

Oct. 31, 1944.

B. BOLLI ET AL

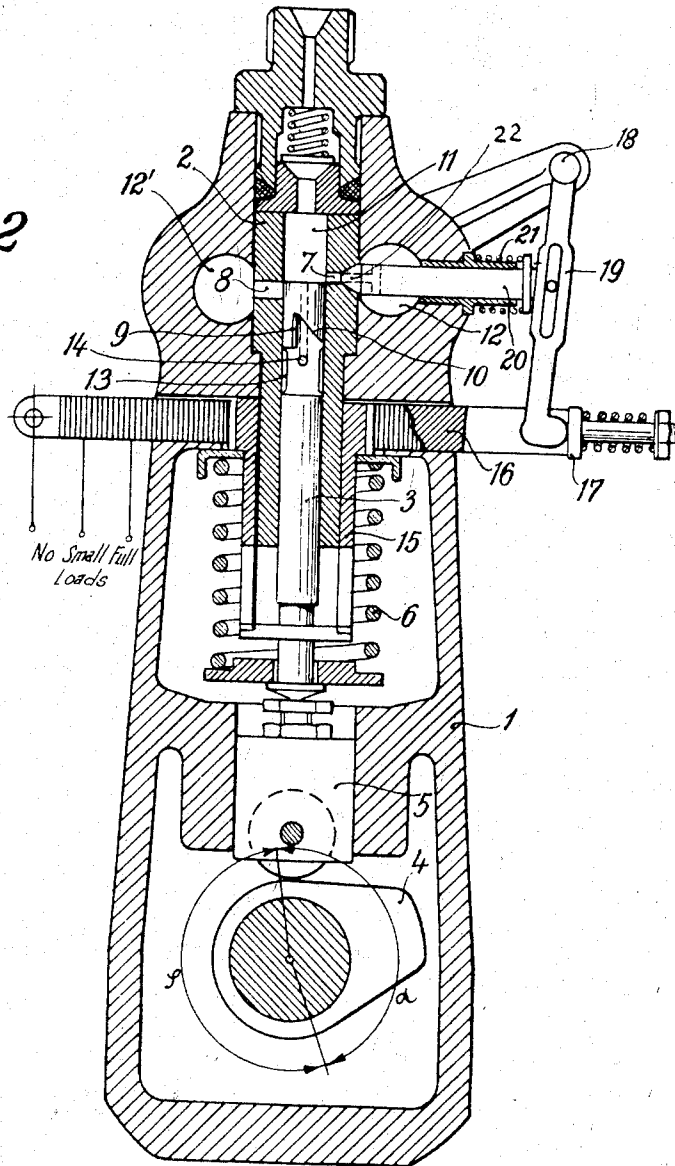
2,361,817

FUEL INJECTION PUMP FOR INTERNAL-COMBUSTION ENGINES

Filed March 26, 1942

5 Sheets-Sheet 2

Fig. 2



INVENTORS
Bernard Bolli & Heinrich Boll
BY
Kichauz & Kichauz
ATTORNEYS

Oct. 31, 1944.

B. BOLLI ET AL

2,361,817

FUEL INJECTION PUMP FOR INTERNAL-COMBUSTION ENGINES

Filed March 26, 1942

5 Sheets-Sheet 4

Fig. 4a

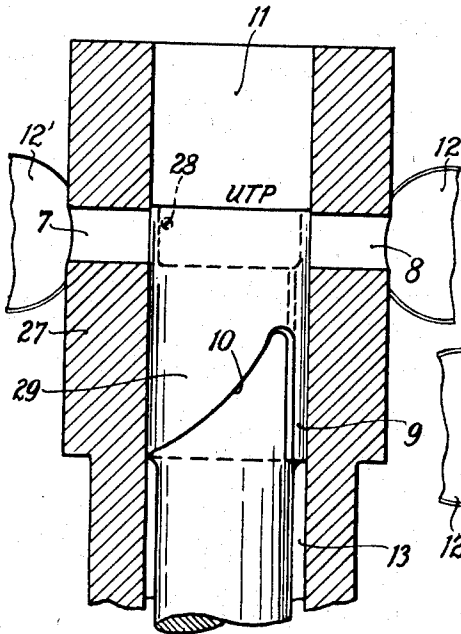


Fig. 4b

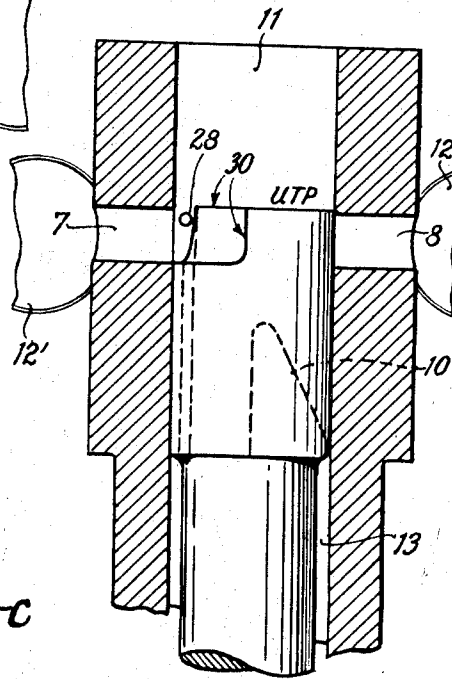
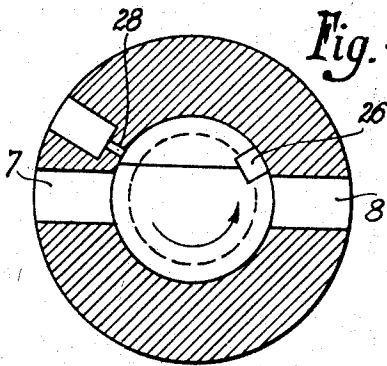
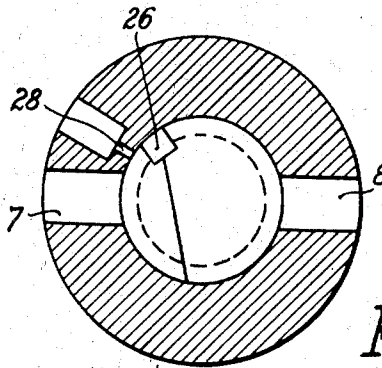


Fig. 4c



Position for no load and starting



Position for Full Load

Fig. 4d

INVENTORS

Bernard Bolli, Kenneth DeK
BY Michael & Michael
ATTORNEYS

Oct. 31, 1944.

B. BOLLI ET AL

2,361,817

FUEL INJECTION PUMP FOR INTERNAL-COMBUSTION ENGINES

Filed March 26, 1942

5 Sheets-Sheet 5

Fig. 6a

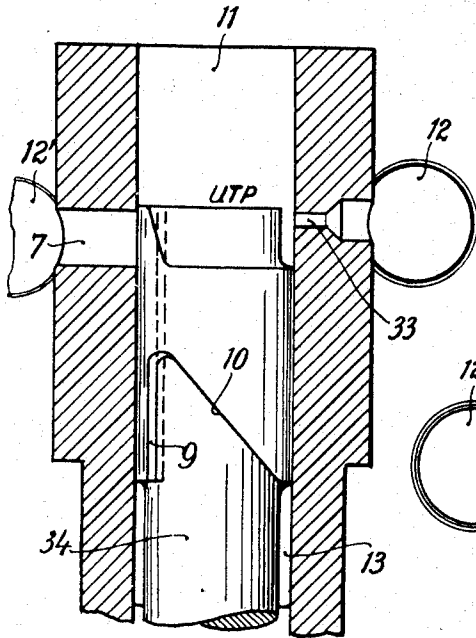


Fig. 6b

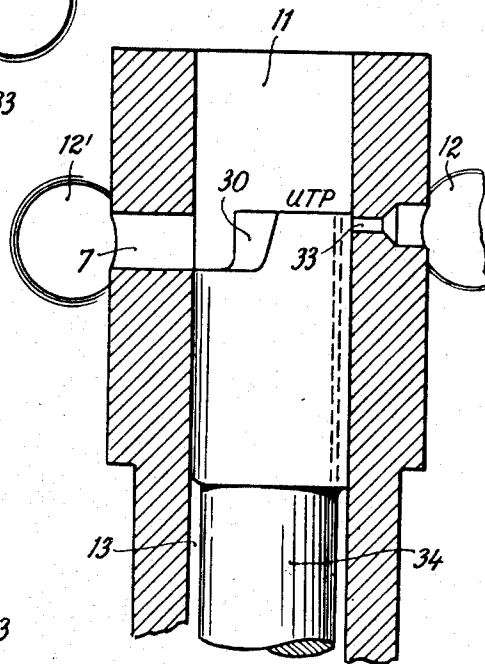
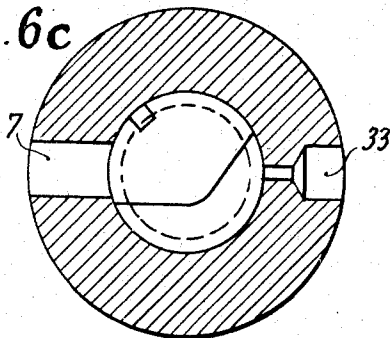
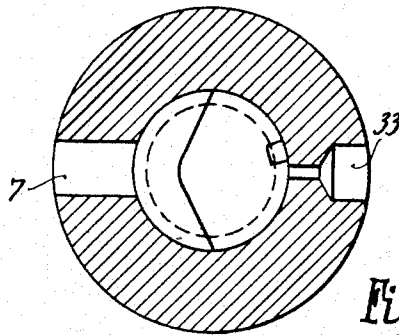


Fig. 6c



No Load - Starting



Full Load

Fig. 6d

INVENTORS

Bernhard Bolli & Heinrich Bell

BY

Michaelis & Michaelis
ATTORNEYS

UNITED STATES PATENT OFFICE

2,361,817

FUEL INJECTION PUMP FOR INTERNAL-COMBUSTION ENGINES

Bernhard Bolli and Heinrich Bek, Arbon, Switzerland, assignors to Société Anonyme Adolph Saurer, Arbon, Switzerland

Application March 26, 1942, Serial No. 436,262
In Germany June 10, 1949

5 Claims. (Cl. 103-41)

This invention relates to fuel injection pumps for internal combustion engines.

It has particular reference to injection pumps of the short-delivery type, in which the time available for feeding fuel into the pump chamber is inversely proportional to the engine speed.

It is an object of this invention to provide a pump of the kind aforesaid which is more effective than similar injection pumps hitherto devised and which is simpler in design and operation, while rendering superfluous the provision of a special no-load governor such as was required as a rule in connection with former injection pumps of this type.

In the pump according to this invention means are provided for narrowing the fuel admission port of the pump by substituting for it a second fuel admission port which is controlled by an angular movement of the piston for the purpose to vary, when changing over to idle-running at low speed, the quantity of fuel fed to and filling the working chamber of the pump per unit of time.

In the drawings affixed to this specification and forming part thereof various embodiments of the invention are illustrated diagrammatically by way of example.

In the drawings

Fig. 1 is a curve diagram illustrating the interdependency between the engine speed and the quantity of fuel injected.

Fig. 2 is a sectional elevation of the first embodiment.

Figs. 3a and 3b are similar views of part of a second embodiment in the no-load and full-load positions, respectively,

Figs. 3c and 3d being cross-sections on the lines A—A and B—B in Figs. 3a and 3b, respectively.

Figs. 4a, 4b, 4c and 4d are corresponding views of a third embodiment.

Figs. 5a and 5b are developments of the control surfaces of the pump piston of the embodiment illustrated in Figures 4a and 4b for no-load and full-load, respectively.

Figs. 6a, 6b, 6c and 6d are views corresponding to Figs. 3a, 3b, 3c and 3d, respectively, showing a fourth embodiment at no-load and at full-load, respectively.

Referring to the drawings and first to Fig. 1, the quantity V of fuel delivered by the injection pump is plotted against the engine speed n . The full-line curve A with index m shows how, with unchanged position of the fuel regulator, the quantity injected by a pump as hitherto used varies as a function of the speed. At the maximum speed n_m the quantity of fuel V_m is injected, as shown at 1. If the engine speed were

raised further beyond n_m , the quantity injected would at first remain constant up to the limiting speed n_s (point 2). At this speed the time available for filling is just sufficient for completely filling the pump chamber. If the engine speed rises further, the filling period is insufficient for a complete filling of the pump chamber, and the quantity of fuel injected drops in proportion to the equation

$$V_x = V_m \cdot n_s \frac{(1)}{n_x}$$

wherein V_x is the quantity injected at a speed n_x which is greater than the limiting speed n_s . Therefore beyond the point 2 the curve becomes a hyperbolic curve extending asymptotically to the base line for $V=0$. The corresponding curve is marked B in Fig. 1.

Below the speed n_m the quantity of fuel delivered remains constant, but then drops, upon further slowing down of the engine, owing to increasing leakage losses. At partial load, within the lower range of speeds, the delivery curve, for an invariable position of the quantity regulator, is similar to the curve A_m . One such partial-load delivery curve is shown at A. With the reduction of injected fuel during idling periods the delivery curve drops as shown at A_L in Fig. 1. At the no-load speed n_L , the quantity of fuel V_L is injected. The corresponding point on the delivery curve A_L is marked 3. According to this delivery curve, with the quantity-regulator remaining stationary, at a speed higher than n_L the quantity of fuel injected rises, at a speed lower than n_L it drops. With such a delivery characteristic it is impossible to maintain the no-load speed n_L . The engine will either stop or will run at too high speed. Therefore, with injection pumps of this type as hitherto used, the speed n_L can be maintained only, if the quantity-regulating members of the injection pump are adjusted by means of a centrifugal governor or a pneumatic or hydraulic regulator for the injection of a smaller quantity, when the speed rises, and a larger quantity, when it drops.

According to this invention, now, by closing the main admission port through which fuel is supplied to the pump chamber and substituting for it another, relatively narrow, admission port, the dropping of the delivery curve towards B, that would otherwise occur with a large admission port, is shifted to a lower range of speeds, and, by appropriately dimensioning the narrow admission port, this shift extends into the region of the no-load speed n_L . The delivery curve obtained with the narrow port is marked C in Fig.

1. Simultaneously with the changing over to the narrow admission port, the pump must be adjusted for delivery of a large quantity of fuel. In the neighbourhood of the no-load speed n_L , and with a fixed adjustment of the quantity-regulator, the pump will now work according to the delivery curve C, so that as the speed rises, the quantity of fuel injected drops, while with dropping speed the quantity injected rises. Thus the engine automatically adjusts itself to the speed n_L , even if influences from without tend to drive it away from this speed. According to whether the quantity-regulator is adjusted for injection quantities corresponding to curve A or A_m or A_s , the quantity of fuel injected rises, below the level of the no-load speed n_L , following curve C, until this curve intersects the corresponding curve A, A_m or A_s , respectively.

The first embodiment of this invention illustrated in Fig. 2 of the drawings shows the application of the invention to the kind of injection pump hitherto mostly used, with slide-valve control and cam regulation.

Referring to Fig. 2, 1 is the pump piston, 4 the cam-shaft, 5 a plunger, 6 a return spring. The pump cylinder 2 is formed with two ports 7 and 8 which are controlled by the pump piston 3. In the lower end position of the piston, the port 8 which serves as a reflux port, remains closed by the piston, while the main admission port 7 through which the pump chamber 11 is filled, is uncovered. The main admission port is so dimensioned that during the filling period which is controlled by the cam face α and the engine speed, the working chamber 11 of the pump, even at maximum speed, is completely filled through the suction chamber 12. For the purpose of varying the quantity of fuel delivered, piston 3 is formed with a cam edge 10, a recess 13 and a reflux bore 14. The piston is operatively connected with a toothed sleeve 15 meshing with a rack 16 which can be reciprocated transversely to the piston axis. Delivery begins as soon as piston 3 during its upward stroke has covered the main admission port 7. Delivery ends when the cam edge 10 begins to uncover the reflux port 8 in the cylinder 2.

In the operation of this pump, when the rack 16 is shifted towards the left, the quantity of fuel injected through the main admission port 7 into the working chamber of the pump drops gradually, since the cam edge 10 on the piston uncovers the reflux port after a progressively shorter stroke of the piston. With the cam edge 10 on the piston is associated a cam face 9 which, when the rack 16 is shifted towards the left, uncovers the reflux port 8 only after the piston has gone through a longer stroke. In this position, which is shown in Fig. 2, the quantity of fuel delivered by the pump rises again considerably. However the rack 16 on being shifted toward the left by the spring 17 carries along a lever 19 fulcrumed at 18 which displaces the needle 20 toward the left against the action of a spring 21. The conical end of this needle enters and closes the main admission port 7. It is formed with a narrow T-shaped bore 22 which communicates with the suction chamber of the pump. With the needle in the closing position shown in the drawings, fuel from the suction chamber can enter the pump chamber 11 only through the narrow bore 22 which constitutes another admission port of greatly restricted cross-sectional area of passage. It is so dimensioned that at no-load speed the pump chamber

11 is filled only partially. Only at a still lower speed—the starting speed—the greatest possible quantity of fuel, determined by the cam face 9, is injected.

Obviously the needle 20 might be replaced by some other kind of shut-off member closing, according to the position of the rack 16, the main admission port 7. For instance a rotary valve embracing the top end of the pump cylinder might be rotated by the rack similarly as the sleeve 15, and, towards the no-load position of the rack, would close the main admission port, leaving open only a narrow passage corresponding to the bore 22.

In Figs. 3a-3d a second embodiment is illustrated. Here the pump piston 23, in order to provide for the closing of the main admission port 7, is formed with an extension 24 which, when the piston is rotated by means of the rack 16 (not shown) into no-load position and the cam face 9 closes the reflux port 8, closes the main admission port 7. The extension 24 is formed with a narrow calibrated bore 25, which here constitutes the second (narrow) admission port and allows the working chamber 11 of the pump to be filled only incompletely at no-load speed, so that notwithstanding the large-delivery adjustment brought about by the cam face 9, the pump delivers only the quantity of fuel required for idle-running. Delivery takes place in accordance with curve C in Fig. 1, point 3 being particularly characteristic, and the pump keeps the engine self-regulating at no-load speed as desired. When the piston is turned still further to the left in Figure 3a a groove 26 provided in the control surface of the piston is aligned with the main admission port 7 and keeps the working chamber 11 of the pump in communication with the suction chamber 12. The pump then no longer delivers fuel, and the engine comes to a standstill. For starting the pump piston is rotated back into the position shown in Figure 3a. At the low speed at which the starter turns the motor, the charging period is sufficient to completely fill the working chamber 11 of the pump with fuel through the narrow admission port 25 and the pump now delivers the large quantity of fuel determined by the cam surface 9. With an appropriately formed surface 9 this quantity may be greater than the quantity of fuel delivered when the engine runs under full load. The pump then operates in the region of point 4 of the diagram of Fig. 1.

In the position of the pump piston 23 shown in Fig. 3b the pump is adjusted for injecting the full-load quantity of fuel. The main admission port 7 is uncovered, so that even at maximum engine speed the working chamber 11 of the pump can be completely filled with fuel from the suction chamber 12, and the pump delivers the entire quantity of fuel corresponding to the reflux port 8. The pump then operates in the region of point 1 of Figure 1.

In the third embodiment of the invention, illustrated in Figures 4a-4d, the narrow admission port 28 for no-load operation is provided in the pump cylinder 27, while the pump piston 29 is formed at its upper end with a step 30, which keeps the reflux port 8 covered even in the lowest position of the piston, and which upon adjustment to slow idling (Fig. 4a) closes the main admission port 7, so that in this position of the pump piston the working chamber 11 of the pump can be filled only through the narrow admission port 28. The cross section of this port is so dimensioned, that at no-load speed the working cham-

ber 11 is only partially filled with fuel, whereby notwithstanding the long delivery stroke adjusted by the cam face 9, only the quantity of fuel V_L needed for idling is delivered, the pump operating according to the characteristic C in Fig. 1. In this position of the parts the pump at starting speed delivers the maximum quantity V_a (Figure 1) determined by the cam face 9. Upon further rotation of the pump piston to the right beyond the position shown in Figure 4a, the longitudinal groove 26 takes up a position in front of the reflux port 8, whereby delivery by the pump is interrupted, and the engine stops.

In this embodiment the groove 26 may be so dimensioned as to constitute the sole communication between the working chamber 11 and the space 13 adjoining the cam face 9. In that case the connecting conduit 14 (Figs. 2, 3a and 3b) can be dispensed with.

In Figs. 5a and 5b, a development of the control surface of the pump piston is shown, in which the cylinder ports are also indicated. Fig. 5a shows the relative positions of the cam face and the cylinder ports during the idling and starting periods. Fig. 5b shows their relative positions during full-load operation. The cam face is designed for the lowermost position of the pump piston.

In the no-load and starting positions the main admission port 7 is covered by the cam face. While the piston and its cam face execute a stroke in the direction of the arrow, delivery, if the working chamber of the pump is entirely filled with fuel, begins when the narrow admission port 28 is covered by the cam face. Delivery is interrupted when the uncovering of the reflux port 8 by the lower edge 32 of the cam face 9 begins. All this takes place at starting speed. The quantity of fuel delivered is determined by the piston stroke h_a marked in Fig. 5a. At idling speed, however, the working chamber of the pump has not been completely filled. The shortage of fuel that occurred owing to the charging period being too short, corresponds to a piston stroke h_o , so that delivery does not begin until the narrow admission port is located, in relation to the control face, in the lower position marked in Fig. 5a. Delivery then continues only during the piston stroke h_i . The area of the piston multiplied by the stroke h_a determines the quantity of fuel delivered at starting speed. The same area multiplied by the stroke h_i determines the quantity of fuel delivered at no-load speed.

An angular movement of the pump piston in Fig. 5, corresponding to a displacement of the developed control surface towards the right, leads to the full-load position shown in Fig. 5b. A slight rotation of the piston uncovers the main admission port 7, but the reflux port 8 still remains covered in the lowermost position of the piston. Owing to the large cross-sectional area of passage of the main admission port the working chamber of the pump is still completely filled, even at the highest engine speed. Delivery begins as soon as port 7 is covered by the control surface. It ends as soon as the reflux port 8 begins to be uncovered by the cam edge 10. The delivery of the pump is accordingly determined by the stroke h_m , shown in Fig. 5b, multiplied by the area of the piston.

In Figs. 6a-6d a further form of construction of the invention is shown, Figure 6a representing the position for idling and for starting and Figure 6b the full-load position of the pump piston. In the embodiments illustrated in Figures 2, 3

and 4 the large filling hole 7 has not served as a reflux aperture, a separate reflux aperture 8 having been provided to carry away the oil that flows back into this separate chamber. In the embodiment shown in Figs. 6a and 6b, however, the filling aperture 7 acts as a reflux aperture as well, through which, in the loading range of the engine, the working chamber 11 of the pump is not only filled but is also, at the end of injection, relieved only when covered by the cam edge 10. In this pump the suction chamber 12 is not separated from the reflux chamber 12', as is the case in Figs. 2, 3 and 4. The small filling aperture 33, for idling, is here arranged diametrically opposite the large aperture 7. The piston 34 is again formed at the upper end with a step or shoulder 30, by which the large filling aperture 7 is covered in the no-load position shown in Fig. 6a. The mode of operation of this arrangement will be obvious from Figs. 6a and 6b after the above description.

The idea of the invention can be applied, on the general lines indicated, not only to a pump with piston-valve control and cam edge regulation but also to any other kind of short-delivery pumps.

The cross section of the filling aperture that comes into action when running at idling speed, may be so designed as to be variable in size from the outside, for instance in a known manner by means of a conical needle engaging in this filling aperture and adjustable from the outside while the engine is running. It thereby becomes possible to adjust the no-load speed of the engine to any desired value.

Instead of the no-load filling apertures 25 and 26 bored directly in the piston or in the cylinder as shown in Figs. 3a, 3b, and 4a, 4b, nozzles may be inserted, which may be exchangeable. The no-load speed of the engine can then be adjusted to the desired value by suitably selecting and exchanging these nozzles.

We wish it to be understood that we do not desire to be limited to the exact details above described, for obvious modifications will occur to a person skilled in the art.

We claim:

1. In a fuel injection pump for internal combustion engines in combination, a pump cylinder and a piston formed with a control surface and arranged for cooperation with said cylinder in metering fuel into the working chamber of the pump, means for reciprocating said piston, means for imparting to it an angular movement about its axis, a main fuel admission port in the cylinder wall and a second relatively narrow admission port under control by the angular movement of said piston for varying the quantity of fuel admitted into and filling the working chamber per unit of time.

2. The combination of claim 1, in which a throttling member arranged for coaction with the main admission port is formed with a bore forming the second admission port.

3. The combination of claim 1, in which one of the two cooperating parts is formed with the second admission port.

4. The combination of claim 1, in which an extension of the piston is formed with the second admission port.

5. The combination of claim 1, in which the second admission port is also formed in the cylinder wall and an extension of the piston is arranged to control both admission ports.

BERNHARD BOLLI.
HEINRICH BEK.