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Introduction

This workshop manual represents the product's technical status as indicated on each page (month / year). It has been compiled in such a way that any trained mechanic can perform all repairs satisfactorily. No reference is made to such work as cleaning parts etc., as it is assumed that this will always be carried out by a competent workshop when needed.

The work is to be carried out in all cases only with the specified tools or absolutely equivalent ones.
It is assumed that the mechanic has access to a full range of regular hand tools.

For maintenance work, operating fluids and other materials, troubleshooting etc., please refer to the operating manual.

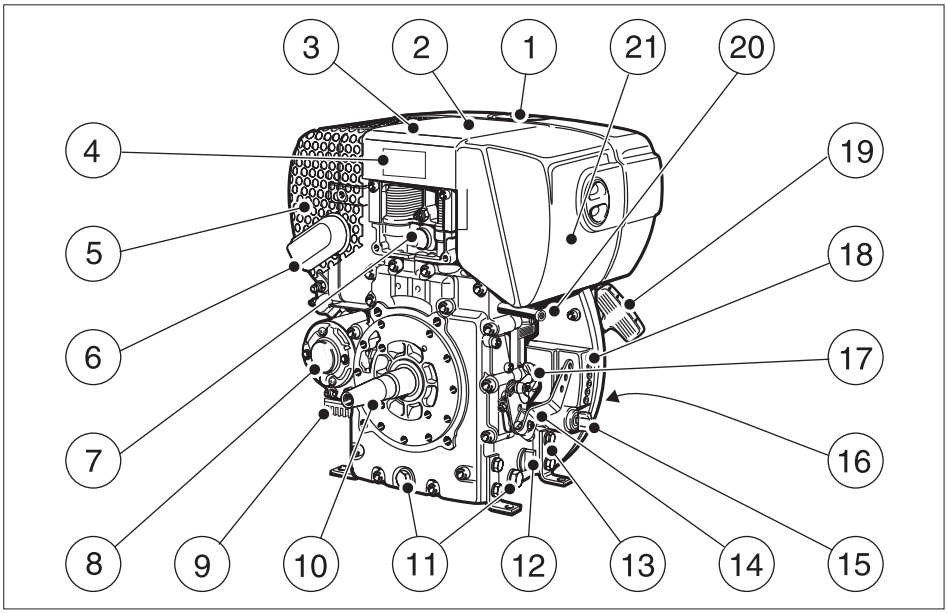
Use only Original HATZ Spare Parts.
Only these guarantee the correct dimensions, ratings and quality standards.

In all relevant areas, statutory requirements and the regulations issued by authorised trade associations and industrial accident insurers are applicable.

The details supplied here may vary if special equipment is incorporated; such deviations cannot be taken into account in the workshop manual or in the spare parts list.
If any difficulties arise, please contact the nearest HATZ Service point.

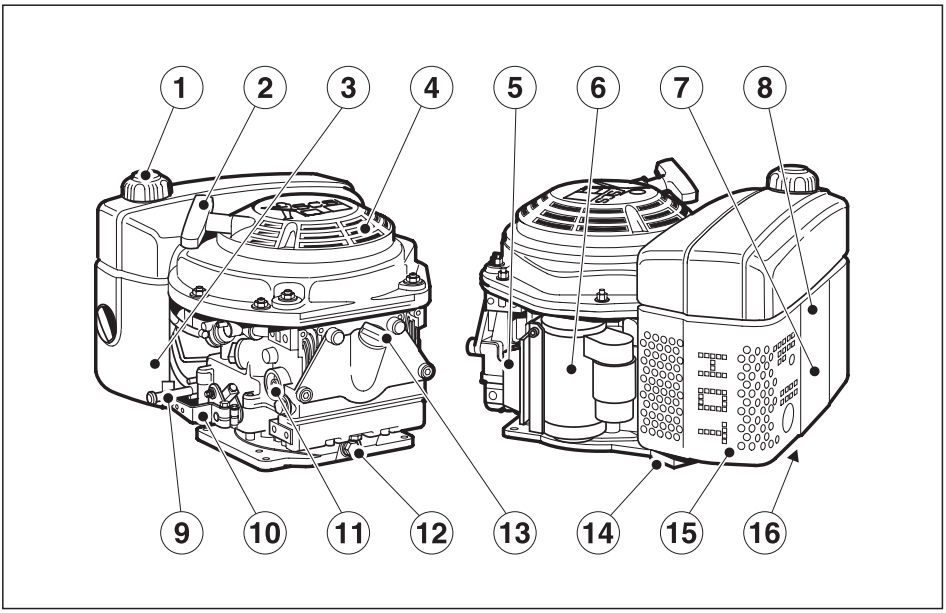
1. General information

Illustration of engine



1 Tank cover
2 Tightening strap (concealed by the noise insulating hood)
3 Noise insulating hood
4 Type plate
5 Silencer (exhaust)
6 Exhaust screen
7 Oil pressure switch
8 Electric starter
9 Voltage regulator
10 Crankshaft - power take-off
11 Oil drain plugs
12 Screw plug for oil filter
13 Engine mounting
14 Speed control lever
15 Start key
16 Intake opening for cooling and combustion air
17 Oil filler and dipstick
18 Indicator lights
19 Recoil starter
20 Shutdown pin
21 Dry-type air cleaner

Illustration of engine



1 Tank cover
2 Recoil starter
3 Dry-type air cleaner
4 Intake opening for cooling and combustion air
5 Voltage regulator
6 Electric starter
7 Noise insulating hood
8 Tightening strap (concealed by noise insulating hood)
9 Shutdown pin
10 Speed control lever
11 Oil filter
12 Oil drain plug
13 Oil filler and dipstick
14 Exhaust screen
15 Silencer (exhaust)
16 Type plate

Technical data

Type		1 B 20	1 B 30	1 B 40
Description			air-cooled four-stroke diesel	
Fuel supply/combustion system			direct injection	
Number of cylinders		1	1	1
Bore / stroke	mm	69 / 62	80 / 69	88 / 76
Displacement	cc	232	347	462
Compression ratio		1:21.0	1:21.0	1:20,5
Max. lubricating oil content	app. l	0.9*	1.1*	1.5*
Amount of oil between "max" und "min" marks	app. l	0.5*	0.5*	0.8*
Engine oil consumption (after running in for approx. 50 hours)	max.		0.5 % of full-load fuel consumption	
Engine oil pressure at oil temperature 100 °C	app.		2.5 bar at 3000 rpm	
Direction of rotation (power take-off end)			counter-clockwise	
Weight (incl. tank, air cleaner, silencer, recoil starter and electric starter)	app. kg	33	38	55
Cooling air requirement at n = 3000 rpm	m^3 / min	4.5	6.3	8.7
Combustion air requirement at n = 3000 rpm	m^3 / min	0.35	0.52	0.69
Max. continuous operating angle – with flywheel end lower – in other directions			 25° 35°	
Starter			12 V - 0.8 kW	
Generator charging current at 3000/1500 rpm			12 V - 14 A / 6.5 A	
Battery	min/max		12 V - 36 / 60 Ah	

* These values are to be understood as approximate.
Always refer to the max. mark on the dipstick.

Type plate information

Engine No.

Type No. 090 | 16 | 93 | 016883

Engine serial No.:
The serial no. begins with 10 and changes continously (11, 12) if any major changes are carried out.

Year of production

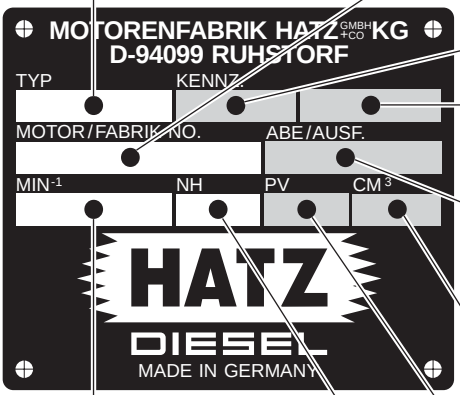
Fabrication No. (continous)

Type designation

e.g. 1 D 80 Z | 36

Engine type

Variation



Customer spec. list no. 1)
Customer specifikation

Output in kW 2)

Execution code 2)

Displacement in cm^3

Engine speed

e.g. 3000 / 60

Nominal speed

Speed increase under no-load condition

Max no-load speed
$3000 + 60 = 3060\ min^{-1}$

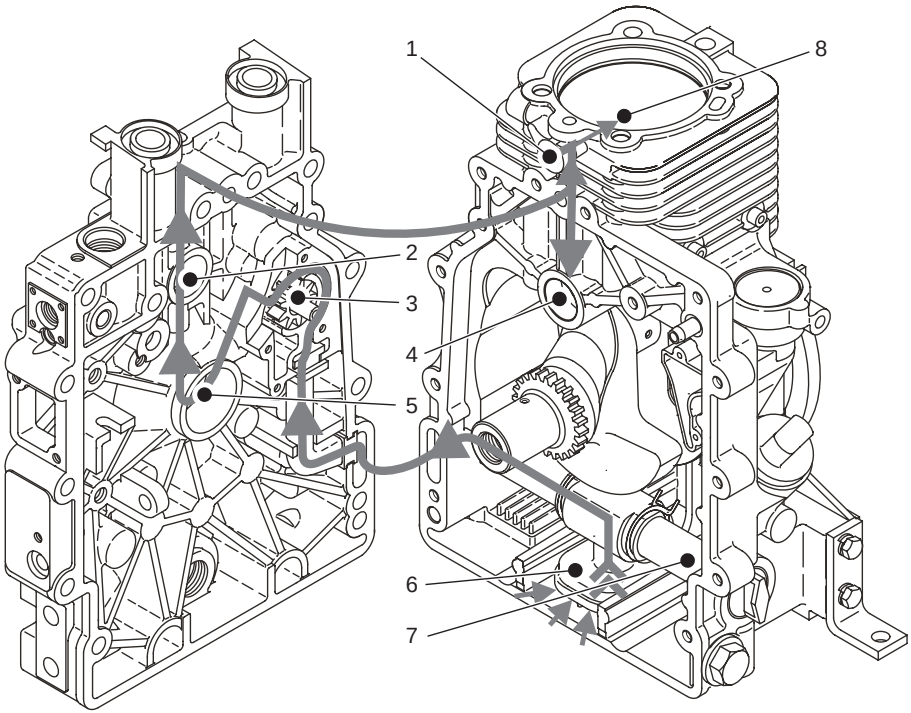
Adjustment instruction 1)
Special adjustm. regarding engine speed, power output etc.

Injection pump delivery lift in mm to obtain the required engine output

1) If required

2) In special cases only; e.g. engines acc. to Federal Authority for Automobilism

Engine oil circuit



1 Oil pressure switch
2 Camshaft bearing, timing end
3 Oil pump
4 Camshaft bearing, flywheel end
5 Main and big-end bearings (crankshhaft)
6 Intake screen
7 Oil mesh filter
8 Gap between crankcase and cylinder liner (for heat dissipation)

Sealants and adhesives

Use of sealants and adhesives:
Code letters on the drawings refer to the materials listed below. The same details appear in our spare parts lists.

A =	502 230 01	Loctite Activator	500 ml
B =	502 231 00	Loctite 573	50 ml
C =	502 232 00	Loctite 601	50 ml
D =	502 233 00	Loctite 221	50 ml
E =	502 234 00	Loctite 648	10 ml
F =	502 238 00	Technicoll 8058	750 g
+	502 239 00	Technicoll 8367	750 g
G =	502 565 01	Loctite IS 407	20 g
H =	502 825 01	Silicon	30 ml
J =	502 830 02	High-temperature paste	1000 g
K =	503 426 00	High-temperature grease	100 g
L =	502 566 00	Silicon	100 g
M =	504 851 00	Grinding paste K 240	80 ml

Special tools and workshop equipment

Series 1 B .. engines

No.	Ident. No.	Code	Designation
1	629 223 01	03.1.2	Valve lifting tool
2	635 389 00	03.1.1	Holder to prevent flywheel movement
3	626 753 91	03.1.2	Driving-out tool with accessories
4	629 055 00	02.1.2	Cable plug removal tool
6	612 090 01	03.1.2	Piston ring pliers
7	624 845 01	03.2.2	Crimping pliers, max. width 6 mm^2
8	620 926 92	03.1.2	Oil pressure gauge, 0...6 bar with flexible hose
10	630 094 00	03.1.2	Test nozzle, 400 bar
11	624 838 91	03.1.2	Revolution counter
12	625 383 02	03.1.2	Digital multimeter
13	634 142 00	03.1.2	Honing tool
14	632 913 00	05.1.1	High-pressure pump, complete
15	626 383 00	03.1.2	Piston ring compressing tool
16	631 392 00	03.1.2	Assembly pin for valve stem seal

Key to code

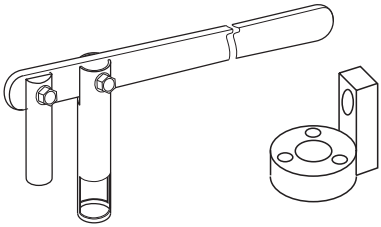
Example: 03. 1. 2

Supplier:
1 Only available from HATZ
2 . . . Same item (or functionally similar item) also available from trade sources

Requirement level:
1 . . . Essential
2 . . . Desirable, useful

Repair level:
01. . . Maintenance
02. . . Breakdown repairs
03. . . Upper area/external repairs
05. . . Repairs to reciprocating parts
5Q. . . General overhauls (including all the necessary tests)
06. . . Reconditioning components

Special tools and workshop equipment



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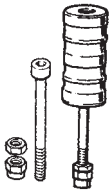

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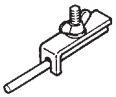

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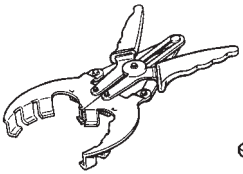

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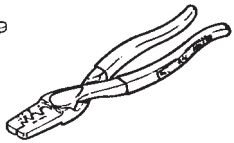

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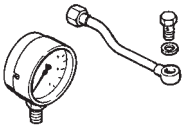

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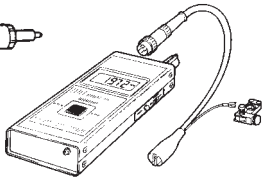

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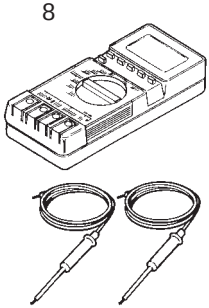

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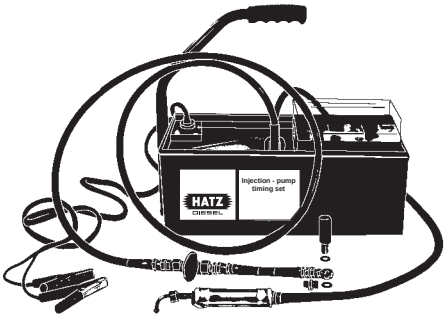

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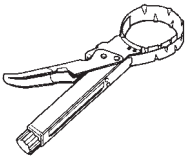

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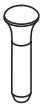

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2. Additional equipment

A 01.00 Fuel

A 01.10 Fuel tank 1B 20.10 up to January 1997

–

Preliminary work

–Take off the air cleaner cover.
–Take off the noise insulating hood.

Dismantling

–Detach fuel feed line **1**.
–Pull line **1** off the engine-end connection.
–Pull off oil leak-off line **2**.
–Pull vent hose **3** off connecting pipe **4** at the insulating flange.
–Unscrew nuts **5** and take off washers **6**.
–Unscrew nuts **7** and take off spring washer **8**.
–Carefully take off fuel tank **9** with air guide housing **10** ; note bushings **11** and washers **12**.
–Loosen screws **13** and take off washers **14** and **16** and retaining angle **15**. Loosen and remove machine screws **17** with spring washers **18** and washers **19** ; note bushings **20** between fuel tank and air guide housing.

Testing / repair:

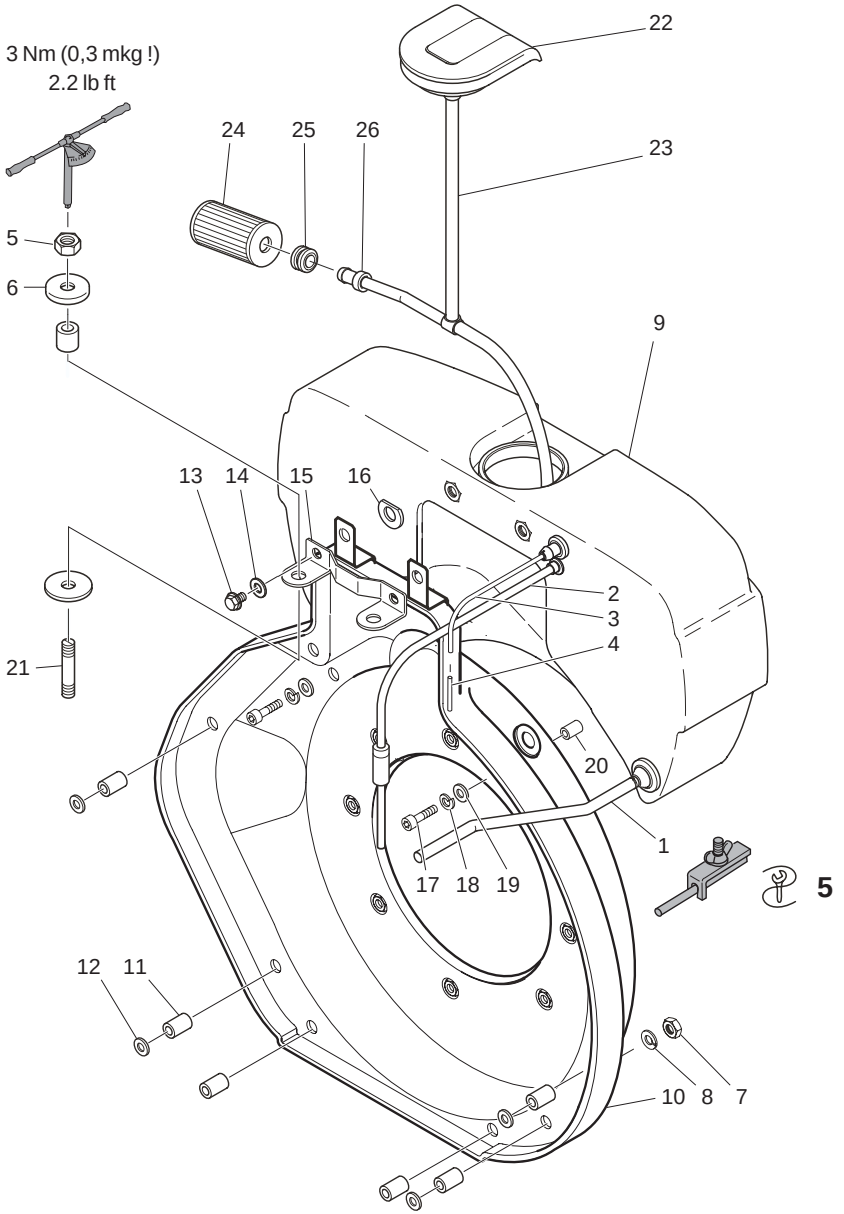
–Visual inspection.
–Look for cracks and signs of leakage.
–Check that retaining components are in good condition.

Assembly

–Follow the dismantling procedure in the reverse order.
–Make sure that the tank is held without trapped stresses at all retaining points.
–Make sure that all bushings and washers are in their correct positions.
–Tighten nuts **5** very carefully to the specified torque (the stud bolts **21** are made of plastic, and must **not** be replaced by metal bolts for thermal reasons).

Renewing fuel filter

–Open filler cap **22**.
–Pull line **23** with filter **24** carefully out of the tank.
–Pull fuel filter **24** with grommet **25** away from connecting nipple **26**.
–Assemble in the reverse order of work.


3 Nm (0,3 mkg !)
2.2 lb ft
22
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25
26
23
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6
9
13
14
15
16
2
3
4
21
20
1
17
18
19
5
12
11
10
8
7

A 01.11 Fuel tank 1B 20.10 from January 1997 on

–

General information:
The fuel return system and the upper tank mounting have been modified. The previous plastic stud bolts **24** have been replaced by steel stud bolts. In connection with this change, the following parts were also modified:
7, 8, 9, 25, 26, 15, 16, 17, 18.

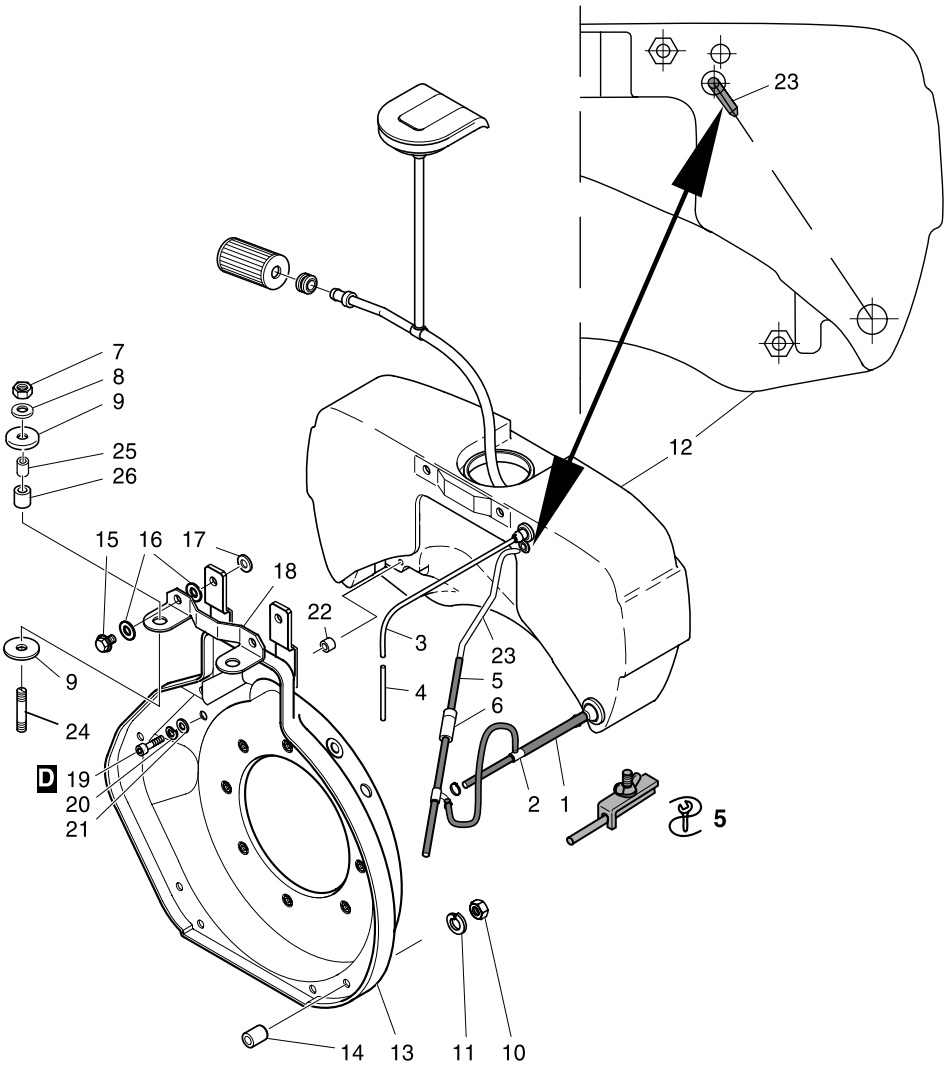
Preliminary work:
– Take off the air cleaner cover.
– Take off the noise insulating hood.

Dismantling:
– Disconnect fuel line **1** and pull it off T-piece **2**.
– Pull vent hose **3** off connecting pipe **4** at the insulating flange.
– Pull return line **5** off vent valve **6**.
– Unscrew nuts **7** and take off washers **8** and **9**.
– Unscrew nuts **10** and take off spring washers **11**.
– Carefully take off fuel tank **12** with air guide housing **13**; note bushings **14** .
– Loosen and remove screws **15** and take off washers **16** and **17** and retaining angle **18**.
– Loosen and remove machine screws **19** with spring washers **20** and washers **21**; note bushings **22** between the fuel tank and the air guide housing.

Testing / repair:
– Visual check.
– Look for cracks and signs of leakage.
– Check that retaining components are in good condition.

Assembly:
– Follow the dismantling procedure in the reverse order.
– Make sure that the tank is held without trapped stresses at all retaining points.
– Make sure that all bushings and washers are in their correct positions.
– Install return pipe **23** so montieren, so that the end of the pipe in the tank faces the outlet nipple.

Note:
It is possible to convert the tank mounting from the old to the new version if all the parts stated above are replaced.


23
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7
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26
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16
17
18
22
3
4
23
5
6
2
1
5
9
24
D
19
20
21
14
13
11
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A 01.12 Fuel tank 1B 20.13, 1B 30

–

General information:
On 1B 20 engines from Series 13 and 1B 30 engines from the start of series production, an injector with oil leak-off return line to the tank was introduced.

Dismantling / assembly:
See A 01.11

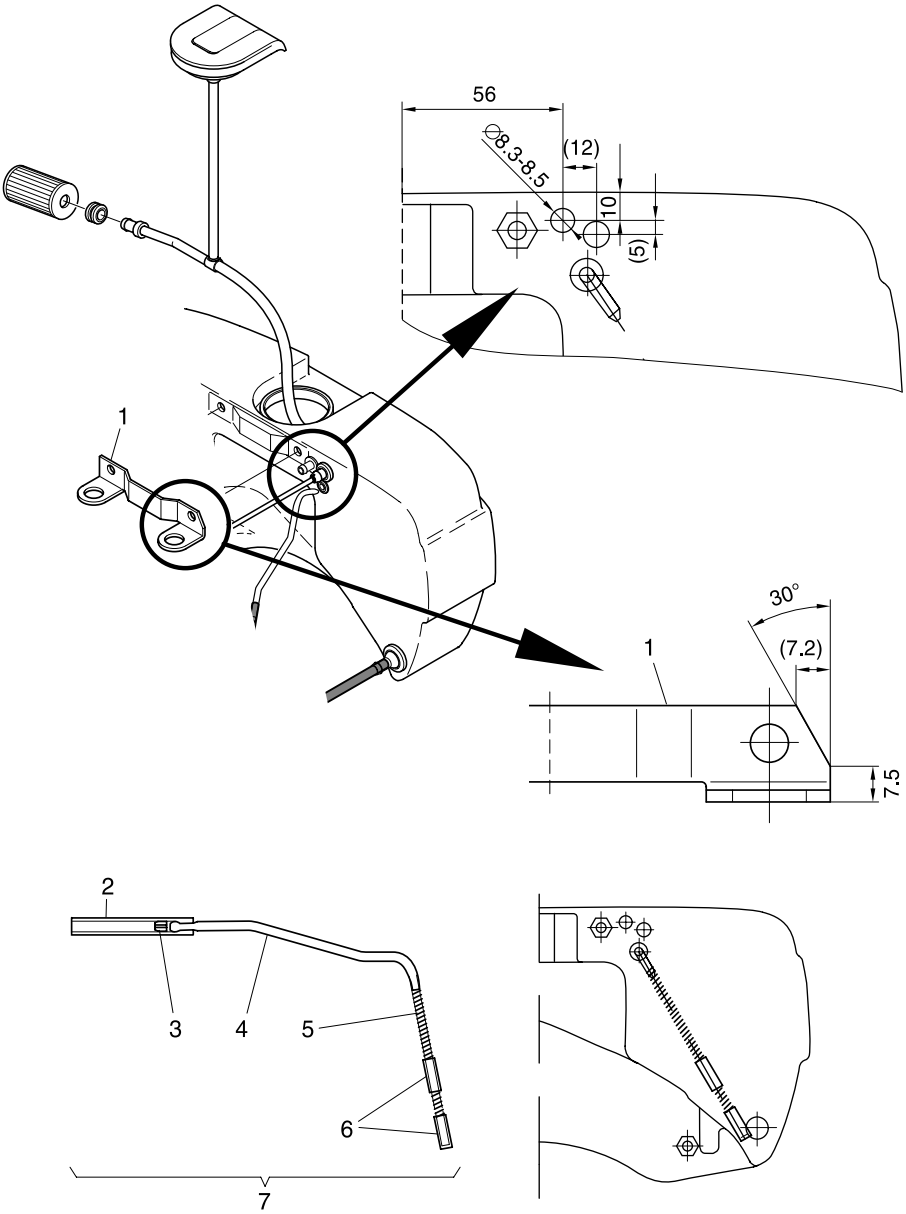
Retrofitting (see also M 14.40)**:**
– Remove the edge at the angle for fuel tank **1** as illustrated.
– Drill an 8.3 - 8.5 mm diameter hole in the tank at the point shown, and deburr it.
– Insert the rubber grommet and hose nipple.

Note:
Only the new injector is available as a spare part.
All the parts needed for retrofitting are supplied with it.

Fuel return line:
From the end of 1998 on, the fuel return line was modified again.
It now consists of fuel line **2**, restrictor **3**, fuel pipe **4**, coil spring **5** and fuel lines **6**.
The complete line **7** is supplied as a spare part.

Note:
The lines for 1B 20 and 1B 30 engines are of different lengths.

Assembly instructions:
– Install return pipe **4** so that the end of the pipe in the tank faces towards the outlet nipple.


56
⌀8.3-8.5
(12)
10
(5)
1
30°
(7.2)
1
7.5
2
3
4
5
6
7

A 02.00 Combustion air

A 02.11 Dry-type air cleaner

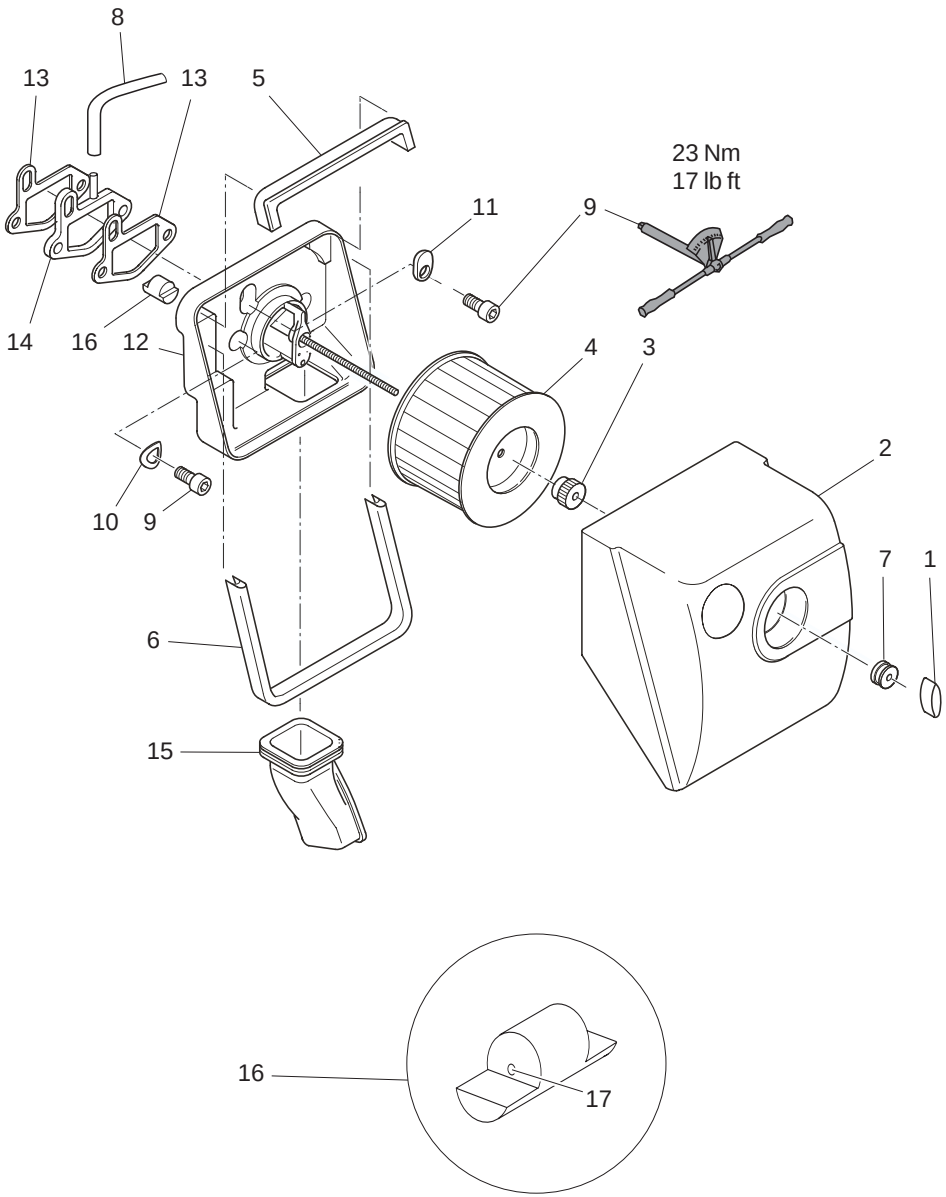
–

Preliminary work: –

Dismantling:
– Take off the parts in the order **1 ... 4** .
– Pull tank vent hose **8** off insulating flange **14** .
– Loosen and remove machine screws **9** with spring washers **10** and shim washer **11**.
– Extract air guide sleeve **15** out of air cleaner housing **12**.
– Take off air cleaner housing **12** with seals **13** and insulating flange **14**.

Testing / repair:
– Check filter element **4** and sealing strips **5 / 6** on the housing and also rubber grommet **7** in the cover and plug **16** .
– Renew damaged parts.

Assembly:
– Install the parrs by following the dismantling procedure in the reverse order.
– Note the correct installed position of plug **16** :
without maintenance indicator:
Axial bore **17** faces the cylinder head
with maintenance indicator:
Axial bore **17** faces the air cleaner
– Renew the seals.
– Note correct tightening value.
– Make sure that no lines are trapped between the air cleaner housing and the cylinder head.


8
13
13
5
23 Nm
17 lb ft
11
9
14
16
12
4
3
2
10
9
7
1
6
15
16
17

A 02.13 Maintenance indicator

–

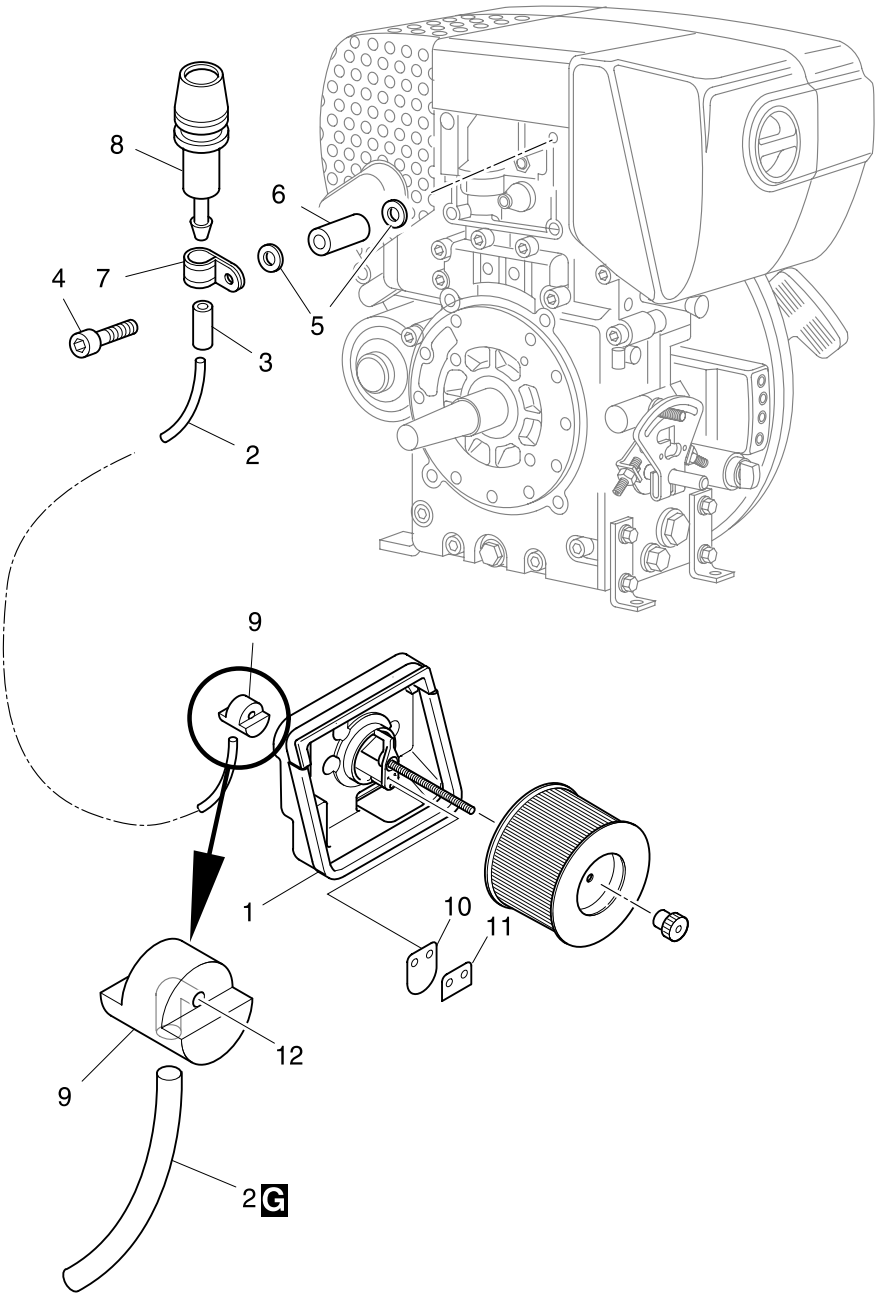
Preliminary work:
– Take off air cleaner housing **1**.
  See A 02.11

Dismantling:
– Pull plug **9** out of air cleaner housing **1**.
– Pull hose **3** off maintenance indicator **8**.
– Remove the parts in the order **4...8**.

Testing / repair:
– Visual check.
– Check the maintenance indicator by applying suction to the connecting hose or connecting stub pipe:
  Vacuum = maintenance indicator is "CLOSED" (green signal ring not visible)
  Atmospheric pressure = maintenance indicator is "OPEN" (green signal ring is visible).
– Check that rubber parts have not aged, and renew if necessary.
– Check that all relevant parts are correctly seated.

Assembly:
– Install parts by following the dismantling instructions in the reverse order.
– Secure connecting hose **2** in plug **9** with adhesive **G**.
– Insert plug **2** in air cleaner housing **1**.
  Axial bore **12** must face towards the air cleaner housing.

Checking operation:
– Press the cap / bellows:
  At least 3 seconds must be allowed for full opening.
– Raise valve plates **10** and **11**:
  The cap / bellows must return to the "OPEN" position, with the green signal ring visible. If necessary, check the seat of the seal in the housing or renew the valve plates.
– Install parts on engine.


8
6
4
7
5
3
2
9
1
10
11
12
9
2 G

A 03.00 Exhaust system

A 03.11.1 Silencer 1B 20, sand-cast version

–

Dismantling:

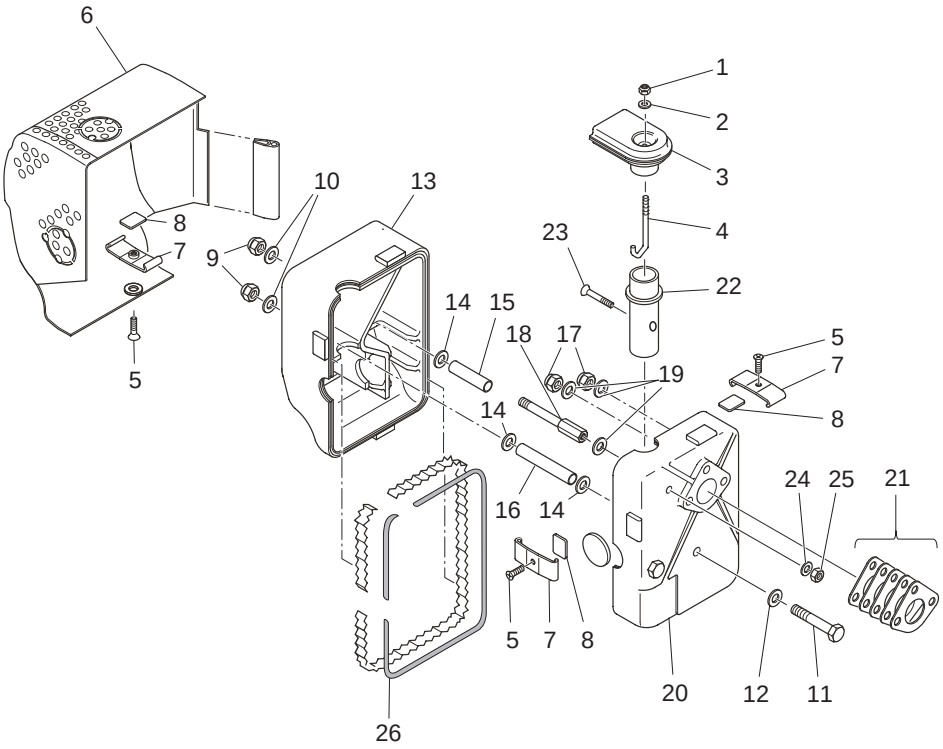
– Unscrew nut **1** with washer **2**, pull off exhaust manifold **3** and detach threaded pin **4** .
– Take out screws **5** and take off guard **6**.
– Take off clamp **7** and plate **8**.
– Unscrew nuts **9** with washers **10** (to unscrew the lower nut, hold screw **11** to prevent it from turning); take off silencer cover **13**.
– Remove washers **14** and spacing tubes **15** and **16**.
– Unscrew and remove nuts **17** and **18** and take off washers **19**.
– Take off rear panel of silencer **20** and gaskets **21**.
– Exhaust pipe **22** is secured with countersunk screw **23**, washer **24** and nut **25** to the rear panel of the silencer and does not need to be take off unless damage has occurred.

Testing / repair:

– Examine parts for damage.
– Clean the silencer halves, exhaust pipe and exhaust manifold.
– Renew gaskets **21** (5 items) and cord seal **26**.

Assembly:

– Follow the dismantling instructions in the reverse order.


6
1
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8
14
16
14
24
25
21
5
7
8
20
12
11
26

A 03.11.2 Silencer 1B 20, pressure-cast version

–

Dismantling:

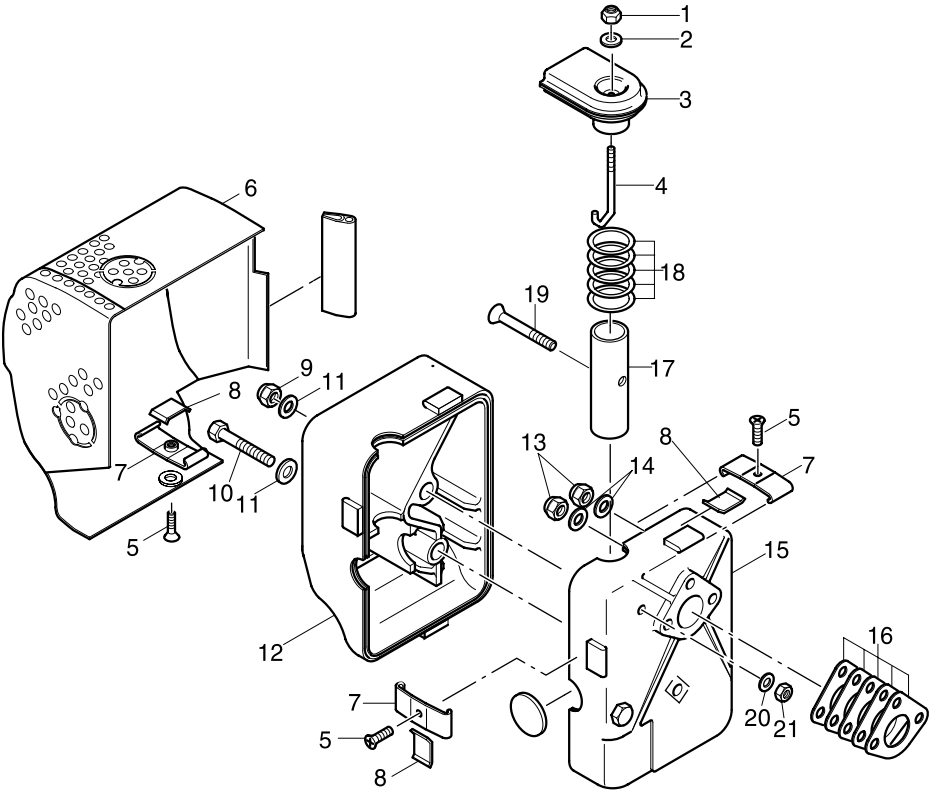
– Unscrew nut **1** with washer **2**, pull off exhaust manifold **3** and disconnect threaded pin **4**.
– Take out screws **5** and remove guard **6**.
– Take off clamp **7** and plate **8**.
– Unscrew nuts **9** and screw **10** with washer **11** and take off silencer cover **12**.
– Unscrew nuts **13** and take off washers **14**.
– Take off rear silencer panel **15** and gaskets **16**.
– Exhaust pipe **17** with washers **18** is secured with countersunk screw **19**, washer **20** and nut **21** to the rear silencer panel and does not have to be removed unless damage has occurred.

Testing / repair:

– Examine parts for damage.
– Clean the silencer halves, exhaust pipe and exhaust manifold.
– Renew gaskets **16** (5 items).

Assembly:

– Follow the dismantling instructions in the reverse order.


1
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17
6
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11
8
7
10
11
5
12
13
14
8
5
7
15
16
7
5
8
20
21

A 03.11.3 Silencer 1B 30, sand-cast version

–

Dismantling:

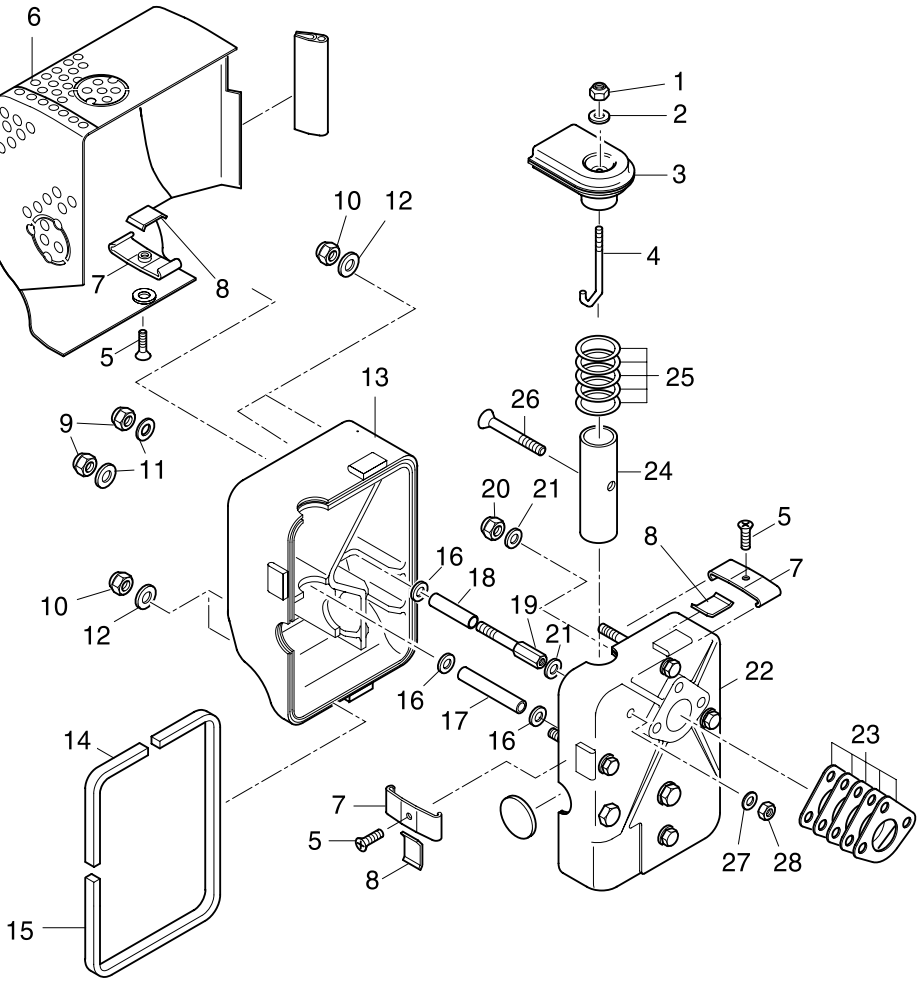
– Unscrew nut **1** with washer **2**, pull off exhaust manifold **3** and disconnect threaded pin **4**.
– Take out screws **5** and remove guard **6**.
– Take off clamp **7** and plate **8**.
– Unscrew nuts **9** and **10** with washers **11** and **12**.
– Take off silencer cover **13** and inserts **14** and **15**.
– Take off washers **16** and spacing tubes **17** and **18**.
– Unscrew nuts **19** and **20** and take off washers **21**.
– Take off rear silencer panel **22** and gaskets **23**.
– Exhaust pipe **24** with washers **25** is secured with countersunk screw **26**, washer **27** and nut **28** to the rear silencer panel and does not need to be removed unless damage has occurred.

Testing / repair:

– Check parts for damage.
– Clean the silencer halves, exhaust pipe and exhaust manifold.
– Renew gaskets **23** (5 items).

Assembly:

– Follow the dismantling instructions in the reverse order.
– Make sure that inserts **14** and **15** are correctly seated.
– Note that the lengths of spacing tubes **17** (65 mm) and **18** (51.6 mm) are different.


6
1
2
3
10
12
4
7
8
5
25
13
26
9
11
24
20
21
5
8
7
10
12
16
18
19
21
22
16
17
16
23
14
7
5
8
27
28
15

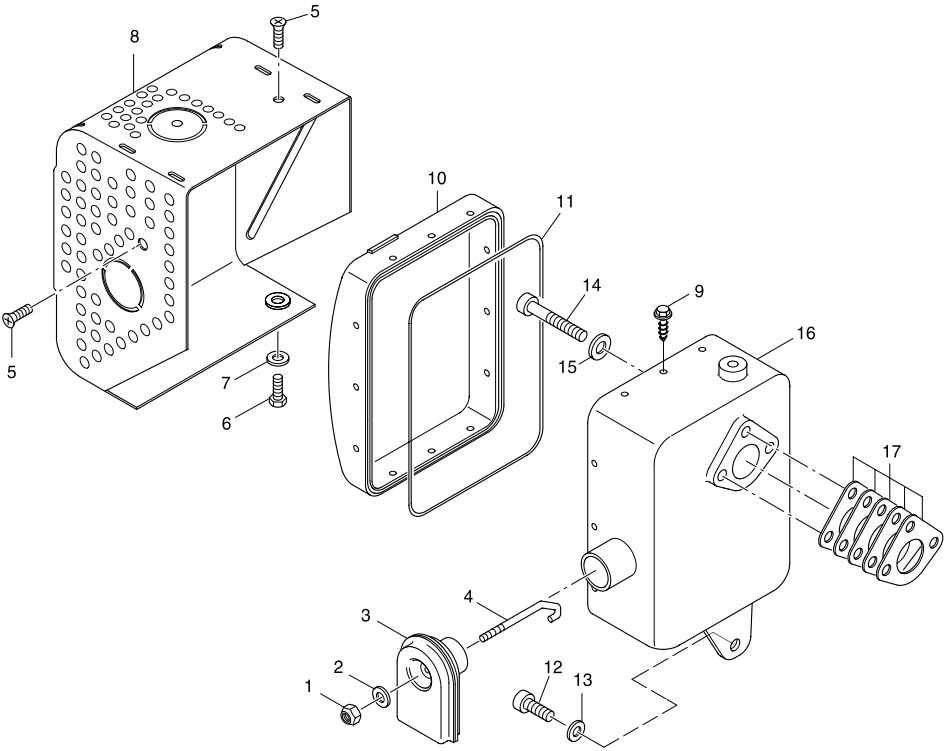
A 03.11.4 Silencer 1B 30 / 40, sheet metal version

–

Dismantling:
–Remove in numerical sequence **1 ... 17.**

Testing / repair:
–Check parts for damage.
–Clean the silencer halves, exhaust pipe and exhaust manifold.
–Renew gaskets **17** (5 items).

Assembly:
–Follow the dismantling instructions in the reverse order.
–Make sure that gasket **11** is correctly seated.


5
8
5
7
6
10
11
14
15
9
16
17
4
3
2
1
12
13

A 05.00 Electric starting

A 05.20 Starter

–

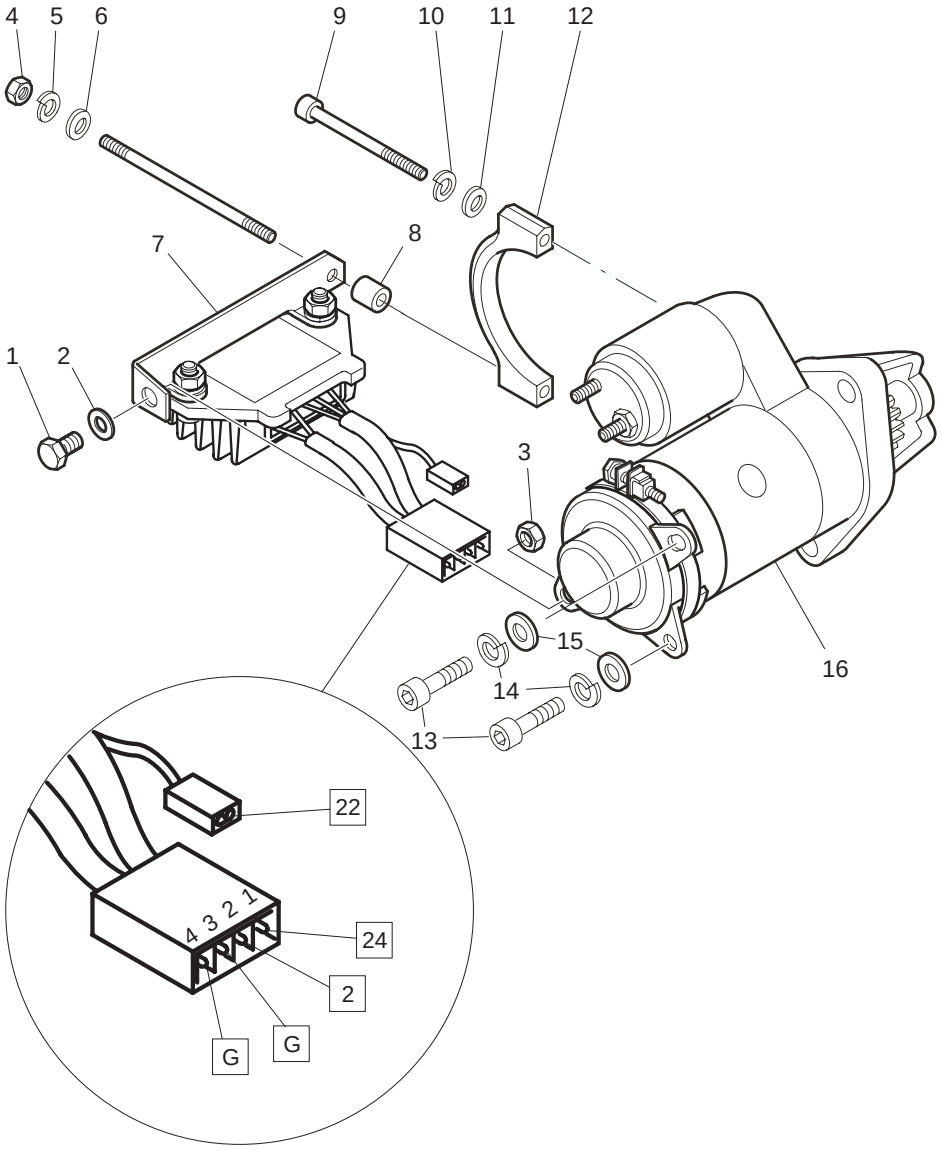
Preliminary work:
– Disconnect the battery: negative pole first, positive pole second.
– Disconnect cables as far as necessary.

Dismantling:
– Take out screw **1** with washer **2** and nut **3**.
– Unscrew nut **4** with spring washer **5** and washer **6**.
– Take off regulator switch **7** and bushing **8**.
– Remove machine screw **9** with spring washer **10** and washer **11**; take off stirrup **12**.
– Take out machine screws **13** with spring washers **14** and washers **15**; take off starter **16**.

Testing / repair:
– Examine bearings and pinion for signs of wear or damage.
– Check that pinion turns freely.

Note:
Repairs to the starter motor should only be performed by an authorised HATZ Service point.

Assembly:
– Follow the dismantling instructions in the reverse order.
– Restore the electrical connections.
– Reconnect the battery: first the positive pole and then the negative pole.


4
5
6
9
10
11
12
7
8
1
2
3
15
16
14
13
22
4 3 2 1
24
2
G
G

A 05.00 Electric starting

A 05.40 Generator

- 4 -

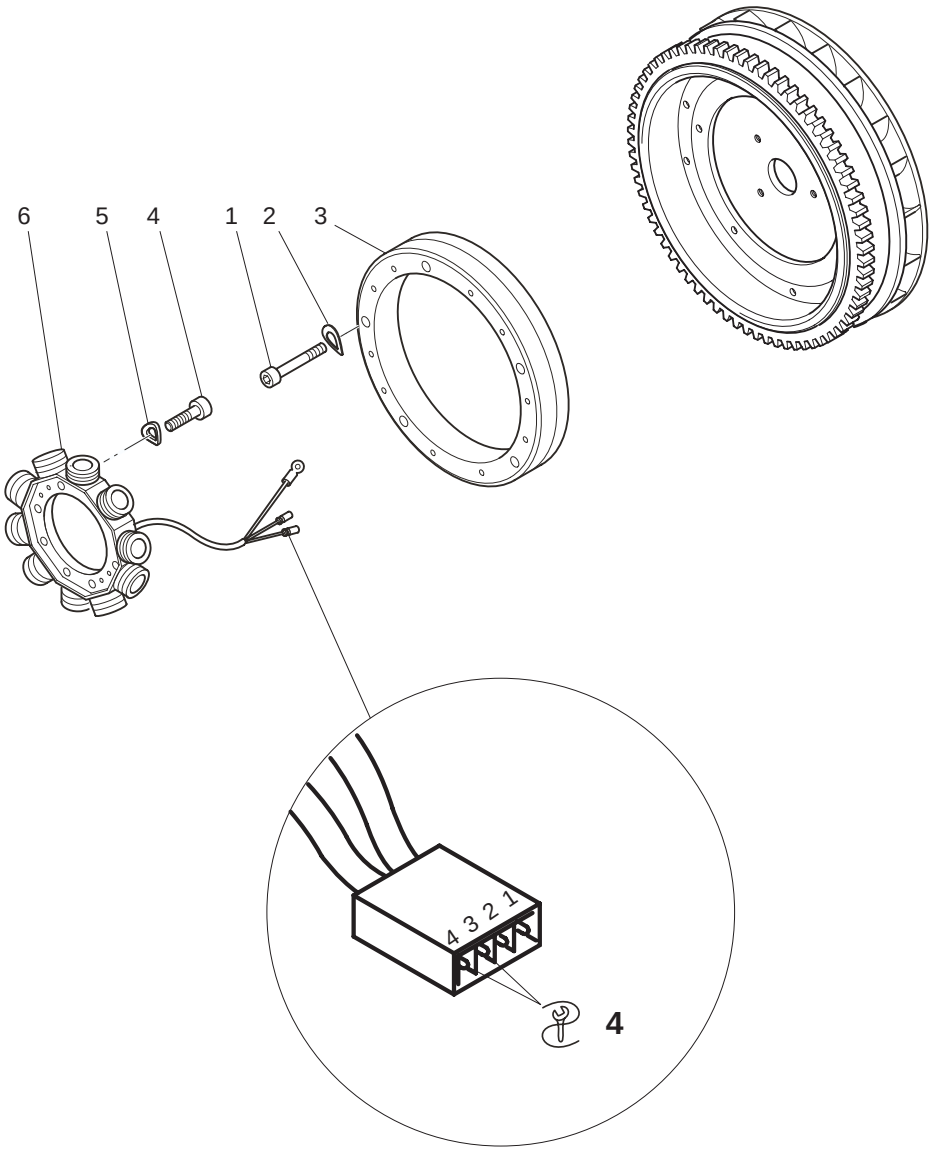
General information:
Before dismantling, check operation of the generator (measure off-load voltage, see Section **4**).

Preliminary work:
– Disconnect the battery: negative pole first, positive pole second.
– Take off the fuel tank with the air guide housing (A 01.10).
– Take off the flywheel (M 17.00) and the starter (A 05.20).

Testing / repair:
– Check parts for damage and renew if defective.

Dismantling:
– Take out machine screws **1** with spring washers **2**; take off rotor **3**.
– Unscrew the equipment box from the partition panel.
– Remove the partition panel (M 26.00).
– Detach the cable connector at the regulator switch.
– Open the plug and detach the two yellow wires in sockets 3 and 4 using tool **- 4 -.**
– Pull the generator cable out of the hole in the crankcase.
– Mark the position of the coil in relation to the crankcase with a scriber, so that it can be centred correctly.
– Take out machine screws **4** with spring washers **5** and take off coil **6**.

Assembly:
– Follow the dismantling procedure in the reverse order.
– Before tightening coil **6**, align it so that it is concentric with the crankshaft (scriber mark).


6
5
4
1
2
3
4 3 2 1
4

A 05.60 Fittings

–

Preliminary work:

– Disconnect the battery: first the negative pole, then the positive pole.

Dismantling:

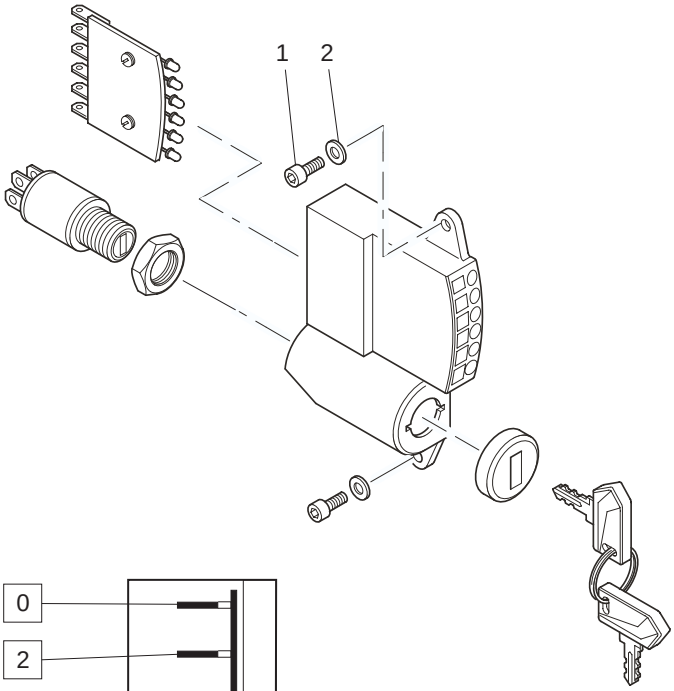
– Take out machine screws **1** with washer **2**.
– Detach cables and take off the electrical fitting.

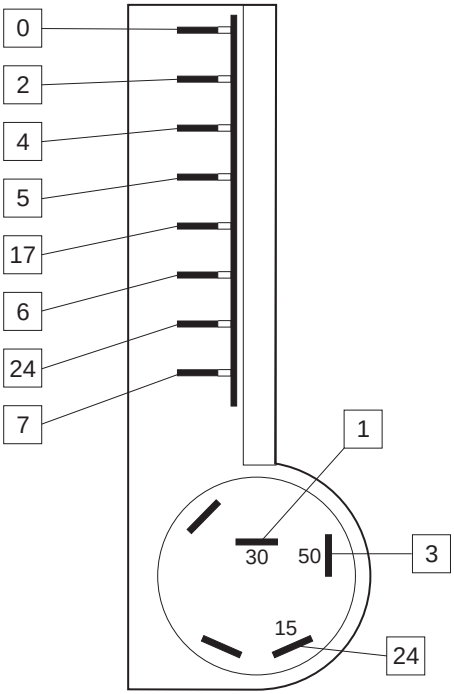
Testing / repair:

– Examine parts for damage and renew if necessary.

Assembly:

– Following the dismantling procedure in the reverse order.
– Make sure that the cables are reconnected correctly (see also Section 4).


1
2


0
2
4
5
17
6
24
7
1
30
50
3
15
24

A 05.80 Gear ring

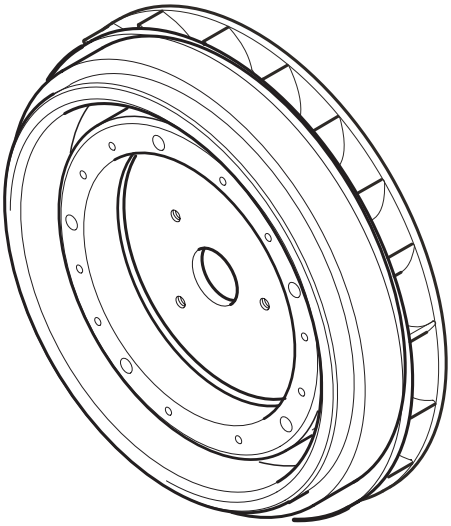
–

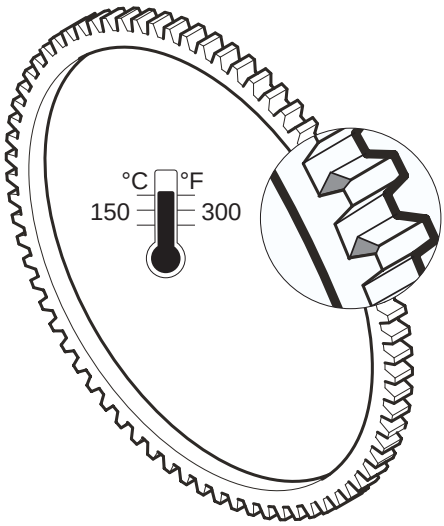
Preliminary work:
– Take off the flywheel (M 17.00)

Testing / repair:
– Inspect the gear ring for broken teeth or other damage.
– If necessary, file the gear ring to shape or renew it.

Dismantling:
– Heat the gear ring carefully until it can be removed from the flywheel,
or:
– Drill into the gear ring and chisel it open.

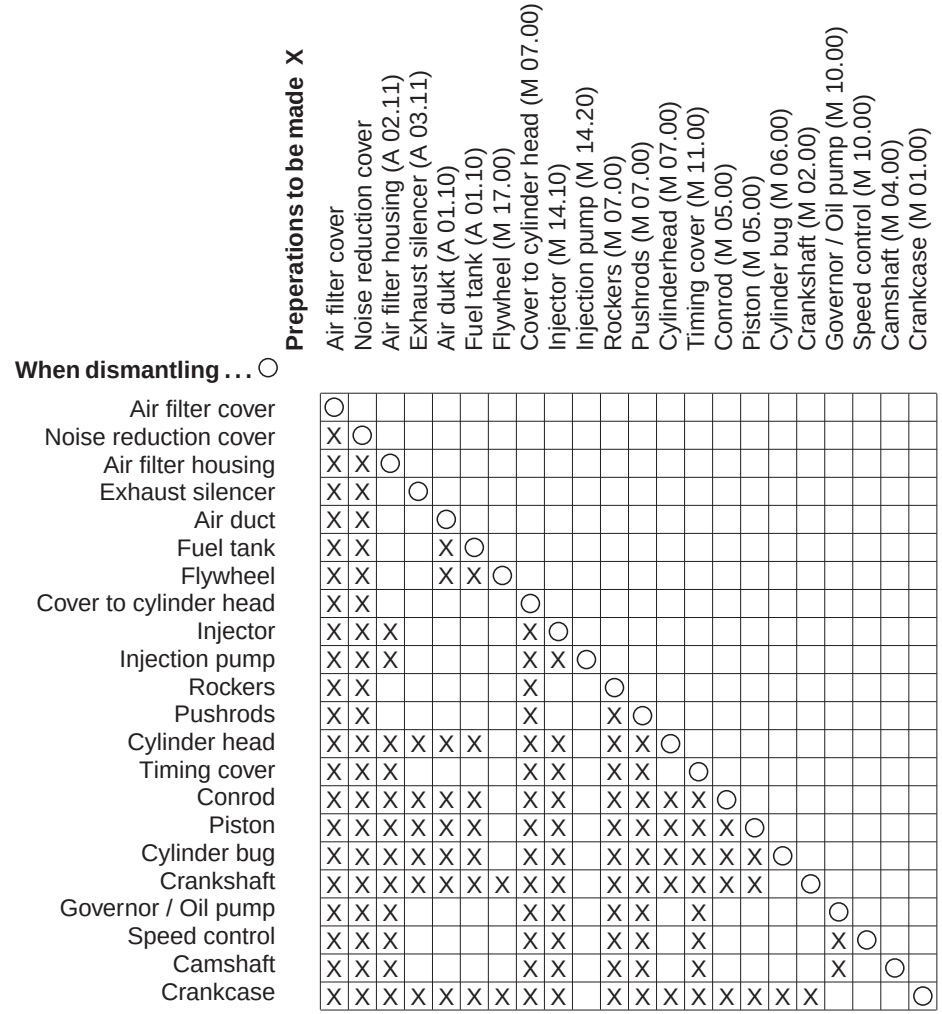
Assembly:
– Heat the gear ring to approx. 150°C and pull it on to the flywheel.
Note:
The chamfered side of the teeth must be towards the starter.




°C
°F
150
300

3. Basic engine equipment

Dismantling – cross-references



M 01.00 Crankcase

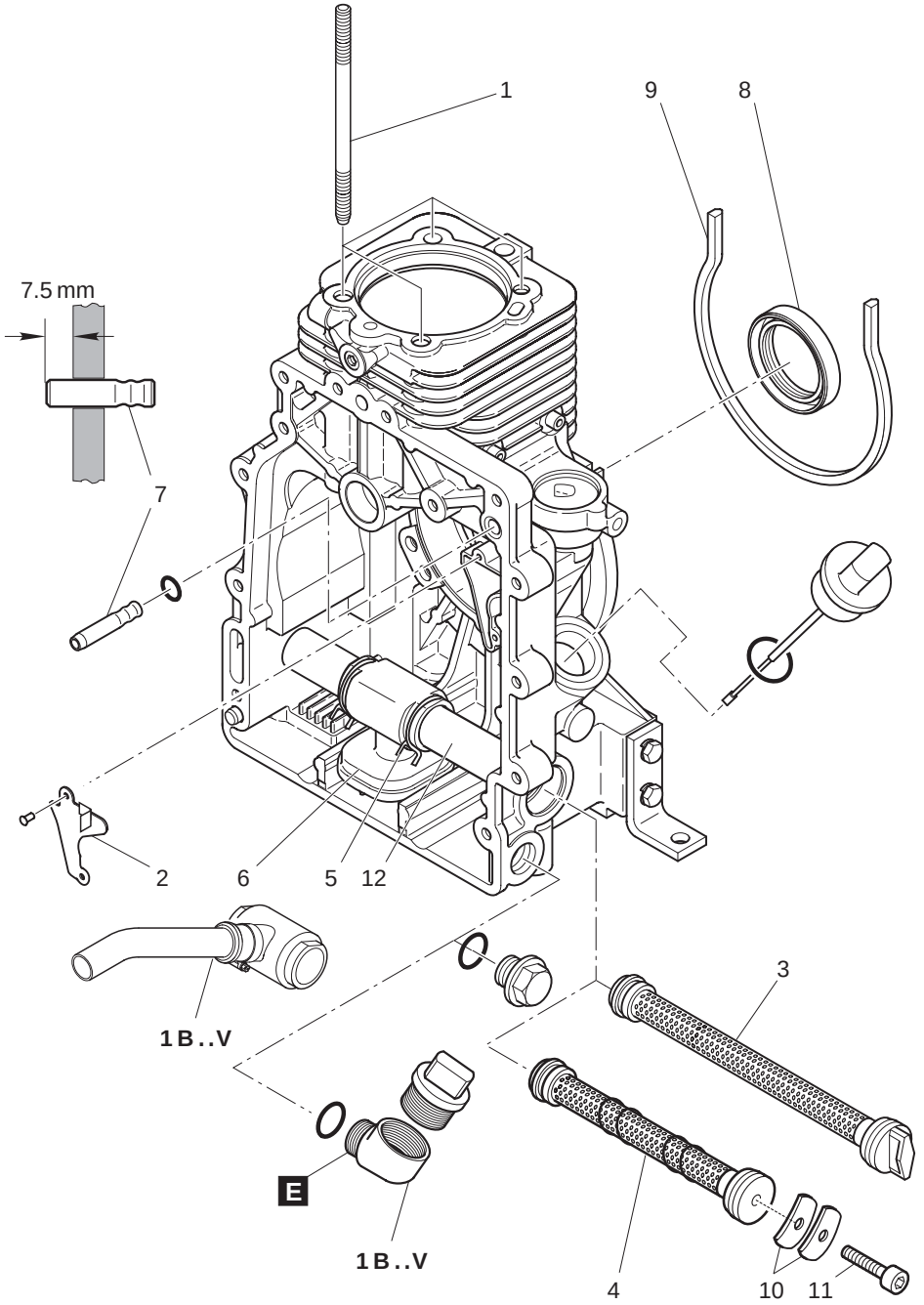
–

Preliminary work:
For dismantling, see M cross-reference list.

Testing / repair:
– Inspect for damage and broken cooling fins.
– If stud bolts **1** are renewed, screw them in fully and then unscrew by 1 turn (this will avoid stresses caused by different thermal expansion rates).
– Check firm seating of oil deflector plate **2**.
– Clean oilways and oil filter **3** and **4** thoroughly; to do this, remove wire hose clips **5** from suction head **6**, turn the suction head forwards and remove the intake mesh screen.
– Check the distance by which connecting nipple **7** projects.
– Press the new shaft sealing ring **8** in until it is flush with the crankcase.
– Renew sealing strip **9** if necessary.

Oil filter:
1 B 20 – from engine number 700 on
1 B 20 V and 1 B 30 – all:
The oil filter was modified and is now retained in position in the crankcase by the two tensioning springs **10** and machine screw **11**.
This oil filter cannot be used on 1 B 20 engines with engine numbers below 700.

Oil filter housing:
1 B 20 from Series 20
1 B 20 V from Series 11
1 B 30 from Series 15
The external diameter of oil filter housing **12** was increased and with it the corresponding bore in the crankcase.
The parts are **not** interchangeable.
New crankcases are supplied as spare parts only with the new oil filter housing.


1
9
8
7.5 mm
7
2
6
5
12
1B..V
3
E
1B..V
4
10
11

M 01.00 Crankcase

M 01.10 Mass balance (1B40)

–

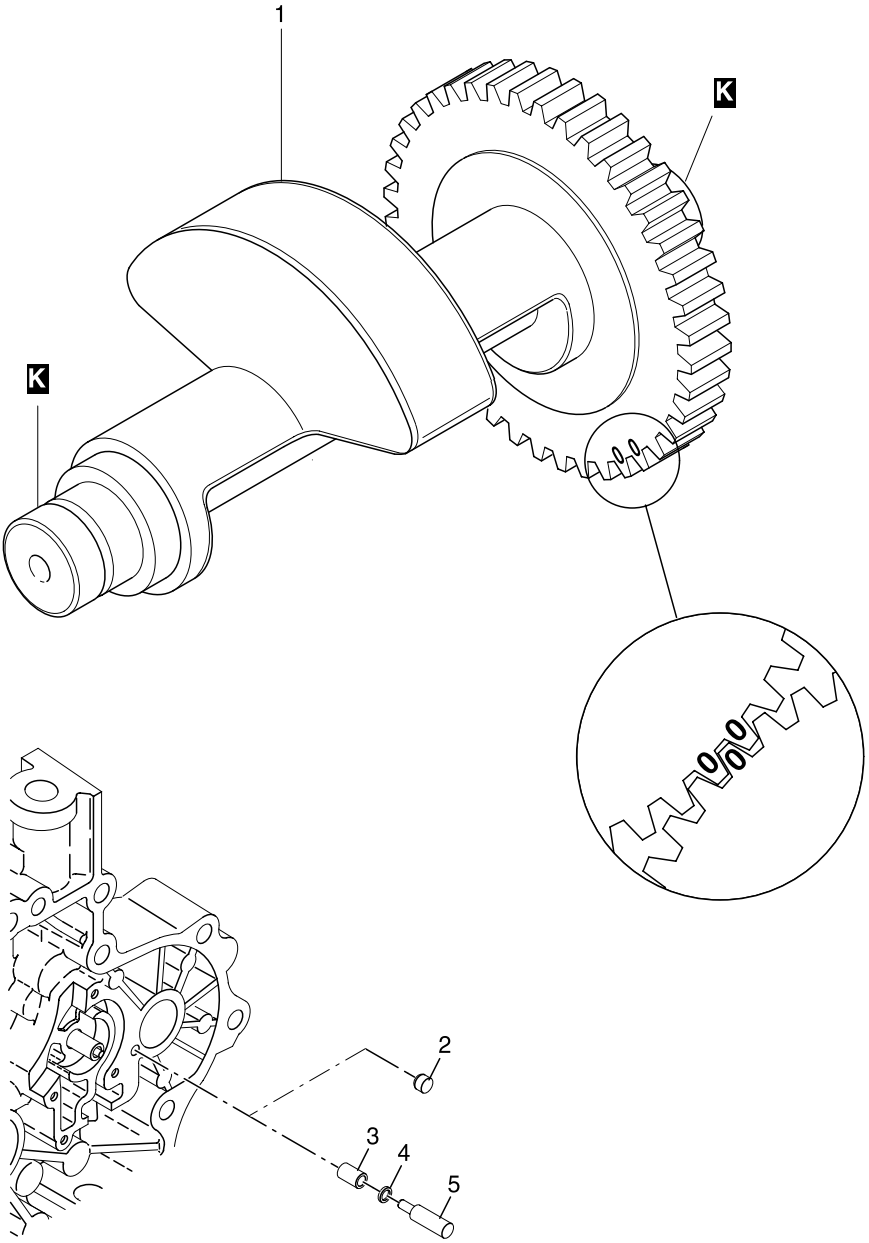
Preliminary work:
Remove the timing case cover.
See M – dismantling cross-reference list.

Dismantling:
– Turn the crankshaft until the markings on the gearwheels are opposite each other as illustrated.
– Remove balancer shaft **1** from the crankcase.

Testing / repair:
– Inspect parts for damage or wear; renew if necessary.

Assembly:
– Apply grease **K** to the mounting points of the balancer shaft.
– Place balancer shaft **1** in the crankcase, making sure that the markings are opposite each other as illustrated.
– Assemble the engine.

Note:
The oilway between the oil pump and the bearings of the balancer shaft in the timing case cover is fitted with various plugs according to the equipment.
Here the following applies:
Engine **with** mass balance:
Plug **2** is inserted = oilway **open**
Engine **without** mass balance:
Plugs **3** and **5** and O-ring **4** are fitted = oilway **closed.**
This should be especially noted in conversions, as otherwise sufficient engine lubrication is not guaranteed!


1
K
K
2
3
4
5

M 02.00 Crankshaft

–

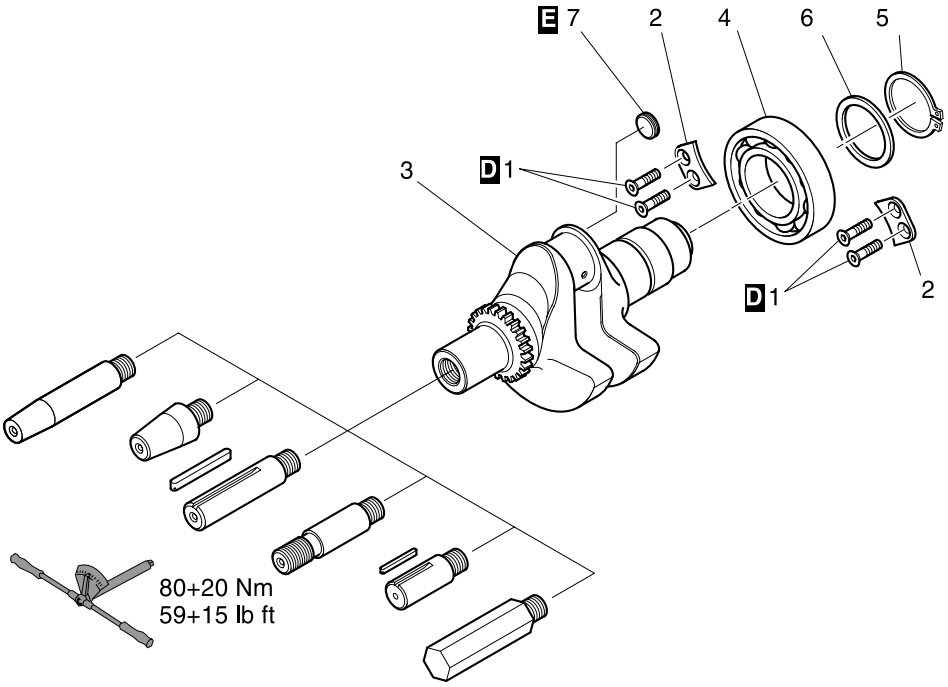
Preliminary work:
See M – dismantling cross-reference list.

Dismantling:
– Take out screws **1** and remove plates **2**.
– Use a plastic-faced hammer to dislodge crankshaft **3** and main bearings **4** from the crankcase.
– Take off circlip **5** and thrust washer **6**.
– Press out main bearing **4**.

Testing / repair:
– Inspect the crankshaft for wear.

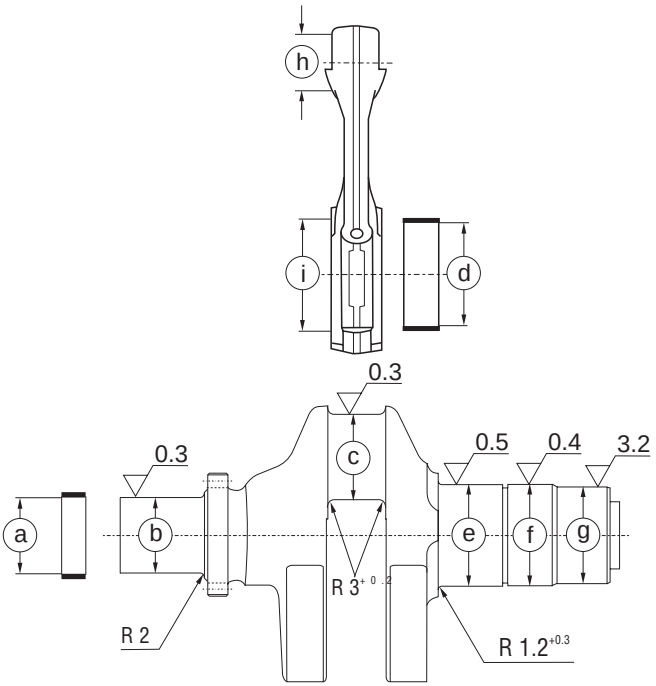
Note:
If the crankshaft is remachined, cover **7** should be removed and the oilways cleaned out thoroughly. Insert a new cover using sealant **E** and caulk into position.

Assembly:
– Follow the dismantling instructions in the reverse order.
– Heat the main bearing to approx. 80°C before pulling it on to the crankshaft.
– Heat the crankcase to appox. 80°C before installing the crankshaft.
– Apply sealant **D** to screws **1** and tighten them.
– **Stub shaft** (if fitted):
Degrease the cones (inner and outer) and threads (inner and outer) and tighten to specified torque.


E 7
2
4
6
5
3
D 1
D 1
2
80+20 Nm
59+15 lb ft

M 02.00

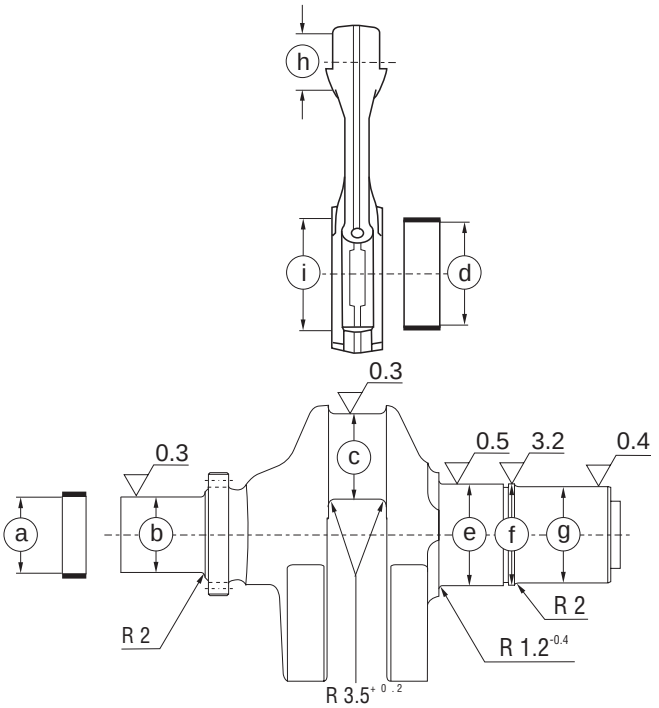
Wear and regrinding dimensions – 1B 20



	Nom. value (mm)	Wear tolerance (mm)	Grinding dimensions -0.5 (mm)	Wear tolerance -0.5 (mm)
a* Ø	30.01 - 30.04	30.10	29.51 - 29.54	29.60
b Ø	29.987 - 30.000	29.95	29.487 - 29.500	29.45
a - b	0.01 - 0.06	0.15	0.01 - 0.06	0.15
c Ø	33.975 - 33.991	33.94	33.475 - 33.491	33.44
d* Ø	34.004 - 34.026	34.07	33.504 - 33.526	33.57
c - d	0.02 - 0.05	0.13	0.02 - 0.05	0.13
e Ø	40.002 - 40.013	–		
f Ø	40.000 - 40.160	39.85		
g Ø	38.00 - 38.20	–		
h Ø	18.016 - 18.027	18.04		
i Ø	37.000 - 37.016	37.03		

*Bearings in fitted condition
all dimensions at 20±10°C / 68±18°F
Hardness at bearing journals
600 - 680 HV

Wear and regrinding dimensions – 1B 30

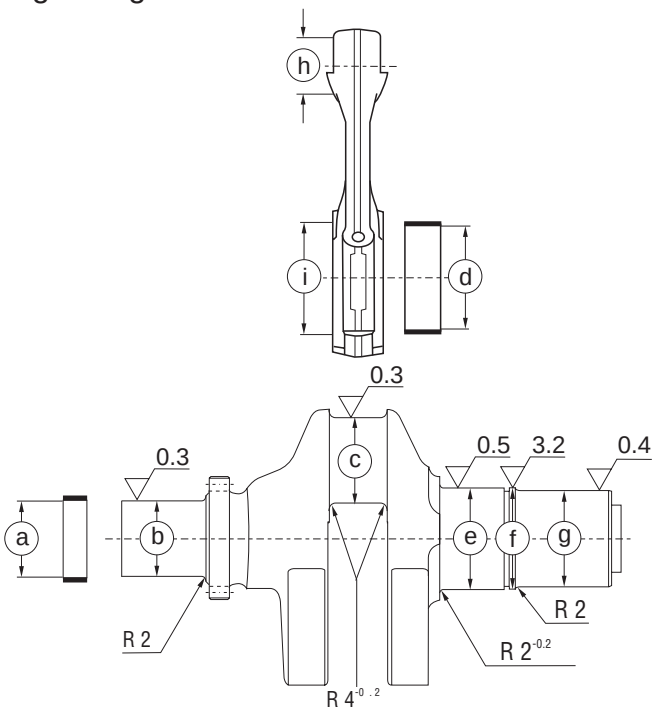


	Nom. value (mm)	Wear tolerance (mm)	Grinding dimensions -0.5 (mm)	Wear tolerance -0.5 (mm)
a* Ø	30.01 - 30.04	30.10	29.51 - 29.54	29.60
b Ø	29.987 - 30.000	29.95	29.487 - 29.500	29.45
a - b	0.01 - 0.06	0.15	0.01 - 0.06	0.15
c Ø	35.975 - 35.991	35.94	35.475 - 35.491	35.44
d* Ø	36.010 - 36.050	36.09	35.510 - 35.550	35.59
c - d	0.02 - 0.075	0.15	0.02 - 0.075	0.15
e Ø	45.009 - 45.020	–		
f Ø	44.80 - 45.00	–		
g Ø	41.840 - 42.000	41.70		
h Ø	20.020 - 20.033	20.045		
i Ø	39.000 - 39.016	39.03		

* Bearings in fitted condition
all dimensions at 20±10°C / 68±18°F
Hardness at bearing journals
600 - 680 HV

M 02.00

Wear and regrinding dimensions – 1B 40



	Nom. value (mm)	Wear tolerance (mm)	Grinding dimensions -0.5 (mm)	Wear tolerance -0.5 (mm)
a* Ø	36.035 - 36.081	36.10	35.535 - 35.581	35.60
b Ø	35.984 - 36.000	35.95	35.484 - 35.500	35.45
a - b	0.035 - 0.097	0.15	0.035 - 0.097	0.15
c Ø	47.975 - 47.991	47.94	47.475 - 47.491	47.44
d* Ø	48.010 - 48.053	48.09	47.510 - 47.553	47.59
c - d	0.019 - 0.078	0.15	0.019 - 0.078	0.15
e Ø	50.009 - 50.020	–		
f Ø	49.80 - 50.00	–		
g Ø	44.975 - 45.000	44.80		
h Ø	22.020 - 22.033	22.045		
i Ø	51.000 - 51.016	51.03		

*Bearings in fitted condition
all dimensions at 20±10°C / 68±18°F
Hardness at bearing journals
600 - 680 HV

M 04.00 Camshaft and automatic decompressor

- 3 -

Preliminary work:
See M – dismantling cross-reference list.

Dismantling:
Camshaft:
– Swing cam follower **1** away from camshaft.
– Press the rocker arm for injection pump **2** away from the camshaft with a suitable lever and pull camshaft **3** out of the timing case cover.

Cam follower and injection pump rocker arm:
– Detach injection pump rocker arm **2** from ther pump piston and disconnect it from the return spring.
– Take out screws **4** and **5** and remove shafts **6** and **7** using driving-out tool **- 3 -**.

Automatic decompressor:
– Take off circlips **8**.
– Take off bob-weights **9** and **10** and stirrup **11**. Note shims **12**).

Testing / repair:
– Examine parts for damage or wear and renew if necessary.

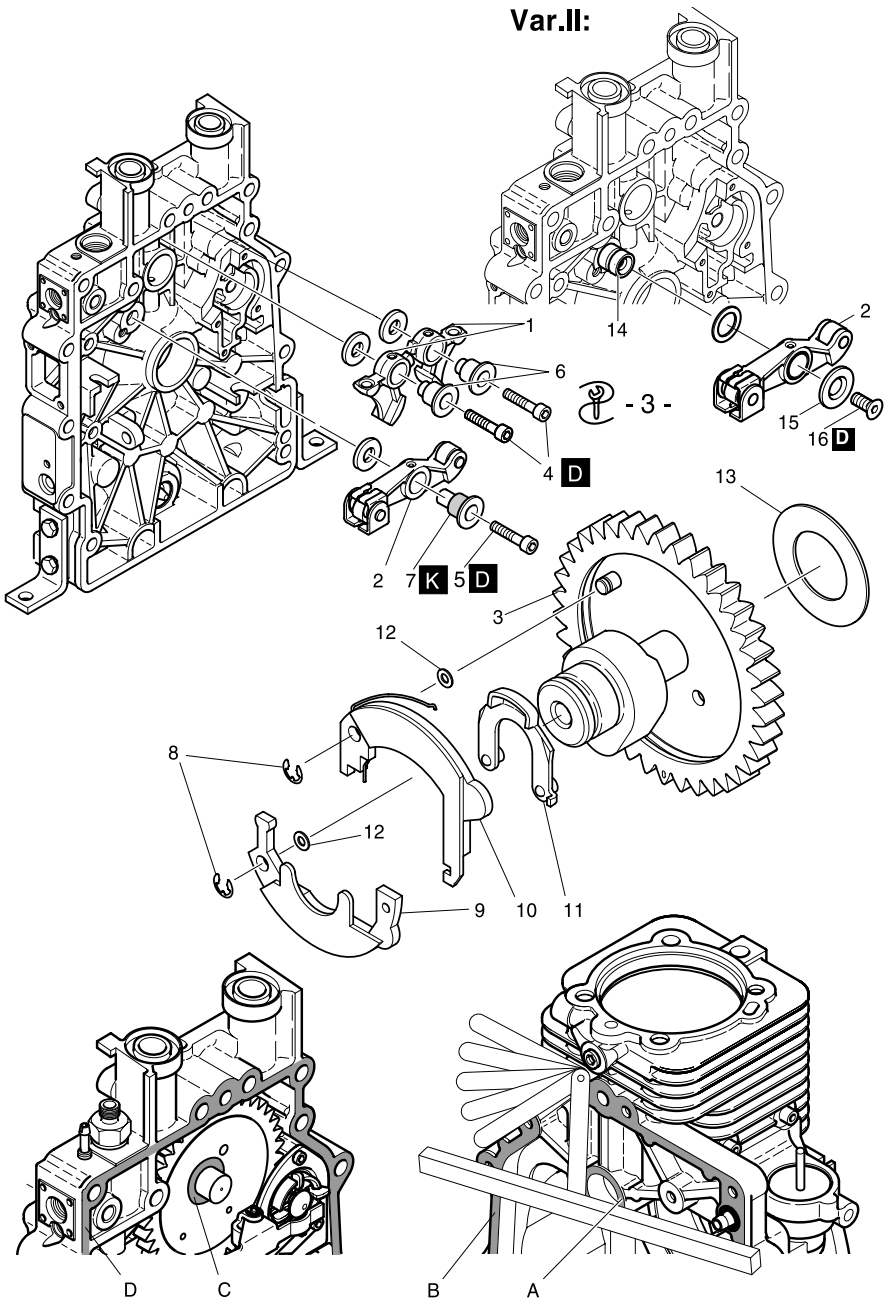
Assembly:
– Follow the dismantling instructions in the reverse order.
– Note the shims **12**; without them, friction between the bobweights and the camshaft gearwheel would be too high, so that the automatic decompressor would be unable to operate.
– Check that all parts move freely.
– Grease the sliding contact face on shaft **7** with lubricant **K**.
– Apply sealant **D** to screws **4** and **5** when inserting and tightening them.

Note:
1B20 from Series 12
1B20V from Series 10
1B30 from Series 10
Shafts **6** were lengthened to 25 mm and machine screws **4** were increased to strength rating 10.9.
Shaft **7** was lengthened to 28 mm and secured with M6x30 machine screw **5**.

Var. II:
1B20 from Series 21
1B20V from Series 13
1B30 from Series 17
1B40 from Series 10
The position of the rocker arm in relation to injection pump **2** was modified. It is secured by washer **15** and countersunk screw **16**. Shaft **14** is fixed in the timing case cover.

Camshaft endplay:
– Endplay is adjusted to 0.2 mm with washer **13**.

Determining washer thickness:
– Using a ruler and a feeler gauge, determine the amount by which thrust face **A** is set back in relation to sealing face **B**, and the amount by which thrust face **C** is set back in relation to sealing face **D**.
– Add the two values together and deduct the correct endplay of 0.1 mm.
– The value obtained in this way is the thickness of washer **13** that must be inserted.


Var.II:
1
14
2
6
- 3 -
15
16 D
4 D
13
2
7 K
5 D
3
12
8
12
9
10
11
D
C
B
A

M 05.00 Piston with conrod

- 6 - 15 -

General information:
The complete conrod can be installed either way round.
However, when installing the conrod and the big end bearing cap, make sure that the numbers on both components and the grooves to prevent the bearing shells from turning are on the same side.

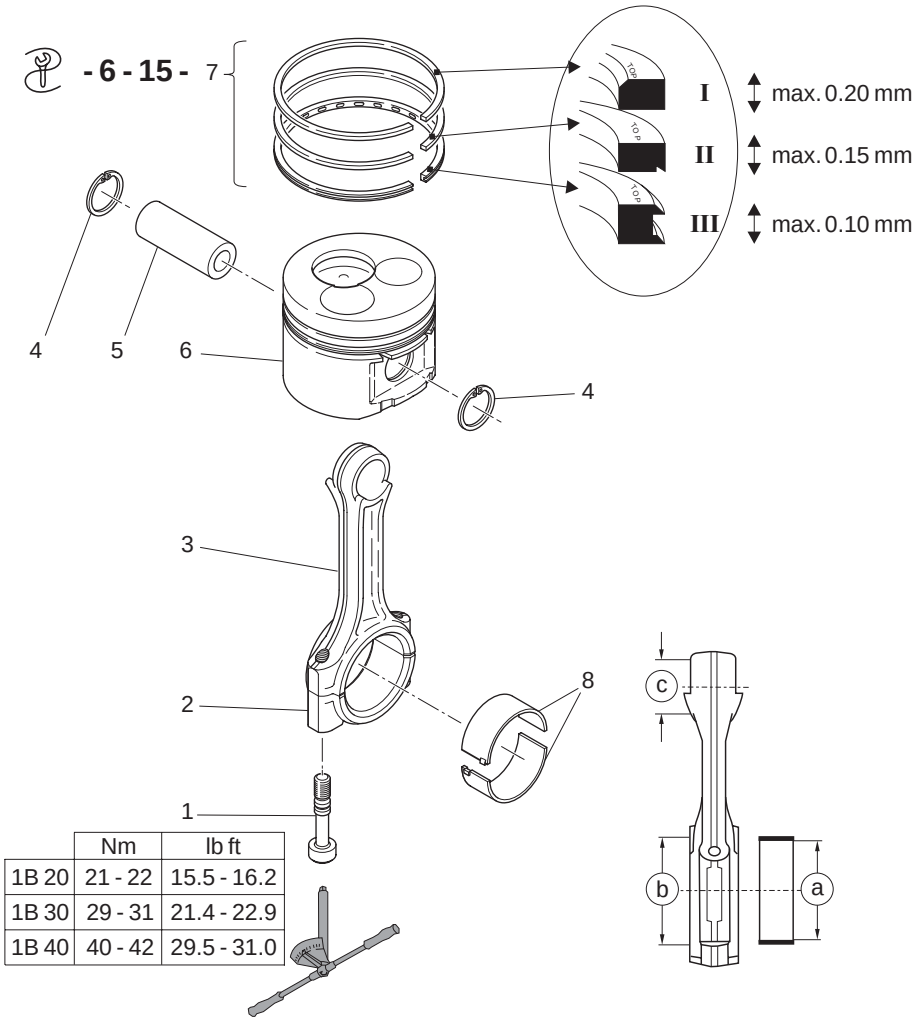
Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove soot and carbonised oil in the upper cylinder liner area.
– Take out screws **1**.
– Remove big end bearing cap **2** downwards.
– Pull the upper part of conrod **3** upwards out of the cylinder complete with the piston.
– Remove circlips **4** and pull out piston (gudgeon) pin **5**.
– Take off piston **6**.
– Remove piston rings **7** with piston ring pliers **- 6 -**.

Testing / repair
Conrod:
– Check bearing for wear and score marks.
– Check that the two bearing bores are parallel with one another.

Piston and piston rings:
– Examine for wear and score marks.
– Check axial play of piston rings in their grooves.
– Remove carbonised oil and other combustion deposits.
– Check piston rings for wear (see M 06.00).

Assembly:
– Use pliers **- 6 -** to fit the piston rings to the piston.
– Place the piston on the conrod and insert the piston pin, which should first be oiled.
– Fit circlips **4**.
– Clean the conrod and big end bearing cap and place bearing shells **8** in position.
– Turn the piston rings so that their end gaps are offset by approximately 120°.
– Oil the piston and cylinder and compress the piston rings with clamping tool **- 15 -**.
– Insert the conrod and piston into the cylinder from the top with the combustion chamber bowl towards the timing case cover (to correspond with tthe position of the injector nozzle).
– Attach the big end bearing cap and tighten its screws uniformly to the specified torque.
– Check that the components move freely.



	Nm	lb ft
1B 20	21 - 22	15.5 - 16.2
1B 30	29 - 31	21.4 - 22.9
1B 40	40 - 42	29.5 - 31.0

	[mm]	a* Ø	b Ø	c Ø
1 B 20	nom.	34.004 - 34.026	37.000 - 37.016	18.016 - 18.027
	max.	34.07	37.03	18.04
1 B 30	nom.	36.010 - 36.050	39.000 - 39.016	20.020 - 20.033
	max.	36.09	39.03	20.045
1 B 40	nom.	48.010 - 48.053	51.000 - 51.016	22.020 - 22.033
	max.	48.09	51.03	22.045

*M 02.00

- 13 -

Preliminary work:
For dismantling, see M cross-reference list.

Testing / repair:
– Check for seizure marks and cracks.

Checking for wear:
Piston rings:
– Measure below bottom dead centre (BDC), since the cylinder is not subject to any wear at this point.
– Insert the used piston ring into the cylinder and use the piston to align it at a right angle to the cylinder axis.
– Measure ring gap **a** with a feeler gauge, and renew the piston ring if the limit value is exceeded.

Cylinder:
– Measure just under top dead centre (TDC), since this is where maximum wear takes place.
– Insert a **new** piston ring and align it at a right angle.
– Determine ring gap **b** and renew the cylinder liner if the limit value is exceeded.

Dismantling:
– Working from below with a plastic drift, force the cylinder liner out of the crankcase and pull it off upwards.

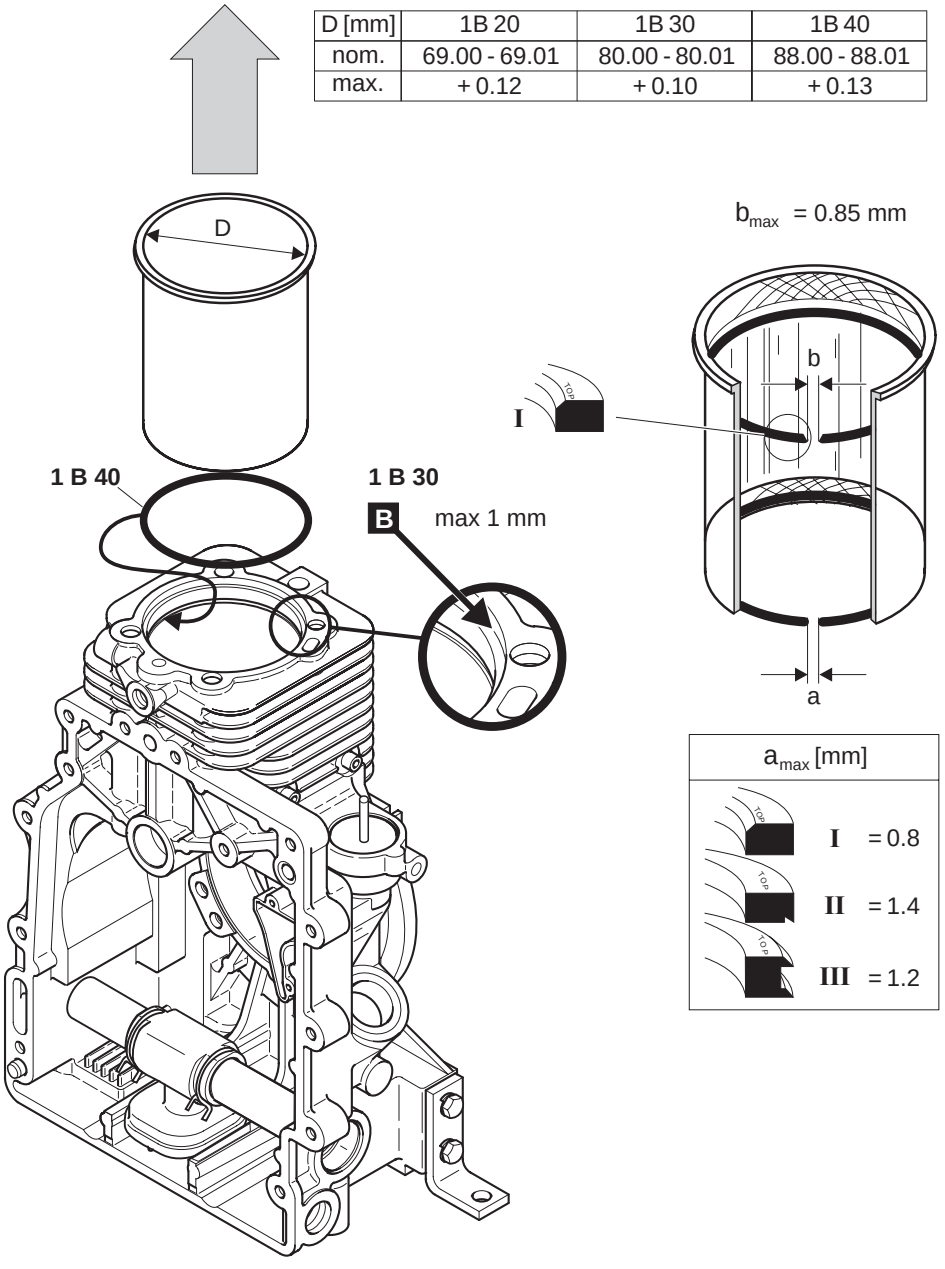
Assembly:
1 B 20
– Insert the cylinder liner into the crankcase from above, and press down fully.

Assembly:
1 B 30
– Apply sealant **B** to the cylinder liner. Max. sealant coating 1 mm on the inner face of the crankcase, or else it will not be possible to drive the cylinder liner in fully.
– Insert the cylinder liner into the crankcase from above, and press down fully.

1 B 40
– Place the O-ring in the groove in the crankcase and smear with mounting lubricant.
- Insert the cylinder liner into the crankcase from above and press down fully, making sure that the O-ring is not pushed out of the groove.

Note:
If a cylinder liner is re-used (with either used or new piston rings), it must be re-honed.
Perform the honing work with honing tool **-13-**.
After honing, check measurements **a** and **b** again.

D [mm]	1B 20	1B 30	1B 40
nom.	69.00 - 69.01	80.00 - 80.01	88.00 - 88.01
max.	+ 0.12	+ 0.10	+ 0.13



M 07.00 Cylinder head

- 1 - 16 -

Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove the parts in the order **1 ... 16**.
– Pull the cylinder head off upwards.
– Take off cylinder head gasket **17** and sealing rings **18**, **19** and **20**.
– If necessary, remove the valves with tool **- 1 -**.

Testing / repair:
– Examine parts for wear and damage.
– Use new seals and gaskets.
– Check the valves for leakage (blow-by).

Adjusting gap:
– Place a cylinder head gasket of known thickness **b** on the cylinder head.
– Measure precisely above the piston pin in order to avoid errors due to the piston tilting.
– Use a depth gauge to determine value **S**, turning the engine over until the piston has passed TDC.
– Value **S** can be adjusted by fitting a thikker or thinner gasket.

Never re-use an old gasket!

1 B 20 / 30:
S = 0.55 - 0.65 mm

1 B 40:
S = 0.60 - 0.70 mm

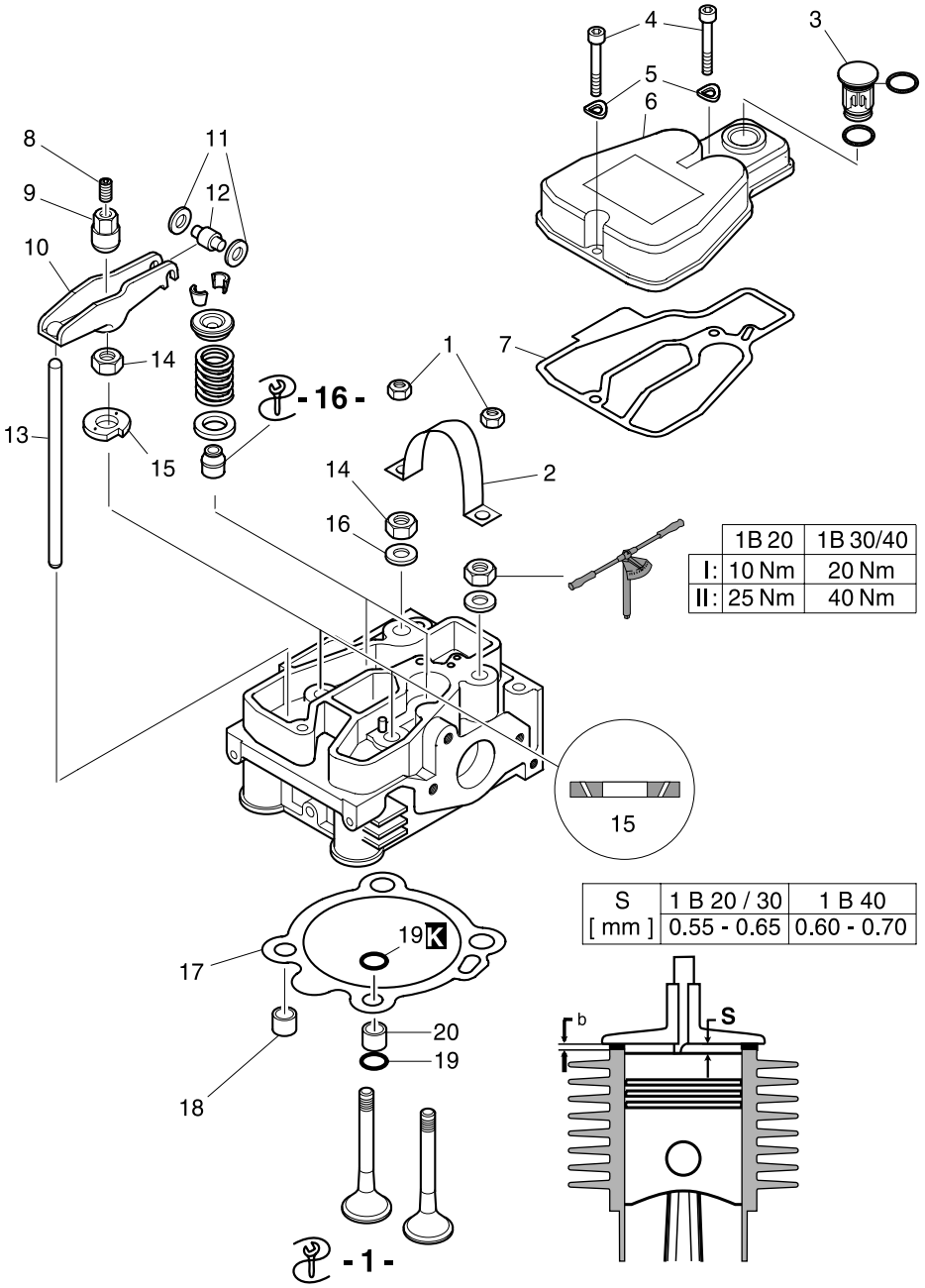
Assembly:
– Follow the diamentling instructions in the reverse order.
– To fit new valve steam seals, use tool **- 16 -**.

1 B 20:
– When placing the cylinder head in position, avoid damage to sealing rings **18**.
– The rockers were lubricated from production start onwards by way of oilways drilled in washer **15**.
Pins in the cylinder head prevent these washers from turning. The washers must be installed with the upper oilways facing outwards (see picture).

1 B 30 / 40:
– Insert lower O-ring **19** (1B30 only) and sealing ring **20** into the crankcase at the tierods at the timing end. Coat upper O-ring **19** with lubricant **K** or multi-purpose grease and insert it into the cylinder head. Install the cylinder head.
– Tighten the cylinder head down in a crosswise pattern, working in two stages:
(nuts of strength category 10.9)

	1 B 20	**1 B 30/40**
Stage I:	10 Nm	20 Nm
Stage II:	25 Nm	40 Nm

– Adjust valve clearance to 0.10 mm at adjusting nut **9** and lock this nut with grub screw **8**.
Important:
The engine must be precisely at TDC on the ignition stroke, or else the automatic decompressor will take effect and falsify the valve clearance adjustment.
– Tighten locknuts **1** to secure the retaining strap until the tie bolt extends by 1.5 mm beyond the nut.



	1B 20	1B 30/40
I:	10 Nm	20 Nm
II:	25 Nm	40 Nm

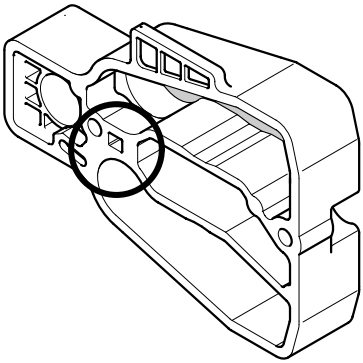
S	1 B 20 / 30	1 B 40
[mm]	0.55 - 0.65	0.60 - 0.70

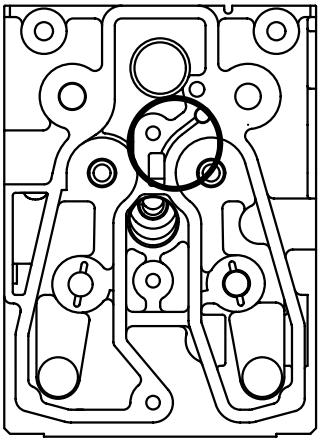
M 08.00 Cylinder head cover

–

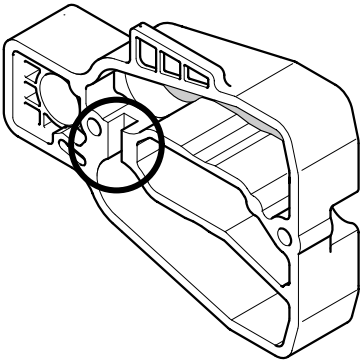
1B20 only:
From serial number: 1B20.16
The oilway in the cylinder head was sealed and a new cylinder head cover introduced.
The new cover must **never** be used on earlier cylinder heads, or else engine oil will be drawn into the inlet port and the engine could then overspeed and destroy itself.

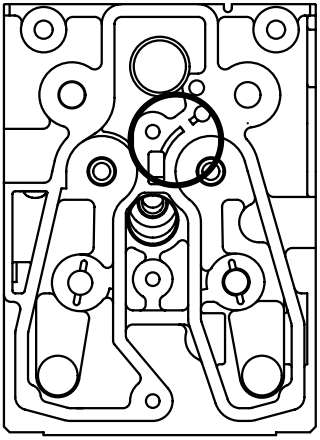
Up to 1B20.15:





From 1B20.16:





M 10.00 Oil pump, governor

M 10.10 Oil pump

–

Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove circlip **1** and pull out shaft **2**.
– Take off reverse-motion lever **3** and governor sleeve **4**.
– Take off bobweights **5** (8 and 4 weights).
– Remove machine screws **6** with stop plate **7** and pressure relief valve spring **8**, noting the presence of ball **9**.
– Take off oil pump cover **10**.
– Parts **11 ... 14** need not be removed unless damaged.

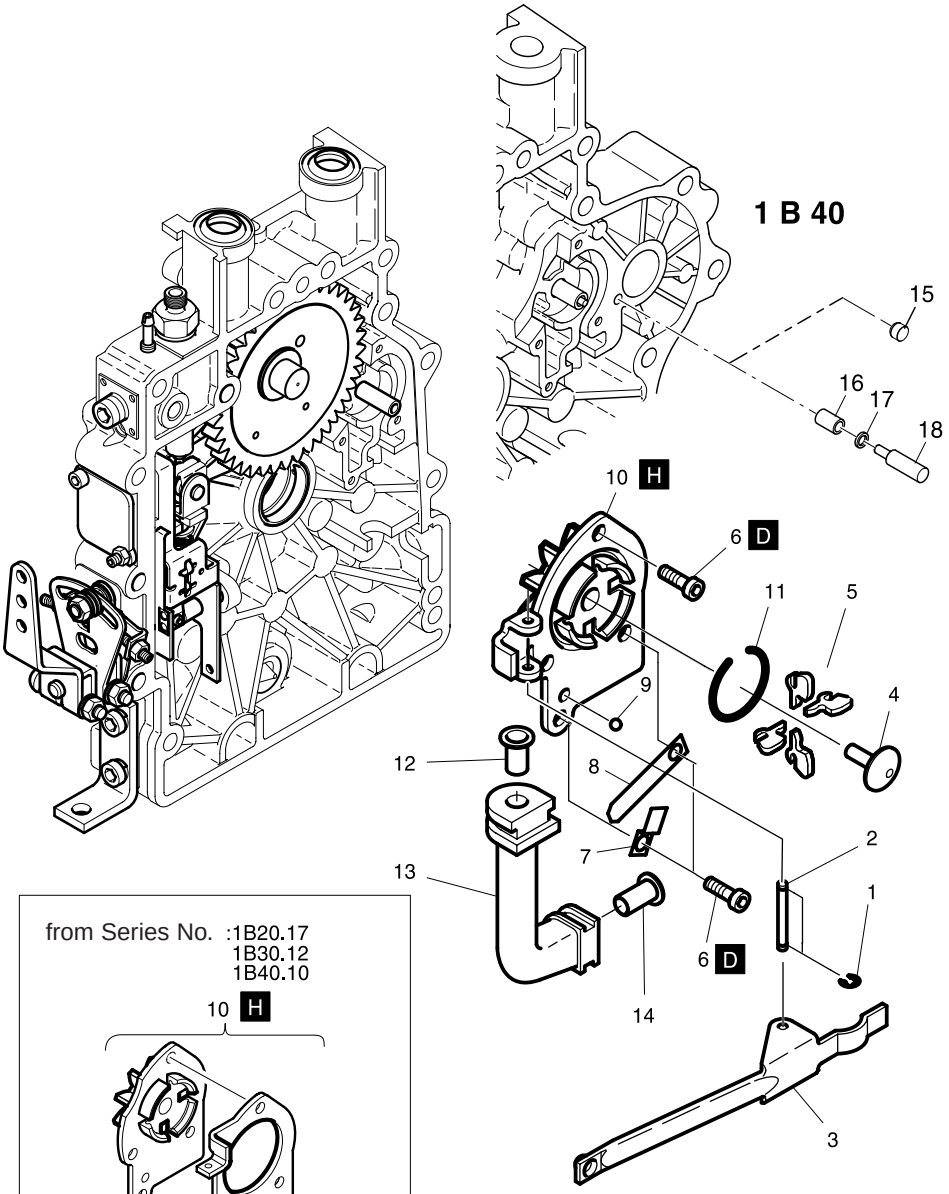
Testing / repair:
– Examine parts for wear or damage and renew if necessary..

Assembly:
– Follow the dismantling procedure in the reverse order.
– Apply sealant **H** to oil pump cover **10**.
– Insert screws **6** with sealant **D**.
– After assembly, set the gap between spring **8** and stop **7** to 0.4 mm (bend the stop as necessary).

1 B40:
Make sure that the correct plugs **15** or **16 ... 18** are fitted
(see M 01.10)

Note:
From Series No. 1B 20.17
1B 30.12
A new oil pump was introduced, with two covers (see picture). The installation procedure is the same as for the previous oil pump.
The two oil pumps are interchangeable.

From Series No. 1B 20.18
1B 20 V.10
1B 30.13
The timing case cover, camshaft and oil pump cover were modified.
These parts are **not** interchangeable separately with the old versions.


1 B 40
15
16
17
18
10 H
6 D
11
5
9
4
12
8
2
7
13
1
6 D
14
3
from Series No. :1B20.17
1B30.12
1B40.10
10 H

M 10.00 Oil pump, governor

M 10.20 Governor, speed control 1B20 up to Series 14, 1B30.10

- 11 -

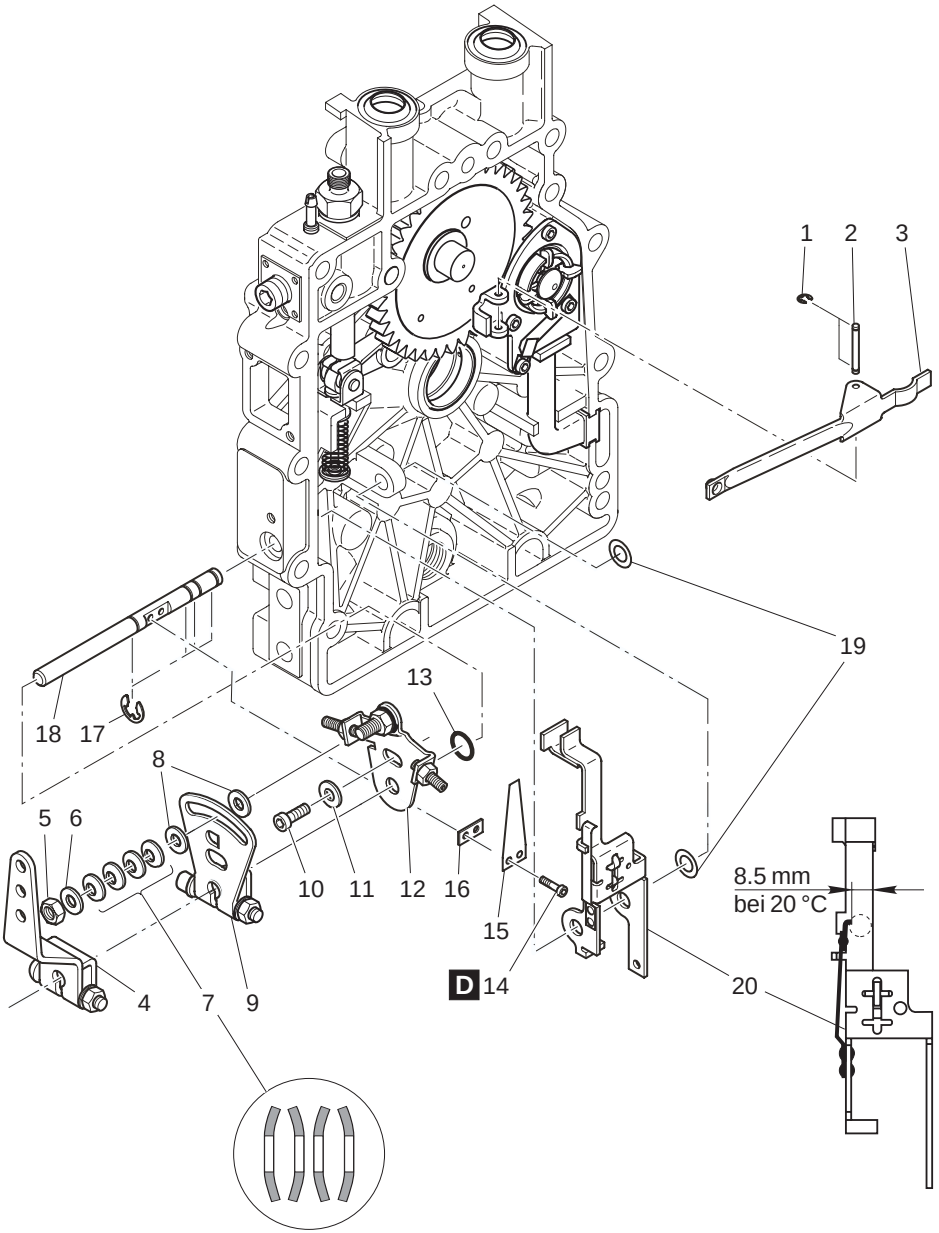
Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove circlip **1** and pull out shaft **2**.
– Take off reverse-motion lever **3**.
– Take off speed control lever **4**.
– Remove nut **5**, washer **6**, cup springs **7** and friction disc **8**.
– Mark the position of stop plate **9** in relation to speed control shaft **18**.
– Take off stop plate **9**.
– Mark the position of retaining plate **12** in relation to the timing case cover, using a scriber.
– Take out machine screw **10** with washer **11** and take off retaining plate **12** and O-ring **13**.
– Remove machine screws **14**, governor springs **15** and intermediate plates **16**.
– Take off circlips **17** (4 circlips) and pull speed control shaft **18** out of the timing case cover (note washers **19**).
– Take off governor lever **20**.

Testing / repair:
– Examine the parts for wear or damage.
– Check the position of the bimetallic strip at the governor lever as shown in the drawing.

Assembly:
– Follow the dismantling procedure in the reverse order.
– Make sure that washers **19** are correctly positioned.
– Note the marks made to indicate the positions of the parts when dismantling.
– For position of governor spring cluster, see Section **4**.
– After assembling, run the engine until it is warm, check the speed setting with revolution counter **- 11 -** and correct if necessary.

Note:
The speed control does not have to be removed to renew the governor springs. If only O-ring **13** or governor lever **20** are to be removed, proceed as follows:
– Remove reverse-motion lever (**1, 2, 3**), governor spring cluster (**14, 15, 16**) and speed control lever **4**
Take off circlips **17**.
– Mark the position of retaining plate **12** in relation to the timing case cover.
– Slacken off machine screw **10** through the opening in stop plate **9** and pull out the complete unit.
– Assembly takes place in the reverse order of work.
– Check the speed setting.


1
2
3
19
13
18
17
8
5
6
10
11
12
16
15
D
14
4
7
9
20
8.5 mm
bei 20 °C

M 10.00 Oil pump, governor

M 10.30 Standard governor, speed control from 1B20 Series 15, 1B30 Series 11 and 1B20V Series 10

- 11 -

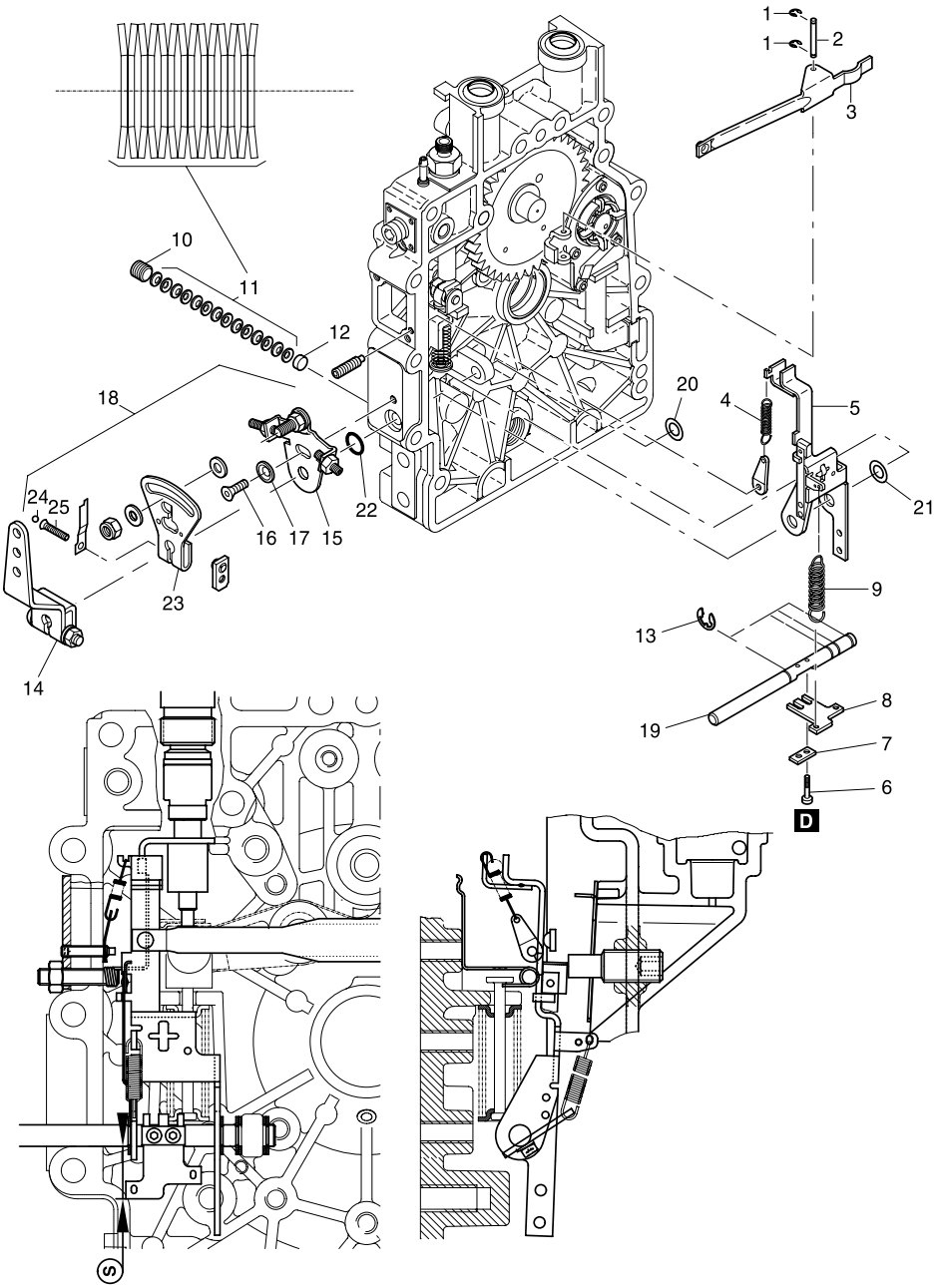
Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove parts in the order **1...14**.
– Mark the position of retaining plate **15** in relation to the timing case cover with a scriber.
– Remove parts in the order **15...22**.

Testing / repair:
– Examine parts for wear or damage.
– Check the position of the bimetallic strip at the governor lever as shown in the drawing (M 10.20).

Assembly:
– Follow the dismantling instructions in the reverse order.
– Make sure that washers **21** (1.0 mm) and **20** (0.5 mm) are in their correct positions.
– Note the correct position of retaining plate **15** (scriber mark).
– Make sure that governor spring **9** is connected correctly.
– When assembling, bend the ends of idle spring **4** inwards to prevent them from escaping accidentally.
– Apply sealant **D** to screws **6** when installing them, and set stop **8** to value **"S"** (see Section **4**)
– Not the correct way in which cup springs **11** (14 springs) must be installed (the cup springs were later replaced by a coil spring).
– Tighten screw **10**, loosen again and retighten to a torque of 20 Nm; after this, set the correct friction value.

Note:
To prevent it from being reset accidentally, stop plate **23** has pressed-in ball **24** in the head of screw **25** to secure it.
When dismantling, the screw head must therefore be ground away.
When installing the stop plate, apply grinding paste **M** to shaft **19**.


1
1
2
3
10
11
12
18
20
4
5
21
24
25
16
17
15
22
23
14
9
13
19
8
7
6
D
S

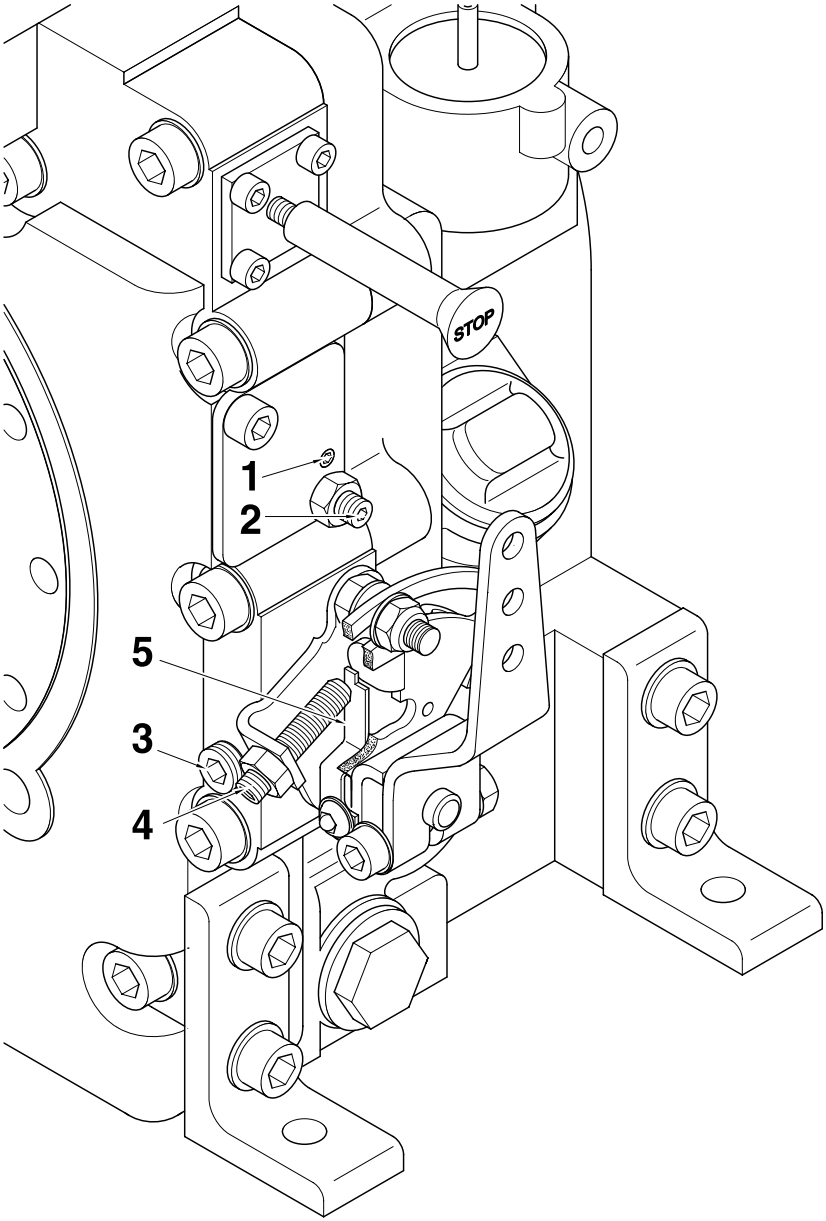
M 10.31 Adjusting lower idle speed

- 11 -

General information:
The lower idle speed must only be adjusted when the engine is warm and with power take-off components attached.

Initial adjustment with engine stopped:
– Turn adjusting screw **1** for the idle spring until the inner lever and the spring are aligned (see picture M 10.30).
– Turn adjusting screw **2** for the stabilising spring fuilly to the left.

Adjustment with engine running:
– Release friction brake **3** (speed control will then move freely).
– Start the engine and run it at a constant speed of approx. 1300 rpm by moving the speed control lever.
– Carefully turn adjusting screw **1** for the idle spring to the right until a speed of 1300 - 1400 rpm is maintained when the control lever is released.
– Reduce the speed carefully at the adjusting screw to 1100 - 1150 rpm.
– Move up idle speed stabilising spring **2** carefully until engine speed rises by 8 - 10 rpm and there is no further tendency for the speed to vary.
– Check the upper idle speed and correct it if necessary.
– Ease off stop screw **4** for the lower idle speed until the lower idle speed does not change when the speed control lever makes contact, but the engine can still be stopped by pushing against leaf spring **5**.


STOP
1
2
5
3
4

M 10.40 Generator governor, speed control from 1B20 Series 15, 1B30 Series 11 and 1B20V Series 10

- 11 -

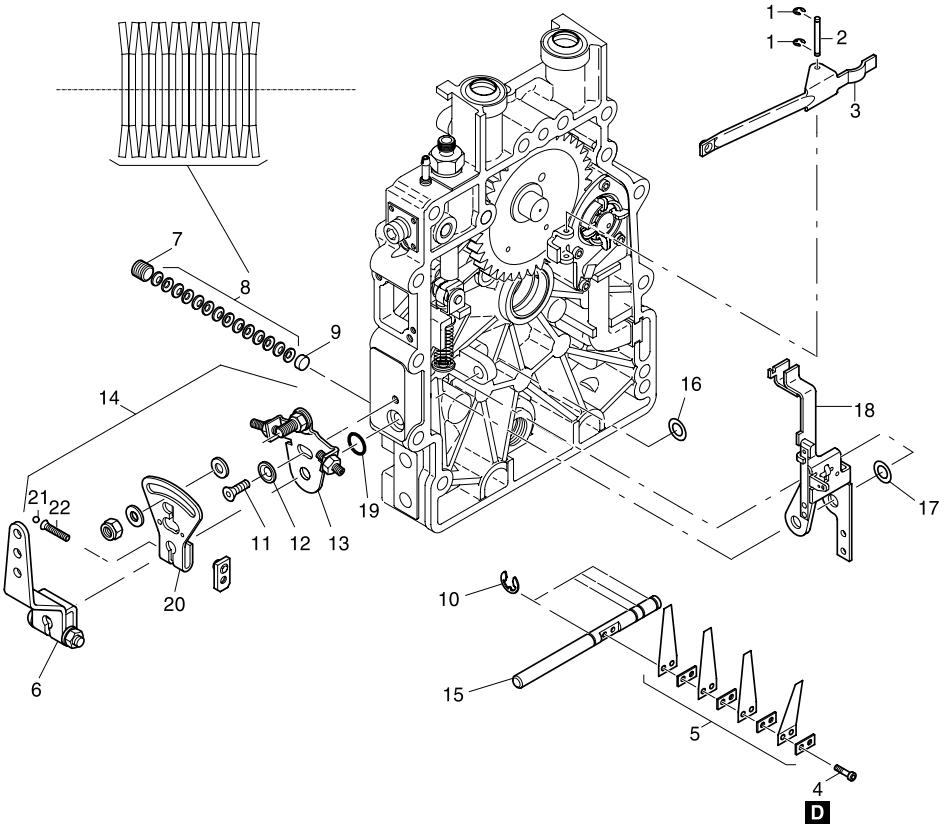
Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove parts in the order **1...10**.
– Mark the position of retaining plate **13** in relation to the timing case cover with a scriber.
– Remove parts in the order **11...18**.

Testing / repair:
– Check parts for wear and damage.
– Check the position of the bimetallic strip at the governor lever as shown in the drawing (M 10.20).

Assembly:
– Follow the dismantling instructions in the reverse order.
– Check that the positions of washers **17** (1.0 mm) and **16** (0.5 mm) are correct.
– Note correct position of retaining plate **13** (scriber mark).
– Apply sealant **D** to screws **4** when installing.
– For correct governor springs, see Section **4**.
– Note correct assembly arrangement of cup springs **8** (14 springs). These were later replaced by a coil spring.
– Tighten screw **7**, loosen again and retighten to 20 Nm, then adjust to the necessary friction value.

Note:
To prevent it from being moved accidentally, stop plate **20** is secured by ball **21** pressed into the head of screw **22**.
To remove, the screw head must be ground away.
When installing the stop plate, apply grinding paste **M** to shaft **15**.


1
1
2
3
7
8
9
14
16
18
17
21
22
19
11
12
13
20
6
10
15
5
4
D

M 10.50 Governor, engine speed adjustment with internal stop from 1B20 Series 24, 1B30 Series 19, 1B20V Series 14, 1B30V Series 11, 1B40 Series 10

- 11 -

General:

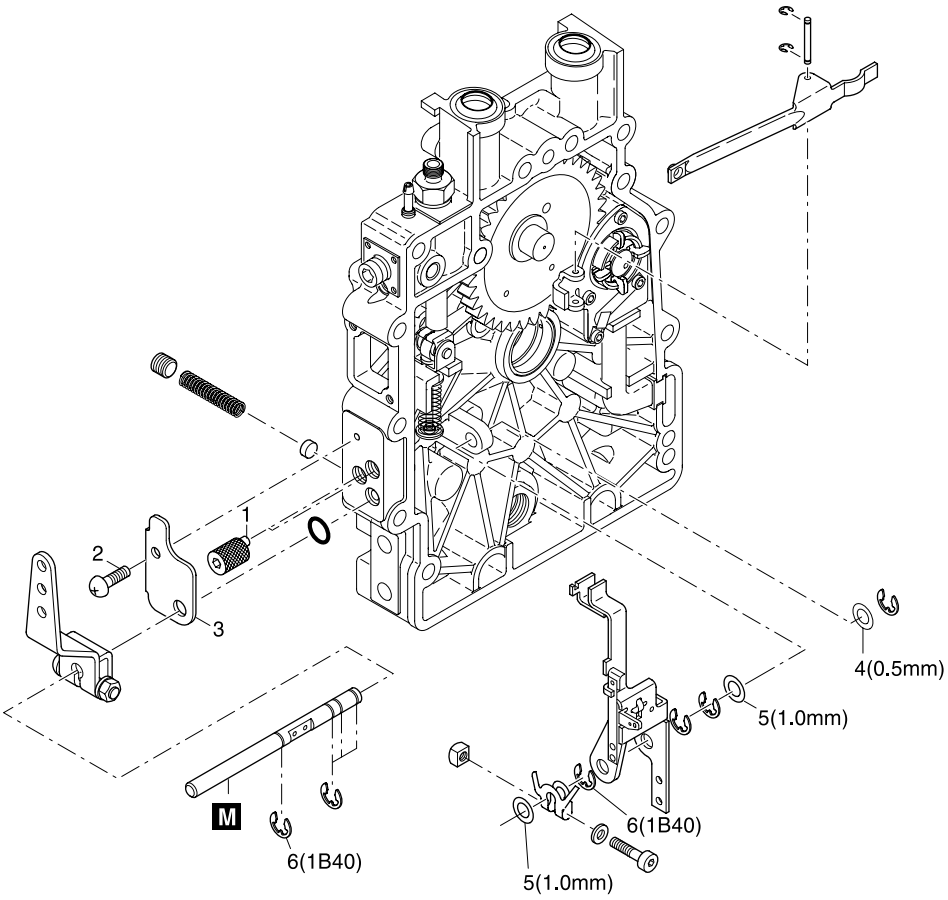
In connection with EPA certification, the engine speed adjustment screws together with stop were located inside the timing case cover.

The rest of the governor is the same as the previous version (M 10.30 or M 10.40)

The adjustment screws **1** are protected by screw **2** and plate **3** against unauthorised adjustment.

Dismantling / assembly:

- Takes place as in the previous version.
- Make sure that washers **4** and **5** are in the right position.
- Circlip **6** is only installed on 1B40 engines.


1
2
3
4(0.5mm)
5(1.0mm)
6(1B40)
M
6(1B40)
5(1.0mm)

M 11.00 Timing case cover

- 9 -

Preliminary work:
For dismantling, see M cross-reference list. Remove the recoil starter so that the engine can be turned over by hand.

Dismantling:
– Detach the fuel feed from the tank.
– Pull the oil leak-off line and oil trap off their connections at the timing case cover.
– Take out machine screws **1...6** with washers and sealing rings.
– Take off the timing case cover.

Testing / repair:
– Check parts for wear or damage.
– Renew sealing rings **7** and O-ring **8**.
– Press on a new shaft sealing ring **9** until recessed by 5.5 mm.
– Press the new main bearing **10** in until flush, using drift **- 9 -** (note the oilways).

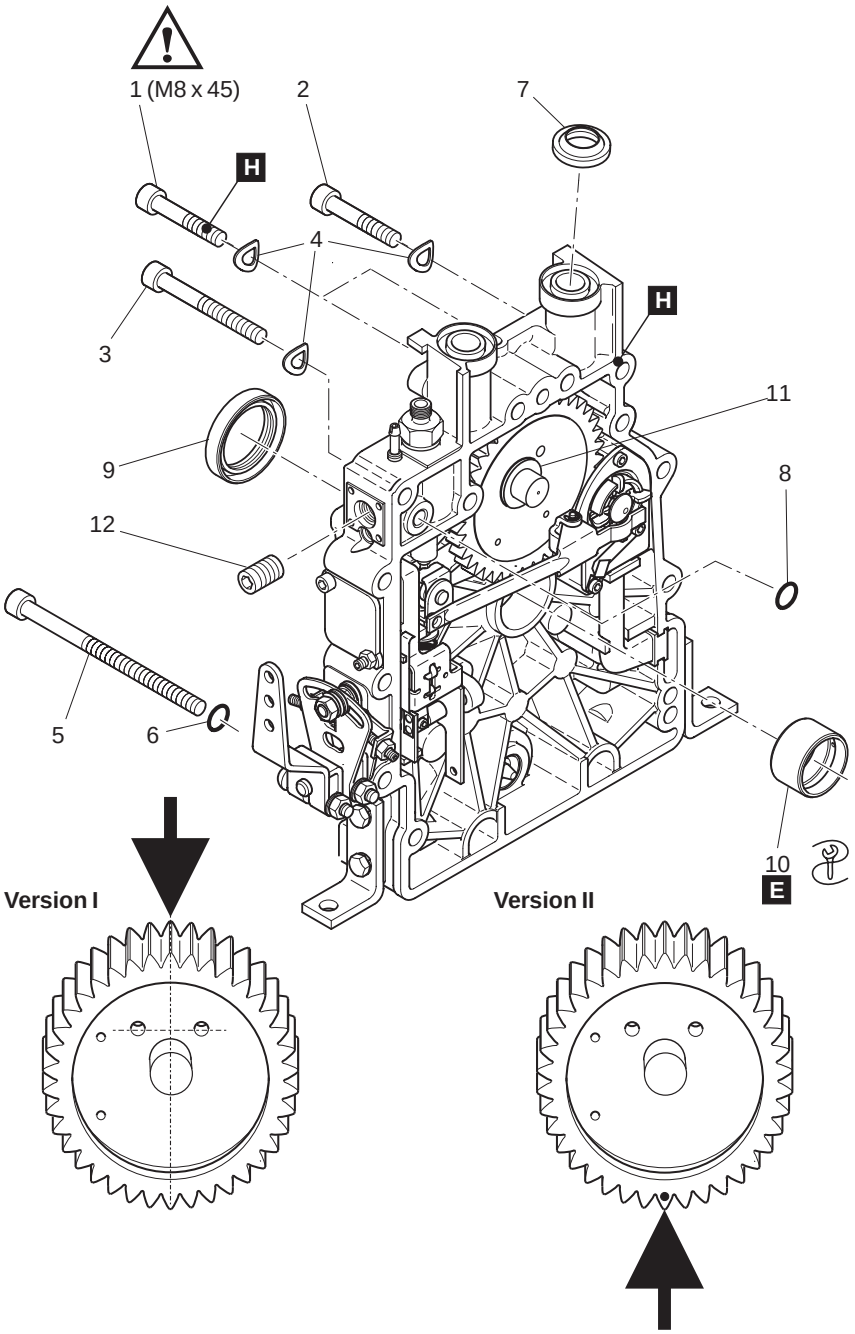
Assembly:
– Turn the crankshaft to TDC.

Version I:
(First-series engines without marking on camshaft)
– Remove adjusting washer **11** from the camshaft. Two holes to accept the stirrup for the automatic decompressor will then be visible. Make a chalk mark on the camshaft gearwheel tooth that is centrally above an imaginary line between these two holes (equivalent to maximum cam lift).
– Install adjusting disc **11** again.
– Turn the camshaft to TDC on the valve-overlap stroke, so that the tooth marked with chalk is again at the very top.

Version II:
(camshaft with marking)
– Turn the camshaft to TDC on the overlap stroke, so that the tooth with a punch mark is pointing vertically down.
– Apply sealant **H** to the sealing face on the timing case cover.
– Place the timing case cover against the crankcase and knock it into position until it makes complete contact with the crankcase.
– Insert the pushrods and check that the crankshaft is precisely at TDC when the valves are in the overlap position. This ensures the correct position of the camshaft in relation to the crankshaft.
– Machine screws **5** (M8 x 120) are installed with copper sealing rings **6**.
All other timing case cover screws **1...3** are installed with spring washers **4**.
– Machine screw **3** is 60 mm long, since the air guide support hoop is attached to it.
– Apply sealant **H** to the threads of machine screws **1**.

Important!
The tapped holes for the machine screws in item **1** extend through to the cylinder liner. For this reason, only **M8 x 45** screws are to be inserted here, or else the cylinder liner will be damaged.
– Continue assembly work by following the dismantling instructions in the reverse order.

Note:
Setscrew **12** must not be inserted too far; it must project from the timing case cover by at least 2.5 mm, or else the fuel supply hole will be blocked.


1 (M8 x 45)
2
7
H
4
H
3
11
9
8
12
5
6
10
E
- 9 -
Version I
Version II

M 14.00 Fuel injection system

M 14.10 Injector

–

Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Remove machine screw **1**, washer **2** and fork **3**.
– Unscrew collar nut **4** and pull the complete injector **5** out of the cylinder head.

Checking:
– Look for blue discoloration or impurities at the injector nozzle.
– Check the spray pattern, spray pressure and leakage in a suitable injector tester. If the spray pattern is poor or the spray pressure incorrect, repair the injector.

DANGER:
Keep the hands clear of the injector spray. The fuel spray from an injector nozzle can cause severe injuries.

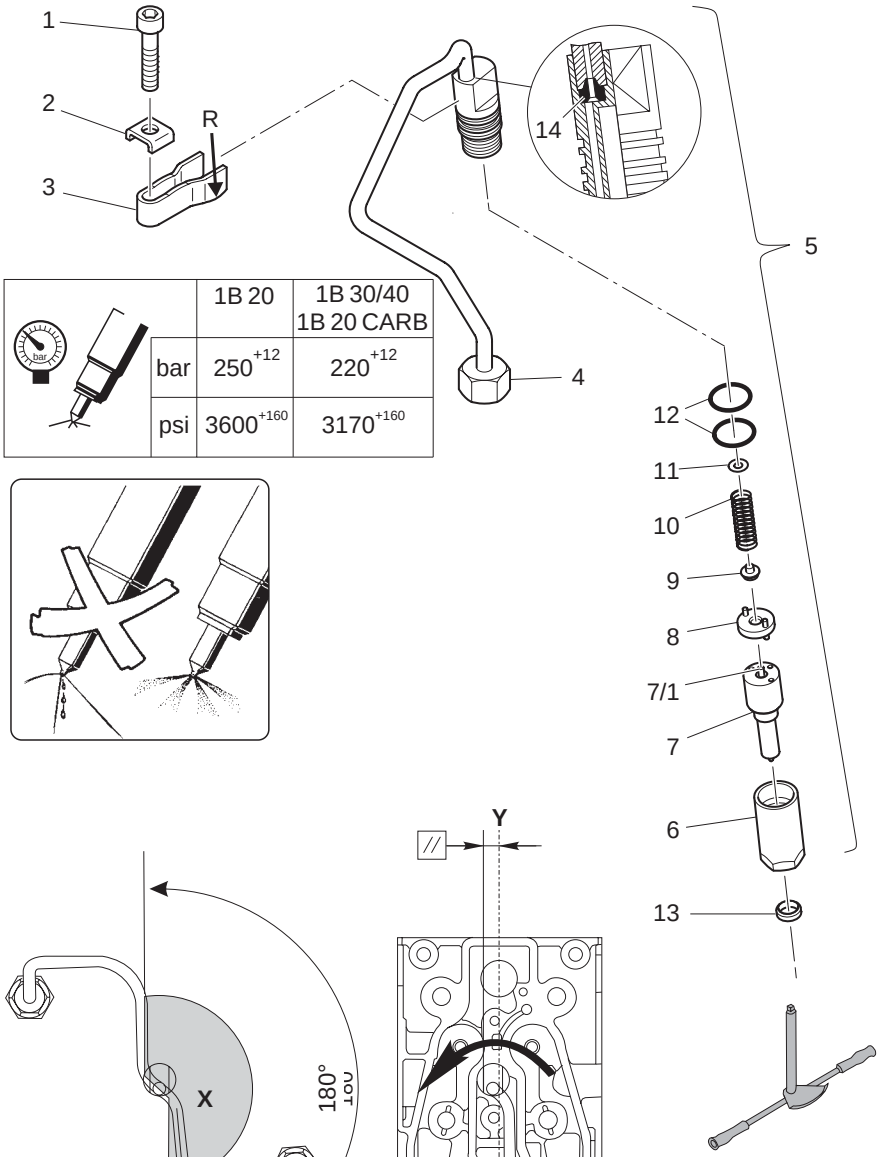
Repair:
– Dismantle parts **6 ... 11** of the injector.
– Examine the injector body/injector needle for damage caused by overheating, score marks, micro-wear (visible as a matt grey, compacted surface) and carbonised nozzle holes.

Checking sliding action:
– If injector needle **7/1** is clean and has been coated with fuel, it should slide in the seat in injector body **7** under its own weight.
– Renew worn or defective parts.
– The nozzle body and needle have been lapped together and must only be exchanged or renewed as a pair.
– Assembly by following the dismantling instructions in the reverse order.
– Tighten the nozzle clamp nut to the specified torque.
– Spray pressure can be corrected at shim washers **11**.
Adjust spray pressure as specified!

Assembly:
– Follow the dismantling instructions in the reverse order.
– Renew O-rings **12**.
– Renew seal **13** (with chamfer towards injector).
– Radius R on fork **3** faces the injector.

Threaded connection between pressure pipe and nozzle holder:
Do not separate this connection, or else the system will no longer be tight at high pressure.
A taper seal **14** is provided, and is available in two lengths (4.9 mm or 5.3 mm).

Threaded connection:
– Place the taper seal in the nozzle holder with the smaller taper upwards and screw the fuel pressure pipe in fully by hand.
– If the pressure pipe comes to a halt in the marked zone **X**, the other length of taper seal must be used instead.
– Apply sealant **D** to the pressure pipe thread but make sure that the sealant does not enter the fuel passage. Tighten the threaded connection to approx. 5 degrees before its final position.
– Install the injector in the cylinder head and tighten the collar nut.
– Turn the wrench flats on the nozzle holder in a **counterclockwise** direction until they are parallel with crankshaft axis **Y**.
– Do not turn clockwise or the taper seal will be loosened.



	1B 20	1B 30/40 1B 20 CARB
bar	250^{+12}	220^{+12}
psi	3600^{+160}	3170^{+160}

M 14.00 Fuel injection system

M 14.20 Injection pump

–

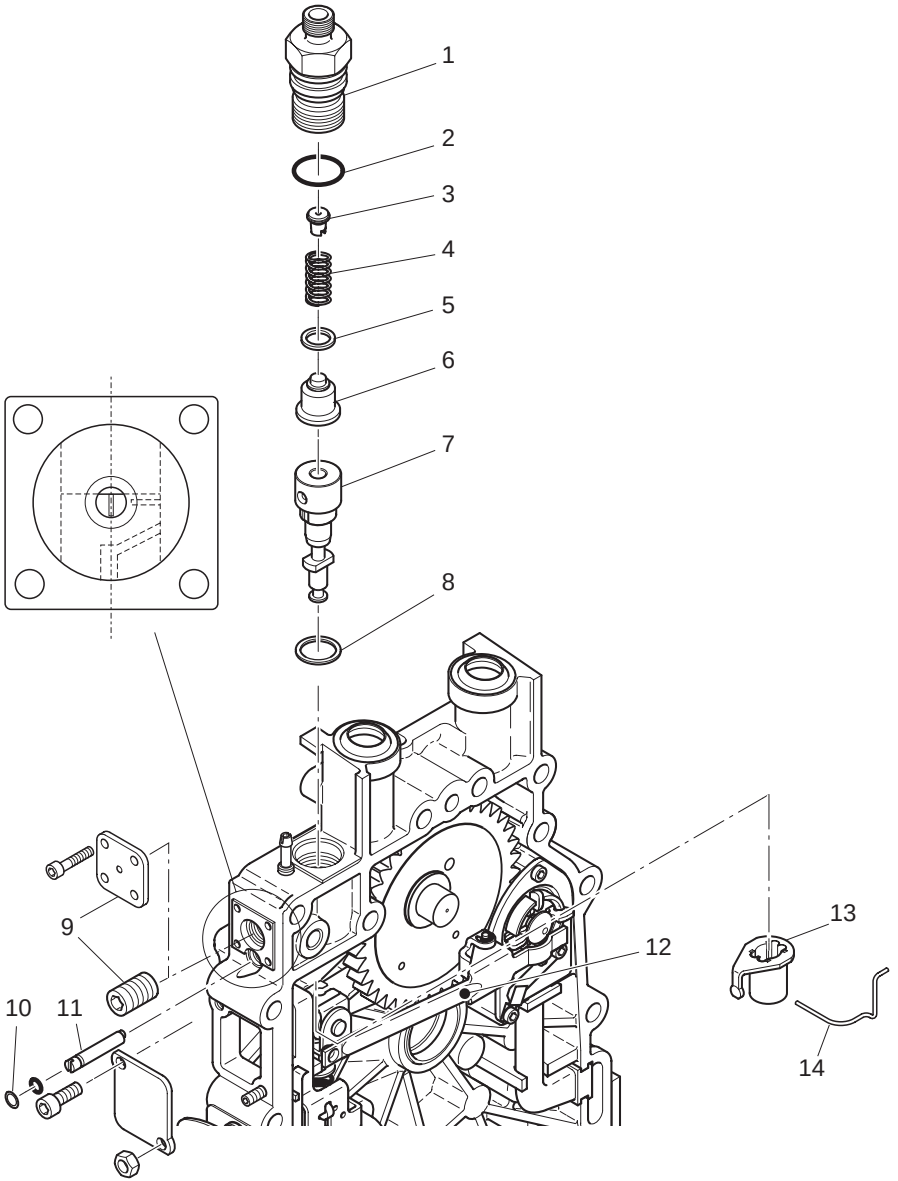
Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Disconnect the pump piston at the rocker arm.
– Unscrew pressure valve holder **1** with O-ring **2**.
– Take off spacer **3**, spring **4**, sealing ring **5** and pressure valve **6**.
– Pull pump element **7** and washer **8** out upwards.
– Remove screw plug respectively cover **9**.
– Governor sleeve **13** is located by hoop **14** and does not need to be removed.

Testing / repair:
– Check that the pump piston can move freely over its entire stroke.
– Renew worn or damaged parts.

Assembly:
– Insert shim washer **8**.
– Insert pump element **7**, making sure that the suction hole (hole with taper) and the element tab are in the correct position (the number 400 or 4.. must be on the opposite side to the suction hole).
– When inserting the element assembly, make sure that the plunger tab enters the governor sleeve (this can be more easily achieved if the governor sleeve is turned to and fro slightly), and that the eccentric pin engages in the slot on the element cylinder.
– Install parts **6 ... 1** but do not tighten pressure valve holder **1** fully yet (tighten to about 10 Nm).
– Turn the speed control lever fully to the right and lock in this position.
– Raise the pump piston by app. 2 mm.
– At this stage, check the position of the starting slot in relation to the suction hole (can be seen through the hole in which screw plug **9** was situated).
– The starting slot must be central in relation to the suction hole or not displaced to the left by more than its own width. It this is not the case, pull off cap **10** using a suitable scriber as a tool, and correct the setting by turning eccentric **11**.
– If the suction hole can only be positioned well away from the centre, reverse-motion lever **12** must be damaged and should be renewed.
– Tighten the pressure valve holder to the specified torque:
30 - 0 - 30 - 0 - 35 ± 2 Nm
(tighten - release - retighten ...)
– Install other parts previously removed from the engine.

Note:
If a new pump element or a new reverse-motion lever is installed, or the eccentric or volume shutoff screw turned, check the settings for the start of fuel injection and delivery period (M 14.30).


1
2
3
4
5
6
7
8
9
10
11
12
13
14

M 14.30 Start of injection stroke, delivery period

- 14 -

Note:
Before undertaking adjusting work, check that the TDC marking on the flywheel agrees with the actual top dead centre position of the engine's piston (M 17.00).

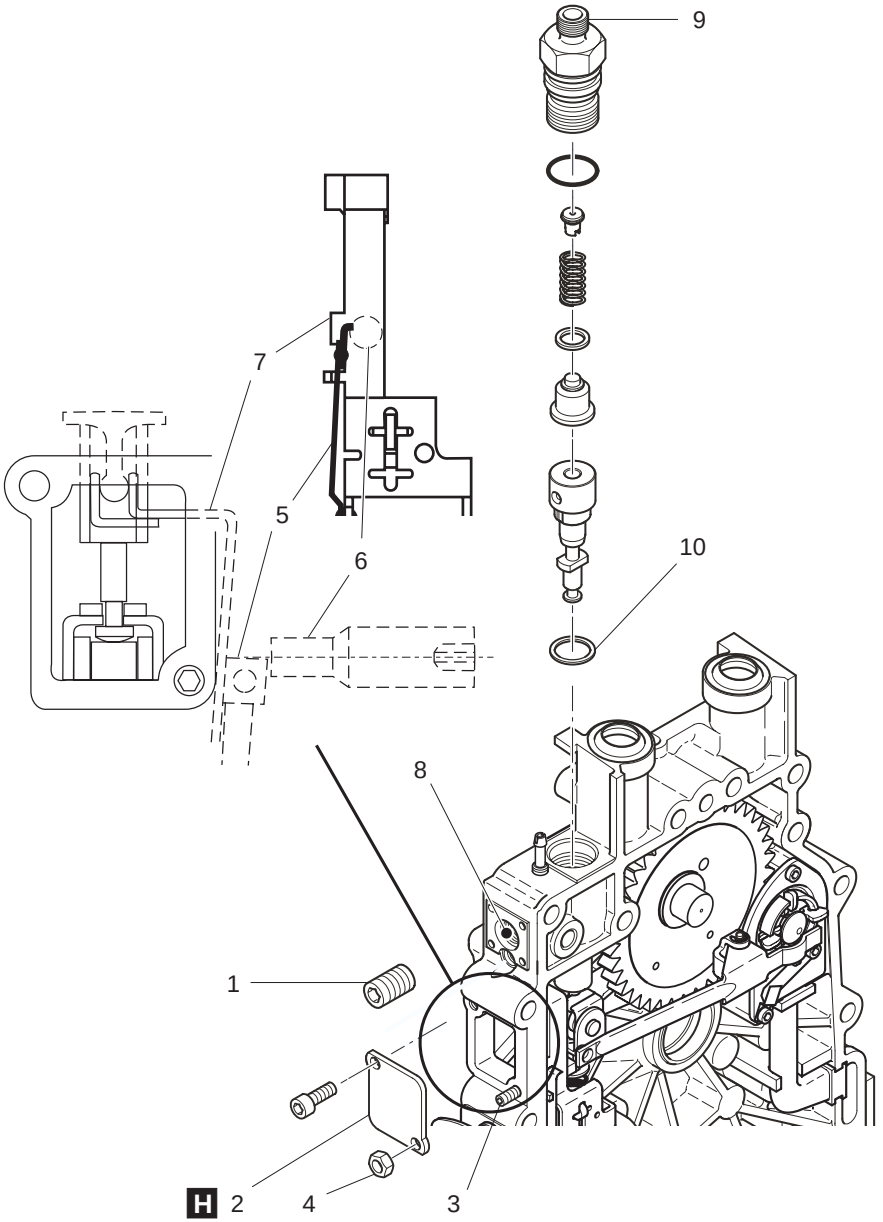
Preliminary work:
– Take out screw plug **1** and remove cover **2**.
– Setscrew **3** bears against an internal spring. The setscrew must therefore not be allowed to turn when unscrewing nut **4** (hold it with an Allen key).
– Disconnect the fuel supply line and pull it off the connecting nipple on the crankcase.
– Pull the vent line off the connection on the timing case cover.
– Seal both connections with suptably prepared lines.
– Using a piece of wire or by heating with a hot air blower, make bimetallic spring **5** on governor lever **6** move into the area where it acts on volume shutoff screw **7**.
– Turn the speed control to the right and lock it there.
– To ensure that the governor lever is in the full-load position and **not** in the starting position, check the position of the pump piston through hole **8**.
The starting slot should **not** be visible through the suction hole (see picture M 14.20).
– Connect high-pressure pump **- 14 -** to bore **8** and pressure valve holder **9**.

Adjusting start of delivery stroke:
The start of delivery for each engine is marked on the flywheel (• or |).
For a detailed table, see **Section 4**.
– Turn engine in correct direction of rotation until fuel just ceases to drip from the pressure pipe union (1 drop every 1 - 2 seconds).
In this position the marking for the start of delivery (• or |) on the flywheel must be aligned with the pointer on the partition panel.
– If the discrepancy is more than ±1° at the crankshaft, correct the start of delivery by inserting a thicker or thinner washer **10**.
Delivery starts too early: thicker washer
Delivery starts too late: thinner washer
0.1 mm equals approx. 0.85° of crankcase rotation.

Adjusting delivery period:
– The delivery period is adjusted by varying the end of the delivery stroke. The basic setting is:
1B 20 = 6,2° KW
1B 30 = 6,5° KW
1B 40 = 8,2° KW
– The end of injection is set by turning the volume shutoff screw.

This basic setting is equivalent to the IFN (B) performance rating. The other two performance ratings are derived from this basic setting as follows:

F rating:	Slacken off shutoff screw by 1/6th of a turn
ICXN rating:	Tighten the shutoff screw by 1/6th turn


9
7
5
6
10
8
1
H
2
4
3

M 14.31 Start of delivery and power adjustment using capillary tube

–

Information:
Before starting adjustment, check that the TDC mark on the flywheel corresponds with actual TDC of piston (M 17.00).

Preparation:
– Remove recoil starter and fit a suitable lever to the flywheel, to enable slow rotation of engine by hand.
– Using a suitable air heater, warm bimetal spring on governor lever to enable activaction of the fuel stop adjustment screw.
– Turn speed control lever to the right and fix in position.
– Please insure that the governor lever is in the full-load position **(A)** and **not** in starting position.
– Block off the fuel return line by clamping hose.
– Block off the fuel feed line by clamping hose and disconnect the hose from the fuel connection nipple at crankcase.
– Drain fuel from the suction side of the injection pump (measurement works with air only).
It may be necessary to remove the side cover (B) or any stop device which may be fitted to achieve this.
– Replace the side cover or stop device.
– Prime capillary tube with a small amount of fuel and connect to fuel nipple.

Measurement:
– Slowly turn the engine in direction of rotation at the same time watch the capillary tube.

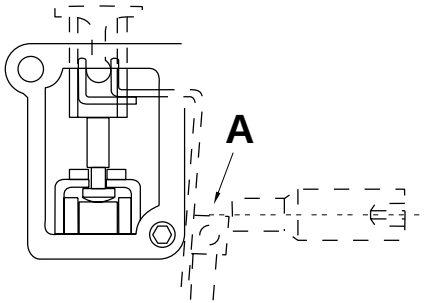
I: The plunger moves upwards and forces the air out of the barrel of the injection pump, the fuel column in the capillary tube is moving.

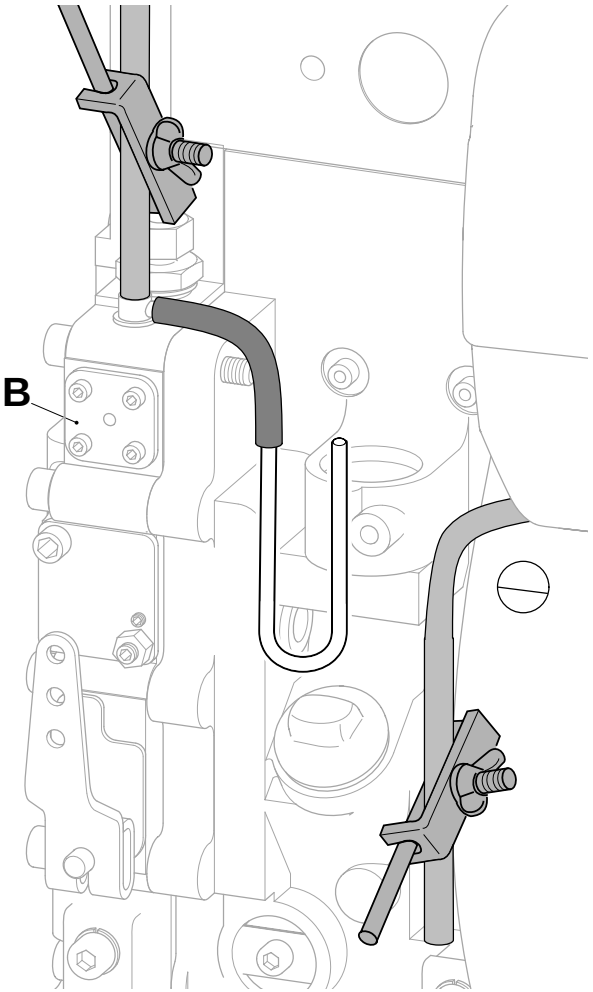
II: As the plunger moves further upwards, the inlet bore is closed off, compressing the air inside the pump element **C**. The fuel column in the capillary tube stops.

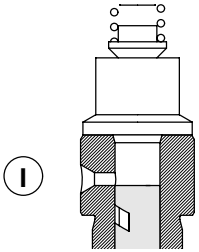
III: The plunger moves further upwards, the helix of the plunger opens the inlet bore releasing the air caseing the fuel column in the capillary tube to move rapidly. This is the exact point of end of delivery. Take reading of degrees at flywheel.
Now slowly turn the engine in reverse direction of rotation, the helix of the plunger closes the inlet bore and vacuum is generated in the pump element **C**. The fuel column in the capillary tube stops.

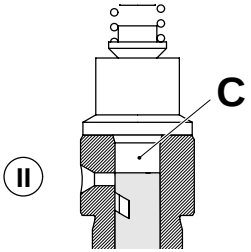
IV: The plunger opens the inlet bore and the released vacuum causes the fuel column in the capillary to move rapidly. This is the exact point of start of delivery. Take reading of degrees at flywheel.

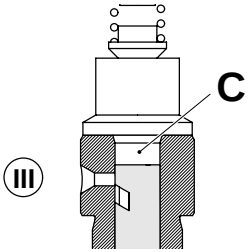
The power adjustment is determined by the delivery lift in degrees (difference between start and end of delivery).
Adjustment description M 14.30.

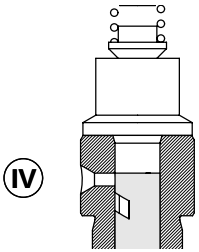

A


B


I


II
C


III
C

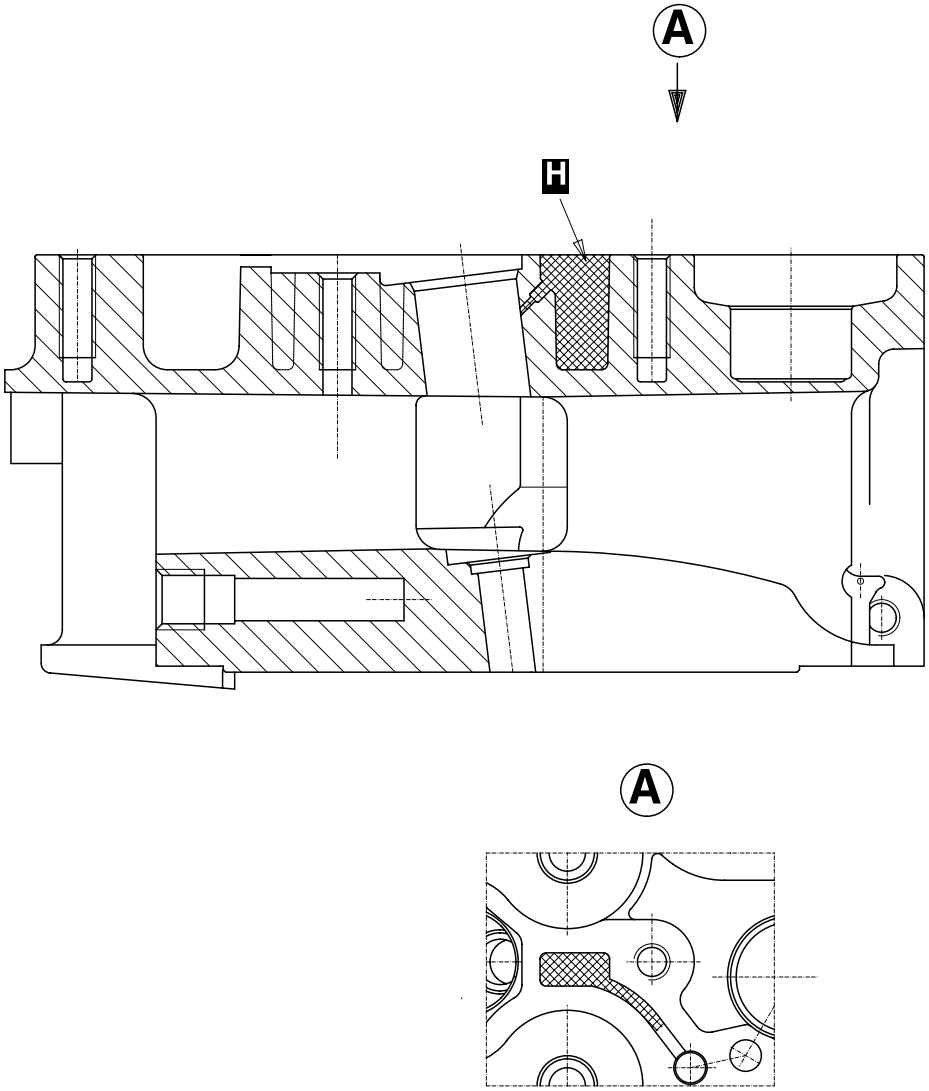

IV

M 14.40 Retrofitting oil leak-off return line to injector

–

Applies only to 1B 20 up to Series 12.
All other B Series models were equipped from the start of production with the injector incorporating an oil leak-off line leading back to the fuel tank.
Only the new injector is supplied as a spare part.
It is supplied with all the necessary parts for the conversion work.

Notes on retrofitting:
– Modify the fuel tank as described in A 01.12.
– Carefully degrease the return bore that is still present in the cylinder head but no longer needed, then seal it with silicon sealant **H** (see picture).
Wait half an hour for the sealant to set before the engine is next started, or else the bead of silicon sealant could be drawn into the engine's inlet port.
– Check all parts for leaks.


A
H
A

M 15.00 Recoil starter

–

Preliminary work:–

Dismantling:

– Take out retaining screws **1** and pull housing **2** off horizontally by hand.
– Pull starting cable **3** out of handgrip **4** and unfasten the knot.
– Turn cable pulley **5** back slowly until return spring **6** is relieved of load.
– Loosen screw **7** and take off spring washer **8** and brake disc **9**.
– With return spring **6** entirely relieved of load, turn cable pulley **5** to and fro and lift it carefully out of housing **2**.
Turning to and fro is essential, or else return spring **6** will be pulled out of its seat in housing **2**. However, it need not be removed unless damaged.

Warning: risk of injury!

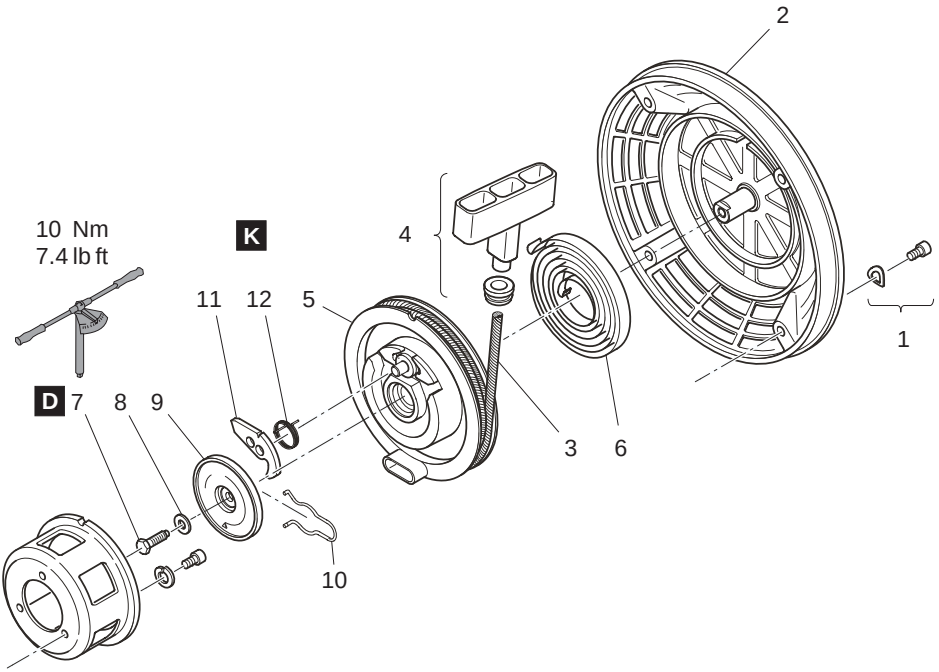
– Take pawl **11** and torsion spring **12** off cable pulley **5**.

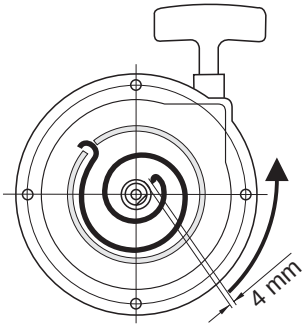
Testing / repair:

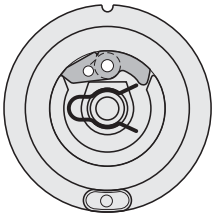
– Perform a visual check.
– Check parts for wear or damage and renew if necessary.

Assembly:

– Apply a light coating of high-temperature grease **K** to all moving metal parts.
– Wind return spring **6** back into housing **2** if it had to be removed, or insert a new wrapped spiral spring and remove its wrapping. The outer eye of the spring must engage in the milled cutout in housing **2**. The inner spring eye must be about 4 mm from the shaft.
– Wind on starting cable **3** and place cable pulley **5** on the shaft in housing **2**.
– Turn the cable pulley to and fro slightly until the projection on the cable pulley engages in the return spring eye.
– Insert the longer arm of torsion spring **12** into the hole on the cable pulley.
– Install pawl **11** and engage the shorter arm of the torsion spring in the cutout.
– Insert brake spring **10** as illustrated, and install brake disc **9**.
– Install spring washer **8** and screw **7**.
Use sealant **D**.
Note correct tightening torque (10 Nm).
– Preload the cable pulley by giving it 4 1/2 turns in the engine's direction of rotation, and lock it in this position.
– Thread the cable thrrough handgrip **4** and secure it with a knot.
– Check that the recoil starter operates correctly.
– Install remaining parts on engine.


2
10 Nm
7.4 lb ft
K
4
11
12
5
1
D
7
8
9
3
6
10


4 mm



M 17.00 Flywheel

- 2 -

Preliminary work:
For dismantling, see M cross-reference list.

Dismantling:
– Take out machine screws **1** and **2** and remove fan ring **3**.
– Attach tool **- 2 -** to flywheel **6** and take out screw **4** with washer **5**.
– Mark the relative positions of the flywheel and crankshaft with a scriber and take off flywheel **6**.
– Take off tool **- 2 -**.

Testing / repair:
– Check the parts for damage.

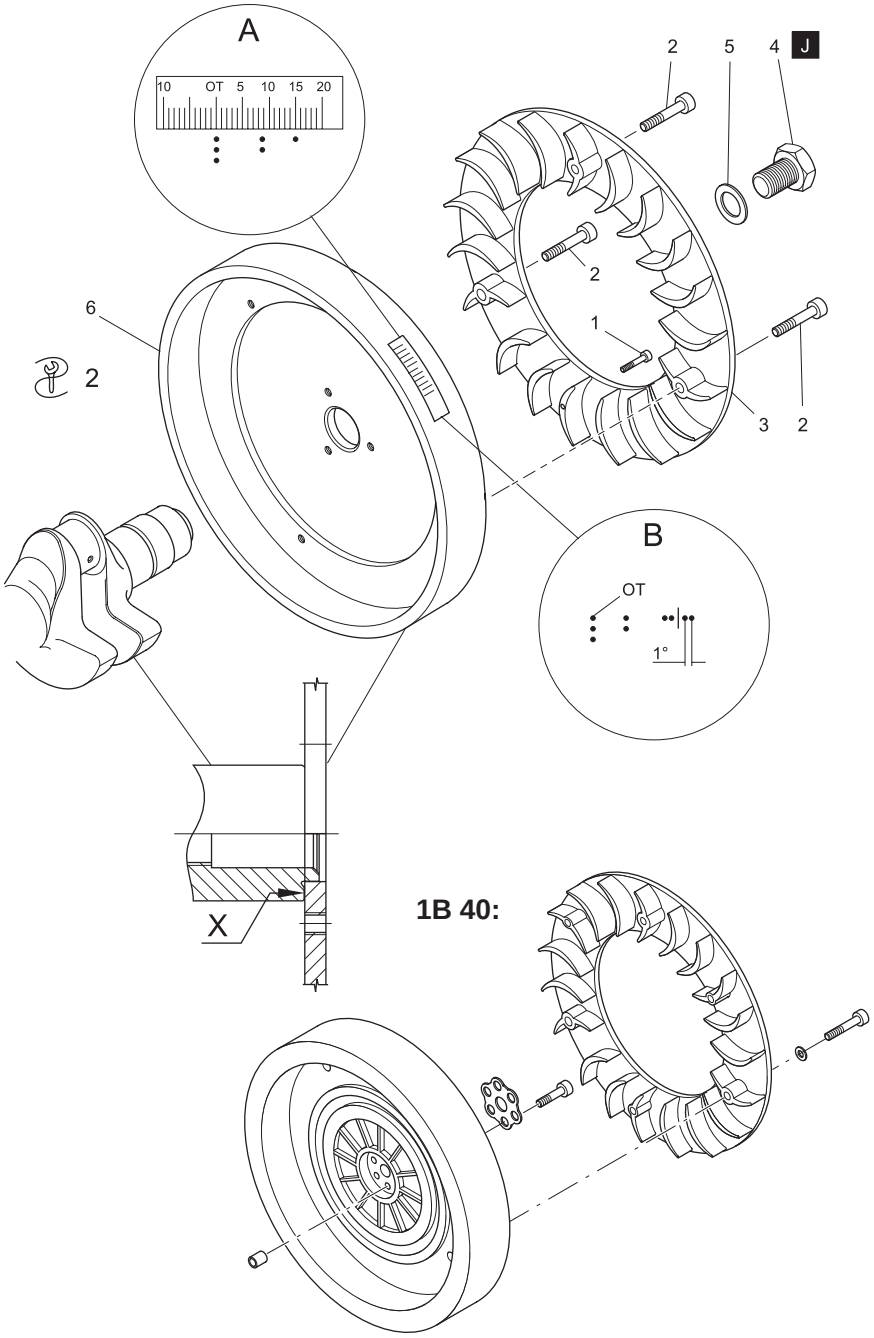
Assembly:
– Clean and degrease contact face **X** on the crankshaft and flywheel, and apply grinding paste with K = 240.
– Place the flywheel on the crankshaft so that the previous scriber marks are aligned.
– Apply a coating of lubricant **J** to the thread and contact face of screw **4**.
– Insert screw **4** with washer **5** and tighten it without preventing the flywheel from turning (this ensures that the flywheel does not change its position relative to the crankshaft).
– Attach tool **- 2 -** and tighten screw **4** to the specified torque.
– Re-attach parts previously removed from engine.

1B 40:
The flywheel is attached to the crankshaft with 6 machine screws. These are tightened to a torque of 40 +2 Nm.

Flywheel markings up to 01/99
(illustration A)**:**
An adhesive label with markings in degrees is attached to the flywheel.
In addition, there are three centre-punch markings with the following meanings:
• = Start of delivery
• • = End of delivery
• • • = Top dead centre (TDC)

Flywheel markings from 01/99 on
(illustration B)**:**
The adhesive label has been deleted, the markings are made mechanically and have the following meanings:
| = Start of delivery
• • = End of delivery
• • • = Top dead centre (TDC)

Checking the TDC mark:
– Insert a 3 mm spacer between the roller and the stem of one of the two valves (the piston must not be at TDC when this is done).
– Turn the engine in one direction until the piston touches the valve (do not apply any undue force, or the valve could be bent!).
– Make a temporary mark on the flywheel under the pointer.
– Turn the flywheel in the other direction and repeat the above procedure.
– The top dead centre mark (OT) must be precisely in the middle, between the two marks made in this way.


A
10 OT 5 10 15 20
2
5
4
J
2
1
3
2
6
2
B
OT
1°
X
1B 40:

M 26.00 Air guide

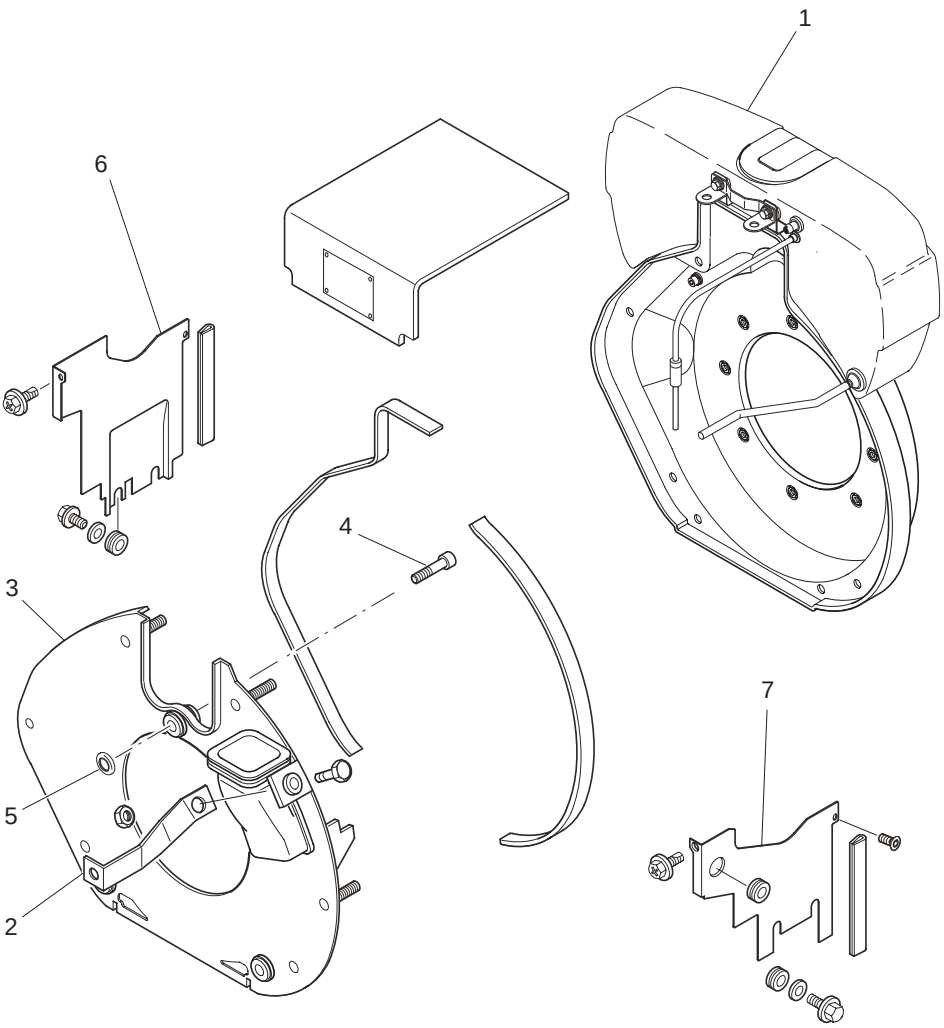
–

Preliminary work:
– Take off the fuel tank and air guide housing **1** (A 01.10).
– Take off the flywheel (M 17.00).

Dismantling:
– Unscrew support bracket **2** from dividing plate **3**.
– Take out machine screw **4**, noting the presence of washer **5**.
– Take off dividing sheet **3**.
Air guide sheets **6** and **7** can remain in position.

Testing / repair:
– Check the sealing strips for damage.
– Remove any foreign bodies.

Assembly:
– Follow the dismantling instructions in reverse.
– It is essential for all air guides to be installed completely and correctly so that the engine's thermal operating condition is not affected.


1
6
4
3
5
2
7

M 31.00 Breather

–

Preliminary work:

– Take off the air cleaner cover, the noise insulating hood and the air cleaner housing.

Dismantling:

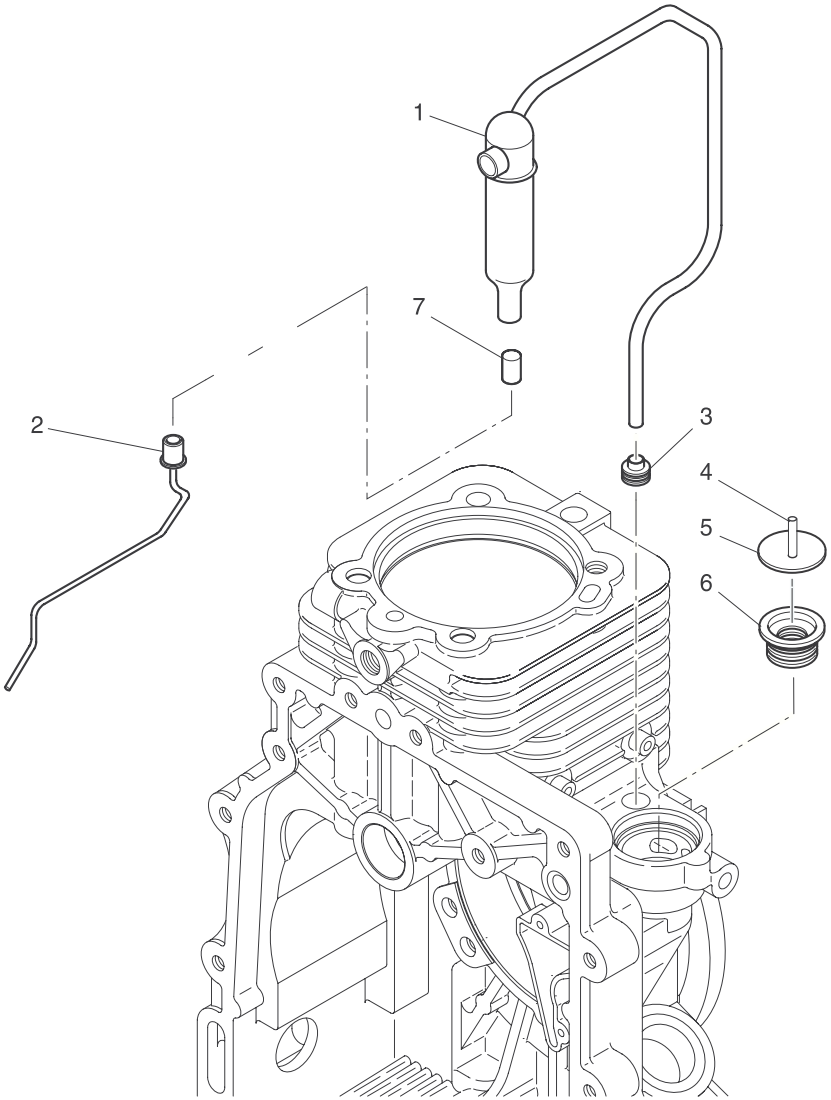
– Pull oil trap **1** out of suction pipe **2** in the timing case cover, and take out of the crankcase complete with seal **3**.
– Pull off hose **4**, lever cover **5** out of the crankcase with a suitable drift and take out diaphragm **6**.

Testing / repair:

– Check parts for damage.
– If necessary, renew diaphragm **6** and filter insert **7**.

Assembly:

– Follow the dismantling instructions in the reverse order .
– Drive cover **5** fully into the crankcase with a suitable drift.
– Re-attach parts removed from engine.

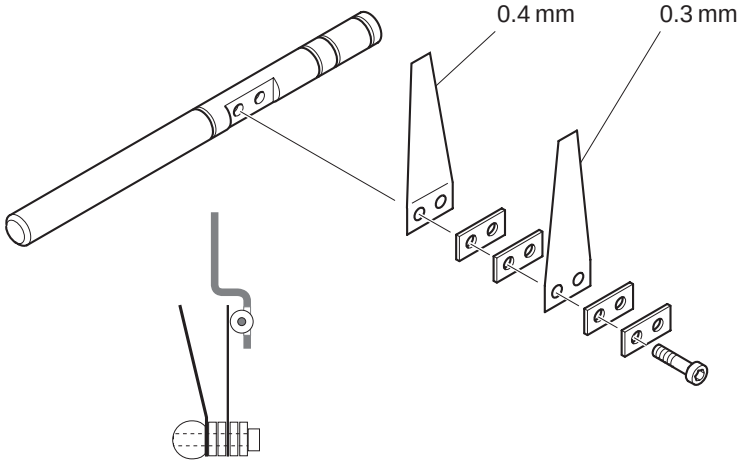

1
7
2
3
4
5
6

4. Tables

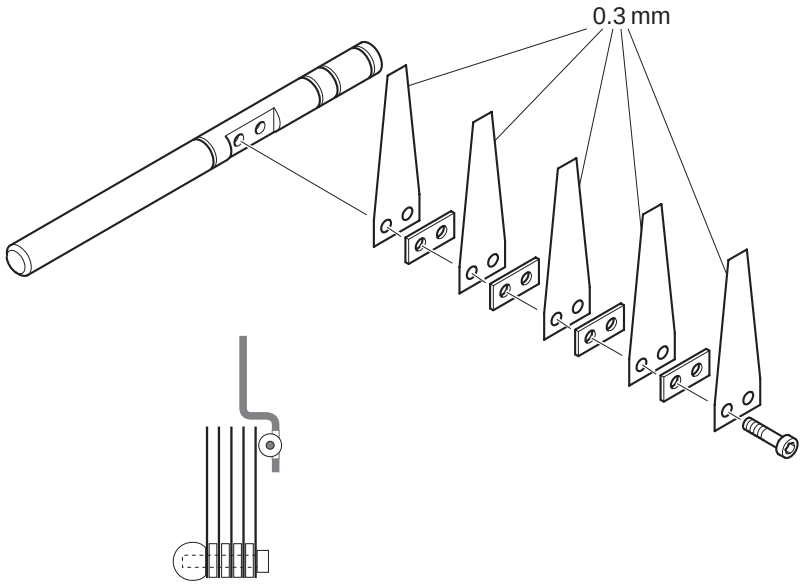
Governor components

Up to Serial No. 1B 20.14, 1B 30.10
8 bobweights 050 796 01 / governor sleeve 050 785 00

3000 rpm



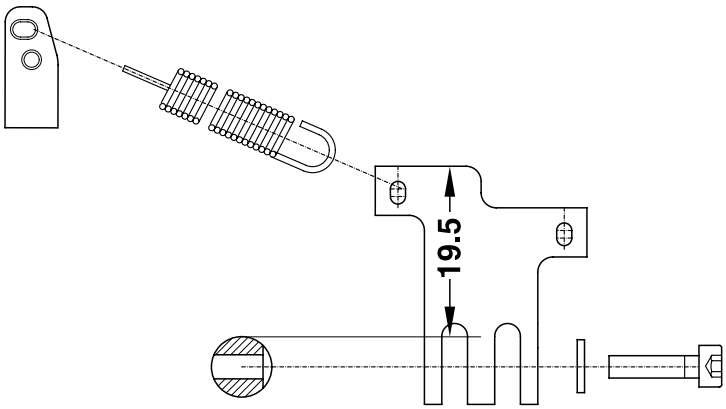
3600 rpm



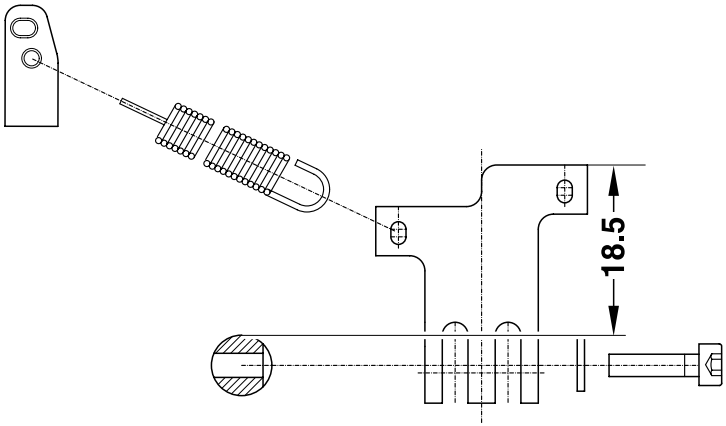
Governor components – 1B 20 / 30 / 40, 1B 20V / 30V / 40V

All-speed governor
8 bobweights 050 796 02

3000 - 3600 rpm



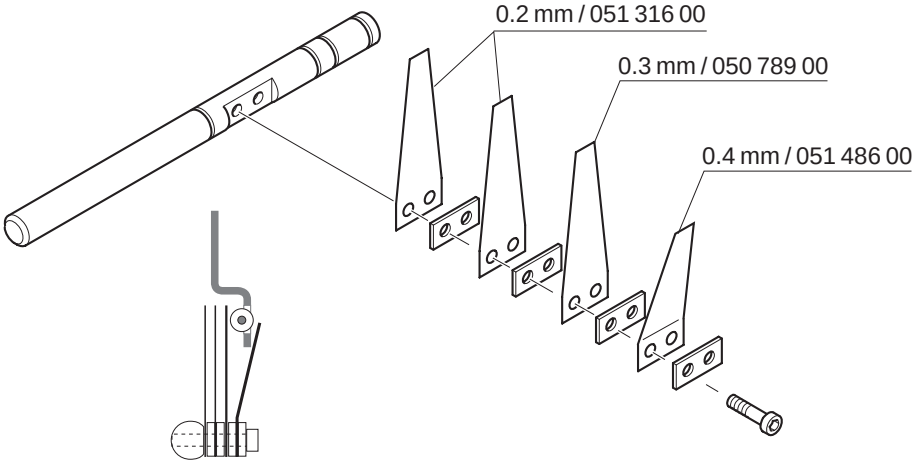
Special fixed-speed governor, 1500 rpm



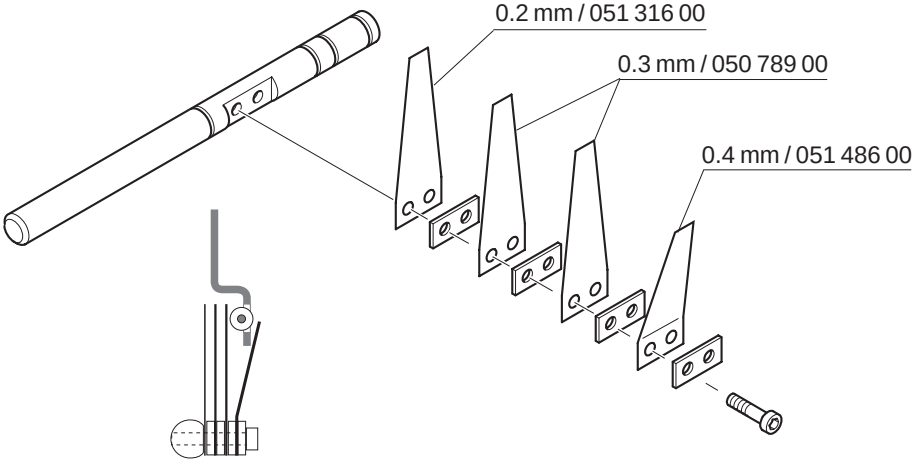
Governor components, 1B 20

Generator operation - PV 78 from Serial No. 1B 20.15 until 11/99
4 bobweights for gen. 051 469 00 / governor sleeve for gen. 051 470 00

3000 rpm



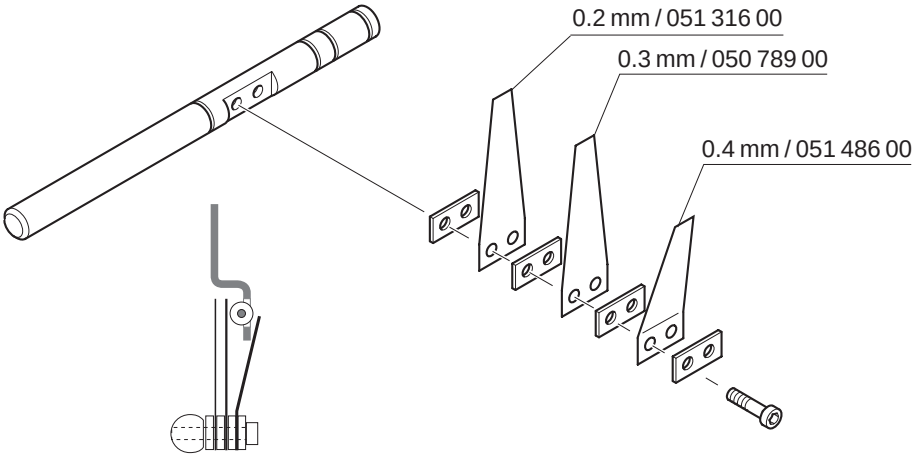
3600 rpm



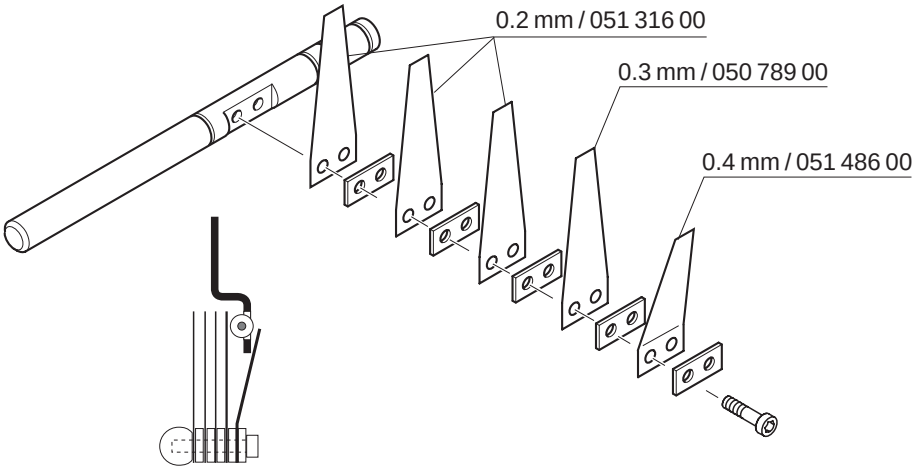
Governor components, 1B 30

Generator operation - PV 78 from Serial No. 1B 30.11 until 11/99
4 bobweights for gen. 051 469 00 / governor sleeve for gen. 051 470 00

3000 rpm



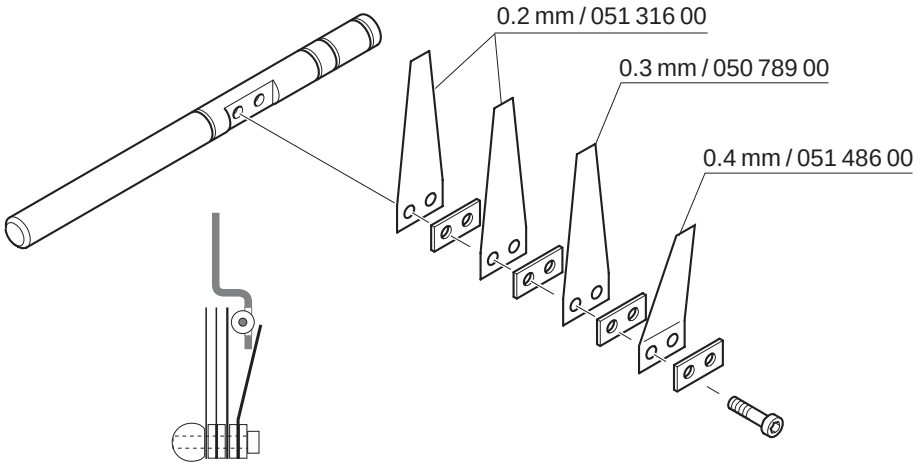
3600 rpm



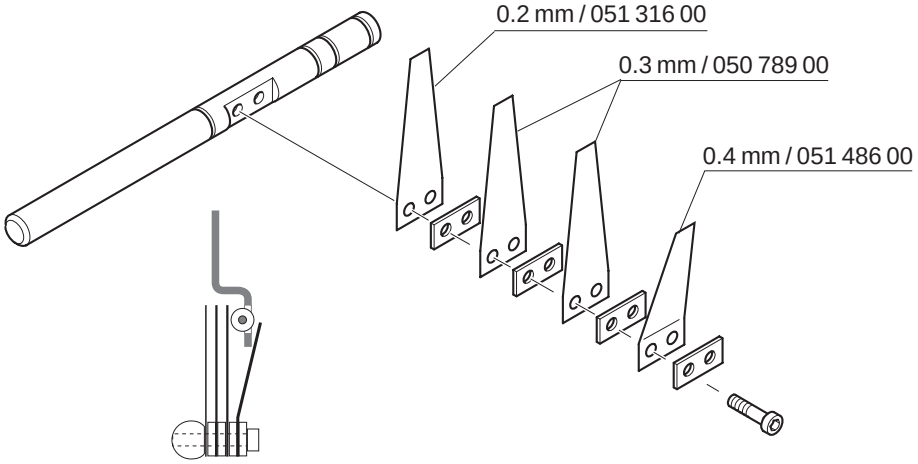
Governor components, 1B 20

Generator operation - PV 78 from 11/99 on
4 bobweights for gen. 050 796 02 / governor sleeve for gen. 050 785 02

3000 rpm



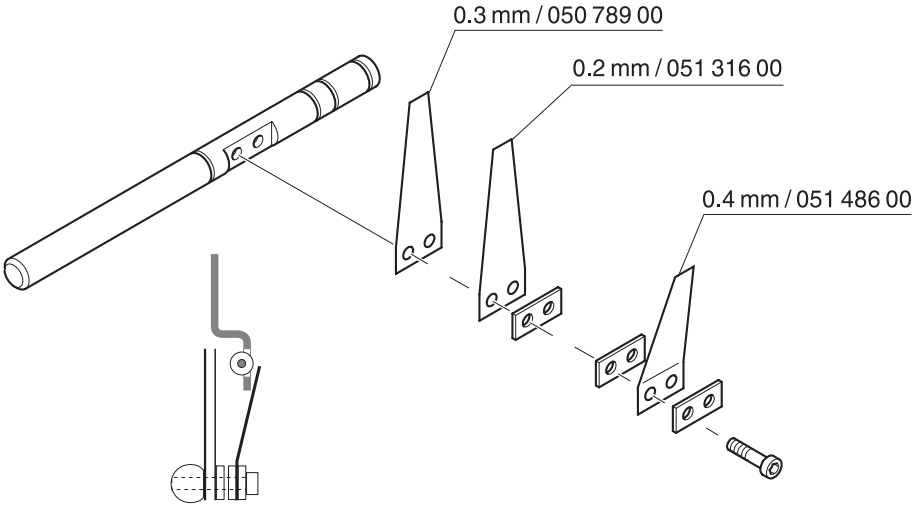
3600 rpm



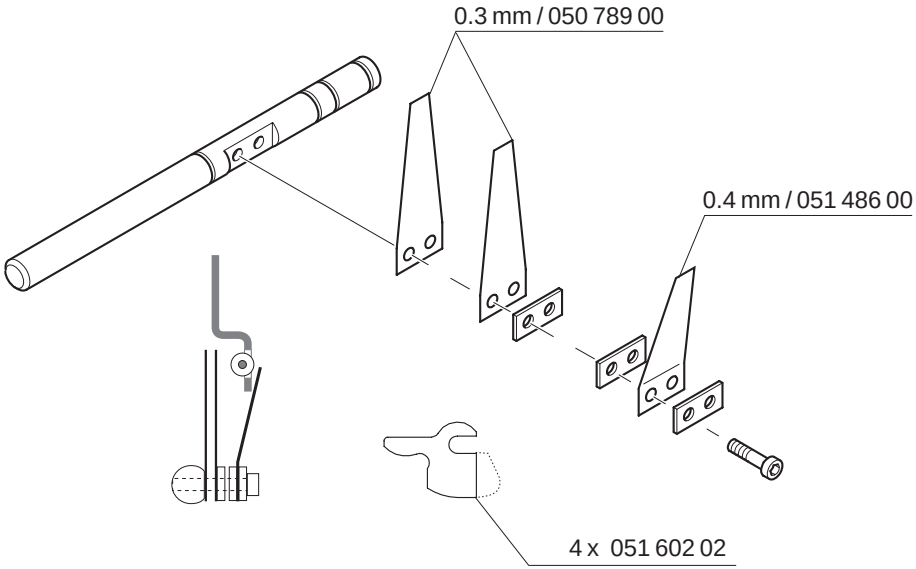
Governor components, 1B 30

Generator operation - PV 78 from 11/99 on
4 bobweights for gen. 050 796 02 / governor sleeve for gen. 050 785 02

3000 rpm



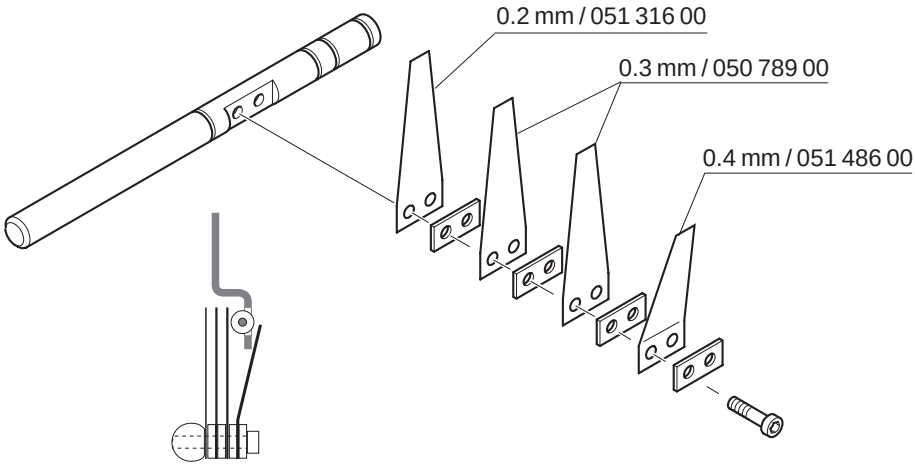
3600 rpm



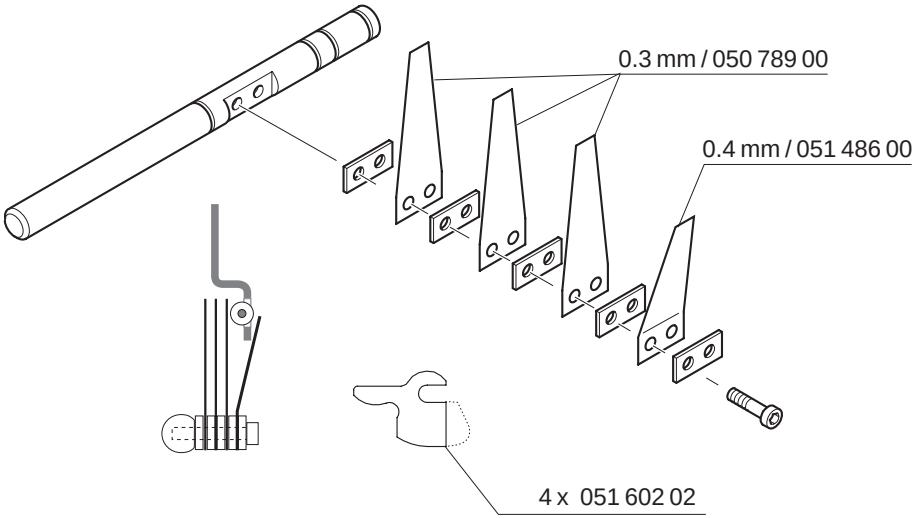
Governor components, 1B 20V

Generator operation - PV 78 from 11/99 on
4 bobweights for gen. 050 796 02 / governor sleeve for gen. 050 785 02

3000 rpm



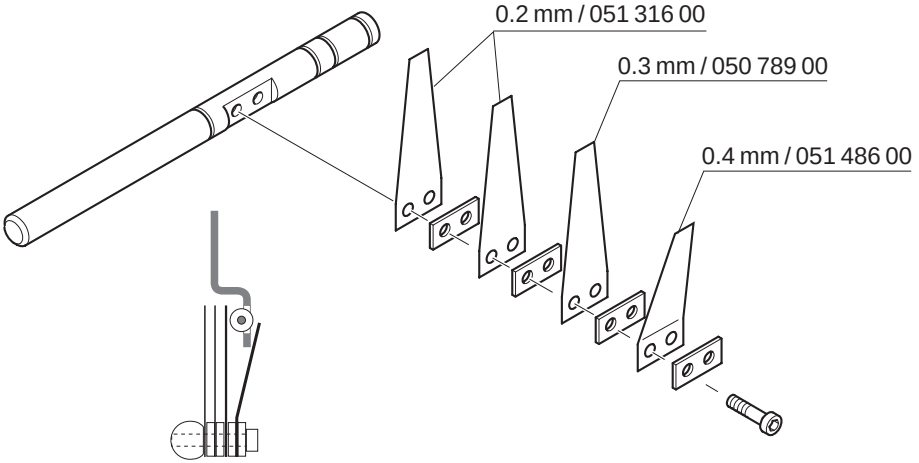
Special governor, 4200 rpm



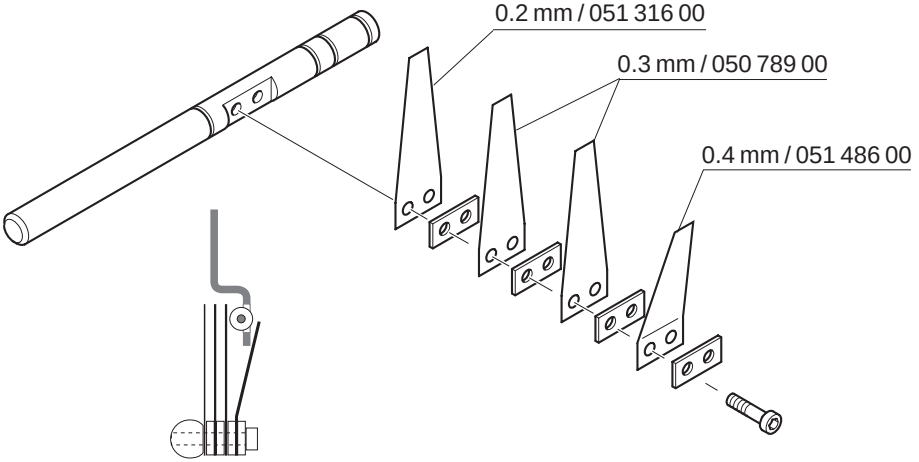
Governor components, 1B 40

Generator operation - PV 78
4 bobweights for gen. 051 602 02 / governor sleeve for gen. 050 785 02

3000 rpm



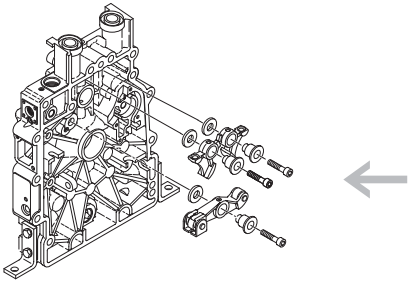
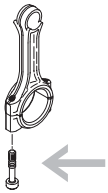
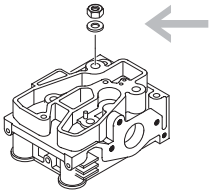
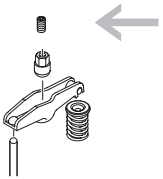
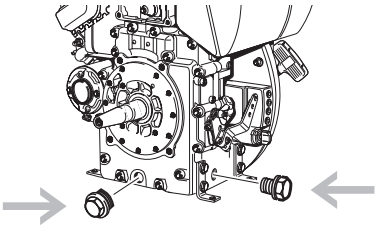
3600 rpm



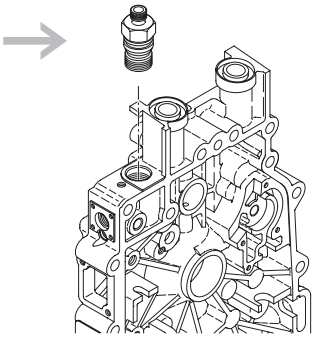
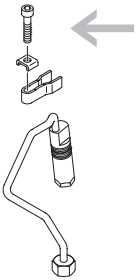
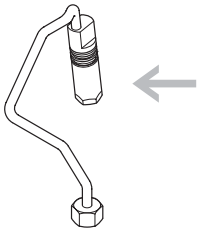
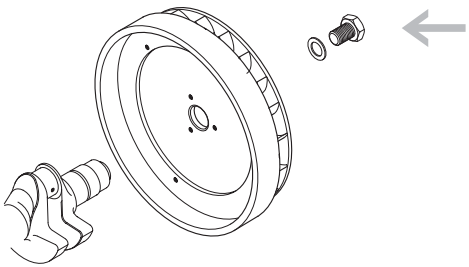
Start of delivery

	1/min	°bTDC at crankshaft
1B 20 / 1B 20V:	3000 ≤ n ≤ 3600	14
	2000 ≤ n < 3000	10
	1500 ≤ n < 2000	8
1B 30 / 1B 30V:	2400 < n ≤ 3600	13
	1500 ≤ n ≤ 2400	10
1B 40 / 1B 40V:	3000 < n ≤ 3600	18
	2500 < n ≤ 3000	16
	2000 ≤ n ≤ 2500	14
	1500 ≤ n < 2000	12

Screw tightening torques

	Nm		
	9.6		
	1 B 20 21 - 22	1 B 30 29-31	1 B 40 40-42
	1 B 20 1.Step: 10 2.Step: 25	1 B 30 20 40	1 B 40 20 40
	16		
	50		

Screw tightening torques

	Nm
	23 -0 - 23 - 0 - 25 (tighten-unscrew-tighten)
	9.8
	30+5
	350 + 20 1 B 40: 40 + 2

Screw tightening torques

General, in Nm:

Nm ÷ 9.81(10) = kpm
Nm ÷ 1.3558 = lb-ft

Thread	Screw strength rating			
	5.8	8.8	10.9	12.9
M 4	1.7	2.8	3.9	4.7
M 5	3.4	5.5	7.8	9.3
M 6	6.0	9.5	13	16
M 8	14	23	33	39
M 10	29	46	65	78
M 12	50	80	110	140
M 14	80	130	180	220
M 16	120	190	270	330
M 18	170	270	380	450
M 20	240	380	530	640
M 22	320	510	720	860

Code designations in circuit diagrams (DIN 40719)

Code	Designation of electrical component
A 1	Equipment box
A 2	Equipment panel
A 3	Automatic start-stop
A 4	Starter protection module
B 1	Temperature sensor
B 2	Speed pulse sensor
B 3	Oil pressure sensor
B 4	Horn
C1	Capacitor
E1	Heater for fuel filter
F1	Fuse
G1	Battery
G2	Generator (alternator)
G3	Flywheel generator
H 1	Indicator lamp, generator telltale
H 2	Indicator lamp, oil pressure
H 3	Indicator lamp, engine temperature
H 4	Indicator lamp, air cleaner (maintenance switch)
H 5	Indicator lamp, broken belt
H 6	Indicator lamp, preheat monitor
H 7	Indicator lamp, fan monitor
H 8	Remote display: engine on
K 1	Control relay 1 for start / start repeat interlock
K 2	Control relay 2 for preheat
K 3	Control relay 3 für speed control
K 4	Engine protection relay
K 5	Delay relay
K 6	Start interlock relay
K 7	Timer relay (impulse relay)
K 8	Power relay
M1	Starter motor
MG	Starter-generator
N 1	Regulator for starter-generator
N 2	Regulator for flywheel generator
N 3	Regulator for alternator (unless integrated)
N 4	Pulse sensor (additional for syncro-regulator)

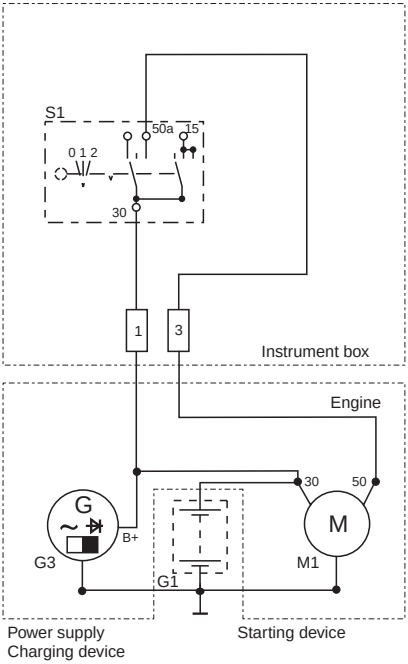
Code designations in circuit diagrams (DIN 40719)

Code	Designation of electrical component
P 1	Operating hours counter
P 2	Revolution counter
P 3	Pressure display
R 1	Preheat glowplug
R 2	Heating flange
R 3	Line resistor for preheat system
R 4	Resistor
R 5	Line resistor with thermal time switch
S 1	Preheat starter switch (5 positions)
S 2	Master switch
S 3	Preheat starter switch (3 positions)
S 4	Start-stop switch
S 5	Speed control switch
S 6	Engine temperature switch
S 7	Oil pressure switch
S 8	Pressure switch for air cleaner
S 9	Fan monitoring switch
S 10	Preheat temperature switch
S 11	Remote start switch
S 12	Remote stop switch
T1	Engine speed measurement transmitter
V 1	Decoupling diode
V 2	Freewheeling diode
V 3	Zener diode
V 4	Suppressor diode
W 1	Earth (ground), negative return line
W 2	Screened line at generator
X 1	Terminal strip on equipment box
X 2	Flat-plug distributor
X 3	Plug at emergency stop switch
X 4	Socket on emergency stop switch
X 5	Terminal block on control box / terminal box
Y 1	Speed control actuating solenoid
Y 2	Engine shutdown actuating solenoid
Y 3	Servo solenoid (= valve solenoid) for engine shutdown
Y 4	Fuel shutoff valve
Y 5	High-pressure shutdown valve
Z 1	Suppressor choke
Z 2	Suppressor capacitor

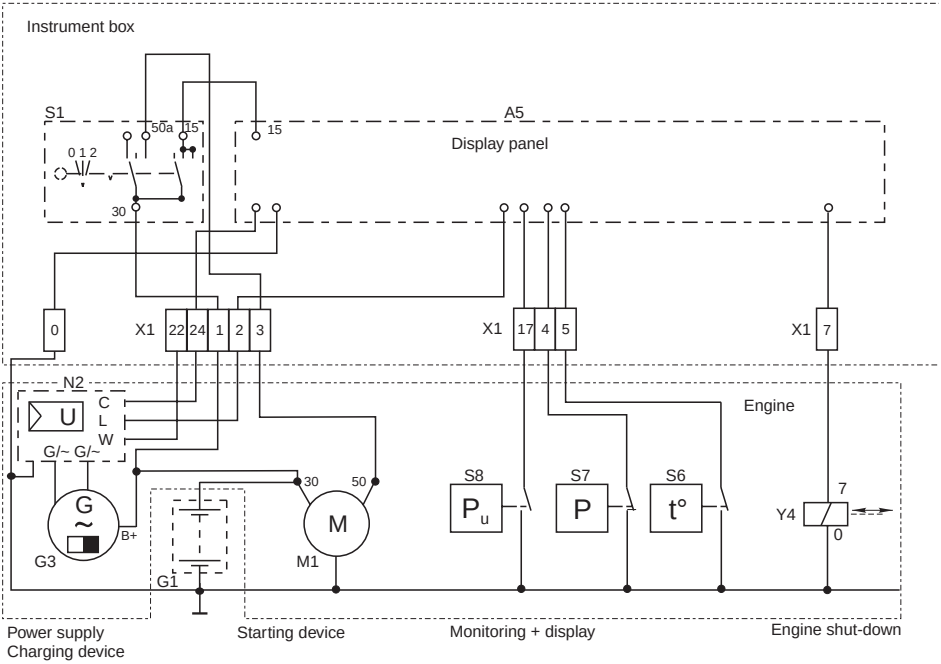
HATZ wiring designations

Terminal	Designation
0	Earth (ground)
1	Generator B+
2	With alternator: D+ With flywheel generator: Terminal L at regulator
3	Starter terminal 50
4	Oil pressure switch
5	Temperature switch on cylinder head
6	Preheat glowplug I
7	Engine shutdown solenoid
8	Preheat glowplug II
9	Start-stop input
10	Positive terminal for DC motor, precision speed control
11	Negative terminal for DC motor, precision speed control
12	Oil pressure sensor
13	* * * reserved for special applications * * *
14	Speed control solenoid - holding-on winding
15	* * * reserved for special applications * * *
16	Actuating solenoid for decompressor
17	Maintenance switch for air cleaner
18	Engine shutdown solenoid (energising winding)
19	Temperature sensor at cylinder head
20	Oil temperature switch
21	Fan monitoring switch
22	Terminal W for engine-speed measurement
23	Starter 30 (with ammeter connection)
24	Terminal C with regulator on flywheel generator
25	Oil temperature sensor
26	Terminal 50f at starter protection module
27	* * * reserved * * *
28	Speed control solenoid (energising winding)
29	* * * reserved * * *

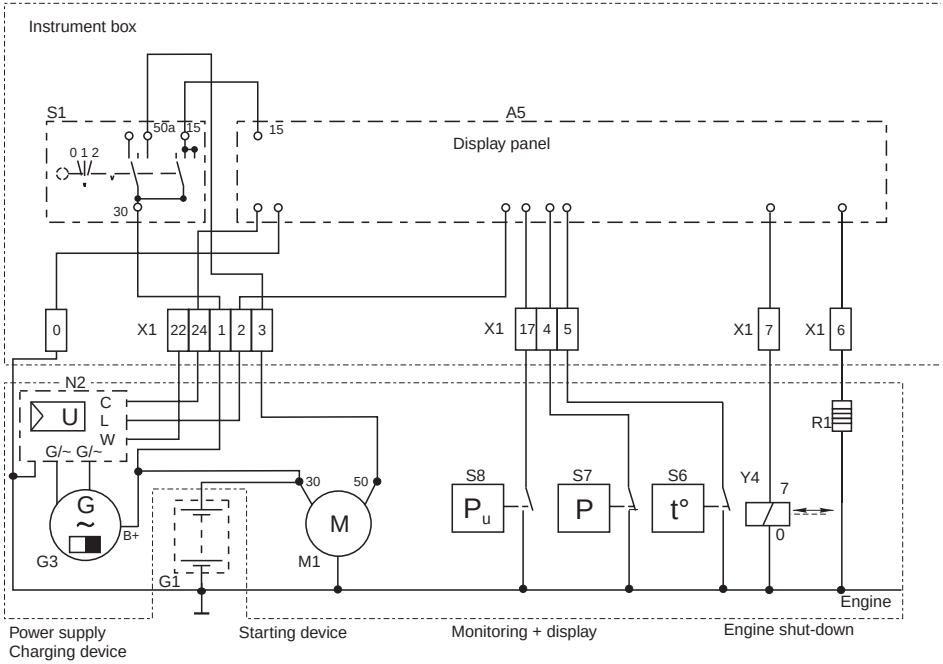
Electrical wiring diagram, 12 V system



Electrical wiring diagram, 12 V system with display



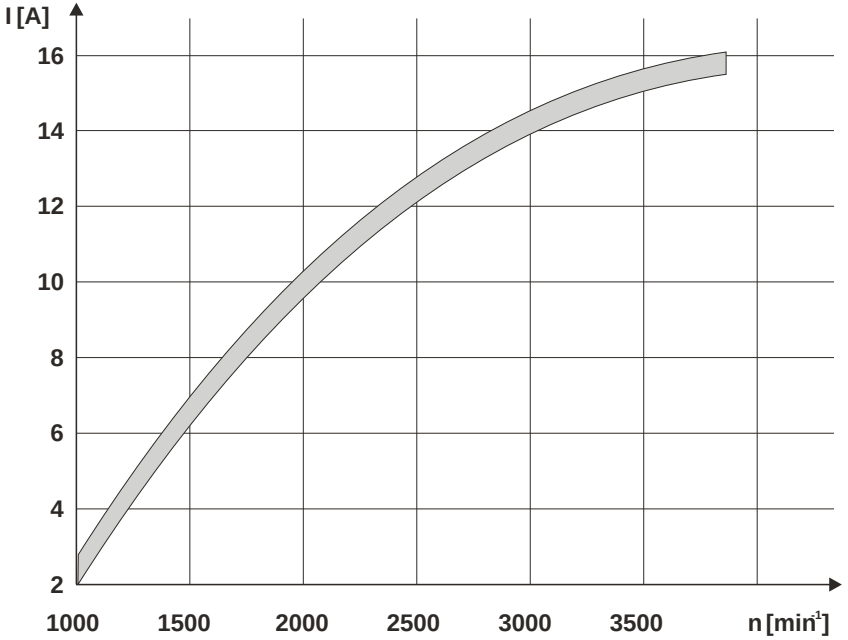
Electrical wiring diagram, 12/24 V system with display and automatic preheat



Generator characteristics, 12 V

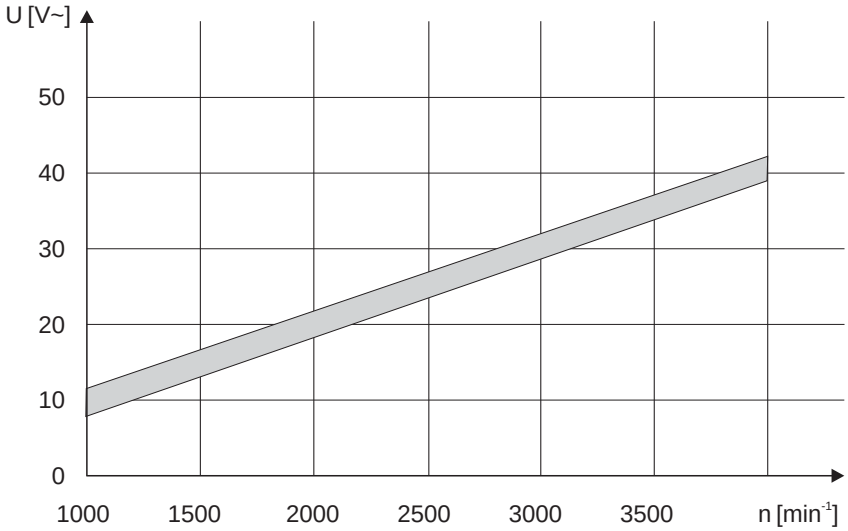
Charge current:

Battery voltage 12.5 V, normal operating temperature



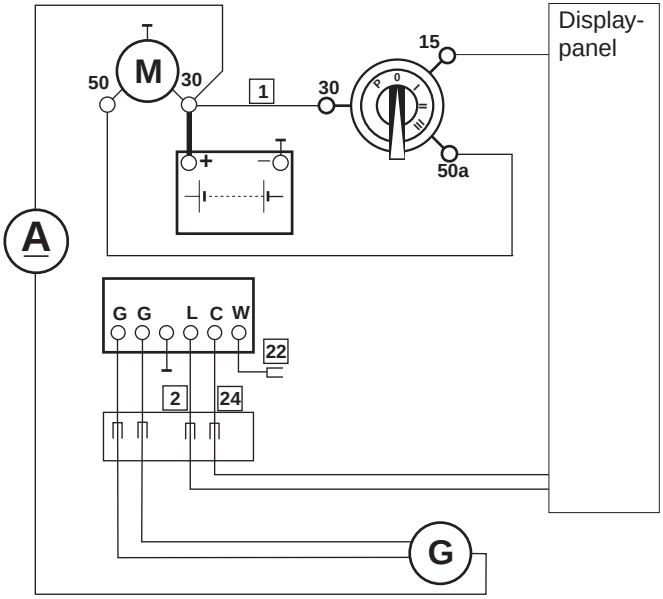
Off-load AC voltage:

measured between a yellow and a red wire at the coil (without regulating switch)

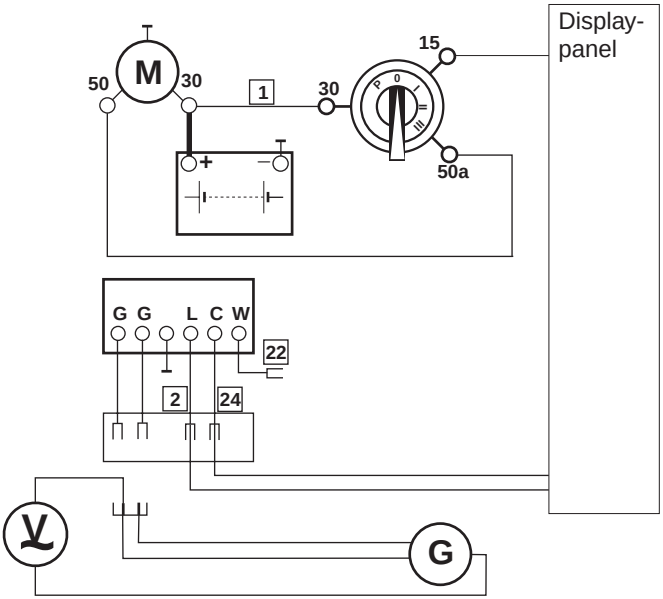


Circuit diagram for current and voltage measurements

Measuring charge current:



Measuring off-load voltage:



Troubleshooting chart - electrical system

Troubleshooting at the battery

Malfunction	Indication	Possible cause	Remedial action
Battery is not being charged sufficiently or at all, or is being discharged too rapidly.	Even shortly after charging, the terminal voltage drops rapidly to 7 V on systems with 12 V nominal voltage.	Poor connections, open circuit or contact resistance in charging circuit, short-circuit in line.	Eliminate open circuit, clean posts and clips, tighten loose terminals.
		Battery defective (internal short circuits).	Renew the battery.
		Battery capacity has dropped severely due to severe discharge for a lengthy period (grey-white coating on plates ("sulphatising").	Recharge battery at low current (app. 1/40 of nominal capacity in Amps) for about 50 hours. (Only possible if suplhatising not yet too far advanced.) Otherwise: renew battery.
		Charging rate too low (especially in winter).	Recharge the battery.
		Battery capacity too large.	Install a smaller battery.
		Defective voltage regulator (e.g. overheated/overloaded).	Renew the voltage regulator.
Battery is overcharged.	Terminal voltage permanently above 16.5 V at 12 V nominal voltage, acid density above 1.285 kg/l, battery acid boils.	Charge voltage too high.	Check voltage regulator, renew if necessary.
		Battery capacity is too low.	Install a larger-capacity battery. As a temporary measure, discharge the battery at intervals, e.g. by switching on consumers without running the engine.
		Defective voltage regulator.	Check voltage regulator, renew if defective.
	Acid emerging at cell plugs.	Acid level too high.	Draw off excess acid with hygrometer.

Troubleshooting chart - electrical system

Troubleshooting at the battery

Malfunction	Indication	Possible cause	Remedial action
Post terminals corroded.	Insufficient current transfer, “bloom” (white salt deposit).	Sulphuric acid attacks metals (except lead).	Wash the posts and terminals down with hot soda solution (but this must not enter the battery!), rinse with cold water and apply acid-resistant grease.
Acid level too low.	Acid level less than 10 mm (0.4 in) above top of cell plates.	Overloading, natural water loss caused by evaporation (esp. in summer).	Add distilled or demineralised water.
Battery life too low.		Battery was discharged too far or too frequently.	Check ratings of battery and generator, if necessary use a special “Z” or “HD” battery.
		Battery tends to over-heat.	Choose a better installed position.
		Excessive loads im-posed by vibration.	Choose a better installed position or use an “Rf” (vi-bration-proof) battery.
		Batterie is “sulphatising”.	Recharge battery at low current (app. 1/40 of nom. capacity in Amps) for app. 50 hours. Other-wise: renew battery
		Impurities in battery acid.	Renew the battery.

Troubleshooting chart - electrical system

Troubleshooting at the battery

Malfunction	Indication	Possible cause	Remedial action
Battery output is too low.	Voltage drops severely when a load is applied.	Battery is flat (discharged).	Recharge battery.
		Charging voltage is too low: voltage regulator is defective.	Renew the voltage regulator.
		Connecting terminals loose or oxidised.	Clean connecting terminals, apply acid-resistant grease, tighten terminal clips.
		Battery capacity too low (too many consumers).	Install a larger battery.
		Battery discharged because of impurities in the acid..	Renew the battery.
		Battery is “sulphatising” (white deposit on cell plates).	Recharge the battery at low current for app. 50 hours, or renew the battery.
		Battery is exhausted; active material has failed.	Renew the battery.
		Acid level too low.	Add distilled water.
Long-term charging rate is insufficient.	Terminal voltage drops to 7 V nominal voltage (12 V circuit) even shortly after recharging.	Fault at generator, voltage regulator or cable connections.	Repair or renew the generator and voltage regulator, make sure that all line connections are tight.
		Too many consumers connected to the circuit, or generator is too small.	Choose more suitable battery - generator ratings.

Troubleshooting chart - electrical system

Troubleshooting at the starting equipment

Malfunction	Indication	Possible cause	Remedial action
Starter does not rotate when preheat - starting switch is operated.	Generator indicator lamp is not on.	Poor connection (loose or oxidised), break in cable or short to earth (ground).	Check battery cables and connections, clean battery posts and terminals, make sure that connections are tight.
		Battery flat or defective.	Recharge or renew the battery.
	Indicator lamp darkens slowly when preheat-starter switch is operated.	Battery is flat (discharged).	Recharge the battery.
	Indicator light remains on brightly. Bridge terminals 30 and 50 briefly at the starter. The starter then runs.	Break in line between terminal 50 and starting switch or in line between terminal 30 and battery, or defective starting switch.	Repair the break; if necessary, renew the starting switch.
	Indicator light remains on brightly, but no connection between terminal 30 and positive pole of battery.	Pull-in winding of starter has burned out.	Renew starter, ensure good connection between terminal 30 at starter and positive battery pole (main lead to starter).
	Indicator light remains on brightly, solenoid switch is energised; starter runs when solenoid switch is bridged.	Solenoid switch contacts worn or dirty.	Renew solenoid switch.

Troubleshooting chart - electrical system

Troubleshooting at the starting equipment

Malfunction	Indication	Possible cause	Remedial action
Starter turns too slowly or is unable to turn the engine over.	Lengthy period of use without maintenance or in severe conditions.	Carbon brushes sticking.	Renew carbon brushes and brush holder guides.
		Carbon brushes worn.	Renew carbon brushes.
		Brush springs too weak, brushes not making contact.	Renew springs.
		Commutator dirty.	Clean commutator.
		Commutator scored or burned.	Recondition or renew starter.
		Armature or field coils defective.	Recondition or renew starter.
Starter engages and is energised, but engine turns over jerkily or not at all.	Lengthy period of use without maintenance, neglect of electrical system.	Battery flat (discharged).	Charge the battery.
		Insufficient current flow because of loose or oxidised connections.	Clean battery posts and terminals, tighten connections.
		Carbon brushes sticking.	Renew carbon brushes and brush holder guides.
		Carbon brushes worn.	Renew carbon brushes.
		Commutator dirty.	Clean commutator.
		Commutator scored or burned.	Recondition or renew starter.
		Armature or field coils defective.	Recondition or renew starter.
Drive pinion does not engage or disengage.	Engine turns over jerkily or not at all.	Drive pinion or helical thread dirty or damaged.	Renew drive pinion, recondition starter.
		Damaged flywheel gear ring.	Remachine or renew gear ring.
		Faulty solenoid switch.	Renew solenoid switch.
		Return spring weak or broken.	Renew return spring.

Troubleshooting chart - electrical system

Troubleshooting at the starting equipment

Malfunction	Indication	Possible cause	Remedial action
Starter continues to turn after switch has been released.	Noise of starter turning.	Preheat/starting switch does not return automatically from position 2 to position 1.	Reset the preheat/starting switch to 0 by force if necessary and renew it. If this is not possible, disconnect the battery immediately. **Warning! If this action is not taken within 2 - 3 minutes, the starter will overheat and burn out.**
Engine starts reluctantly or not at all although starter turns quickly.		Defective preheat system (this is only of significance at temperatures below -10°C).	Check the preheat circuit, renew defective parts if necessary.