

curve (1H, in Fig. 1) of Zhou Engine. While the power-cam (3B) is rotating, the piston (3E) will be in reciprocating motion (4D) following the piston-top motion curve (1H, in Fig. 1), and keep repeating. This power-cam (3B) has two work cycles each round, and corresponding to the pistons (3E) are set in pairs, to remove this engine vibrating.

- 5 The vibration of this Zhou Engine can be removed by specifying the number of work cycles of the power-cam each round to be greater than one. But, if the number is greater than two, the solid mechanical parameters of this Zhou Engine will worsen.

Example A needs one power-cam (3B).

Fig. 5: The shell (3C) of Example A. The meanings of the symbols are in the following table (table 5).

10 Table 5

Symbols	Meanings
3C	shell
3M	bearing surface, of the toothed-track (3R), for the toothed-rollers (3I) rolling on
3N	Teeth, in a row, of the toothed-track (3R), for the toothed-rollers (3I) meshing
3R	toothed-track
5B	shaft hole
5C	Through-hole, to attach another shell together
5D	Hole, to install the small wheels of the pistons, showing in Fig. 3 is 3O
5E	cylinders inlay here

This shell has 20 toothed-tracks (3R), 1 shaft hole (5B), 10 through-holes (5C), 10 holes (5D). Each toothed-track (3R) has 1 bearing surface (3M), and many teeth (3N) in a row.

Example A needs two shells (3C).

Fig. 6: The piston (3E) of Example A. The meanings of the symbols are in the following table (table 6).

15 Table 6

Symbols	Meanings
3E	Piston
3J	bearing surface, of the toothed-track (3Q), for the toothed-rollers (3I) rolling on
3K	Teeth, in a row, of the toothed-track (3Q), for the toothed-rollers (3I) meshing
3Q	toothed-track, the same as 3R, reference the Detail F of Fig. 5
6A	Big wheel
6B	Small wheel
6C	bearing surface of the wheel
6E	roller bearings

This piston (3E) comprises: 1 big wheel (6A), 2 small wheels (6B), and 4 toothed-tracks (3Q). Each toothed-track has many teeth (3K) in a row, and 1 bearing surface (3J).

Example A needs 5 pairs of pistons (3E).

Fig. 7: The cylinder (3D) of Example A. The meanings of the symbols are in table 7.

20 Table 7

Symbols	Meanings
3D	Cylinder
7A	this end inlay shells (3C)

Example A needs 5 pairs of cylinders (3D).

Fig. 8: The toothed-roller array (3F) of Example A and toothed-roller (3I) of Example A. The meanings of the symbols are in the following table (table 8).

Table 8

Symbols	Meanings
3F	Toothed-roller array
3I	Toothed-roller
3L	cage, that restricts and synchronizes the many toothed-rollers (3I)
8A	bearing surface, of the toothed-roller (3I)
8B	Teeth, of the toothed roller (3I)

- 25 A toothed-roller array (3F) is that a cage (3L) restricts and synchronizes many toothed-rollers (3I). A toothed-roller has 1 bearing surface (8A) and many teeth (8B). Or rather, a toothed-roller (3I) is a roller, but with teeth (8B). While they are working, the synchronized toothed-rollers (3I) roll between the **toothed-track** of the shell (3R) and the toothed-track of the piston (3Q), and mesh their teeth (8B, 3K, 3N).

Example A needs 40 toothed-roller arrays.

- 30 **Fig. 9:** The General Assembly of Example B of Zhou Engine. The meanings of the symbols in this

drawing are in table 9 below. The main parts of Example B are shown in Fig.10 to 13, and listed in table 9.1 below.

Table 9

Symbols	Meanings
9A	General Assembly of Example B of Zhou Engine
9B	shell
9C	Power-cam
9D	piston
9E	Toothed-roller array A
9F	Toothed-roller array B
9G	main shaft, of the power-cam (9C)
9H	Big wheel, of the piston (9D)
9I	bearing surface here and rolling here
9J	meshing here
9K	Sections of the piston (9D)
9L	cylinder, of the shell (9B)
9M	Joint bolt, to joint two shells and two cylinder heads together.
9N	Cam, for driving valves, fixed on the main shaft (9G) directly
9O	Intake valve
9P	Exhaust valve
9Q	Cylinder head
9R	Air
9S	Exhaust gas
9T	Spring
9U	Toothed-track, of the shell (9B)
9V	Toothed-track, of the piston (9D)
9W	fuel supply system and ignition system, are necessary and not shown here

Table 9.1

Parts	Quantity	Reference
Shell (9B)	2	Fig. 10
Power-cam (9C)	1	Fig. 11
Piston (9D)	6	Fig. 12
Toothed-roller array A (9E)	12	Fig. 13
Toothed-roller array B (9F)	12	Fig. 13

5 This Zhou Engine comprises: 3 pairs pistons (9D), 2 shells (9B), 1 power-cam (9C), 12 toothed-roller array A's (9E), 12 toothed-roller B's (9F). The number of cylinders (9L) equals that of pistons (9D). This engine has 3 characteristics as follow:

(a) The pistons (9D) work as pairs, at the same axial line, and precisely inverse motion.

10 (b) The one power-cam (9C) drives all the pistons (9D), and vice versa, by the tracks of the power-cam and the wheels mounted on the pistons.

(c) Each piston (9D) is in reciprocating motion, and is confined by the cylinder (9L) and toothed-roller arrays (9E, 9F).

15 The cylinder heads (9Q), valves (9O, 9P) actuating mechanism, fuel supply system, and ignition **system**, can be designed conventionally. The intake valves (9O) open in the intake stroke (1O), close in all other times, and are driven by the cams (9N). The exhaust valves (9P) open in the exhaust stroke (1S), close in all other times, and are driven by the cams (9N). The fuel injection starts at the beginning of the combustion period (1Q), then spark ignite if it's needed. The intake valve (9O), the exhaust valve (9P), the fuel injection and the spark ignition work the same as in a conventional four-stroke engine. The cams (9N) direct fixed on the main shaft (9G) of the power-cam (9C), and are synchronous rotation with the
20 power-cam (9C).

Zhou Engine can have any number of pistons (or cylinders).

Fig. 10: The Shell (9B) of Example B. The meanings of the symbols in this drawing are in table 10 below.

25 This shell (9B) comprises: 3 cylinders (9L), 12 toothed-tracks (9U), 6 through holes (10C), and 3 holes (10D). Each toothed-track has 1 bearing surface (10B), and many teeth (10E) in a row.

Example B needs two shells (9B).

Table 10

Symbols	Meanings
9B	Shell
9L	Cylinder
9U	toothed-track, toothed-rollers (13A, in Fig. 13) rolling here
10A	main shaft hole
10B	bearing surface, of the toothed-track (9U), for toothed-rollers (13A) rolling on
10C	through hole, to attach with another shell and cylinder heads together
10D	hole, for easy to install the small wheel of the piston (9D)
10E	teeth, of the toothed-track (9U), for meshing toothed-rollers (13A)

Fig. 11: The power-cam (9C) of Example B. The meanings of the symbols in this drawing are in the following table (table 11).

Table 11

Symbols	Meanings
1O	intake stroke
1P	compression stroke
1Q	combustion period
1R	expansion stroke
1S	exhaust stroke
9C	Power-cam
9D	Piston

Symbols	Meanings
9G	main shaft
11A	Rotation direction
11B	track
11C	Cylinder U
11D	Expanded View
11E	Piston (9D) reciprocating motion

- 5 The curvature of the tracks (11B) of the power-cam (9C) is designed according to the piston-top motion curve (1H, in Fig. 1). While the power-cam (9C) is rotating, the piston (9D) will be in reciprocating motion (11E) following the piston-top motion curve (1H, in Fig. 1), and keep repeating. The tracks (11B) are for the wheels of the piston (9D) rolling along. The tracks are symmetrical, for corresponding to the piston pairs, to remove this engine vibrating.
- 10 Example B needs one power-cam (9C).

Fig. 12: The piston (9D) of Example B. The meanings of the symbols in this drawing are in table 12.

Table 12

Symbols	Meanings
9D	Piston
9H	Big wheel
9V	Toothed-track
12A	Small wheel
12B	Bearings, of the wheels, conical roller bearing
12C	bearing surface, of the toothed-track (9V)
12D	Teeth, in a row, of the toothed-track (9V)
12E	bearing surface, of the big wheel (9H)
12F	bearing surface, of the small wheel (12A)

- 15 **This** piston (9D) has one big wheel (9H), one small wheel (12A), and four toothed-tracks (9V). Each wheel (9H or 12A) has bearings (12B). The bearing (12B) is conical roller bearing. Each toothed-track (9V) has one bearing surface (12C) and many teeth (12D) arranged in a row, for the toothed-roller array (9E or 9F) rolling along.

Example B needs 3 pairs of pistons (9D).

Fig. 13: Toothed-roller array A (9E), toothed-roller array B (9F) and toothed-roller (13A) of Example B.

- 20 The meanings of the symbols in this drawing are in the following table (table 13).

Table 13

Symbols	Meanings
9E	Toothed-roller array A
9F	Toothed-roller array B
13A	Toothed-roller
13B	Cage A, of the Toothed-roller array A (9E)

Symbols	Meanings
13C	Cage B, of the Toothed-roller array B (9F)
13D	teeth, of the toothed-roller (13A)
13E	bearing surface, of the toothed-roller (13A)

Each toothed-roller array A (9E) comprises one cage A (13B) and many toothed-rollers (13A). Each