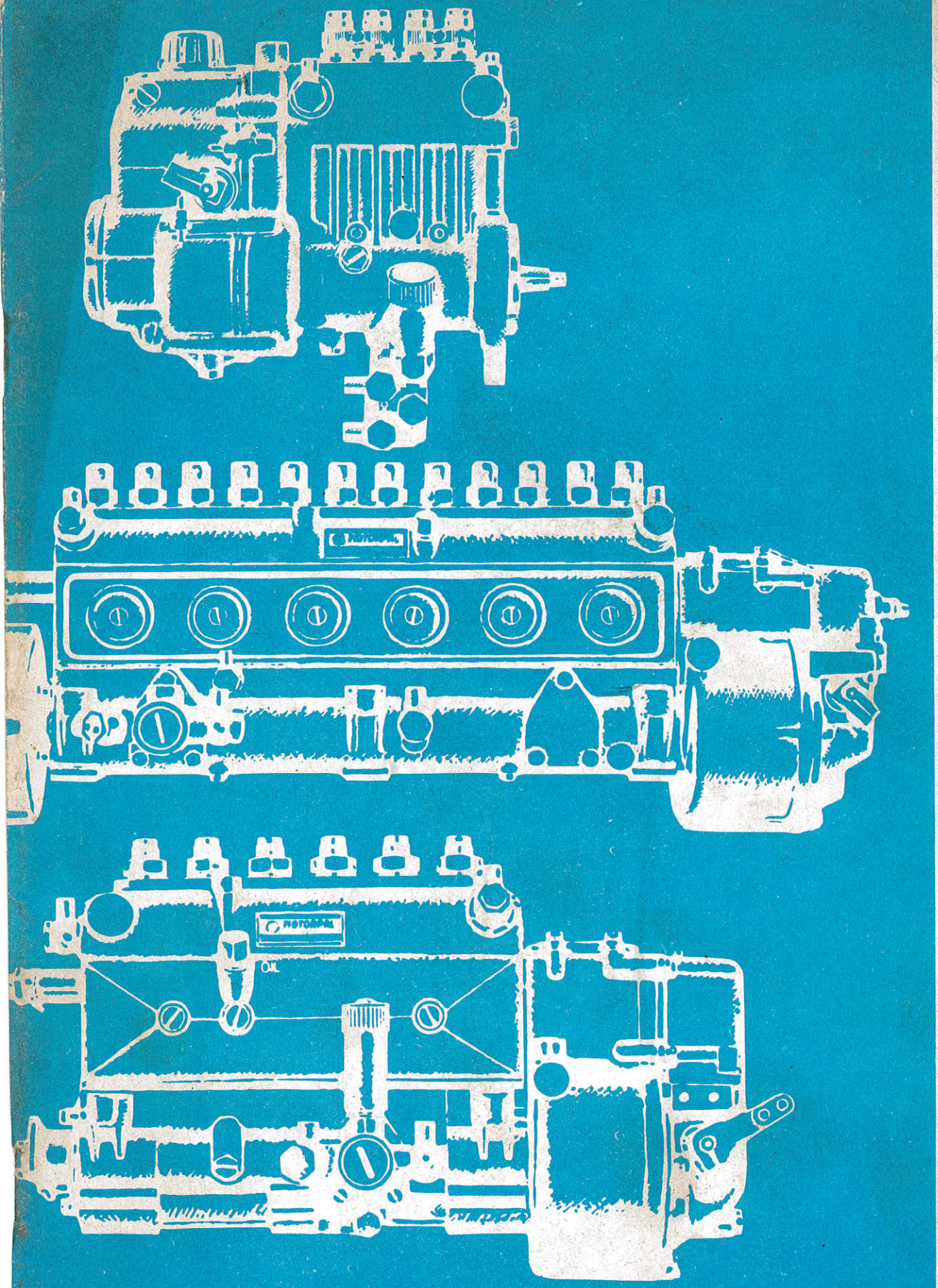
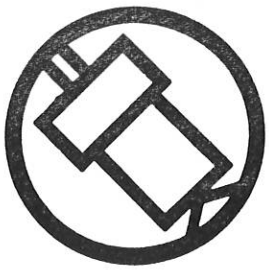


INSTRUCTION FOR THE OPERATION AND MAINTENANCE OF FUEL INJECTION EQUIPMENT

MOTORPAL JIHLAVA

INSTRUCTION FOR THE OPERATION AND MAINTENANCE OF MOTORPAL FUEL INJECTION EQUIPMENT



CONTENTS

INTRODUCTION

The spraying of fuel into combustion chambers of compression ignition engines is taken care of by a complex fuel injection system, placing high demands on technical perfection and precision manufacture.

On its correct functioning largely depends the engine power output as well as the engine running reliability and economy. Important factors affecting the correct functioning and long service life of the injection equipment are periodic maintenance, skilful handling, and the use of well filtered fuel.

The purpose of this manual is to acquaint you with the principles of the correct operation and maintenance of your fuel injection equipment.

With the exception of minor repairs described in this manual, we recommend you to get in touch in the case of a defect with specialized repair shops and service stations of the MOTORPAL National Corporation, Jihlava, equipped with special tools, instruments and fixtures, and familiar with the latest development and changes in the manufacture of fuel injection systems.

When replacing a defective fuel injection pump, always use a pump of the same make and type designation or another new pump recommended by the manufacturer as suitable replacement part for your engine.

The suitability of fuel injection systems for the individual engine types, their assembly and interconnection, have been tested and determined by the fuel injection system designers in close co-operation with engine designers.

We advise therefore against any interference with the fuel injection equipment.

FUEL INJECTION EQUIPMENT

The fuel injection equipment is designed to deliver the fuel into combustion chambers of a compression ignition engine in accurately metered quantities at the optimum moment and rate required for obtaining the optimum engine output.

From the point of view of function the fuel injection equipment can be divided into the following components:

1. Fuel line — low-pressure and high-pressure part
2. Fuel filters — prefilter and fine filter
3. Fuel feed pumps — feed pump, hand pump (primer)
4. Fuel injection devices — fuel injection pumps with accessories
5. Injectors — injection nozzles, nozzle holders.

With regard to the different designs and outputs of C. I. engines, their injection equipment has also to be designed and manufactured in different sizes and types to satisfy all requirements placed on them.

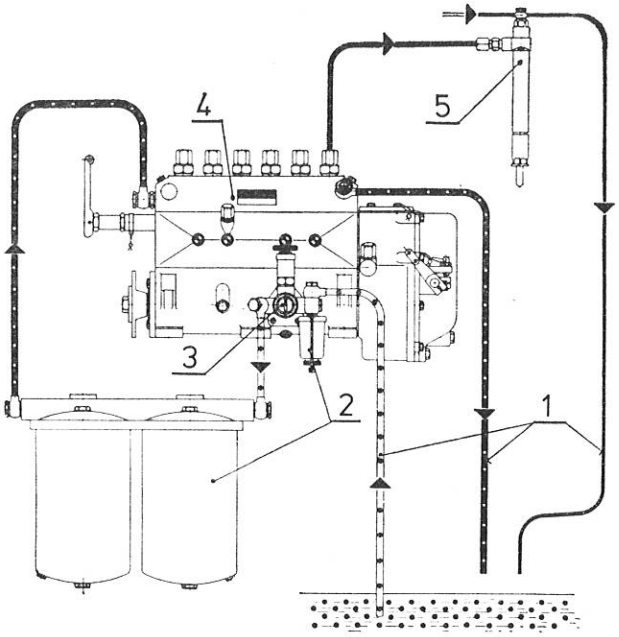


Fig. 1

The individual components of the fuel injection equipment can be arranged in several ways, but they must always ensure that the fuel injection pump is filled with the required quantity of fuel at the required pressure.

The drawing shows one of the ways in which the fuel is sucked by the fuel feed pump from the fuel tank through the suction piping and the fuel prefilter and then delivered via the delivery piping and the fine fuel filter into the fuel channels of the fuel injection pump.

The required fuel pressure is maintained by the pressure-relief valve.

Excess fuel transferred by the pressure-relief (or overflow) valve returns through the overflow pipe into the fuel tank. The fuel feed pump incorporates a hand pump (primer) enabling the priming of the fuel injection equipment with fuel and its bleeding with the engine stopped.

The accurately metered quantity of fuel is delivered by the injection pump under high pressure into the injectors through injection pipes, and fuel injection nozzles spray the fuel into combustion chambers of the engine cylinders.

The fuel that seeps past the nozzle needle drips off the injector and is returned by the drip-off piping into the fuel tank.

The most frequently used arrangements of the fuel injection equipment:

— Fuel flows into the injection pump by gravity from the fuel tank installed at a sufficient height. In this case, the fuel feed pump and the pressure-relief valve are obviated.
— Instead of on the injection pump, the fuel feed pump is installed direct on the engine.
— Two fuel feed pumps are used.

— The fuel prefilter is installed outside the fuel feed pump, for instance at the fuel tank cock.
— The hand primer is not installed on the fuel feed pump but in a more readily accessible place, or it is replaced with an electrically driven pump (with an electric motor).
— The pressure-relief or overflow valve is not installed at the end of the injection pump fuel channel (chamber) but on the fine fuel filter, and excess fuel returns into the fuel tank from the fine filter.
— Fuel seeping past the nozzle needle of the injector is not returned into the fuel tank.
— Fuel in the tank is warmed up by a special preheater connected to the overflow piping.
— Instead of the injection device, individual single-cylinder injection pumps of the types PC and PR are installed on the engine for each cylinder separately.

1. FUEL LINE

The fuel line used for MOTORPAL fuel injection systems is not made by the MOTORPAL National Corporation, Jihlava

According to working pressure, the fuel line can be divided into a low-pressure and a high-pressure line.

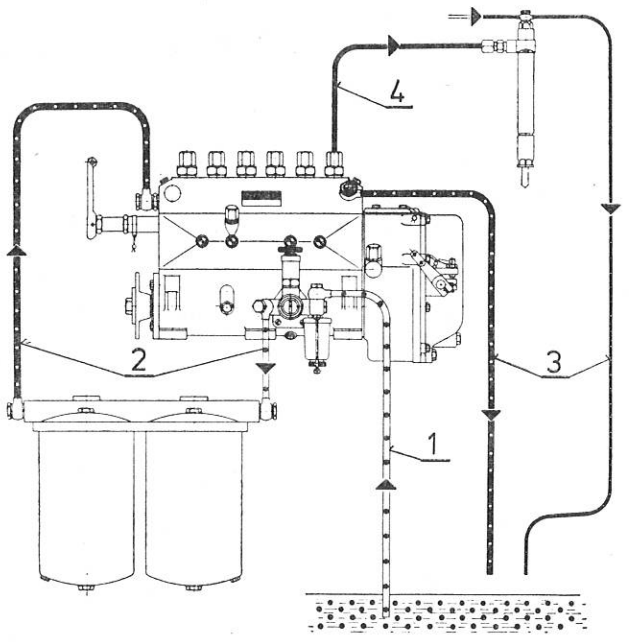


Fig. 2

LOW-PRESSURE LINE

It connects the fuel tank with the individual parts of the fuel injections equipment. There must be no sharp bends, and the line must have an upward gradient to prevent formation of air pockets or sediments, especially water, that would obstruckt the smooth flow of the delivered fuel.

According to function, the low-pressure line is divided into suction, delivery, and overflow piping. Trough *the suction piping* (1) passes the fuel sucked by the feed pump from the fuel tank via the prefilter. This piping must be perfectly leak-proof to prevent the drawing-in of air and thus an aeration of the injection equipment causing its poor performance.

Trough *the delivery piping* (2) passes the fuel delivered by the feed pump via the fine fuel filter into the fuel channel (chamber) of the injection pump.

The overflow piping (3) returns the fuel from the pressure-relief (overflow) valve and drip-off fuel from the injector into the fuel tank.

HIGH-PRESSURE LINE (4)
(DELIVERY PIPES TO NOZZLES)

Through the delivery pipes pass the accurately metered quantities of fuel from the injection pump to the injector. The fuel is delivered under high pressure and therefore the pipes must be made from high-pressure, thick-walled and seamless steel tubes. Delivery pipes should be as short as possible, without sharp bends, and of eqaul length. Fuel delivery is greatly affected by their lengths and bore.

SERVICE OND MAINTENANCE OF FUEL LINE

Fuel line doesn't require service. Maintenance of fuel is done by testing the tightness and tightening of all connections.

FUEL LINES REPAIRS

Untight joints of the fuel line, and especially a leaky suction piping, cause an aeration of the fuel injection equipment resulting in its poor performance. They may also be the cause of a difficult engine starting (especially after a prolonged period of inactivity) and the necessity of frequent injection system bleeding. Moist spots with dirt sticking to them indicate points where the fuel is leaking.

Repairs of low-pressure piping

Fuel piping must be made of a material resistant to aggressive effects of the fuel, for example armoured tubes of synthetic rubber, steel pipes, etc.

Before refitting a repaired or a new, replacement low-pressure piping, clean it thoroughly and remove burrs and iron scale from steel pipes. Never use doubtful or defective packing rings — keep always on hand a sufficient stock of new packings.

Repairs of high-pressure piping (delivery pipes)

When repairing delivery pipes by brazing of cold-upsetting new connecting cones, calibrate them in a length of about 30 mm from their ends using a drill with a diameter larger by 0.2 mm than their bore of the whole delivery pipes with a length of steel wire. Blow through the repaired

pipes with compressed air or flush them with a testing liquid, for example on the NC 50 tester.

Before installing new pipes, shape them after the original one by bending them suitably, and then blow them through or flush them to remove any particles that have come loose while bending the pipes.

Any repaired or replacement pipe must have the recommended length and bore.

Delivery pipes should be attached in a way that shall protect them from excessive vibration and from striking against some part of the engine.

2. FUEL FILTERS

The primary condition of a correct and trouble-free operation and long service life of the fuel injection equipment is the use of clean fuel free of all foreign matter. Dirt particles contained in fuel cause serious defectes of the most precisely machined parts, i. e. injection pump barrels and plungers, delivery valves, and injection nozzles.

First of all, the fuel tank should be filled only with diesel oil that has been allowed a sufficient period for sedimentation. In addition, a thorough filtering during the vehicle operation is ensured by two filters, the fuel prefilter or coarse filter, and the fine filter.

FUEL PREFILTER

The purpose of the prefilter is to trap coarse dirt particles contained in the fuel before it enters into the fuel feed pump and so to protect the moving parts and valves of the feed pump from damage. It also traps part of the water contained in the fuel. In contrast to the former filters incorporated directly in the fuel feed pump, the FJ 2R prefilter is a separate unit that can be installed on the feed pump or any other part of the suction line, to which there is a better access.

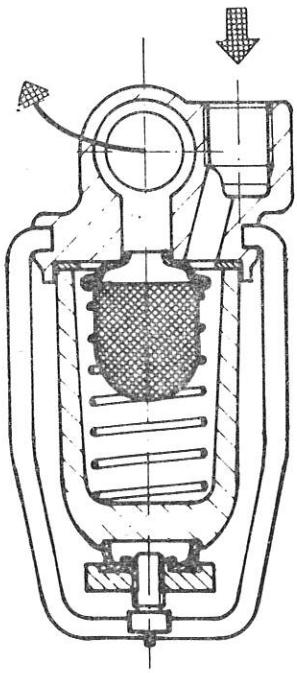


Fig. 3

Description

Main parts of the prefilter are the filter housing, the glass bowl, and the filter element of fine wire meshing, held against the housing by a spring. The glass bowl is fastened to the filter housing by the nut of the clamping yoke, and sealed off by a rubber sealing ring. To make foreign matter settle in the glass bowl, the fuel must be led on to the outer surface of the filter element from above trough a vertical inlet.

FINE FUEL FILTER (Fig. 4)

The fine fuel filter used for trapping fine, microscopically small dirt particles contained in the fuel, is installed as a part of the delivery line between the fuel feed pump and the injection pump. The filter element of the fine filter can be made either of felt, cloth, or cellulose (paper). On its filtering capacity depends greatly the service life and the function of precision matched parts of the injection equipment. To achive a still better filtering of the fuel, two-stage filters are often used, especially in vehicles intended for work in heavy-duty conditions.

A dual fuel filter is used where it is necessary to clean or replace filter elements during the vehicle operation.

The MOTORPAL National Corporation, Jihlava, manufactures only some of the types of fine fuel filters. Their main manufactures is the AUTOBRZDY National Corporation, Jablonec nad Nisou.

Description

Fine fuel filters made by MOTORPAL and AUTOBRZDY have filter housings of different designs. The housing of MOTORPAL filters is formed by the bowl, and the filter cover is removable. On the contrary, AUTOBRZDY filters have a bowl that is removable together with the filter element.

The fuel enters into the fine fuel filter top part, usually in the tangential direction, circulates around the filter element fastened on the centre (through) bolt and passes through the filter element from outside to its inside. In this process, the finest dirt particles are trapped by the filter element and clean fuel flows from the inside of it through a hole drilled for this purpose in the centre bolt.

A bleeding screw is provided in the top port of the fine fuel filter for its bleeding. Some of the filters have a pressure-relief valve, through which air escapes and by which excess fuel is returned into the fuel tank.

A drain screw or nut in the bottom part of the filter bowl is used for draining the settled mud.

Two-stage fuel filter (Fig. 5)

A two stage filter is formed by two single-stage filters connected one behind the other in a single

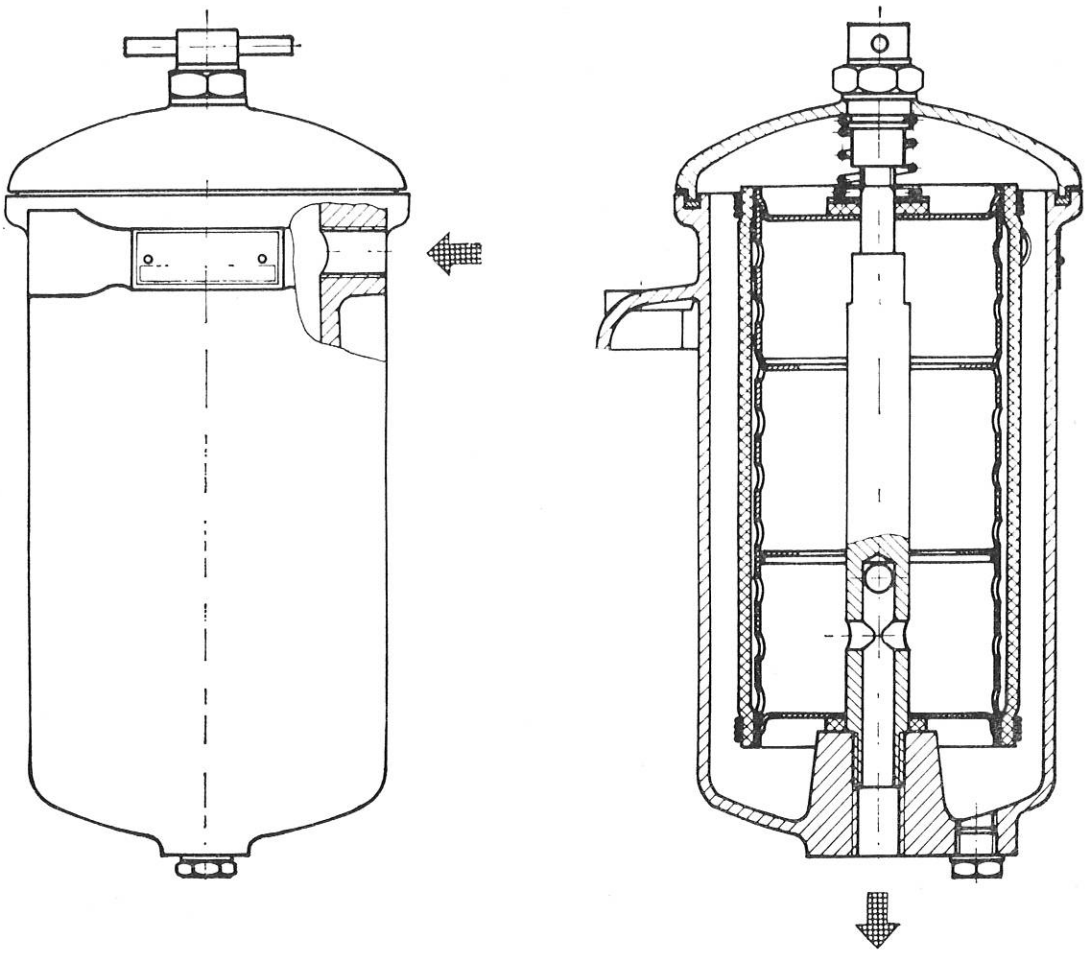


Fig. 4

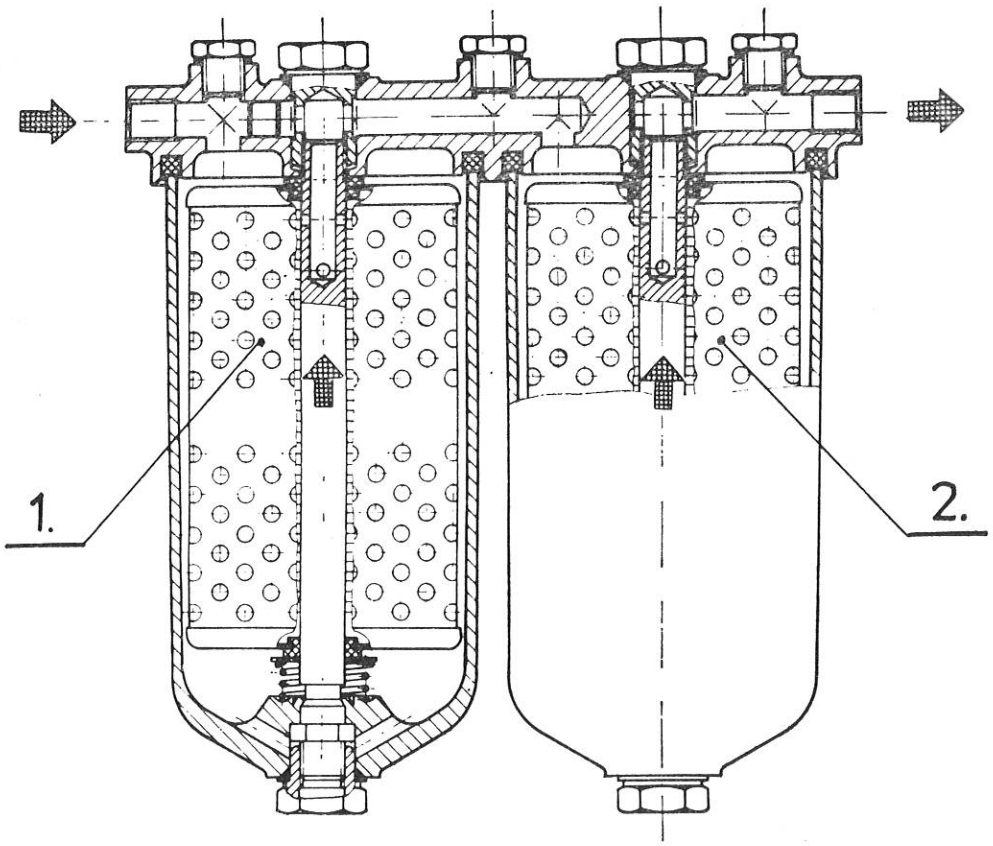


Fig. 5

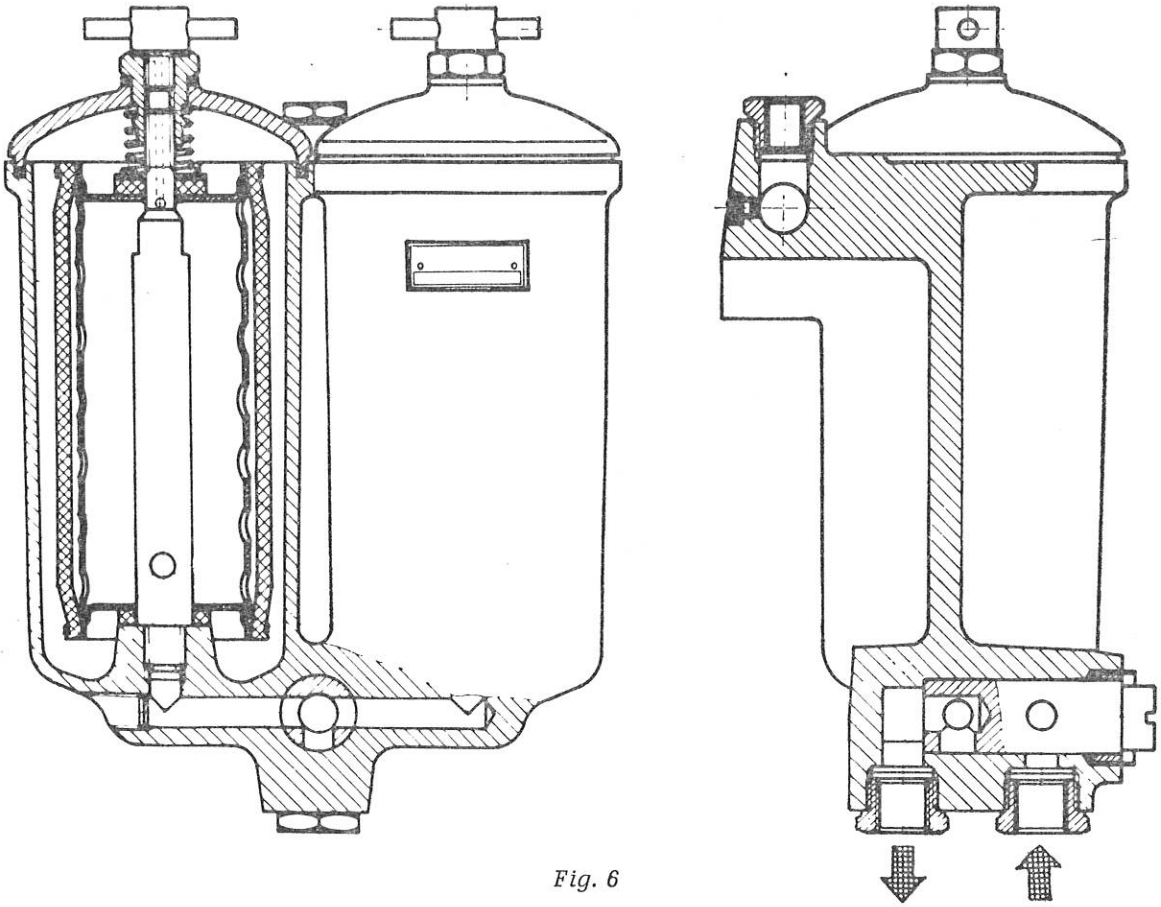


Fig. 6

housing. The fuel passes from one filter into the other, and the result is a better filtering of the fuel.

Dual fuel filter (Fig. 6)

A dual filter is formed by two single-stage filters connected side by side in a single housing. Inlet and outlet channels interconnect the bottom parts of both bowls. The fuel flow can be changed over by means of a three-way cock so that each of the two filters can be shut off for sleaning, etc. Slots on the cock indicate the fuel flow direction.

ATTENDANCE OF FUEL FILTERS

The fuel prefilter does not require any attendance during operation. Attendance required by the fine fuel filter consists in its bleeding, usually after the vehicle has not been used for a certain time, after repairs or maintenance of the fuel injection equipment, and whenever air has been sucked into the injection equipment from the fuel tank.

Fine fuel filter bleeding

Loosen the bleeding screw and operate the hand primer till fuel free of air bubbles begins flowing past the bleeding screw. Then retighten the screw.

MAINTENANCE OF FUEL FILTERS

Fuel prefilter maintenance

Inspect the glass bowl periodically and wash it out if mud has accumulated on its bottom.

Glass bowl cleaning

Loosen the nut of the clamping yoke.

Remove the bowl together with the filter element and wash them in petrol or diesel oil.

Blow off the filter element with compressed air.

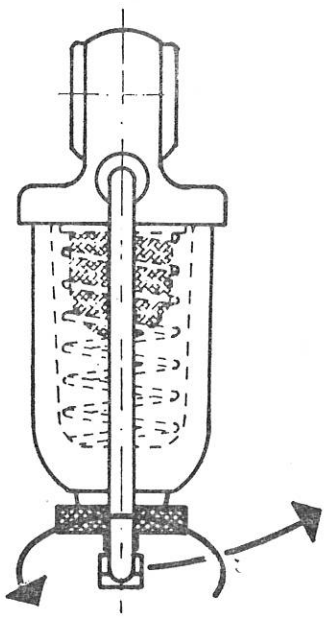


Fig. 7

Reinstall the filter element with its spring into the glass bowl, and fit the glass bowl carefully on the rubber packing in the filter housing.

Retighten the clamping yoke nut. Air gets into the suction line while the glass bowl is removed and so it is necessary to bleed it. Loosen the bleeding screw of the fine fuel filter, and prime fuel into the prefilter by operating the hand pump (primer). Retighten the bleeding screw of the fine fuel filter after having bled it.

Fine fuel filter maintenance

The maintenance of the fine fuel filter consists in discharging the mud, cleaning, and replacement of the filter element with a new one.

Mud discharging

Remove the drain (mud discharging) screw or nut from the bottom part of the filter and drain the sediment. Operate the hand pump to flush the filter, and then reinstall the screw or nut and tighten it properly.

discharge the mud first from the stage I and then from the stage II filter.

In the case of dual filters first shut off the part, from which the mud has to be discharged. The duel filter can be bled without stopping the engine. Loosen the bleeding screw and then change over the three-way cock to interconnect the bled part of the filter. If a great quantity of mud is discharged from the filter, clean the filter elements or replace them with new ones.

Cleaning and replacement of filter element

Remove the mud discharging screw from the bottom of the filter housing and drain the mud.

Loosen the screw of the filter cover and lift away the cover.

Withdraw the filter element and flush the filter interior with diesel oil. Felt or cloth filter elements fitted on a perforated support sleeve can be cleaned by washing in petrol and blowing through with compressed air. Examine the filter elements

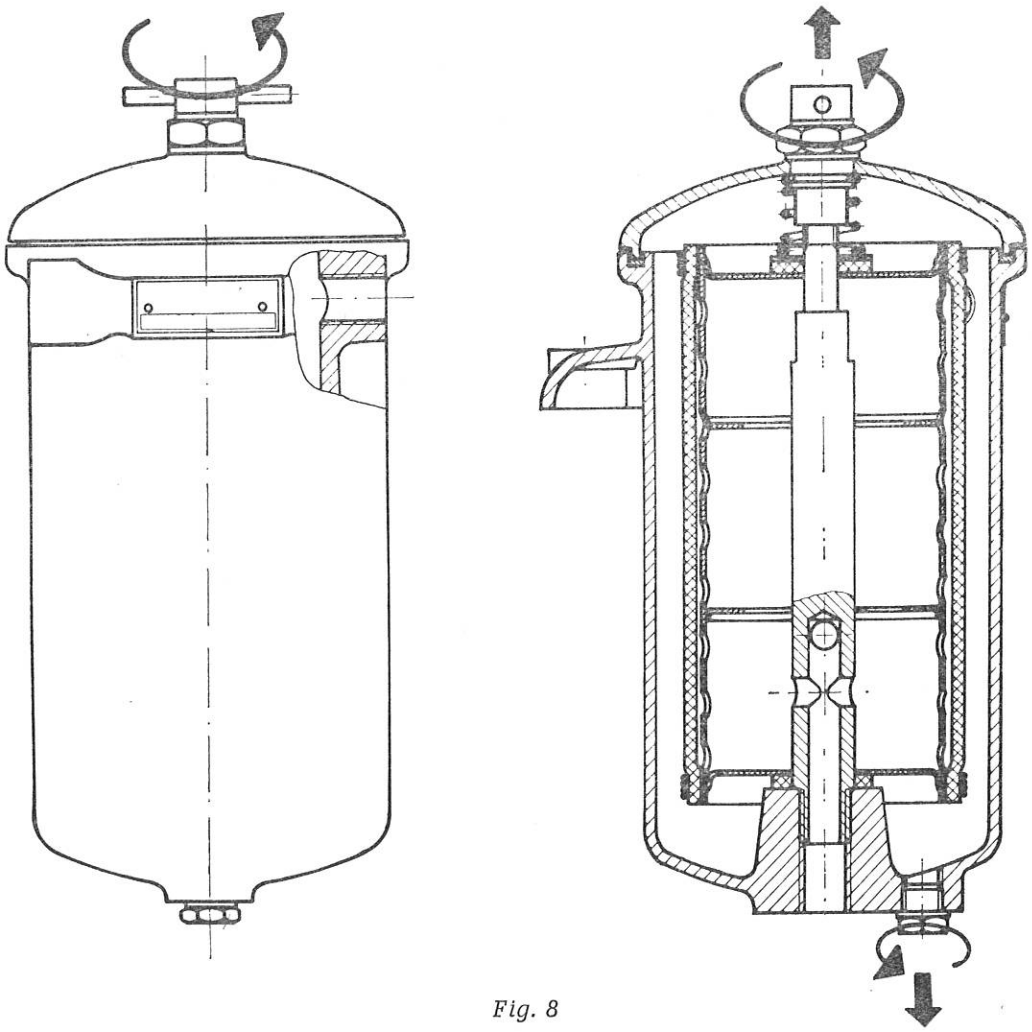


Fig. 8

Loosen the bleeding screw, operate again the hand pump to bleed the fine fuel filter, and retighten the screw. When cleaning a two-stage filter,

whether they are not damaged or otherwise defective. Discard defective elements as well as element that were already cleaned two or three times, and

replace them with new ones. Paper (cellulose) filter elements cannot be cleaned. Discard them when clogged and fit new ones. Fasten every new filter element properly to its supporting sleeve. Felt filter elements should be fastened about 5 mm from their ends. Examine carefully every filter element to make sure that its density and thickness are uniform and that it is not damaged at any point. A cloth (calico) filter element must be properly stretched on the sleeve, and both its ends must be drawn together so that no thick folds are formed, along which dirt particles could penetrate inside.

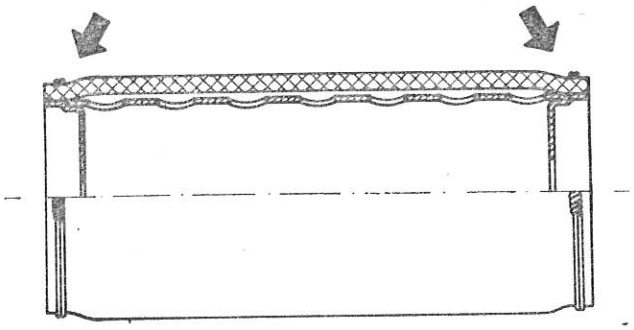


Fig. 9

Wash and blow trough also new filter elements to clean them of dust and loose fibres.

Do not forget to put felt sealing rings under and above the filter element when reinstalling it into the filter. These felt rings seal off the filter element around the centre bolt. Finally fit the filter cover carefully on the rubber packing in the recess of the filter housing and tighten the cover fastening screw.

Loosen the bleeding screw and operate the hand primer to bleed the fine fuel filter. Retighten the bleeding screw.

In the case of filters made by the AUTOBRZDY National Corporation, Jablonec nad Nisou, loosen the cover fastening screw and remove the filter bowl with the filter element instead of the cover. The following procedures are the same as in the case of fuel filters made by the MOTORPAL National Corporation, Jihlava.

Two-stage fuel filter

The procedure of cleaning a two-stage filter is the same as when cleaning a single-stage filter. Filter elements of two-stage filters can however be, of different quality. In that case, the filter element of stage II must have a higher filtering capacity than the filter element of stage I.

Dual fuel filter

Cleaning of a dual filter is likewise the same as the cleaning of a simple single-stage filter. Since the dual filter is usually cleaned during the vehicle operation, it is necessary first to put out of operation the part of the filter to be cleaned by means of the three-way cock.

FUEL FILTER REPAIRS

When due attention is paid to the maintenance of fuel filters, the only defect that can occur is a leakage, and, in the case of fine fuel filters with a pressure-relief valve, a failure of the valve.

Other defects caused by a mechanical damage have to be removed by replacing the defective part with a new one.

Fuel filter leakage

Leakage of fuel prefilters and fine fuel filters is usually caused by dirt on the mating surfaces or by a defective rubber so that it can be removed by fitting a new rubber packing or by cleaning the mating surfaces.

3. FUEL FEED PUMPS

FUEL FEED PUMP

The fuel feed pump delivers the fuel from the fuel tank via fuel filters to the injection pump, always in a larger quantity and at a higher pressure than required, to ensure the immediate filling of the injection pump barrels with fuel during the suction stroke. A pressure-relief valve maintains a constant filling pressure of the fuel in all working conditions. Fuel feed pumps can be installed on the engine cylinder block and driven by the camshaft of the engine timing gear. In the case of fuel injection pumps with selfdrive, they can be installed on the fuel injection pump housing and driven by the eccentric of the injection pump camshaft.

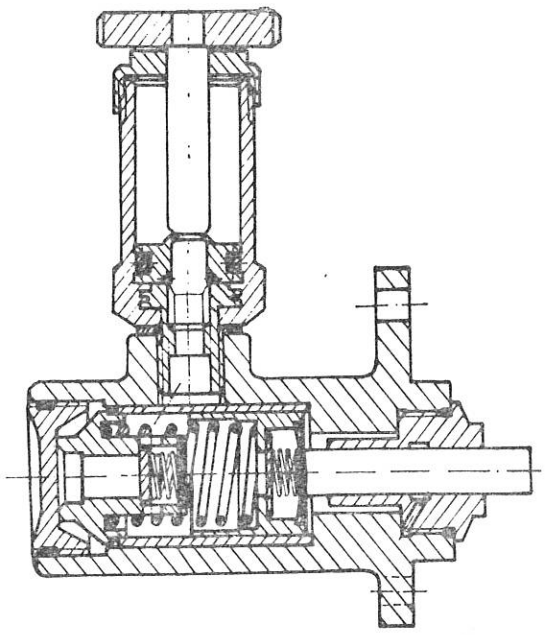


Fig. 10

MOTORPAL fuel feed pumps are of the piston-type, and they have a suction and a delivery valve. The return stroke of the piston is derived from a pressure spring, the thrust (force) of which also determines the attainable fuel pressure.

HAND PUMP

To enable pumping of the fuel with the engine stopped, fuel feed pumps are supplemented with a hand pump (hand primer) installed between the suction and delivery valve of the fuel feed pump. When operating the hand primer, the fuel is drawn in through the suction valve and discharged through the delivery valve in any position of the feed pump piston.

The CR 1... hand pump installed outside the fuel feed pump for better access has its own suction and delivery valves.

In some instances, the CS 1A... motor driven (electric) fuel feed pump is used instead of the hand pump.

PRESSURE-RELIEF VALVE

The pressure-relief or overflow valve can be fitted on the fine fuel filter or at the end of the injection pump fuel channel. Its purpose is to maintain a constant filling pressure in the fuel

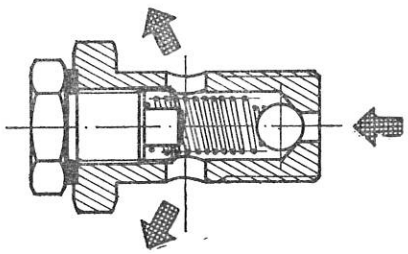


Fig. 11

chamber of the pump and to transfer the surplus quantity of the fuel delivered by the fuel feed pump back into the fuel tank. Its opening pressure is set in accordance with the design injection pump barrel and plunger. A pressure drop results in an imperfect filling of the fuel chamber above the plunger during the suction stroke, and an excessive pressure rise can cause, for instance, a marked diffusion of the fuel into the oil filling of the injection pump.

FUEL FEED PUMP OPERATION

Hand priming

Rotate the hand pump piston to release it from the thread holding it in locked position. By pushing and pulling the push rod of the piston, the fuel is drawn in through the suction valve and discharged through the delivery valve. After having completed the priming, lock again the piston in position by rotating it in the opposite direction.

The moving barrel of certain types of hand pumps is locked in position by two pins in a groove. It can be released or relocked in its lower position by rotating it through about 90 degrees.

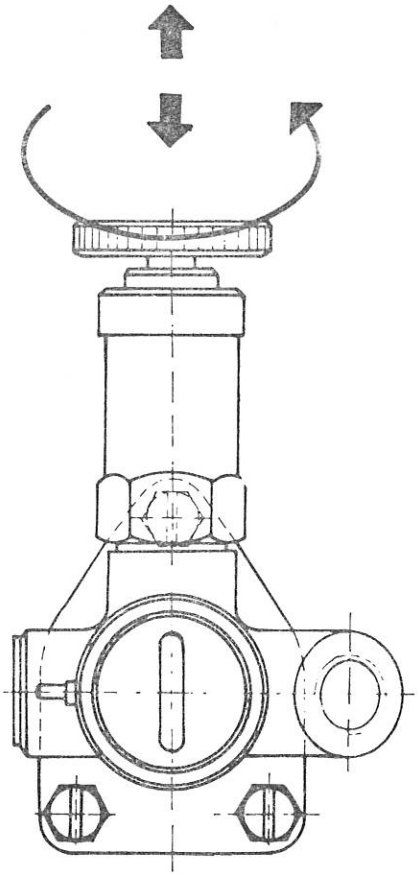


Fig. 12

FUEL FEED PUMP MAINTENANCE

The push rod of the fuel feed pump is lubricated with oil from the engine or the fuel injection pump so that no maintenance is required from the point of view of lubrication.

FUEL FEED PUMP REPAIRS

A leaky suction or delivery valve, a worn piston, and a leaky piston of the hand pump cause invariably a decrease of the pump discharge.

Whatever the defect, it is necessary to replace the whole fuel feed pump. The only exception is the leaky piston of the hand pump, in which case the replacement of only the hand pump is indicated.

When installing a new fuel feed pump, check the travel of its push rod, but especially take care not to lose or interchange it. It forms namely with its sleeve an accurately matched pair, the individual parts of which cannot be interchanged arbitrarily.

Have defective fuel feed pump repaired by specialists in a service station or specialized repair shop of the MOTORPAL National Corporation.

PRESSURE-RELIEF VALVE REPAIRS

Faulty operation of the pressure-relief (overflow) valve can be due to a leakage of its seat or its clogging.

A leaky seat of the pressure relief valve is the cause of a drop of the filling (delivery) pressure and an aeration of the fuel line of the fuel injection equipment whenever the engine is stopped.

To remove this defect, dismantle the valve and clean it, or replace it with a new one.

Take care not to lose the sealing ball and spring when dismantling and cleaning the valve.

4. FUEL INJECTION DEVICE

The most important and the most accurate part of the fuel injection equipment is, beside the injection nozzle, the fuel injection pump. To satisfy all requirements placed on the engine and thus also on the fuel injection pump (for instance a ready starting of the engine regardless of climatic conditions, or constancy of engine speed at varying loads), fuel injection pumps are complemented with suitable accessories. The fuel injection pump plus these accessories form the fuel injection device.

A fuel injection device consist usually of the following units and parts:

1. The fuel injection pump
2. The governor
3. The excess fuel device, the pressure-operated corrector
4. The coupling
5. The injection advance device
6. The fuel feed pump — described in Chapter 3.

FUEL INJECTIONS PUMPS

The purpose of the injection pump is to inject, under high pressure, an accurately metered quantity of fuel, corresponding to the required engine output, at the specified moment.

The basic functional unit of the fuel injection pump is the injection pump element. According to the type of drive of this element, fuel injection pumps are divided into pumps with separate drive (with type designations PC and PR), and fuel injection pumps with self-drive (type designations PV, PP and PW).

The injection pump element consists of:

— a plunger reciprocating in the pump cylinder (barrel) — the plunger meters and discharges the fuel
— a delivery valve with a spring and a filling member
— the delivery valve closes the working space of the plunger barrel and also reduces the fuel pressure in the delivery pipe after the end of the delivery, the filling member fills up the empty space enclosed by the spring
— a delivery valve holder with jointing ring — it clamps and seals off the plunger barrel and the delivery valve while enabling its connecting to the delivery pipe
— a control sleeve and its segment — they transmit the movement of the control rod to the plunger, and by rotating the plunger they enable the control of the delivered quantity of fuel
— the plunger spring with its lower and upper spring plates — the spring controls the return movement of the plunger.

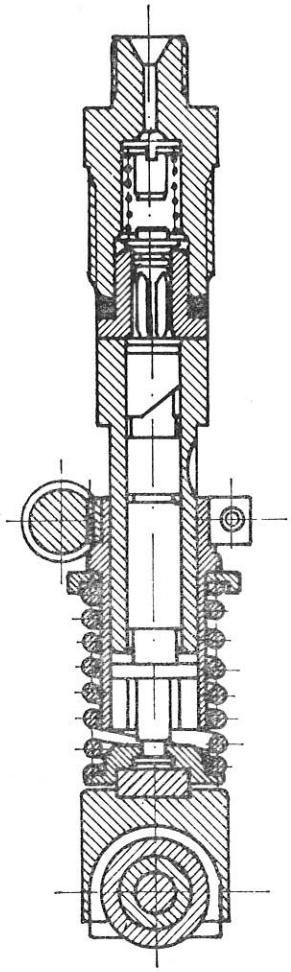


Fig. 13

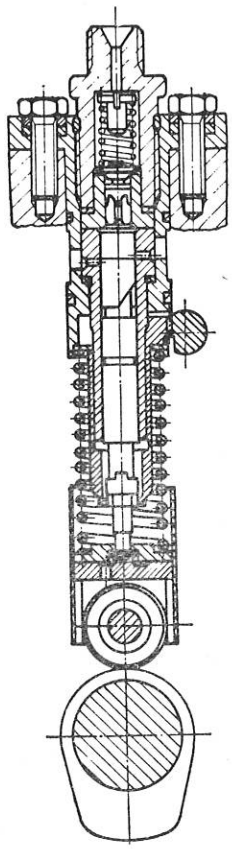


Fig. 14

Function of the injection pump element

While the plunger moves downward to its B. D. C. position, underpressure is formed in the working space above the plunger. The suction port in the barrel is uncovered and fuel is sucked from the fuel chamber of the pump into the space above the plunger.

From the moment, the face of the plunger closes the suction port during the lift of the plunger, fuel is discharged via the delivery valve and the delivery pipe into the injection nozzle.

As soon as the control edge of the plunger uncovers the by-pass port in the barrel, the fuel returns into the fuel channel and the delivery is terminated.

The delivery valve opens at the same time, and the cylindrical land of the conical seated valve,

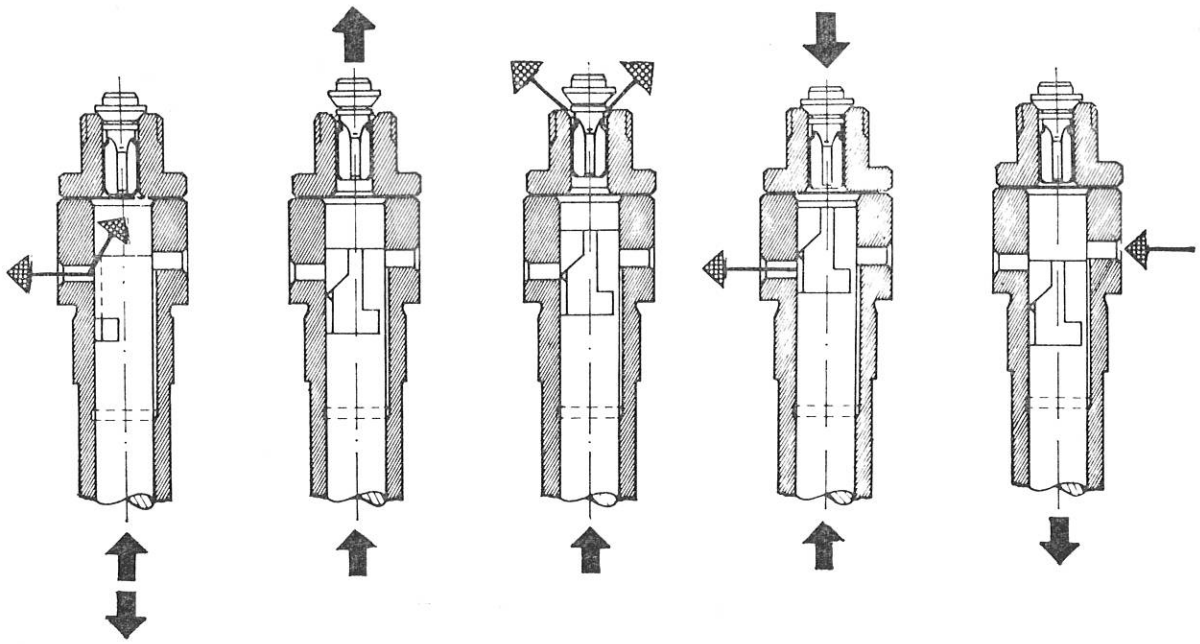


Fig. 15

acting as a piston, reduces the pressure in the delivery pipe after the end of the delivery.

This decrease of pressure prevents any after--dribble of fuel from the injection nozzle caused by pressure waves.

Rotation of the plunger in the pump barrel changes the so-called effective stroke of the plunger, at which the suction and by-pass port in the barrel are covered, and in this way also the delivered quantity of fuel is changed.

From the point of view of design, injection pump elements are assembled either of separate parts that are installed successively into the injection pump housing during assembly, or they form and integral assembly unit, as is the case of the more recent designs, more convenient to handle when removing or reinstalling it.

Fuel injection pumps with self-drive (fig. 16)

Fuel injection pumps driven by their own camshaft are made in two- to twelve-cylinder variants. The number of pump cylinders (pump elements) corresponds to the number of engine cylinders. The injection pump elements are clamped in the upper part of the fuel injection pump housing where there is also the bore (fuel channel) for feeding fuel to all injection pump elements and a bore for the control rod common to the control of all pump elements. The camshaft runs in antifriction bearings in the lower part of the fuel injection pump housing, and is rotary motion it transmitted to the injection pump elements (or injection units) by roller tappets.

Fuel injection pumps with separate drive (fig. 17)

Fuel injection pumps with separate drive are usually of the single-cylinder design. Each engine cylinder has its own injection pump driven by the camshaft of the engine valve gear.

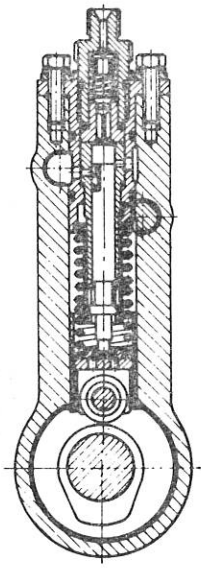


Fig. 16

Injection pump elements of larger injection pumps with separate drive are fastened by means of a four-bore flange instead of the delivery valve holder. Fuel injection pumps with separate drive have no accessories. They are mutually interconnected on the engine and controlled by indirect--acting governors.

SPEED GOVERNOR

Tough the delivery of the pump is under the direct control of the driver, the governor regulates automatically the quantity of fuel delivered and protects the engine from overstepping the speed required for the maximum engine output.

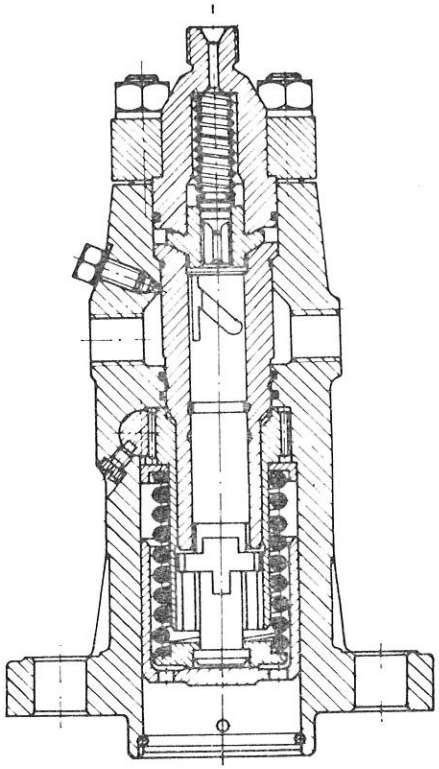


Fig. 17

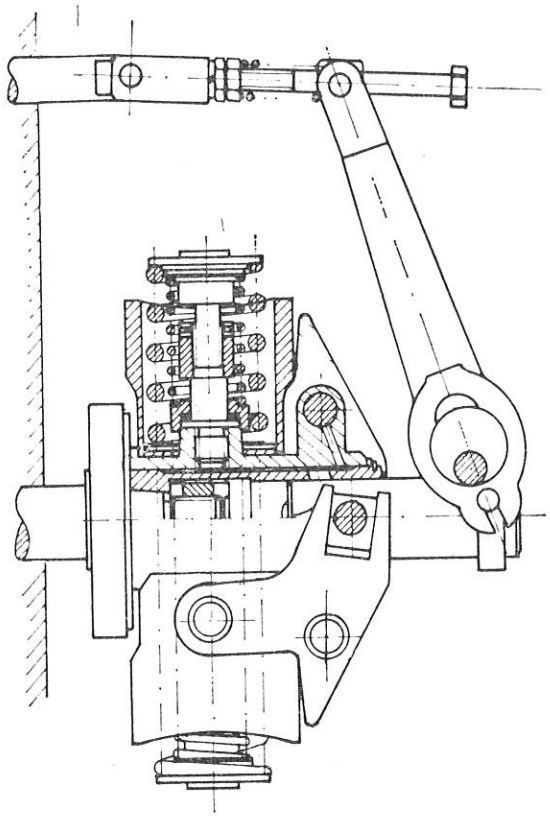


Fig. 18

The governor housing is mounted on the fuel injection pump housing, and it is enclosed by the rear cover housing the eccentric shaft with the delivery regulating lever.

A leverage connects the regulating lever and the weight assembly with the control rod that turns the plunger and thus changes the delivered fuel quantity.

The governor weight assembly (or rotor) is fitted on the fuel injection pump camshaft, or it is driven by it.

A change of the engine speed changes the centrifugal force of the governor weights counterbalanced by governor springs.

The centrifugal and the centripetal movement of the governor weights is transmitted by a leverage to the control rod. The movement of the control rod is limited by a stop, and a further movement of governor weights at a decrease of the speed of the engine, loaded in excess of its maximum output, is eliminated by the spring on the link of the control rod. This regulation of fuel delivery takes place within the entire range of operating speeds of the majority of engines. For some engines, especially those designed for road vehicles, a delay of the regulation is required, and so the movement of the governor weights in the required speed range is limited by suitably preloaded springs. In this speed range, the fuel delivery is controlled only by the delivery regulating lever. Depending on the manner of regulation the governors are divided into single-stage and double-stage speed governors.

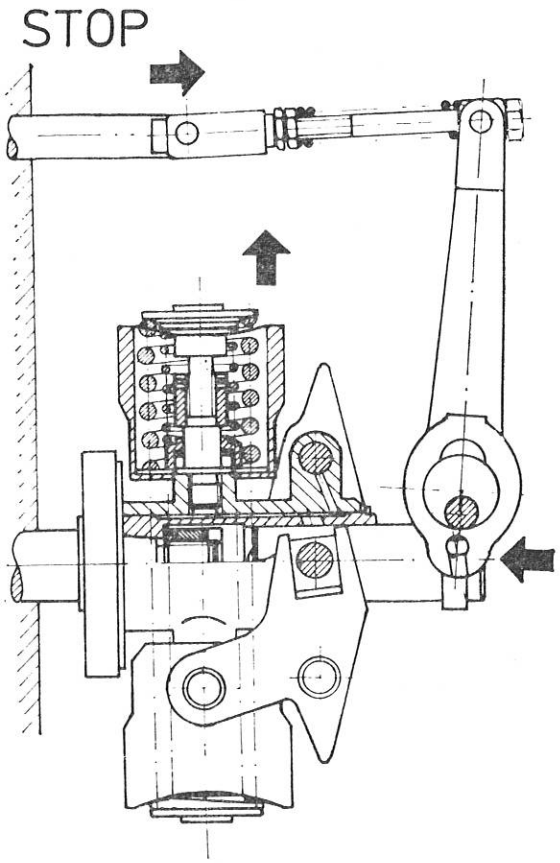


Fig. 19

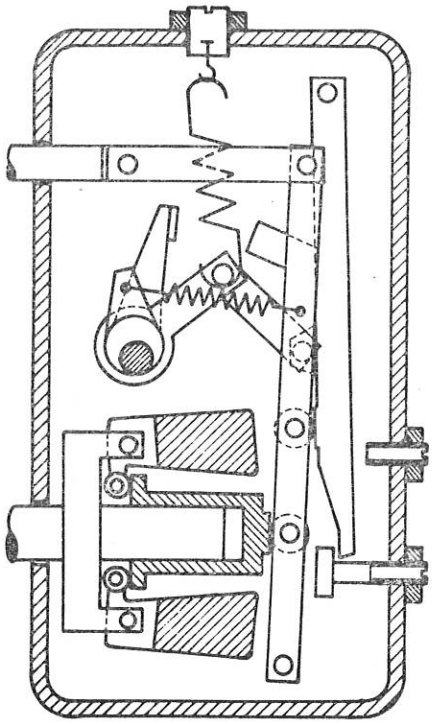


Fig. 20

Single-stage speed governor (type designation RV)

This governor controls the fuel delivery and thus the engine output within the whole operation speed range, i. e. from idling speed up to maximum speed that must not be overstepped. By changing the fuel delivery (engine output) in dependence on the engine load, it maintains the selected speed within very narrow limits. The required engine speed it set by the delivery regulating lever.

Double-stage speed governor (type designation RN)

It controls fuel delivery at idling speed, and at the range of r. p. m. from the rated to the maximum speed of a not loaded engine. The governor does not operate in the interval between the idling and the rated speed. Fuel delivery is controlled (set) by the driver by means of the delivery regulating lever.

Vibration dampers can be used with single-stage speed governors to eliminate shocks of the governor linkage and to enhance smooth running of the engine.

Vibration dampers

Hydraulic governor vibration damper

This damper eliminates harmful vibration of the governor and the control rod, and thus also the „rocking" of the engine, especially at lower speeds. It can be used with single-stage speed governors of the sizes „A", „R", „B", and „Z" if they are of the mechanical type with weights.

The movement of the regulating pin is transmitted by a piston rod to the piston reciprocating in the hydraulic damper cylinder. Hydraulic oil flows from one side of the piston to the other side through a port in the piston and does not permit any sharp oscillation of the piston and the whole governor mechanism. On the other hand, it does not prevent a slow resetting. The throughflow of the port varies in accordance with the resetting force of the governor.

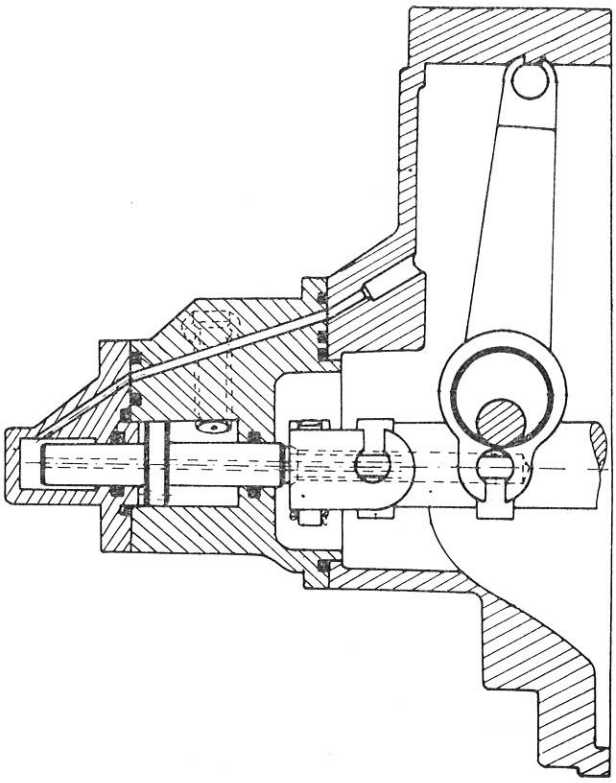


Fig. 21

Control rod vibration damper

To eliminate harmful vibration (oscillation) of the control rod, some of the fuel injection pumps have a mechanical vibration damper fitted in the place of the control rod lock screw. Basically, the

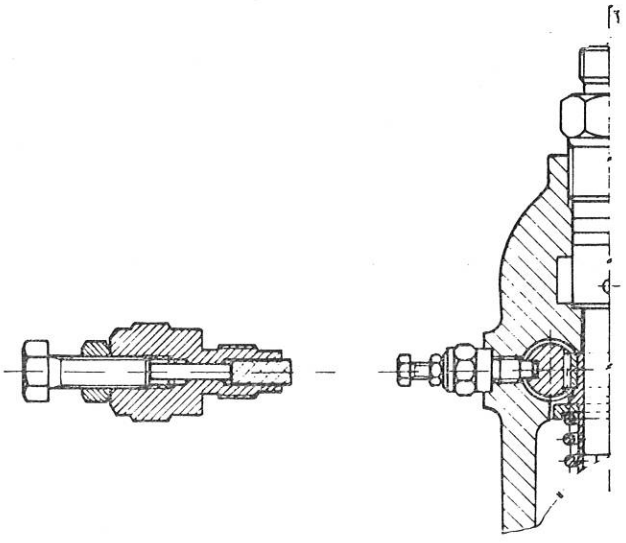


Fig. 22

damper is a rubber pin with an adjustable thrust that takes up the oscillatory motion of the control rod.

EXCESS FUEL DEVICES

The excess fuel device is installed in the control rod sleeve. By releasing the fixed stop, it enables an increase of the out-travel of the control rod and thus the turning of the pump plunger into the position for increased fuel delivery required for starting a cold engine. With the so-called starting plungers, the turning of the plunger results also in a change (decrease) of the injection advance.

Excess fuel devices are of different types distinguished by the manner of their control:

— lever actuated devices are controlled direct by the driver or by the engine operator by means of a control cable or pull rod

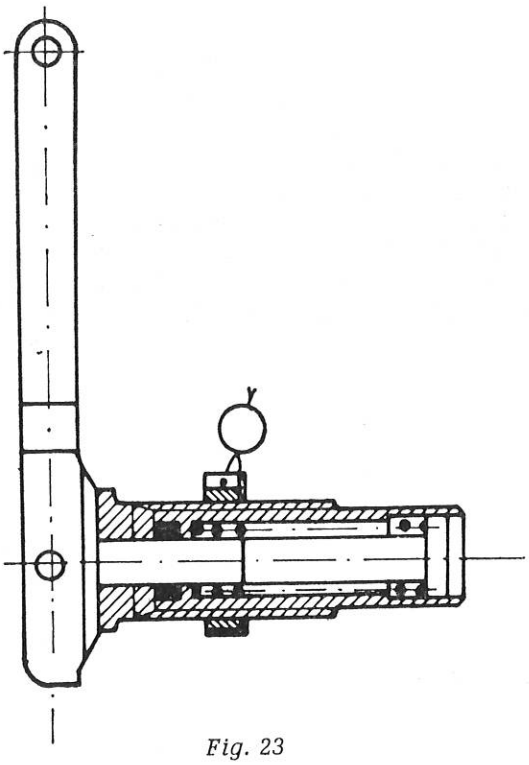


Fig. 23

— push-button actuated, controlled by depressing the push button

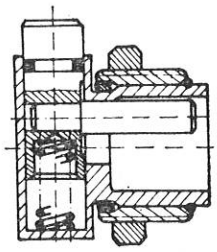


Fig. 24

— pin actuated, controlled by turning and partly pulling out the pin

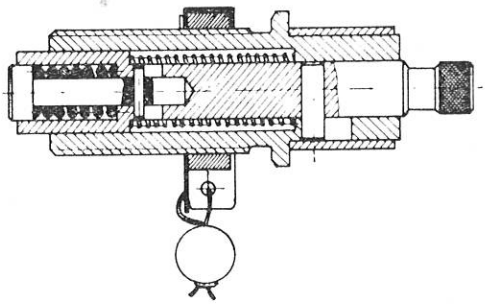


Fig. 25

— automatic, forming part of the governor (RV.M)

An excess fuel device must not be misused for increasing the maximum engine torque.

In fuel injection devices with a single-stage speed governor, the excess fuel device forms also the stop of the control rod for maximum fuel delivery. The excess fuel device can be fitted with a corrector for the correction of fuel delivery in dependence on engine speed, or a pressure-operated corrector for the correction of fuel delivery in dependence on the air pressure (overpressure) in the intake manifold of supercharged engines.

Pressure-operated corrector

This corrector connected to the engine intake manifold is suitable for the automatic control of fuel delivery of supercharged engines. Operating in dependence on the air delivery, it keeps the engine smoking rate within permissible limits, especially in the region of low engine speed.

The dimensions of the pressure-operated corrector enable this corrector to be used with fuel injection pumps of various sizes equipped both with the single-stage and double-stage speed governors, even when an automatic injection advance device is fitted.

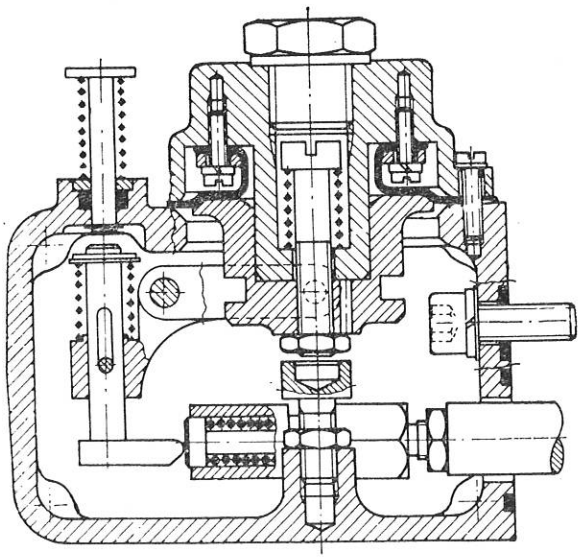


Fig. 26

The function of the pressure-operated corrector is based on the action of the pressure of air led from the intake manifold to a rubber diaphragm controlling the swinging stop of the control rod.

The deflection (swing) of the stop is limited by the adjustable spring resistance and the adjustable fixed stop.

The pressure-operated corrector has no lubrication oil filling and does not require any maintenance.

COUPLINGS

The fuel injection pump coupling couples the injection pump camshaft with the driving shaft of the engine.

A flexible coupling disc transmits the rotary movement of the shaft and compensates minor misalignments of the driving and driven shafts. The adjustable part of the coupling formed by the flange of the driving (engine) half of the coupling enables the injection advance to be accurately adjusted.

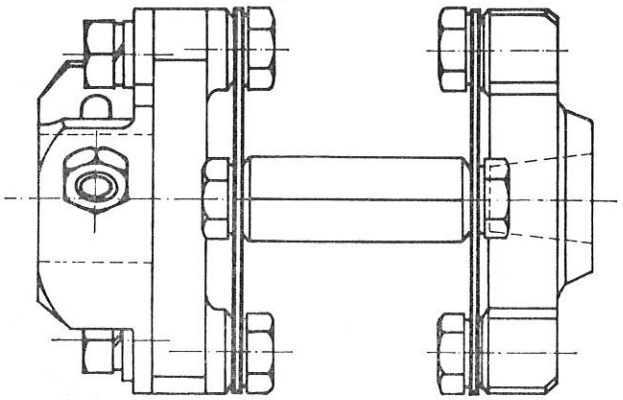


Fig. 27

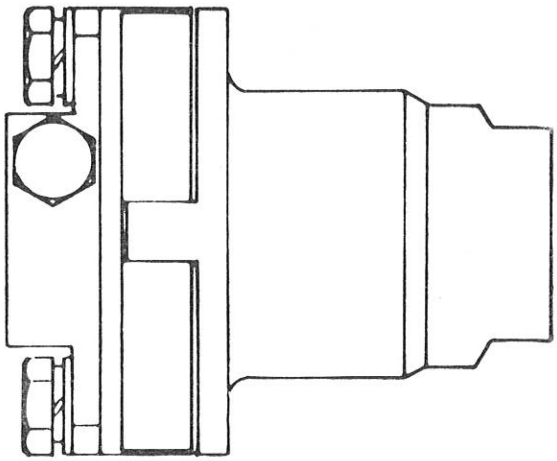


Fig. 28

According to their use, the couplings are divided into:

— standard couplings (SN) — one half of the coupling is clamped on the driving shaft of the engine (engine half coupling) and the other half on the injection pump camshaft (pump half coupling)

— injections-advance couplings (SP) — they consist actually of only the engine half clamped on the driving shaft of the engine, the other being formed by the injection advance device

— intermediate couplings (SM) — they are used to connect camshafts of two fuel injection pumps

Flanged fuel injection pumps can be fitted with gears or splined couplings that are not adjustable. In such a case, the injection advance has to be adjusted by swivelling the fuel injection pump.

INJECTION ADVANCE DEVICE

The constant angle of injection advance is the cause of uneconomical combustion of fuel in high-speed engines.

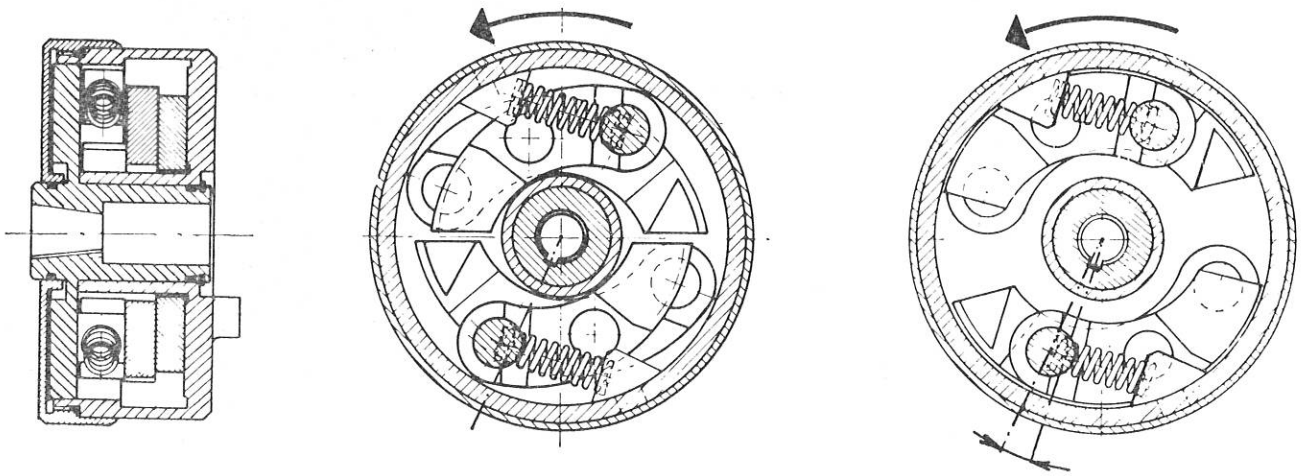


Fig. 29

A suitable adaptation of this angle to the full engine speed range improves the output characteristic of the engine as well as its torque. The engine is livelier, responds more readily, and its fuel consumption decreases.

At an increasing engine speed, the automatic injection advance device turns continuously the injection pump camshaft in the direction of rotation of its drive and increases so the injection advance angle.

The rate of the turning of the camshaft with regard to the drive at a change of the engine speed is given by the change of the centrifugal force of the weight of the injection advance device suitably compensated (outbalanced) by the moment of load of the automatic injection advance device springs.

OPERATION OF THE FUEL INJECTION DEVICE

As regards the fuel injection device operation, the task of the driver or engine operator includes:

- resetting of the delivery regulating lever in operation
- actuation of the excess fuel device when starting the engine
- handling of the bleeding screws and the operation of the hand primer (see the section on fuel injection system bleeding).

Resetting of the delivery regulating lever

By changing the position (resetting) of the delivery regulating lever, the speed (single-stage speed governor) or the output (double-stage speed governor) of the engine can be changed arbitrarily up to the maximum speed and maximum output while the engine is running.

In the case of road vehicle and tractor engines, this lever is controlled direct by the driver.

In the case of stationary engines, this lever is operated by the engine operator from his position or by a special device in dependence on the operation of the entire set, for example in dependence on the air pressure in the air receiver of a compressor.

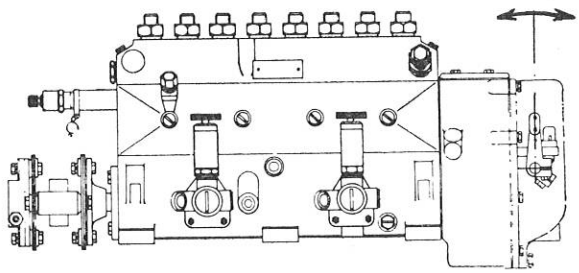


Fig. 30

Actuation of the excess fuel device

Lever controlled device

The excess fuel device is controlled by the driver or the engine operator by means of a cable or pull rod. A deflection of the excess fuel device lever actuates the delivery regulating lever that shifts the control (governor) rod by the distance of the travel of the excess fuel device. The pull rod must by returned to its starting (original) position after the engine has started running.

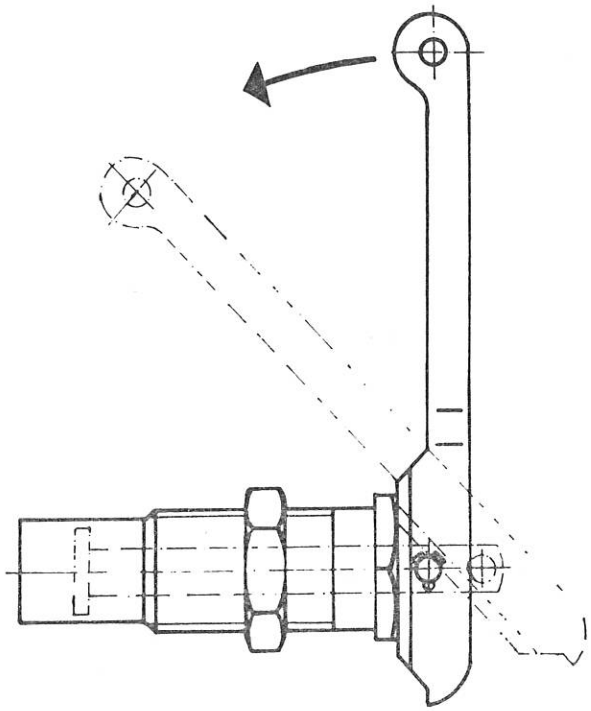


Fig. 31

Push-button controlled device

When starting the engine, first set the delivery regulating lever in its approximately half-way position, i. e. its medium speed position. Then depress the push button on the excess fuel device to move the control rod in the direction of increased fuel delivery. In this position, the control rod will hold the push button depressed. As soon as the engine starts running the control rod retracts from the increased delivery position and releases the push button that returns automatically to its original position.

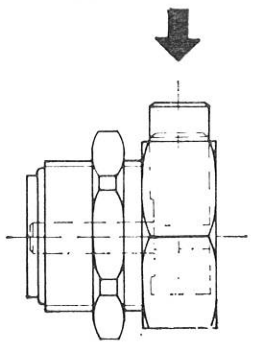


Fig. 32

Pin actuated device

Turn the knurled head of the excess fuel device controlling pin anticlockwise and push the pin in the direction of its longitudinal centre line to release the stop of the control (governor) rod. The deflection of the delivery regulating lever will result in the moving out of the control rod and the excess fuel device control pin. After the engine has started running or after returning the delivery regulating lever to its original position, the pin returns to its original position too.

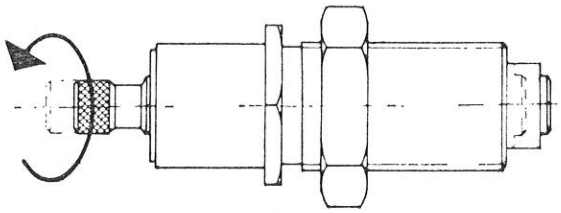


Fig. 33

Pressuse-operated corrector

Increased fuel delivery required for engine starting can be obtained by releasing the control rod stop with the aid of the push button just as in the case of the push-button controlled excess fuel device.

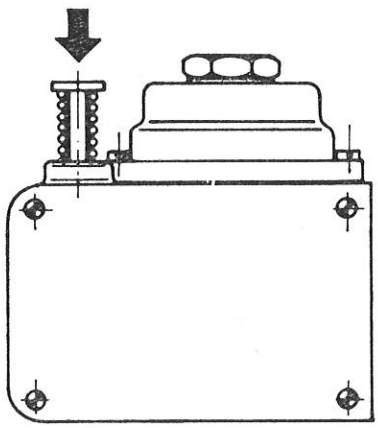


Fig. 34

Operation of the fuel injection pump with separate drive

Here the task of the driver or engine operator. is limited to loosening the bleeding screw when bleeding the fuel injection system because the control rod is controlled by a special mechanism.

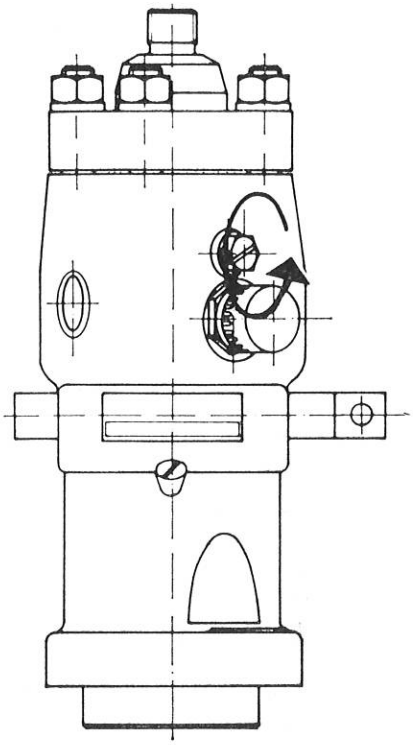


Fig. 35

MAINTENANCE OF FUEL INJECTION DEVICE

This maintenance consists of

— cleaning
— oil level checks
— oil changes

and, in the case of fuel injection devices with an automatic injection advance device or a hydraulic vibration damper also of

— the maintenance of the hydraulic vibration damper and
— the maintenance of the automatic injection advance device.

Cleaning of the fuel injection device

To prevent leakages, the fuel injection device must be kept clean especially at points, where dirt affects the rubber sealing rings (of the camshaft, eccentric shaft, and excess fuel device), and around the breather that might become clogged by the dirt.

For cleaning the fuel injection device, it is possible to use all chemicals and preparations suitable for engine cleaning. Avoid washing (hosing down) the fuel injection pump and its accessories with tap water as, in this way, the water could get into the injection pump through the breather, the excess fuel device, or past the sealing rings.

Oil level checks

Check the oil level in the injection pump and the governor whenever checking the oil level in the engine.

Separate checking points, i. e. an oil level gauge or a plugged inspection hole, are provided for the housing and for the governor. After screwing off the plug, the oil must flow slowly out of the inspection hole. If it does not, or if the oil level does not reach the bottom line of the oil level gauge, top up the oil. If, on the contrary, too much oil flows through the inspection hole or the oil level reaches above the upper line of the oil level gauge, it is necessary to drain off part of the oil. If the oil is diluted with fuel, consult a specialized repair shop, and change the oil more frequently. Some of the injection pumps have an overflow pipe for fuel diluted oil connected by means of a union to the inspection hole, or simply an overflow nipple provided on the pump housing.

The governors of some of the fuel injection pumps have no inspection hole or an oil level gauge. This is the case of fuel injection devices with an oil filling in common both to the fuel injection pump and the governor, and the oil level should be checked only in the fuel injection pump housing (PP.M fuel injection equipment), or in the case of fuel injection devices connected by an oil feed and overflow line to the force-feed lubrication system of the engine when no checks of the pump oil level are required.

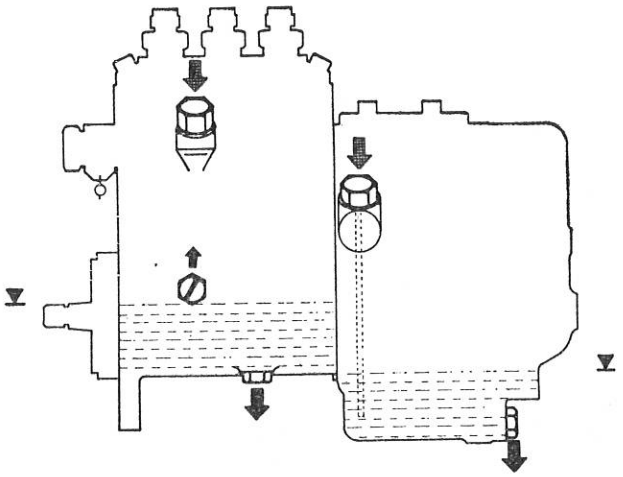


Fig. 36

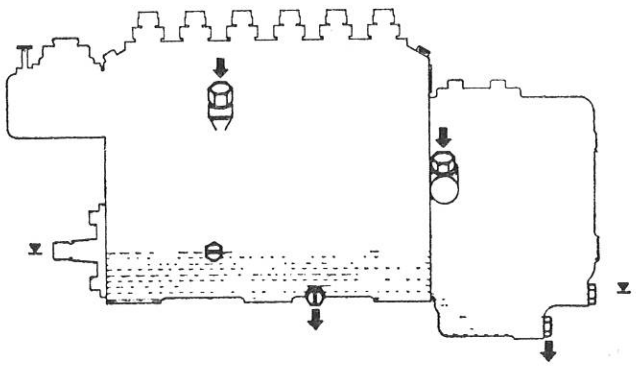


Fig. 37

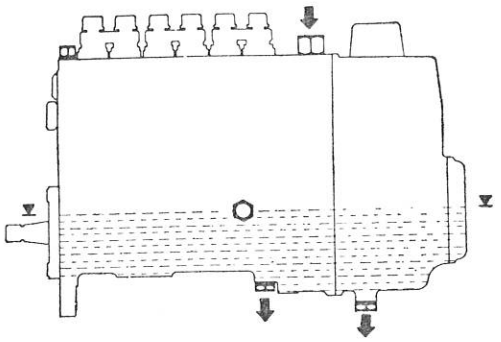


Fig. 38

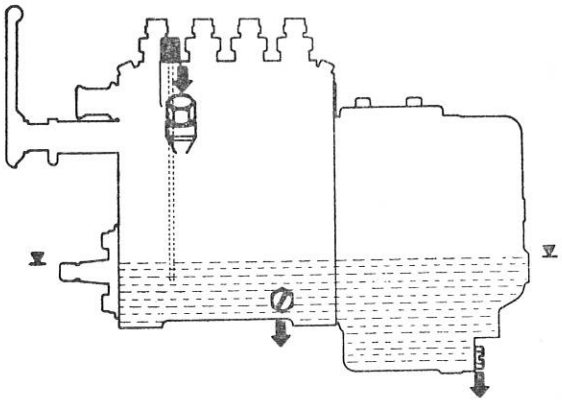


Fig. 39

Oil changes

Change the oil in the fuel injection device periodically when changing the engine oil, preferably while the oil is still warm. Drain screws are provided on the fuel injection pump and the governor.

It is recommended to drain the oil from the injection pump and the governor of fuel injection devices connected to the force-feed lubrication system of the engine when changing the engine oil filling. In the case of V-engines, the draining is rather laborious and it is therefore possible to drain the oil from the fuel injection pump and governor also after several changes of the engine oil in accordance with the engine manufacturer's instructions. After having changed the oil in the lubrication system, it is not necessary to refill the fuel injection pump.

Fill the fuel injection device with lubrication oil through the filling holes up to the height of inspection holes or the line of the oil level gauge. When pouring the oil into fuel injection devices with a single filling hole (PP.M) and interconnected oil chambers of the governor and fuel injection pump housings, proceed slowly and wait till oil levels in both chambers settle in the height of the inspection hole. Excessive quantity of lubricating oil in the fuel injection device affects unfavourably the function of the speed governor.

Maintenance of hydraulic vibration damper

Remove the plug of the inspection hole to check the oil level after every 320 hours of engine ope-

ration. If the level drops before the specified interval, have the oil topped up in a specialized repair shop. The hydraulic vibration damper is filled with 4 c. c. of brand NM1-25 000 silicone oil.

Maintenance of automatic injection advance device

The type AM 2A automatic injection advance device (AVIA engines) is lubricated with oil from the crankcase and requires no maintenance.

The type AM 3A injection advance device (TATRA engines) has its own oil filling that has to be changed after 100,000 kilometres travelled or, at the latest, after an interval of three years.

The change the oil, remove both capscrews of the front side of the device housing and set the holes into the vertical position. Fill the housing with the grade PP 90 oil through the bottom hole, the top hole being used for venting. Tighten both screws properly after having completed the filling.

Whenever checking the oil level in the fuel injection device check also the injection advance device for leakage.

Maintenance of fuel injection pump with separate drive

This maintenance consists only of cleaning the injection pump which is lubricated with oil from the engine, and therefore does not require any oil checks or changes.

REPAIRS OF FUEL INJECTION DEVICE

All defects of fuel injection devices that cause the engine to run irregularly at idling speed, to overspeed, to lose power at higher speeds or that result in a fuel leakage from the fuel injection device, have to be removed only by skilled mechanics in specialized repair shops. For engines especially dangerous are such defects that prevent the engine to be stopped in the usual manner (for instance seizing of the pump plunger).

If at a sudden rise of the engine speed, the delivery regulating lever cannot be reset into its STOP position, it is necessary to stop the engine immediately in another manner.

The best procedure with vehicle engines is to engage a gear and to stop the engine by engaging slowly the clutch.

A stationary engine can be stopped for example by loosening the bleeding screws of the injector, shutting off the fuel supply by means of the shut-off cock, loosening the glass bowl of the fuel prefilter or the connection of the suction line, or by loosening the union nuts of fuel delivery pipes.

Of the fuel injection pump accessories it is permitted to repair only those that have no direct bearing on its adjustment.

These accessories are: the coupling, and the fuel feed pump (see Chapter 3)

Repairs of couplings

The flexible coupling disc gets worn as the result of its shaft-aligning function. Increased clearance of the coupling dogs affects unfavourably the service life and the function of the fuel injection device, and it is manifested by a noisy running of the device. Replace the worn flexible coupling disc with a new one after having removed the fuel injection device from the engine. On reinstallation, check the injection advance and readjust it, if necessary.

Removal of fuel injection device from engine

When it is necessary to remove the fuel injection device from the engine for a brief period for the purpose of an inspection or a replacement, it is recommended to set the engine to the timing mark of the specified injection advance (refer to engine manufacturer's instruction), and the mark of the geometrical beginning of fuel delivery on the pump half coupling opposite the mark on the injection pump frontend cover. These precautions will prevent an inadvertent off-setting of the injection order through 180° when reinstalling the fuel injection device on the engine. Flanged fuel injection devices are exempt from this procedure. Clean (wash) the fuel injection device before removing it to prevent foreign matter from getting into the feed line delivery pipes, or the fuel injection pump during its removal and reinstallation.

Disconnect the control linkage of the speed governor and/or the excess fuel device. Disconnect the feed line and delivery pipes. Protect the uncovered holes with blinding plugs and caps against an ingress of foreign matter.

Remove the fastening screws, lift away the fuel injection device, and clean it once more.

Reinstallation of fuel injection device on engine

Before installing a new fuel injection device on the engine, wash off its preserving coating with petrol or diesel oil. Drain the preserving oil from the fuel channel, the pump housing, the governor housing, and the fuel feed pump. Fill the injection pump and governor housings with the same lubricating oil as used in the engine, up to the edges of inspection holes.

Installation of PV fuel injection devices

Set the engine to the timing mark of the specified basic injection advance of the first cylinder according to the injection order. Make sure that timing marks are not off-set through 180°. The piston of the given engine cylinder must be in the compression position. Set the mark on the pump half coupling, indicating the geometrical beginning of the first plunger and barrel according to the injection order against (opposite to) the mark on the fuel injection pump front-end cover. Locate the fuel injection device on the engine clamping brackets, fit the coupling dogs into the flexible coupling disc, or connect the engine and pump halves of the coupling by the coupling plate.

Screw in and tighten properly the capscrews fastening the fuel injection device. Pay special attention to a uniform tightening of the capscrews to prevent a crossstressing of the fuel injection device.

Recheck the positioning of timing marks on the pump half of the coupling and the injection pump front-end cover. If the marks (lines) are not exactly opposite each other, loosen the screws of the adjustable part of the coupling, and correct the positioning.

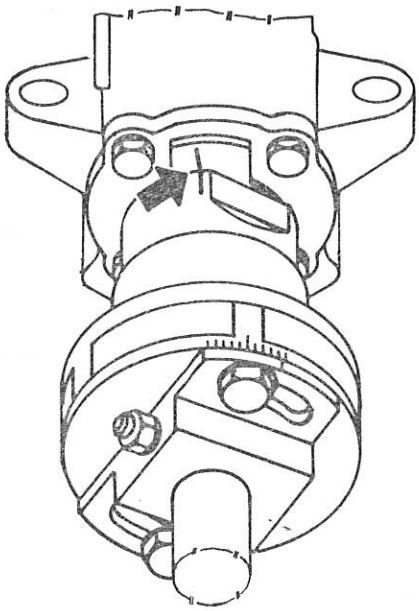


Fig. 40

Connect the fuel line, the control links of the delivery regulating lever and/or the excess fuel device, and other accessories. Bleed the fuel injection device (refer to the section dealing with its bleeding).

Recheck the advance timing after bleeding the fuel line and starting the engine.

Installation of PP fuel injection devices

The installation of flanged fuel injection devices is considerably simpler. They are namely driven over a splined coupling with one spline omitted that excludes off-setting through 180°. After having installed the fuel injection device, bleed it and adjust the injection advance.

Injection advance timing

Check the injection advance timing after having installed a new fuel injection device or when a deviation is assumed.

Bleed properly the fuel injection equipment, disconnect the delivery pipe of the injector of the first cylinder according to the injection order from the fuel injection pump, and fit to the delivery valve holder (discharge union) a glass capillary tube with a small bore (approximately 1 mm). Operate the delivery regulating lever to increase the fuel injection pump delivery approximately to its maximum. Usually, full starting delivery cannot be attained because its geometrical beginning is still partly shifted in the majority of cases.

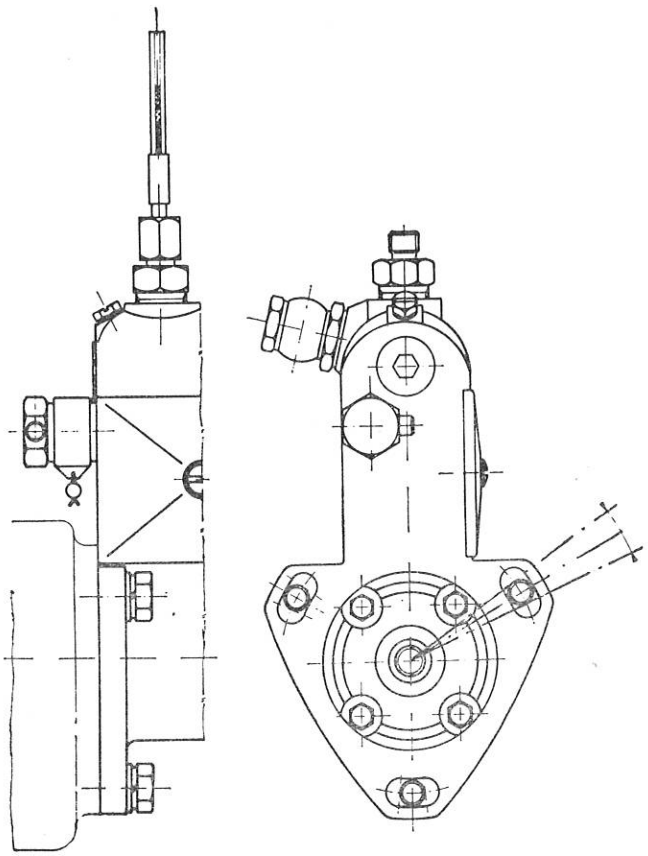


Fig. 41

Crank the engine several times till fuel appears in the capillary tube, then rotate the engine slowly while watching the fuel level in the capillary. At the first indication of a movement of the fuel level stop turning the engine and check the position of the crankshaft according to the engine timing mark. If there is a deviation from the correct injection advance timing, eliminate it by a final adjustment of the adjustable part of the coupling or, in the case of a flanged fuel injection pump, by rotating the pump about the longitudinal centre line. This turning of the pump is enabled by elliptical holes provided for the fastening screws in the flange.

For a correct checking of the injection advance you must know whether the pump is fitted with plungers with a constant beginning or a constant end of fuel delivery. In the latter case, it is necessary to watch for the end instead of the beginning of fuel delivery in the capillary tube. The end will manifest itself by a drop of the fuel level in the capillary tube due to the operation of the delivery valve.

Repairs of fuel injection pumps with separate drive

All repairs of fuel injection pumps with separate drive must be made by skilled mechanics in

specialized repair shops since technical knowledge is required for a correct installation of such fuel injection pumps on the engine.

5. INJECTORS

The purpose of the injector is to perfectly atomize the fuel in the engine combustion chamber.

The injector consists of two parts, the nozzle holder and the injection nozzle.

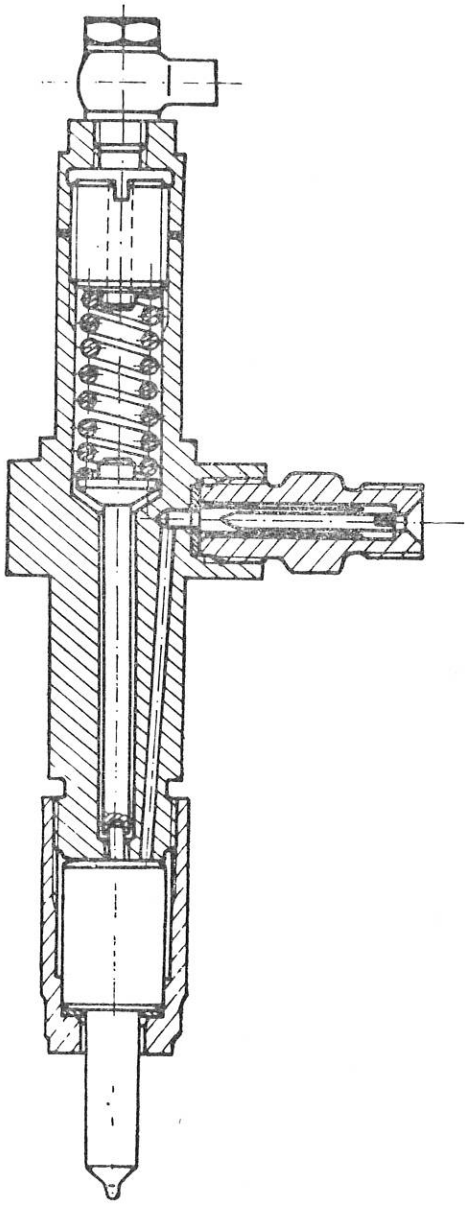


Fig. 42

The fuel injection pump delivers fuel to the injector inlet union through the delivery pipe. A metallic filter may be installed in the inlet union to trap particles larger than 0.02 mm loosened from the fuel line and the injection pump fuel channel in operation. From the inlet union, the fuel passes through a duct to the lapped face of the nozzle holder body, and continues to flow through ports in the nozzle body to the nozzle needle seat. The pressure of the fuel acting on the annulus of the nozzle needle lifts the needle from its seat against the pressure of the preloaded spring. The pressure of this spring is transmitted to the nozzle needle by the nozzle push rod passing through the centre bore of the nozzle holder. The nozzle opening pressure can be changed by changing the spring preload with the aid of the pressure regulating screw or an adjusting washer.

INJECTION NOZZLE HOLDERS

They are used for fastening the injection nozzle in the engine cylinder head, for connecting the nozzle to the delivery pipe, and the adjustment of the correct nozzle opening pressure.

The size of the nozzle holder, its shape, the method of fuel inlet and overflow, as well as the manner of its fastening depend on the size of the respective nozzle and the design of the engine cylinder head.

INJECTION NOZZLES

The purpose of the injection nozzle is to atomize the sprayed fuel into the engine combustion chamber so that it is properly mixed with air. On the mixing of fuel with air depends the combustion efficiency and economy, i. e. the transformation of the greates possible part of heat energy into the work of the engine.

Generally, injection nozzles are divided into

- pinte nozzles — type designation DC; generally, they are used in engines with pre-chamber (indirect fuel injection)
- multi-hole nozzles — type designation DO; they are used in direct injection engines. This type of nozzles is the most widely used today.

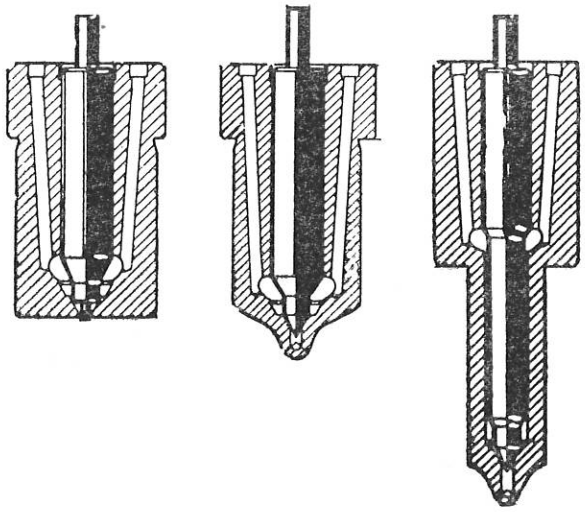


Fig. 43

Injection nozzles are made in various sizes, with differing numbers of jet (spraying) holes with different diameters and different spraying angles.

Beside being stressed mechanically, injection nozzles are also subjected to heat stress due to

their working direct in the engine combustion chambers.

An imperfect atomization of the fuel results in a loss of engine power and often in a damage to the engine (burning of the piston, etc.). This is why injection nozzles require the greatest care.

INJECTION SERVICE

A service is required only by injectors that have a bleeding screw, after the loosening of which the delivered fuel is not sprayed into the combustion chamber of the engine cylinder but flows into the overflow (drip-off) pipe. The engine cylinder can be used then for example, as a compressor. This screw has also to be loosened when bleeding the delivery pipe or for putting the injector out of operation because of a defect that cannot be removed immediately.

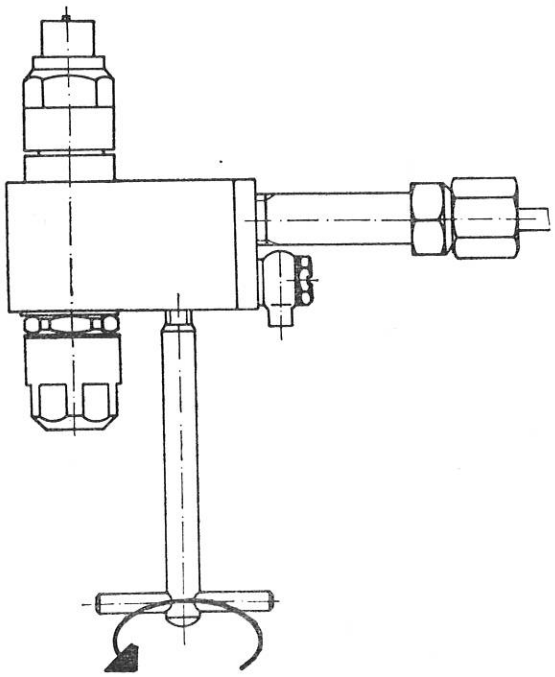


Fig. 44

INJECTOR MAINTENANCE

Maintenance of injectors includes:

— cleaning of the filter in the inlet union
— checking of the opening pressure and injector operation.

Cleaning of the filter in the inlet union

Clean the inlet union and the adjacent areas so that dirt cannot get into the injector or delivery pipe.

Screw off the delivery pipe union nut and the inlet union. Take care not to lose the inlet union sealing washer, and do not let the filter fall out of the inlet union. Some types of injectors have a cone fitted instead of the washer, and held in position in the inlet union by means of a lock ring that has to be taken out before withdrawing the filter. Sometimes it is not possible to simply withdraw the filter from the inlet union due to chips and scallings trapped by it, and it must be driven out.

Wash the filter, the inlet union, and the cone in petrol, blow them off with compressed air, and reassemble them. Replace all damaged parts, and especially the crushed sealing washer.

In the majority of types of injectors, the filter is installed in the inlet union, but there are also injectors without the filter, or with the filter fitted between the injection nozzle and the nozzle holder body. The actual location of the filter can be ascertained only when referring to the catalogue of spare parts or by removing the inlet union.

Checking of the opening pressure and injector operation

Injectors can be checked by fitting them to the NC 50 nozzle tester or by using the portable NC 51 nozzle tester, enabling the injector to be checked and tested without removing it from the engine.

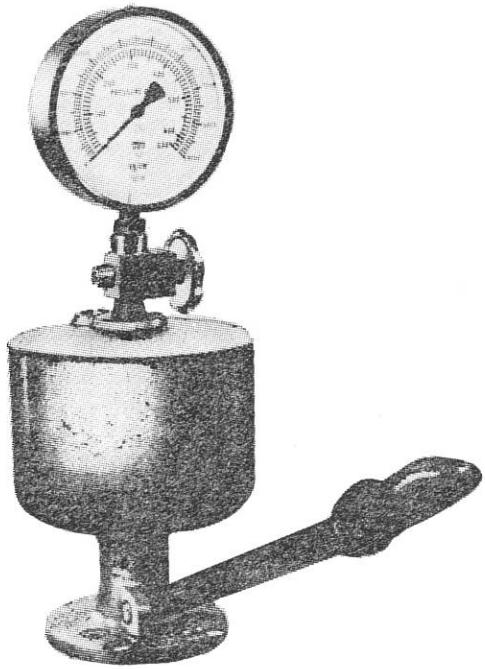


Fig. 45

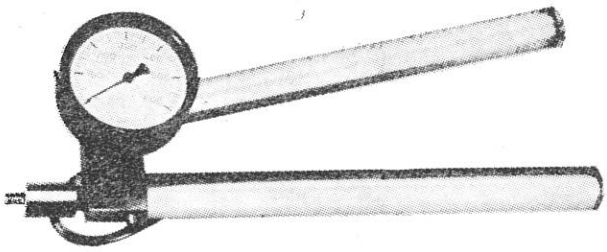


Fig. 46

The injector testing method and procedure is described in the respective tester operating instructions.

Repair a defective injector or replace it with a spare one that has to be always to hand.

Removal of injector from engine

To remove the injector from the cylinder head, first disconnect the delivery pipe and the drip-off piping. On some engines (for instance TATRA) it is also necessary to remove the injector inlet union. It is usual that, after a certain time of engine operation, the lower part of the injector with the nozzle sticks in the cylinder head so that it cannot be loosened and lifted away with the hand. Use the right tools in the right manner, never try to remove the injector by crossing and prising. Any violent handling is apt to result in a distortion or breaking off of the nozzle.

Installation of injector on engine

Before fitting the injector into the cylinder head, remove dirt and carbon deposits from the hole for the nozzle and particularly from the seat for the injector. The contact surface must not be damaged.

Never use old crushed or distorted sealing washers.

Insert the injector into the hole in the cylinder head in the direction of the hole axis and check whether it bears correctly against the seat and whether the surface of the injector is concentric with the hole. The injection nozzle must not touch the wall of the hole in the cylinder head. An unequal heat removal by the contact of the nozzle with the hole wall might be the cause of a distortion and a defect of the nozzle.

The tightening of the injector in position must not disturb its concentricity with the hole or cause the crossing of the nozzle. Before tightening the union nut of the delivery pipe, bleed this pipe by cranking the injection pump (by means of the engine starter).

INJECTOR REPAIRS

Injectors have to be repaired with due caution. Especially cleanliness is of vital importance when handling the nozzles. Take care not to touch their lapped surface with a bare hand, and if you have done so, wash them with clean diesel oil.

To dismantle the injector

Remove carbon deposits from the injector, loosen the pressure regulating screw, the inlet union, the nozzle lock nut, and take apart the injector.

Wash the dismantled parts of the nozzle holder, clean the metallic filter, and the injection nozzle.

Examine all parts of the nozzle holder, above all the lapped face of the nozzle holder, the push rod, and the nozzle lock nut. Their contact areas must show no traces of wear.

To clean the injection nozzle

Remove the needle from the nozzle body. Clean the jet (spray) holes with a calibrated needle.

Clean the nozzle body using tools contained in NC 32 S cleaning boxes for the size „S“ and „T“ injection nozzles, and in the NC 401 boxes for the size „U“ and „V“ nozzles in accordance with instructions enclosed in the boxes. Wash the nozzle body and needle in clean petrol, and blow them through and off with compressed air.

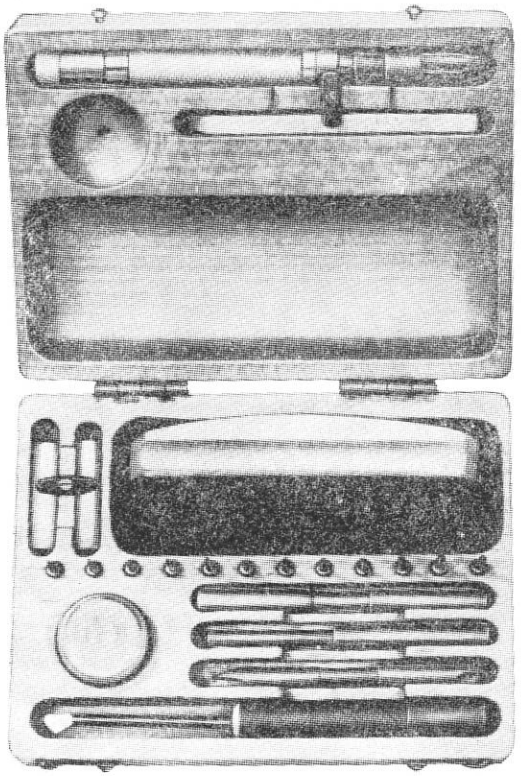


Fig. 47

Dip the nozzle body and needle in diesel oil or protect them with KONKOR 101 preserving oil before inserting the needle into the nozzle body.

To reassemble the injector

Reassemble the nozzle holder parts with the exception of the lock nut.

New injection nozzles are protected with KONKOR 101 preserving oil, which it is not necessary to remove before their installation. After a prolonged storage, it is however advisable to wash the nozzles in diesel fuel or petrol (nozzles washed with petrol must be subsequently dipped in diesel oil) to remove any sticking dirt before installing them. Check whether the nozzle needle of a cleaned or new injection nozzle returns by its own weight into the nozzle inlined by 30° after it has been pulled out of it by about 1/3 of its length.

Loosen the pressure regulating screw to allow the injection nozzle to bear unhampered against the face of the nozzle holder.

Locate the injection nozzle on the cleaned nozzle holder face and screw down the lock nut.

Injection nozzles with different distances (spacing) of jet holes or with a deflected spraying angle, etc. must be correctly positioned with regard to the nozzle holder by setting the index line on the stem of the injection nozzle opposite a similar index line on the nozzle holder.

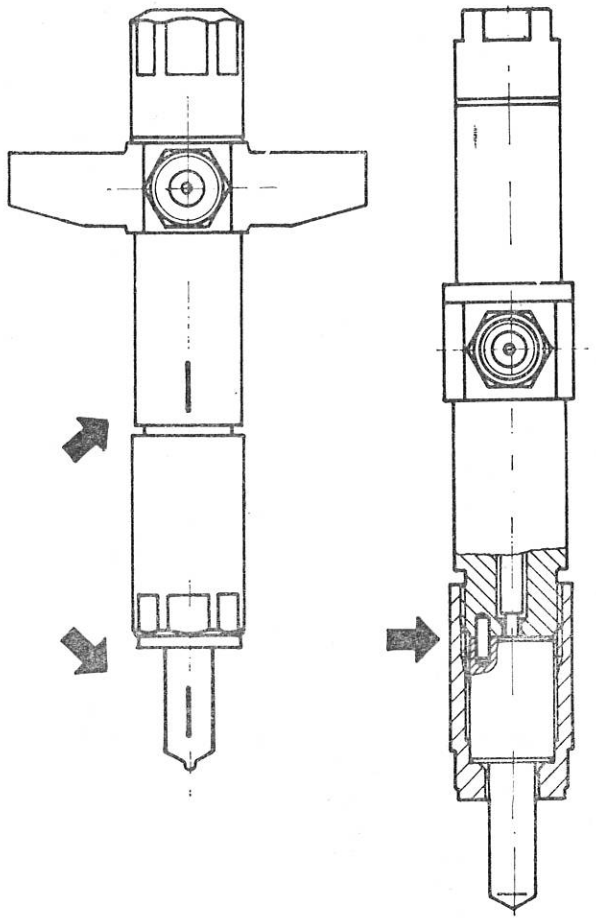


Fig. 48

For injection nozzles with locating holes is the proper position secured by putting them on locating pins in the body of the nozzle holder.

An incorrect positioning of nozzle with an asymmetrical arrangement of jet holes affects unfavourably the combustion process, decreases the engine power output, and may even be the cause of a defect of the engine.

Before tightening the lock nut, check the run-out (0.25 mm maximum) of the injection nozzle with regard to the surface of the lock nut.

Finally tighten the lock nut of the injection nozzle.

The clamping of the injection nozzle by the tightened lock nut must not distort the nozzle body and so prevent the free movement of the nozzle needle.

Recommended tightening torque of the lock nut for the individual injector sizes:

Injector size marking:	Lock tightening torque
S	55± 5 Nm (5.5±0.5 kpm)
T	90±10 Nm (9 ±1 kpm)
U	220±20 Nm (22 ±2 kpm)
V	560±35 Nm (56 ±3.5 kpm)

Injector adjustment

Adjusting the opening pressure includes the following checks on the tester:

1. check of tightness of the nozzle needle seating in the nozzle body
2. check for a leak-off under the needle sealing seat
3. check of the nozzle function and fuel automatization

Check of tightness of the nozzle needle

Set the opening pressure to 25 MPa by means of the pressure regulating screw, and, after having bled the system, operate the tester to effect one injection. Then release the lever of the tester and watch the down deflection of the pressure gauge pointer. As soon as the pressure drops to 20 MPa, start the stop watch and measure the time of the pressure drop to 15 MPa. Repeat this procedure once more. The two measurings must not differ by more than 2 seconds. Unless the customer has ordered specifically another tightness, the time of the pressure drop from 20 down to 15 MPa is permissible within the range from 29 to 8 seconds for the size „S" of DO and DOP injection nozzles.

Check for a leak-off under the needle sealing seat

Adjust the injector to the recommended opening pressure with an accuracy of ±0.3 MPa.

Increase gradually the pressure by operating the tester lever from the lowest pressure up to a pressure lower by 2 MPa than the recommended pressure. During this pressure increase, the nozzle must not get moist around the jet holes for a period of 15 seconds. A leak-off under the needle sealing seat is not checked at a further increase of the pressure.

Check of the nozzle function and fuel atomization

Test the function of the injector at the recommended pressure and at a pressure decreased by 3 MPa.

In both instances, the fuel must be sprayed by the nozzle intermittently during a continuous increase of the pressure by the lever of the tester.

Increase the pressure continuously at a speed that will ensure that the spraying interruption intervals do not exceed 2 seconds.

The spraying must be accompanied by a clearly defined sound. The pitch and timbre depend on the construction of the nozzle. (Compare with a check nozzle.)

Perfect atomization — misty appearance — of the test fluid sprayed through the jet holes must take place, in both instances, during the quick upward stroke (lift) of the tester piston at a minimum rate of 2 injections per 1 second.

No core of the jet and not formation of droplets must be visible with the naked eye.

No local concentration and no deflection of the jet are permissible.

With pintle nozzles, the spraying angle of which is smaller than 10°, a slightly marked core of the jet is permitted.

The atomization of fuel by size U, V, and W nozzles must be assessed by tests on testers with a piston diameter of at least 20 mm.

If the test of a nozzle is unsatisfactory, it is recommended to check-test it on a test nozzle holder, because the unsatisfactory operation of the nozzle may be due to its defective nozzle holder (damaged bearing surfaces).

BLEEDING OF FUEL INJECTION EQUIPMENT

Bleed the fuel injection equipment always atfer the engine has not been used for a prolonged period of time or when air has got into the fuel line during the cleaning of filters, replacement of some part of the injection equipment, or if the fuel tank has run dry.

Bleeding of the low-pressure line

Loosen the bleeding screws of the fine fuel filter and the injection pump.

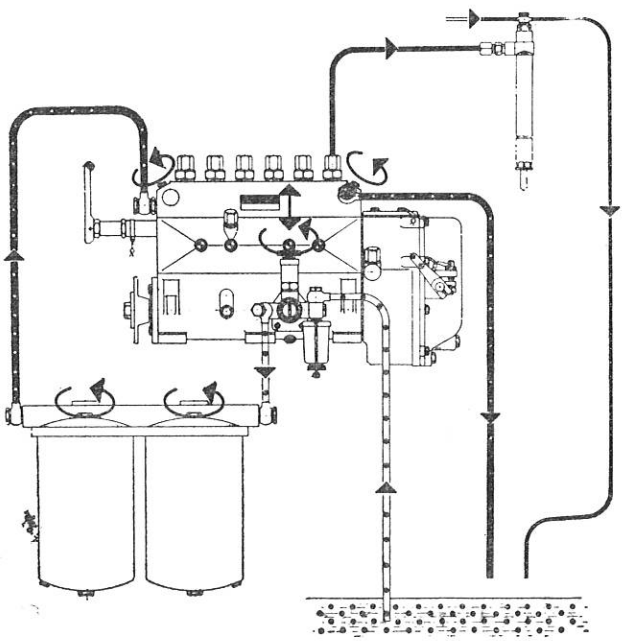


Fig. 49

Rotate the piston (piston rod) of the hand pump anticlockwise or turn in through 90° to release it and then operate it till fuel without air bubbles starts flowing past the bleeding screw of the fine fuel filter. Retighten this screw and continue operating the hand pump piston till bubble-free fuel starts flowing out past the bleeding screw of the fuel injection pump. Retighten also this screw and listen to the fuel flowing through the pressure-relief valve. If you do not hear the soft rattle of the valve metal ball, dirt has settled on the ball seat, and the valve does not operate correctly. In such a case clean the valve or replace it with a new one. After having completed the bleeding, screw home the hand pump piston or lock it in position by turning it back through 90° (engagement of the lock pins).

Bleeding of the high-pressure line

Loosen the bleeding screws of the injectors, or the union nuts of delivery pipes connecting them to the injectors.

Swing the delivery regulating lever to its full delivery position and crank the engine using the starting crank or the starter motor till fuel begins spraying from the delivery pipes.

Then retighten the bleeding screws or the union nuts.

WORKING CONDITIONS AND SAFETY PRECAUTIONS

The rooms, in which the nozzle tester is used, must be furnished with an exhauster installation. Special precautions have to be taken during maintenance or minor repairs of the fuel injection equipment when using, for example, flammable liquids for washing the parts. The room must be adequately ventilated to provide for an exchange of air ensuring the removal of flammable liquid vapours and preventig their dangerous concentration that is harmful to health and may represent an explosion hazard (see the respective National Standard).

Equipment of the work-shop and manipulation with inflammable liquids must be as per the norm of the country (British Standard).

FUEL INJECTION EQUIPMENT MAINTENANCE SCHEDULE

For periodic checks, inspections, and maintenance of the fuel injection equipment, observe instructions of the final product manufacturer contained in the vehicle driver's handbook or the handbook for the operation and maintenance of the diesel engine.

Usually, the interval specified for the injection pump oil level checks and oil changes coincide with intervals recommended for checking the oil

level or changing the oil in the engine. The same lubricating oil grade is used both for the engine and the fuel injection pump.

If not specified otherwise by the manufacturer, observe the following intervals of maintenance of the individual parts of the fuel injection system:

Daily

— Check visually the entire fuel system for leake (page 6).

After the first 1,000 kilometres (20 hours of engine operation)

— Clean the metal filter inserted in the injector inlet union, and check the injector opening pressure as well as the function of injection nozzles (page 24).

After every 1,000 kilometres (20 hours of engine operation)

— Check the oil level in the fuel injection device, and top up the oil, if necessary (page 21).

— Inspect the glass bowl of the fuel prefilter (page 9).

After every 8,000 kilometres (160 hours of engine operation)

— Change the oil in the injection pump and the governor (page 21).

— Discharge the mud from the fine fuel filter (page 10).

— Clean the fuel injection device — fuel injection pump (page 20).

— Check on the operation of the pressure-relief valve (page 12).

After every 16,000 kilometres (320 hours of engine operation)

— Clean or replace the filter element of the fine fuel filter (page 11).

— Clean the filter in the injectors, check the injector opening pressure as well as the function of injection nozzles (page 24).

— Check the oil level in the hydraulic vibration damper (page 21).

After every 100,000 kilometres (2,000 hours of engine operation)

— Change the oil filling of the automatic injections advance device (but never later than after three years — page 21.

Oils recommended for fuel injection devices:

Commercial grade designation	SAE viscosity class
M 8AD	20 W/50
M 6AD	30
M 5AD	20 W/30
M 3AD	10 W/30
M 6ADS	30
M 6ADS II	30
M 9ADS	40
M 9ADV	40

Oil recommended for automatic injection advance devices:

Commercial grade designation	SAE viscosity class
PP 90	90

Oil recommended for filling in the hydraulic vibration damper:

Commercial brand designation	Vicosity
Silikonöl (silicone oil) NM1 - 25 000	25,000 mm . sec.$^{-1}$ (25,000 cSt)

WARRANTY CONDITIONS

Warranty Period

Unless otherwise specified in the respective Technical Standard, the warranty period of the product is 6 months from the date of putting the product into operation, or up to a maximum period of 12 months after taking delivery of the product, or, at the most, up to 20,000 kilometres travelled or 500 hours of engine operation.

If on claiming, the whole product is exchanged, the warranty period runs anew as from the day of taking delivery of the new product. If parts are exchanged, the warranty period runs anew for the exchanged parts only.

Scope of Suppliers Responsibility

The supplier guarantees that the product has, and will have for the specified period, properties set down by technical standards, acceptance conditions, an economic agreement, an economic arbitration award, provisions of a governmental or another authorized body, and/or usual properties, and that the product is complete and without legal defects, especially as regards patent rights, copyrights, and trade-mark protection.

Concerning overhauled products, the supplier shall agree with the customer upon a new scope, subject, and period of the warranty that may be less extensive than guaranties stipulated in these Warranty Conditions.

The supplier does not recognize claims of unsatisfactory function (properties) of the product and defects of the product supplied by him caused by normal wear, and repudiates all liability for the destruction parts of the product by excessive stressing, if the purpose of these parts is the protection of the product from destruction or damaging. The guarantee does not cover injection nozzles.

The warranty becomes null and void if the supplied product is not used for the purpose, for which it has been intended. The supplier does not take upon himself free maintenance of the product in use withing the warranty period, for example its cleaning, cleaning of its parts, adjusting, refilling of lubricants, etc.

Subject of the Warranty

The subject of the warranty granted by the supplier to the customer also through the mediation of authorized repair shops is either a free of charge repair or replacement of the defective product or a reimbursement of the cost in the form of a credit note, or a reimbursement of repair expenses incurred in accordance with the supplier's time standards. The supplier does not reimburse the customer for the difference between the wholesale and retail prices.

When the customer claims a defect, the supplier has the right to decide whether the product will be repaired or replaced. The supplier also decides on the manner of the defect removal.

Claim Lodging Proceedings

Claims of defects of the product and other claims, arisen in connection with the defect of the product, have to be mailed by the customer to the supplier in the form of a report of defects or a claim report, in which the customer shall also numerically specify his financial demands and assert his proper claims.

The customer is obliged to return the claimed product to the supplier without any undue delay, nut not later than within two weeks after the lodging of the claim.

The claim report should include especially the following data:

a) the date of delivery of the product to the customer by the supplier
b) the date of taking delivery of the product by the customer
c) the type designation of the product, its Serial Number and/or the indication of the month and year of manufacture
d) the date on which the defect was ascertained
e) a detailed description of the defect and its probable cause
f) the date of the working out of the report and the signature of the customer's representative
g) when claiming a defect of the storage battery, the date of putting the battery into operation
h) Serial Number of the engine or vehicle, the number of kilometres travelled, or the number of hours of engine operation.

Claims can be lodged either direct with the supplier or with an authorized repair shop of the supplier.

Claim Settling Proceedings

The supplier is obliged to inform the customer of his acknowledgement of the claim or of the reasons, for which he repudiates it, within fifteen days after receipt of the claim report at the latest.

Expenses incurred by the customer in returning the claimed defective products shall be reimbursed to him by the supplier only up to the amount corresponding to the post, railway or trucker's tariffs; it is therefore advisable to use the most expedient and economic means of transport.

Defective parts and products that have been replaced with new ones under the terms of the Warranty Conditions become the property of the supplier and must be returned to him, if not agreed upon otherwise.

The supplier or the authorized repair shop appointed by him is obliged to settle the claim within two weeks (fourteen days) from its acknowledgement, at the latest.

If the supplier fails to settle the claim within the said time-limit he is obliged to pay the customer a penalty for having delivered him a defective product (a product of poor quality).

The final decision concerning the acknowledgement of the claim and/or the manner of the disposal of the original parts rests with the person employed by the supplier for settling claims, or with a person or organization appointed by the supplier to act as his representatives.

Warranty Nullification

The warranty becomes null and void if

a) the product is not used in the specified or usual manner

b) the customer has failed, to give the product the recommended care, especially as regards storing, maintenance, and attendance.

c) the product has been changed, modified, or repaired by the customer or a third person in any way

d) seals or check (timing) marks have been interfered with

e) some part of the product has been replaced with another, not genuine part

f) the defect was caused by unskilled interference or violent handling of the product

g) the product has been damaged by a demonstrably faulty installation

h) defective products have been returned incomplete, or if not genuine (original) parts have been returned

i) the vehicle was involved in a road accident, unless the accident has been caused by a defect covered by this warranty.

Supplementary Provisions

Unless otherwise specified by these Warranty Conditions, provisions of Law No. 109/63 Coll. Decree No. 135/64 Coll. are applicable together with the respective amending and supplementing regulations.

These Warranty Conditions form an inseparable part of contracts concluded between the supplier and the customer, concerning the delivery of products.

Issued by Service Department MOTORPAL JIHLAVA, National Corp.
1979