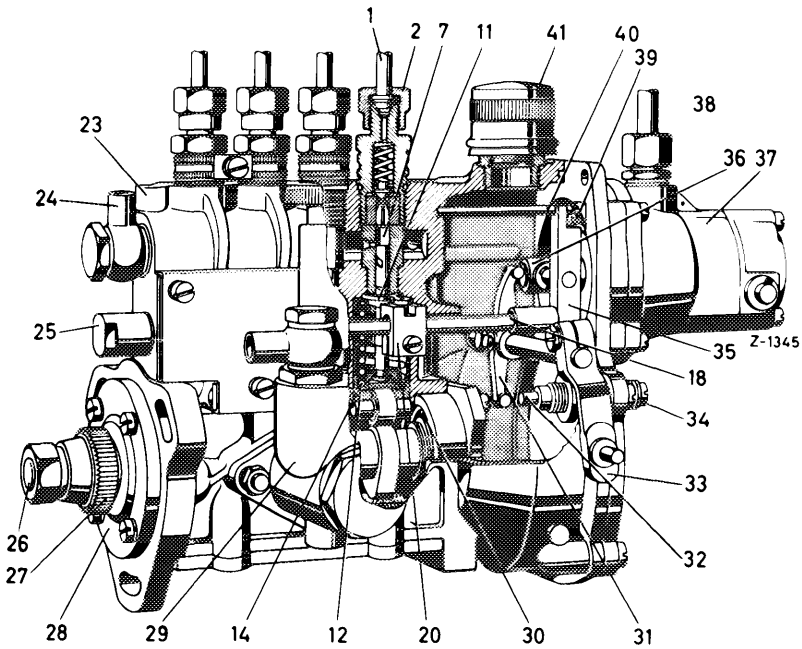
A. M-injection pump with pneumatic governor

The injection pump with pneumatic governor is provided with a mechanical starting and stopping device, as well as with a valve governor (venturi governor) mounted on intake manifold.

The injection pump has a separate oil lubrication system and should be serviced at regular maintenance intervals.

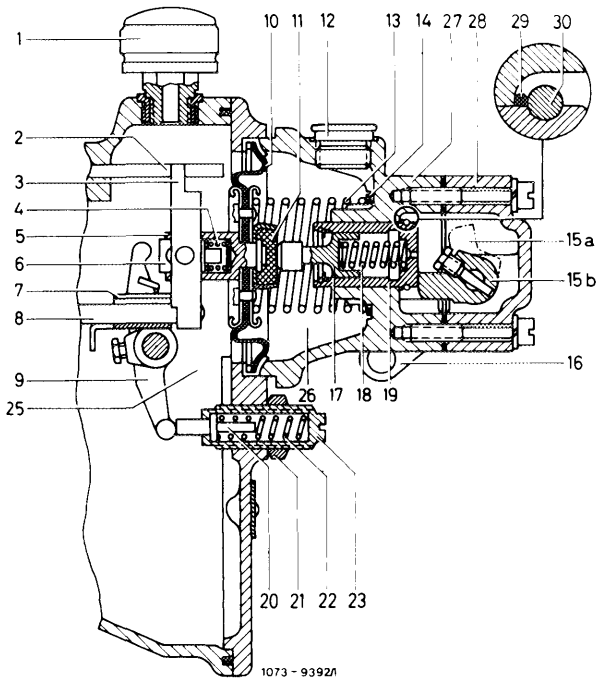
1 Injection line
2 Coupling nut
7 Pressure chamber
11 Control sleeve with steering arm
12 Tappet spring
14 Roller tappet
18 Control rod
20 Adjustable clamping piece with guide groove
23 Injection pump housing
24 Fuel feed connection
25 Control rod guide bushing and excess fuel stop for starting
26 Camshaft (drive end)
27 Driver
28 Bearing cap with oil retaining ring and centering pilot
29 Fuel delivery pump
30 Magneto-type ball bearing
31 Double lever
32 Connecting bolt for full load stop
34 Adjusting lever stop or adjusting screw with full load stop
35 Guide lever
36 Diaphragm bolt with thrust bolt and compensating spring
37 Governor
38 Vacuum line
39 Diaphragm
40 Guide bolt
41 Air cleaner and oil filter bore



Layout and operation of pneumatic governor

The vacuum originating in intake manifold of engine is routed to vacuum chamber (26) of governor by means of a vacuum line attached to throttle valve housing. The atmospheric pressure chamber (25) of the governor is connected to atmosphere by way of the air cleaner.

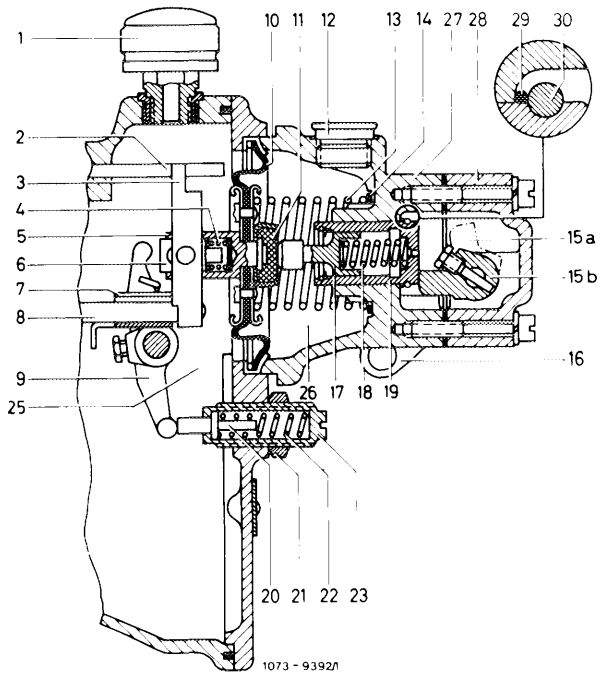
Both pressure chambers are hermetically separated from each other by a diaphragm. Control rod (8) attached to diaphragm is displaced under influence of differential pressure between the atmospheric pressure chamber (25) and the vacuum chamber (26) and controls the injected quantity. The control spring pushes the diaphragm and the attached control rod (8) in direction of "full load" at the most up against double lever (9, full load), which rests with its other end against full load stop. The full load stop adjusts the max. permissible injection quantity.



1 Air cleaner
2 Guide bolt
3 Guide lever
4 Compensating spring
5 Diaphragm bolt
6 Thrust bolt of compensating spring
7 Excess starting fuel stop
8 Control rod
9 Double lever
10 Diaphragm
11 Rubber buffer
12 Vacuum connection to vacuum chamber
13 Control spring
14 Washer
15a Full load position (poppet cam)
15b Idle position (poppet cam)
16 Control lever
17 Stop bolt
18 Idle speed auxiliary spring (poppet)
19 Poppet housing or spring capsule, sliding
20 Stop bolt for full load stop
21 Counternut
22 Spring
23 Adjusting screw for full load stop
25 Atmospheric pressure chamber
26 Vacuum chamber
27 Governor housing
28 Poppet housing
29 Spring washer
30 Stop ring

The full load stop is resiliently supported, so that the lever can still be pulled by way of bowden wire beyond full load position into starting position when starting. When starting, the engine is provided with an injected fuel quantity, which is higher than the full load quantity. In addition to the control spring, the vacuum chamber (26) also houses the idle speed auxiliary spring (18, poppet). The idle speed auxiliary spring is connected to throttle valve on throttle valve housing by means of regulating linkage. As a result the poppet cam (15) is adapted to the respective throttle valve position.

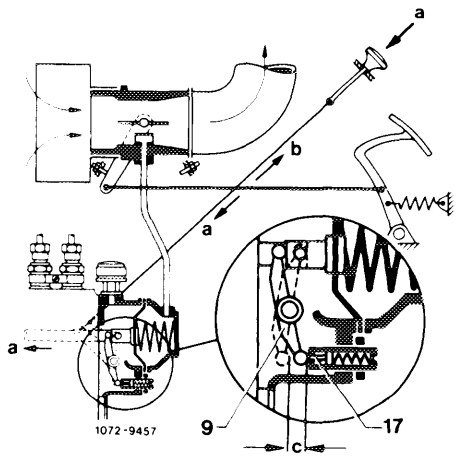
The idle speed auxiliary spring serves the purpose of limiting the vibrations of control rod (8) in lower rpm and load range, as well as at idle to prevent any hunting of engine. At idle and in partial load range the control rod of the injection pump is therefore in balance between the forces of the vacuum, the control spring and the idle speed auxiliary spring (poppet).



1 Air cleaner
2 Guide bolt
3 Guide lever
4 Compensating spring
5 Diaphragm bolt
6 Pressure bolt of compensating spring
7 Excess starting fuel stop
8 Control rod
9 Double lever
10 Diaphragm
11 Rubber buffer
12 Vacuum connection on vacuum chamber
13 Control spring
14 Washer
15a Full load stop (poppet cam)
15b Idle stop (poppet cam)
16 Control lever
17 Stop bolt
18 Idle speed auxiliary spring (poppet)
19 Poppet housing or spring capsule, sliding
20 Stop bolt for full load stop
21 Counternut
22 Spring
23 Adjusting screw with full load stop
25 Atmospheric pressure chamber
26 Vacuum chamber
27 Governor housing
28 Poppet washer
29 Spring washer
30 Stop ring

Starting of engine

For starting, the stopping and starting lever is actuated in direction of starting. As a result, the spring-loaded stop bolt (17) in full load stop is pushed via double lever (9) into adjusting screw and the control spring can displace the diaphragm and thereby the control rod in direction of start (a). This means, that the engine is receiving more fuel while starting than during full load operation.

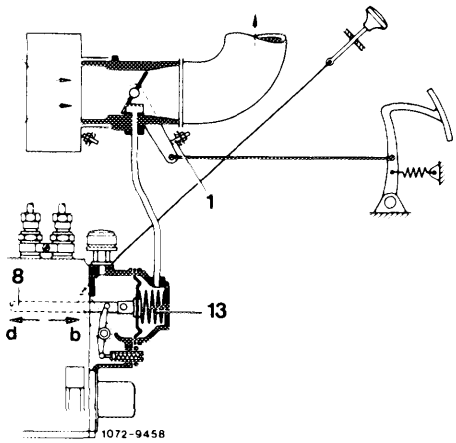


9 Double lever
10 Stop bolt
a Start
b Stop
c Excess starting fuel

Idle range of engine

With the engine running at idle, the adjusting lever of the throttle valve rests against adjustable idle speed stop, and the venturi tube is almost completely closed. A vacuum will be established in vacuum chamber already at idle speed, which is enough to pull the control rod (8) into its idle speed position against the pressure of control spring (13). At reducing load, the engine accelerates and the vacuum increases. Consequently, the diaphragm will displace the control rod still further in direction of "stop": The engine will again run more slowly.

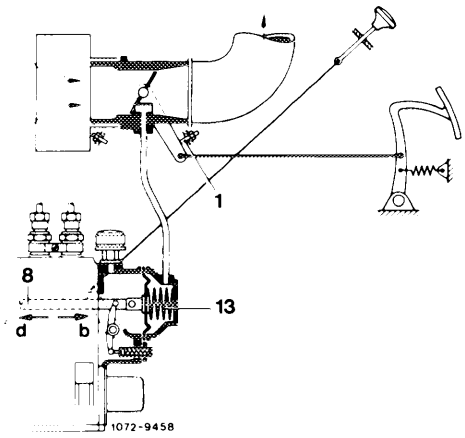
If, on the other hand, the load is increasing, the engine speed goes down and the vacuum decreases; the control spring will therefore displace the control rod in direction of "full" and the engine is again running faster. The governor is thereby limiting the idle speed in upward and downward direction, that is, it is controlling the idle speed.



1 Idle speed stop
8 Control rod
13 Control spring
b Stop
d Full

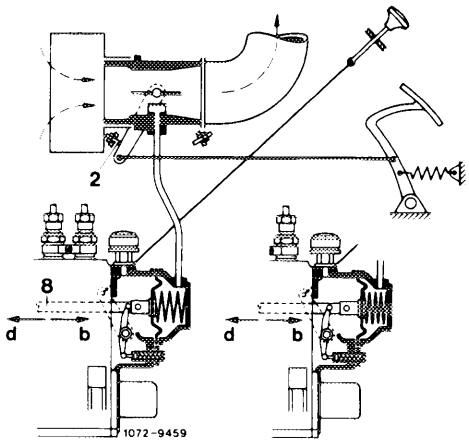
Between idle and final speed

The governor keeps any speed between idle and final speed constant. The more the accelerator pedal, (or control flap respectively) is adjusted in direction of "FULL" (d) the higher the engine speed.



Maximum speed range of engine (full-load speed regulation)

To obtain nominal speed (full output) completely depress accelerator pedal; the adjusting lever of the throttle valve will then rest against its (adjustable) end stop (full load stop (2). The throttle valve is fully open. At first, the vacuum in vacuum chamber will be low; the vacuum required for max. speed control will be attained at nominal speed only.

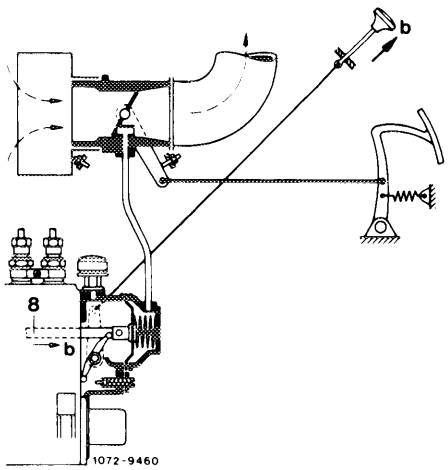


2 Full load stop
8 Control rod
b Stop
d Full

When the nominal speed is exceeded, the control rod (8) will move away from its full load stop and will be displaced in direction of stop until the delivered fuel quantity has become so small that the upper idle speed can no longer be exceeded.

Stopping the engine

For stopping engine, the control rod (8) is pushed to stop by means of start and stop cable control. No more fuel will then be injected.



8 Control rod
b Stop

B. M/RSF-injection pump with mechanical governor

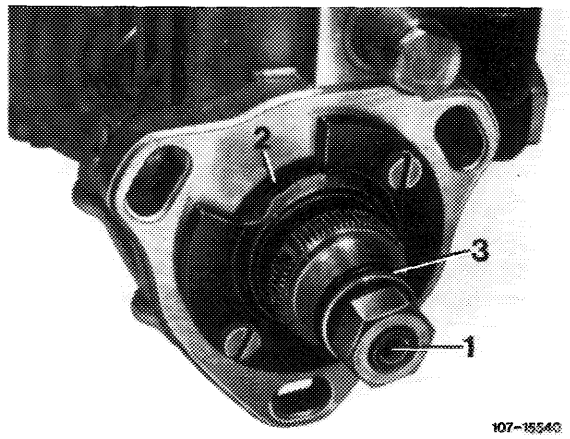
Layout of M/RSF-injection pump corresponds essentially to that of M-injection pump.

Lubrication of injection pump

The injection pump is connected to engine oil circuit via intermediate gear shaft (refer to group 05) and via injection pump-camshaft (1) which is provided with an oil bore.

The return oil flows via ring gap on bearing cap (2) back into cylinder crankcase.

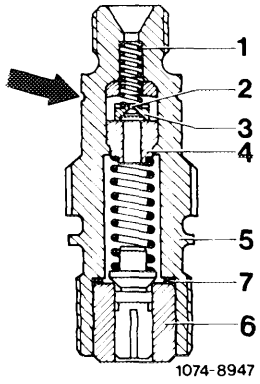
The drive pinion is provided with an O-ring (3) to seal the clutch space between intermediate gear shaft and camshaft.



1 Camshaft
2 Bearing cap
3 O-ring

Relief choke in pipe connection

Relief chokes are installed in pipe connections of injection pump to reduce hydrocarbons in exhaust gas. A ring groove on pipe connection (arrow) serves for identification. The relief choke (2) is a plate valve (3) which opens in direction of injection nozzle and is provided with an orifice of 0.6 mm dia. The valve seat (4) is riveted into pipe connection.



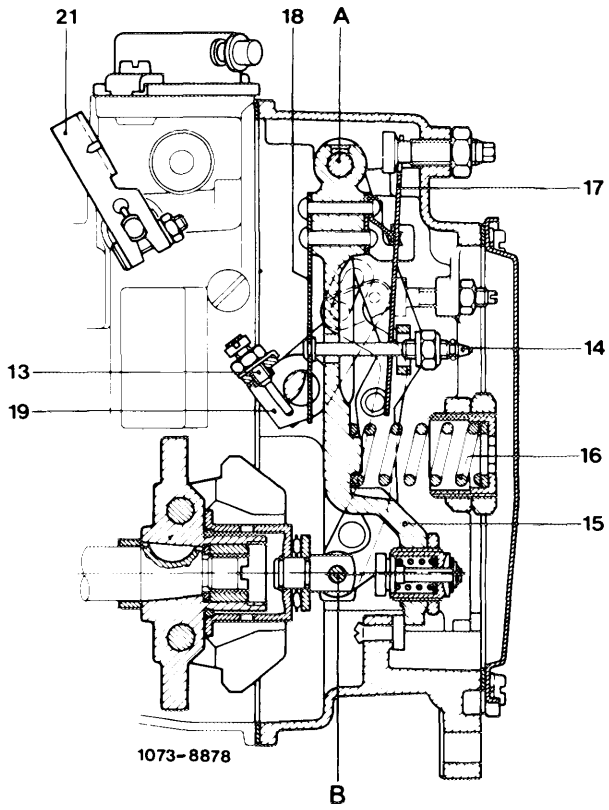
1 Compression spring
2 Relief choke (orifice)
3 Plate valve
4 Valve seat
5 Pipe connection
6 Pressure valve carrier with pressure valve
7 Sealing ring

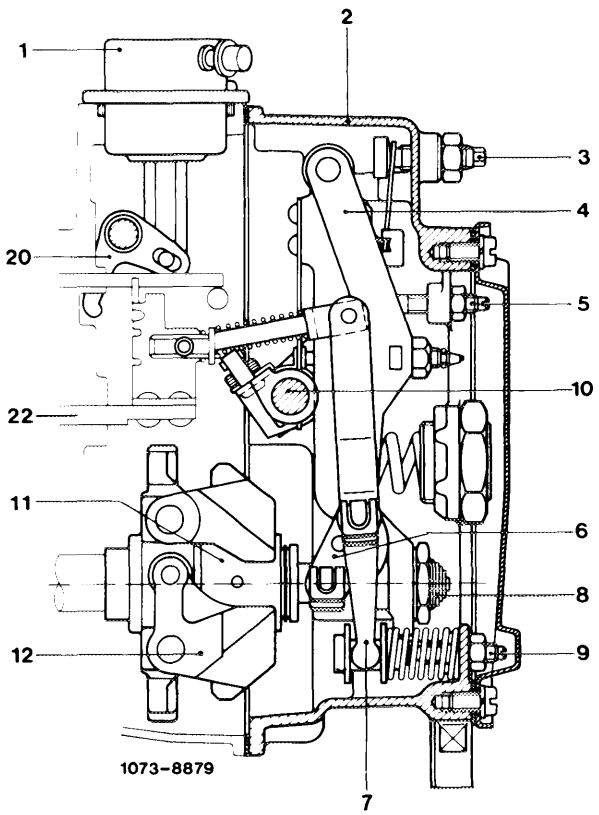
Layout and operation of RSF-governor

The governor is an idle speed-max. speed governor with its control spring (16) dimensioned and adjusted in such a manner that the governor is not governing in partial load range, except for adaptation (refer to "control during start and full load").

In partial load and full load range, the control rod (22) of the injection pump is operated by means of accelerator pedal only, which is connected to the adjusting lever (10) of governor via regulating linkage.

The adjusting screw (3) pre-loads idle speed spring and adjusts the idle speed.





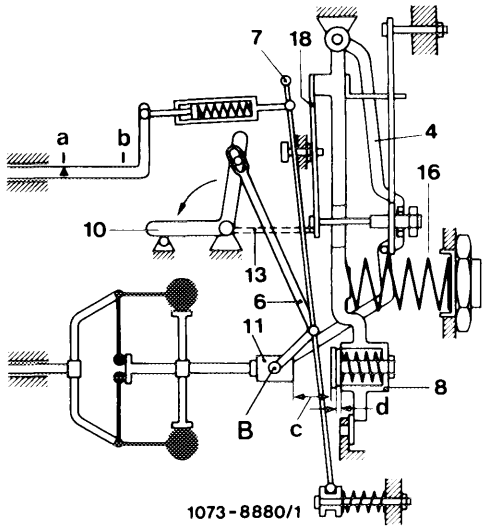
1 Vacuum control unit
2 Governor cover
3 Adjusting screw for idle speed
4 Guide lever
5 Stop screw for idle speed excess fuel
6 Reverse transfer lever
7 Regulating lever
8 Spring capsule (adaptation)
9 Full load adjusting screw
10 Adjusting lever
11 Governor sleeve
12 Fly weights
13 Idle speed auxiliary spring-shutoff
14 Adjusting screw for idle speed auxiliary spring (poppet)
15 Tensioning lever
16 Regulating spring
17 Idle speed spring
18 Idle speed auxiliary spring (poppet)
19 Linkage lever
20 Stop lever
21 Emergency stop lever
22 Control rod

Regulation during start and full load

If, with the engine stopped, the adjusting lever (10) is placed against full load stop (fixed stop on governor housing) the reverse trasfer lever (6) will rotate around pivot "B" and will take the regulating lever (7) along in direction of start.

In full load position of adjusting lever (10) ("full throttle") the idle speed auxiliary spring (18, poppet) is pushed away from guide lever by the idle speed auxiliary spring-shutoff (13). As a result, speed regulation from starting position of governor will be faster.

a Start
b Stop
c Idle speed stage
d Adaptation



After passing through idle speed stage (c) the governor sleeve (11) rests against spring capsule (8). This will move control rod of injection pump into full load position via reverse transfer lever (6) and regulating lever (7).

After attaining a given speed, the influence of the spring capsule (8) is overcome by a given distance (d) (adaptation).

If the engine speed is still further increasing, the force of the fly weights is enough to overcome regulating spring (16) (full-load speed regulation).

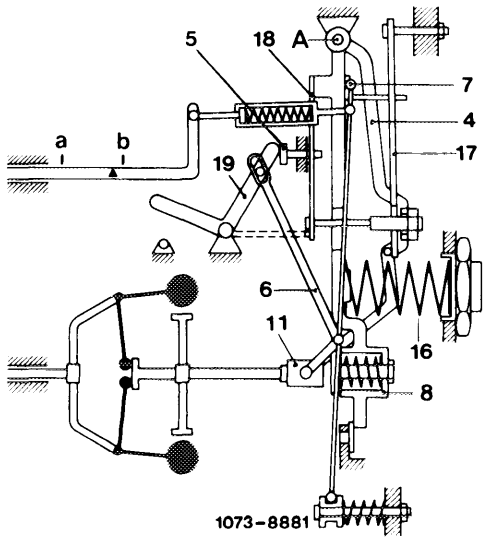
Break away depends on preload of regulating spring (16).

Regulation at idle

Linkage lever (19) rests against idle speed stop screw (5). AT increasing speed the governor sleeve (11) runs through idle speed stage. Guide lever (4) swivels around pivot "A" and thereby acts against idle speed spring (17).

At a given speed the guide lever (4) rests against adjusting nut of idle speed auxiliary spring (18). The movement of the governor sleeve (11) is transferred to control rod of injection pump via reverse transfer lever (6) and regulating lever (7) in similar direction. After running through idle speed stage, the governor sleeve (11) will rest against spring capsule (8).

If the engine speed continues to increase, (e. g., under deceleration) the spring capsule (8), at a given speed, and then the regulating spring (16) will be overcome. This will move control rod into "stop position".

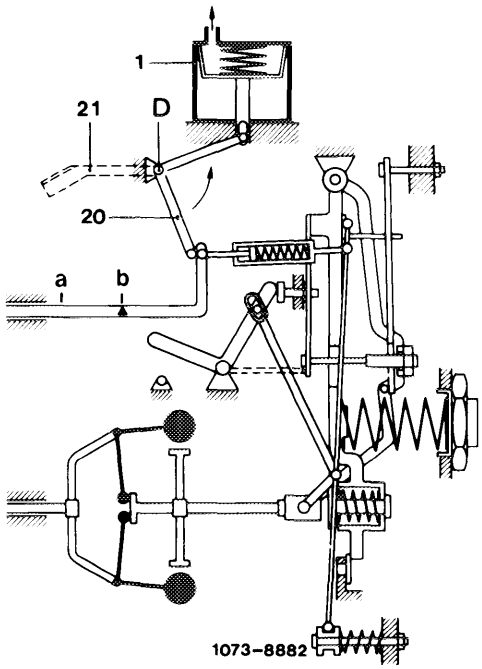


a Start
b Stop

Stop position of governor

The vacuum control unit (1) is provided with vacuum from vacuum pump via steering lock of the vehicle. As a result, the diaphragm of the vacuum control unit is attracted against pressure of compression spring.

The vacuum control unit (1) is connected to a stop lever (20). This lever will swivel around pivot "D" and will thereby pull the control rod of the injection pump into "stop position", while the shunt spring of the regulating lever will be overcome. The emergency stop lever (21) can be applied to pull the control rod likewise from outer side of governor into "stop position".

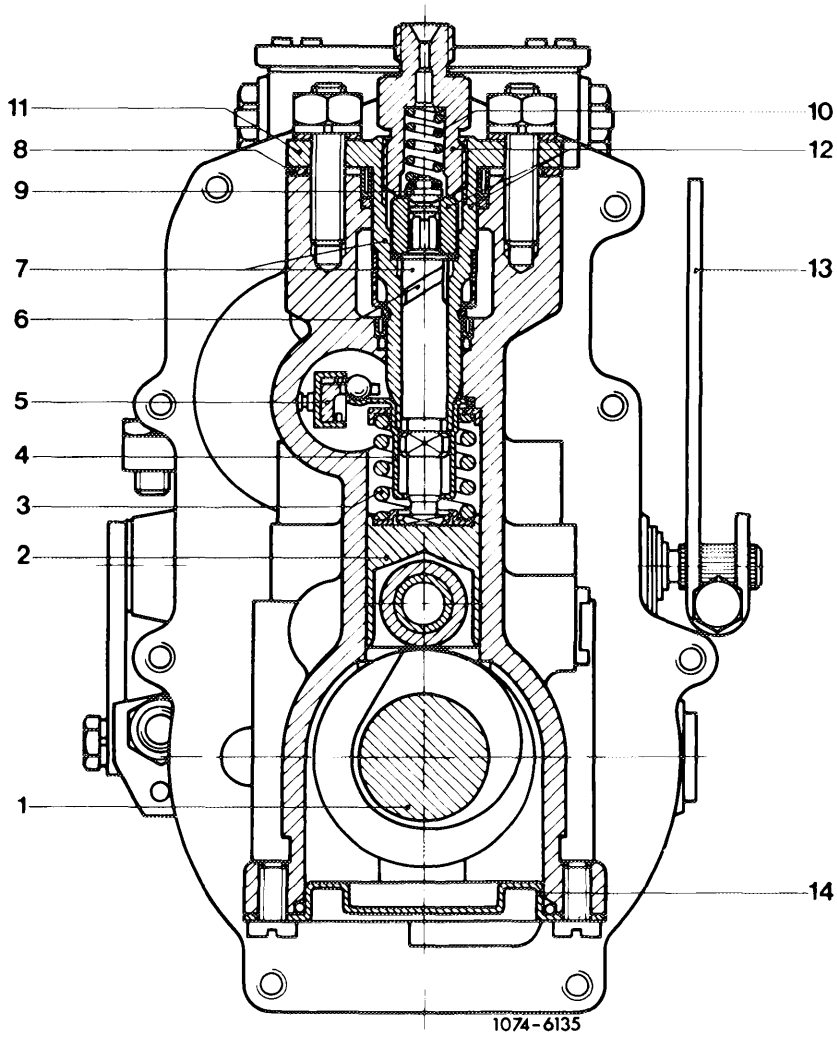


C. MW-injection pump with mechanical governor (RW)

Layout of injection pump

The layout of the injection pump is essentially the same as that of M-injection pump.
However, the element assembly (12) is mounted to injection pump housing by means of holding flange (11).

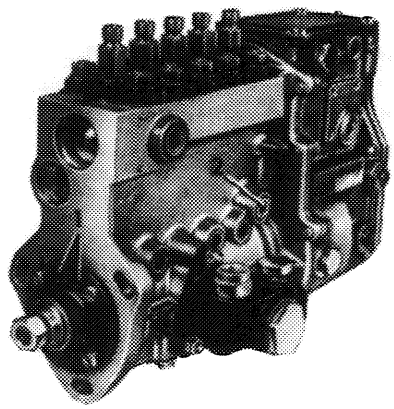
Never release fastening nuts of element assembly, because otherwise the basic adjustment of the respective element will be changed and new adjustments on test bench will be required.



1 Camshaft
2 Roller tappet
3 Compression spring
4 Control bushing
5 Control rod
6 Control edge
7 Element
8 Adjusting plate
9 Delivery valve
10 Delivery valve spring
11 Holding flange
12 Element assembly
13 Adjusting lever
14 Closing cover

Lubrication of injection pump

The injection pump is connected to engine circuit for lubrication. The oil intake (2) for lubrication is at 5th pump element. The oil flows through bores (1) on sealing flange of camshaft back into crankcase.



1 Oil outlet
2 Oil inlet

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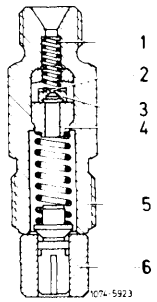
Relief choke in pipe connection (USA only)

To reduce hydrocarbons in emissions, the pipe connections of the injection pump are provided with relief chokes (orifices). Relief choke (2) is a plate valve (3) with an orifice of 0.6 mm dia., opening in direction of injection nozzle. The valve seat (4) is riveted to pipe connection.



1 Compression spring
2 Relief choke (orifice)
3 Plate valve
4 Valve seat
5 Pipe connection
6 Delivery valve mounting bracket with delivery valve

Layout and operation of RW-governor

The governor is an idle speed-maximum speed governor, with its breakaway spring (11) dimensioned and adjusted in such a manner that the governor will not be operative in partial load range, except for adaptation (refer to "governing at start and full load").

In partial load and full load range the control rod (B) of the injection pump is operated from direction of accelerator pedal only, which is connected to adjusting lever (10) of governor via regulating linkage.

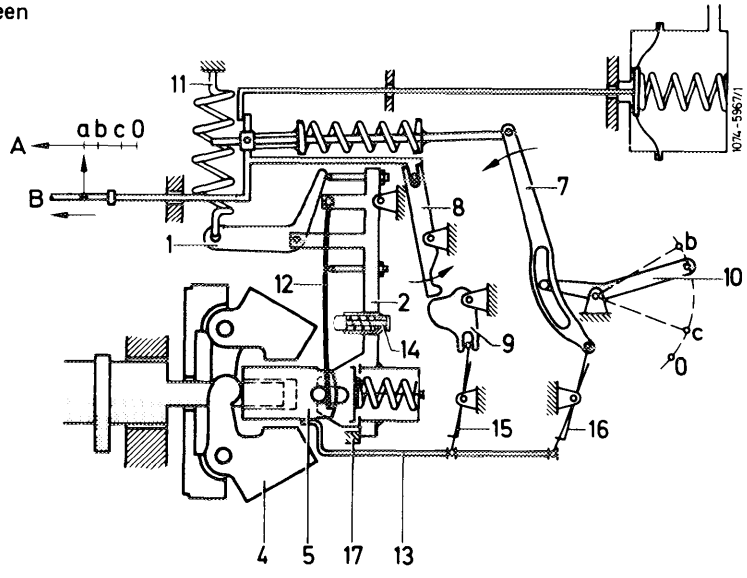
At increasing engine speed, the fly weights will move in outward direction as soon as the centrifugal force has become higher than the pressure of the regulating springs. The movement of the fly weights is transmitted to control rod (B) via governor sleeve (5), linkage (13) and regulating lever (7).

The control rod will be displaced in direction of stop as soon as the maximum speed is attained. As a result, the delivered quantity of fuel will become smaller, and the engine speed will be limited. With dropping speed, operation is vice versa.

Governing at start

In rest position, the swivel lever (2) is pushed to the left against stop (17) under influence of brakaway spring (11) and angle lever (1).
In addition, the fly weights (4) are pushed into their starting position completely inwards by means of the idle speed spring (12) via governor sleeve (5).

When the accelerator pedal or the adjusting lever (10) is operated, the control rod (B) can be moved into starting position (a), since the starting fuel lock, comprising cam (9) and sensor finger (8) has been switched off.



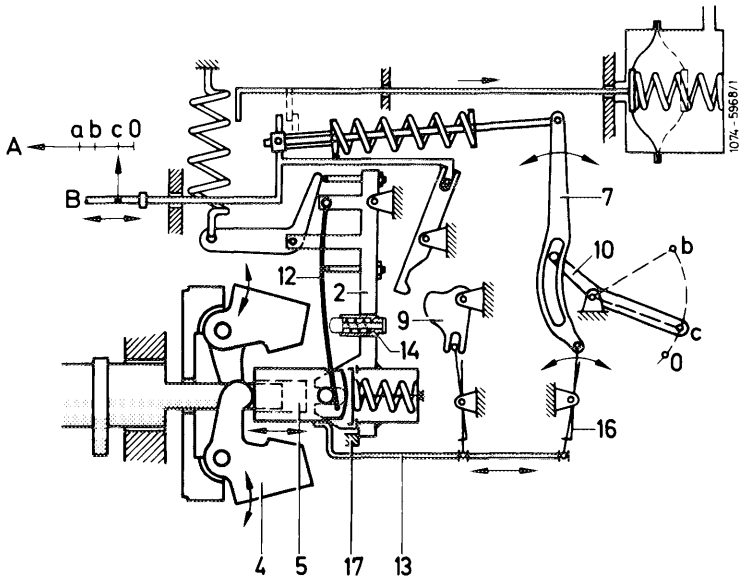
1	Angle lever	13	Linkage
2	Swivel lever	15	Connecting lever
4	Fly weights	16	Connecting lever
5	Governor sleeve	17	Stop
7	Regulating lever	A	Control path
8	Finger	B	Control rod
9	Cam	a	Starting position
10	Adjusting lever	b	Full load position
11	Breakaway spring	c	Idle speed position
12	Idle speed spring		

As soon as the engine and thereby the camshaft of the injection pump are beginning to rotate, the fly weights (4) will be moving in outward direction while governor sleeve (5) together with linkage (13) are moved to the right against the spring pressure of the idle speed spring (12).

The pin of the governor sleeve is slidingly located in slot of swivel lever (2). The respective movement will be transferred to the control rod by way of the connecting lever (16) and the regulating lever (7). Finger (8) is swivelled out of cam (9) under influence of control rod. If the speed increases, since the engine is starting, the governor sleeve (5) with linkage (13) and control rod (B) are each moving in the same direction, that is, a movement of the governor sleeve to the right causes the control rod to move also to the right. The injected quantity of fuel is reducing, the engine speed is decreasing.

Governing at idle

The adjusting lever (10) rests outside against resilient idle speed stop. (As a result, the idle speed stop can be overcome during manual shutoff.) In this position, the fly weights (4) together with the idle speed spring (12) are establishing a constant idle speed.



2 Swivel lever
4 Fly weights
5 Governor sleeve
7 Regulating lever
10 Adjusting lever
12 Idle speed spring
13 Linkage
14 Poppet
16 Connecting lever
A Control path
B Control rod
a Starting position
b Full load position
c Idle speed position

If the speed drops, the fly weights (4) are pushed inwards through spring force of idle speed spring (12). The governor sleeve (5) and thereby the linkage (13) will move to the left. The linkage moves the control rod (B) also automatically to the left via connecting lever (16) and regulating lever (7), which means an increase in quantity and thereby an increase in speed.

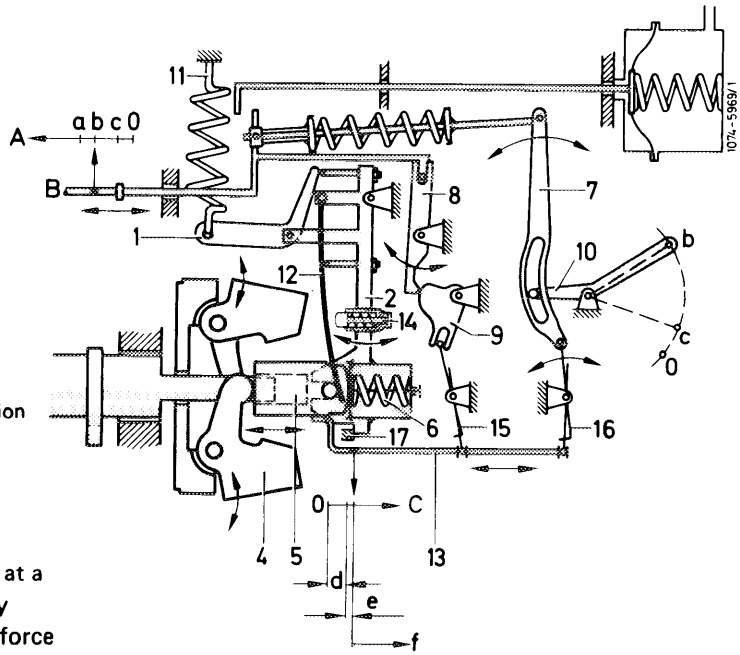
The fly weights are again moving away from each other. The governor sleeve and thereby the control rod are moved to the right (less injected fuel) until centrifugal force and spring force of idle speed spring (12) are in balance. By this means, an almost constant speed can be maintained even if the air contitioning system, power steering or a driving position are engaged.
To stabilize idle speed, the swivel lever (2) is provided with an idle speed auxiliary spring (14, poppet), which pushes against idle speed spring as from a given speed and thereby stabilizes the idle speed.

Full load and breakaway

In partial and full load range the control rod (B) of inspection pump is actuated from direction of accelerator pedal only, which is connected to the adjusting lever (10) of the governor by way of the regulating linkage.

In full load position, the adjusting lever (10) rests outside against full load stop, that is, the control rod is at full load = max. delivered quantity which can be burned free of smoke by engine.

The starting quantity lock, comprising finger (8) and cam (9) prevents merely that no starting fuel is injected during full load and at low speeds.



1	Angle lever	A	Control path
2	Swivel lever	B	Control rod
4	Fly weights	C	Governor-sleeve travel
5	Governor sleeve	a	Starting position
6	Compensating spring	b	Full load position
7	Regulating lever	c	Idle position
8	Finger	d	Idle path
9	Cam	e	Adaptation path
10	Adjusting lever	f	Full-load speed regulation
11	Breakaway spring		
13	Linkage		
17	Stop		

Breakaway at full load and partial load proceeds at a given max. speed. The centrifugal force of the fly weights (4) will become higher than the preload force of the breakaway spring (11), so that swivel lever (2) will move from housing stop (17) to the right.

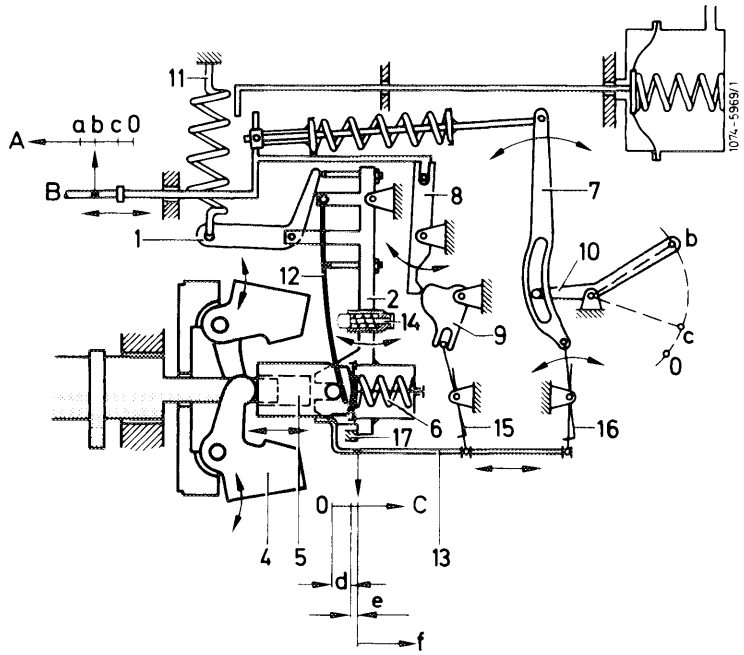
The resulting governor sleeve path will lead by way of the various transmission elements to a control rod movement in the direction of stop (0), until a given speed and injection quantity in accordance with engine load have been achieved.

If the engine is relieved with the position of the adjusting lever unchanged, speed will increase under no-load conditions up to max. speed. A speed difference between begin of breakaway and end of breakaway (max. speed unloaded) can be used to determine the P-degree (proportional degree).

Position between idle speed and full-load speed regulation

Except for adaptation, there will be no additional governing in this range.

Adaptation serves the purpose of providing the engine with the respectively correct quantity of injected fuel during each operating point on full load curve.

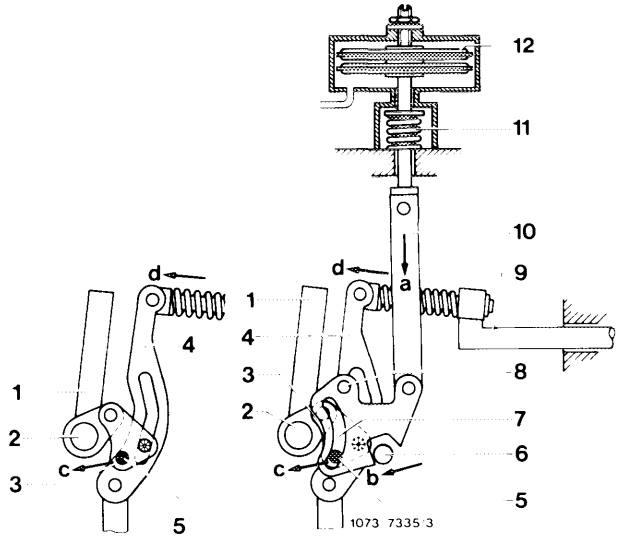


2 Swivel lever
4 Fly weights
5 Governor sleeve
7 Regulating lever
10 Adjusting lever
12 Idle speed spring
13 Linkage
14 Poppet
16 Connecting lever
A Control path
B Control rod
a Starting position
b Full load position
c Idle speed position

Prior to adaptation the governor is again in the position as shown in illustration. The fly weights have overcome the idle speed spring (12) and the adaptation spring (6) by way of the governor sleeve (5), so that the governor sleeve (5) now rests rigidly against swivel lever (2). If the engine load is increased, the speed will drop; the compensating spring (6) will push the adaptation bolt which rests on governor sleeve (5) in outward direction, and the fly weights will move towards each other. The path made by the compensating spring is restricted by means of a stop on compensating bolt. Under influence of moving sleeve, the control rod will be pushed forward for a given distance (adaptation path) via linkage (13) and regulating lever (7), which will increase the injected quantity of fuel and the torque. The operating range of the adaptation is determined by the preload of the compensating spring in compensating capsule and its rigidity.

Automatic altitude adjusting unit

At increasing altitude above sea level (decreasing atmospheric pressure) the two diaphragm units (12) will expand. As from a given outside pressure (atmospheric pressure) the inner force of the diaphragm unit will become higher than the preload of the altitude adjusting unit-preload spring (11). Pushrod (10) will then move in direction "a". As a result, template (7) is lifted from stop (6) in direction "b" by means of a lever and the lever (3) will move in the direction of "c" (refer to lefthand drawing cutout).



1 Adjusting lever
2 Adjusting lever shaft
3 Lever
4 Regulating lever
5 Bolt
6 Stop
7 Template
8 Pivot
9 Control rod
10 Push rod
11 Altitude adjusting unit-preload spring
12 Diaphragm unit

Since the regulating lever (4) is coupled to lever (3) by means of a bolt, the regulating lever (4) and thereby the control rod (9) are moving in direction "d", so that less fuel will be injected. The more the adjusting lever (1) is adjusted in direction of idle (stop) the closer will bolt (5) of lever (3) move toward pivot (8).

As a result, adjustment at partial load is constantly getting lower and will move to almost zero adjustment in idle speed position. At low altitudes above sea level the template (7) constitutes a concentric circle around adjusting lever shaft (2), so that behaviour of governor will not be corrected.