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(54) A camshaft

(57) A composite camshaft for use in an internal combustion engine comprises a tubular steel shaft 1 and a plurality of cams 31—38 mounted on the shaft. The shaft has a plurality of circumferentially spaced longitudinally extending grooves or projections 11—14 which in number are equal to or less than the engine cylinders. Every cam is identically shaped to have at least one projection or groove 30 in its inner periphery for co-operation with one of the grooves or projections of the shaft. The projection or groove 30 is angularly spaced by a preselected angle β from a symmetrical centre-line of the cam, passing through the cam nose, the preselected angle being one half of an angle α defined between the cam noses of a pair of inlet and exhaust cams.

FIG. 2

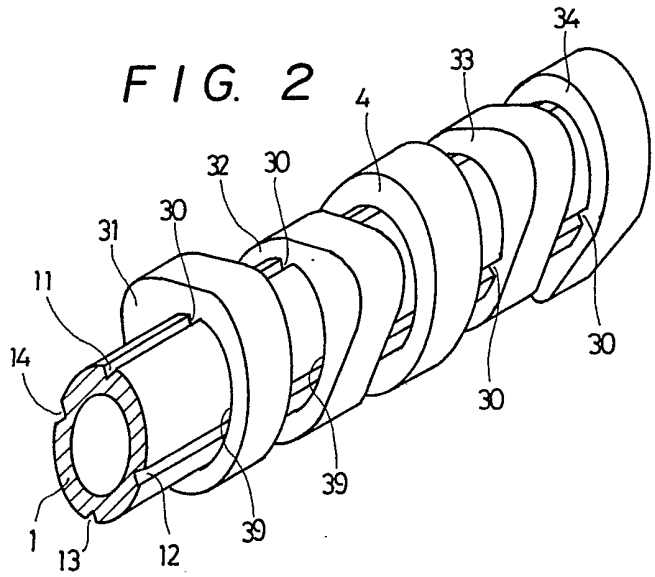
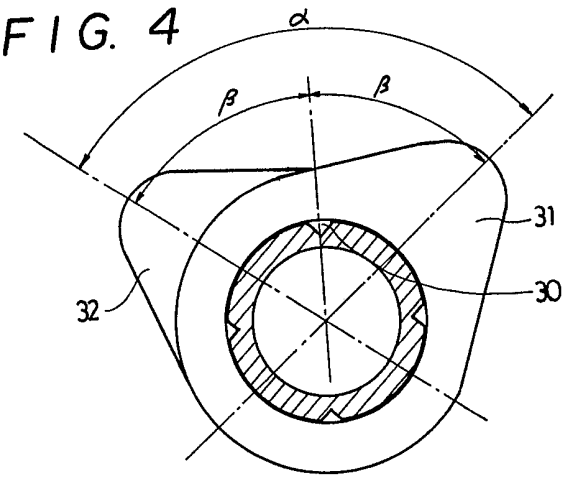


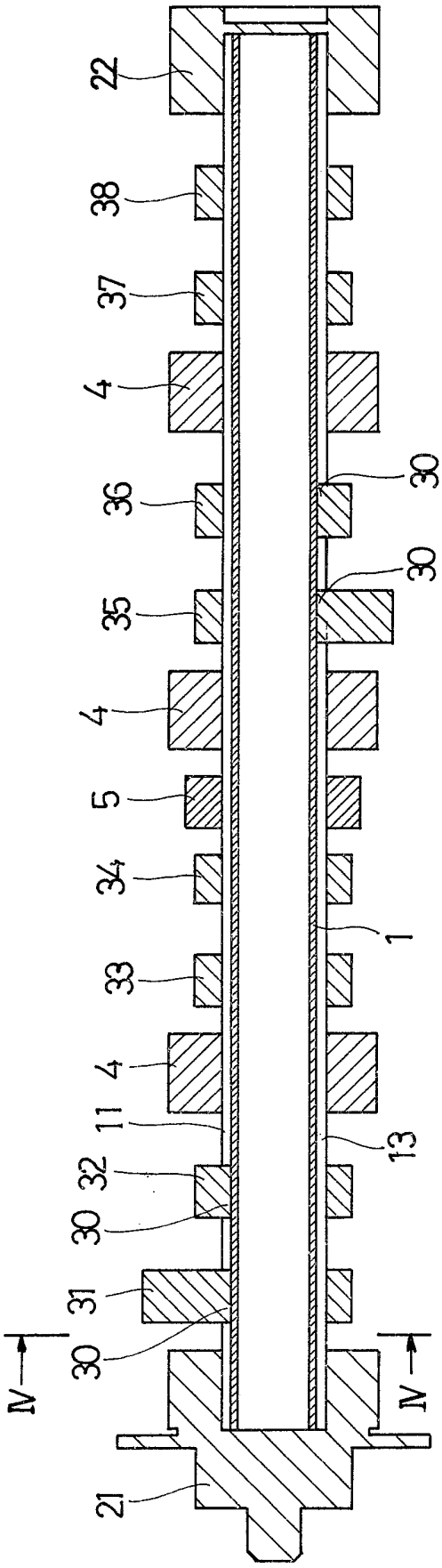
FIG. 4



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FIG. 1



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FIG. 3

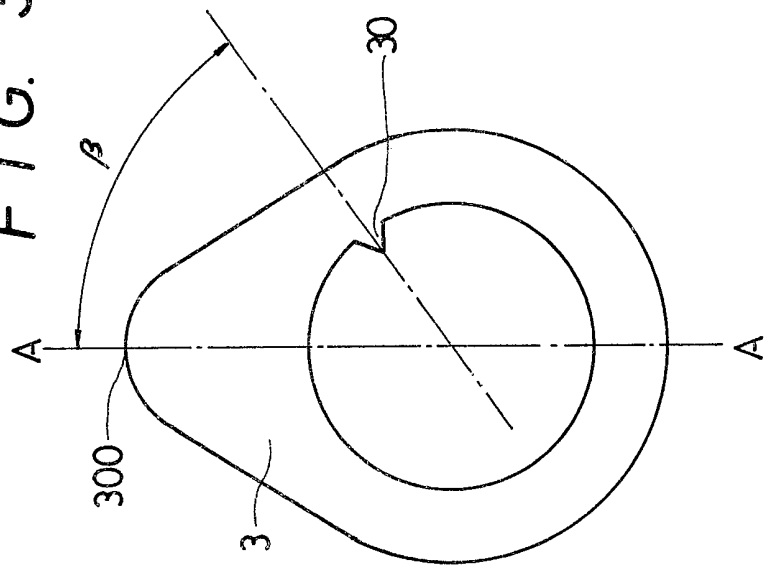
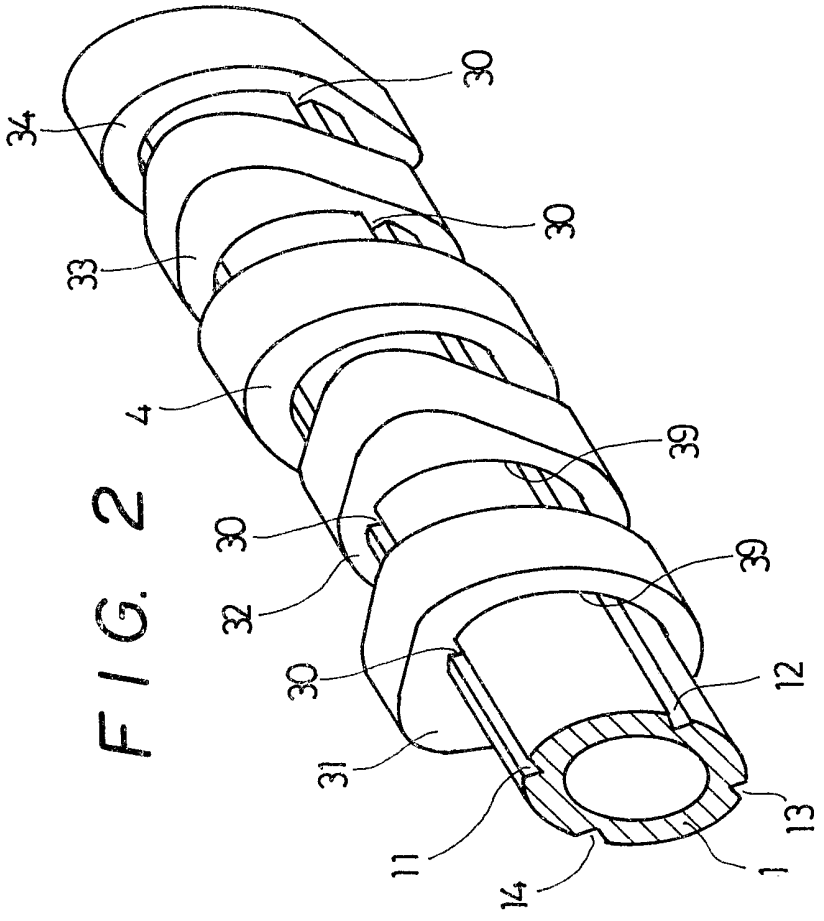


FIG. 2



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FIG. 4

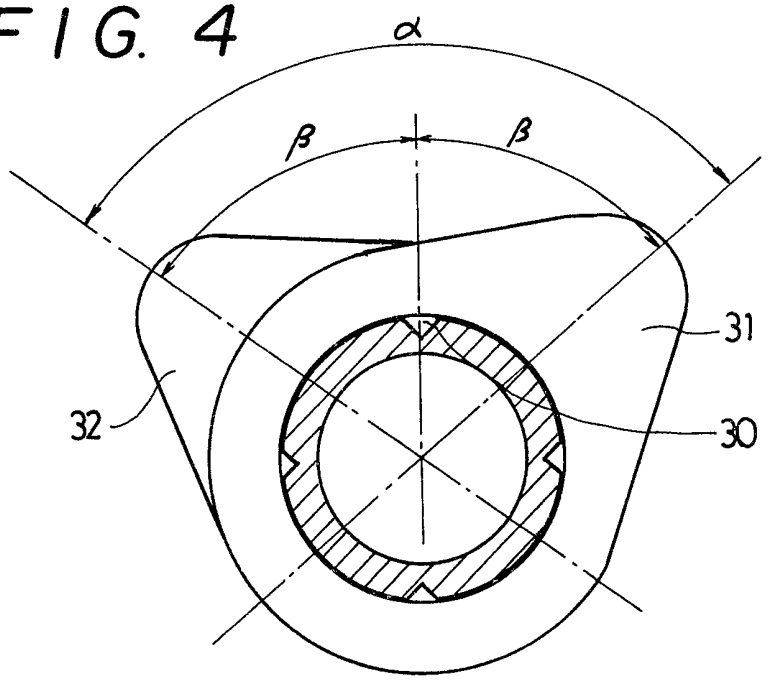


FIG. 5

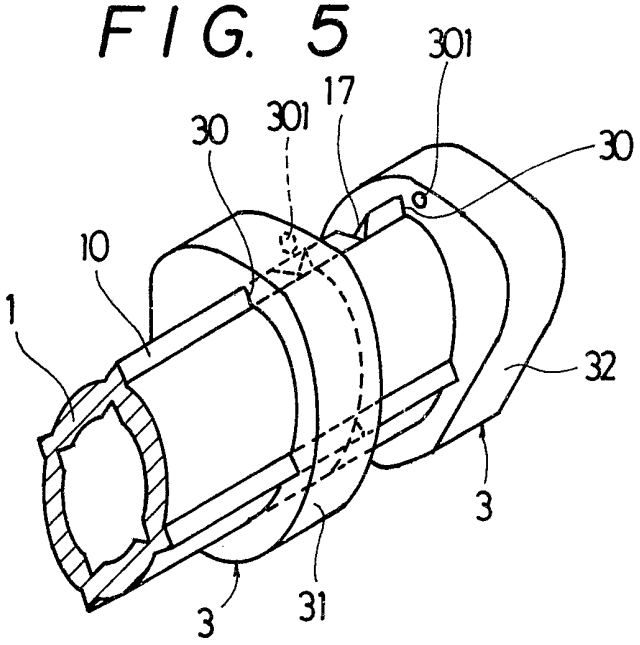
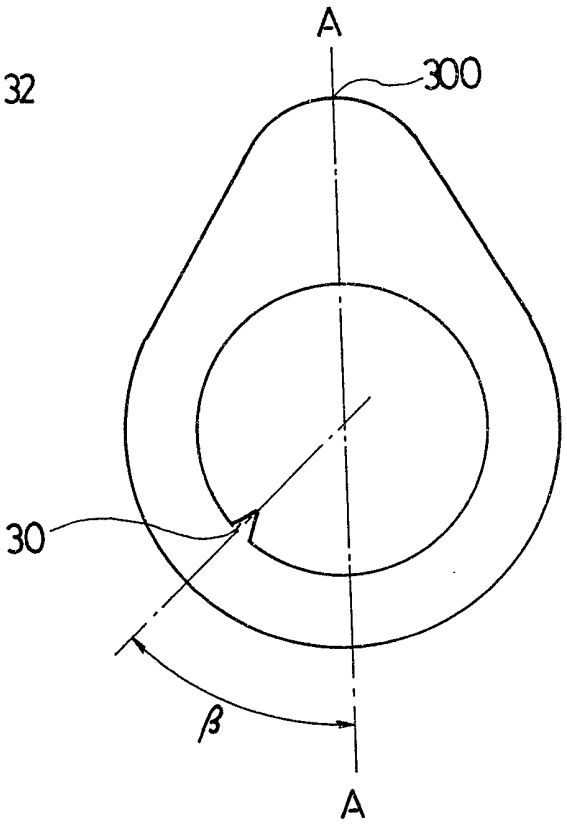


FIG. 6



SPECIFICATION
A camshaft

The invention relates to a camshaft for operating inlet and exhaust valves in an internal combustion engine.

Camshafts for use in an internal combustion engine are required to have wear-resistant cams as well as a rigid and fatigue-resistant shafts. Moreover, it has recently become desirable for camshafts to be light in weight in order to save on fuel. In general, one piece camshafts of chilled iron or hardened alloy cast iron are superior in wear-resistance. However, the camshaft of cast iron becomes disadvantageous with length, because it cannot be lengthened without increasing warpage by casting and thickness to have a desired strength.

A composition camshaft has been disclosed in Published Japanese Utility Model Application No. 51-7367 and Published Unexamined Japanese Patent Application No. 54-41266 which has a tubular shaft of steel pipe and cams made of oil-impregnated sintered alloy. The cams are positioned on the shaft by means of groove-projection connections. The disclosed camshaft has a shaft formed with grooves equal in number to the cams which are double in number of the engine cylinders, because every cylinder has a pair of different crank angles for actuation of its inlet and exhaust valves. However, providing so many grooves on the shaft leads to disadvantages one of which is that the shaft needs many expensive machining operations. Another disadvantage is that the shaft cannot compensate for reduction in strength due to many grooves without increasing weight and thickness.

In contrast, if the number of grooves in the shaft is reduced to less than the number of cams, the cams increase in kind because of the need to have the projections formed at two or more different positions in accordance with the reduced number of grooves. Each kind of cam of sintered alloy or cast-steel requires a different kind of mould. This leads to disadvantages one of which is that the cams become costly. Another disadvantage is that there is a greater risk that the cams will be incorrectly assembled on the shaft.

According to the invention there is provided a camshaft for use in an internal combustion engine with a plurality of cylinders, comprising a tubular steel shaft and a plurality of cams mounted on the shaft, the shaft having a plurality of grooves or projections for co-operation with at least one groove or projection provided in the inner periphery of each cam, the groove or projection in the inner periphery of the cam being spaced by a preselected angle from a symmetrical line of the cam passing through a cam nose, said preselected angle being one-half of an angle defined between the respective cam noses of a pair of inlet and exhaust cams.

Preferred and/or optional features of the invention are set fourth in claims 2—6.

The invention will now be more particularly described with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section of one embodiment of a camshaft according to the invention;

Figure 2 is a perspective view of the relevant portion of the camshaft of Figure 1;

Figure 3 is a front elevation of a cam of Figure 1;

Figure 4 is a section taken along the line IV—IV of Figure 1 but somewhat rotated;

Figure 5 is a view, similar to Figure 2, of another embodiment of the invention; and

Figure 6 is a front elevation of a cam of another embodiment.

Referring firstly to Figure 1 the camshaft shown therein has a tubular shaft 1 of steel pipe provided with longitudinally extending circumferentially spaced grooves 11, 12, 13 and 14. The camshaft also has inlet cams 31, 33, 35, 37, exhaust cams 32, 34, 36, 38, journals 4, a gear 5, a driving side end part 21, and a free end part 22 all of which are individually mounted on the shaft 1. Each cam has a projection 30 formed in its inner periphery for fitting engagement with one of the longitudinally extending grooves 11—13. The cams are generally made of sintered alloy which is readily mouldable, appropriately lubricative, and metallurgically wear-resistant. Particularly, the cams are made of liquid phase sintered alloy to obtain high compression strength and metallurgical bonding with the shaft when the assembly of the cams and the shaft is sintered as one-piece at a temperature causing a diffusion of liquid phase. The journals 4, the gear 5, and the end parts 21, 22 are not required to be highly wear-resistant and therefore may be made of steel, plastic resin, cast-iron, or sintered alloy.

As seen in Figure 2, the longitudinally extending grooves 11, 12, 13, 14 formed in the shaft 1 are equal in number to the number of cylinders of a non-illustrated four cylinder engine to position each cam at a predetermined position. Each cam has, as previously mentioned, a projection 30 formed on its inner periphery 39 for fitting engagement with one of the four grooves 11, 12, 13, and 14. Cams 31, 32 for the first cylinder are angularly positioned by groove 11 in which the respective projections 30 are located and cams 33, 34 for the second cylinder are positioned by groove 12 in which the respective projections 30 are located. The other cams for the third and fourth cylinders are positioned by grooves 13, 14. The journal 4 is metallurgically secured to the stem 1.

As seen in Figure 3, the projection 30 is angularly spaced by an angle β from a symmetrical line A—A passing through the top of the cam nose 300 of the cam 3.

As seen in Figure 4, the inlet and exhaust cams 31, 32 have their cam noses located on opposite sides of a plane passing through the respective projections 30. The symmetrical lines of the inlet and exhaust cams 31, 32 define therebetween an angle of α and intersect the aforesaid plane with

the same angle of β on opposite sides. The inlet and exhaust cams 31, 32 are identical in shape but reversed with respect to each other in order that their projections 30 can be fitted in a common groove in the shaft. The result of this is that the number of grooves is one half of the number of cams or equal to the number of the cylinders. The angle β is one half of an angle of α defined between the respective cam noses of inlet and exhaust cams 31 and 32 of the same cylinder.

In the case of cams of sintered alloy, the alloy powder can be moulded in the same kind of mould and shaped into a kind of cam, which is available both as an inlet valve cam and as an exhaust valve cam when reversed.

The shaft of the camshaft requires only one half of the number of grooves of the known arrangement. One advantage of this is that expensive machining operations are significantly decreased. Another advantage is that the shaft strength is reduced less due to the grooves.

In the embodiment of Figure 5, the tubular shaft 1 has projections 10 in place of the grooves of the previous embodiment, while the cams 3 are each formed with a groove 30 for fitting engagement with the projection. The shaft can be thinned without losing its strength because of having no groove. The cams and the shaft are easily and correctly assembled by making a notched mark 17 indicating the individual cylinder on the projection 10 and another mark 301 on the side of the cam prior to assembling. The inlet and exhaust cams 31 and 32 are easily paired when their same marks 301 oppose each other and their angular and axial positions on the shaft can be confirmed by the mark 17.

The projection or groove of each cam can be formed not only on the side of the cam nose 300, i.e. at a position angularly spaced from the cam nose by an acute angle, as seen in Figure 3 but also on the side opposite to the cam nose 300, i.e. at a position angularly spaced from the cam nose by an obtuse angle, as seen in Figure 6, in which the cam 3 has its projection 30 located at a position spaced by an angle of β from the symmetrical line A—A passing through the cam nose 300 on the side opposite to the cam nose. The cam may have two projections on the same and opposite sides of cam nose, if the side is marked.

Cams of steel can have as many projections as the number of cylinders. For example, it can have four projections in the case of an engine with four cylinders each having a phase difference of 90 degrees. However, in the case of cams of sintered alloy, it is desirable to have only a single projection, because of the difficulty otherwise in producing the necessary mold. The projection is rather shaped in the form of an arc than a triangle.

The projection on or grooves in the shaft are equal in number to the cylinders. However, two or more cylinders with the same phase should be counted as one cylinder. For example, eight cylinders are counted as four cylinders if every two cylinders are of the same phase, resulting in that the shaft is formed with four projections or grooves. This means that a camshaft embodying the invention becomes more advantageous with the number of engine cylinders.

While only certain embodiments of the invention have been illustrated and described, it is apparent that alterations, modifications and changes may be made without departing from the scope thereof as defined by the appended claims.

CLAIMS

1. A camshaft for use in an internal combustion engine with a plurality of cylinders, comprising a tubular steel shaft and a plurality of cams mounted on the shaft, the shaft having a plurality of grooves or projections for co-operation with at least one groove or projection provided in the inner periphery of each cam, the groove or projection in the inner periphery of the cam being spaced by a preselected angle from a symmetrical line of the cam passing through a cam nose, said preselected angle being one-half of an angle defined between the respective cam noses of a pair of inlet and exhaust cams.

2. A camshaft as claimed in claim 1, wherein the number of said grooves or projections in said shaft is at most equal to the number of cylinders of the engine in which the camshaft is designed to operate.

3. A camshaft as claimed in claim 1 or claim 2, wherein each cam is of sintered alloy.

4. A camshaft as claimed in any one of claims 1—3, wherein the groove or projection in the inner periphery of said cam is spaced from the nose of the cam by an acute angle.

5. A camshaft as claimed in any one of claims 1—4, wherein the shaft is provided with grooves and each is provided with at least one projection.

6. A camshaft as claimed in any one of claims 1—4, wherein the shaft is provided with projections and each cam is provided with at least one groove.

7. A camshaft for use in an internal combustion engine, substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.

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