Oct. 25, 1960 C. W. CLARK 2,957,462

INTERNAL COMBUSTION ENGINES OF THE SWASH OR WOBBLE PLATE TYPE

Filed Dec. 12, 1958 2 Sheets-Sheet 1

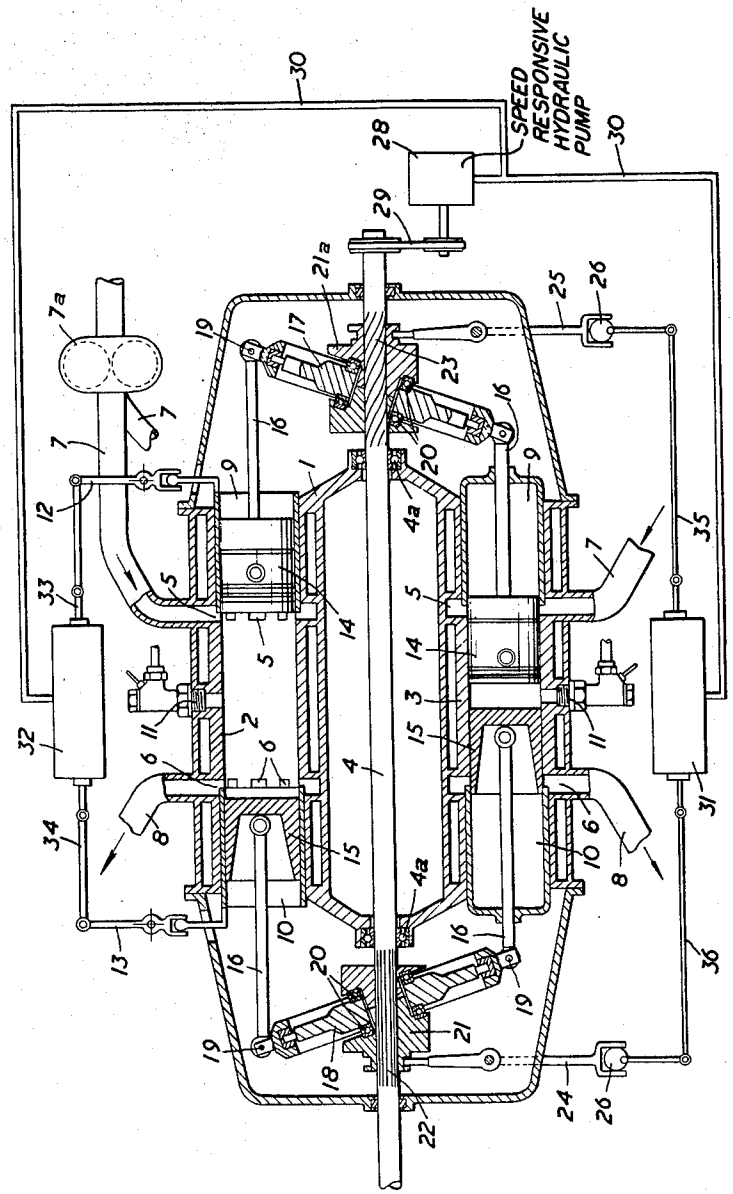

FIG. 1.

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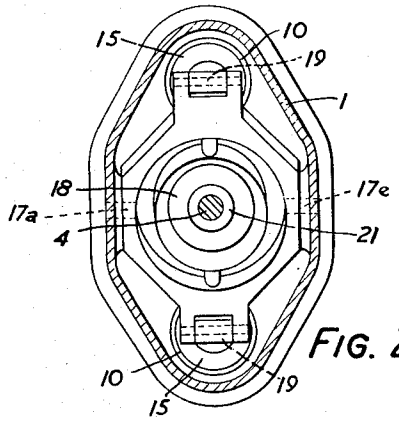

FIG. 2.

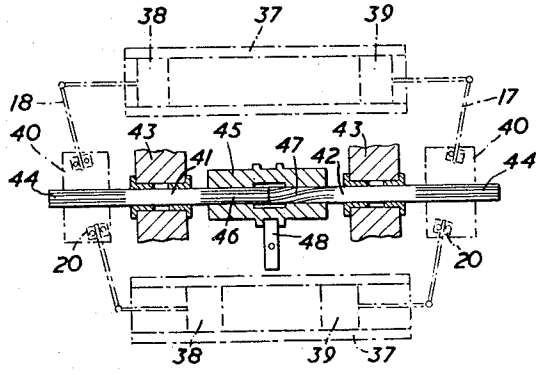

FIG. 3.

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United States Patent Office 2,957,462 Patented Oct. 25, 1960

2,957,462

INTERNAL COMBUSTION ENGINES OF THE SWASH OR WOBBLE PLATE TYPE

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Filed Dec. 12, 1958, Ser. No. 779,908

Claims priority, application Great Britain Dec. 17, 1957

2 Claims. (Cl. 123—58)

This invention relates to reciprocating internal combustion engines of the kind comprising two swashplates or wobble plates arranged to rotate at the same speed about a common axis and axially displaced from one another, at least two cylinders arranged with their axes parallel to and equally displaced from the rotational axis of the swashplates or wobble plates, and two pistons arranged to reciprocate in each cylinder and to act respectively on the swash plates or wobble plates to cause rotation thereof, the swashplates or wobble plates being so arranged that the two pistons in each cylinder move towards and away from one another while each cylinder is provided with inlet and exhaust ports which are uncovered respectively by the two pistons at the ends of their outward travel to permit the exit of the products of combustion and the entry of a fresh charge ready for compression into the combustion chamber between the pistons on their next instrokes so that the engine operates upon the two stroke cycle.

The term "swashplate or wobble plate" used herein is to be understood as including a member having a continuous thrust surface lying in a plane inclined to its axis of rotation and acted upon through slippers or the like by the pistons as well as a member which carries or forms one part of a thrust bearing the axis of which is inclined to the axis of rotation of the member and which connects it to the member and is itself connected to the pistons. For convenience herein the term "swashplate" will be used to include both such known arrangements. Nevertheless the invention is particularly though not exclusively applicable to engines of the type in question in accordance with the present applicant's British Patent No. 762,777.

A reciprocating internal combustion engine of the kind referred to according to the present invention includes means by which the opening periods of the inlet and/or exhaust ports by the pistons can be varied to suit different running conditions. Such means may be arranged to alter the phase relationship between the two swashplates so as to alter the relationship between the periods of opening respectively of the inlet and exhaust ports in each cylinder and/or to vary the axial length of the inlet ports and/or the exhaust ports to vary the moment of opening and/or closing of the inlet and/or exhaust ports in relation to one another and/or the rotational position of the swashplates.

Thus in one form of the invention one or each of the swashplates may be movable relatively to the cylinders in a direction parallel to the axis of the cylinders, in which case the swashplates may be mounted on a common main shaft extending between them and on which one or each of them can slide axially. Moreover in such a case the connection between one of the swashplates and the main shaft may be such that as it is moved axially it also rotates relatively to the main shaft as by being connected to the main shaft through helical splines.

Alternatively the swashplates may be mounted upon separate coaxial main shafts which are connected to one another through a coupling member capable of sliding axially relatively thereto, one of the connections being such that the axial movement produces no relative rotation between the shaft and the coupling while the other is such that such relative rotation is produced as by the connection being through helical splines. It will be apparent that in each of the above arrangements embodying a helical spline or like connection the adjustment will produce a change in the phase relationship between the swashplate and hence between the movements of the pistons connected respectively to them.

Alternatively or in addition one or each of the pistons in each cylinder may be arranged to operate with in a sleeve which is axially adjustable in the cylinder to vary the period of opening of the ports controlled by that piston.

In all arrangements according to the invention the means by which adjustment is effected are capable of being operated during operation of the engine so that adjustment can be effected during such operation to suit operating conditions. It is thus possible with the invention to vary the "timing" of the inlet and exhaust port opening periods in each cylinder to suit operating conditions, and the means would conveniently be arranged to be adjusted automatically in accordance with the speed of the engine.

The two examples of the invention are shown diagrammatically in the accompanying drawings, in which

Figure 1 is a somewhat diagrammatic side elevation, mainly in section, of one arrangement.

Figure 2 is an end elevation showing one of the wobble plates assemblies of Figure 1 and

Figure 3 is a diagrammatic side elevation, partly in section, of another arrangement.

In the construction diagrammatically illustrated in Figures 1 and 2 the engine comprises a main body part indicated generally at **1**, in which are formed or rigidly carried two cylinders indicated generally at **2** and **3**, the axes of the cylinders being spaced from one another and parallel to one another and lying on diagrammatically opposite sides of a main shaft **4** which is supported in bearings **4***a* in the body **1**. Each of the cylinders **2** and **3** has formed in its wall inlet and exhaust ports **5** and **6** communicating respectively with an inlet passage **7** and an exhaust passage **8**. The inlet passages **7** are connected to an air compressor **7***a* and the effective positions of the edges of the inlet and exhaust ports **5** and **6** are determined respectively by the axial positions of two sleeves **9** and **10** mounted to slide within the outer ends of the cylinders and forming in effect the outer ends of the cylinder bore.

A fuel injection device **11** is mounted in each cylinder wall adjacent to the centre of its length, that is to say in the part of the cylinder which constitutes the combustion chamber. The axial positions of the two sleeves **9** and **10** are controlled by levers indicated at **12** and **13** for the cylinder **2** and omitted for convenience of illustration as regards the cylinder **3**. Thus as regards the sleeves **12** and **13** associated with the cylinder **3** the levers **12** and **13** and associated control mechanism hereinafter described, and shown associated with cylinder **2** would be disposed behind cylinder **3** in Figure 1.

Arranged to reciprocate within each cylinder are pistons **14** and **15** which act through connecting rods **16** on swashplates **17** and **18** through bearings indicated at **19**. Each of the swashplates **17** and **18** is connected to the casing **1** by a pair of coaxial trunnions **17***a* or **18***a* and is connected by inclined bearings **20** to a supporting member **21** or **21***a* carried by and arranged to rotate with the main shaft **4**. The arrangement is thus similar to that described and shown in British patent specification No. 762,777.

The supporting member 21 is connected to the main shaft 4 by parallel splines as indicated at 22, while the member 21*a* is connected to the main shaft 4 through helical splines indicated at 23, and levers indicated at 24 and 25 controlled by cams indicated at 26 are provided by which the members 20 and 21 can be moved axially relatively to the cylinders 2 and 3.

It will therefore be seen that by moving the member 21 axially relatively to the cylinders by operation of the appropriate cam 26 both the timing of the opening of the ports 6 and if desired the compression ratio of the engine can be varied, while by similarly moving the member 21*a* axially the timing of the opening of the ports 5 and the phase relationship between the movements of the pistons 14 and 15 can be varied. Further by adjustment of the sleeves 9 and 10 by the levers 12 and 13 the opening periods respectively of the inlet and exhaust ports can be varied.

The cams 26 and the levers 12 and 13 may moreover be connected to speed-responsive control mechanism by which they are moved automatically in accordance with changes in the speed of rotation of the shaft 4. Such mechanism may be of known hydraulic type and in the example shown comprises a speed-responsive hydraulic device 28 including in known manner a hydraulic pump driven from the shaft 4 through driving mechanism indicated at 29 and constructed so as to produce and maintain in pipe lines 30 a pressure dependent upon the speed of the shaft 4 and piston type hydraulic servo devices 31 and 32 subject to the pressure in the pipe lines 30 and having their pistons connected by connecting rod systems indicated generally at 33, 34, 35 and 36 respectively to the levers 12 and 13 and the cams 26 acting on the levers 25 and 24.

Thus during operation of the engine the positions of the cams 26 and of the sleeves 9 and 10 are varied automatically by and are dependent upon the engine speed.

The movement imparted to the cams 26 and the levers 12 and 13 with variations in engine speeds will be such as to suit the characteristics of the particular engine concerned and would be determined in accordance with those characteristics in the manner hereinafter described.

In the alternative arrangement shown diagrammatically in Figure 3 the general construction and disposition of the cylinders, indicated at 37, will be the same as the cylinders 2 and 3 in the construction shown in Figure 1 the cylinders, however, being in this case of normal open-ended form without embodying sleeves similar to the sleeves 9 and 10 in Figure 1. It will be understood that the cylinders will be provided in known manner with inlet and exhaust ports arranged to be uncovered by pistons indicated at 38 and 39 therein. Moreover the pistons are connected to swashplates 17 and 18 similar to the swashplates 17 and 18 shown in Figure 1, these swashplates being connected through appropriate bearings similar to the bearings 22 to supporting member 40. In this construction, however, instead of a one-piece main shaft 4 as shown in Figure 1 the main shaft comprises two sections 41, 42 each individually mounted in bearings in part of the body of the engine indicated at 43. The two shaft parts 42, 43 are connected respectively to the two supporting members 40 through parallel splines as indicated at 44 and are connected to one another by a sleeve 45 which is arranged to rotate with them and is connected to the shaft part 41 by parallel splines 46 and to the shaft part 42 by helical splines 47. The sleeve 45 is arranged to be axially movable relatively to the two shaft parts by means of an operating fork indicated at 48 and it will be apparent that this movement will cause rotation of the shaft part 41 relatively to the shaft part 42 and thus vary the phase relationship between the supporting members 40 and hence between the movements of the two pistons in each cylinder.

In this arrangement the operating fork 48 could be connected to speed-responsive actuating apparatus, for example hydraulic apparatus similar to that operating one of the levers 24, 25 in Figure 1, so that the phase relationship is varied automatically in some predetermined manner in accordance with the speed of rotation of the shaft 41, 42.

The manner in which the control means embodied in engines according to the invention are moved in accordance with speed changes will vary according to the characteristics of the engine concerned and the appropriate movements would normally be determined by experimental operation of any particular engine having such control means over its working range. Thus under each operating condition within the appropriate range of operating conditions the control means would be adjusted manually to determine what adjustment gives to the maximum degree the desirable operating characteristics for that condition. The automatic control means would then be arranged so that it moves the appropriate parts, as through the cams and levers to provide substantially the best operating conditions over the whole speed range.

In this connection it is well recognised that existing internal combustion engines, and particularly high efficiency internal combustion engines, have compression ratios and timing for inlet and exhaust port openings which represent a compromise aimed at meeting to a reasably satisfactory degree the required conditions, but that this results in the ideal requirements having to be to some degree sacrificed under each running condition. For example, the port timing appropriate to give the maximum efficiency at high speed is frequently inefficient and wasteful at lower speeds, while starting may be rendered difficult by use of a port timing which gives maximum power output at high speed. The present invention thus aims at providing an engine of the particular kind to which the invention relates in which the best operating conditions over the whole operating range of the engine can be more nearly approached than in existing engines.

What I claim as my invention and desire to secure by Letters Patent is:

1. A reciprocating internal combustion engine comprising two swashplates arranged to rotate at the same speed about a common axis and axially displaced from one another, at least two cylinders arranged with their axes parallel to and equally displaced from the rotational axis of the swashplates, two pistons arranged to reciprocate in each cylinder and to act respectively on the swashplates to cause rotation thereof, the pistons in each cylinder moving towards and away from one another and each cylinder being provided with inlet and exhaust ports which are uncovered respectively by the two pistons at the ends of their outward travel to permit the exit of exhaust gases and the entry of a fresh charge, sleeves axially movable in the cylinders and controlling the effective length of the ports, mechanisms controlling the positions of the sleeves, and speed-responsive means controlling said mechanisms.

2. A reciprocating internal combustion engine as claimed in claim 1 in which the mechanisms controlling the sleeves act independently on each of the sleeves.

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