

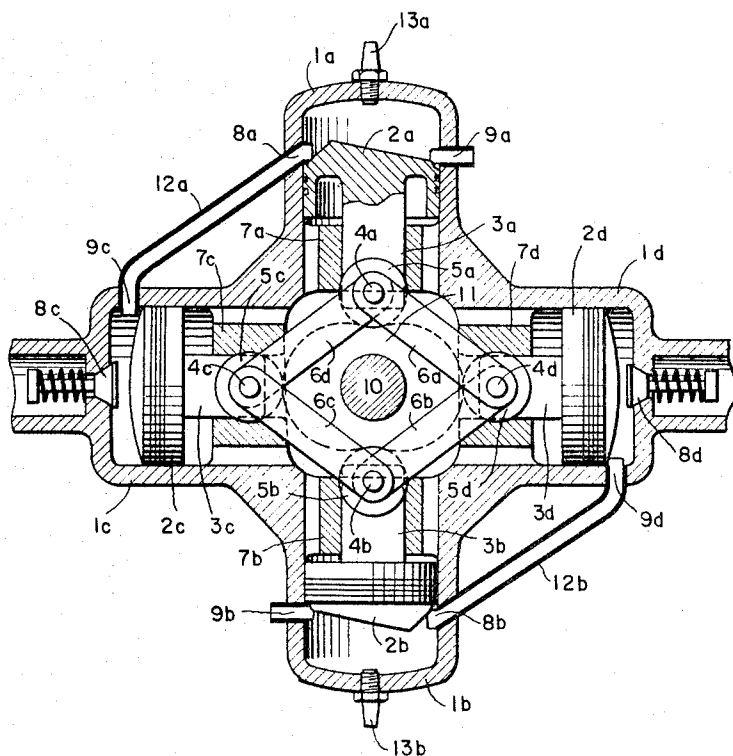
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TWO-CYCLE TWO-CYLINDER INTERNAL COMBUSTION ENGINE

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*Masaaki Noguchi and
Shigero Sakakibara
Inventors*

*By Wenderoth, Lind and Paepe,
attorneys*

1

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TWO-CYCLE TWO-CYLINDER INTERNAL
COMBUSTION ENGINEMasaaki Noguchi, Nagoya, and Shigeru Sakakibara,
Aichi, Japan, assignors to To Yota Motors Company,
Limited, Aichi Prefecture, Japan

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This invention relates to a two-stroke-cycle two-cylinder internal combustion engine, and its object is to provide a new and improved two-stroke-cycle internal combustion engine adapted to be operated quietly with minimum vibration in highly dynamic equilibrium.

With the abovementioned object in view, the two-stroke-cycle engine according to the present invention comprises a pair of opposed cylinders serving as engine cylinders, and another pair of opposed cylinders serving as feed pump cylinders, both being disposed radially with respect to a drive or engine shaft, with the center line of the first pair of cylinders crossing the center line of the second pair of cylinders at right angle at the axis of the engine shaft so as to form a cruciform. The engine shaft is provided with a securely mounted control cam having a double lobed cocoon shape cam edge. Inner or bottom end of each of the piston rods carries a rotatable antifriction roller adapted for making rolling contact with the cam edge of said control cam, said antifriction rollers serving as cam followers and actuators. The axes of four antifriction rollers on the inner ends of the piston rods are connected through a linkage to form a parallelogram or pantagraph and so arranged that on inward stroke of the pistons of the engine cylinders the pistons of the pump cylinders make inward stroke, and vice versa.

The invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawing, in which an embodiment of the invention is shown.

Referring now to the drawing, two pairs of cylinders 1a, 1b, 1c and 1d are radially arranged and so disposed in a cruciform that the cylinders 1a and 1b are opposed to each other while the cylinders 1c and 1d are opposed to each other, with the longitudinal axis through the first pair of opposed cylinders and the longitudinal axis through the second opposed pair of cylinders crossing at right angle at the axis of the engine shaft 10. For the purpose of explanation it is assumed that the cylinders 1a and 1b serve as the engine cylinders while the cylinders 1c and 1d serve as the reciprocating feed pumps for feeding the engine cylinders 1a and 1b.

Pistons 2a, 2b, 2c and 2d for the cylinders 1a, 1b, 1c and 1d, respectively, have piston rods 3a, 3b, 3c and 3d, respectively, which piston rods have at their inner or bottom ends stud bolts 4a, 4b, 4c and 4d, respectively, on which antifriction rollers 5a, 5b, 5c and 5d, respectively, are journaled. In practice, preferably two antifriction rollers are mounted on opposite ends of said stud bolt in conjunction with each piston rod. However, for the sake of brevity of explanation, it will be described on the basis of provision of a single antifriction roller for each piston rod.

As shown, the roller axis 4a is operatively connected to the roller axis 4d by a link 6a; the roller axis 4d in turn is connected to the roller axis 4b by a link 6b; the latter is connected to the roller axis 4c by a link 6c; and the roller axis 4c is connected to the roller axis 4a by a link 6d, thereby forming an equilateral parallelogram or pantagraphic linkage. 7a is a guide wall forming a part of the cylinder 1a for guiding the piston 2a and the piston rod 3a for reciprocating movement. Similar guide walls 7b, 7c and 7d are provided in the cylinders 1b, 1c and 1d,

2

respectively. The engine shaft 10 has secured thereto a control cam 11 having a double lobed cocoon shaped cam edge as shown in dotted line. The antifriction rollers 5a, 5b, 5c and 5d are held in rolling contact with the cam edge of the control cam 11. It is to be noted that two control cam plates of similar configuration may be disposed in parallel where there are used two antifriction rollers in conjunction with each piston rod. For the sake of brevity of explanation and illustration, however, in the explanation about to be made, the control cam will be described as consisting of a single cam plate and each piston rod will be described as carrying a single antifriction roller.

As mentioned above, two opposed cylinders 1a and 1b serve as the engine cylinders, while the other two opposed cylinders 1c and 1d serve as the feed pump. The engine cylinders 1a and 1b are provided with inlet ports 8a and 8b and outlet or scavenging ports 9a and 9b, respectively, said inlet and outlet ports being disposed diametrically. On the other hand, with respect to the pump cylinders 1c and 1d, there are provided suction valves 8c and 8d, respectively, and delivery ports 9c and 9d, respectively, which are in communication with the inlet ports 8a and 8b, respectively, through the ducts 12a and 12b, respectively. 13a and 13b are spark plugs provided in the heads of the engine cylinders 1a and 1b, respectively.

The operation of the internal combustion engine thus far described is as follows:

For the purpose of explanation, the description will first be made with reference to the reciprocating movements of the respective pistons during the rotation of the engine shaft 10 together with the cocoon shaped control cam 11. In the position shown in the drawing, the pistons 1a and 1b of the engine cylinders are in their bottom dead center while the pistons 1c and 1d of the feed pump cylinders are in their top dead center. When the engine shaft 10 together with the control cam 11 is rotated in the clockwise or anticlockwise direction, the pistons 1a and 1b are moved outwardly by means of the rotating cam 11, the antifriction rollers 5a and 5b making rolling contact with the cam edge of said rotating cam. At the same time the pistons 2c and 2d are moved inwardly for the reason that the parallelogram linkage 6a-6b-6c-6d has one diagonal associated with those pistons and being decreased in length. In this regard, it is to be noted that the cam face of the control cam 11 is so designated and arranged that the antifriction rollers 5c and 5d associated with the pistons 2c and 2d, respectively, are always maintained in rolling contact with the cam face of the control cam. Upon 90° rotation of the control cam 11, the pistons 2a and 2b reach their outermost positions, i.e., the outer dead center, while the pistons 2c and 2d reach their innermost positions, i.e., the inner dead center. On further 90° rotation of the control cam 11, the pistons 2c and 2d are moved outwardly toward their outer dead center, while the pistons 2a and 2b are moved inwardly toward their inner dead center, the engine shaft 10 with the control cam 11 making half rotation. Thus, it will be noted that each engine piston and each feed pump piston makes two strokes and complete one cycle of operation.

With the pistons in the position as shown in the drawing, in the feed pump cylinders 1c and 1d, the fuel mixture (or air only) is under maximum compression, while the engine cylinders 1a and 1b the gas is under maximum expansion; the compressed fuel mixture is being fed from the feed pump cylinders to the engine cylinders through the ducts 12a and 12b, while completing the scavenging of the exhaust gas. During 90° rotation of the engine shaft 10, in the engine cylinders the pistons make the compression stroke, while in the feed pump cylinders the pistons make the suction stroke sucking in the fuel mix-

ture. Just before the pistons reach the top dead center of the engine cylinders, at a predetermined advance angle, the spark plugs **13a** and **13b** are ignited. The explosion stroke is effected during further 90° rotation of the control cam **11**, and the rotational power is transmitted to the engine shaft **10** through the control cam **11**. On the other hand, in the pump cylinders the compression stroke is effected, the valves **8c** and **8d** being closed. From the above, it will be noted that, according to the present invention, in the engine cylinders **1a** and **1b** combustion is effected twice during one rotation of the engine shaft **10**.

While the two-cycle engine of so-called traverse type scavenging system is shown in the drawing, it should be noted that the present invention may similarly be applied to another type two-cycle engine in which an exhaust valve is provided at the top of the cylinder. It should also be noted that according to the present invention the feed pump cylinders may be so designed that air only is sucked in and forced out of the feed pump cylinders, providing appropriate means for injecting fuel into the engine cylinders.

From the foregoing it will be understood that the internal combustion engine according to the present invention is operated at high dynamic equilibrium for the reason that the two pairs of opposed pistons make respective reciprocating movement symmetrically with respect to the central engine shaft **10**. Moreover, due to the fact that impacts due to the explosion of the combustion gas are balanced out between the opposed engine pistons, and that inertia forces at the top dead center are also balanced out between each pair of opposed pistons, with the result that any vibration which has been considered one of the significant disadvantages of the conventional two-stroke cycle internal combustion engines can be substantially completely eliminated. It will be possible to devise a practically reliable and long-life internal combustion engine according to the teaching of the present

invention by appropriately determining diameter, material and heat treatment of the antifriction rollers **5a**, **5b**, **5c** and **5d**.

While the invention has been described in conjunction with the single embodiment illustrated in the drawing, it is to be understood that various changes and modification may be made without departing from the spirit and scope of the appended claims.

What we claim is:

1. A two-cycle two-cylinder internal combustion engine comprising an engine shaft, a control cam of double lobed cocoon shape fixed to said engine shaft, two opposed engine cylinders each having a piston, two opposed feed pump cylinders each having a piston, said opposed cylinders being arranged radially with respect to the engine shaft in a cruciform, a piston rod of each of said pistons in the said four cylinders, each piston rod being provided on its inner end with a rotatable antifriction roller, and a linkage connecting the axes of said four antifriction rollers to form a parallelogram and adapted to hold said four antifriction rollers in rolling contact with the cocoon shaped cam edge of said control cam on the engine shaft.

2. A two-cycle two-cylinder internal combustion engine as recited in claim 1, wherein the control cam on the engine shaft consists of two cocoon shaped plates fixed on the engine shaft, said two cam plates being spaced axially.

3. A two-cycle two-cylinder internal combustion engine as recited in claim 2, wherein each of the piston rods in the engine cylinders and the pump cylinders carries two antifriction rollers adapted to be held in rolling contact with the cocoon shaped cam edges of said two cam plates.

No references cited.

MARK NEWMAN, *Primary Examiner*.
W. E. BURNS, *Assistant Examiner*.