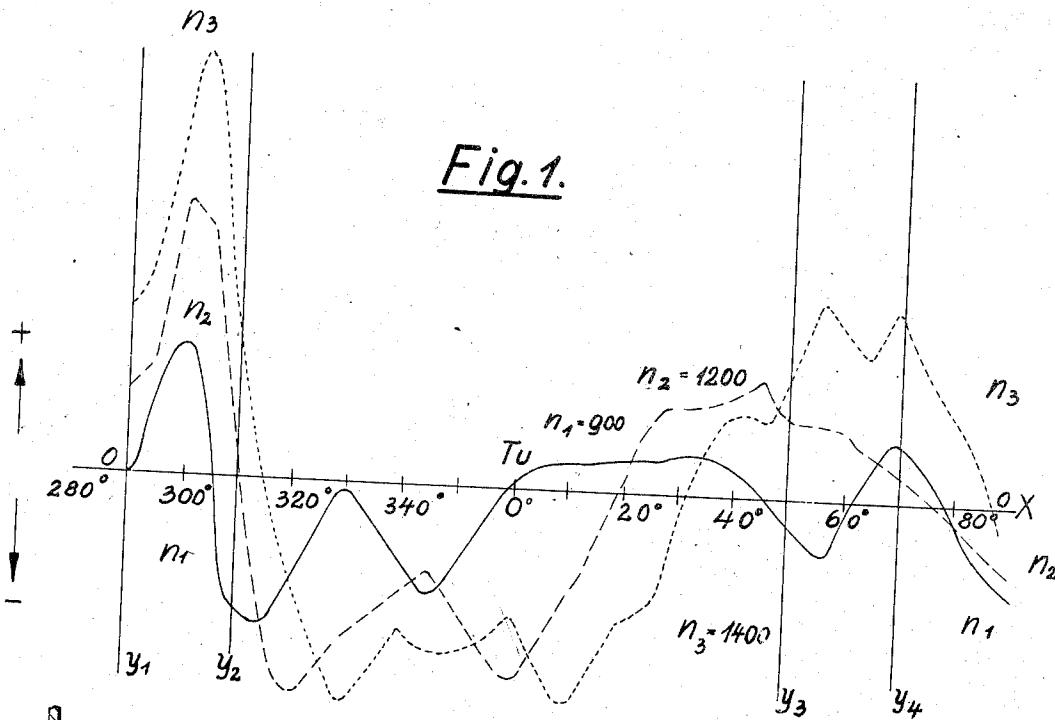
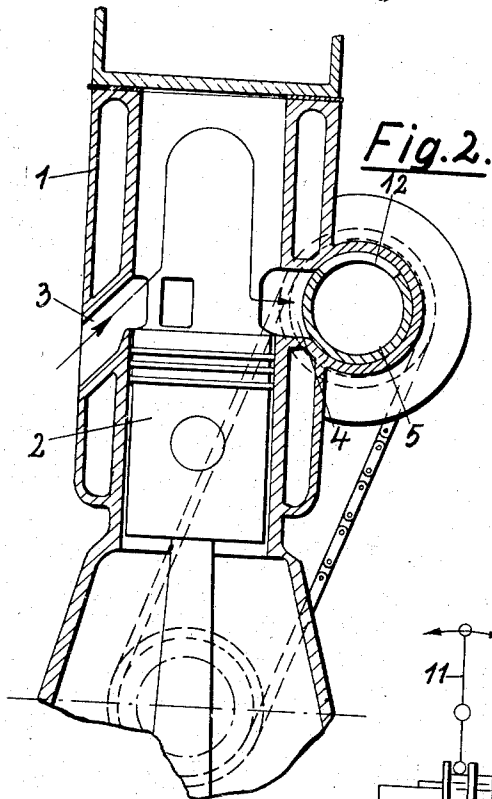
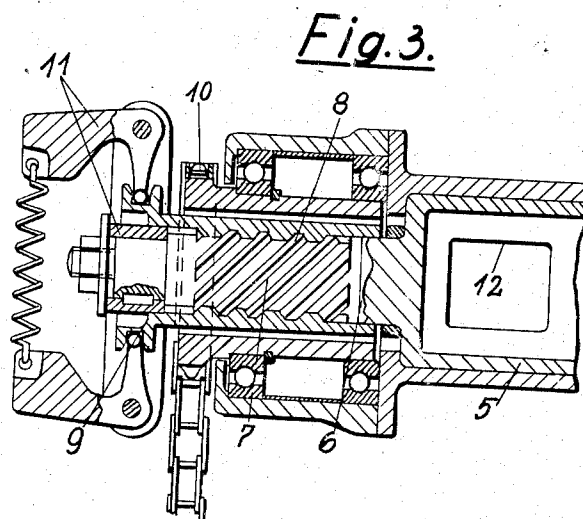
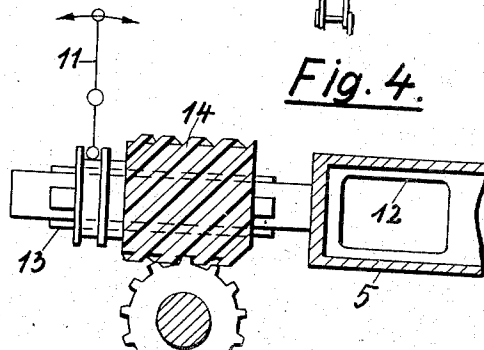


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INTERNAL COMBUSTION ENGINE
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INTERNAL COMBUSTION ENGINE

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This invention relates to two-stroke cycle internal combustion engines wherein at least a substantial portion of the burnt gases leaves the cylinder at a speed much higher than that obtaining when an adiabatic flow only is involved, and in such a short interval of time that it is discharged as a mass leaving a depression behind it, which is utilised in introducing a fresh charge into the cylinder by opening the inlet orifice with the required delay after the opening of the exhaust orifice to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct, and that a suction effect is exerted at the inlet orifice as a consequence of the exit of the said mass.

When the burnt gases leave the cylinder as a mass in the manner stated above, they leave a depression which may approach a complete vacuum behind them in the cylinder and in the exhaust duct close to the cylinder. The volume of this depression will depend upon the distance to which the mass of burnt gases travels away from the cylinder. Thereafter this outward movement is reversed in direction and a return of the gases towards the cylinder takes place. Consequently if the inlet orifice is opened while the exhaust orifice is open and the burnt gases are moving outwardly through the exhaust orifice or duct and a suction effect is exerted at the inlet orifice, the charge will enter into a substantially void space and may, therefore, if desired be introduced by atmospheric pressure alone.

If the reversal in direction of motion of the burnt gases occurs while the exhaust orifice is still open, burnt gases may re-enter the cylinder. This objectionable effect may be avoided by closing the exhaust orifice of the cylinder before the return of the burnt gases into the cylinder occurs. However if a crank angle is selected for exhaust closure which is suitable for a low engine speed, this will result in exhaust being closed at higher speeds not only before the return of the burnt gases occurs but while a depression still exists in the cylinder and in the exhaust pipe close to the cylinder. Thus, special provision will have to be made for completing the charge if maximum results are to be obtained.

According to the present invention the closure of exhaust is regulated in such a way that the suction effect created by the mass exit of the burnt gases from the cylinder is utilised as completely as possible at all engine speeds, and at the same time the return of the burnt gases into the cylinder is prevented.

For this purpose a regulating device is provided

which permits a shifting of the exhaust closure in relation to the commencement of exhaust or in relation to the crank, more particularly in such a way that the exhaust closure occurs relatively later at high speeds than at low speeds.

In the drawing the invention is illustrated in various embodiments.

Figure 1 shows a diagram of pressures existing in the exhaust pipe of a two-stroke Diesel engine during the exhaust period.

Figure 2 is a longitudinal section through such an engine with a rotary valve, and

Figures 3 and 4 each show a rotary valve control.

In Figure 1 the base line x denotes a development of a portion of the crank circle, and at the same time the zero line for the pressures. The lines n_1 , n_2 and n_3 represent the variation of the pressure in the exhaust connection after the opening of the exhaust and during the scavenging and charging operation at speeds of $n_1=900$, $n_2=1200$ and $n_3=1400$ R. P. M. The diagram shows that with a varying period of delay after the opening of the exhaust (y_1) the pressure at first rises rapidly, indicating the mass exit of the burnt gases but then falls just as rapidly, and descends below zero. After this, in the diagram illustrated, in about the region of the lower dead centre T_u of the piston movement, a pressure above zero occurs again denoting the return of the burnt gases towards the cylinder. As will be seen, with varying engine speeds, the particular moment at which the return occurs is shifted very considerably, in such a way that at high speeds the return occurs later and at low speeds already occurs correspondingly earlier in accordance with the longer time available for a definite crank angle. Now if the inlet and exhaust apertures are controlled by the piston at all speeds invariably and symmetrically in relation to the lower dead centre (as indicated by the vertical lines y_1 , y_2 , y_3 and y_4 of the diagram in Figure 1) and if the exhaust closure is adjusted to the normal high speed, the scavenging and charging of the cylinder is very materially hindered in the lower range of speeds, since a return of the burnt gases and the recurrence of the raised pressure occurs substantially earlier at a lower speed than at the normal upper speed. Thus for example, it will be seen from the diagram represented, that at 900 R. P. M. the return of the burnt gases occurs at the lower dead centre, whereas at a speed of 1400 R. P. M. the return only occurs at about 30° after the lower dead centre. On the other hand with an earlier invariable closing of the

exhaust the suction effect of the mass exit of the burnt gases could not be fully utilised at higher speeds.

Accordingly, the present invention provides a regulating means which is dependent upon the speed of the engine, and by which the closing of the exhaust port is shifted according to the speed of revolution in such a way that at all speeds it is effected substantially at the moment at which the mass of burnt gases would return into the cylinder. At low speeds, therefore, the exhaust must be closed earlier (for instance at $\pi=900$ at the lower dead centre) than at higher speeds (for example 30° after the lower dead centre at $\pi=1400$).

Within the ambit of the invention there may be employed any desired mechanical, pneumatic, hydraulic or electrical regulating device, known in itself, which is dependent upon the speed of revolution, in conjunction with any desired shut-off member, such as a rotary valve, a tubular valve, a piston valve, a lift valve or the like.

In Figure 2 the invention is illustrated as applied to a two-stroke Diesel engine, 1 denoting the cylinder, 2 the piston and 3 the inlet directly connected to the atmosphere without a blower, and 4 the outlet controlled by the piston like the inlet. As a supplementary controlling device for the exhaust there is also provided a rotary valve 5, which is connected according to Figure 3, with a shaft 6, which in its turn is provided with oblique keys or wedges 7 in the nature of inclined teeth. In the latter there mesh the twisted grooves 8 of a slide valve bush 9 which carries non-rotatably a driving toothed wheel 10, driven by the engine, and which can be displaced from time to time to left or right, directly or indirectly, for instance by means of a centrifugal governor to which it is connected by a lever 11. The angle of adjustment of the slide valve 5 is thereby shifted in the cylinder in relation to its drive 10, and therefore the control aperture 12 thereof is adjusted in relation to the exhaust port 4, so that the slide valve closes the exhaust port earlier at a lower speed, for instance about 20° after the lower dead centre in relation to the line π_2 in Figure 1, and correspondingly later at higher speeds.

The device according to Figure 4 acts in the same manner, except that here, instead of a bush provided with twisted grooves, a helical wheel 14 displaceable along keys 13 is provided. Means may also be provided for enabling the adjusting to be effected by hand.

I claim:

1. In an internal combustion engine, a cylinder having an inlet port subjected to substantially constant pressure, and an outlet port, means for opening said outlet port for momentarily reducing the pressure within said cylinder below atmospheric pressure and means for closing said outlet port before the pressure in said cylinder reaches said constant pressure, irrespective of the speed of the engine, said last means including means responsive to the speed of the engine.

2. In an internal combustion engine of the kind described having a cylinder, a piston adapted to reciprocate in said cylinder, an inlet opening in said cylinder adapted to supply scavenging air at substantially atmospheric pressure thereto, an outlet opening in said cylinder for the exhaust of the burnt gases, said openings being so positioned in said cylinder that the piston reciprocating therein opens said exhaust outlet before the admission inlet, whereby when the admission begins the mass of exhaust gases escaping through said

outlet has produced a vacuum or high depression in the cylinder for sucking in the scavenging air, and means for closing said exhaust before the pressure in said cylinder equals that of the incoming air, irrespective of engine speed, said last means including means responsive to the speed of the engine.

3. The combination according to claim 1 in which the means for closing the outlet port comprises a rotary sleeve valve, means for driving said valve from said engine, and a speed-change mechanism responsive to speed of the engine interconnecting the valve and said driving means.

4. The combination according to claim 2, in which said last means comprises a rotary slide valve, means adapted to rotate said slide valve in accordance with the speed of the engine, and means intermediate said engine and valve for adjusting said rotary slide valve, said means being responsive to the speed of the engine and so constructed and arranged that the outlet is closed relatively early for slow engine speeds and relatively late at higher engine speeds.

5. The combination according to claim 2 in which said last means comprises a rotary slide valve, a driving wheel for the same driven by the engine, a coupling device interconnecting said wheel and valve comprising two meshing wheels with oblique teeth, one rotating with said valve and the other with said wheel, and means responsive to the speed of the engine for varying the meshing of said wheels.

6. A method of controlling two-stroke cycle internal combustion engines, which comprises establishing communication between the exhaust system and the cylinder during the firing stroke, providing for the issuance of the gases at high speed as a compact mass leaving a high degree of vacuum in the cylinder, admitting a fresh charge when a suction effect is exerted in the cylinder and while the burnt gases are moving outwards through the exhaust system as a compact mass, cutting off the communication between the exhaust system and cylinder in relation with the movement of the burnt gases through the exhaust system as a compact mass, and varying the instant at which the said communication is cut off in relation with the engine speed.

7. A method of controlling two-stroke cycle internal combustion engines, which comprises establishing communication between the exhaust system and the cylinder during the firing stroke, providing for the issuance of the gases at high speed as a compact mass leaving a high degree of vacuum in the cylinder, admitting a fresh charge when a suction effect is exerted in the cylinder and while the burnt gases are moving outwards through the exhaust system as a compact mass, cutting off the communication between the exhaust system and cylinder in relation with the movement of the burnt gases through the exhaust system as a compact mass, and varying the instant at which the said communication is cut off in dependence upon engine speed, for producing an earlier closure of exhaust at lower speeds and a later closure of exhaust at higher speeds.

8. A method of controlling two-stroke cycle internal combustion engines, which comprises establishing communication between the exhaust system and the cylinder during the firing stroke, providing for the issuance of the gases at high speed as a compact mass leaving a high degree of vacuum in the cylinder, admitting a fresh charge when a suction effect is exerted in the cylinder and while the burnt gases are moving outwards

through the exhaust system as a compact mass, cutting off the communication between the exhaust system and cylinder in relation with the movement of the burnt gases through the exhaust system as a compact mass, so that the said communication is cut off before the return of the said mass of burnt gases to the cylinder, and varying the instant at which the said communication is cut off in dependence upon engine speed, for producing an earlier closure of exhaust at lower speeds and a later closure of exhaust at higher speeds.

9. In a variable speed two-stroke cycle internal combustion engine of the kind described, the combination with a cylinder, an exhaust system and an exhaust port leading to the exhaust system, of means for varying the crank angle occupied by the exhaust period.

10. In a variable speed two-stroke cycle internal combustion engine of the kind described, the combination with a cylinder, an exhaust system, an exhaust port leading to the exhaust system, of means for opening and closing the exhaust port and means for increasing the crank angle between exhaust opening and exhaust closure as the engine speed increases and for decreasing said crank angle as the engine speed decreases, said exhaust being closed at all speeds over a desired range of speeds immediately before the return of the burnt gases to the cylinder occurs.

11. In a variable speed two-stroke cycle internal combustion engine of the kind described, the combination with a cylinder, an exhaust system, an exhaust port leading to the exhaust system, of means for opening the exhaust port at a

constant crank angle and means for closing said exhaust port at a variable crank angle.

12. In a variable speed two-stroke cycle internal combustion engine of the kind described, the combination with a cylinder, an exhaust system, an exhaust port leading to the exhaust system, of a rotary exhaust valve, means for driving said valve in phase with the engine and means for adjusting said valve in relation to its driving means for varying the instant of exhaust closure.

13. Apparatus as claimed in claim 10, wherein said adjusting means comprises an axially displaceable helical member and speed responsive means for axially displacing said member.

14. In a variable speed two-stroke cycle internal combustion engine of the kind described, the combination with a cylinder, an inlet orifice, means for opening the inlet orifice and for closing the inlet orifice at a fixed crank angle after the opening thereof, an exhaust system and an exhaust port leading to the exhaust system, of means for varying the crank angle occupied by the exhaust period.

15. In a variable speed two-stroke cycle internal combustion engine of the kind described, the combination with a cylinder, an inlet orifice, means for opening the inlet orifice, an exhaust system, an exhaust port leading to the exhaust system, and means for opening and closing the exhaust port, of means for varying the crank angle between exhaust opening and exhaust closure and means for closing the inlet orifice after the closure of the exhaust port.

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