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DRAWINGS ATTACHED

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(54) TIMING SYSTEM FOR INTERNAL COMBUSTION ENGINES

(71) I, JEAN HENVAUX, nationality Belgian, of 27 rue des Melezes a Bruxelles 5, Belgium, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an improved timing system for internal combustion engines.

Valves and the means actuating them are a source of trouble in all engines, because they are often subject to annoying and expensive breakdowns.

Conventional internal combustion engines are provided with a valve system to open and close exhaust and inlet ports, these valves being operated by mechanism including tappets, push rods, rockers, return springs, etc.

An object of the invention is to devise a new timing system which is much simpler and is consequently much cheaper to manufacture than known systems.

According to the present invention therefore there is provided a timing system for an internal combustion engine having a crankshaft wherein a cylinder head of a combustion cylinder has rotatably mounted therein a timing shaft formed with an inlet port and an exhaust port, the ported timing shaft being arranged to be driven by a Maltese cross driving device operatively connected with the crankshaft, the continuous rotating motion of which produces intermittent rotation of the ported timing shaft.

If desired, the timing system may be applied to an engine cylinder operating on the four stroke cycle, the crankshaft actuating a drive wheel having two drive pins in order to cooperate with the Maltese cross having four drive slots, whereby the crankshaft rotates twice as fast as the timing shaft which is rotatable with the Maltese cross, the timing shaft having four dwell periods

during each revolution thereof.

Advantageously, the cylinder head, the ported shaft and the Maltese cross may form a unit which is independent of the engine unit and is therefore readily interchangeable.

The invention will be more readily understood from the following non-limitative example which refers to a four-stroke internal combustion engine and is illustrated by the drawings, in which:

Figure 1 is a view in elevation showing a Maltese cross actuating unit;

Figure 2 is a horizontal section through the timing unit;

Figure 3 is a plan view of the timing unit shown in Figure 2;

Figure 4 is a perspective view of a ported shaft;

Figure 5 is a vertical section showing the position of the intake port in the ported shaft with respect to the intake pipe when the piston is at top dead centre;

Figure 6 is a view similar to Figure 5 but referring to the exhaust port and pipe;

Figure 7 is a view corresponding to Figure 2, except that the engine has four cylinders instead of one as in Figure 2;

Figure 8 diagrammatically shows the periods of rotation and rest of the ported shaft with respect to the rotation of the crankshaft; and

Figures 9 to 24 are sectional diagrams of the different positions of the intake and exhaust ports with respect to the intake and exhaust pipes for successive positions of the crankshaft (i.e. of the piston).

Crankshaft 1 transmits rotary movement, without stepping it down, to a circular plate 2 comprising a drive wheel, which has mounted on the periphery thereof two pins 3 and 3<sup>1</sup> and a projection 4. The pins 3 and 3<sup>1</sup> of plate 2 in turn transmit the movement to a Maltese cross 5, the plate 2 and the Maltese cross 5 together comprising a known Maltese cross driving system which converts

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continuous rotation of plate 2 into intermittent rotation of the cross 5. The plate 2 has shaft bearings, and a support for these bearings is provided as shown in Figure 2. Since plate 2 has two pins 3 and 3<sup>1</sup> to engage the Maltese cross which has four drive slots, the cross 5 makes a quarter-turn when plate 2 makes a half-turn, and cross 5 thus rotates at half the speed of plate 2, i.e. at half the speed of driving crankshaft 1.

The Maltese cross 5 is keyed to a ported shaft 6 (Figure 4) comprising two spindles 7 and 7<sup>1</sup> rotatable in bearings 8 and 8<sup>1</sup> of cylinder head 9. The shaft 6 has a cylindrical part 10 formed with an intake port 11 which, in the example, has a sector shaped opening having an apex angle of 155° and an exhaust port 12 of similar shape but having an apex angle of 180°.

It will be appreciated of course that in each case the apex angles of the ports will be calculated as a function of the position of the intake and exhaust pipes of the cylinder head and as a function of the shape of the cylinder head combustion chamber.

Cylinder head 9 has a base 13 (Figure 5) attached by bolts (not shown) to the top of cylinder 14, and a hollow cylindrical upper part 15 in which the cylindrical part 10 of ported shaft 6 turns. The part 15 has an intake pipe 16 extending approximately radially therefrom to connect the inside of the cylinder head and consequently the cylinder with the carburettor via the intake port 11. The part 15 also has an exhaust pipe 17 extending approximately radially therefrom so as to connect the inside of the cylinder head and consequently the cylinder with the atmosphere via exhaust port 12. An opening 18 for a sparking plug is provided extending into the combustion chamber. The cylinder head 15 is also provided with two bearings 8 and 8<sup>1</sup> for the ported shaft 6 and a support (not shown) for the shaft bearings of drive wheel plate 2.

Figure 7 shows a timing system according to the invention for a four-cylinder engine. The cylindrical part 10 of ported shaft 6 comprises four intake ports 11<sup>1</sup> to 11<sup>4</sup> and four exhaust ports 12<sup>1</sup> to 12<sup>4</sup> arranged in accordance with the engine cycle for each cylinder. An intake manifold 16<sup>1</sup> brings the mixture to cylinder head 15<sup>1</sup> and an exhaust manifold 17<sup>1</sup> evacuates the waste gas.

The ported shaft 6 is driven in the manner already described.

Figure 8 is a diagram showing the relation between the cycle of the ported shaft driven by the Maltese cross and a complete theoretical cycle of a four-stroke engine. It will be seen that 720° of rotation of the crankshaft correspond to  $4 \times 90^\circ = 360^\circ$  of rotation by the ported shaft.

Figures 8 to 24 and the accompanying description are given in order to assist in

an understanding of the working of the engine, and the values of relative positions given are calculated for simplicity on the basis that the angular velocity of the Maltese cross is constant during each period of rotation thereof.

In practice however, the angular velocity of the Maltese cross 5 is not constant during each 90° period of rotation but commences at zero and increases to a maximum at 45° after commencement of rotation and reduces to zero at 90° after commencement of rotation. Numerical values given in Figures 8 to 24 and in the description are therefore incorrect insofar as they are based on the assumption of a constant angular velocity of the Maltese cross.

However, as stated above, Figures 8 to 24 are given for assistance only, and there is no need for precise numerical accuracy.

According to a preferable feature of the invention, the intake and exhaust phases begin and end when the ported shaft is rotating. This is the case in the diagram, Figure 8, where the mixture intake begins 10° after the top dead centre (0° TDC); the intake is closed 30° after the bottom dead centre (180° BDC); exhaust outlet begins 45° before the bottom dead centre (540° BDC) and exhaust closure coincides with the top dead centre (720° TDC).

Figure 9 shows the respective positions of the intake and exhaust ports at the beginning of a cycle or when the crankshaft 1 is at an angle of 0°, i.e. at the top dead centre (TDC). As may be seen, the ported shaft is rotating and the intake pipe 16 and exhaust 17 pipe of the cylinder head are blocked by the cylindrical part 10 of the ported shaft.

In Figure 10 (crankshaft at 10°), the ported shaft is still rotating and the intake port 11 begins to open the cylinder head intake pipe 16. This is the beginning of the intake phase, which theoretically lasts for 200°.

In Figure 11 (crankshaft at 40°), the ported shaft has stopped rotating (see diagram, Figure 8). The intake port has completely uncovered the cylinder head intake pipe and the mixture is sucked into the cylinder by the piston.

In Figure 12 (crankshaft at 130°), the ported shaft, which has not moved from its position in Figure 11, begins a new quarter-turn rotation. The intake continues.

In Figure 13 (driving shaft at 180° or BDC), the ported shaft is rotating and the clearance for mixture to enter the cylinder is reduced by the cylindrical part 10 of the ported shaft.

In Figure 14 (crankshaft at 210°) the ported shaft continues to rotate. The mixture intake pipe is no longer connected to the cylinder. This is the end of the intake phase.

In Figure 15 (crankshaft at 220°) the

ported shaft actuated by the Maltese cross has finished its 90° rotation and the intake and exhaust pipes are still closed. At this stage rotation of the crankshaft is compressing the mixture prior to ignition.

5 In Figure 16 (crankshaft at 310°) the ported shaft begins a new 90° rotation which does not, however, have any effect on the intake of mixture or on the evacuation of  
10 waste gases.

In Figure 17 (crankshaft at 360° or TDC) the ported shaft is rotating. The intake and exhaust pipes are still closed and the compression phase has finished. At this  
15 point combustion begins.

In Figure 18 (crankshaft at 400°) the ported shaft has finished rotating but the intake and exhaust pipes are still blocked. This is the expansion or working phase.

20 In Figure 19 (crankshaft at 490°) the ported shaft begins a new 90° rotation while the expansion continues.

In Figure 20 (crankshaft at 495°) the ported shaft is rotating and the exhaust  
25 port 12 begins to connect the cylinder with the cylinder head exhaust pipe 17. This is a stage towards opening the exhaust.

In Figure 21 (crankshaft at 540° or BDC) the ported shaft is rotating, so that  
30 the exhaust port increases the size of the opening for waste gas passing to the exhaust pipe, although the gas is not yet being expelled by the rising piston. This is the beginning of the exhaust phase.

35 In Figure 22 (crankshaft at 580°) the ported shaft has finished rotating and the clear space between the cylinder and the cylinder head exhaust pipe is at a maximum. The waste gases are expelled by the piston.  
40 This is the exhaust phase.

In Figure 23 (crankshaft at 670°) the ported shaft begins a new 90° rotation; the exhaust port 12 rotates so that the exhaust  
45 pipe 17 is blocked by cylindrical part 10. This is a continuation of the exhaust phase.

In Figure 24 (crankshaft at 720°; TDC), the ported shaft is rotating; the exhaust  
50 pipe is blocked and all the waste gas has been expelled since the piston has stopped rising. This is the end of the exhaust phase. The cylinder head intake pipe 16 is also blocked, but when the driving shaft has rotated 10°, a new engine cycle begins, initiating the intake phase (Figures 9 and  
55 10).

#### WHAT WE CLAIM IS:—

1. A timing system for an internal combustion engine having a crankshaft wherein a cylinder head of a combustion cylinder has  
60 rotatably mounted therein a timing shaft formed with an inlet port and an exhaust port, the ported timing shaft being arranged to be driven by a Maltese cross driving device operatively connected with the crank-  
65 shaft, the continuous rotating motion of

which produces intermittent rotation of the ported timing shaft.

2. A timing system according to Claim 1, wherein the engine cylinder operates on the four stroke cycle, the crankshaft actuating a drive wheel having two drive pins in order to cooperate with the Maltese cross having four drive slots, whereby the crankshaft rotates twice as fast as the timing shaft which is rotatable with the Maltese cross, the timing shaft having four dwell periods during each revolution thereof.

3. A timing system according to claim 2, wherein the four dwell periods of the timing shaft occur each time after a rotation of 90° of it, the first dwell period occurring when the inlet port of the timing shaft places the cylinder mixture inlet passage into full flow communication with the combustion chamber and the cylinder piston commences its inlet stroke, the second dwell period occurring during the compression stroke when the cylinder inlet and outlet are both isolated from the combustion chamber by the ported timing shaft, the third dwell period occurring during the working or combustion stroke when again both the cylinder inlet and outlet are isolated from the combustion chamber, and the fourth dwell period occurring during the exhaust stroke when the combustion chamber is placed in full flow communication with the exhaust outlet.

4. A timing system according to any one of the preceding claims, wherein the timing shaft is cylindrical, and the ports therein are sector shaped.

5. A timing system according to claim 4, wherein the apex angle of the sector shaped inlet port is 155°.

6. A timing system according to claim 4 or claim 5, wherein the apex angle of the sector shaped outlet port is 180°.

7. A timing system according to any one of the preceding claims, wherein the timing shaft serves a plurality of engine cylinders, the shaft having an inlet and on outlet port disposed in the head of each cylinder.

8. A timing system according to any one of the preceding claims, wherein the cylinder head, the ported shaft and the Maltese cross form a unit which is independent of the engine unit and is therefore readily interchangeable.

9. A timing system according to any one of the preceding claims, wherein the cylinder head comprises a base which can be fixed on an engine unit; a hollow cylindrical part in which the cylindrical part of the ported shaft rotates; an intake pipe disposed approximately radially on the hollow part to connect the inside of cylinder head and consequently the cylinder *via* the intake port with the intake pipe, an exhaust pipe being disposed approximately radially on the

hollow part to connect the inside of the cylinder head and consequently the cylinder, *via* the exhaust port, with the atmosphere, an aperture for a sparking plug; two bearings for spindles of the ported shaft; and a support for the shaft bearings of the drive wheel of the Maltese cross.

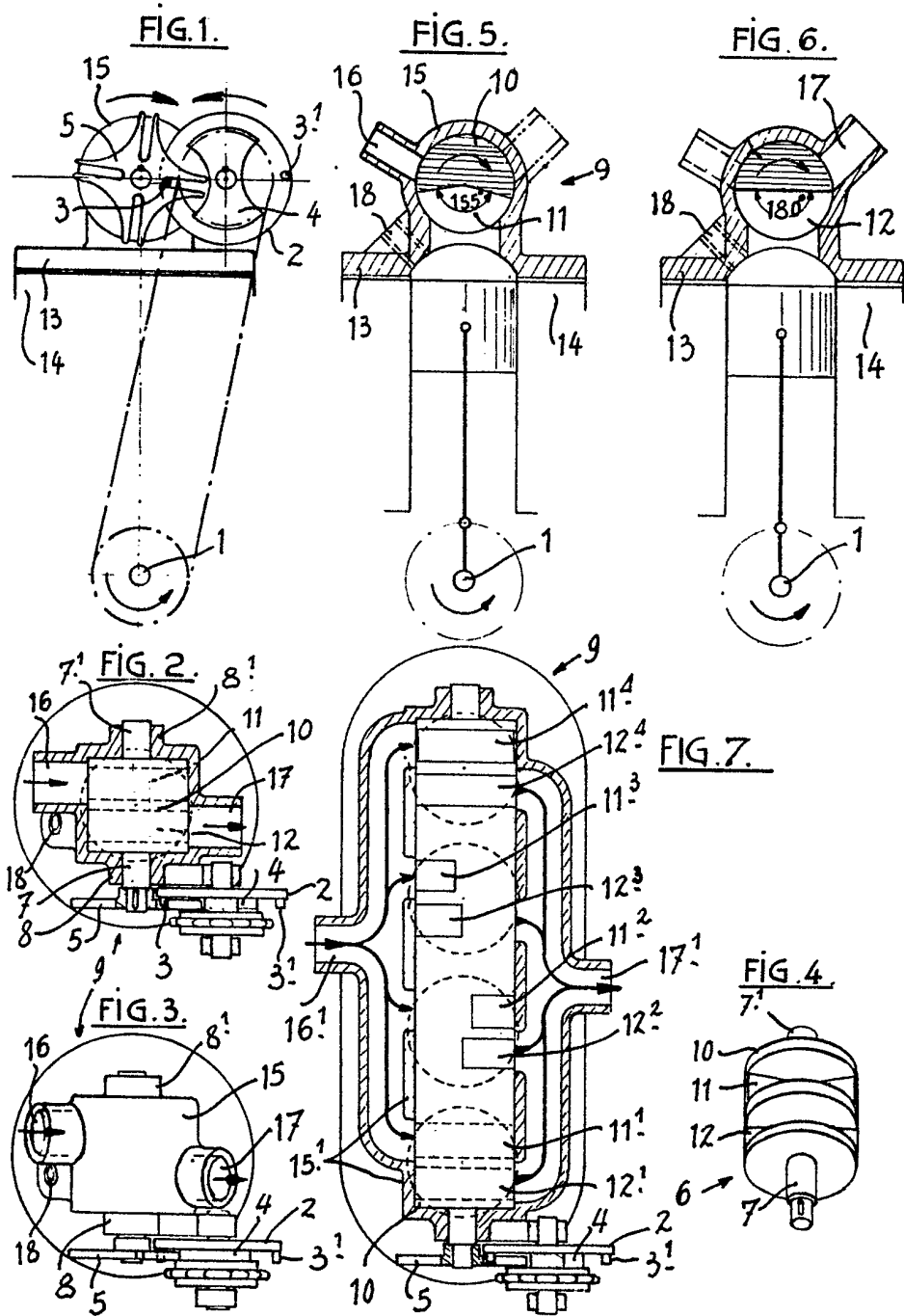
10. A timing system according to any of claims 1 to 9, wherein the apex angle of the intake and exhaust ports of the timing shaft is calculated as a function of the position of the intake and exhaust pipes of the cylinder head and as a function of the shape of the cylinder head combustion chamber.

15 11. A timing system substantially as hereinbefore described with reference to and

as shown in Figures 1 to 7 of the accompanying drawings.

12. A timing system according to any one of the preceding claims and having a 20 cycle of operation substantially as hereinbefore described with reference to and as shown in Figures 8 to 24 of the accompanying drawings.

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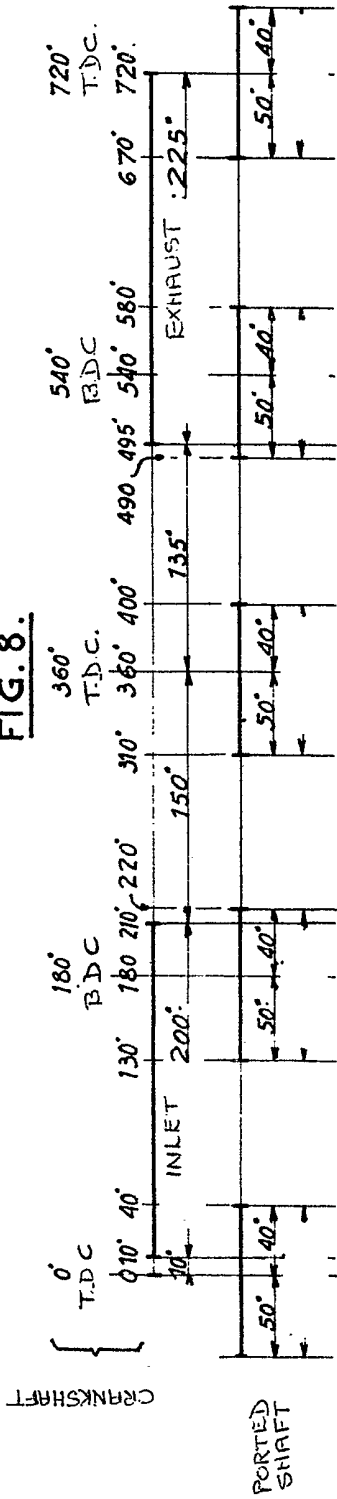
5 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.

SHEET 2

FIG. 8.



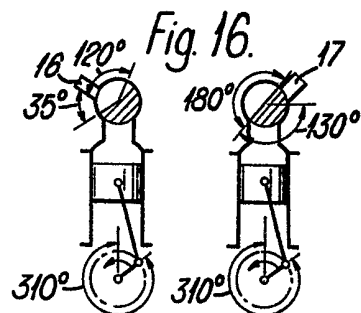
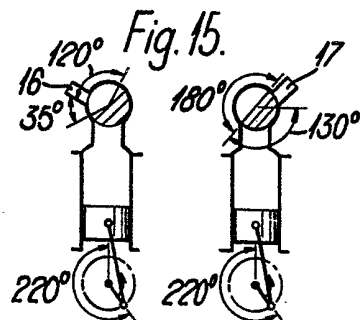
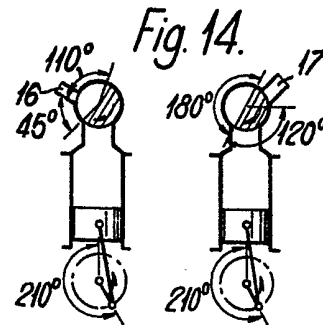
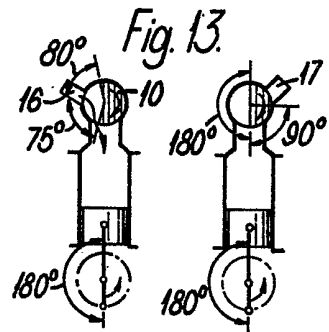
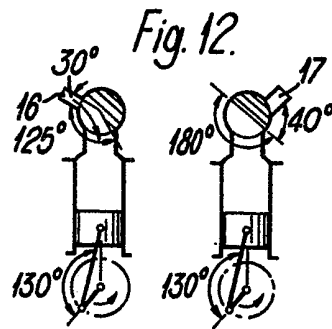
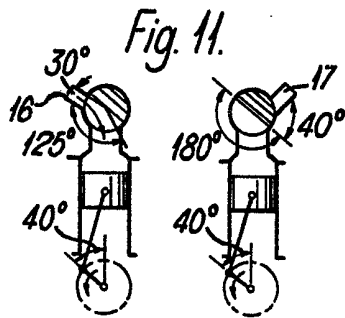
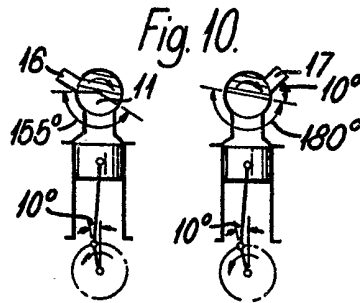
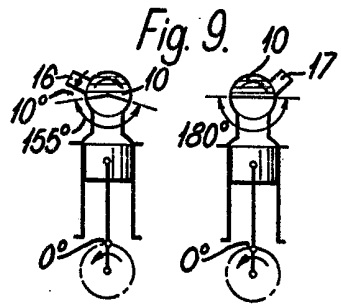


FIG.20.

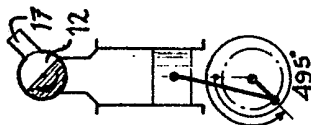


FIG.19.

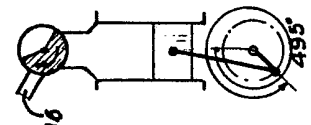


FIG.18.

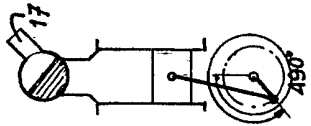


FIG.17.

