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(56) Documents Cited:
DE 000271400 A **JP 020041734 A**
US 6557514 A

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Other: **EPODOC, TXTE, WPI**

(54) Title of the Invention: **Piston**
Abstract Title: **I.c. engine piston cooling gallery**

(57) An internal combustion engine piston comprises a crown portion for compressing fluids within the engine and a skirt portion for supporting side loads exerted on the piston, in use. The crown portion comprises a cooling gallery or channel 18 formed by a number, eg five to twelve, of intersecting straight bores 20a-20h each extending from an outer peripheral surface 22 of the piston into the body of the crown portion. The cooling channel 18 is provided with an inlet 32 and an outlet 34. The bores 20 may be of different diameters and may be unevenly distributed eg for a piston with an off-centre combustion bowl. The longitudinal axes of the bores 20 may be relatively inclined to provide an undulating channel 18. Each bore 20 may have an outer section 24b of greater diameter than the inner section 26b to provide a step 28b for locating a bung 30b preferably made of the same material as the piston, eg aluminium alloy. The outer surface 22 of the piston crown is machined smooth after insertion of the bung. The channel 18 may be honed by abrasive flow machining (AFM).

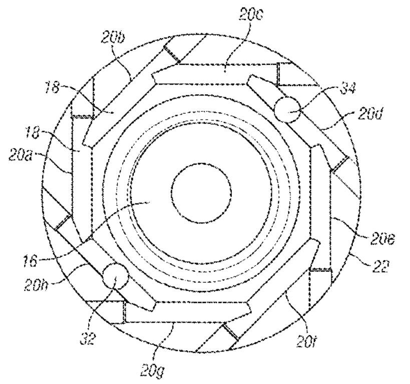

FIG. 3

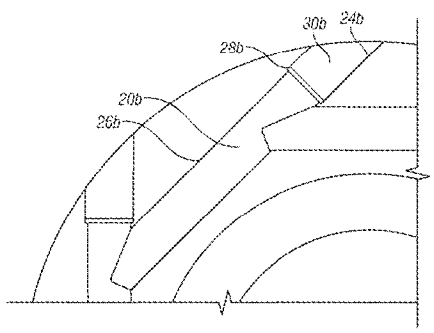

FIG. 4

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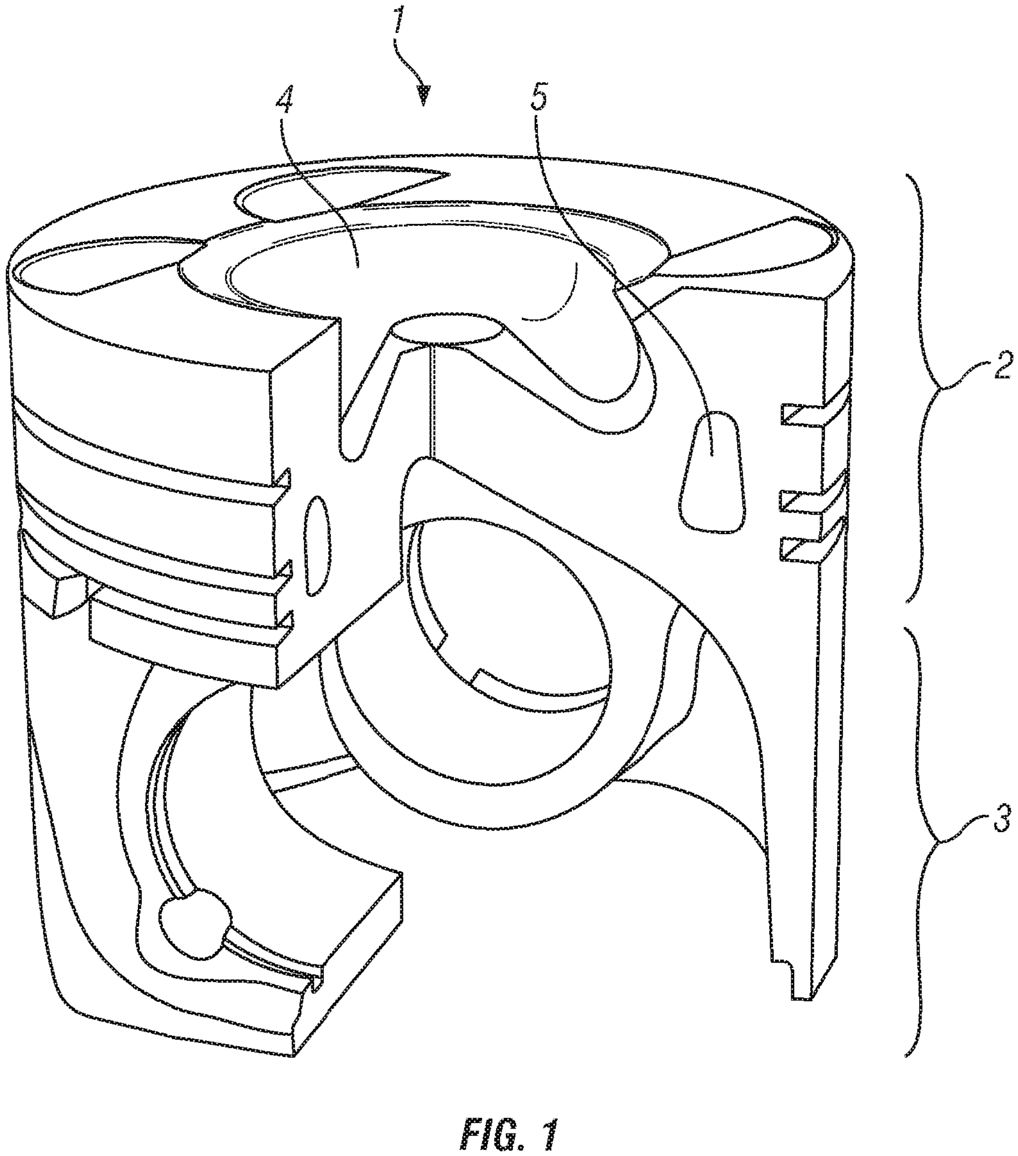

FIG. 1

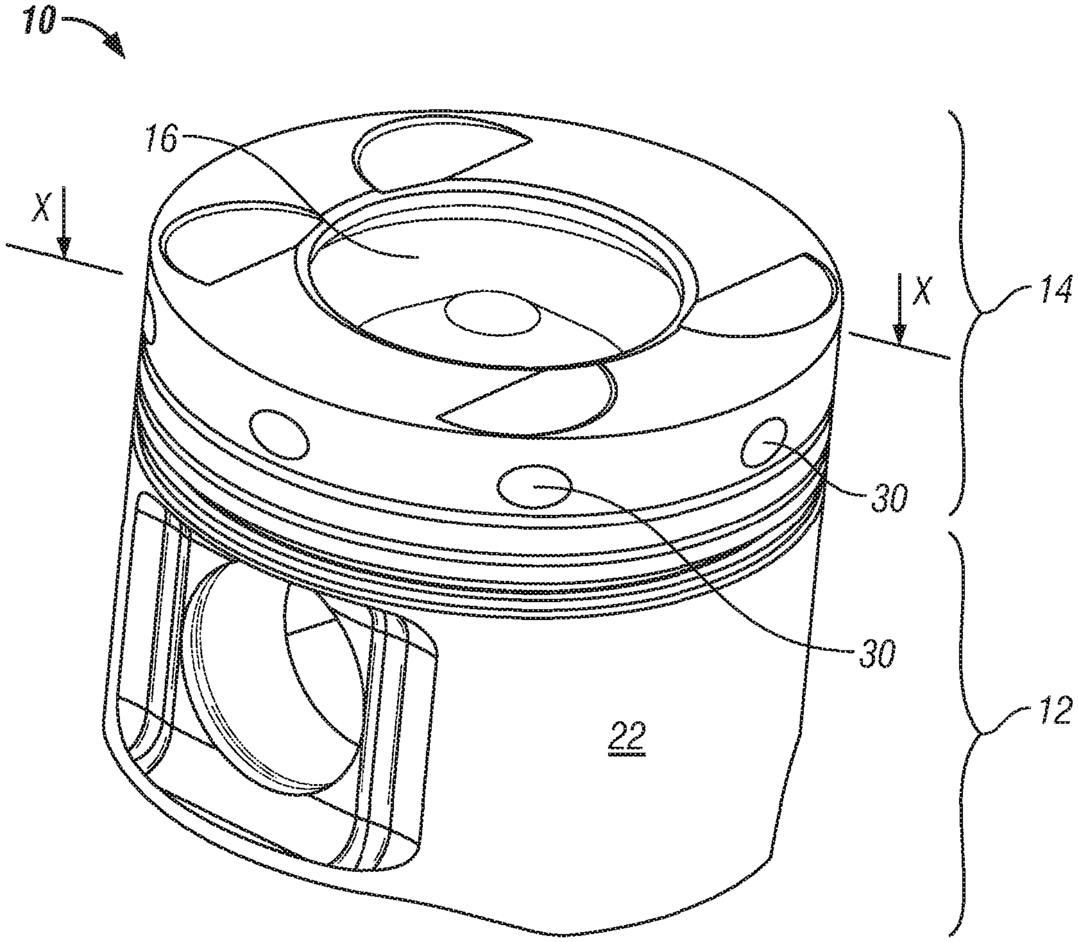

FIG. 2

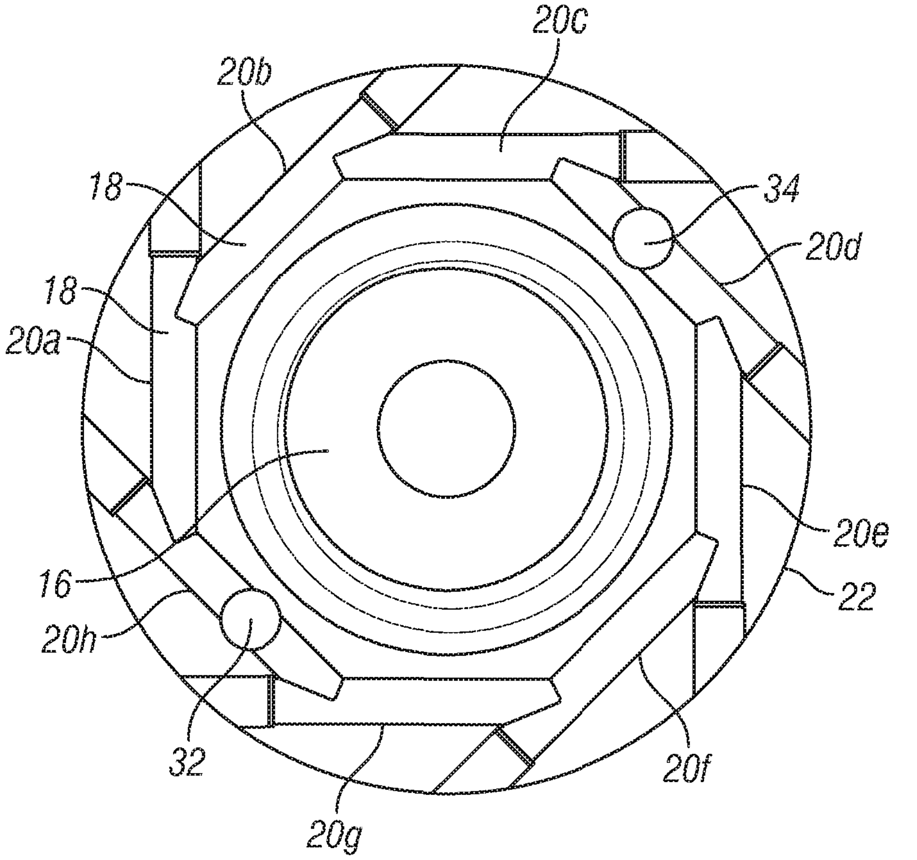
20c
20b
18
34
20d
18
20a
20e
16
22
20h
32
20f
20g

FIG. 3

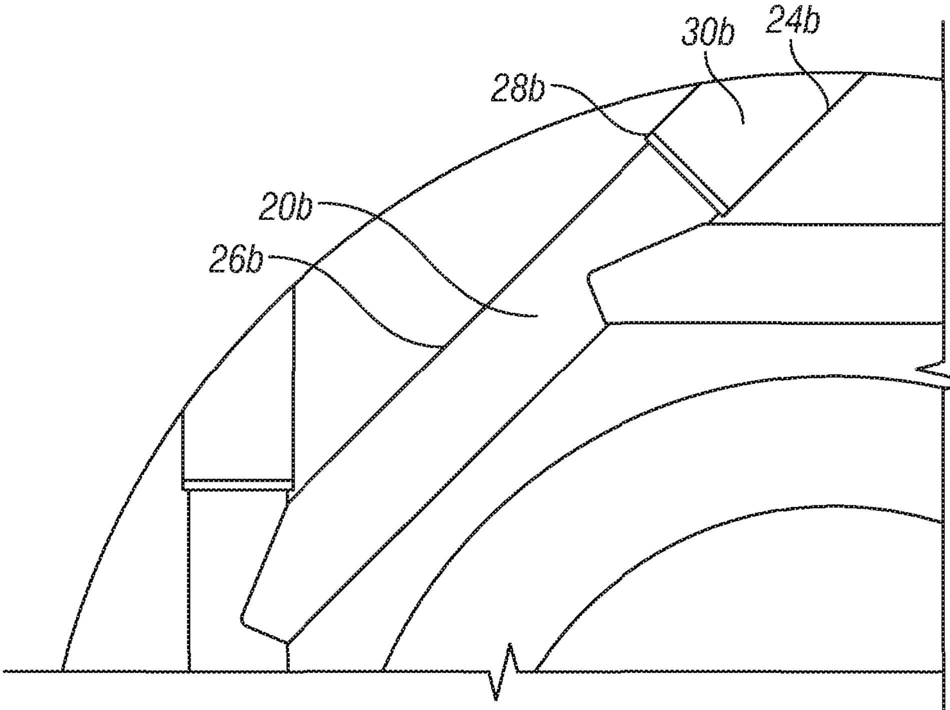
30b
24b
28b
20b
26b

FIG. 4

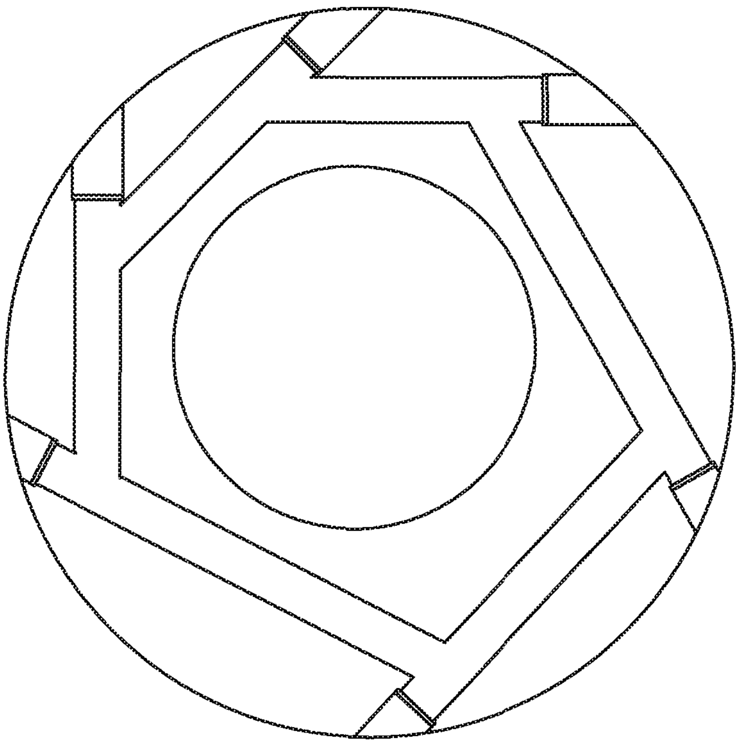

FIG. 5

PISTON

The present invention relates to a piston for an internal combustion engine, in particular to a cooling gallery formed in such a piston.

Improvements in engine performance typically lead to corresponding increases in the thermomechanical loading of components of the internal combustion (IC) engine which ultimately restricts performance and or longevity. There is, therefore, motivation to overcome this limitation by using materials having improved thermomechanical properties, and/or reducing thermomechanical loading of the components by introducing more efficient component cooling.

Figure 1 illustrates a conventional piston for a diesel fuelled internal combustion engine. The piston 1 comprises a crown portion 2 and a skirt portion 3. In particular, in a piston used in a compression ignition (CI) engine of this type, the crown portion 2 generally comprises a combustion bowl 4. The combustion bowl 4 is configured to achieve a particular airflow therewithin such that fuel (say diesel) is efficiently introduced, mixed and combusted therewithin. The presence of the combustion bowl 4 within the crown portion 2 of piston 1 serves to elevate the temperature of the crown portion 2. It is, therefore, desirable to provide a cooling mechanism within the crown portion 2. Such a cooling mechanism may be provided, as illustrated here, by a cooling gallery 5.

Conventionally, the cooling gallery 5 is formed into the crown portion 2 during manufacture of the piston 1, in particular, during the casting process. Thus, materials that can be used to form a piston 1 in this way are limited to those materials which may be cast (e.g. certain aluminium alloys). Many of the stronger materials that would, otherwise, be regarded as appropriate for forming the piston 1 cannot be used in this way.

Wrought materials, such as aluminium alloys 4032 or 2618 are unsuitable for casting. These alloys can be used to manufacture a piston having a cooling gallery 5 but the piston must be formed in two component parts that are joined in the region of the cooling gallery 5. A channel is formed in one, or each, component prior to assembly of the piston. The piston components may be electron beam welded to one another however, this process is expensive. In IC engines of larger vehicles, mechanical joining techniques (e.g. bolts) may be used. However, mechanical joining is also relatively expensive and cannot readily be scaled down for use in engines for smaller, passenger vehicles as they add significant weight to the piston.

It is desirable, to provide a cooling gallery within a piston made from high strength materials in an inexpensive way that avoids impact of the strength of the finished component.

According to a first aspect the present invention provides an internal combustion engine piston comprising:

a crown portion for compressing fluids within the engine; and

a skirt portion for supporting side loads exerted on the piston, in use, the piston being configured to receive a connecting rod of the engine wherein the crown portion comprises a cooling gallery, the cooling gallery comprising a first linear bore, the bore extending from an outer periphery of the crown portion of the piston into a body of the crown portion.

By providing a cooling gallery comprising a linear bore extending from an outer periphery of the piston, the cooling gallery can be formed by a machining process rather than by a casting technique. Consequently, the uncertainties in material properties effected by a casting process can be avoided. Rather, the material properties are more predictable and reliable such that a greater level of performance can be expected. Furthermore, a greater level of accuracy in the geometrical formation of the cooling gallery can be achieved as the variations associated with casting techniques, e.g. due to salt core shifting, can be avoided.

The cooling gallery may comprise a second linear bore extending from an outer periphery of the crown portion of the piston into a body of the crown portion and connecting to the first linear bore to provide fluid communication therebetween. The cooling gallery may comprise a plurality of interconnected linear bores extending from an outer periphery of the crown portion of the piston into a body of the crown portion, at least one bore may be connected to two other bores to provide fluid communication therebetween, the plurality of bores may be located about a central longitudinal axis of the piston.

The, or each, bore may be closed at an external region thereof to thereby define a cavity within the piston. The gallery may comprise an inlet for permitting ingress of cooling fluid and an outlet for permitting egress of cooling fluid.

Each respective bore may be connected to two other bores and, each bore may be closed at an external region thereof to thereby define a substantially toroidal channel within the piston.

A longitudinal axis of each bore may be substantially coplanar to a longitudinal axis of each other respective bore. Alternatively, longitudinal axes of respective adjacent bores may be inclined to one another such that an undulating channel is thereby defined.

The gallery may comprise three or more bores. The number of bores in the gallery may be in the range of five to twelve bores. A dimension of each respective bore, say a diameter thereof, may be configured in dependence on a cooling requirement of the piston.

The internal combustion engine may be configured to use a fuel from the group of diesel, gasoline, liquid petroleum gas (LPG), methane, hydrogen, ethanol, bioethanol and compressed natural gas (CNG).

According to a second aspect, the present invention provides a method of manufacture of a cooling gallery within a piston for an internal combustion engine, the piston comprising a crown portion and a skirt portion, the method comprising the steps of:

drilling a series of linear bores into the piston, each bore extending from an external surface of the piston into a body of the crown portion and being spaced from a longitudinal axis of the piston;

closing each bore to thereby define a cavity within the piston;

forming an inlet in the piston extending to the cavity for permitting ingress of cooling fluid thereto; and

forming an outlet in the piston extending from the cavity for permitting egress of cooling fluid therefrom.

The bores may be reamed after the drilling step, to improve the surface finish thereof. An internal surface of the cavity may be honed to reduce any discontinuity presented therein. The honing step may comprise an abrasive flow machining technique.

An outer periphery of the piston may be machined after the closing step is undertaken.

The present invention will now be described in more detail, by way of example only, in reference to the accompanying drawings, in which:

Figure 1 represents a known piston of an internal combustion engine;

Figure 2 represents an isometric view of a piston having bores formed therein;

Figure 3 represents cross-section of the piston of Figure 2;

Figure 4 represents a detailed view of a portion of Figure 3; and

Figure 5 represents a cross-section of an alternative piston.

Figure 2 illustrates a piston 10 of an internal combustion engine (not shown). Piston 10 comprises a skirt portion 12 configured to receive a gudgeon pin for securing a connecting rod of the internal combustion engine to the piston. A crown portion 14 is connected to the skirt portion 12 and configured to compress air residing in a cylinder within which the piston 10 is located. The crown portion 14 comprises a combustion bowl 16 designed to achieve a particular flow rate of air contained therein and thereby effect efficient combustion upon introduction of a fuel. The material of the crown portion 14 in which the combustion bowl 16 is formed experiences particularly elevated temperatures in operation and so a cooling gallery 18 (see Figure 3) is formed therein.

Figure 3 illustrates a cross section on X-X shown in Figure 2 through the crown portion 12 of the piston 10. Bores 20a, 20b, 20c, 20d, 20e, 20f, 20g, 20h are formed in the crown portion 14 to create a channel 18 located about the combustion bowl 16. Each bore 20 extends from an outer peripheral surface 22 of the piston 10 to intersect with an adjacent bore. Each bore 20a-h interconnects with an adjacent bore 20b-a in this way to define the cooling channel 18.

As illustrated in Figure 4, each bore 20 is preferably provided with a first section 24 adjacent to the peripheral surface 22 of the piston having greater diameter than a second section 26 formed within the piston 10. A step 28 is therefore provided in each bore 20 and serves to locate a bung 30 that is subsequently inserted into an open end of the bore 20.

The bung 30 is preferably made from the same material as that used for the piston 10. Alternative materials (e.g. aluminium alloys) may be used but they, preferably, substantially match the thermal expansion properties of the piston material. Each bung 30, may be retained within a respective bore 20 through friction (e.g. via a threaded interface), adhesion, welding, shrinkage or a combination thereof.

The peripheral surface 22 of the piston 10 is preferably machined after insertion of the bungs 30 such that a smooth outer surface to the piston 10 is provided as shown in Figure 2.

Returning to Figure 2, an inlet 32 to the channel 18 is provided for permitting ingress of a cooling fluid, e.g. oil. An outlet 34 is also provided to permit the egress of the cooling fluid from the channel 18. In this embodiment, the inlet 32 and outlet 34 are diametrically opposed to one another. Consequently, the flow path for the cooling fluid is minimised such that a distinct temperature differential between the piston 10 and the cooling fluid and, therefore, the thermal transfer therebetween is maximised.

In the illustrated embodiment, each bore 20 is provided with approximately the same diameter as each other bore 20 and the bores 20 are evenly distributed about the combustion bowl 16. However, the bores may be provided with different diameters to effect a different level of cooling as required and they may be unevenly distributed as is illustrated in Figure 5. Such a non-uniform configuration is particularly useful where the geometry of the piston is similarly non-uniform e.g. a non-centrally located combustion bowl is used.

Furthermore, in the previous embodiment, eight bores are depicted however as few as three bores can be interconnected to form a channel 18 through which cooling fluid may pass. In practice, the number of bores is likely to be in the range from five to twelve although a larger number may be used. The configuration of the bores shown is roughly octagonal however the even distribution of bores is not necessary. Indeed, it may be desirable to alter the angles and customise the spacing to achieve a particular cooling requirement at different locations about the piston, as exemplified in Figure 5.

A longitudinal axis of each bore may lie in substantially the same plane as that of each other respective bore. Preferably, this plane is a plane substantially parallel to an axial end face of the piston 10. However, the longitudinal axes of progressive bores may be inclined or reclined with respect to one another such that an undulating channel 18 is provided. Preferably, an angle by which the longitudinal axis of each respective bore deviates from the plane parallel to the axial end face of the piston lies within the range of ± 10[redacted]

In a more sophisticated embodiment of the present invention, the channel 18 may be honed using an abrasive flow machining process (such as that developed by Extrude Hone Corporation). Abrasive Flow Machining (AFM) is a very precise and economical method of smoothing and polishing internal surfaces and producing controlled radii. A specially formulated abrasive laden polymer is hydraulically forced over, or through, areas to be finished thus the contour of the channel can be smoothed. Once the angles/discontinuities are removed or smoothed fluid flow through the channel is enhanced.

In the embodiments described above, a piston suitable for use in a compression ignition engine is illustrated, however a piston for use in a spark ignition (SI) engine also benefits from a cooling gallery as described herein. A piston for use in combination with spark ignition does not generally comprise a combustion bowl but does experience elevated temperatures and, therefore, requires efficient cooling to be incorporated in combination with materials having good thermomechanical properties.

Possible fuels that could be used in an engine implementing the present invention include diesel, gasoline, liquefied petroleum gases (LPG), methane, hydrogen, ethanol, bioethanol and compressed natural gas (CNG).

CLAIMS

1. An internal combustion engine piston comprising:

a crown portion for compressing fluids within the engine; and

a skirt portion for supporting side loads exerted on the piston, in use, the piston being configured to receive a connecting rod of the engine wherein the crown portion comprises a cooling gallery, the cooling gallery comprising a first linear bore, the bore extending from an outer periphery of the crown portion of the piston into a body of the crown portion.

2. A piston according to Claim 1, wherein the cooling gallery comprises a second linear bore extending from an outer periphery of the crown portion of the piston into a body of the crown portion and connecting to the first linear bore to provide fluid communication therebetween.

3. A piston according to Claim 1 or Claim 2, wherein the cooling gallery comprises a plurality of interconnected linear bores extending from an outer periphery of the crown portion of the piston into a body of the crown portion, at least one bore is connected to two other bores to provide fluid communication therebetween, the plurality of bores being located about a central longitudinal axis of the piston.

4. A piston according to any preceding claim, wherein the, or each, bore is closed at an external region thereof to thereby define a cavity within the piston.

5. A piston according to any preceding claim, wherein the gallery comprises an inlet for permitting ingress of cooling fluid and an outlet for permitting egress of cooling fluid.

6. A piston according to Claim 5, wherein each respective bore is connected to two other bores and wherein each bore is closed at an external region thereof to thereby define a substantially toroidal channel within the piston.

7. A piston according to Claim 6, wherein a longitudinal axis of each bore is substantially coplanar to a longitudinal axis of each other respective bore.

8. A piston according to Claim 6 or Claim 7, wherein the gallery comprises three or more bores.

9. A piston according to Claim 8, wherein the number of bores in the gallery is in the range of five to twelve bores.

10. A piston according to any of Claims 2 to 9, wherein a dimension of each respective bore is configured in dependence on a cooling requirement of the piston.

11. A piston according to any preceding claim, wherein the engine is configured to use a fuel from the group of diesel, gasoline, liquid petroleum gas (LPG), methane, hydrogen, ethanol, bioethanol and compressed natural gas (CNG).

12. A method of manufacture of a cooling gallery within a piston for an internal combustion engine, the piston comprising a crown portion and a skirt portion, the method comprising the steps of:

drilling a series of linear bores into the piston, each bore extending from an external surface of the piston into a body of the crown portion and being spaced from a longitudinal axis of the piston;

closing each bore to thereby define a cavity within the piston;

forming an inlet in the piston extending to the cavity for permitting ingress of cooling fluid thereto; and

forming an outlet in the piston extending from the cavity for permitting egress of cooling fluid therefrom.

13. A method according to Claim 12, comprising a step of reaming the bores after the drilling step, to improve the surface finish thereof.

14. A method according to Claim 12 or Claim 13, comprising the step of honing an internal surface of the cavity to reduce any discontinuity presented therein.

15. A method according to Claim 13, wherein the honing step comprises an abrasive flow machining technique.

16. A method according to any of Claims 12 to 15, wherein an outer periphery of the piston is machined after the closing step is undertaken.

17. An internal combustion engine piston substantially as herein described, with reference to the accompanying drawings.

Application No: GB0821761.4 **Examiner:** John Twin
Claims searched: 1 to 17 **Date of search:** 6 March 2009

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-9,12 at least	JP 02041734 A (Asahi Tec) - see eg fig.2, noting two annular cooling passages made up of intercommunicating straight bores 61,71, respectively
A	-	DE 271400 A (Windhoff)
A	-	US 6557514 A (Federal Mogul)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F02F; F16J

The following online and other databases have been used in the preparation of this search report

EPODOC, TXTE, WPI

International Classification:

Subclass	Subgroup	Valid From
None		