

Nov. 1, 1938.

M. KADENACY

2,134,920

INTERNAL COMBUSTION ENGINE

Filed Jan. 23, 1936

2 Sheets-Sheet 1

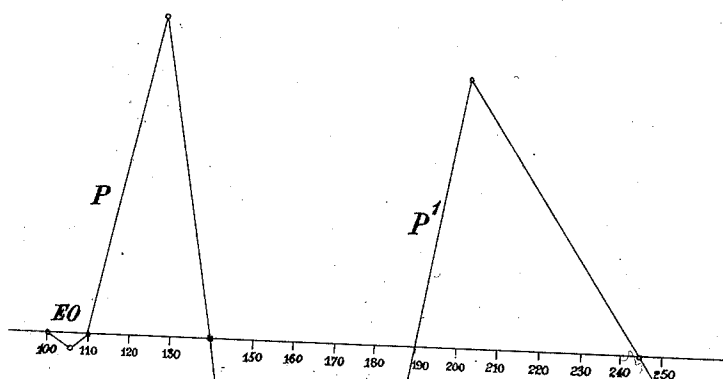


Fig. 1.

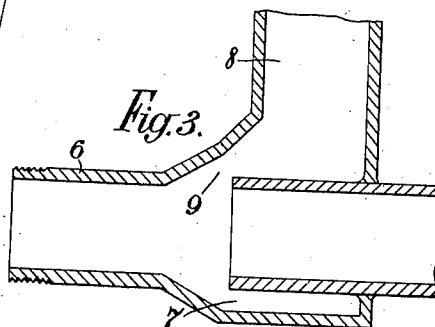


Fig. 3.

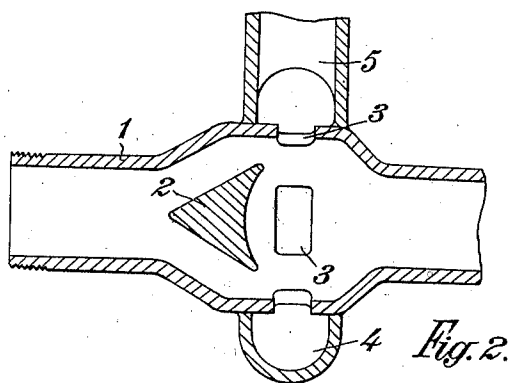


Fig. 2.

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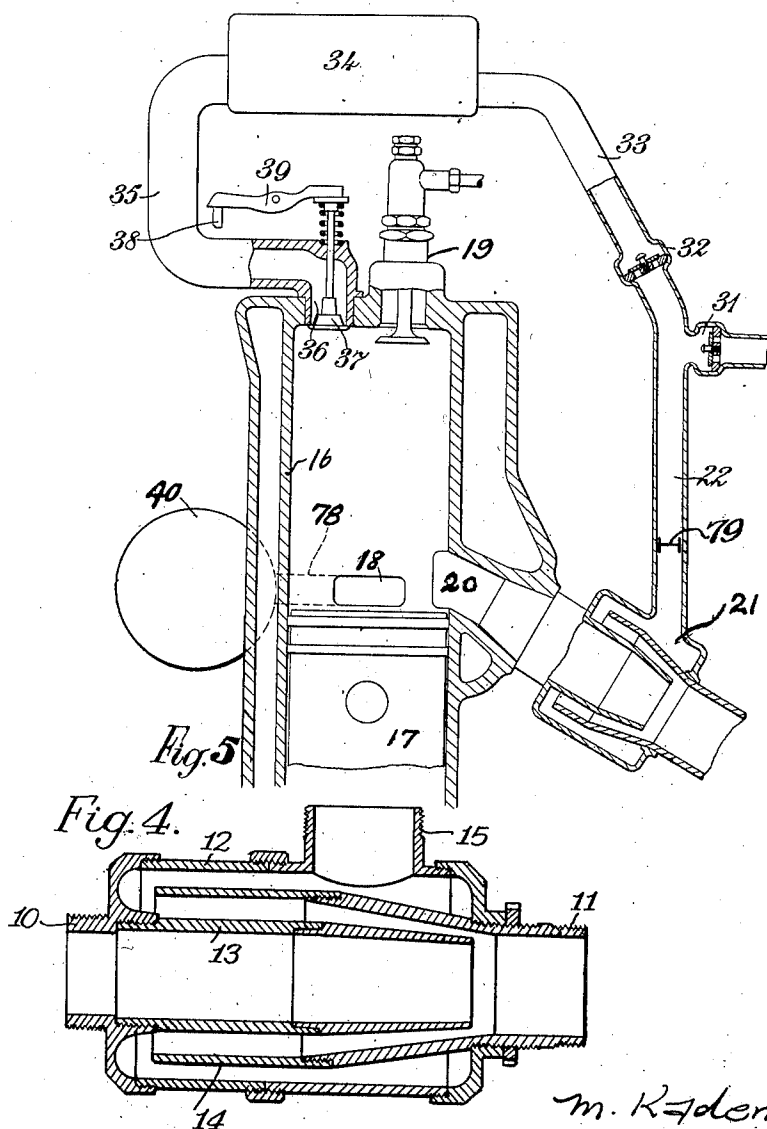
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INTERNAL COMBUSTION ENGINE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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INTERNAL COMBUSTION ENGINE

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38 Claims. (Cl. 123—65)

The applicant has found that in an internal combustion engine, the behaviour of the gases is such as to lead to the conclusion that as a consequence of the combustion of the charge, the burnt gases form a mass having a high initial velocity and possessing properties similar to those of a resilient body, so that when the exhaust orifice opens this mass seeks to project itself bodily from the cylinder and to leave the latter in a consequent vacuum condition.

The applicant has already proposed to utilize the void left in the cylinder when the burnt gases are discharged from the cylinder into the exhaust system as a mass, for the purpose of introducing a fresh charge into the cylinder.

In the operation of such engines the applicant has found that the burnt gases do not leave the cylinder immediately the exhaust orifice commences to open. There is first a period of delay, during which the burnt gases do not issue from the cylinder and after this delay has elapsed the burnt gases issue bodily from the cylinder with an extremely high velocity as a mass which responds to the laws of reflection and rebound and it leaves in the cylinder a profound depression. Subsequently, this outward motion of the burnt gases is reversed in direction and if the gases are allowed to re-enter the cylinder they destroy the depression left therein.

Accordingly the applicant has already proposed a method of charging two-stroke cycle internal combustion engines which consists in opening the admission orifice for the introduction of a fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust system as a consequence of their mass exit from the cylinder.

The present invention relates to such engines, but more generally to internal combustion engines or machines wherein the burnt gases, issue from the explosion chamber as a mass at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber.

In such engines or machines as a consequence of each exhaust operation, when the burnt gases are discharged through an exhaust duct, two pressure or impulse phases will be produced in the exhaust duct as a consequence of the mass exit and return of the burnt gases, and one depression or suction phase will be produced in the exhaust duct after the mass of burnt gases has left the cylinder and before it returns to the latter.

The intensity of the depression left in the working chamber by the exhaust gases when they leave the latter in mass form is very great. This depression exists in the cylinder and also the exhaust duct in a space which may be several times greater than the volume of the cylinder.

The invention consists in a method of utilizing an internal combustion engine or machine wherein the burnt gases are evacuated from the working chamber as a mass at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber for producing a flow of fluid external to the said engine, consisting in employing the periods of depression and impulse or pressure left and produced in the exhaust duct of the said engine by the mass exit of the burnt gases from the cylinder into the exhaust system in order to aspirate the said fluid and deliver the aspirated fluid to a point of utilization, disposal or storage.

The invention further consists in the combination of an internal combustion engine or machine, wherein the burnt gases are evacuated from the working chamber of the engine or machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber with a pump having suction and delivery orifices and a communication with the interior of the exhaust duct, at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, the arrangement being such that the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the mass exit of the burnt gases and/or the return of the said mass towards the cylinder initiates a delivery stroke or strokes of the said pump.

In a practical embodiment of the invention the engine to which the invention is applied is a two-stroke cycle internal combustion engine of the kind wherein the void left in the cylinder by the mass exit of the burnt gases from the cylinder into the exhaust duct is utilized in charging the cylinder, by opening an inlet for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the cylinder.

The action which creates the suction effect occurring in engines according to the present invention originates in the working chamber in which the combustion has been effected and is propagated from this chamber into the exhaust duct and into the pump, in that this suction effect is caused by the exit of the burnt gases from the working chamber at a speed greatly in excess of that obtaining when adiabatic action only is involved and in such a short interval of time that it is discharged as a mass.

In carrying out the present invention the natural tendency of the burnt gases to project themselves from the cylinder as a mass should be facilitated and not opposed, that is to say the area of the exhaust orifice available for the discharge of the burnt gases should be as large as possible and the interval of time in which the area required for this discharge of the burnt gases is made available should be as short as possible, in order to obtain the most satisfactory results.

As stated above the effects utilized in carrying out the present invention originate in the working chamber and are not produced by any action exerted by the exhaust duct but in carrying out the invention the exhaust duct should be of such a form that it permits the utilization of the actions in question. The exhaust pipe between the working chamber and the pump provided upon the exhaust duct should be free from abrupt restrictions or enlargement of cross-section and the connection between the pump and the exhaust duct should be situated at a point nearer the working chamber than the point of return of the burnt gases in the exhaust duct.

Some embodiments of the invention will now be described, simply by way of example, and with reference to the accompanying drawings, in which:

Figure 1 is a curve of pressures and depressions taken in the exhaust duct of an engine during the exhaust period.

Figures 2, 3 and 4 illustrate examples of exhaust duct arrangements whereby the depression left in the exhaust duct may be utilized in order to aspirate a fluid, and the pressure impulses occurring therein may also be utilized to deliver this aspirated fluid.

Figure 5 shows an embodiment, in which the invention is employed for supplying a supplementary charge of air to a two-stroke engine.

In Figure 3 the delivery is chiefly obtained by the direct impulse produced by the explosion gases upon issuing from the cylinder.

In Figure 4 the delivery is chiefly effected by the return impulse of the discharged exhaust gases, and in Figure 2 both the direct impulse and the return impulse of the exhaust gases are utilized.

If a record is taken of the pressure variations in the exhaust pipe of an internal combustion engine of the kind referred to during the exhaust period, a curve similar to that shown in Figure 1 may be obtained, in which EO represents the opening of exhaust, the ordinates represent pressures above and below atmospheric pressure and the abscissae crank angles in degrees.

It should be mentioned that in the figure the pressures above and below atmospheric pressure are not shown in scale relationship.

Such a curve may be obtained for example by utilizing a stroboscopic device formed by a ported tube mounted in or on the exhaust duct and ro-

tating with the engine and a stationary but angularly adjustable ported sleeve on this tube having its port connected to a manometer, a pressure or depression impulse being obtained each time the port in the tube and sleeve coincide and a record being taken when a steady reading is given on the manometer, the crank angle at which each reading is taken being determined by the angular adjustment of the sleeve.

The curve shows clearly the two phases of pressure or impulse P, P' that occur during the outflow and return of the gases and the intervening phase of depression D. This curve is characteristic for all internal combustion engines of the kind referred to but the moments at which the outflow and return of the gases occur will vary.

The moments during the operation of the engine at which the aspiration of fluid and the delivery of such aspirated fluid may be produced in accordance with the invention, will be seen from Figure 1.

In the first place, a delivery phase may be produced by the direct shock or impulse of the issuing exhaust gases which occurs very shortly after the opening of exhaust, as shown by the part P of the curve.

A depression is then formed in the cylinder and a little later a depression D is formed in the exhaust duct and the intensity and magnitude of the volume in which it exists will be proportionate to the kinetic energy contained in the exhaust gases.

At this moment the aspiration of external fluid through the medium of a communication with the interior of the exhaust duct may be obtained.

The return shock or impulse P' follows and destroys this depression phase and may constitute a second delivery phase.

The cycle may thus be considered to occur in the following manner: aspiration of fluid on account of the depression existing in the exhaust duct; then the delivery of the aspirated fluid by the return impulse of the discharged gases which follows this depression and after a rotation of the crank through about 280°, a second delivery by the direct impulse of the burnt gases from the following explosion.

It should be noted that the intensity of the phenomena described above is inversely proportional to the distance from the cylinder. Consequently, the communication with the interior of the exhaust duct should be located close to the cylinder.

In prior British specifications, the applicant has described internal combustion engines in which it is proposed to utilize the vacuum or high depression left in the cylinder by the explosion gases when they issue from the cylinder as a mass in order to introduce a fresh charge through the main admission ports.

In an engine of this kind, the fresh charge admitted to the cylinder cannot fill the complete cavity left in the cylinder and in the exhaust duct by the issuing gases for practical reasons depending upon the position, shape and surface of the admission orifices.

In fact, the applicant has found that if an orifice is provided in the exhaust duct close to the cylinder and is opened to a source of gaseous fluid external to the exhaust duct, the volume of gaseous fluid drawn directly into the exhaust duct through this orifice during the depression phase described above does not in any way impede or reduce the charge admitted directly into the cylinder through the usual admission orifices, 75

although the volume of gaseous fluid drawn into the exhaust duct may be equal to this charge.

Consequently by providing a chamber communicating with the interior of the exhaust duct of an internal combustion engine, and with a source of fluid external to the exhaust duct, this fluid can be aspirated into the said chamber and if desired it can be delivered into a receiver, where it may be stored under a suitable or chosen pressure and from which it may be utilized for supplying the engine or for any required purpose, and if desired the depression left in the cylinder by the issuing exhaust gases may still be utilized in order to introduce a fresh charge through the main admission ports.

Suitable distribution means must be provided so that the aspirated air or other gaseous fluid will follow the required direction during the suction and delivery periods, and so that it cannot return from the paths it is required to follow.

These means may for example consist of non-return valves or of controlled valves or of means such as those described in British Specifications Nos. 35069/33 and 25165/34.

The communication with the interior of the exhaust duct must be suitably arranged to permit a utilization of the depression and pressure phases in accordance with the invention, the communication may be so arranged that use is made chiefly of the return impulse of the exhaust gases or of both these impulses one after the other, for the purpose of delivering and/or compressing the aspirated charge.

Figures 2, 3 and 4 illustrate three examples of arrangements of the communication with the interior of the exhaust duct.

Figure 2 illustrates an arrangement of intake which makes use of means such as those described in the applicant's prior British Specification No. 35069/33. In this figure, which may be considered as a section through the exhaust duct of an internal combustion engine, the duct 1 is enlarged in order to receive a cone shaped obturator 2, the point of which will face the cylinder and the concave base of which will be turned towards the outlet end of the exhaust pipe, this obturator being arranged in relation to the walls of the duct in such a manner as to permit the outflow of the burnt gases and to prevent a return wave of these gases from re-entering the cylinder.

The part of the duct receiving the obturator 2 is provided with orifices 3, communicating with an annular chamber 4 provided or formed around the duct 1, and having an outlet 5 for connection to a source of fluid external to the duct 1.

In this example, the intake orifices 3 for the aspirated fluid are arranged so that the direct impulse and the return impulse of the exhaust gases will be transmitted in such a way that the aspirated gases may be delivered by the highest intensity of each of these two compression agents although it will be understood that the intensity of the direct impulse will always be higher than that of the return impulse.

Figure 3 illustrates a form of intake which ensures that the direct impulse will have the greatest action in delivering the aspirated charge.

In this figure, the exhaust 6 is surrounded by an annular chamber 7 having an outlet 8 and the duct is interrupted by an annular space 9 establishing a communication between the chamber 7 and the interior of the duct 6. The walls of the chamber 7 are flared in continuation of the walls of the duct on the side for connection to the cylinder so as to ensure that the direct impulse

of the exhaust gases will be transmitted into this chamber.

A practical form of intake which chiefly facilitates the utilization of the return impulse, and which has given satisfactory results in practice is illustrated in Figure 4.

In this figure the exhaust duct is formed by two portions 10 and 11 connected together by a chamber 12. The portion 10 of the duct is extended into the said chamber by means of a tubular element 13 opening into the portion 11, and situated in the interior of a tubular element 14 which extends the portion 11 of the duct and stops short of the inner wall of the said chamber 12. The annular space left between the elements 13 and 14 establishes a communication between the interior of the exhaust duct and the chamber 12.

The portion 11 of the duct is adjustably connected with the chamber 12 in order to permit a regulation of the distance between the free end of the element 14 and the internal wall of the chamber situated towards the cylinder.

The diameter of the free end of the element 13 is slightly smaller than that of the duct 11 and the element 14 at this point is slightly flared so as to provide a passage of increasing section between the elements 13 and 14 from the free end of the element 13.

The length of the element 13 may also be regulated by means of the screw connection provided between this element and the duct 10. These adjustments enable the action of the device to be varied so as to vary the relation between the suction and the delivery of fluid and the intensity of these actions which will be exerted through the outlet 15 of the chamber 12.

Figure 5 shows an engine arrangement in which the aspirated fluid is drawn from the atmosphere and the pressure impulses in the exhaust duct are utilized in order to deliver this aspirated air to a supplementary inlet port on the cylinder.

This figure shows an engine cylinder 16 in which moves a piston 17. Air is admitted by atmospheric pressure through the inlet 18 and fuel is introduced by the injector 19. Exhaust takes place through the duct 20. Upon the exhaust duct close to the cylinder is provided an intake 21, which, by way of example, is shown similar to that illustrated in Figure 4 communicating with a first chamber 22.

It is of advantage for the chamber 22 to be of tubular form because the aspirated charge and the exhaust gases that will deliver this charge will be in contact with each other and it will be of interest to prevent them from mixing.

The chamber 22 is provided at its end remote from the exhaust duct with a suction valve 31 or the like communicating with an external source of fluid, which in the example will be the air of the atmosphere, and a delivery valve 32 or the like. This delivery valve is followed by chambers, which may according to requirements be tubular or in the form of reservoirs or may be simply ducts for storing, leading or presenting the aspirated and delivered gas to its point of utilization.

In the example, the valve 32 leads through a duct 33 to a reservoir 34 itself connected to a duct 35 which leads the aspirated and delivered gas to a point of utilization.

The operation of this apparatus may be compared to a piston pump in which the function of the piston is taken by the exhaust gases while in mass form in the exhaust duct which exhaust

the chamber 22 during what may be considered as a downward stroke of the piston and then deliver the charge thus aspirated by means of what may be considered as two upward strokes of the piston.

An apparatus such as that described above may be employed for example as a compressor and the compressed charge thus obtained may be utilized for supplying a charge of air or combustible gas to the engine cylinder.

In the example, the duct 35 is put into communication with a supplementary admission orifice 36 provided upon the cylinder and serves for supplying an additional charge of air under pressure to the engine, the main charge being admitted by atmospheric pressure through the orifice 18. This additional charge may, for example be introduced at the end of the main admission in order to serve as correcting air, as described in the applicant's prior British Specification No. 24372/34, or it may serve for supplying a charge at any chosen moment through a suitable distribution means. In this case a great advantage is obtained as compared with the use of a compressor which draws power from the engine, is more costly, and complicates the construction.

The orifice 36 is controlled by any suitable means, for example by a valve 37, operated by push rod 38 and rocker arm 39 as indicated diagrammatically in the figure, in order to open at the chosen moment during the cycle of operations of the engine.

If the delivery valve 32 is omitted and the air is delivered directly to the admission valve 37, the engine will work at a more or less fixed speed because in this case the moment of opening of the valve 37 will have to coincide with a moment at which a charge is delivered from the chamber 22. But in the case when the chamber 22 delivers into the reservoir 34 through a non-return valve or equivalent means, the engine will draw its charge from the reservoir 34 at the required moment and its speed will become independent of the moments at which the suction and delivery stages occur in the chamber 22.

By suitably proportioning the chambers 22, 33, 34 and 35, the charge delivered from the chamber 22 may be stored or supplied to the point of utilization at or above atmospheric pressure.

In the example described with reference to Figure 5, instead of supplying the main charge to the engine by atmospheric pressure, this main charge may be introduced by any suitable means, for example by a compressor 40, connected to the inlet port 18 by a duct 19 as indicated in Figure 5.

It should be noted that as shown in Figure 5, a piston element such as a light, freely movable disc 19 may be arranged in the chamber 22, without in any way affecting the principle of operation of the device.

The invention is applicable to engines or machines having any number of strokes per cycle, but as only two strokes are essential to complete the cycle, the invention will most advantageously be applied to two stroke cycle engines in which the charge is introduced, at or above atmospheric pressure, into the combustion chamber by utilizing the phenomena described.

The valves employed for the suction and for the delivery of an aspirated fluid in an arrangement according to the invention may be simple or multiple. These valves may be arranged so as to provide a passage of large area and they may

have any shape provided they respond to rapid suction and equally rapid deliveries.

As stated above, these valves may be replaced by deflectors such as those described in the applicant's prior British Specification No. 35069/33, but in this case the delivered fluid cannot be stored under compression.

In this last example, it may be imagined that the delivery pulsations of fresh air or of the fresh charge are synchronized with the appropriate moments for the introduction of these gases into the engine cylinder, so that the inlet opening for these gases will coincide with the moment at which a high pressure exists in the ducts that deliver the gases, which pressure is produced by one of the delivery agents described above, that is to say, either by the direct impulse or the return impulse of the exhaust gases after their reflection from the atmosphere external to the cylinder.

I claim:

1. A method for producing a flow of fluid external to an internal combustion engine, consisting in employing the periods of depression and impulse or pressure left and produced in the exhaust duct of the said engine by the mass exit of the burnt gases from the cylinder into the exhaust system, in order to aspirate the said fluid, compress this aspirated fluid and if desired deliver the aspirated fluid to a reservoir which may be the engine cylinder.

2. A method for producing a flow of fluid external to an internal combustion machine wherein the burnt gases are evacuated from the working chamber as a mass at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, consisting in employing the periods of depression and impulse or pressure left and produced in the exhaust duct of the said machine by the mass exit of the burnt gases from the working chamber into the exhaust system in order to aspirate the said fluid and deliver the aspirated fluid to a point of utilization, disposal, or storage.

3. A method for producing a flow of fluid external to an internal combustion engine wherein the burnt gases are evacuated from the working chamber as a mass at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, consisting in employing the periods of depression and impulse or pressure left and produced in the exhaust duct of the said engine by the mass exit of the burnt gases from the working chamber into the exhaust system in order to aspirate the said fluid and deliver the aspirated fluid to a point of utilization, disposal, or storage.

4. The combination with an internal combustion machine comprising a working chamber and an exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices, and a communication with the interior of the exhaust duct, at a point situated near the working chamber than the point of return of the burnt gases within the exhaust duct, the arrangement being such that the depression left in the exhaust duct

by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump.

5 The combination with an internal combustion engine, a working chamber, an exhaust orifice and an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and wherein the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, means to open said inlet orifice for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the working chamber, with a pump having suction and delivery orifices and a communication with the interior of the exhaust duct, at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, the arrangement being such that the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump.

6. A combination as claimed in claim 4, including a source of gaseous fluid, a conduit connecting said source to the suction orifice of the pump, means for utilizing and storing said fluid, and a conduit connecting said means with the delivery orifice of the pump and wherein the pump includes a chamber having at one end said communication with the exhaust duct and at points remote from the exhaust duct said suction orifice and said delivery orifice.

7. A combination as claimed in claim 4, including a source of gaseous fluid, a conduit connecting said source to the suction orifice of the pump, means for utilizing and storing said fluid, and a conduit connecting said means with the delivery orifice of the pump, and wherein the pump includes a chamber of tubular form having at one end said communication with the exhaust duct and at points remote from the exhaust duct, said suction orifice and said delivery orifice.

8. The combination with an internal combustion machine a working chamber, and an exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices and a communication with the interior of the exhaust duct, at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and means arranged in the exhaust duct in such a way relative to the communication between the exhaust duct and the said pump as to ensure that the depression left in the exhaust duct by the mass exit of the

burnt gases from the working chamber initiates a suction stroke of the said pump and that both the direct impact and the return impact of the burnt gases will deliver the charge aspirated into the pump.

9. A combination as claimed in claim 8, wherein the said means are formed by deflecting and reflecting surfaces so arranged in the exhaust duct as to permit the free outward passage of the mass of burnt gases and to oppose the return of the said gases to the working chamber while at the same time serving to direct the impacts caused by the said mass of burnt gases on both its outward and return motions into the pump.

10. A combination as claimed in claim 4, including non-return valves for controlling the suction and delivery orifices and opening in the desired direction under the effect of a suction or of a delivery action and closing automatically.

11. A combination as claimed in claim 4, including deflectors for controlling the suction and delivery orifices and permitting the passage of a fluid in one direction and opposing the return of the said fluid.

12. A combination as claimed in claim 4, including distribution means for controlling the suction and delivery orifices so that said orifices open and close at predetermined moments.

13. A combination as claimed in claim 4, wherein the suction orifice communicates with the atmosphere.

14. A combination as claimed in claim 4, including a reservoir and a conduit connecting the delivery orifice of the pump with the said reservoir whereby fluid delivered by the pump may be stored or conveyed or presented to a point of utilization.

15. A combination as claimed in claim 4, including a reservoir and a conduit connecting the delivery orifice of the pump with the said reservoir whereby fluid delivered by the pump may be stored under pressure in said chamber.

16. A combination as claimed in claim 4, including a reservoir, a conduit connecting the delivery orifice of the pump with said reservoir whereby fluid delivered by the pump may be stored under pressure in said reservoir, a supplementary admission orifice upon the working chamber, a conduit connecting said supplementary admission orifice with said reservoir and means controlling said orifice to open said orifice at a chosen moment during the cycle of operations of the machine and put the working chamber into communication with the reservoir.

17. A combination as claimed in claim 5, including a source of gaseous fluid, a conduit connecting said source to the suction orifice of the pump, means for utilizing and storing said fluid and a conduit connecting said means with the delivery orifice of the pump and wherein the pump includes a chamber having at one end said communication with the exhaust duct and at points remote from the exhaust duct said suction orifice and said delivery orifice.

18. A combination as claimed in claim 5, including non-return valves for controlling the suction and delivery orifices and opening in the desired direction under the effect of a suction or of a delivery action and closing automatically.

19. A combination as claimed in claim 5, wherein the suction orifice communicates with the atmosphere.

20. A combination as claimed in claim 5, including a reservoir and a conduit connecting the delivery orifice of the pump with the said reservoir

voir whereby fluid delivered by the pump may be stored or conveyed or presented to a point of utilization.

21. A combination as claimed in claim 5, including a reservoir and a conduit connecting the delivery orifice of the pump with the said reservoir whereby fluid delivered by the pump may be stored under pressure in said chamber.

22. A combination as claimed in claim 5, including a reservoir, a conduit connecting the delivery orifice of the pump with said reservoir whereby fluid delivered by the pump may be stored under pressure in said reservoir, a supplementary admission orifice upon the working chamber, a conduit connecting said supplementary admission orifice with said reservoir and means controlling said orifice to open said orifice at a chosen moment during the cycle of operations of the machine and put the working chamber into communication with the reservoir.

23. A combination as claimed in claim 5, including a reservoir, a conduit connecting the delivery orifice of the pump with said reservoir whereby fluid delivered by the pump may be stored under pressure in said reservoir, a supplementary admission orifice upon the working chamber, a conduit connecting said supplementary admission orifice with said reservoir and means controlling said orifice to open said orifice towards the commencement of the main atmospheric admission to put the working chamber into communication with the reservoir and supply a correcting charge of air to the working chamber.

24. A combination as claimed in claim 5, including a reservoir, a conduit connecting the delivery orifice of the pump with said reservoir whereby fluid delivered by the pump may be stored under pressure in said reservoir, a supplementary admission orifice upon the working chamber, a conduit connecting said supplementary admission orifice with said reservoir and means controlling said orifice to open said orifice towards the end of the main atmospheric admission to put the working chamber into communication with the reservoir and supply a correcting charge of air to the working chamber.

25. A combination as claimed in claim 5, including a reservoir, a conduit connecting the delivery orifice of the pump with said reservoir whereby fluid delivered by the pump may be stored under pressure in said reservoir, a supplementary admission orifice upon the working chamber, a conduit connecting said supplementary admission orifice with said reservoir and means controlling said orifice to open said orifice to supply a supercharge to the working chamber after the closure of exhaust.

26. The combination with an internal combustion engine comprising a working chamber, an exhaust orifice, an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and wherein the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, by opening the inlet orifice for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass

exit from the working chamber, with a pump having suction and delivery orifices and a communication with the interior of the exhaust duct, at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and means arranged in the exhaust duct in such a way relative to the communication between the exhaust duct and the said pump as to ensure that the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and that both the direct impact and the return impact of the burnt gases will deliver the charge aspirated into the pump.

27. A combination as claimed in claim 26, wherein the said means are formed by deflecting and reflecting surfaces so arranged in the exhaust duct as to permit the free outward passage of the mass of burnt gases and to oppose the return of the said gases to the working chamber, while at the same time serving to direct the impacts caused by the said mass of burnt gases on both its outward and return motions into the pump.

28. A combination as claimed in claim 4, wherein the exhaust duct comprises two longitudinally displaced portions, the portion nearer the working chamber being of such length that the interruption in the exhaust duct provides an annular space at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including an annular chamber enclosing the exhaust duct at the zone of said interruption, said annular chamber having walls situated towards the working chamber flared in continuation of the walls of the duct and having a communication with said pump, whereby said annular space establishes a communication between the pump and the interior of the exhaust duct via said chamber.

29. The combination with an internal combustion machine comprising a working chamber and exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that the interruption in the exhaust duct provides an annular space at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including an annular chamber enclosing the exhaust duct at the zone of said interruption, said annular chamber having walls situated towards the working chamber flared in continuation of the walls of the duct and having a communication with said pump, whereby said annular space establishes a communication between the pump and the interior of the exhaust duct via said chamber and whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump.

30. The combination with an internal combustion machine comprising a working chamber and

exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump.

31. The combination with an internal combustion machine comprising a working chamber and exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of

the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump, means being provided whereby the length of one or the other of the two tubular elements can be varied in order to vary the action of the intake between the pump and the interior of the exhaust duct and/or the relation between the suction and the delivery of external fluid by the pump.

32. The combination with an internal combustion machine comprising a working chamber and exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump, means being provided whereby the length of one or the other of the two tubular elements can be varied in order to vary the action of the intake between the pump and the interior of the exhaust duct and/or the relation between the suction and the delivery of external fluid by the pump, the diameter of the free end of the second tubular element being slightly smaller than that of the first tubular element at this point, and the said first element being flared at this point in order to permit the area of the annular inlet aperture between the two tubular elements to be varied by a relative longitudinal movement of these elements.

33. The combination with an internal combustion machine comprising a working chamber and exhaust orifice, wherein the burnt gases are evacuated from the working chamber of the machine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working cham-

ber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump, means being provided whereby the length of one or the other of the two tubular elements can be varied in order to vary the action of the intake between the pump and the interior of the exhaust duct and/or the relation between the suction and the delivery of external fluid by the pump, the diameter of the free end of the second tubular element being slightly smaller than that of the first tubular element at this point, and the said first element being flared at this point so that the passage between the tubular elements increases in section from the free end of the second element in order to permit the area of the annular inlet aperture between the two tubular elements to be varied by a relative longitudinal movement of these elements.

34. The combination with an internal combustion engine comprising a working chamber, an exhaust orifice and an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and wherein the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, means to open said inlet orifice for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that the interruption in the exhaust duct provides an annular space at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including an annular chamber enclosing the exhaust duct at the zone of said interruption, said annular chamber having walls situated towards the working chamber flared in continuation of the walls of

the duct and having a communication with said pump, whereby said annular space establishes a communication between the pump and the interior of the exhaust duct via said chamber and whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump.

35. The combination with an internal combustion engine comprising a working chamber, an exhaust orifice and an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and wherein the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, means to open said inlet orifice for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump.

36. The combination with an internal combustion engine comprising a working chamber, an exhaust orifice and an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and wherein the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, means to open said inlet orifice for the in-

roduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump, means being provided whereby the length of one or the other of the two tubular elements can be varied in order to vary the action of the intake between the pump and the interior of the exhaust duct and/or the relation between the suction and the delivery of external fluid by the pump.

37. The combination with an internal combustion engine comprising a working chamber, an exhaust orifice and an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and whereby the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, means to open said inlet orifice for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting

chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump, means being provided whereby the length of one or the other of the two tubular elements can be varied in order to vary the action of the intake between the pump and the interior of the exhaust duct and/or the relation between the suction and the delivery of external fluid by the pump, the diameter of the free end of the second tubular element being slightly smaller than that of the first tubular element at this point, and the said first element being flared at this point in order to permit the area of the annular inlet aperture between the two tubular elements to be varied by a relative longitudinal movement of these elements.

38. The combination with an internal combustion engine comprising a working chamber, an exhaust orifice and an inlet orifice, wherein the burnt gases are evacuated from the working chamber of the engine through a duct as a mass, at a speed much higher than that obtaining when adiabatic action only is involved and in such a short interval of time that they are discharged wholly or substantially wholly from the working chamber and wherein the void left in the working chamber by the mass exit of the burnt gases from the said chamber into the exhaust duct is utilized in charging the said chamber, means to open said inlet orifice for the introduction of the fresh charge after the exhaust orifice opens, but only with the required delay to ensure that the burnt gases are then moving outwardly through the exhaust orifice or duct as a consequence of their mass exit from the working chamber, with a pump having suction and delivery orifices, the exhaust duct comprising two longitudinally displaced portions, the portion nearer the working chamber being of such length that an interruption in the exhaust duct occurs at a point situated nearer the working chamber than the point of return of the burnt gases within the exhaust duct, and including a chamber connecting the two portions of the exhaust duct, an orifice in said chamber, a conduit connecting said orifice to said pump, a first tubular element situated in the interior of said chamber and extending the portion of the exhaust duct more distant from the working chamber towards the working chamber and stopping short of an internal wall of the chamber connecting the exhaust duct portions, and a second tubular element situated within the first tubular element and extending the portion of the exhaust duct nearer the working chamber towards the other portion of the exhaust duct, the space between said tubular elements establishing a communication between the interior of the exhaust duct and the chamber connecting

the exhaust duct portions and thence to the pump whereby the depression left in the exhaust duct by the mass exit of the burnt gases from the working chamber initiates a suction stroke of the said pump and the shocks produced by the return of the said mass towards the cylinder and of the next mass exit of the burnt gases initiate delivery strokes of the said pump, means being provided whereby the length of one or the other of the two tubular elements can be varied in order to vary the action of the intake between the pump and the interior of the exhaust duct and/or the relation between the suction and the delivery of

external fluid by the pump, the diameter of the free end of the second tubular element being slightly smaller than that of the first tubular element at this point, and the said first element being flared at this point so that the passage between the tubular elements increases in section from the free end of the second element in order to permit the area of the annular inlet aperture between the two tubular elements to be varied by a relative longitudinal movement of these elements.

MICHEL KADENACY.