner surface of the cylinder is then ground to form a smooth surface, which removes the mushroom heads 6 from the studs 5; and, since the body material is much softer than that of the liner, the grinding effects slight undercuts of the ends of the studs, as shown, in exaggerated form at 7, Figure 3. In the actual cylinder, the amount of undercutting is seldom as much as 1/1000th of an inch, and is not noticeable upon ordinary or casual inspection of the interior of a cylinder.

As was stated above, a hard steel surface of the character produced upon the liner is oil repellent; therefore maintaining adequate lubrication over a large surface of this kind is difficult. The slight depressions 7 formed in the studs 5 engaging the perforations 2 serve as oil reservoirs, however; and since the aluminum alloy is very readily wetted by the oil, these depressions maintain a supply which is spread over the small intervening steel surface by the motion of the piston and keeps the entire cylinder thoroughly lubricated. Owing to the extreme hardness of the liner, no appreciable wear occurs on the cylinder wall during the entire useful life of the engine, and the aluminum studs being depressed, are not subject to wear. Therefore, insofar as wear is concerned, the cylinder may be considered practically indestructible.

In operating the engine, the cylinder heats up, and its body tends to expand away from the liner in the usual manner. The studs 5, however, expand at the same rate as the cylinder wall, and their contact with the edges of the perforations improves to the same extent that that of the jacket with the outer face of the liner is impaired. With the dimensions given above as preferred, this means that the same

area as before continues in good thermal contact with the liner, and therefore over-heating of the liner, with its consequent disastrous effect, does not occur. Moreover, the ends of the studs, with their great thermal conductivity, are at all times presented to the interior of the cylinder to aid in carrying away excess heat.

Furthermore, owing to the microscopic dimensions of the depression of the ends of the studs below the surface of the liner, and to their readily wettable nature, the oil seal formed between the cylinder wall and the piston is not impaired by these depressions; and as high a degree of compression may be maintained in a cylinder of this character as within a cylinder of ordinary type.

A modified form of the invention is shown in Figures 5 and 6. In this case the sheet 10 from which the liner is formed is perforated with elongated holes 11, which are staggered as before. With elongated holes thus arranged, the perforated sheet is capable of being stretched slightly in a direction perpendicular to the longer axis of the holes. The stretching is, of course, accompanied by a slight enlargement of the holes in the direction of their minor axis.

The sheet 10 is formed and welded in the same manner as already described in connection with the sheet 1, and a jacket 12 having cooling fins 13 is cast thereon as described in the former case. When the temperature of this type of cylinder rises the expansion of the studs 15 not only improves their contact with the edges of the perforations, but also actually spreads the holes 11, expanding the liner and tending to maintain its outer surface in contact with the more rapidly expanding jacket.

The cylinder of this modified form, since its contact with the jacket is maintained not only at the edges of the perforations but also on its outer surface, cools somewhat better than that first described. However, since the holes 11 are longer than the holes 2, it is somewhat more difficult to maintain the oil seal than in the previously described modification. No real trouble has been found in maintaining adequate compression with this form of liner, however; and the two forms of cylinders are believed to be of substantially equal merits, the choice of the form to be used is, therefore, largely a matter of engineering judgment, depending largely upon the size of cylinder, and somewhat, upon the compression ratio of the engine of which the cylinder forms a part.

Referring directly to Figure 7 it will be seen that the liner 1 may be provided with a flange 16 extending outwardly to form a base ring by which the cylinder may be attached to a crank case 17 or other support. Both the outer wall material and the liner may be included between the bolt head 19 and the case, or the liner alone may be used. In either case the strong tough material of the liner carries the strains set up by the explosions. In this way softer materials having higher heat conductivities may be used for the outer portion of the cylinder without detracting from the strength of the completed engine assem-

bly. Pure aluminum may be used for the jackets, which by itself would not be suitable for attachment in high powered engines such as the aircraft radial types, but by including the turned sleeve flange in the junction with the crank case, the composite cylinder will then stand all required stresses.

I claim:

1. In an engine cylinder, the method of maintaining a perforated liner in intimate contact with an enclosing jacket when said cylinder is heated, which comprises fastening said liner to said cylinder by extending the jacket material into the perforations and upsetting said extended jacket material to tightly fit the perforations.

2. In forming an engine cylinder, the method of maintaining a perforated liner in intimate contact with an enclosing jacket having a greater coefficient of expansion than said liner when said cylinder is heated, which comprises fastening said liner to said cylinder by extending hot jacket material into the perforations, and upsetting said extended jacket material to tightly fit the perforations when cold.

3. In forming an engine cylinder, the method of maintaining a perforated liner in intimate contact with an enclosing jacket having a greater coefficient of expansion than said liner when said cylinder is heated, which comprises fastening said liner to said cylinder by extending hot jacket material into the perforations, upsetting said extended jacket material to tightly grip the edges of said perforations when cold, and removing the excess extended material to a point below the inner surface of the liner.

4. The method of maintaining a metallic sheet in intimate contact with a mass of metal having a greater coefficient of expansion than said sheet which comprises perforating said sheet, extending portions of the metallic mass through said perforations, cooling the composite structure to cause the extended portions to shrink away from the edges of said perforations, and upsetting the extended material to tightly fit the perforations when cold.

5. The method of maintaining a metallic sheet in intimate contact with a mass of metal having a greater coefficient of expansion than said sheet which comprises perforating said sheet, extending portions of the metallic mass through said perforations, cooling the composite structure to cause the extended portions to shrink away from the edges of said perforations, upsetting the extended material to tightly fit the perforations when cold, and removing all material extended above the outer surface of said sheet.

6. In an engine cylinder, the method of maintaining a perforated liner in intimate contact with an enclosing jacket when said cylinder is heated which comprises fastening said liner to said cylinder by extending the jacket material through the perforations, upsetting the jacket material to tightly fit the perforations, and removing all jacket material extended beyond the inner surface of said liner.

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