Sept. 19, 1933. V. A KJÆR 1,927,368

FOUR-STROKE INTERNAL COMBUSTION ENGINE

Filed Aug. 12, 1930

Fig. 1.

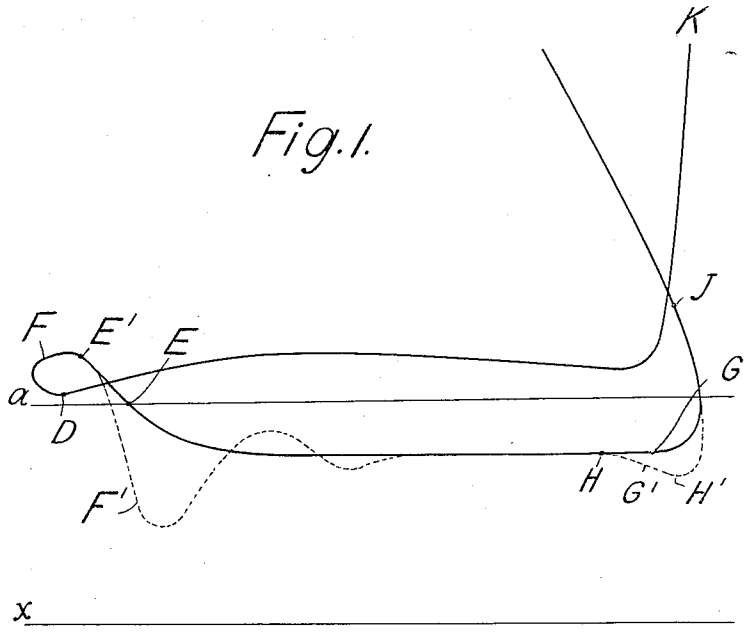


Fig. 2.

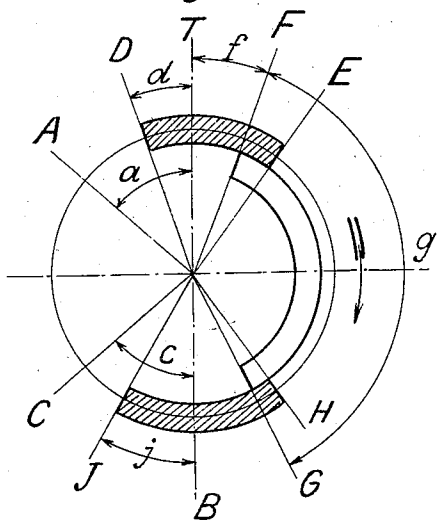
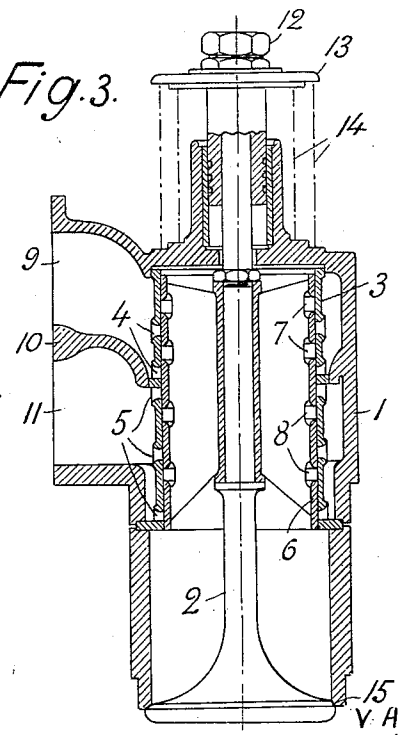


Fig. 3.



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FOUR-STROKE INTERNAL COMBUSTION ENGINE

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1 Claim. (Cl. 123—76)

The invention relates to an improvement in fourstroke internal combustion engines of that kind where atmospheric air and compressed air are admitted periodically at intervals. In such engines the compressed air may be supplied for scavenging of the combustion space of the cylinder before the usual suction stroke at the end of which compressed air may be supplied with the purpose of supercharging the engine. In the known internal combustion engines of the said kind, the usual charge of induction air is introduced through suction passages communicating with the atmosphere, while the compressed air is introduced through other passages leading from blowers or compressors to the individual engine cylinders. In some known apparatus pertaining to the stated kind the introduction of both the normal air charge and the compressed air is controlled by the usual suction valve of the cylinder, and in addition hereto special means are provided and combined with the suction and pressure passages effecting the transition from atmospheric air to compressed air. The communication from the pressure passage to the suction valve may e. g. be controlled by a special, controlled valve, while the suction passage may be provided only with an automatic non-return valve which remains closed as long as the pressure in the valve housing of the suction valve is higher than that of the atmosphere. In other known apparatus the supply of compressed air as well as the supply of atmospheric air is controlled by a piston- or sleeve valve which may be situated in the intake manifold or arranged in some other way. In the known arrangements of internal combustion engines of the above mentioned kind, in which compressed air is supplied for scavenging of the combustion space of the cylinder before the usual suction stroke, the supply of air is so controlled that the usual induction of atmospheric air begins just shortly after the compressed-air supply for the scavenging is cut off. On account hereof a considerable pressure reduction is effected in the cylinder at the transition from the compressed air to the atmospheric induction air. These pressure variations give rise to various drawbacks. They lead for example to noise and objectionable pulsations and constant surging in the induction pipes and compressed-air supply pipes; they also increase the power required during the suction stroke of the engine. The present invention is principally directed to avoiding these drawbacks by so constructing or controlling the part or parts which control the supply of atmospheric air and/or compressed air to an engine cylinder that the period during which the cylinder is open to the atmosphere overlaps the scavenging period during which the cylinder is in communication with the compressed air supply. The invention can be applied as well to internal combustion engines, which only work with scavenging as also internal combustion engines employing both scavenging and supercharging. In the latter case it is often found desirable that the period during which the engine cylinder is open to the atmosphere besides the scavenging period should also overlap the supercharging period during which the engine cylinder is again in communication with the compressed air supply. The part or parts controlling the supply of atmospheric air and/or compressed air to the engine cylinder is or are preferably so constructed or controlled that the pressure in the cylinder during the entire suction stroke, does not pulsate or produce pressure waves, the pressure reductions occurring smoothly between the different periods during which compressed air and atmospheric air are introduced. The air control is preferably so arranged that the opening of communication between the engine cylinder and the atmosphere at the end of the scavenging period takes place gradually and simultaneously with or approximately simultaneously with the gradual closing of the communication between the engine cylinder and the compressed-air supply pipe supplying scavenging air. In a corresponding manner the opening of the communication between the engine cylinder and the compressed-air supply at the end of the normal suction period, in engines in which the normal suction period also overlaps the supercharging period, may take place gradually and simultaneously with or approximately simultaneously with the gradual closing of the supply of atmospheric induction air to the engine cylinder. By the present invention it is, as already stated, possible to attain a pressure cycle in the engine cylinder in which the pressure rises and falls smoothly between the different periods so that it does not give rise to objectionable noisy pulsations, and at the same time the useless work in the engine cylinder is reduced to a minimum. The manner in which the arrangement operates is illustrated in the drawing, in which Fig. 1 is a weak spring indicator diagram, and Fig. 2 a corresponding crank diagram relating to a device according to the invention. Fig. 3 shows a suitable constructional form of a valve device according to the invention. In the two diagrams, corresponding positions of the crank and piston are designated by the same

reference letters. In Fig. 1 the pressure conditions in a cylinder are given in full lines when the air supply is controlled according to the invention, while the variations in the pressure conditions in an engine controlled in known manner are indicated in dotted lines. In the known arrangements the exhaust occurs in the usual manner as indicated by the exhaust line K—D. The point D represents the moment when the compressed-air supply is established for scavenging, which causes the pressure to rise in the succeeding period, that is, during the latter part of the exhaust stroke and the beginning of the suction stroke, until the supply of compressed-air is cut off when the piston is in the position indicated by the point E'. As the communication to the atmosphere has not yet been established a sharp drop in pressure occurs in the cylinder until the piston reaches the position where the communication to atmosphere is established, viz. in the position indicated by the point F'. Thereafter the pressure still falls somewhat as a certain time elapses before the particular valve or like device establishes full communication with the atmosphere. On account of the sharp drop in pressure above mentioned and the subsequent pressure rise during the induction of atmospheric air, pressure waves and pulsations occur as indicated by the first part of the suction line shown in dotted lines. During the latter part of the suction period these pulsations are suppressed. In the position of the piston indicated by the point G' the communication to atmosphere is completely cut off and the pressure has already before this moment begun to fall and falls still further for a while, because the valve admitting the compressed-air supply has not been sufficiently opened yet until the piston is in the position indicated by H'. Only then does the pressure begin to rise. By the arrangement according to the present invention, the exhaust takes place as above described along the exhaust line K—D, and at the moment determined by the point D the supply of compressed air for scavenging is established, causing the pressure to rise, and the cylinder is scavenged during the period corresponding to the line D—E. According to the invention, however, the communication with the atmosphere is established when the piston is in the position designated F and during the period F—E the communication with the compressed-air supply is gradually closed, whilst at the same time the communication between the cylinder and the atmosphere is gradually established. As a consequence hereof a smooth drop in pressure occurs in the period F—E and further in the first part of the succeeding period, so that the suction line gets a slight downwards curved form on the portion E—H, in which period the sucking in of atmospheric air takes place. At the moment corresponding to the point H the compressed-air supply is again established, opening gradually during the period H—G, and simultaneously the communication between the engine cylinder and the atmosphere is gradually cut off, so that in the position of the piston corresponding to the point G it is completely cut off. Through proper timing of the period of overlap H—G the suction line forms a straight continuation of the preceding portion of the suction line, that is to say, there is no drop in pressure. In the succeeding period G—J a sharp rise in pressure occurs in the cylinder because the supply of compressed air is established during this period. The pressure rise is continued during the succeeding compression stroke. It is apparent from the diagram of Fig. 1 that the manner wherein the parts effecting the supply of the compressed air and atmospheric air to the cylinder are controlled according to the invention results in practically entirely avoiding the sharp pressure surges and pressure falls occurring in hitherto known arrangements as indicated in dotted lines. In the crank diagram shown in Fig. 2, the arrow indicates the direction of rotation of the crank, and the suction valve is supposed to open in the position A of the crank during the exhaust stroke, i. e. at an angle *a* before the top dead centre T of the crank. The supply of compressed air for scavenging purposes is, however, only opened in the position D of the crank, i. e. at an angle *d* before the top dead centre T, this supply being held open until the position E of the crank. According to the above the communication with the atmosphere has then already been opened, viz. in the position F of the crank, i. e. at an angle *f* after the top dead centre. The communication with the atmosphere is open during the period F—G corresponding to the angle *g*, but already in the position H of the crank the supply of compressed air for the supercharging is opened, this supply taking place until the position J of the crank, i. e. at an angle *j* after the bottom dead centre B. C indicates the position of the crank (angle *c* after the bottom dead centre) where the suction valve proper is again closed. In Fig. 2 it is assumed that there are special controlling parts for the supply of atmospheric air and/or compressed-air, in addition to the suction valve. The said parts may either be independent of the suction valve or connected with the latter. The controlling arrangement described is not limited to any special valve device so long as it fulfills the conditions required by this invention. These conditions require, however, as will be manifest, that controlled valves or the like must be employed by means of which the period for the opening and closing of the communication with the atmosphere and/or the compressed-air supply pipe can be regulated in the desired manner and consequently selfacting check valves or the like will probably not be used. In Fig. 3 is shown a valve arrangement where the means controlling the supply of atmospheric air and compressed air respectively are combined with the suction valve proper, the air supply being controlled by a sliding valve arrangement situated in the valve housing of the suction valve and connected with its spindle so as to be affected by the same cam arrangement as the suction valve. 1 is the valve housing and 2 the spindle of the suction valve ending at its lower end in a customary valve disc. In the housing 1 is inserted a liner 3, the upper portion of which has a number of ports 4 for the supply of previously compressed air, while ports 5 for the supply of the normal air charge are provided in the lower portion of the liner. Within the liner 3 a cylindrical slide valve 6 is secured to the valve spindle 2 and provided with a set of ports 7 in its upper portion and with a set of ports 8 in its lower portion. 9 is a branch to which a compressor pipe may be connected and which is separated by a partition 10 from a branch 11 communicating with the atmosphere. The spindle 2 is provided at its top with an abutting surface for a pressure screw, cam roller or the like on a lever or the like controlling the valve from a cam. The valve spindle 2 is also provided with a spring socket 13 and spring 14 serving to keep the disc of the valve pressed against the valve seat 15. By proper ar-

rangement of the sets of ports 4, 5, 7, 8 relatively to each other the valve device acts in the manner specified above in connection with the diagrams shown in Figs. 1 and 2.

In my co-pending application No. 398,724 a construction of a valve is set forth which is of similar kind as that which is preferably used according to my present application. However, said prior application relates to the more specific construction of the valve and its arrangement in relation to the valve housing of the engine, whilst the present application more particularly concerns the special feature of the arrangement of the controlling means for the supply of atmospheric air and compressed air in a definite manner, as described in the following. In the valve construction which here is set forth, and which is of similar kind as that of the prior application, the idea of the invention essentially appears in the definite relative positions of the different ports in the valve sleeve and in the cylindrical liner, in which the valve is inserted.

I claim:

A four-stroke-cycle internal combustion engine in which atmospheric air and compressed air are admitted periodically at intervals the compressed air being supplied before the usual suction stroke in order to scavenge the combustion space of the engine cylinder and at the end of said stroke with the purpose of supercharging the cylinder, atmospheric air being sucked in during the interposed period, comprising an engine cylinder, pipes connected respectively with the atmosphere and a source of supply of compressed air, and means controlling communication between said pipes and said cylinder, said control means being constituted by a main suction valve, a movable sleeve connected with and operated by said main suction valve, a fixed sleeve cooperating with said movable sleeve, each of the two sleeves having separate sets of ports communicating respectively with the compressed air supply pipe and the atmospheric pipe, the respective sets of ports being successively moved into registration during displacement of the movable sleeve and being arranged to effect gradual opening and closing of the atmospheric ports coincident respectively with the closing and opening of the compressed air supply ports, whereby the opening and closing movements of the respective sets of ports overlap.

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