

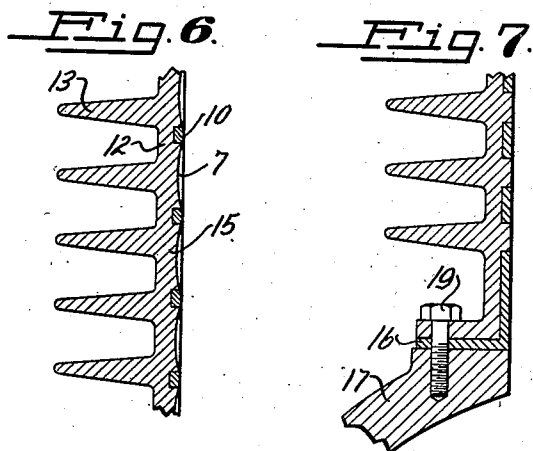
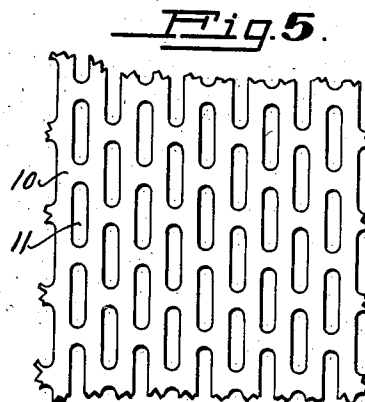
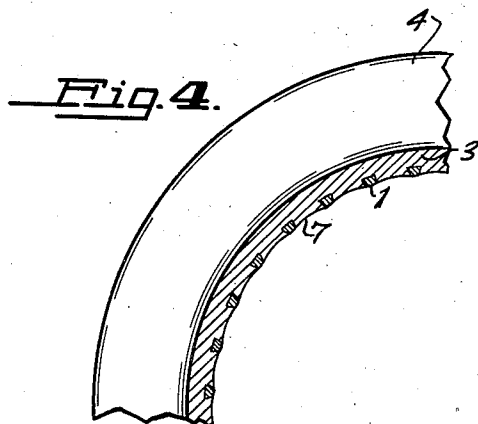
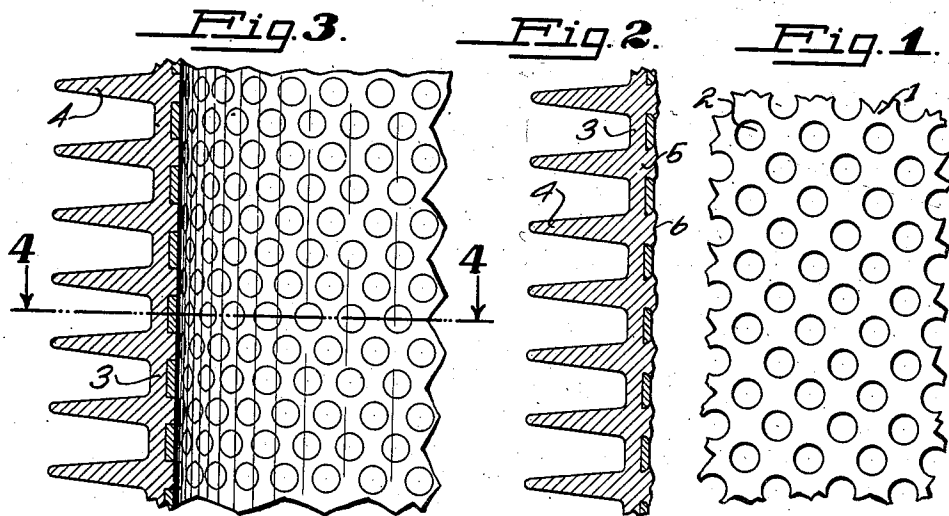
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CYLINDER LINER

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UNITED STATES PATENT OFFICE

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CYLINDER LINER

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Continuation of application Serial No. 511,280,
January 26 1931. This application February
25, 1936, Serial No. 65,639

4 Claims. (Cl. 123—193)

My invention relates to liners for engine cylinders, and particularly to liners for the cylinders of air-cooled internal combustion engines.

This application is a continuation of my prior
5 copending application, Serial No. 511,280, filed
January 26, 1931.

Among the objects of my invention are: First,
to provide a cylinder liner which will resist wear
indefinitely; second, to provide a cylinder liner
10 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
15 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
20 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,
25 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
30 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
35 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
40 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
45 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
50 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
55 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
5 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
10 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 perhaps 1/1,000 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 a 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 inside 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 of 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 1/1,000 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 is cast into a jacket 12 having cooling fins 13 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 18 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 assembly. 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. An engine cylinder comprising a perforated cylindrical liner, the number and arrangement of said perforations being such that the liner is capable of being circumferentially expanded by the application thereto of expansive forces acting thereon, and a jacket having a higher coefficient of thermal expansion than said liner surrounding said liner in contact therewith and having studs thereon extending into said perforations and interlocking therewith to apply said expansive forces to the liner.

2. An engine cylinder of the type adapted for reciprocation of a piston therein, comprising a cylindrical liner having relatively spaced perforations throughout that portion of the areas thereof which provides bearing wall surface for the reciprocation of the piston, said perforations occupying, in any given area of said bearing wall of the liner, substantially the same total area as in any similar given area of said liner, and a jacket encasing said liner and having a relatively higher coefficient of linear expansion than said liner and having studs thereon extending into and fixedly engaging the liner at the edges of said perforations, said studs terminating in a surface microscopically depressed below the inner surface of said liner to form oil pockets.

3. An engine cylinder comprising a cylindrical liner of hard oil-repellent material and having perforations therein, the area of said perforations being substantially equal to the remaining area of said liner, and a body of relatively soft oil-wettable metal having a higher coefficient of thermal expansion than the material of said liner surrounding said liner in intimate contact therewith and extending into said perforations to terminate slightly below the inner surface of said liner.

4. An engine cylinder comprising a cylindrical liner having a relatively low coefficient of thermal expansion having uniformly distributed perforations therein, said perforations being sufficient in number to render said liner circumferentially expansible beyond that due to thermal expansion alone, and a jacket having a relatively high coefficient of thermal expansion surrounding said liner and in intimate contact therewith and projecting into said perforations to form a lock with said liner whereby the inherent expansion of said jacket will expand said liner circumferentially without buckling.

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