

## 4. Tables

# Tightening torques for threaded connections

## General requirements in Nm:

$\text{Nm} \div 9.81(10) = \text{kpm}$

$\text{Nm} \div 1.3558 = \text{lb.ft}$

Thread	Strength category			
	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

## Tightening torques in Nm

Engine	L 30	L 31. M 31 L 40. M 40 L 41. M 41
Shouldered nuts on stud bolts (tierods) for cylinder head (Coat the tierod thread and washer contact face in the oil cavity with sealant <b>D</b> )	50	65
Big end bolts:                    M 10 x 1 (8 mm Allen screw)	60	60
M 11 x 1 (10 mm Allen screw)	–	115
Machine screws for counterweights	65	65
Machine screws for end cover, flywheel end (Coat thread with sealant <b>D</b> )	10	10
Hex nuts for securing injectors	15	15
Pressure valve at injection pump	35	35
Collar nut for injector nozzle	85 L41. M41	85 40-50
Machine screws at balancing weight bearing journals (4-cyl.)	30	30
Machine screws at drive gearwheel for balancing weights (4-cyl.) (Coat thread with sealant <b>D</b> )	75	75
Hex nut for attaching spring bridge (governor)	25	25
Machine screws M 12 x190 (crankcase halves)	90	90
Flywheel bolts	135	200
Machine screws for gearwheel on crankshaft	30	30
Machine screws, M 6. for securing cam tracks (injection timer)	14	14
Hex bolts for connecting housing (Coat thread with sealant <b>D</b> )	140	140
Front engine feet support mount (Silent Pack)	130	130
Hex bolts for governor weight holder	25	25
Hex nut for cylinder head cover (pressure-cast version)	–	10
Machine screws holding solenoid valve to engine monitoring block	–	9.5

## Repair data

Cylinder head		L 41 M 41	L 31. M 31 L 40. M 40	L 30	H .L 30
Gap	mm	0.85-0.95	1.0 - 1.1		1.0 - 1.5
Gasket at cylinder head	mm	0.7 - 0.8 - 0.9 - 1.0 - 1.1 - 1.2			1.2
Shim washers <sup>1)</sup>	mm	-			0.10 - 0.20
Valve clearance, cold (20±10°C)	mm	0.10			0.40 <sup>2)</sup>
Valve stem	∅ mm	8.96 <sup>-0.015</sup>			
Wear limit	∅ mm	8.85			
Inlet valve head	∅ mm	43.1 <sup>-0.3</sup>			40.1 <sup>-0.3</sup>
Exhaust valve head	∅ mm	39.1 <sup>-0.3</sup>			35.1 <sup>-0.3</sup>
Recess of valve head	max. mm min. mm	0.15 0.00	1.70 0.85		
Valve guide	outer	∅ mm	15	+0.046 +0.038	
	inner	∅ mm	9H6	+0.009 0	
Wear limit	inner	∅ mm	9.5		
Bore in cylinder head	∅ mm		15	+0.006 -0.012	
Pressing-in force	N		1000		
Valve guide projection	mm	20.5	23.5 (l=70.5) 20.5 (l=67.5)	20.5	14.5
Valve seat angle			45°		

- 1) As required, between cylinder and crankcase  
 2) If steel pushrods are used: 0.20 mm

## Repair data

Cylinder head		L 31. M 31 L 40. M 40 L 41. M 41	L 30	H .L30
Length of inner valve spring, off-load	mm		45.5	
Wear limit	mm		44.0	
Length of outer valve spring, off-load	mm		58.0	
Wear limit	mm		56.5	
Rocker shaft	∅ mm		19 f 6	<sup>-0.020</sup> <sub>-0.033</sub>
Wear limit	∅ mm		18.90	
Bore in rocker	∅ mm		21 H 7	<sup>+0.021</sup> 0
Rocker bushing	inner ∅ mm		19	<sup>+0.046</sup> <sub>-0.012</sub>
Wear limit	inner ∅ mm		19.20	
Radius at rocker (no flats must have formed)	mm		8	
Rocker endplay (insert shims only on the circlip side)	mm		0.1 - 0.2	

## Repair data

### Camshafts (injection pump drive and valve gear)

#### Camshaft bearing journal diameters

Timing-gear side and centre	mm	54 e 6	-0.060 -0.079
Wear limit	mm	53.85	
Flywheel end (ball bearing seat)	mm	20 m 6	+0.021 +0.008

#### Internal diameter of bearing bore in crankcase

Timing end	mm	54 H 7	+0.030 0	(bushing for. 54	+0.058 -0.002
Wear limit	mm	54.10			
Centre	mm	54 H 7	+0.030 0		
Wear limit	mm	54.10			
Flywheel end (ball bearing seat)	mm	47 K 7	-0.007 -0.018		
Bore for tappet in crankcase	mm	16 H 7	+0.018 0		
Wear limit	mm	16.05			
Tappet shaft	∅ mm	16 f 7	-0.016 -0.034		
Wear limit	mm	15.9			
Camshaft endplay	mm	0.1			

# Repair data

## Balancing weights

### Bearing point diameters – two- and three-cylinder engines

Balancing weight shaft	mm	28 h 5	$\begin{matrix} 0 \\ -0.009 \end{matrix}$
Endplay – two-cylinder engines	mm	0.15 - 0.6	
–three-cylinder engines	mm	0.15 - 0.7	
Wear in the needle roller bearing area	∅ mm	down to 27.97	

### Bearing point diameters – four-cylinder engines

Bearing journals for balancing weights	mm	44 d 6	$\begin{matrix} -0.080 \\ -0.096 \end{matrix}$
Bearing bushing for balancing weights (pressed-in)	mm	44	$\begin{matrix} +0.018 \\ +0.083 \end{matrix}$
Endplay	mm	0.15 - 0.4	

# Repair data

	.L 30 / H .L30	.L 31 / .M 31 .L 40 / .M 40	.L 41 / .M 41
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## Conrod

Bore for piston pin (small end) bushing	∅ mm	35 H 6 +0.016 0	39 H 6 +0.016 0
Big end bore	∅ mm	63 H 6 +0.019 0	67 H 6 +0.019 0
Piston pin bushing external	∅ mm	35 +0.085 +0.045	39 +0.085 +0.045
pressed-in internal	∅ mm	32 +0.075 +0.030	36 +0.080 +0.035
Wear limit internal	∅ mm	32.30	36.30
Max. misalignment*	mm	0.08	0.08

## Cylinder

Bore	mm	95 +0.01	102 +0.01
Wear limit	mm	95.15	102.15
Oversize	mm	+1.0	+0.5 / +1.0**
Roughness	Ra	0.9 - 1.3 μ (1μ= 1/1000 mm)	

## Piston

Normal	∅ mm	94.94	101.92	101.90
Oversize	mm	+1.0	+0.5 /	+1.0**
Play max.	mm	0.07	0.09	0.11
Play min.	mm	0.06	0.08	0.10
Piston pin bore	∅ mm	32 +0.009 +0.004	36 +0.010 +0.004	
Wear limit	mm	32.05	36.05	
Piston pin	∅ mm	32 0 -0.006	36 0 -0.006	
Wear limit	mm	31.95	35.95	
Piston ring endplay max.	mm	0.2	0.2	



# Repair data

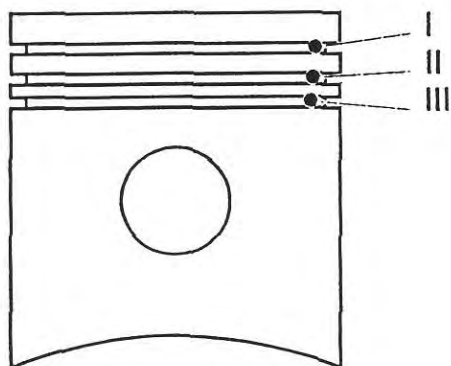
## Piston rings .L30. H.L 30

Ring groove No.		Designation	Dimensions	End gap mm:	
				normal	max. <sup>1)</sup>
I	Standard	Trapezoidal	95 x 87 x 3	0.40 - 0.65	1.0
	Oversize		96 x 87.9 x 3		
II	Standard	Cutaway micro-chamfer	95 x 87 x 3	0.40 - 0.65	2.0
	Oversize		96 x 87.9 x 3		
III	Standard	D-ring	95 x 87 x 5	0.30 - 0.60	2.0
	Oversize		96 x 87.9 x 5		

## Piston rings

.L 31, .M 31, .L 40, .M 40, .L 41, .M 41,

Ring groove No.		Designation	Dimensions	End gap mm:	
				normal	max. <sup>1)</sup>
I	Standard	Trapezoidal	102 x 93.4 x 3	0.40 - 0.65	1.2
	Oversize		102.5 x 93.9 x 3 103 x 94.4 x 3 *		
II	Standard	Cutaway micro-chamfer	102 x 93.4 x 2.5	0.40 - 0.65	2.5
	Oversize		102.5 x 93.9 x 2.5 103 x 94.4 x 2.5 *		
III	Standard	D-ring	102 x 93.4 x 4	0.30 - 0.60	2.5
	Oversize		102.5 x 93.9 x 4 103 x 94.4 x 4 *		



1) These are maximum limit values which can still be accepted without risk of engine power output, oil consumption and exhaust emissions being affected.

The piston rings should be renewed during repair work if they have worn to 60 % of the limit value.

\* These oversize piston rings are no longer available.

# Repair data

Crankshaft		.L 30 / H .L 30		.L 31 / .M 31 .L 40 / .M 40 .L 41 / .M 41	
Crankpins	∅ mm	60 h 6	$\begin{matrix} 0 \\ -0.019 \end{matrix}$	64 h 6	$\begin{matrix} 0 \\ -0.019 \end{matrix}$
Wear limit	mm	59.88		63.88	
Out-of-roundness max.	mm		0.05		
Conicity max.	mm		0.003		
Width	mm	32 H 9	$\begin{matrix} +0.062 \\ 0 \end{matrix}$	32 H 9	$\begin{matrix} +0.062 \\ 0 \end{matrix}$
Radius	mm	3.5		4.0	+0.3
Centre bearing journal	∅ mm		72 h 6		$\begin{matrix} 0 \\ -0.019 \end{matrix}$
Out-of-roundness max.	mm		0.05		
Conicity max.	mm		0.003		
Width	mm		32		+0.3
Radius	mm	3.5	-0.2	3.75	-0.2
Main bearing journal, timing end	∅ mm		72 h 6		$\begin{matrix} 0 \\ -0.019 \end{matrix}$
Out-of-roundness max.	mm		0.05		
Conicity max.	mm		0.003		
Width	mm		26.5		-0.2
Radius	mm		3.5		-0.2
Main bearing journal, flywheel end	∅ mm		72 h 6		$\begin{matrix} 0 \\ -0.019 \end{matrix}$
Out-of-roundness max.	mm		0.05		
Conicity max.	mm		0.003		
Width	mm	27	±0.2	32	+0.3
Radius	mm	3.5	-0.2	3.75	-0.2
Contact face for shaft sealing ring, flywheel side	∅ mm	70 h 11	$\begin{matrix} 0 \\ -0.190 \end{matrix}$	80 h 11	$\begin{matrix} 0 \\ -0.190 \end{matrix}$

## Repair data

Crankshaft		.L 30 / H .L 30		.L 31 / .M 31 .L 40 / .M 40 .L 41 / .M 41	
Regrinding during repairs	mm	0.5			
Hardness	Rc	50 - 55			
Hardening depth	mm	2.5			
Big end bearing, internal (installed)					
Normal	∅ mm	60	+0.083 +0.040	64	+0.063 +0.040
Wear limit	∅ mm	60.20		64.20	
Undersize	∅ mm	59.5	+0.083 +0.040	63.5	+0.083 +0.040
Wear limit	∅ mm	59.7		63.7	
Wall thickness, normal	mm	1.468 - 1.480			
Undersize	mm	1.718 - 1.730			
Main bearing, internal (installed)					
Normal	∅ mm	72		+0.099 +0.056	
Wear limit	∅ mm	72.25			
Undersize	∅ mm	71.5		+0.099 +0.056	
Wear limit	∅ mm	71.75			
Wall thickness, normal	mm	2.960 - 2.972			
Undersize	mm	3.210 - 3.222			
Crankshaft endplay	mm	0.15 - 0.65			
Max. permissible bearing play after wear	mm	0.3			

## Fuel injection equipment

Up to engine serial numbers: 2 L 40.16. 3 - 4 L 40.15. .M 40.12. L 30 and H.L 30

Engine type	Injection pump	HATZ Ident No.	Start of delivery
	PFR 1 K 80 A 442/2 1)		
2 - 4 L 30	PFR 1 K 80 A 442/11 1)		17 - 18°
H.L 30	PFR 1 K 80 A 467 1) 2)	501 407 00	before TDC
	PFR 1 K 80 A 467 3)	501 407 10	
2 - 4 L 40	PFR 1 K 80 A 477 2)	502 368 00	17 - 18°
2 - 4 M 40	PFR 1 K 80 A 477 3)	502 368 10	before TDC

- 1) Interchangeable
- 2) With governor-rod stop at pump
- 3) Without governor-rod stop at pump:  
governor-rod limiter needed on engine

From engine serial No.: 2 L 40.17. 3 - 4 L 40.16. M 40.13. L 31. M 31. L 41. M 41

Engine type	Injection pump	HATZ Ident No.	Start of delivery
L 31. M 31 L 40. M 40	PFR 1 K 90 A 498	502 630 00	15° before TDC
L 41. M 41	PFR 1 K 90 A 546	504 442 01	10° before TDC

### Injectors

Engine type	HATZ-Ident-No.	Injector nozzle		Spray pressure
		Bosch	HATZ	
L 30. H.L 30 L 31. M 31 L 40. M 40	401 209 01	DLLA 160 S 908	501 413 01	250 <sup>+8</sup> bar
L 41. M 41	504 440 00	DSL A 150 P 645	504 441 00	230 <sup>+12</sup> bar

# Governors

## L 30. H .L30

Speed	Application	Governor spring		Governor weight Ident-No.
		Ident-No.	Wire Ø mm	
≤ 2300	Normal operation	036 012 01	3.0	035 729 00
> 2300		035 744 01	3.2	
1500 *	Generator drive	036 014 01	2.5	
1800 *		036 013 01	2.6	
3000		035 744 01	3.2	

\* When driving a generator at 1500 and 1800 rpm governor weights with Ident No. 036 349 00 were used from 1979 to 1982. They are identifiable by a „G“ stamped on the end or a white spot.

If needed, renew these governor weights as a complete set, since governor weights with Ident-No. 035 729 00 are now installed for all running-speed ranges.

## L 40. M 40 with injection pumps PFR 1K 80A 477

Speed	Application	Governor spring		Governor weight Ident-No.
		Ident-No.	Wire Ø mm	
≤ 2300	Normal operation	036 012 01	3.0	035 729 00
> 2300		035 744 01	3.2	
1500	Generator drive	037 739 00	2.5 *	
1800		036 013 01	2.6	
3000		035 744 01	3.2	

\* Identification: windings are ground away slightly at circumference.

## L 31. M 31. L 40. M 40 with injection pump PFR 1K 90A 498 and L 41 and M 41

Speed	Application	Governor spring		Governor weight Ident-No.
		Ident-No.	Wire Ø mm	
≤ 2300	Normal operation	036 012 01	3.0	035 729 00
> 2300		035 744 01	3.2	
1500	Generator drive	038 670 00	2.3 *	
1500		036 014 01	2.5	
1800		036 013 01	2.6	
3000		035 744 01	3.2	

\* With this governor spring the spacing ring, Ident No. 037 729 00, is deleted (Fig. 48a/50)

## Lubricating oil content and dipstick

Engine type	Oil sump	Oil content l	Dipstick marking
Two-cylinder engines	with	7.5	C
	without	4.5	A
	with	8.5	C
	without	5.5	A
Three-cylinder engines	with	10.5	D
	without	8.0	A
	with	11.0	D
	without	8.5	A
Four-cylinder engines	with	13	D
	with	14	D

Note:

The lubricating oil contents stated here are to be understood as approximate; they apply to engines with a lubricating oil cooler and refer to oil changes including renewal of the lubricating oil filter.

In certain cases engines of versions „S“ and „Z“ are not equipped with an oil cooler. In this case the oil content is reduced by app. 0.2 - 0.5 litre.

In all cases fill to the „Max“ mark on the dipstick.

## Key to circuit diagrams (DIN 40719)

Key	Designation of electrical component
A 1	Instrument box
A 2	Instrument panel
A 3	Automatic start-stop
A 4	Starter protection module
B 1	Temperature sensor
B 2	Speed pulse transmitter
B 3	Oil pressure sensor
B 4	Signal horn
C 1	Condenser
E 1	Fuel filter heater
F 1	Fuse
G 1	Battery
G 2	Alternator
G 3	Flywheel generator
H 1	Generator telltale light
H 2	Oil pressure warning light
H 3	Engine overheat warning light
H 4	Air cleaner telltale light (maintenance switch)
H 5	Belt break warning light
H 6	Pre-heat monitor telltale light
H 7	Fan monitor warning light
H 8	Remote display: engine running
K 1	Control relay 1 for start / start repeat interlock
K 2	Control relay 2 for pre-heating
K 3	Control relay 3 for speed control
K 4	Engine protection relay
K 5	Delaying relay
K 6	Start inhibit relay
K 7	Timer (impulse) relay
K 8	Power relay
M 1	Starter motor
MG	Starter generator
N 1	Voltage regulator for starter generator
N 2	Voltage regulator for flywheel generator
N 3	Voltage regulator for alternator (unless integrated)
N 4	Pulse transmitter (additional item for synchro-regulator)

## Key to circuit diagrams (DIN 40719)

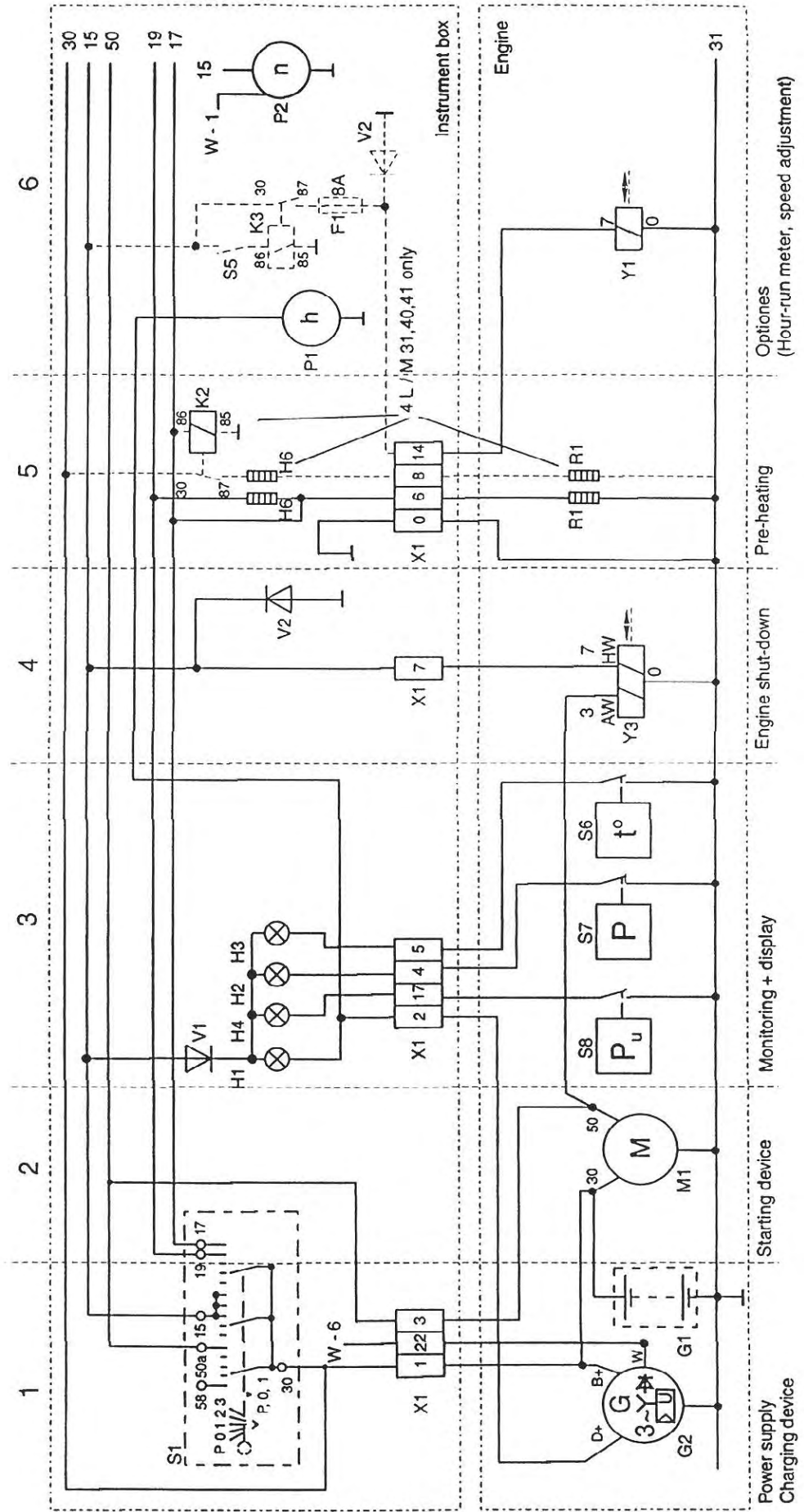
Key	Designation of electrical component
P 1	Operating hours counter
P 2	Revolution counter
P 3	Pressure gauge
R 1	Pre-heat plug
R 2	Heating flange
R 3	Line resistor for pre-heat system
R 4	Resistor
R 5	Line resistor with thermo-times switch
S 1	Pre-heat start switch (5-position)
S 2	Master switch
S 3	Pre-heat/start switch (3-position)
S 4	Start-stop-switch
S 5	Swich for speed control
S 6	Engine temperature switch
S 7	Oil pressure switch
S 8	Pressure switch for air-cleaner
S 9	Fan monitoring switch
S 10	Pre-heat temperature switch
S 11	Remote-start switch
S 12	Remote stop switch
T 1	Transducer for speed measurement
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 at instrument box
X 2	Flat-pin junction box
X 3	Plug at emergency stop switch
X 4	Socket at emergency stop switch
X 5	Terminal block in control box / terminal box
Y 1	Solenoid for speed control
Y 2	Solenoid for engine shutdown
Y 3	Servo (valve) solenoid for engine shutdown
Y 4	Fuel shut-off valve
Y 5	High-pressure shut-down valve
Z 1	Suppressor choke
Z 2	Suppressor capacitor



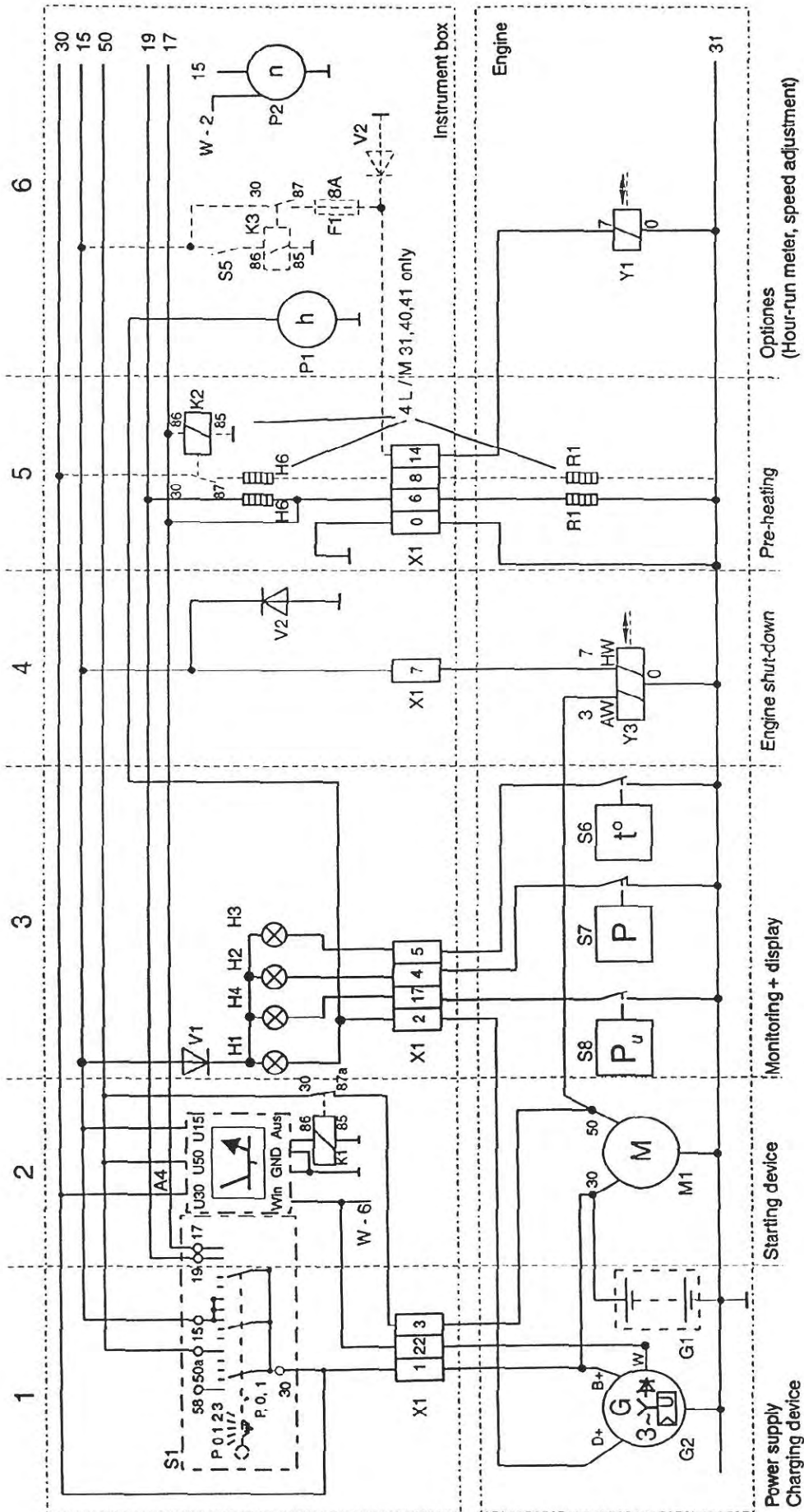
## HATZ - Wiring identification

Terminal	Designation
0	Earth (ground)
1	Alternator B+
2	With alternator: D+ With flywheel generator: terminal L at voltage regulator
3	Starter terminal 50
4	Oil pressure switch
5	Temperature switch on cylinder head
6	Pre-heat plug I
7	Engine shut-down solenoid
8	Pre-heat II
9	Start-stop input
10	Positive terminal for DC fine speed control motor
11	Negative terminal for DC fine speed control motor
12	Oil pressure sensor
13	* * * Reserved for special purpose * * *
14	Speed control solenoid hold-on winding
15	* * * Reserved for special purpose * * *
16	Decompression solenoid
17	Air cleaner maintenance switch
18	Engine shut-down solenoid (energizing winding)
19	Temperature sensor on cylinder head
20	Oil temperature switch
21	Fan monitoring switch
22	Terminal W for engine speed measurement
23	Starter 30 (if ammeter is connected)
24	Terminal C if voltage regulator is on flywheel generator
25	Oil temperature sensor
26	Terminal 50f at starter protection module
27	* * * Reserved * * *
28	Speed control solenoid (energizing winding)
29	* * * Reserved * * *

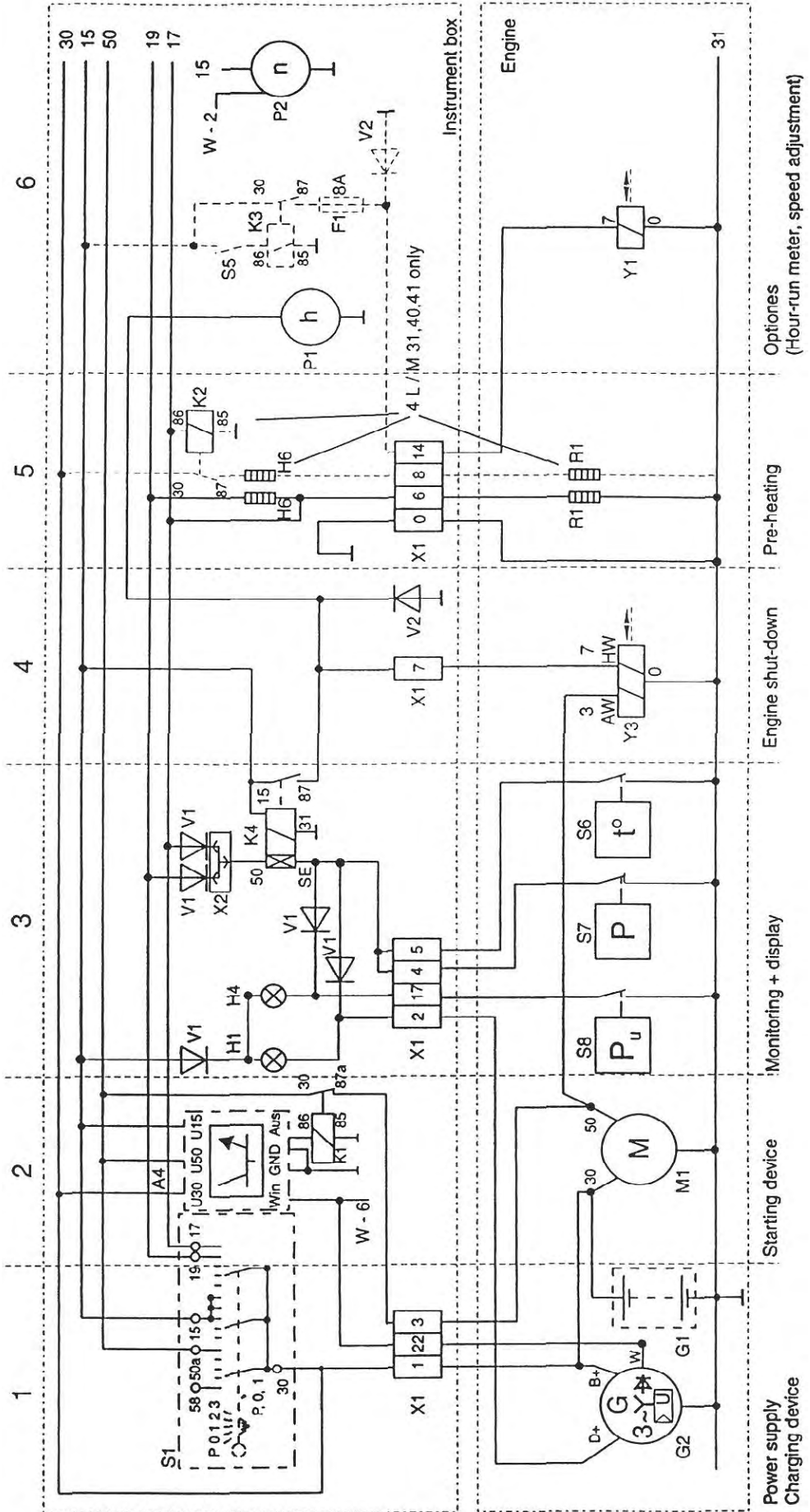
**Circuit diagram 12 V - system with fault display**



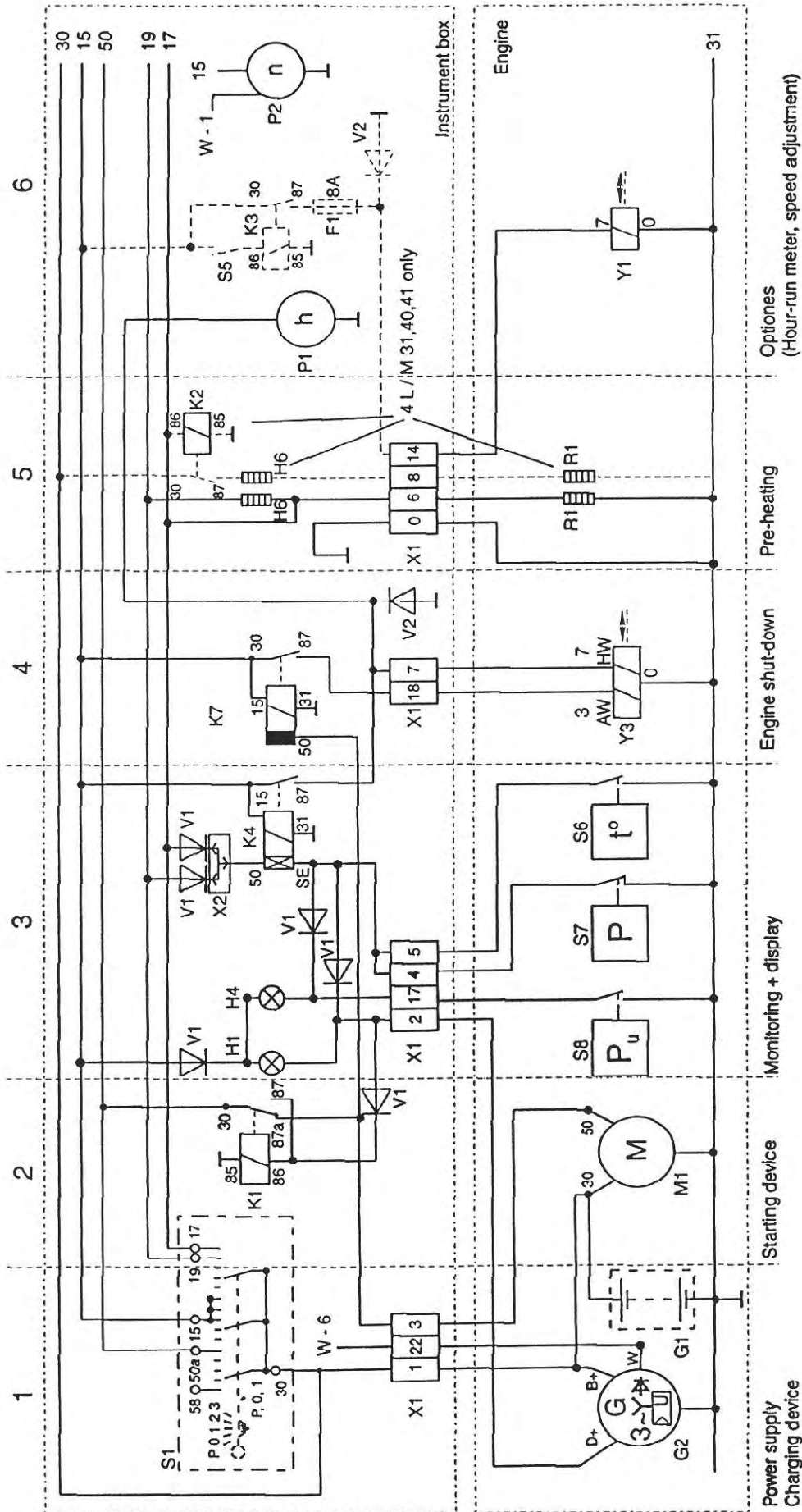
# Circuit diagram 12 V - system with fault display and starter protection module



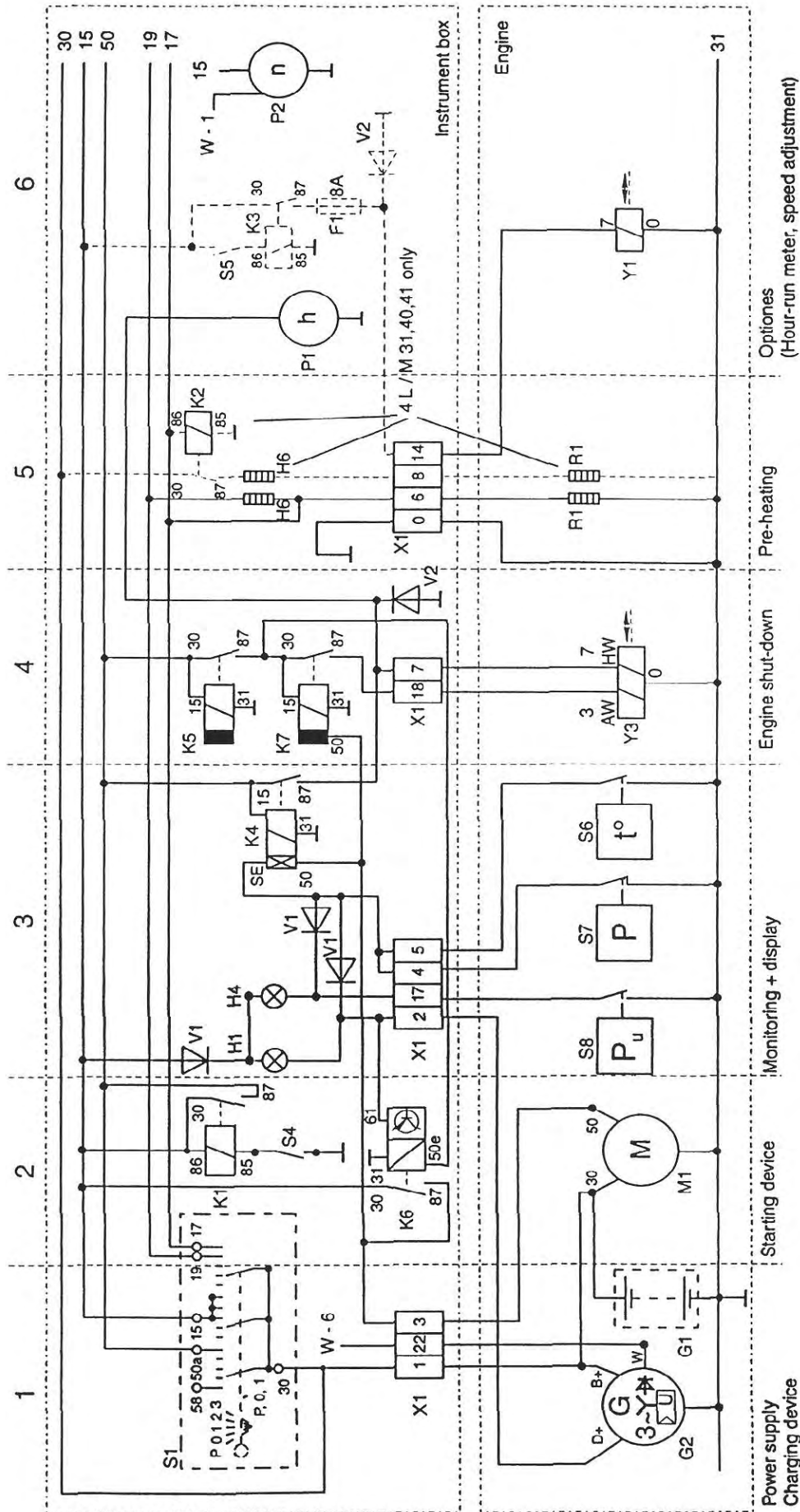
**Circuit diagram 12 V - system with automat. shut-down and starter protection module**



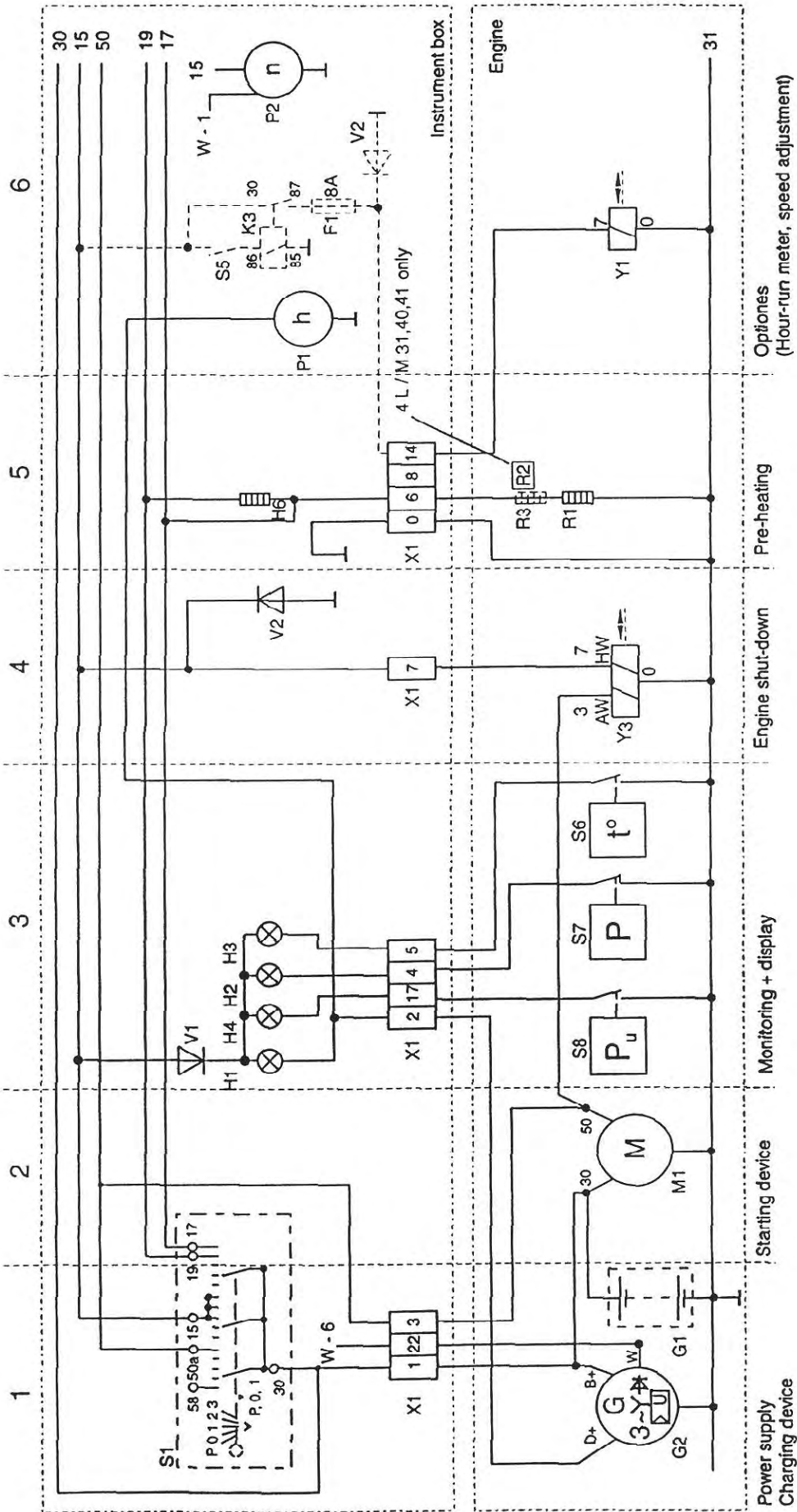
# Circuit diagram 12 V - system with automatic shut-down and time relay



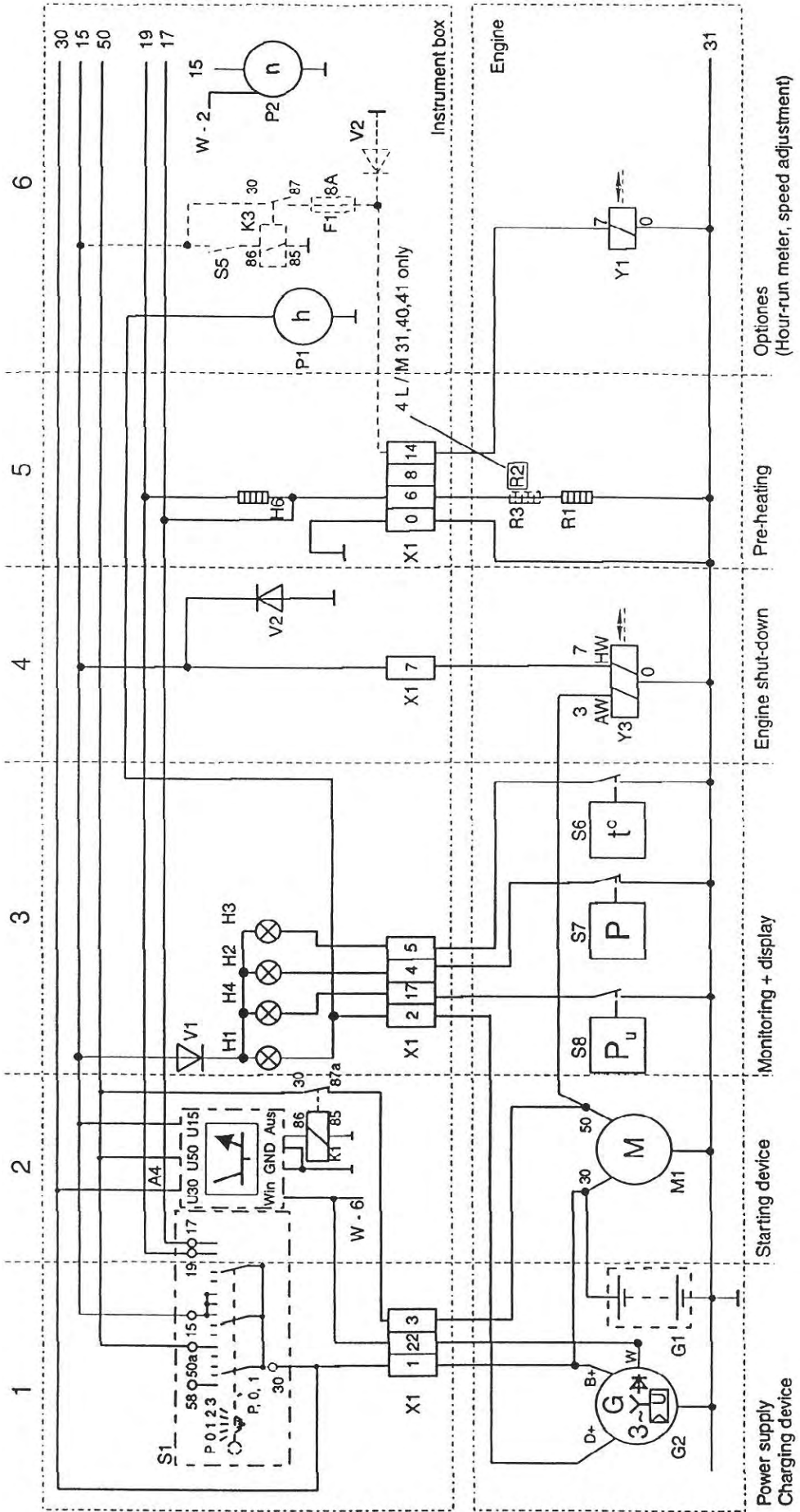
**Circuit diagram 12 V - automatic start/stop with repeat start interlock and time relay**



# Circuit diagram 24 V - system with fault display

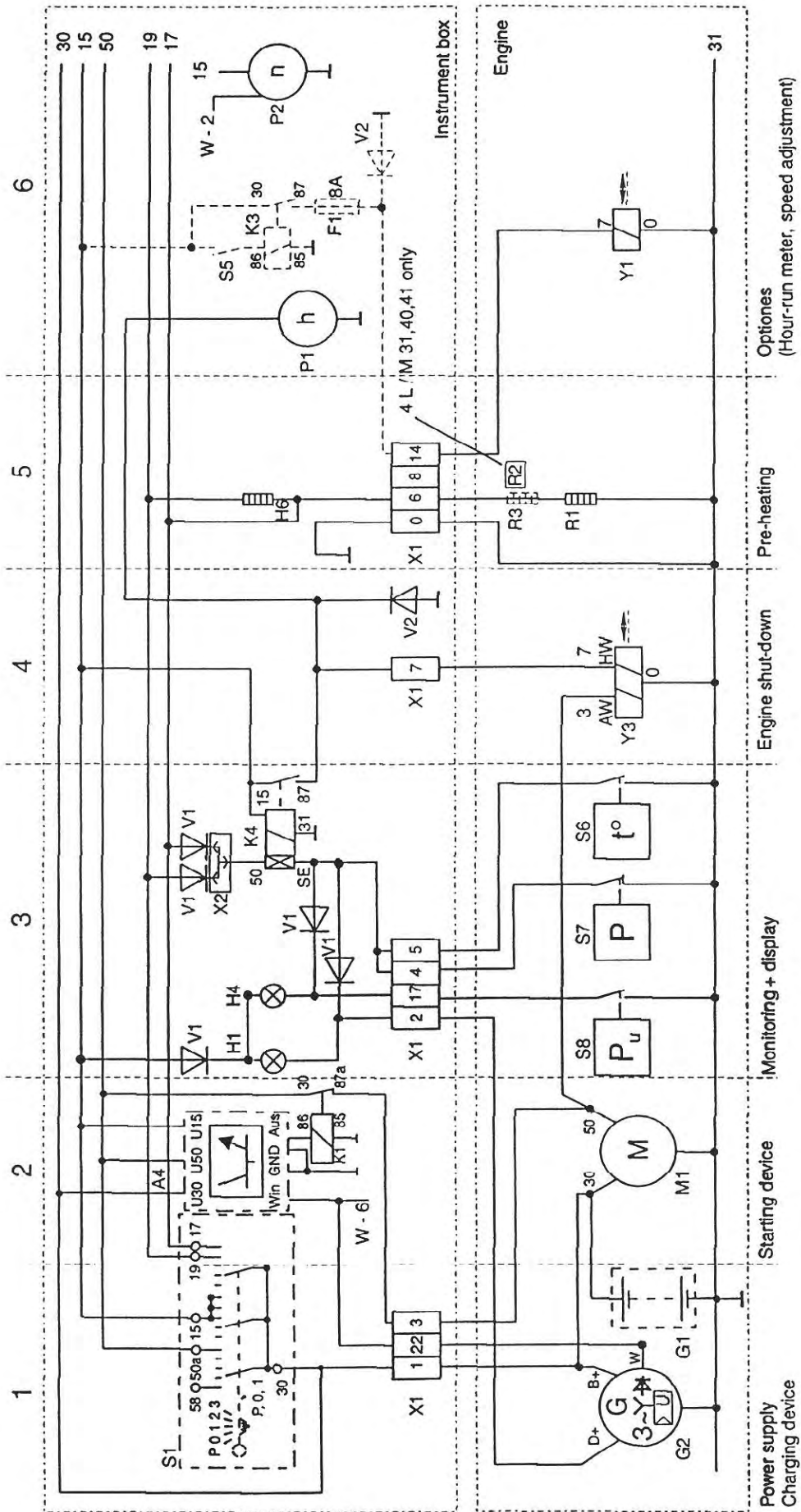


**Circuit diagram 24 V - system with fault display and starter protection module**

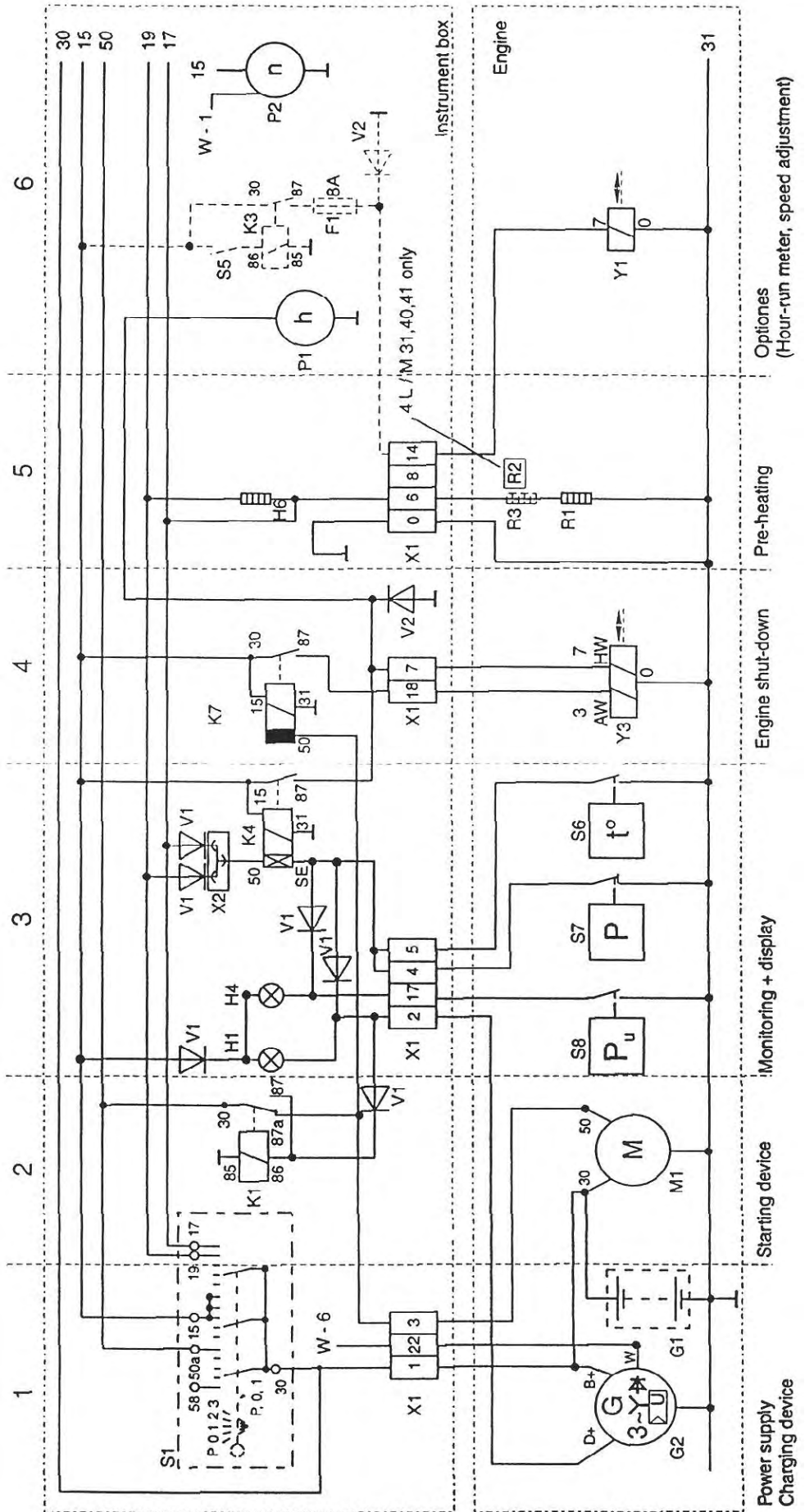




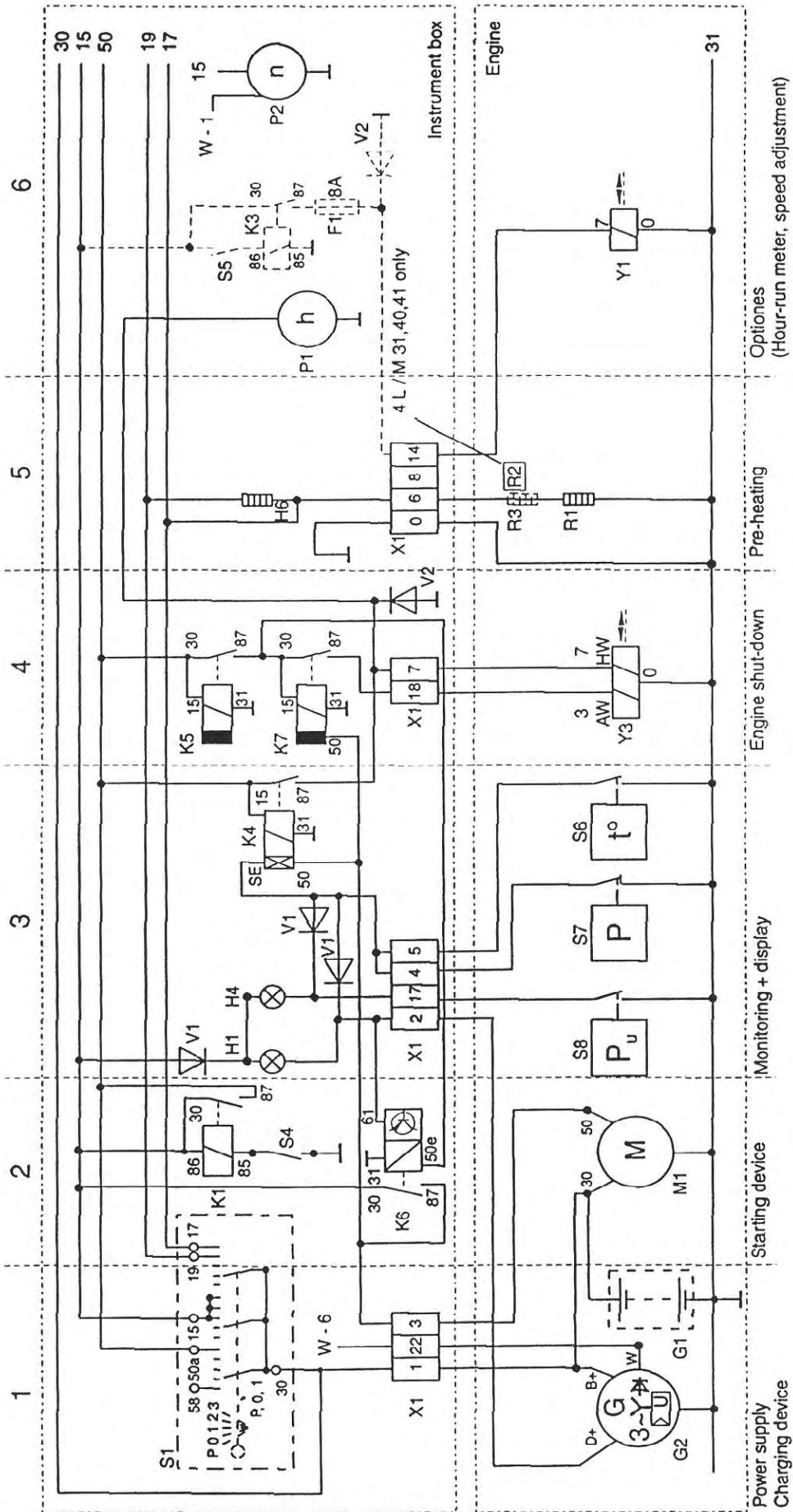
# Circuit diagram 24 V - system with automatic shut-down and starter protection module



**Circuit diagram 24 V - system with automatic shut-down and time relay**



# Circuit diagram 24 V - automatic start/stop with repeat start interlock and time relay



# Trouble-shooting table for electrical system

## Trouble-shooting at instrument box

Malfunction	Cause	Remedy
Starter remains engaged although pre-heat/starter switch was released.	Pre-heat/starter switch sticks in position 3 after starting and does not return automatically to position I.	Set pre-heat/starter immediately to 0 by force; if this is not possible, disconnect the battery at once. (If the starter remains engaged for more than 2 to 3 minutes, it will burn out.) Renew the pre-heat/starter switch.
Alternator telltale light does not come on when engine is stopped and pre-heat/starter switch is on.	Bulb has blown or contacts are corroded.	Insert a new bulb, clean the contacts.
	Battery is flat.	Recharge the battery.
	Battery is defective (internal short-circuits or sulphatised).	Renew the battery.
	Defective pre-heat/starter switch, poor connections, defective wiring, contact resistance in charging current circuit or line to generator telltale light.	Eliminate contact resistance, renew wiring, tighten loose terminals, if necessary renew pre-heat/starter switch.
	Defective voltage regulator.	Renew voltage regulator.
	Short-circuit at exciter or positive diode in generator.	Disconnect charge line B+ (to prevent discharge at a standstill), have generator repaired.
	Worn carbon brushes.	Renew carbon brushes.
	Oxide desposit on sliprings, exciter winding is interrupted.	Have generator repaired.
Generator telltale light flickers.	V-belt loose at generator.	Correct V-belt tension.
Generator telltale light continues to glow, after starting engine.	Poor earth (ground) connection in instrument box.	Make a clean earth connection in the instrument box.
	Wiring error, e.g. generator telltale light leads to oil pressure switch.	Check the line from the generator telltale light to the generator and correct the wiring if necessary.

# Trouble-shooting table for electrical system

## Trouble-shooting at the battery

Malfunction	Indication	Cause	Remedy
Battery not re-charged, re-charged too little or goes flat rapidly.	Terminal voltage drops even a short time after recharging to 7 V despite a 12 V nominal voltage (or 14 V if nominal voltage is 24 V).	Poor connections, open circuit or contact resistance in charging circuit, short-circuit in line.	Eliminate the open circuit, clean the terminals, tighten terminals if slack.
		Battery defective, internal short-circuit.	Renew battery.
		Capacity of battery has dropped severely, because it was heavily discharged for a lengthy period (greyish-white cell plates = „sulphatised“).	Recharge battery at low current (app. 1/40 of Nominal capacity in Amps) for about 50 hours. (This is only possible if sulphate coating is not yet too stron.) Otherwise: renew the battery.
		Battery poles connected up wrongly, destroying one or more diodes in the generator.	Have generator repaired.
		Charge current too weak (esp. in winter).	Recharge the battery.
		Battery capacity is too large.	Install a smaller battery or a larger generator.
		Defective voltage regulator (e.g. overheated/overloaded).	Renew the voltage regulator.
		Loose V-belt at generator.	Correct V-belt tension.

# Trouble-shooting table for electrical system

## Trouble-shooting at the battery

Malfunction	Indication	Cause	Remedy
<b>Corroded terminal clips.</b>	Inadequate current flow, white salt deposits.	Sulphuric acid attacks metals (except lead).	Wash down terminals with hot soda lye (but this must not enter the battery!), rinse with cold water and apply acid-resistant grease.
<b>Battery is over-charged.</b>	Voltage at terminals is always above 16.5 V with 12 V nominal voltage (or above 33 V with 24 V nominal voltage), specific gravity of acid is above 1.285 kg/l so that the battery boils.	Charging voltage too high.	Check voltage regulator, renew if necessary.
		Capacity of chosen battery is too small.	Install a battery of larger capacity. As a temporary measure, discharge the battery at intervals, e.g. by switching on an electrical consumer when the engine is not running
		Engine was run continuously (several days) with very little electrical consumption (e.g. as a boat engine).	Install a voltage regulator with a different characteristic (lower charge-end voltage).
		Defect in voltage regulator or generator.	Have the voltage regulator and generator checked, renew defective components.
<b>Acid level is to low</b>	Acid is escaping from the cell plugs.	Acid level is too high.	Siphon off excess acid.
	Acid level less than 10 mm (0.4 in) below top of cell plates.	Overloading or natural water loss by evaporation (particularly in summer).	Add distilled water or demineralised water.

# Trouble-shooting table for electrical system

## Trouble-shooting at the battery

Malfunction	Indication	Cause	Remedy
Battery fails prematurely.		Battery was discharged too often and too severely.	Check ratings of battery and generator, if necessary fit a special „Z“ or „HD“ battery.
		Battery becomes too warm.	Install it at a more favourable point.
		Excessive vibration.	Install battery at a more favourable point or use an „Rf“ battery (shakeproof)
		Battery is discharging sulphates.	Charge the battery at a small current level (app. 1/40 of its nominal capacity in Amps) for about 50 hours. Failing this, renew the battery.
		Battery acid is contaminated.	Renew the battery.
Too little power from battery.	Voltage drops severely when load is applied.	Run the battery down.	Recharge battery with a suitable charger.
		Voltage regulator is defective, so that charging voltage is too low.	Renew voltage regulator on generator.
		Connecting terminals loose or oxidised.	Clean the terminal clips and apply acid-proof grease to them, then retighten the terminal clips.
		Battery capacity is too small (too many consumers).	Install a larger battery and if necessary a larger generator.
		Battery is going flat because of impurities in its acid.	Renew the battery.
		Sulphate deposits from battery (white coating on plates).	Charge the battery for app. 50 hours at a low current.
		Battery is exhausted, active substance has fallen out of plates.	Renew the battery.
		Acid level too low.	Top up with distilled water.

# Trouble-shooting table for electrical system

## Trouble-shooting at the battery

Malfunction	Indication	Cause	Remedy
Rate of charge never adequate.	Terminal voltage soon drops to 7 V after recharging (12 V nominal voltage) or to 14 V (24 V nominal voltage).	Fault in generator, voltage regulator or wiring connections.	Repair or renew generator and voltage regulator. Connect wiring firmly.
		V-belt too loose.	Correct tension or renew V-belt.
		To many consumers connected or generator is too small.	Install battery and generator with similar ratings.



# Trouble-shooting table for electrical system

## Trouble-shooting at the starting device

Malfunction	Indication	Cause	Remedy
Starter motor does not turn when pre-heat/start switch is operated.	Generator telltale light does not come on.	Poor connections (loose or corroded), break in cable or short to earth (ground).	Check battery lead and connections, clean battery posts and terminals, make sure connections are clean.
		Battery flat or defective.	Recharge or renew battery.
	Telltale light grows slowly dimmer when pre-heat/start switch is operated.	Battery is flat.	Recharge the battery.
	Telltale light is on brightly.	Line between terminal 50 and starter switch or between terminal 30 and battery is interrupted or starter switch is faulty.	Repair the break or if necessary renew the starter switch.
	Bridge terminals 30 and 50 briefly at the starter motor, the starter then turns.	Starter inhibit relay or delaying relay defective.	Renew defective relay.
	Telltale light burns brightly. Terminal 30 is not connected to positive battery pole.	Starter pre-engagement winding has burned out.	Renew the starter motor and ensure a good connection between terminal 30 at the starter and the positive battery post (main starter line).
Telltale light burns brightly, solenoid switch is energised, when solenoid switch is bridged, starter motor turns.	Worn or dirty contacts on solenoid switch.	Renew solenoid switch.	

# Trouble-shooting table for electrical system

## Trouble-shooting at the starting device

Malfunction	Indication	Cause	Remedy
<b>Starter motor turns too slowly or cannot turn the engine over.</b>	Lengthy operating period without maintenance or in tough environmental condition.	Carbon brushes sticking.	Renew brushes and brush holder guides.
		Carbon brushes worn.	Renew carbon brushes.
		Poor spring pressure, carbon brushes not making contact.	Renew springs.
		Commutator is dirty.	Clean the commutator.
		Commutator is scored or burnt.	Recondition or renew starter motor.
		Armature or field coils defective.	Recondition or renew starter motor.
<b>Starter engages and is energized, but engine does not turn or only turns jerkily.</b>	Lengthy operating period without maintenance, electrical system has been neglected.	Battery is flat.	Recharge the battery.
		Low current flow because of loose or corroded connections.	Clean battery 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 burnt.	Recondition or renew the starter motor.
		Armature or field windings defective.	Recondition or renew the starter motor.
<b>Starter pinion does not engage or disengage.</b>	Engine does not turn, or turns jerkily.	Starter pinion or helical thread dirty or damaged.	Renew starter pinion, recondition starter motor.
		Flywheel gear ring damaged.	Remachine or renew gear ring.
		Solenoid switch defective.	Renew solenoid switch.
		Return spring weak or broken.	Renew return spring.

# Trouble-shooting table for electrical system

## Trouble-shooting at the starting device

Malfunction	Indication	Cause	Remedy
Starter motor continues to run after switch was released.	Noise of rotation.	Starter relay defective.	Switch off engine manually at once (set speed control lever to „stop“ and disconnect battery). Consequential damage: electronic components destroyed. For example: diodes in generator. Check switches, relays and generator, renew parts if necessary.
		Pre-heat/switch does not return automatically from position 3 to position 1.	Set pre-heat/start switch to 0 immediately using force if necessary and renew it. If this is not possible: disconnect the battery immediately. Consequential damage: diodes in generator destroyed. <b>Warning !</b> <b>Unless the above measures are taken within 2-3 minutes, the starter motor will burn out (overheating)</b>
		Diode in shutdown solenoid (lifting or servo electromagnet) is defective.	Renew solenoid.
Engine does not start or starts reluctantly, although the starter motor is turning strongly.		Valve solenoid on monitoring block is not opening.	Check operation of valve solenoid and renew if necessary.
		Pre-heat system is defective (only significant at temperatures below -10 to -15°C.)	Check pre-heat circuit and renew any defective parts.

# Trouble-shooting table for electrical system

## Trouble-shooting at the pre-heat system

Indication	Cause	Remedy
<b>Spiral indicator element (pre-heat monitor) glows brightly almost immediately.</b>	Short to earth (ground) in a pre-heat plug, pre-heat element (filament) is bent and shorting inside engine.	Renew the pre-heat plug.
	Broken pre-heat wires in a line resistor, winding shorted to an earthed component.	Renew the line resistor.
<b>Unterbrechung der Glühanlage (Glühüberwacher brennt nicht)</b>	Since the pre-heat monitor, pre-heat plug or heating flange (and also the second pre-heat plug or line resistor on 24 V systems) are wired in series, the complete pre-heat system is out of action if a component fails.	Use a test lamp or a voltmeter (with the pre-heat system switched on) to check all the pre-heat monitor connections. Renew defective parts.

# Trouble-shooting table for electrical system

## Trouble-shooting at the alternator

Indication	Cause	Remedy
<b>Generator telltale light does not go out as engine speed increases.</b>	Line D+/61 has a short to earth	Renew the line or repair the short to earth.
	Voltage regulator on generator is defective.	Renew voltage regulator.
	Wiring connections interchanged at generator.	Connect the wiring correctly.
	V-belt for generator is slipping or broken.	Correct V-belt tension or renew V-belt.
	Defective rectifier on generator, dirty sliprings, short-circuit in line DF or rotor winding.	Have generator repaired.
<b>Generator telltale light does not go out at low engine operating speed (e.g. 1500 rpm)</b>	Generator is not sufficiently excited by telltale light. A 2 Watt bulb is normally used in the light.	Install a bulb of higher rating, e.g. 2 W -> 3 W. Warning: bulb rating must not exceed 5 W (or pre-exciter circuit will be destroyed)
<b>Generator telltale light glows only dimly when engine is stopped and pre-heat/start switch is operated, battery not being charged, or charging only at a low rate.</b>	Rate of charge too low, brief engine operating periods (particularly when a maintenance-free, vibration-proof battery is used).	Short-term remedy: recharge battery with a suitable charger. Long-term remedy: use a battery with better charge characteristic.
	Poor connections, open circuit, contact resistance or short-circuit in charging circuit.	Repair the break, clean the battery terminals, tighten loose clamps.
	Battery is defective, internal short-circuit.	Renew battery.
	Battery capacity has dropped severely through being left flat for a long time (sulphate deposits).	Recharge battery at low current for about 50 hours. (Only possible if sulphate deposits are not too extensive). Otherwise: renew battery.
	Battery capacity is too large.	Install a smaller battery or a larger alternator.
	Alternator is defective.	Have alternator repaired.
	Voltage regulator is defective.	Renew voltage regulator.
	Loose V-belt at alternator	Correct V-belt tension.

# Trouble-shooting table for electrical system

## Trouble-shooting at the alternator

Indication	Cause	Remedy
When engine is stopped the generator telltale light burns brightly, but when engine is running telltale light glows dimmer.	Poor connections, contact resistance in charge circuit or in the line to the generator telltale light.	Eliminate contact resistance, clean terminals, tighten loose terminals.
	Defective voltage regulator.	Renew voltage regulator
	Defective alternator.	Have alternator repaired.
Generator telltale light does not come on when engine is stopped and pre-heat/start switch is turned on.	Generator telltale light bulb has blown or contacts are corroded.	Install a new bulb. Clean the contacts.
	Battery is flat.	Recharge with a suitable charger.
	Battery is defective (internal short-circuit or sulphate deposits).	Renew the battery.
	Defective pre-heat/start switch, poor contacts. Defective wiring line resistance in charging circuit or line to generator telltale light.	Eliminate contact resistance, renew wiring, tighten loose terminals, if necessary renew pre-heat/start switch.
	Defective voltage regulator.	Renew the voltage regulator.
	Short-circuit in an alternator exciter or positive diode.	Disconnect charging line B+ (to prevent discharge at a standstill), have alternator repaired.
	Carbon brushes worn.	Renew carbon brushes.
	Corrosion deposits on sliprings, open circuit in exciter winding.	Have alternator repaired.
Generator telltale light flickers.	V-belt at alternator is too slack.	Tension V-belt correctly.

## Trouble-shooting table for electrical system

### Trouble-shooting at engine monitor and display

Indication	Cause	Remedy
<b>Sudden pressure drop in lubricating oil circuit.</b>	Leak in oil circuit.	Check lines and seals, renew if necessary.
	Oil lost from damaged sump.	Renew the oil sump.
	Defective oil pump.	Renew the oil pump.
<b>Engine cannot be stopped at valve solenoid or fuel shut-off valve.</b>	Defective valve solenoid or fuel shut-off valve.	Examine parts and renew if necessary.
	Defective diode between generator telltale light and terminal 15 at pre-heat/start switch, or diode by-passed.	Check the circuit and renew the diode if necessary.
<b>Incorrect display, light does not come on although a fault is present.</b>	Short to earth (ground) in wire or switch.	Check wiring and eliminate short to earth.
	Defective switch.	Renew switch.
<b>No display, display light does not come on despite malfunction.</b>	Broken wire.	Renew broken wire.
	Defective switch or relay.	Renew defective components.
	Defective bulb.	Renew the bulb.

Engine protection relay: see „Instrument box“

# Trouble-shooting table for electrical system

## Trouble-shooting at electromagnetic components

Indication	Cause	Remedy
<b>Electromagnet does not switch engine off or vary engine speed.</b>	Defective electromagnet (e.g. winding burned out).	Renew electromagnet.
	No power supply or open circuit.	Check the circuit.
	Defective switch or relay.	Renew defective component.
	Decoupling diode between generator telltale light and terminal 15 is missing or defective (applies only to shut-down solenoid with alternator).	Check the circuit and install or renew decoupling diode as necessary.
<b>Malfunction or failure of other electrical or electronic components.</b>	Freewheel diode parallel to a solenoid is defective.	Renew freewheel diode.
<b>Starter motor does not disengage.</b>	Defective diode in shut-down solenoid (lifting or servo solenoid).	Renew solenoids.