WORKSHOP MANUAL

FOR

Bellett & Wasp

ENGINE SERIES

ISUZU MOTORS LIMITED

TOKYO, JAPAN

FD-2205

PREFACE

This manual is intended to provide full information relation to the maintenance work for the "Isuzu Bellett" gasoline and diesel engines.

The "Isuzu Bellett" is a sport type sedan of high performance made exclusively available by the superior engineering staff of this company with years of experience in the production of a wide variety of automobiles with the latest equipment and facilities.

Proper care, maintenance and servicing are the important key to maintain the automobile in optimum operating condition and to minimize the maintenance cost.

This manual includes as many photographs and illustrations as possible and so arranged as to furnish the Isuzu Motor Service-men with the point-by-point, easy-to-understand maintenance procedures.

As the reference values given herein are subject to change as amendments dealing with design modifications are made, it is requested that the values given in the revised maintenance standard table may be used as references.

All the numerical values are represented in metric system so that a convension table provided in the last page may be used for converting the values into corresponding inches.

As the Wasp *is equipped with the same gasoline engine as mounted on the* Isuzu Bellett, *this manual may also be used as a reference for the maintenance and servicing of the* Bellett *&* Wasp.

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Supplement

FIVE BEARING ENGINES

CONTENTS

Introduction

The total performance such as durability, smoothness of operation and docility of the Bellett and Wasp engines has been remarkably improved as a result of major changes made recently in the engine design.

The following chapters deal with the details of changes in engine design and alterations that will have to be made in the service procedures. This supplement may be used together with the Bellett workshop manual to obtain correct service information.

Details of changes in engine design

ENGINE COMPONENT

Name of the parts subjected to alteration	G130	G150	G161 (G160)	C180
Crankshaft bearing	O	O	O	
Cylinder head and head bolts	O	O		
Crankshaft pilot bearing	O	O	O	
Dimensions of pistons	O	O		
Profile of camshaft	O	O		
Tappets and valve springs	O	O	O	
Oil pan	O	O	O	
Crankcase ventilation device	O	O	O	
Water pump	O	O	O	
Air cleaner element	O	O	O	
Ignition timing cover oil seal	O	O	O	
Engine front foot	O	O	O	
Connecting rod	O	O	O	

Name of the parts subjected to alteration	G130	G150	G161 (G160)	C180
Carburetor	O	O		
Oil pump	O	O		
Cylinder bore and piston stroke			O	
Camshaft bearings			O	
Cromard liners				O
Piston rings				O

AUXILIARY EQUIPMENT

1. Starter
2. Generator and voltage regulator
3. Distributor
4. Battery
5. Fuse

Details of changes in design and service procedures altered

ENGINE COMPONENT

1. Engine models: G130, G150 and G161 (same as previous model G160)

   a. Crankshaft bearing

   The new 5-bearing support system that replaces the 3-bearing support in the engine of the previous model contributes to: Improved rigidity in the crankshaft support, minimized bearing loads through an even distribution of loads, increased durability of the component parts and minimized engine vibration and operating noises.

In the new engine, the bearings are numbered from the front of the engine in numerical order beginning with No. 1 and ending with No. 5. The names such as front, rear and center which are used to identify the bearings are no longer used in the new engine.

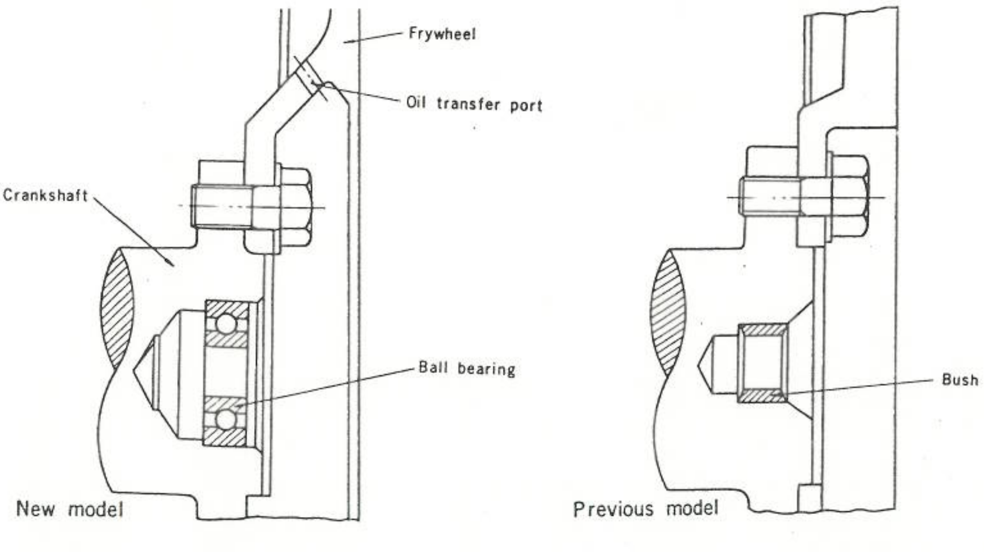
When reassembling the engine, care should be exercised to ensure that the bearings are reinstalled in their correct positions. No. 2 and No. 4 bearings are identical in shape, however, the No. 2 bearing is identified with the mark "A" on the back of the bearing cap.

b. Cylinder head and head bolts

In order to improve the durability of the cylinder head, the outside diameter and threading of the cylinder head bolts are altered from 10ϕ pitch 1.25 to 12ϕ pitch 1.5 with the consequential changes in the bolt hole diameter and threading from 10.5ϕ to 12.5ϕ. The cylinder head bolts tightening torques are as mentioned in subparagraph "Tightening torques".

c. Crankshaft pilot bearing

For improved durability, the new engine uses a ball bearing in place of a bush. As a result, a hole is drilled through the fly wheel to permit flow of grease that is transferred from the ball bearing. A special tool should be used to remove the pilot bearing.



d. Pistons

Pistons have been completely redesigned to eliminate operating noise as well as to prevent piston seizure at high-speed operation under full-load condition. Reduction in piston weight contributes to improved durability of all moving parts. In the model G161 engine, the sizes of the pistons and rings are altered to compensate for the change in bore and stroke. The shape of the piston crown has also been changed from flat to convex for better combustion of fuel mixture.

e. Camshaft

Change in the profile of the camshaft and valve timing contributes to increased low-speed torque and minimized fuel consumption. Improvement in low speed torque results in smoother engine operation, higher stability and minimized vibration and noise. The engine idle speed is now set to 550 - 600 rpm instead of 600 - 650 rpm for previous model.

Valve clearances (hot engine)	New model	Previous model
Intake	0.25mm (0.010 in)	0.30mm (0.012 in)
Exhaust	0.35mm (0.014 in)	0.35mm (0.014 in)

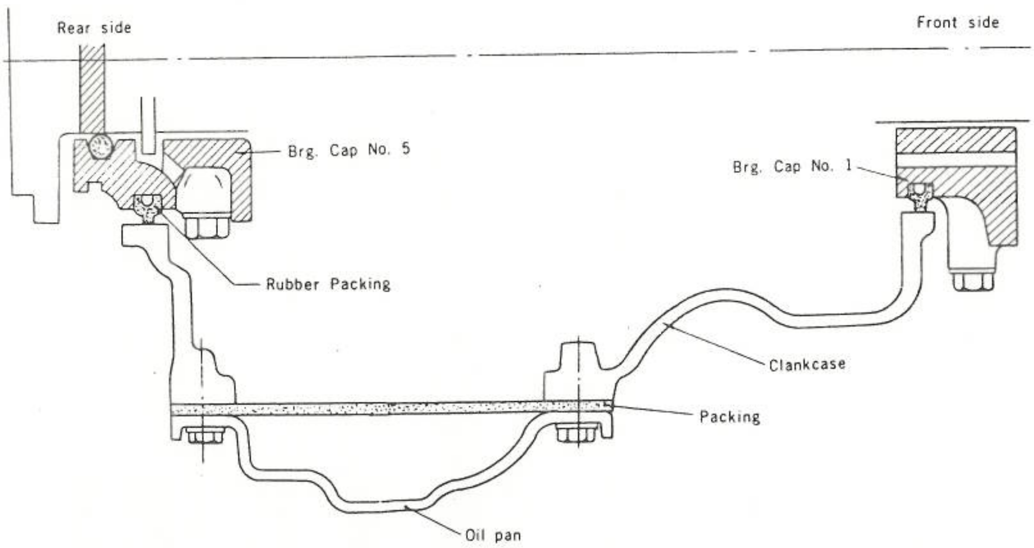
Valve timing		G130	G150
Intake open	15° B.T.D.C.	40°	38°
Close	73° A.B.D.C.	74°	82°
Exhaust open	55° B.B.D.C.	70.5°	73°
Close	29° A.T.D.C.	23.5°	35°

f. Tappets and valve springs

In order to obtain longer service life from the camshaft and tappet and to hold wear to a minimum, the radius of the spherical head of the tappet has been altered with its surface finish upgraded. To remove undesirable factors which are responsible for serging or valve bouncing at higher engine speeds as well as to improve durability of the component parts with lessened engine noises, the new engine adopts valve coil springs with asymmetrical pitching. When reassembling the valve mechanism, the valve springs should be fitted into their positions with their ends with close pitch turned down.

g. Oil pan

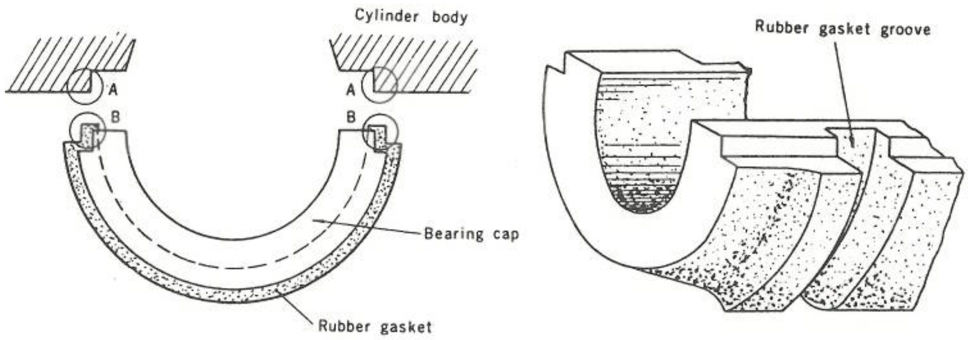
The oil pan in the previous model which is integrally formed of pressed steel is now replaced by the split type oil pan comprising aluminum built upper part and steel pressed lower part. The upper face of the oil pan (referred to as a crankcase hereafter) is bolted to the lower face of the cylinder body with sealing compound applied on the flat faces and rubber gasket on the arches (portions where bearing caps are installed). The lower part of the oil pan is bolted to the crankcase with seat gasket inserted.



The following should be carefully observed when fitting the oil pan and gasket.

1) Fitting the bearing cap gasket

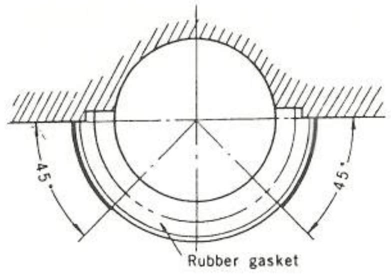
Loosen all the bearing caps (No. 1 bearing to No. 5 bearing) and take out No. 1 and No. 5 bearing caps. Then, fit rubber gasket to their outer faces making sure that both edges of the gaskets protrude evenly on the side edges of the bearing cap.



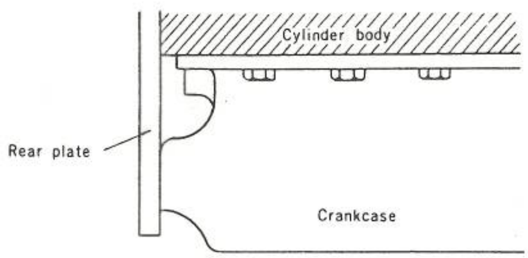
Install No. 1 and No. 5 bearing caps in the cylinder body with the rubber gaskets in their positions while making sure that the ends of the gasket (indicated by "B" in the above figure) are not binding in the cylinder body at portions denoted by "A". Coat the mating faces of the bearing cap and body with sealing compound. (Delco bond No. 4) After the bearing caps are all installed, tighten them to 9 - 10 kg-m torques. (65 - 72 lb-ft)

2) Fitting the crankcase

Coat the mating faces of the crankcase and cylinder body with sealing compound and carefully note the following. When applying the sealing compound, coat only the areas of the bearing cap apart from the center but toward the ends of the cap. (The area that comes within 45° as shown in figure .)



Allow the sealing compound to settle so that it is no more tacky. Then bring the rear end of the crankcase into firm contact with the rear plate and tighten them to 2 kg-m torques. (14 lb-ft)



3) Fitting the oil pan

Coat the mating faces of the crankcase and oil pan and both sides of the gasket with sealing compound. Allow sealing compound to settle so that it is no more tacky. Assemble the parts together and tighten them to 0.8 kg-m torque. (6 lb-ft)

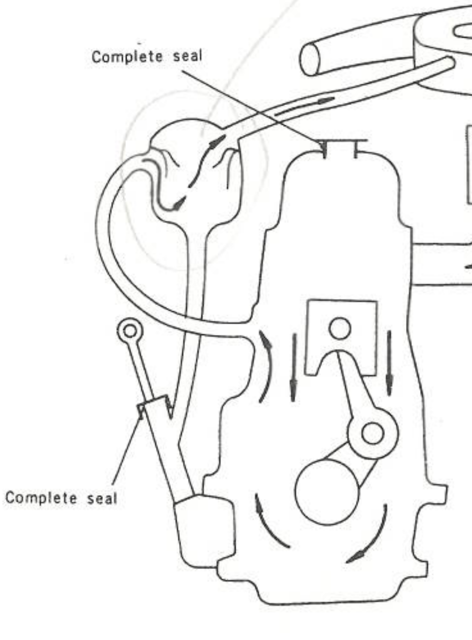
h. Crankcase ventilation

In the conventional ventilating system, fresh air is drawn into the crankcase, through the filler cap for circulation, and is then exhausted through the breather pipe together with the blow-by gases. The new engine, however, has a crankcase which is completely sealed but communicated with the carburetor through the air cleaner. In the new system, the blow-by gases that remain in the crankcase is forced into the carburetor through the air cleaner for recombustion. The new engine is equipped with a screw type filler cap that help retain the crankcase air-tight. The new engine is no longer equipped with the breather pipe.

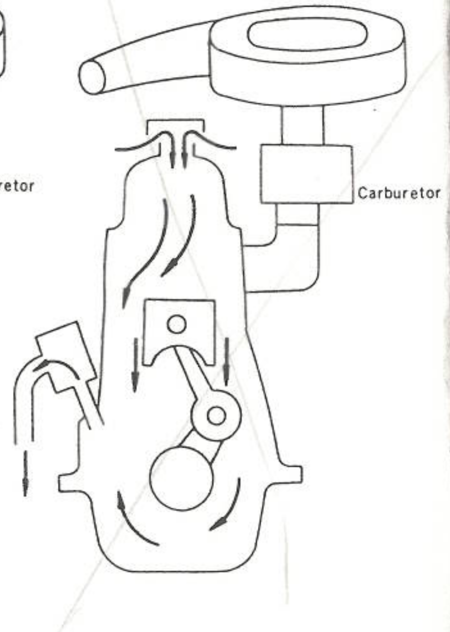
In addition to the above filler cap the new engine has a blow-by gas induction pipe connected between the cylinder body and air cleaner.

The induction pipe has, on its way to the carburetor, an oil separator which prevents entry of oil from the crankcase into the air cleaner and leads the separated oil back into the crankcase. The oil separator has a steel wool strainer which should be cleaned with gasoline or detergent oil at every 18,000 km (12,000 miles) interval.

puhdistettava esim. bensiinillä
joka 18000 km jälkeen!



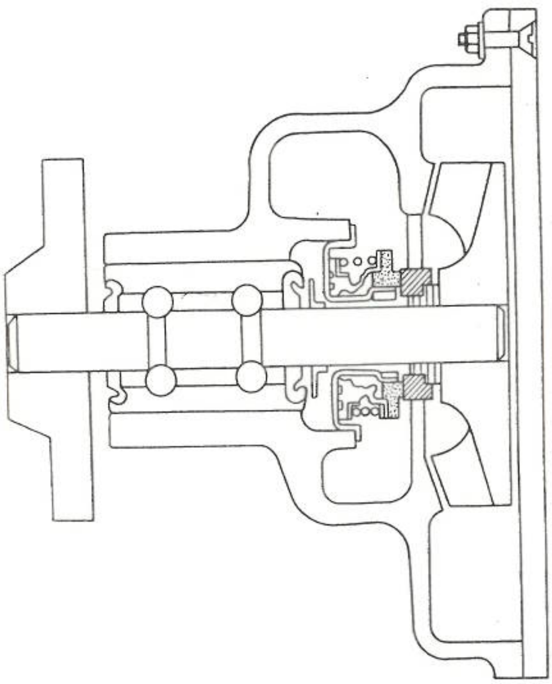
New model



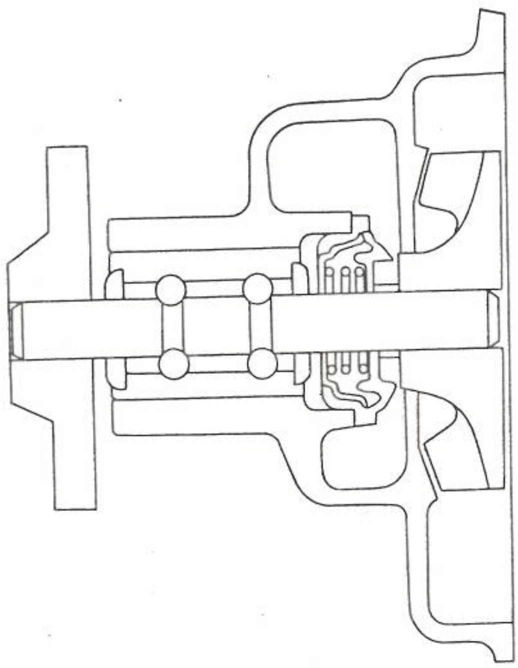
Previous model

i. Water pump

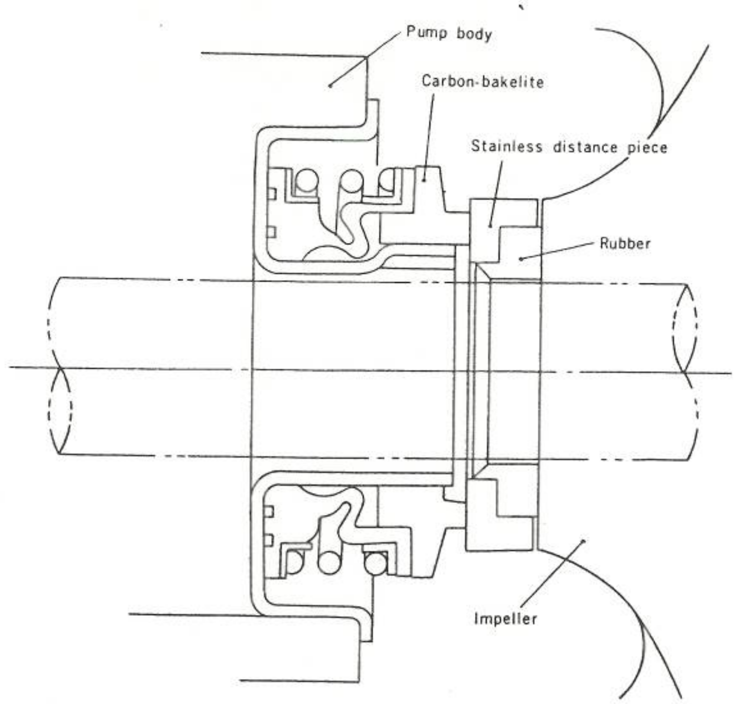
In order to prevent the seal unit from wear and to obtain longer service life from the pump, a stainless distance piece is inserted between the seal unit (carbon-bakelite) and impeller. Due to the change in the design of the front plate, a cover is used in the rear part of the water pump body.



New model



Previous model



Cross-sectional view of the seal unit

j. Air cleaner element

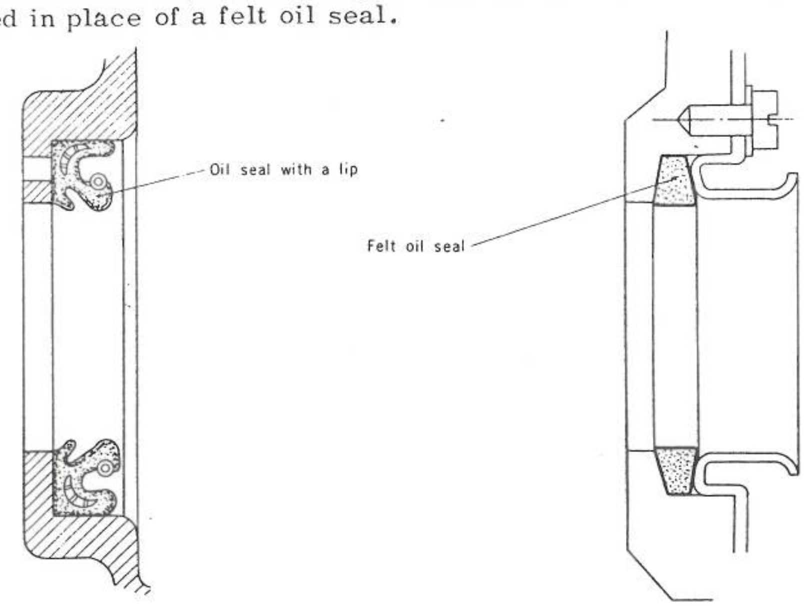
To minimize frequent air cleaner servicing, a viscous type paper element is used in place of the conventional paper element. The entire surface of the paper filter of the viscous type paper element is saturated with special viscous material which remains adhesive to provide an effective filteration. The function of the viscous type filter element is as follows. Dusts or foreign matters taken into the cleaner cling to the surface of the filter element where they are saturated by the viscous material to form a porous layer of dusts. This layer lends itself to an effective filteration thereby collecting dusts or other foreign matters which will become another layer of dusts and thus repeating the cycle of filteration. For this reason, the viscous type paper element will remain effective without any service attention until it becomes due for replacement at 36,000 km (24,000 miles) interval.

Therefore, the viscous type paper element should not be cleaned with compressed air or the like. It should be renewed when it becomes due for replacement.

Ilmansuodatin vaihdettava 36000 km välein.

k. Timing cover oil seal

In order to improve oil-tightness, an oil seal with a lip is used in place of a felt oil seal.

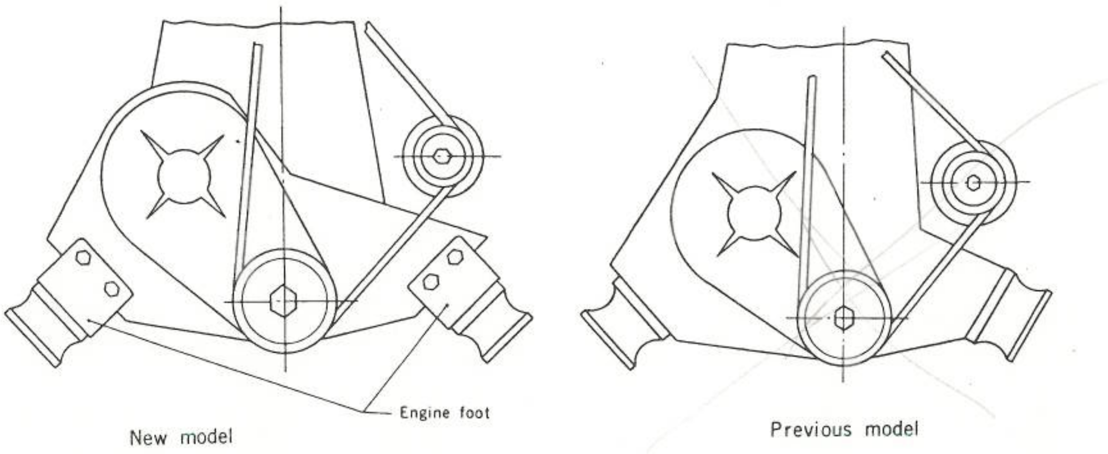


New model

Previous model

l. Engine front foot

In the conventional model, the engine front foot was an integral unit serving also as a front plate. However, the new engine has a separate front foot which is bolted to the engine body and front plate.

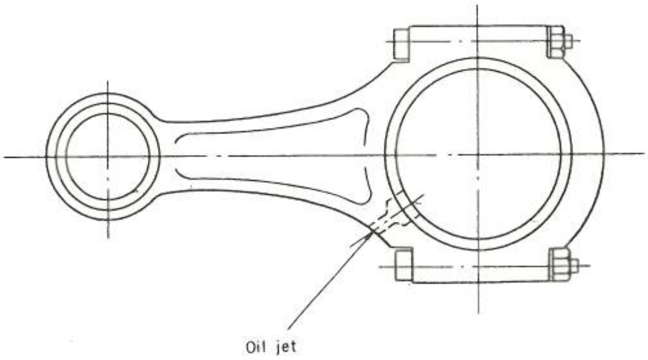


New model

Previous model

m. Connecting rod

In order to improve the durability of the bearings through the reduction in the weight of the connecting rod, the boss on the connecting rod used for weight adjustment is eliminated. The new connecting rod has an oil jet which serves to spit oil on the piston and cylinder wall to deaden tapping noise of the piston as well as to prevent piston seizure.



n. Carburetor

In an effort to meet the standards set forth by the compulsory regulations to minimize atmospheric contamination and to cut fuel consumption, the carburetor is modified with the change in cam profile.

Engine models	Type of carburetors used	
	New model	Previous model
G150	AU-4	AU-3
G130	DAB-308-5B	DAB-308-5A

o. Oil pump

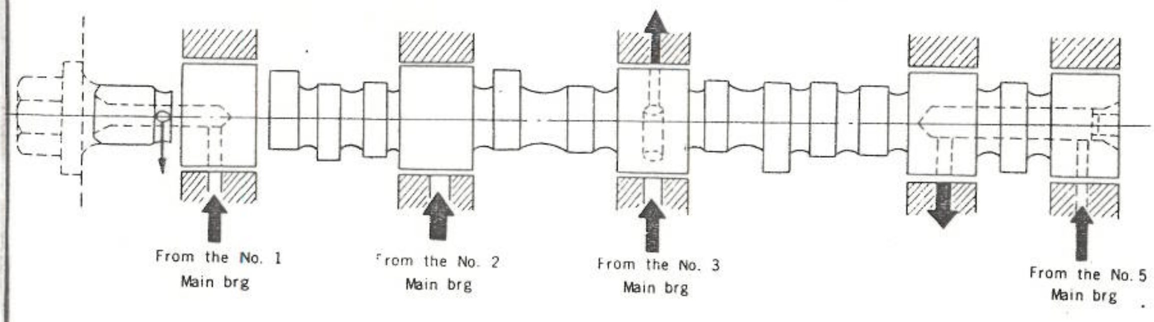
In order to improve the durability of the crankshaft bearings through the better lubrication, the oil delivery of the pump is increased by 22 percent. Redesigning of the engine has made possible the removal and reinstallation of the pump using a special tool with the oil pan removed but without dismantling the engine unit.

p. Bore and stroke

The bore and stroke are altered from 83ø x 73ø to 82ø x 75ø. This alteration has made the crankshafts and connecting rod bearings of the models G130 and G150 completely interchangeable.

q. Camshaft bearing

Due to adoption of 5-bearing crankshaft, the number of camshaft bearings are reduced from 6 to 5. Relocation of camshaft bearings has affected the oil routes through which the bearings are lubricated.



2. Engine model; C180

a. Cromard liners

In order to prevent early wear of the cylinders, cromard liners are newly installed. The cromard liners should not be subjected to honing finish as their inner walls are hard chromium plated.

The liner should be replaced if it has a hard scuffing or ridging which is detrimental to normal engine operation.

b. Piston rings

Due to adoption of cromard liners in the engine, non-plated rings are used with the pistons. Do not use plated piston rings in the cromard liners or piston seizure or damage to the liners will result. The pistons in the new engine have piston rings with coil expanders in their top ring grooves.

AUXILIARY EQUIPMENT

1. Starter

In order to obtain positive engagement from the pinion, a magnet-shift type is used in place of Bendix type.

2. Generator and regulator

With an aim to improve serviceability, the terminals are grouped into a connecting unit.

3. Distributor

Angle advancing characteristics have been altered due to modifications in cam design and carburetor.

4. Battery

To obtain larger capacity from the battery, NS 40Z (35Ah) is used in plate of NS 40 (32Ah).

5. Fuse

Service life is elongated. Spare fuses are removed from the fuse box to gain access.

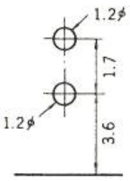
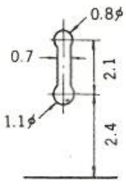
Specifications

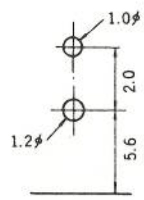
ENGINE

	G130	G150	G161
Bore x stroke mm (in)	75 x 75 (2.96 x 2.96)	79 x 75 (3.11 x 2.96)	82 x 75 (3.23 x 2.96)
Piston displacement cu.cm (cu.in)	1,325 (80.9)	1,471 (89.8)	1,584 (96.7)
Compression ratio	7.5	8.5	9.3
Maximum output (ps/r.p.m.)	58/5,000	68/5,000	88/5,400
Maximum torque kg-m(lb-ft)/r.p.m.	9.8(71)/ 1,800	11.3(81)/ 2,200	13(94)/ 4,200
Compression pressure kg/cm^2 (lb/in^2)	11 (156)	12 (171)	13.5 (194)
Valve timing			
Intake valves open at	15°	15°	38°
Intake valves close at	73°	73°	82°
Exhaust valves open at	55°	55°	73°
Exhaust valves close at	29°	29°	35°
Ignition timing	14°	14°	12°
Engine idle speed (r.p.m.)	550 ~ 600	550 ~ 600	
Carburetor type	Hitachi Solex type DAB-308-5B	Nikki Stromburg type 2D-32-AU4	Hitachi SU type HTD38W

	G130	G150	G161
Fuel pump type	Nikki diaphragm type PD-56Q	Nikki diaphragm type PD-56Q	Nikki diaphragm type PD-56Q
Oil pump type	Trochoid	Trochoid	Trochoid
Amount of delivery ℓ (Imp/US gal)/mm	12.7 (2.8/3.4)	12.7 (2.8/3.4)	12.7 (2.8/3.4)
Oil pressure kg/cm^2 (lb/in^2)	3 ~ 3.5 (42.6 ~ 49.8)	3 ~ 3.5 (42.6 ~ 49.8)	3 ~ 3.5 (42.6 ~ 49.8)
Capacity Max. ℓ (imp/US pints)	3.2 (5.6/6.8)	3.2 (5.6/6.8)	3.2 (5.6/6.8)
Cooling system capacity ℓ (Imp/US pints)	6 (10.6/12.7)	6 (10.6/12.7)	6 (10.6/12.7)
Valve clearances			
(intake) mm (in)	0.25 (0.010)	0.25 (0.010)	0.30 (0.014)
(exhaust) mm (in)	0.30 (0.014)	0.30 (0.014)	0.35
Starter	Hitachi magnet-shift type S114-100	Hitachi magnet-shift type S114-100	Hitachi magnet-shift type S114-100
Capacity (V-KW)	12-1	12-1	12-1
Generator	Hitachi LT-130-35	Hitachi LT-130-35	Hitachi LT-130-35
Capacity (V-KW)	12-300	12-300	12-300

CARBURETOR

	DAB-308-5B (G130)	2D-32-AU4 (G150)
Primary side		
Diameter of outlet	28ϕ	30ϕ
Venturi diameter	20ϕ	20ϕ-8ϕ
Main nozzle	18ϕ x 8	2.8ϕ
Main jet	#93	#86
Main air bleed	#200	Dynamic pressure #60
Emulsion tube	2.4ϕ-4ϕ	—
Emulsion hole	1.6ϕ x 16	0.5ϕ x 20
Slow jet	#40	#42
Slow air bleed	#180	P_1 #0.8ϕ
"		P_2 #200
Idle hole	1.5ϕ	—
Dimensions of slow port		
Throttle valve closing angle	10°	—

	DAB-308-5B (G130)	2D-32-AU4 (G150)
Secondary side		
Diameter of outlet	30ϕ	32ϕ
Venturi diameter	28ϕ	28ϕ-14ϕ-7ϕ
Main nozzle	18ϕ x 8	2.8ϕ
Main jet	#145	#130
Main air bleed	#200	Static pressure #60
Emulsion tube	2.4ϕ-3.2ϕ	—
Emulsion hole	1.0ϕ x 16	Upper 0.6ϕ x 1 Lower 0.5ϕ x 28
Stepped jet	#140	Independent #58
Stepped air bleed	#100	#200
Stepped hole	1.5ϕ x 1	—
Throttle valve closing angle	18°	20°
Throttle opening angle of interlocked carburetors	49°	53°
Damper weight	19 g	Thickness 7 mm
Acceleration pump delivery	0.45 0.35 0.3 0.25 cc/st	0.24 0.34 0.52 cc/st
Dimensions of stepped port	—	

DISTRIBUTOR

1. Specifications (In common with all the models)

Direction of revolution	Counter-clockwise as viewed from the cap side
Contacting pressure	0.5～0.65 kg
Clearance	0.45～0.55 mm
Closing angle	at 49°～55° with the contact gap set to 0.5
Condenser capacity	0.2～0.24 μF
Ignition coil	8251 - 1524 (C14 - 58)

2. Angle advancing characteristics

Model	Governor		
	Distributor Number of revolution	Advance angle of distributor	Allowable error
D414-53 (G130)	① 600 ② 1,100 ③ 2,300	0 5° 14°	± 1°
D412-54 (G150)	① 400 ② 850 ③ 2,100	0 5° 12°	± 1°
D413-55 (G161)	① 400 ② 950 ③ 1,900	0 7° 13°	± 1°

Model	Vacuum control		
	Degree of vacuum mmHg	Advance angle of distributor	Allowable error
D414-53 (G130)	70 250	0 10°	50 x 0, 250 x 11° } A 88 x 0, 178 x 5°, 280 x 9° } B Between A and B
D412-54 (G150)	70 320	0 9°	50 x 0, 320 x 10° } A 90 x 0, 235 x 5°, 350 x 8° } B Between A and B
D413-55 (G161)	50 250	0 7°	30 x 0, 250 x 8° } A 72 x 0, 192 x 4°, 280 x 6° } B Between A and B

Remarks: External dimensions of the distributors are identical, however, the distributors and their components are interchangeable.

STARTER

Type	S114-100
Voltage (V)	12
Output (KW)	1.0
Direction of revolution (as viewed from the pinion side)	Right
Pinion	
D P	10/12
Pressure angle (°)	20
Number of teeth	9
Pitch diameter (mm)	22.86ϕ
Overall diameter (from tooth to tooth) (mm)	29.60ϕ
Distance of travel (mm)	1.27
Hardness (HRC)	58～63
Performance	
No load	
Terminal voltage (V)	12
Current (A)	Below 60
Number of revolution (r.p.m.)	Above 6,000
With load	
Terminal voltage (V)	4.7
Current (A)	Below 27.5
Torque (kg-m)	Above 0.84
Voltage that causes pinion to come into engagement (V)	8

Standard values for assembling

TIGHTENING TORQUES

Engine model / Name of the parts requiring torques	G130, G150 Kg-m (lbs-ft)		G161 Kg-m (lbs-ft)	
Cylinder head bolt	8	(58)	10	(72)
Crankshaft bearing cap	10	(72)	10	(72)
Connecting rod cap	3 ~ 3.5	(22 ~ 25)	4.3 ~ 4.7	(31 ~ 34)
Flywheel	4.5 ~ 6.5	(32 ~ 47)	4.5 ~ 4.6	(32 ~ 33)
Crankcase	2	(14)	2	(14)
Timing gear case	2	(14)	2	(14)
Oil filter (to cylinder body)	2	(14)	2	(14)
Fuel pump	2	(14)	2	(14)
Oil pan	0.8	(6)	0.8	(6)
Rocker bracket	2	(14)	2	(14)
Camshaft	3.5 ~ 4	(25 ~ 29)	3.5 ~ 4	(25 ~ 29)
Oil filter center bolt	3 ~ 4	(22 ~ 29)	3 ~ 4	(22 ~ 29)

STANDARD VALUES FOR ASSEMBLING

	G130	G150	G161
Piston diameter mm	75	79	82
Clearance between piston and cylinder wall when measured at	skirt	skirt	skirt
μ	40	40	40
Clearance between piston pin and connecting rod μ	-4 ~ 12	-4 ~ 12	-4 ~ 12
Clearance between piston pin and piston μ	0 ~ -4	0 ~ -4	0 ~ -4
Connecting rod end play μ	19 ~ 75	19 ~ 75	19 ~ 75
Radial clearance of connecting rod mm	0.20 ~ 0.33	0.20 ~ 0.33	0.20 ~ 0.33
Radial clearance of main bearing μ	20 ~ 65	20 ~ 65	20 ~ 65
Radial clearance of thrust bearing mm	0.06 ~ 0.14	0.06 ~ 0.14	0.06 ~ 0.14
Piston ring gaps mm (Compression ring)	0.2 ~ 0.4	0.2 ~ 0.4	0.2 ~ 0.4
mm (Oil control ring)	0.1 ~ 0.3	0.1 ~ 0.3	0.1 ~ 0.3
Piston ring groove mm (Compression ring groove)	36 ~ 82	36 ~ 82	36 ~ 82
mm (Oil control ring groove)	40 ~ 85	40 ~ 85	40 ~ 85
Clearance between tappet and body mm	0.01 ~ 0.041	0.01 ~ 0.041	0.01 ~ 0.041
Clearance between camshaft and bearing mm	0.055 ~ 0.28	0.055 ~ 0.28	0.055 ~ 0.28
Clearance between rocker arm and shaft mm	0.01 ~ 0.05	0.01 ~ 0.05	0.01 ~ 0.05

	G130	G150	G161
Radial clearance of camshaft mm	0.019 ~ 0.094	0.019 ~ 0.094	0.019 ~ 0.094
Valve clearances			
(Intake) mm	0.25	0.25	0.25
(Exhaust) mm	0.35	0.35	0.35
Valve stem guide clearance			
(Intake) mm	39 ~ 68	39 ~ 68	39 ~ 68
(Exhaust) mm	64 ~ 93	64 ~ 93	64 ~ 93
Inequality of weight between pistons gr	6	6	6
Inequality of weight between connecting rods gr	8	8	8

PART 1 INTRODUCTION

CONTENTS

PART 1 INTRODUCTION

1-1 BELLETT ENGINE (GASOLINE)

The BELLETT engines model G150 with the cubic capacity of 1,471 c.c. and model G130 with the cubic capacity of 1,325 c.c. have prolonged service life and highest rate of operating economy. These are the high performance engines skillfully engineered to secure a stabilized torque and operating flexibility at any travel speed.

Both engines model G150 and G130 comprises major component parts which are in common and have similar appearances except the carburetors.

Gasoline engine model G130

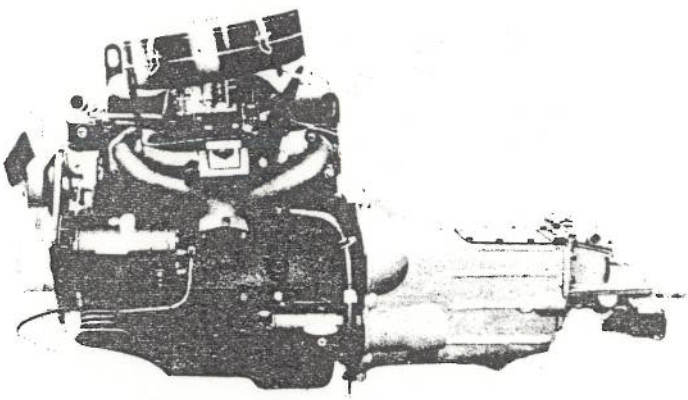


Fig. 1-1

Gasoline engines model G150 and G150C

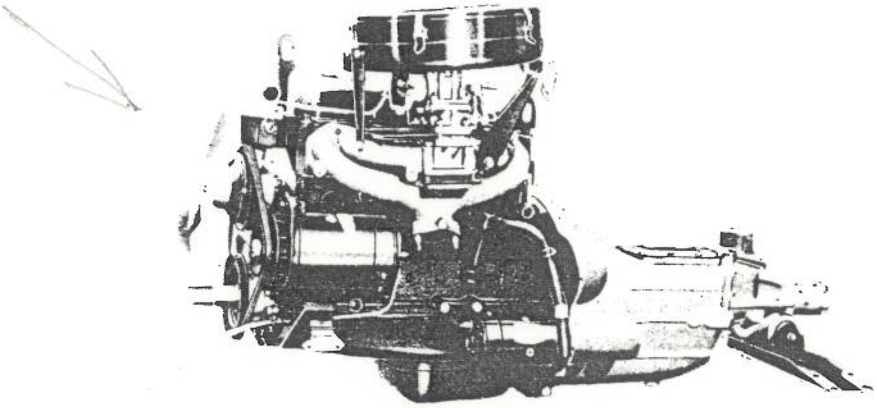


Fig. 1-2

The engines model G150 and G150C have the same appearances except the compression ratios are different

Gasoline engine model G150D

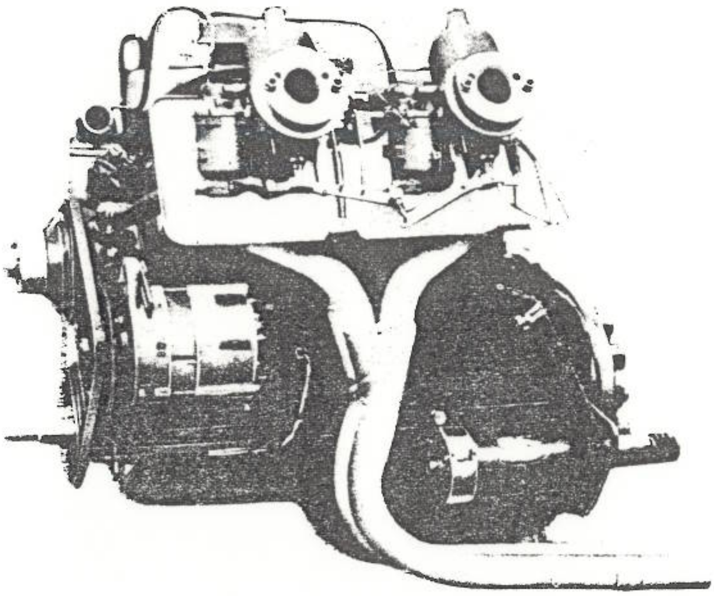
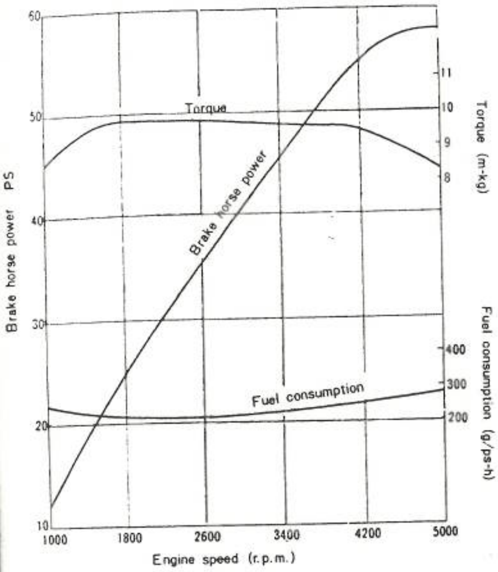


Fig. 1-3

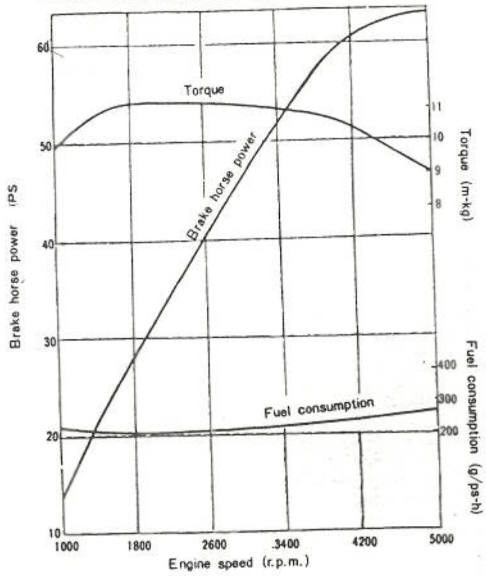
Engine performance curve for model G130
(gasoline engine)

Number of cylinder: 4
Bore of the cylinder and crankshaft stroke: 75mm × 75mm
Total cubic capacity: 1.325 ltr.
Compression ratio: 7.5 : 1
Maximum brake horse power: 58ps (at 5,000 r.p.m.)
Maximum torque: 9.8 m-kg (at 1,800 r.p.m.)
Minimum fuel consumption: 215g ps-h (at 2,200 r.p.m.)



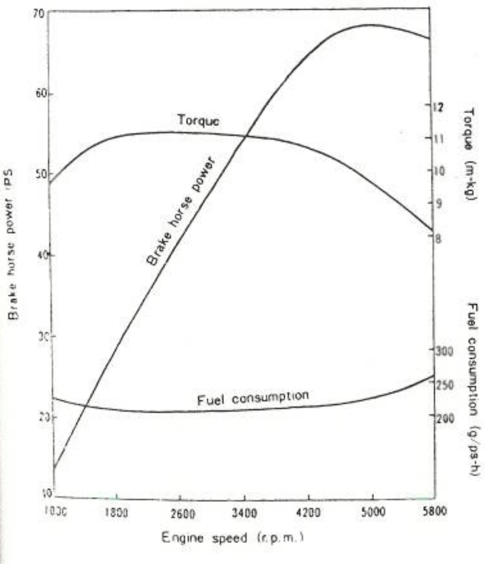
Engine performance curve for model G150
(gasoline engine)

Number of cylinder: 4 Number
Bore of the cylinder and crankshaft stroke: 79mm × 75mm
Total cubic capacity: 1,471 ltr.
Compression ratio: 7.5 : 1
Maximum brake horse power: 63ps (at 5,000 r.p.m.)
Maximum torque: 11.2 m-kg (at 1,800 r.p.m.) 1,800
Minimum fuel consumption: 210g/ps-h (at 2,200 r.p.m) m.)



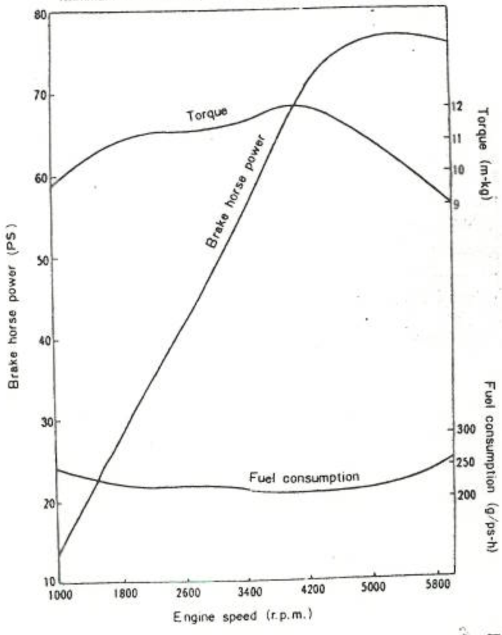
Engine performance curve for model G150C
(gasoline engine)

Bore of the cylinder and crankshaft stroke: 79mm × 75mm
Total cubic capacity: 1,471 ltr.
Compression ratio: 8.5 : 1
Maximum brake horse power: 68ps (at 5,000 r.p.m.)
Maximum torque: 11.3 m-kg (at 2,200 r.p.m.)
Minimum fuel consumption: 210g/ps-h (at 2,200 r.p.m.)



Engine performance curve for model G150D
(gasoline engine)

Number of cylinder: 4
Bore of the cylinder and crankshaft stroke: 79mm × 75mm
Total cubic capacity: 1,471 ltr.
Compression ratio: 8.5 : 1
Maximum brake horse power: 77ps (at 5,400 r.p.m.)
Maximum torque: 12.0 m-kg (at 4,200 r.p.m.)
Minimum fuel consumption: 210g/ps-h (at 3,800 r.p.m.)



1-2 SPECIFICATIONS OF BELLETT ENGINE (GASOLINE)

Engine model	G130	G150	G150C	G150D	G160
Type	Water cooled 4-cylinder in line (gasoline engine)	Same as left	Same as left	Same as left	Same as left
Bore and stroke	75mmx75mm	79mmx75mm	"	"	83mmx73mm
Total cubic capacity	1325cc	1471cc	"	"	1579cc
Compression ratio	7.5	7.5	8.5	8.5	9.3
Maximum brake horse power	58ps/5000r.p.m.	63ps/5000r.p.m.	68ps/5000r.p.m.	77ps/5400r.p.m.	88ps/5400r.p.m.
Maximum torque	9.8 kg-m /1800r.p.m.	11.2 kg-m /1800r.p.m.	11.3 kg-m /2200r.p.m.	12.0 kg-m /4200r.p.m.	12.5 kg-m /4200r.p.m.
Minimum fuel consumption	215 g/psh /2200r.p.m.	210 g/psh /2200r.p.m.	Same as left	210 g/psh /3800r.p.m.	210 g/psh /3800r.p.m.
Maximum mean effective pressure	9.3 kg/cm^2 /1800r.p.m.	9.6kg/cm^2 /1800r.p.m.	9.7 kg/cm^2 /2200r.p.m.	10.3 kg/cm^2 /4200r.p.m.	9.95 kg/cm^2 /4200r.p.m.
Compression	11 kg/cm^2	11 kg/cm^2	12 kg/cm^2	Same as left	13.5 kg/cm^2
Weight of the engine unit (dry)	130 kg	Same as left	Same as left	"	139 kg
Piston type	T-slot type	"	"	"	Same as left
Number of piston ring	Compression ring 2 and oil control ring 1	"	"	"	"
Firing order	1—3—4—2	"	"	"	"
Intake valve opening	40° B.T.D.C.	"	38° B.T.D.C.	"	"
Intake valve closing	74° A.B.D.C.	"	82° A.B.D.C.	"	"
Exhaust valve opening	70°30' A.B.D.C.	"	73° A.B.D.C.	"	"
Exhaust valve closing	23°30' A.T.D.C.	"	35° A.T.D.C.	"	"
Intake valve clearance	0.3mm (cold)	"	Same as left	"	"
Exhaust valve clearance	0.35mm (cold)	"	"	"	"
Ignition timing	14° B.T.D.C. /600 650 rpm	"	12～14°B.T.D.C. /600～650rpm	"	12° /600～650rpm
Ignition timing governor	Combination of centrifugal and vacuum type	"	Same as left	"	Same as left
Spark plug gap	0.7 0.8mm	"	"	"	"
Carburetor	Hitachi DAB 308-5 (single) Solex type	Nihon Kikaki (single) Strongburgh type	" "	Hitachi HJD38W (twin) SU type	" "
Fuel pump	Nihon Kikaki PD-56Q (diaphragm type)	Same as left (")	" (")	Same as left (")	" (")

Engine model	G130	G150	G150C	G150D	G160
Fuel tank capacity	40 ltr	Same as left	Same as left	Same as left	Same as left
Oil feed pump	Forced circulation (Trochoid type)	"	"	"	"
Oil pan capacity	2.6 ltr	3.2 ltr	"	"	"
Cooling method	Pressurized and forced circulation	Same as left	"	"	"
Type of radiator	Flat water tube in 2-row	"	"	"	"
Water pump	Impeller type	"	"	"	"
Type of thermostat	Bellows type for model '64 and Wax pellet type for model '65	Bellows type	Wax pellet type	Same as left	Same as left
Capacity of the cooling system	6 ltr	"	"	"	"
Air cleaner	Paper element	"	"	"	"
Oil filter	Paper filter type	"	"	"	"
Battery	N—40 (12V—40AH)	"	NS—40 (12V—40AH)	"	NS—40 (12V—40AH)
Ground electrode	(-) Negative electrode connected to ground	"	Same as left	"	Same as left
Generator	Hitachi GT123-08 (12V-300W)	"	Hitachi LT123-16 (AC 12V-300W)	"	"
Starter	Hitachi S114-54 (12V-1KW)	"	Same as left	"	"

1-3 PERIODICAL INSPECTION AND LUBRICATION (FOR GASOLINE ENGINE AND ITS ASSOCIATED PARTS)

To maintain the automobile always in top operating condition, routine service, periodical inspection and lubrication should be carried out according to the following table.

REFERENCE TABLE FOR DAILY CHECK-UPS

Check spot	Check up
Engine	1. Cooling water level and leakage 2. Engine oil level and leakage 3. Fuel level and leakage 4. Check oil level in the fuel injection pump 5. Tension and wear of the fan belt 6. Easiness of starting and operating noise 7. Unreasonable exhaust smoke
Steering wheel	1. Check for excessive play and loosened parts 2. Free from undue vibration, swerving or restricted operation
Brake	1. Check for reasonable travel stroke of the foot brake pedal and response of the brakes 2. Check for effective travel stroke of the lever and its response to assure safety of driving
Tires	1. Check for proper tire pressure, abnormal wear and scores or serious damage detrimental to operation
Chassis spring	1. Chassis spring for breakage
Battery	1. Battery electrolyte level and leakage
Horn, flasher and windshield wiper for normal operation	1. Check these parts for operating failure
Meters	1. Check flasher for operating failure, fouling and damage
Rear view mirror	1. Check for proper function
Reflector and license plate	1. Check for fouling and damage
Any trouble or operating failure detected during automobile is in operation	1. Check pertinent parts for operating failure

REFERENCE TABLE FOR PERIODICAL INSPECTION AND LUBRICATION (BELLETT GASOLINE ENGINE)

● Marking denotes "Replacement"

Equipment	Inspection period and interval	When initial 1,000 km covered		After every 3,000 km of travel or 2-month intervals		After every 9,000 km of travel or 6-month intervals		After every 18,000 km of travel or 6-month intervals		After every 36,000 km of travel or 6-month intervals
	Check-up / Personal and business use (classification)	Personal	Business	Personal	Business	Personal	Business	Personal	Business	Business
Engine	Tension and wear of fan belt	○	○	○	○					
	Easiness of starting and operating noise			○	○					
	Draining the engine lubricant through the oil filter's drain plug	○	○	○	○					
	Check all the parts for oil leakage	○	○	○	○					
	Check for fuel leakage through the entire fuel system	○	○	○	○					
	Check for water leakage through the entire cooling system	○	○	○	○					
	Check for leakage in the air intake system	○	○	○	○					
	Tightness of cylinder head and manifolds mounting	○	○			○	○			
	Valve clearances	○	○			○	○			
	Muffler and exhaust pipes for loosened mounting or wear	○	○	○	○					
	Engine mountings for tighteess	○	○			○	○			
	Air cleaner element for clogging or wear			○	○					
	Engine performance at low speed and accelerated speed			○	○					
	Cleaning of air breather system			○	○					
	Check exhaust smoke for normal condition			○	○					
	Check insulated electrode of the spark plug for fouling and wear			○	○					
	Check contact breaker points of distributor for wear and fouling			○	○					
	Ignition timing adjustment			○	○					
	Automatic ignition timing control for normal operation			○	○					
	Cleaning the internal part of oil pan and oil pump strainer									○
	Measuring the cylinder compression									○
	Cleaning the internal part of the fuel tank									○

Equipment	Inspection period and mileage interval	When initial 1,000 km covered		After every 3,000 km of travel or 2-month intervals		After every 9,000 km of travel or 6-month intervals		After every 18,000 km of travel or 12-month intervals		After every 36,000 km of travel or 6-month intervals
	Personal and business use (classification) / Check-up	Personal	Business	Personal	Business	Personal	Business	Personal	Business	Business
Engine	Draining and refilling with recommended oil	●	●	●	●					
	Replacing the cooling water							●		●
	Draining and refilling with recommended oil			●	●					
	Replacing the oil filter element					●	●			
	Replacing the fuel filter element							●	●	
	Replacing the air cleaner element							●	●	
	Lubricating the diaphragm in the fuel injection pump					○	○			
	Lubricating the engine control linkage			○	○					
Electrical system	Check all the wiring for loosened connection and damage			○	○					
	Check meters and pilot lamps for operating failure			○	○					
	Check battery hold down bolts and terminals for loosening	○	○	○	○					
	Check generator for charging operation failure			○	○					
	Check battery electrolyte level			○	○					
	Measuring the specific gravity of the battery electrolyte					○	○			
	Check carbon brush in the starter and commutator surface for wear or fouling							○		○
	Check generator and voltage regulator for operating failure						○	○		
	Check contacting point of the change-over switch for wear or fouling						○	○		
	Check starter pinion for proper engagement						○	○		
	Check starter mounting for loosening						○	○		
	Lubricating the center and rear bearings of the starter					○	○			
	Lubricating the front bearing of the starter									○
	Grease the generator bearing as recommended									●

1-7 LUBRICATION CHART

The automobile should be lubricated with recommended oil or grease according to the following chart when it has covered the specified travel distances.

Lubricant	Parts to be lubricated	Type and brand name	Specified oil	Capacity
Engine Oil	Crankcase	Hi-belpa or White wave engine oil (Showa Sekiyu) and (Nihon Sekiyu)	March through September (SAE 30) and October through February (SAE 20)	G150 3.2 ℓ G130 2.6 ℓ C180 4.0 ℓ
	Transmission	Same as above	SAE 20	2.0 ℓ
Gear oil	Differential	Belpa gear oil 90H (Showa Sekiyu)	Summer season SAE 140 Winter season SAE 90	0.7 ℓ
Grease	Front hub bearing	Sun line grease (Showa Sekiyu)		60 gr
	Rear hub bearing	Same as above		54 gr
	Drive shaft	One-luber with molybdenum disulfide MO—No_2 grease		
	Steering housing and hand brake cable	Belpa special grease or M—1 Grease (Showa Sekiyu) and (Nihon koyu)		
	Joint balls on the front suspension	One-luber with molybdenum disulfide MO—No_2 Grease (Kyodo yushi)		
	Joint balls on the steering track rod	Same as above		
Brake fluid		HIGH GRADE brake fluid		

PART 2 INSPECTION AND ADJUSTMENT

CONTENTS

TARKASTAMINEN JA SÄÄTÄMINEN

PART 2 INSPECTION AND ADJUSTMENT

2-1 GASOLINE ENGINE

Automobiles of latest model are equipped with improved high-speed, high-performance engines which necessitates the use of electrical equipment and all other associated parts with highest rate of performances.

The engine adjustment should be made periodically to maintain the engine in the optimum operating condition.

Appropriate trouble-shooting measures should be taken to cope with any types of failure of the engine performance. The engine adjustment may be classified into two categories, namely: the visual inspection and adjustment without use of any measuring instruments. and the detection and correction of operating failures with the aid of gages and other instruments. Either work should be carried out in the manner outlined below.

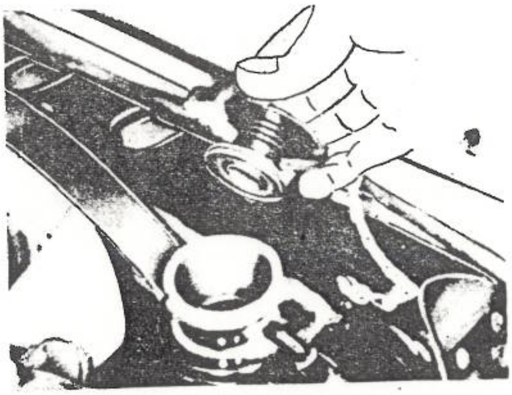


Fig. 2-1

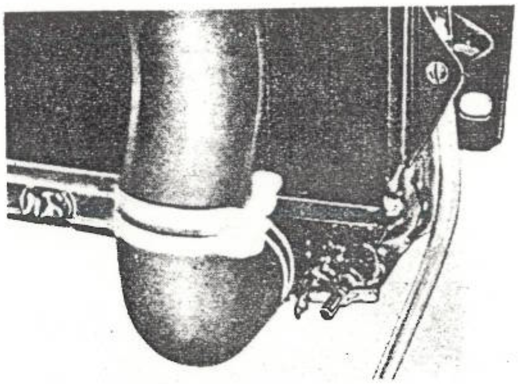


Fig. 2-2

2-1-1 Cooling System

(1) Cooling Water

The water filler cap on the radiator neck should be removed for checking the water level, and clean water (preferably city water) may be added if necessary. For removing the filler cap while the radiator is hot, the cap should be covered with a rag and carefully turned loose to release the internal pressure. The entire cooling water should be replaced at every service intervals of 18,000 km. For replacing the cooling water, the coolant should be well drained by releasing the drain cock on the lower part of the radiator and that on the lower front part of the engine block. The Isuzu genuine anti-freeze is recommended for use in the cooling system during winter season.

(2) Thermostat

A thermostat provided in the cooling system serves to control the cooling water to optimum operating temperatures between 70°C - 80°C (158°F - 176°F). If the water in the cooling system fails to reach the above-mentioned range a few minutes after starting the automobile, the trouble may be attributed to thermostat failure.

2-1-2 Tension of the Fan Belt

If the fan belt is properly adjusted, it should give a lateral deflection of about 10mm - 15mm at its longest section. For adjusting the fan belt tension, the

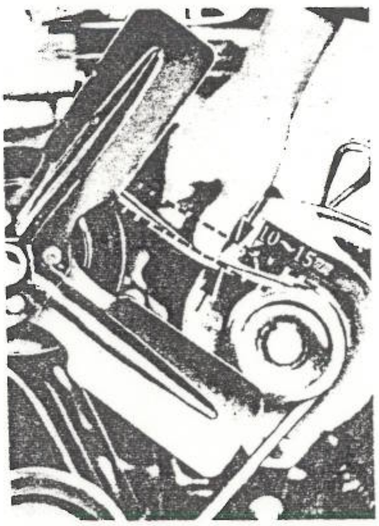


Fig. 2-3

set bolts on the generator mount bracket should be slackened and then the generator partly pivoted. The fan belt tension should be carefully adjusted as improperly tensioned belt leads to the engine trouble.

2-1-3 Engine oil

Before starting the engine, the engine oil level should be checked using a dipstick. If the oil level comes between the arrow markings on the dipstick, the oil level may be regarded as normal.

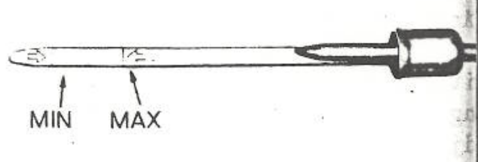


Fig. 2-4

The breather cap on the cylinder head cover should be removed for replenishing the engine with oil. The engine should be drained and

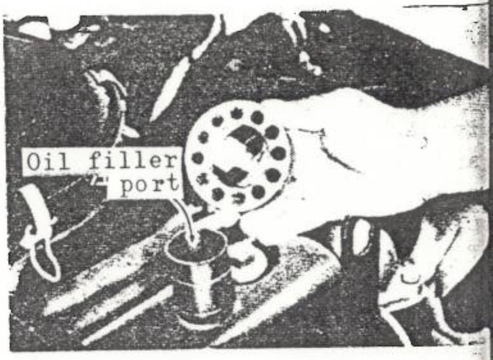


Fig. 2-5

refilled with specified oil after the automobile covered the initial 1,000 km of break-in travel distance and thereafter, the engine oil should be replaced in the same manner after every 3,000 km of travel.

Hi-belper engine oil
a product of Showa Sekiyu

Ambient temperature	Specified oil
Above 10℃	SAE #30
−10℃～+10℃	SAE #20
−20℃～ 0℃	SAE #10
Below −20℃	SAE # 5

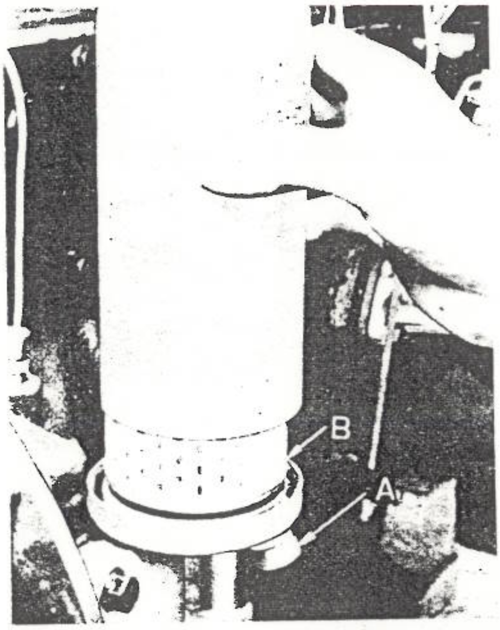


Fig. 2-6

2-1-4 Engine Oil Filter

For replacing the engine oil (after every 3,000 km of travel distance), the drain plug (A) on the oil filter body should also be removed for draining the engine oil therethrough. The oil filter element (B) should be replaced after every 9,000 km of travel distance.

2-1-5 Air Cleaner

The air cleaner element should be removed and cleaned with the aid of compressed air (to blow dust deposit) after every 3,000 km of travel. The dismantling and cleaning intervals may be reduced when the automobile is subjected to road service in dusty areas. If the filter element is smeary or damaged, it should be immediately replaced. The air filter element should be regarded as due for replacement after every 18,000 km of travel distance.

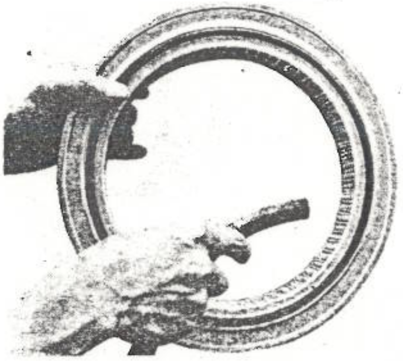


Fig. 2-7

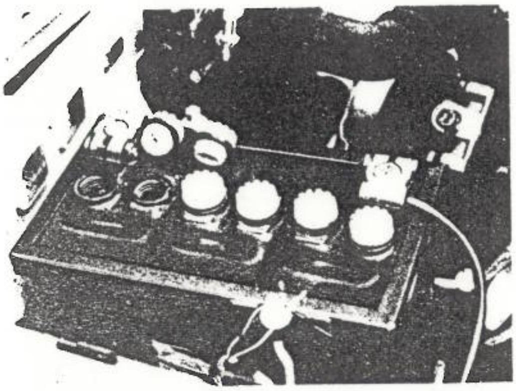


Fig. 2-8

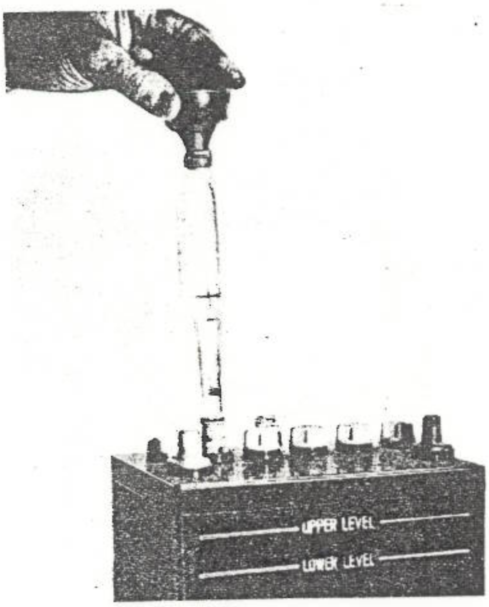


Fig. 2-9

2-1-6 Battery Check-up

(1) The battery electrolyte should be checked to make sure it retains specified level with the battery fully charged.

The battery electrolyte level should be held within 10-15mm above the plates. Distilled water should be used for replenishing the battery as other water is detrimental to normal battery performance.

(2) Measuring the specific gravit of the electrolyte

According to the specificatio the specific gravity of the ele trolyte should be measured whil it is held at the temperature o 20°C, but for all practical pur- poses, the value of the specifi gravity thus obtained by measur- ing the electrolyte at any degr of temperature is represented b the following formula:

$S_{20} = St + 0.007\ (t-20)$

S_{20} ... Specific gravity of the electrolyte measured at 20°C.

t. .... Temperature of the elec trolyte when the specif gravity of which is mea- sured.

St. ... Specific gravity of the electrolyte regardless of its temperature.

If the value of the specific gravity obtained from such cal- culation is less than 1,180, th battery should be regarded due for re-charging.

Specific g of the electrol
1.
1,
1,
1,
Below 1,

(3) The bat with spec pleting t tions in following quent to trolyte l ing opera of the ba removed.

This ch often acc increase due to bu ing the c voltage a be measu minutes a

Batter charge

Specific gravity of the electrolyte	Rate of discharge (%)
1,260	0
1,200	30
1,150	50
1,100	75
Below 1,100	Completely discharged

(3) The battery should be charged with specified power after completing the necessary connections in accordance with the following illustration subsequent to adjustment of the electrolyte level. During the charging operation, the filler caps of the battery should be held removed.

This charging operation may be often accompanied by a sudden increase in the supply voltage due to bubbles and fumes. During the charging period, the voltage at the terminals should be measured every thirty (30) minutes and if the measured value exceed 15V and so continues, the battery may be regarded as fully charged. During the re-charging operation, the temperature of the electrolyte should be measured and if it rises above 45°C (or 113°F), the charging should be temporarily stopped or the charging current should be reduced by 50 percent. The charging may be started again when the temperature of the electrolyte has declined. The current used for re-charging should not exceed one-tenth (1/10) of the battery capacity.

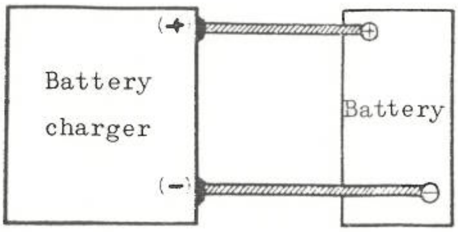


Fig. 2-10

2-1-7 Spark plug

The spark plugs should be cleaned and provided with specified spark gaps after every 3,000 km of travel distance. The spark plug should be provided with a gap of about 0.7 - 0.8mm by adjusting the ground electrode. The spark plugs specified for use with the Bellett engines are: NGK B-6E or HITACHI L45J.

Fig. 2-11

2-1-8 Distributor

A few drops of engine oil should be applied to the rotor shaft of the distributor at the position (B) after every 3,000 km of travel distance. The distributor is also provided with a grease

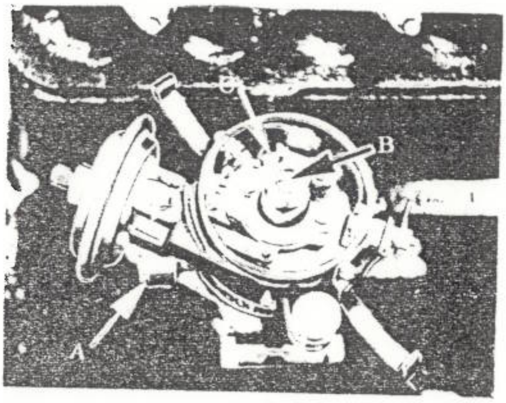


Fig. 2-12

cup (A). The grease cup is adapted to lubricate the distributor shaft as it is turned clockwise. The entire surface of the cam should be provided with a thin coating of grease and the contacting point should be checked for proper gap (C) after every 3,000 km of travel distance. The contacting points should be provided with 0.45 mm of gap. The lock screws on the contact breaker should be loosened and tightened back after the gap is properly adjusted. Fouled contact points may be cleaned with a rag slightly wet with gasoline.

2-1-9 Ignition timing

The engine should be checked for ignition timing and properly adjusted after every 3.000 km of travel distance. The ignition timing is standard at 12-14° (at 600-650 r.p.m.) B.T.D.C. (For models G150 and G130). For mode[l] G160, the ignition timing is standard at 12° B.T.D.C. (at 600-650 r.p.m.)

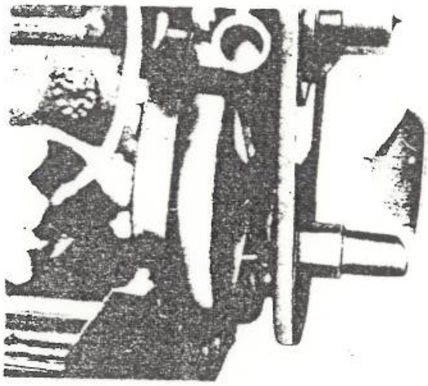


Fig. 2-13

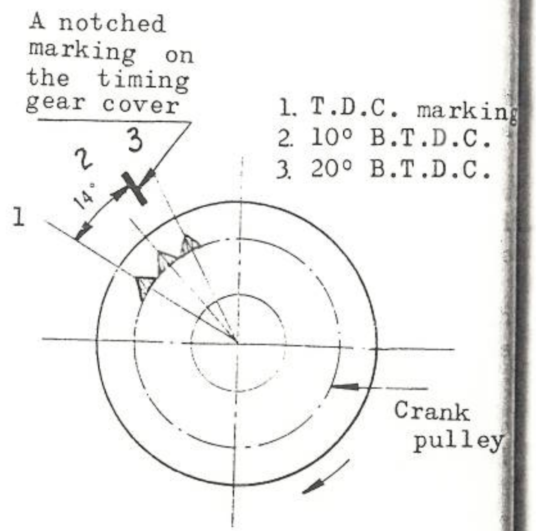


Fig. 2-14

Notched marks on the crank pulley represent T.D.C., 10° B.T.D.C. and 20° B.T.D.C., respectively.

A strobo lamp should be used for inspecting and adjusting the ignition timing. The strobo lamp should be connected in the following manner.

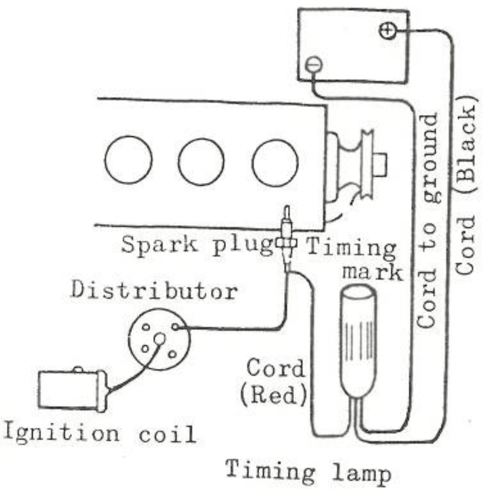


Fig. 2-15

For adjusting the ignition timing, the distributor should be carefully turned after the clamping bolts on the distributor set plate are slackened. The ignition timing retards as the distributor is turned clockwise and advances with the distributor turned counter-clockwise. During the ignition timing adjustment, the vacuum ignition timing control should be held in the intermediate position of the adjusting scale.

To obtain the optimum ignition timing using different octane fuels, the ignition timing may be fractionally adjusted with a micrometer adjuster on the vacuum timing control.

For the most practical purpose to obtain the optimum ignition timing, the ignition timing may be so adjusted that the engine slightly knocks when suddenly accelerated from the travel engine slightly knocks when suddenly accelerated from the travel speed of approximately 25 km/h on the top gear, and the knocking gradually fades away responding to increasing speed.

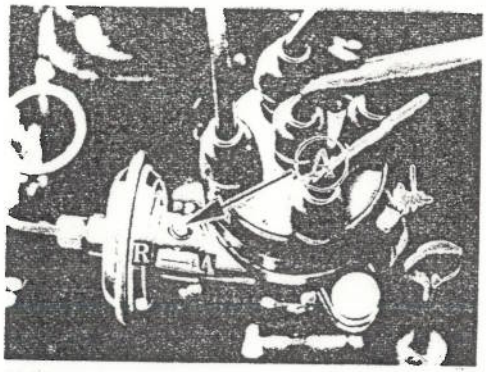


Fig. 2-17

In the instance where the knocking is notable, the timing may be slightly retarded by moving the micrometer adjuster toward "R" and if knocking does not occur the ignition timing may be slightly advanced by moving the micrometer adjuster toward "A". The ignition timing is adjustable in both "R" and "A" directions within 5 degrees using a micrometer adjuster.

2-1-10 Idling

The carburetor should be carefully adjusted as it gives direct influence on the engine performance as well as on fuel consumption.

(1) The adjusting screw (A) on the carburetor should be partially released by turning 1-1/4 - 1-1/2 back after it is screwed all the way in. Then the engine idling speed should be adjusted to approximately 600 - 650 r.p.m. by adjusting the idle speed screw (B).

(2) The engine should be adjusted to provide a smoothest and fastest idling by controlling the carburetor with the aid of adjust screw (A) and then, the engine idling speed is adjusted to 600-650 r.p.m. by adjusting the idle speed screw (B).

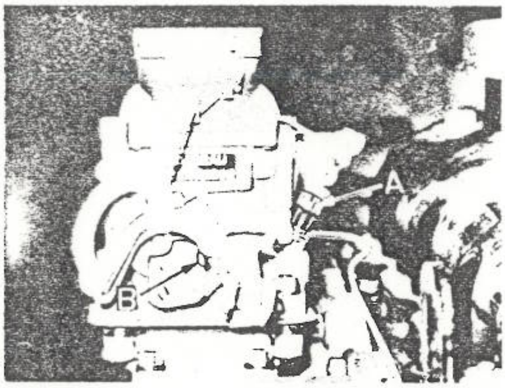


Fig. 2-18

2-1-11 Fuel filter

All internal parts of the fuel filter should be cleaned after every 3,000 km of travel distance. The screw on the clamp should be slackened for removing the glass bowl. The glass bowl should be carefully removed lest it should cause damage to the packing. The filter element should be replaced after the 18,000 km of service.

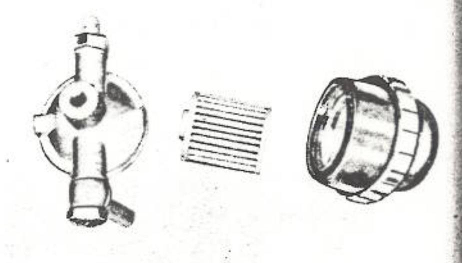


Fig. 2-19

2-1-12 Tappet clearance

Where the tappet noise is considerably high, or the engine performance is poor with out failures in the fuel system or in the electrical system, the trouble may be attributed to maladjusted valve clearance. In such instance, the valve clearance should be adjusted while the engine is cold.

Cautions for valve clearance adjustment:

The set bolts on the following parts should be tightened with application of the specified torque prior to adjustment of the valve clearance.

Cylinder head set bolts ... 6.0 - 7.0 m-kg
Rocker arm shaft bracket set bolts ... 2.3 - 2.6 m-kg

Manifolds set bolts ...
2.3 - 2.6 m-kg

With the cylinder head cover removed, the crankshaft should be carefully rotated with use of a crank handle so as to bring the piston of the first cylinder to the top dead center on the compression stroke. With the piston held in normal position, T.D.C. notch marking on the crank pulley should be set to the corresponding mark on the timing sprocket cover by carefully moving the crankshaft. (When the piston is held in this position, the intake valve on the fourth cylinder is in the primary stage of opening.)

Intake valve clearance
(1st cylinder) ... 0.30mm
Exhaust valve clearance
(1st cylinder) ... 0.35mm

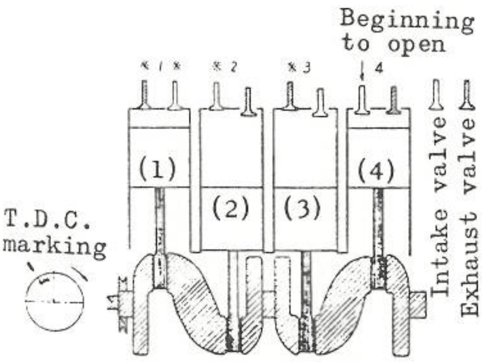


Fig. 2-20

(1) - Compression stroke
(2) - Combustion stroke
(3) - Suction stroke
(4) - Exhaust stroke

Intake valve clearance
(2nd cylinder) ... 0.30mm
Exhaust valve clearance
(3rd cylinder) ... 0.35mm

Upon completion of the above adjustment, the crankshaft should be turned 360° and again the T.D.C. notch markings on the crank pulley should be set to the corresponding mark on the timing sprocket cover. (When the crankshaft is held in this position, the intake valve on the first cylinder is beginning to open). With the valve components held in the relative positions, the clearance of the remaining valves should be adjusted to the following values.

Intake valve clearance
(4th cylinder) ... 0.30mm
Exhaust valve clearance
(4th cylinder) ... 0.35mm

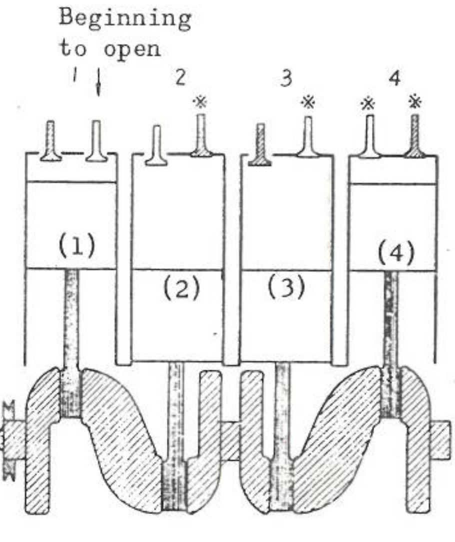


Fig. 2-21

Exhaust valve clearance
(2nd cylinder) ... 0.35mm

Intake valve clearance
(3rd cylinder) ... 0.30mm

When the lock nut is slackened, the screw adjuster should be carefully turned to give a proper clearance. When this adjustment is completed, the lock nuts should be carefully tightened back and the valve clearances re-checked with the aid of a thickness gage.

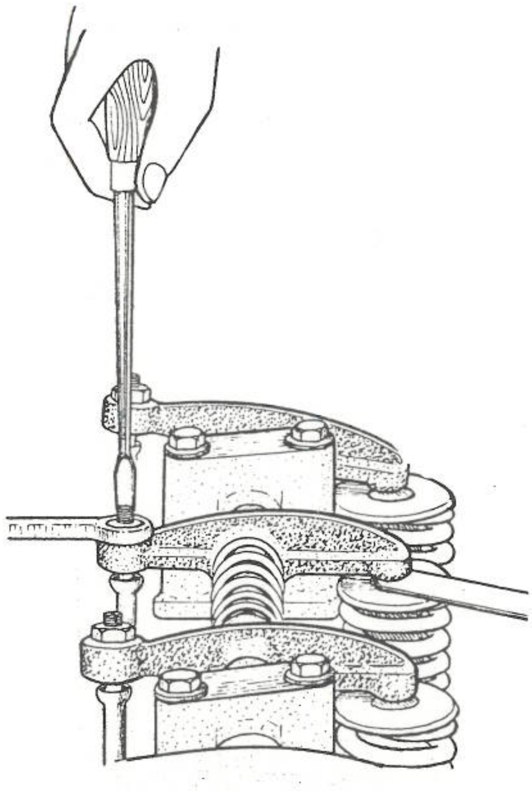


Fig. 2-22

2-1-13 Cylinder compression

Worn or damaged piston rings, tapered piston or worn cylinder wells will lead to the engine failure, power loss, difficulty of starting and so on.

For easier detection of troubles of this sort, a compression measuring may be performed.

(1) All ignition cords should be disconnected.

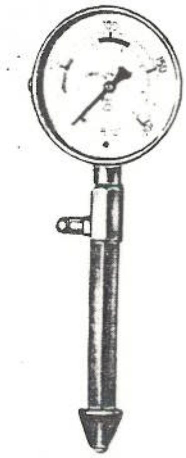


Fig. 2-23

(2) Spark plugs should also be removed.

(3) With the throttle valve fully opened, the engine should be rotated with the aid of the starter (The cranking speeds should be on or above 300 r.p.m.

(4) The gage pointer at maximum should be read at least twice

when the deflection of the pointer is ceased.

If the reading is insufficient to the specified value, the associated parts should be dismantled for correction.

Compression at standard:
$11.0\ kg/cm^2$

Difference of compression between cylinders:
$0.6\ kg/cm^2$ or below

Service limit:
$7.7\ kg/cm^2$ or below

PART 3 TROUBLE-SHOOTING

CONTENTS

PART 3 TROUBLE-SHOOTING

3-1 GASOLINE ENGINE

Following is a trouble-shooting table which deals with operating troubles, most commonly experienced with the gasoline engin.

It is always advisable to make proper corrections of the system before the trouble grows serious.

Trouble	Cause	Repair
1. Starting failure 1) Starter fails to operate	1) Discharged or performance failure of the battery	Recharge the battery or replace if necessary
	2) Poor connections	Clean and retighten the terminals
	3) Starter motor failure or switch with trouble	Overhaul or replace
	4) Engine oil used is too heavy	Drain and refill with specified oil
2) Fuel fails to come to the carburetor	1) Fuel pump failure	Overhaul or replace
	2) Carburetor float valve sticking	Overhaul or clean the carburetor
	3) Clogged strainer or fuel pipe	Overhaul or clean
	4) No fuel in the fuel tank	Supply fuel
3) Ignition system failure	1) Poorly adjusted ignition timing	Adjust
	2) Wear of the contact points of the distributor	Clean or replace
	3) Poorly adjusted contact point gap	Adjust

Trouble	Cause	Repair
	4) Ignition coil or condenser failure	Replace
	5) Short circuitted contact breaker arm or rotor	Inspect connection and tighten as necessary
	6) Poorly adjusted spark plug gap	Clean, adjust or replace if necessary
	7) Poor connection	Check for loose connection and tighten as necessary
4) Carburetor failure	1) Choke valve operating failure	Adjust choke system as necessary
	2) Carburetor operation failure	Adjust engine idling and check other parts for operating failure
	3) Contaminated or clogged carburetor parts	Clean or overhaul
5) Power system failure	1) Valve wear or seizure	Correct by grinding or replace if necessary
	2) Worn or damaged cylinder head gasket	Replace gasket
	3) Poor compression pressure	Replace piston and piston rings Rectify cylinder for distorsion or tapered wear
2. Poor idling condition		
1) Carburetor failure	1) Poorly adjusted carburetor setting	Adjusted
2) Air leakage	1) Loosened carburetor mounting bolts	Retighten or replace gasket
	2) Loosened intake manifolds mounting	Retighten or replace gasket

Trouble	Cause	Repair
	3) Cylinder head blow-by	Retighten or replace gasket
3) Valve system failure	1) Poorly adjusted valve clearance	Adjusted as necessary
	2) Poor valve contact with the valve seat	Rectified with the aid of valve grinding machine
	3) Excessive clearance between the valve stem and valve guide	Replace valve and valve guide as required
3. Engine power failure		
1) Continuous power failure	1) Poorly adjusted valve clearance	Adjust valve clearance as necessary
	2) Poor valve contact with the valve seat	Rectify valve contact with the aid of abrasive compound
	3) Valve stem seizure or bending	Rectify or replace
	4) Weakened valve spring	Replace valve spring
	5) Cylinder head gasket blow-by	Replace cylinder head gasket
	6) Piston ring sticking or damage	Replace piston ring
	7) Piston or cylinder wall wear	Overhaul the engine and replace the parts
	8) Maladjusted ignition timing	Readjust the ignition timing
	9) Spark plug fouling	Clean and readjust the spark gap, replace if necessary
	10) Distributor contact breaker point fouling or wear	Adjust point gap and replace as necessary

Trouble	Cause	Repair
	11) Unsuitable mixture caused by maladjusted carburetor	Clean and overhaul carburetor
	12) Air cleaner clogging	Clean or replace
	13) Carburetor always held choked due to choke system failure	Repair the entire choke system
	14) Residual air in the fuel system	Check and retighten the connections
	15) Fuel system clogging	Clean
	16) Operating failure of the fuel pump	Repair or replace
	17) Use of unsuitable fuel	Drain the fuel tank and refill with recommended fuel
	18) Clutch slipping	Repair the clutch system
	19) Partially draged brakes	Adjust the brakes
2) Mis-firing occurs when accelerated	1) Clogging of the carburetor	Clean or overhaul
	2) Unsuitable mixture	Clean or overhaul the carburetor
	3) Spark plug fouling	Clean or replace
	4) Contact point failure or fouling	Readjust the point gap or replace
	5) Water mixed in the fuel	Drain the tank and refill with recommended fuel
	6) Worn or muladjusted valve clearance	Adjust or replace the valve

Trouble	Cause	Repair
	7) Insufficient cylinder compression	Overhaul the engine and its associated parts
	8) Cylinder head gasket blow-by	Replace cylinder head gasket
4. Overheating	1) Insufficient cooling water	Replenish with soft water
	2) Loose, worn or broken fan belt	Adjust the tension or replace
	3) Maladjusted ignition timing	Adjust the ignition timing as specified
	4) Thermostat operating failure	Replace thermostat
	5) Radiator clogging or leaking	Clean, repair or replace as necessary
	6) Water pump operating failure	Replace water pump
	7) Use of unsuitable engine oil or insufficient oil	Drain and refill with specified oil or replenish
	8) Maladjusted valve clearance	Readjust valve clearance
	9) Partially clogged exhaust system	Clean the fuel system or replace the parts with faulty
	10) Partially dragged brakes	Readjust the brakes
5. Abnormal combustion: (Power failure due to irregular combustion, improper engine performance caused by poorly adjusted ignition	1) Supply of unsuitable mixture (too thin)	Adjust carburetor setting
	2) Mixture leaking in the carburetor or intake manifold	Retighten the mounting bolts or replace the gasket

Trouble	Cause	Repair
timing) (Including after-fire, back fire and other ignition failure are included)	3) Carbon deposit in the combustion chamber	Clean and remove carbon deposit
	4) Spark plug fouling	Clean, adjust the spark gap or replace
	5) Use of unsuitable spark plug	Replace with specified spark plug
	6) Poorly adjusted valve clearance	Readjust the valve clearance
	7) Valve sticking	Overhaul or replace the valve
Operating noises usually arise from various moving and sliding parts and are combined to develop an abnormal operating noise. It is therefore, necessary to detect where the noise comes from.		
1) Crankshaft bearing	1) Excessive clearance between bearing and crankshaft due to bearing or shaft wear	Replace bearing or rectify the crankshaft with the grinding machine
	2) Tapered wear of the crankshaft	Rectify or replace the crankshaft
	3) Clogged oil port	Clean the passage
	4) Bearing seizure	Replace the bearing or rectify the crankshaft as necessary
2) Connecting rod and connecting rod bearing	1) Wear of the connecting rod bearing	Replace bearing
	2) Wear of the crankshaft pin	Rectify the crankshaft

Trouble	Cause	Repair
	3) Connecting rod bending	Rectify the crank-shaft bending or replace
	4) Bearing seizure	Replace bearing and rectify the crank-shaft
	5) Insufficient oil	Clean the oil passage
3) Piston, piston pin and piston rings	1) Excessive piston clearance due to worn cylinder wall	Correct cylinder wall by borning and honing, and then fit the over-sized piston in position
	2) Worn piston or piston pin	Replace piston and piston pin as necessary
	3) Piston seizure	Replace piston
	4) Poor sealing effect of the piston	Rectify or replace piston
	5) Piston ring wear or damage	Replace piston rings
4) Others	1) Worn crankshaft thrust bearing	Replace the thrust bearing
	2) Excessive play in the camshaft end	Replace thrust plate
	3) Loosened timing chain	Replace chain ten-sioner
	4) Excessive valve clearance	Readjust valve clearance
	5) Worn valve lifter	Replace valve
7. Unreasonable fuel consumption	1) Misadjusted car-buretor	Adjust carburetor
	2) Restricted oper-ation of the choke valve	Adjust operation of choke valve system

Trouble	Cause	Repair
	3) Incorrect ignition timing	Readjust ignition timing
	4) Excessively fast engine idling speed	Readjust idling
	5) Poor contact of clutch facing (slipping)	Adjust clutch
	6) Partially dragged brakes	Adjust brakes
	7) Insufficient air pressure in the tires	Check and adjust tire pressure
	8) Excessive use of low speed gears	Use correct method of operation
8. Unreasonable engine oil consumption		
1) Oil leakage	1) Loosened drain plug on the oil pan	Retighten the drain plug
	2) Loosened oil pan set bolts	Retighten the setting bolts
	3) Oil pan gasket wear	Replacing the gasket
	4) Loosened timing sprocket cover setting bolts or worn gasket	Retighten setting bolts or replace the packing
	5) Loosened cylinder head cover setting bolts or gasket wear	Retighten setting bolts or replace the packing
	6) Loosened fuel pump clamping bolts or gasket wear	Retighten setting bolts or replace the packing
	7) Loosened oil filter setting bolts or work gasket	Retighten setting bolts or replace the packing

Trouble	Cause	Repair
	8) Wear of the crank-shaft retainer gasket	Replace the packing
	9) Wear of the crank-shaft rear oil seal	Replace oil seal
2) Oil sinking	1) Excessive clear-ance between valve stem and valve guide	Replace either the valve or valve guide
3) Oil-up	1) Worn or broken piston rings	Replace the piston rings
	2) Malaligned piston ring gaps	Properly align the piston rings
	3) Piston ring stick-ing	Replace the piston rings
	4) Clogged oil slots on the oil control ring	Replace oil control rings
	5) Worn piston and cylinder walls	Replace piston or rectify the cylinder walls by boring.

PURKAMINEN JA KOKOAMINEN

PART 4 DISMANTLING AND REASSEMBLING

CONTENTS

PART 4 DISMANTLING AND REASSEMBLING

4-1 REMOVING AND MOUNTING THE ENGINE

It is easier and more efficient for the dismantling of the engine block together with the transmission unit than dismounting the engine unit separately from the transmission.

With all the wiring and piping disconnected, the engine should be lifted using a chain hoist.

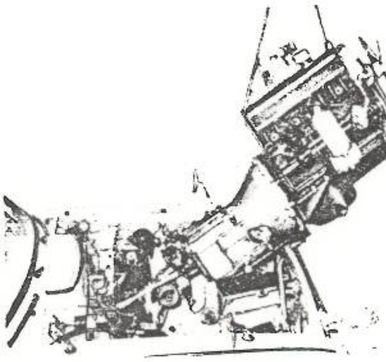


Fig. 4-1

4-1-1 Sequence of dismantling the engine

1) Drain the radiator and the water jacket completely.

2) Remove engine hood.

3) Remove the upper and lower rubber joints from the radiator.

4) First remove the four (4) clamping bolts and then dismantle the radiator.

5) Remove the air cleaner assembly and all its associated parts.

6) First remove the battery strap connected to ground and then disconnect the following circuit.

   (1) Thermo-unit
   (2) Oil pressure unit
   (3) Distributor cord and its high tension cord
   (4) Generator connections
   (5) Starter circuit

7) Disconnect the fuel piping. (fuel filter to fuel pump).

8) Disconnect the carburetor control at the link rod assembly (at the operating control).

9) Disconnect the exhaust pipe from the exhaust manifolds.

10) Disconnect the drive shaft and mount the plug (8529-1408) on the rear cover of the transmission.

pidin kiristyspultti

11) Remove all the clamp bolts on the retainer and remove clutch control relay lever and its associated parts from the transmission case.

kannattaja

12) Put cable of the hoist through the hooks on the engine block.

13) Disconnect all the gear control system.

~~In case of remote gear control system:~~

a. Remove the relay lever bracket with the link rod held in position.

b. Remove the engine rear mounting side member from the body and dismantle the shift lever and select lever's link rod with the engine rear part slightly lowered the level.

In case of direct gear control system:

a. First remove the floor carpet on the gearbox cover.

b. Then, remove the set bolts on the gear shift lever cover and dismantle the gear shift lever assembly.

c. Dismantle the engine rear mounting side member from the body side.

14) Remove the engine front mounting.

15) Lift the engine block slowly and carefully from the chassis. The cable should be often checked to see if it is properly tensioned. The hook on the chain block should be carefully moved forward for slanting the engine to provide free space in the surrounding area.

Note: The work should be carefully carried out lest the engine should scratch the painted surface of the body or the accessories near it.

Moottorin takaisin laitto

4-1-2 Mounting the engine

The engine should be mounted on the chassis in the sequence converse to dismounting, but attention should be invited to the following:

Note: (1) The mounting bolts on the body side of the engine mounting bracket should be carefully checked to see if it is firmly tightened.

(2) Pipes and gasket should be carefully checked for wear or damage and replaced if necessary.

(3) Cords and terminal should be also checked and corrected or replaced as necessary.

(4) The radiator should be carefully mounted to provide uniform spacing between cooling fan and fan guide.

(5) Before the radiator rubber joints are mounted in position, the sealing compound should be applied to the joints to prevent water leakage.

(6) When the engine control link and all other associated parts are connected, the engine should be started and adjusted to ensure optimum idling by adjusting the carburetor setting after the engine has reached the normal operating temperature.

(7) The air cleaner should be put back in place.

(8) For mounting the engine hood, the hinges should be temporarily fastened to provide suitable adjusting margins. The hinges on the engine hood should be firmly tightened after the engine hood and fenders are properly aligned.

4-2 DISMANTLING

4-2-1 Engine details and parts name

Exploded view of the engine

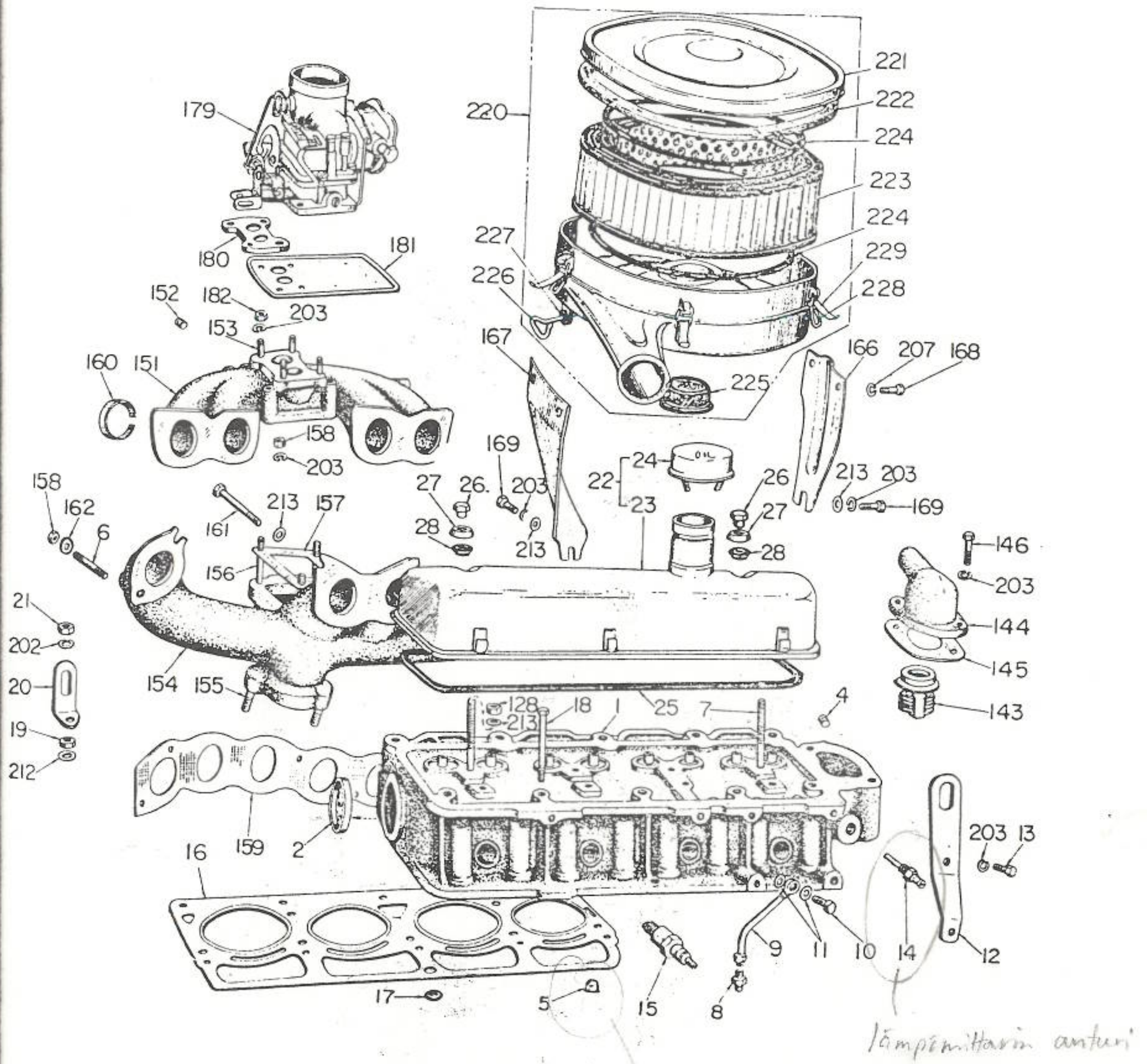


Fig. 4-2 A

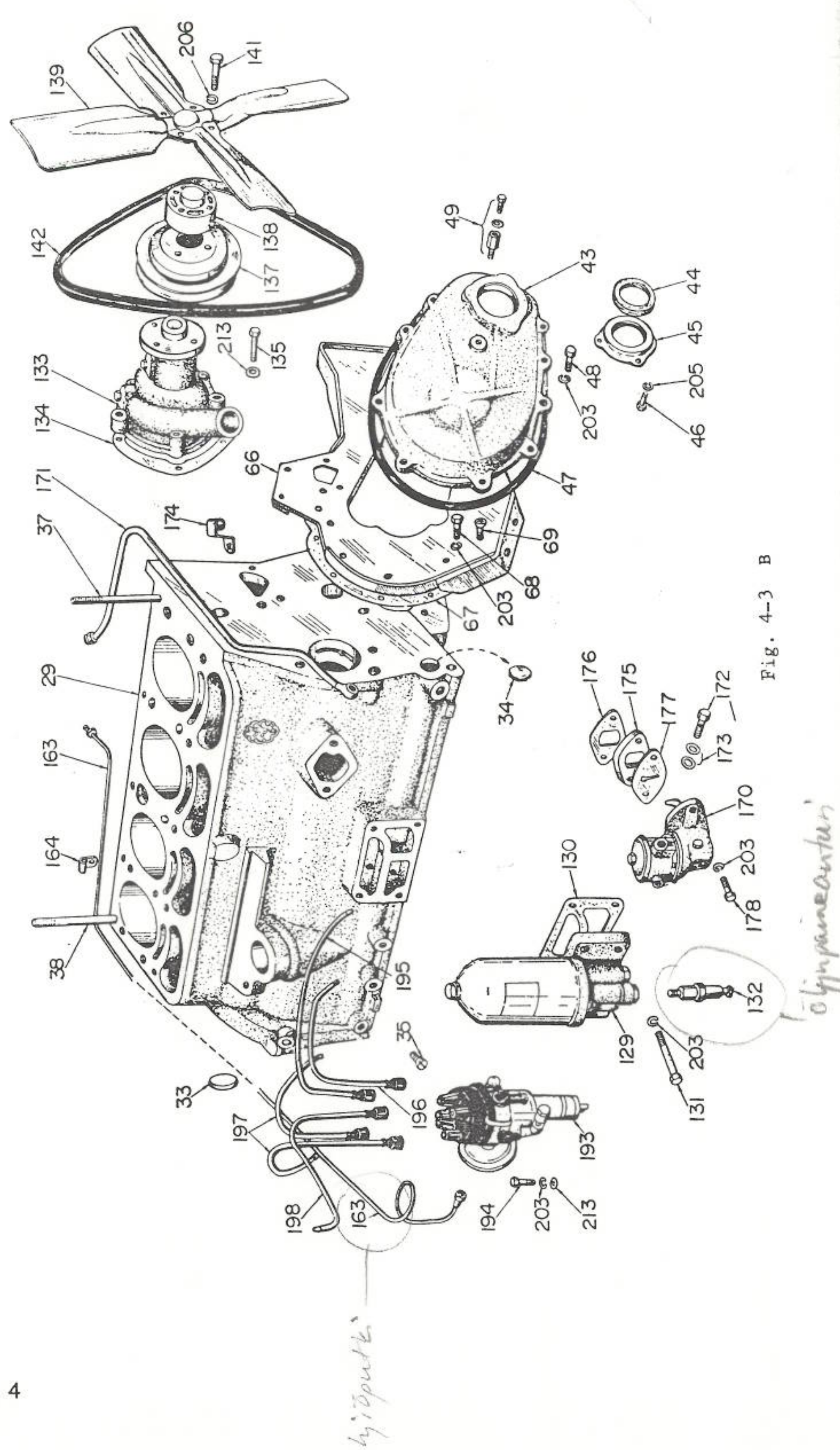


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Fig. 4-3 B

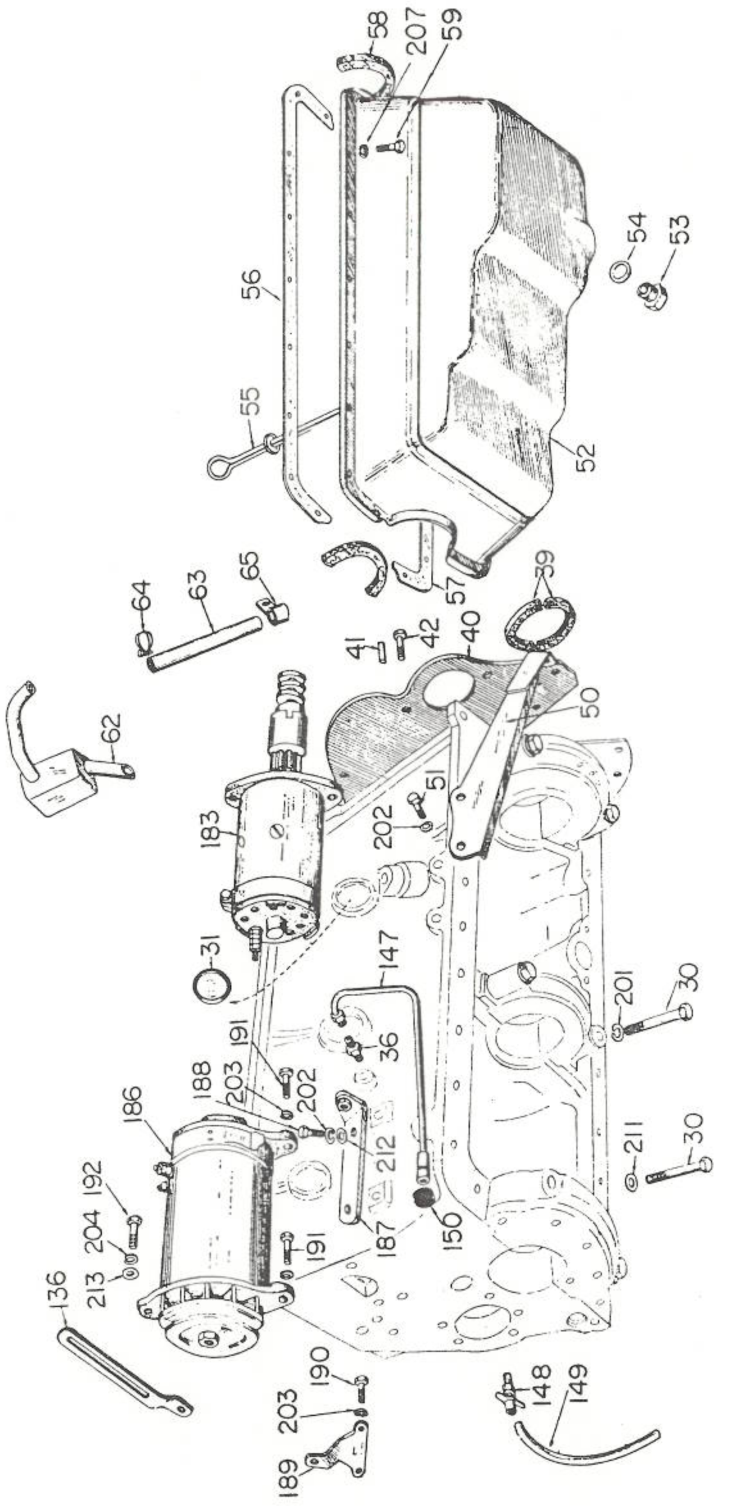

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Fig. 4-4 C

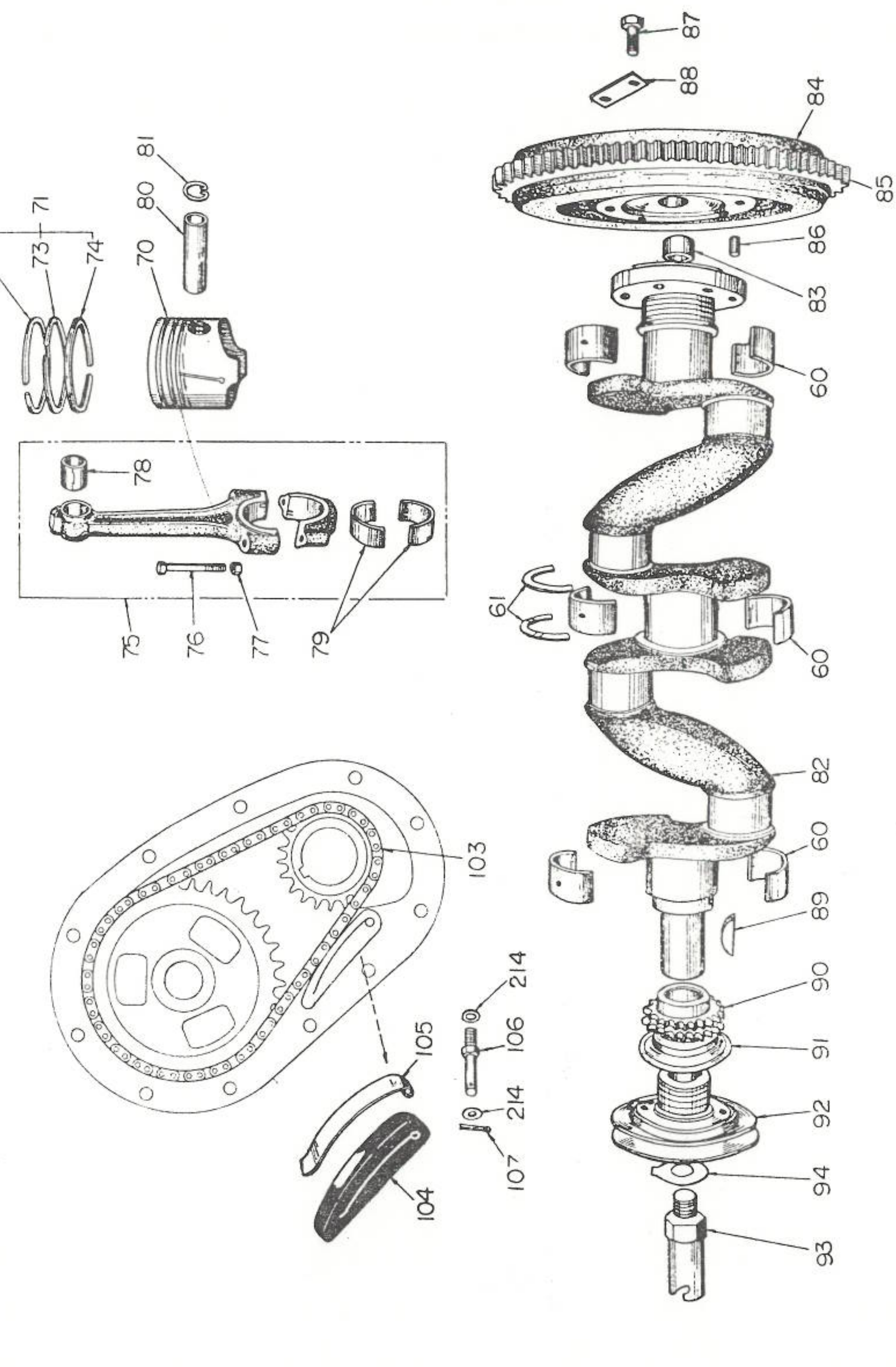
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Fig. 4-5 D

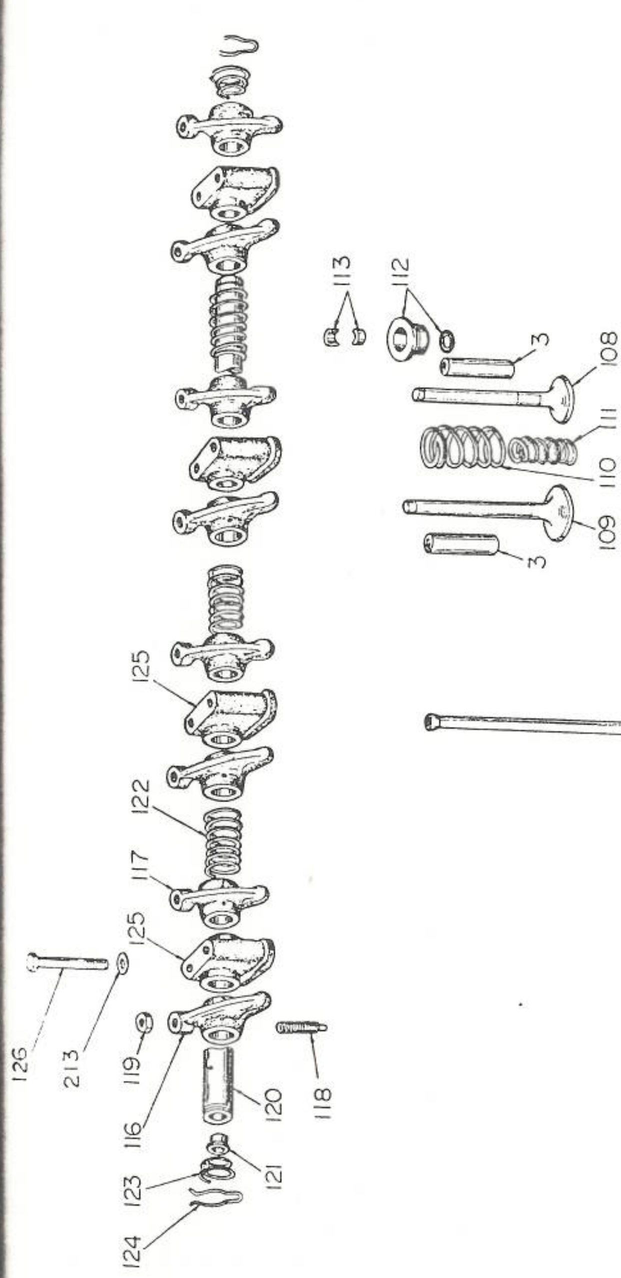


Fig. 4-5 D

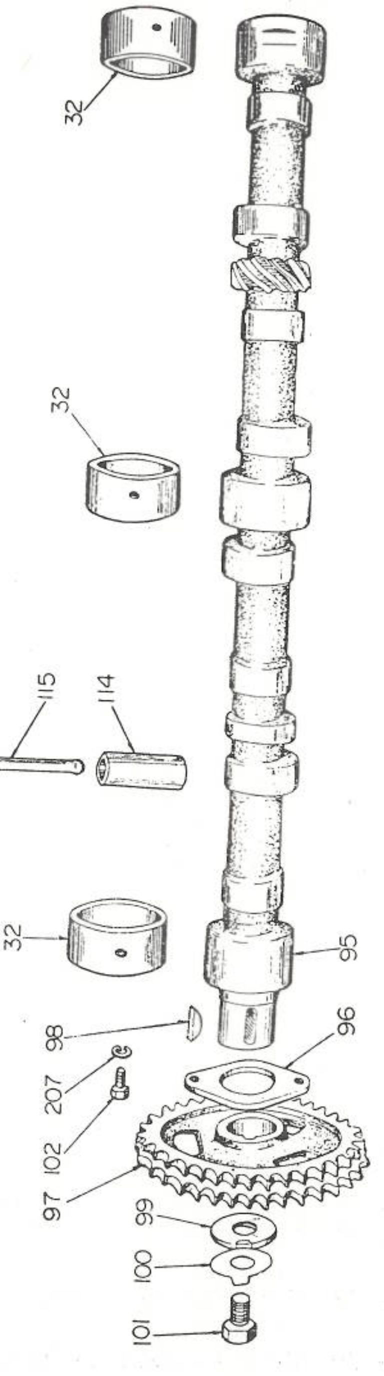


Fig. 4-6 E

PARTS NAME

A - 1 Cylinder head assembly
- 2 Sealing cup
E - 3 Valve guide
A - 4 Plug
- 5 Water jet (front)
- 6 Stud
- 7 Stud
- 8 Nipple
- 9 Oil pipe assembly
- 10 Joint bolt
- 11 Packing
- 12 Front hanger
- 13 Front hanger bolt
- 14 Thermometer unit
- 15 Spark plug
- 16 Cylinder head gasket
- 17 "O" ring packing
- 18 Cylinder head clamp bolt
- 19 Nut
- 20 Rear hanger
- 21 Hanger nut
- 22 Head cover assembly
- 23 Head cover
- 24 Oil filler cap
- 25 Head cover gasket
- 26 Head cover nut
- 27 Head cover washer
- 28 Head cover gasket
B - 29 Cylinder body assembly
C - 30 Bearing cap clamp bolt
- 31 Sealing cup
E - 32 Camshaft bearing
B - 33 Plate plug
- 34 Plate plug
- 35 Taper plug
C - 36 Water drain pipe nipple
B - 37 Cylinder head stud (front)
- 38 Cylinder head stud (front)
C - 39 Rear crankshaft rear seal
- 40 Rear plate
- 41 Pin
- 42 Reamer bolt
B - 43 Timing cover assembly
- 44 Felt ring
- 45 Felt ring retainer
- 46 Screw
- 47 "O" ring packing
- 48 Bolt

C - 50 Stiffener (left) and (right)
- 51 Stiffener bolt
- 52 Oil pan
- 53 Oil pan drain plug
- 54 "O" ring packing
- 55 Dipstick
- 56 Oil pan packing (left)
- 57 Oil pan packing (right)
- 58 Bearing packing
- 59 Oil pan bolt
D - 60 Crank bearing kit
- 61 Thrust bearing
C - 62 Breather assembly
C - 63 Breather vinyl pipe
C - 64 Clip
- 65 Clip
B - 66 Support
- 67 Support plate packing
- 68 Support plate bolt
- 69 Screw
D - 70 Piston
- 71 Piston ring kit
- 72 Compression ring (first)
- 73 Compression ring (second)
- 74 Oil control ring
- 75 Connecting rod assembly
- 76 Connecting rod bolt
- 77 OD nut
- 78 Small end bush
- 79 Connecting rod bearing
- 80 Piston pin
- 81 Piston pin snap ring
- 82 Crankshaft

- 83 Crankshaft bushing
- 84 Flywheel
- 85 Ring gear
- 86 Pin
- 87 Bolt
- 88 Lock plate
- 89 Woodruff key
- 90 Crankshaft timing wheel
- 91 Oil thrower
- 92 Pulley
- 93 Starting handle claw
- 94 Tub washer
E - 95 Camshaft
- 96 Thrust plate
- 97 Camshaft timing wheel
- 98 Camshaft key
- 99 Washer
- 100 Lock washer
- 101 Camshaft bolt
- 102 Thrust plate fixing bolt
- 103 Timing chain
- 104 Chain tensioner
- 105 Chain tensioner plate
- 106 Pivot pin
- 107 Split pin
- 108 Intake valve
- 109 Exhaust valve
- 110 Valve spring (outer)
- 111 Valve spring (inner)
- 112 Spring seat
- 113 Split collar
- 114 Tappet
- 115 Push rod
- 116 Rocker arm A
- 117 Rocker arm B
- 118 Adjusting screw
- 119 Nut
- 120 Rocker arm shaft
- 121 Plug
- 122 Spring
- 123 Spring conical
- 124 Clip
- 125 Rocker arm shaft bracket
- 126 Bolt

A - 128 Rocker bracket fixing nut
B - 129 Oil filter assembly
- 130 Packing
- 131 Bolt
- 132 Oil pressure unit
- 133 Water pump assembly
- 134 Packing
- 135 Bolt
C - 136 Generator adjusting plate
B - 137 Fan pulley
- 138 Spacer
- 139 Fan assembly
- 140
- 141 Fan bolt
- 142 Fan belt
A - 143 Thermostat
- 144 Water outlet pipe
- 145 Packing
- 146 Bolt
C - 147 Water drain pipe assembly
- 148 Drain tap assembly
- 149 Drain hose
- 150 Grommet
A - 151 Intake manifold
- 152 Taper plug
- 153 Stud
- 154 Exhaust manifolds
- 155 Stud
- 156 Stud
- 157 Gasket
- 158 Nut
- 159 Gasket
- 160 Intake manifolds guide tube
- 161 Bolt
- 162 Washer
B - 163 Vacuum pipe
- 164 Clip
- 165
- 166 Air cleaner front bracket
- 167 Air cleaner rear bracket
- 168 Bolt

- 169 Bolt
B - 170 Fuel pump assembly
- 171 Fuel pipe assembly
- 172 Fuel pump joint bolt
- 173 Joint bolt packing
- 174 Clip
- 175 Heat insulator
- 176 Joint
- 177 Joint
- 178 Bolt
A - 179 Carburetor assembly
180 Heat insulator
181 Heat protector
182 Nut
C - 183 Starter assembly
184
185
186 Generator assembly
187 Generator rear bracket
188 Bracket fixing bolt
189 Generator front bracket
190 Bracket bolt
191 Bolt
192 Adjust plate bolt
B - 193 Distributor assembly
194 Bolt
195 Ignition cable assembly (no. 1)
196 Ignition cable assembly (no. 2)
197 Ignition cable assembly (no. 3 and 4)
198 Ignition main cable assembly
199
200
C - 201 Spring washer
A C - 202 Spring washer
- 203 Spring washer
- 204 Spring washer
- 205 Spring washer
- 206 Spring washer
- 207
A C - 207 Spring washer
- 208
- 209
- 210
C - 211 Plain washer
A C - 212 Plain washer
- 213 Plain washer
D - 214 Plain washer
- 215
- 216
- 217
- 218
- 219
A - 220 Air cleaner assembly
- 221 Cover
- 222 Packing
- 223 Element
- 224 "O" ring packing
- 225 Tube packing
- 226 Fixing bolt
- 227 Grommet
- 228 Lever
- 229 Clip

4-2-2 Cleaning and inspecting the engine assembly

(1) Cleaning

The external portion of the engine should be carefully cleaned before assembling. The engine may be cleaned in the manner best suited for a given factory equipment, but steam cleaning is the most effective method. The steam cleaning is one of the cleaning methods to blow steam directly onto the engine thereby removing grease, and dirt deposit from around the grooves, bolts and the like.

The engine may be wiped with a rag and dried. Another method is to use a detergent oil and a rag or a brush to remove the dirt, grease and other deposit from the engine, in this instance, the engine should be dried with compressed air.

(2) Inspecting *tarkastaminen*

1) Exterior of the engine
The water jacket should be carefully checked for cracks or restricted water passage which would often invite freezing in the winter season. It should also be checked for oil leakage.

2) Clutch housing
Kytkinkotelo
The clutch housing should be checked for cracks or rupture. *repeämä*

Öljypohja
3) Oil pan
The oil pan should be checked for serious damage on the surface and for oil leakage. The disassembling work should be started after the above checkup are all complete.

Moottorin purkaminen
4-2-3 Dismantling the engine

The engine should be dismantled in the following sequence.

(1) Remove the dipstick (a)

(2) Disconnect the fuel pipe (2) and the vacuum pipe (3).

To hold the joint in position, hold the joint firmly with the aid of a pair of wrenches and turn loose the socket nut.

(3) Remove the distributor cap (4) together with the high tension cables.

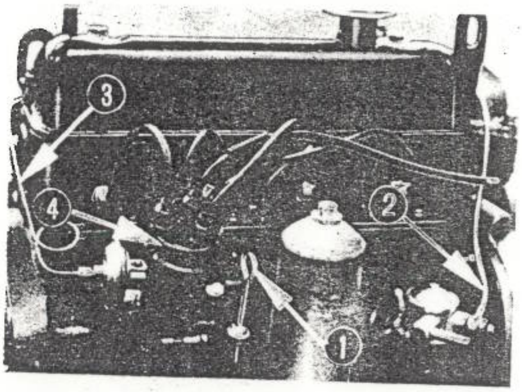


Fig. 4-7 Dismantling (1)～(3)

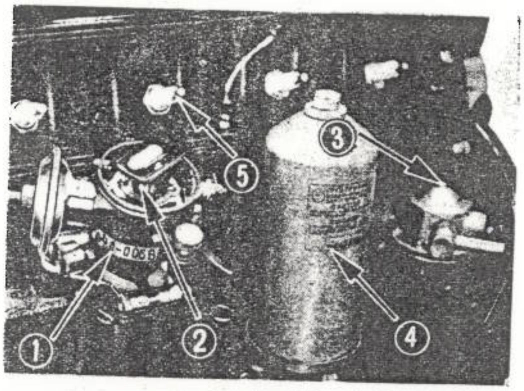


Fig. 4-8 Dismantling (4)～(8)

(4) Slacken the distributor set plate (1) and remove the distributor (2).

(5) Remove the fuel pump (3).

(6) Remove the oil filter (4) from the engine block.

(7) Remove spark plugs (5) with the aid of plug wrench.

(8) Disconnect the oil rocker feed pipe.

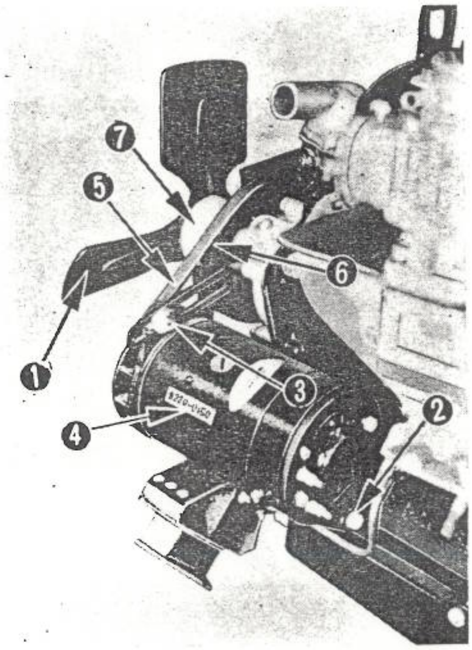


Fig. 4-9 Dismantling (9)~(10)

(9) Remove the fan (1).

(10) Remove the generator bracket bolt (2) and adjust plate bolts (3) and then, remove the generator (4), fan belt (5), fan pulley and the spacer (7).

(11) Remove the carburetor assembly (1) and the heat protector (2).

(12) Remove the head cover (3).

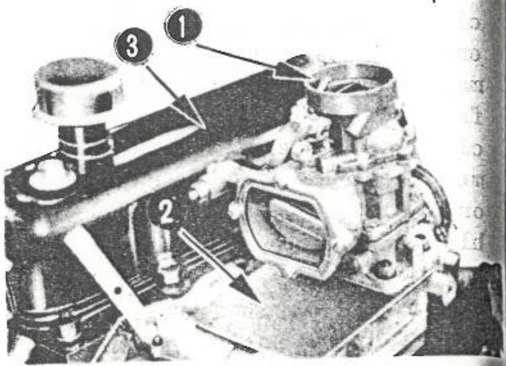


Fig. 4-10 Dismantling (11)~(12)

(13) Remove the manifolds assembly (1).

(14) Remove the breather assembly (2).

(15) Remove the water drain pipe (3).

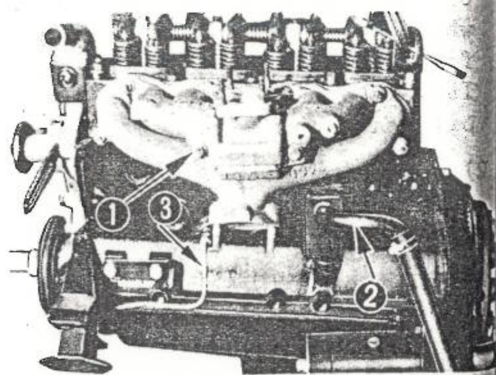


Fig. 4-11 Dismantling (13)~(1
15)

(16) Remove the water pump assembly (2).

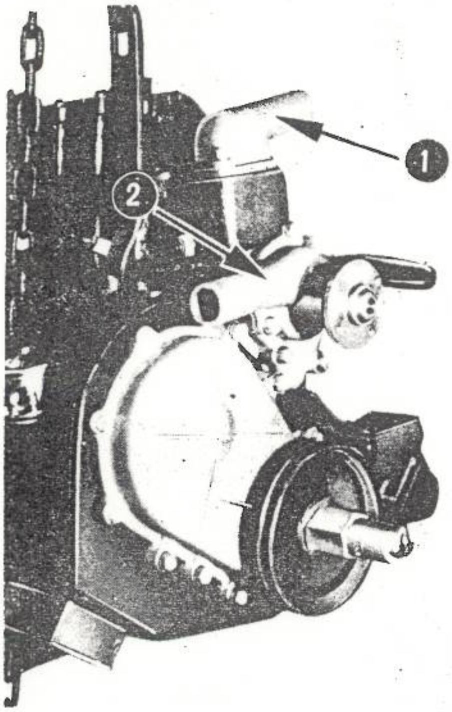


Fig. 4-12 Dismantling (16)～(17)

(17) Remove the thermostat housing (1) and take out the thermostat unit.

(18) Remove the valve rocker shaft assembly (1).

(19) Pull out the Push rod (2).

(20) Remove the cylinder head and cylinder head gasket. The cylinder head clamping bolts should be turned loose in the sequence illustrated in Fig. 4-14.

(21) Remove the tappets.

(22) Hold the engine vertically with the flywheel (1) side down.

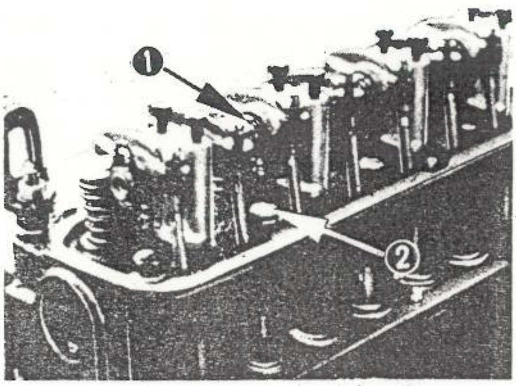


Fig. 4-13 Dismantling (18)～(19)

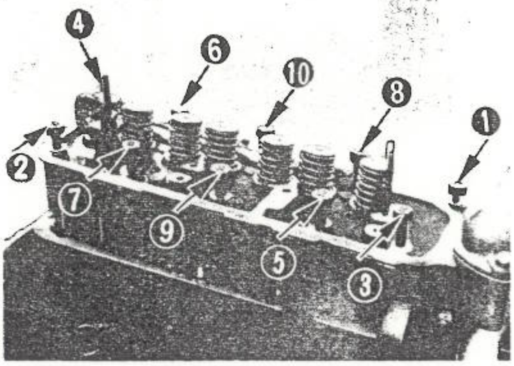


Fig. 4-14

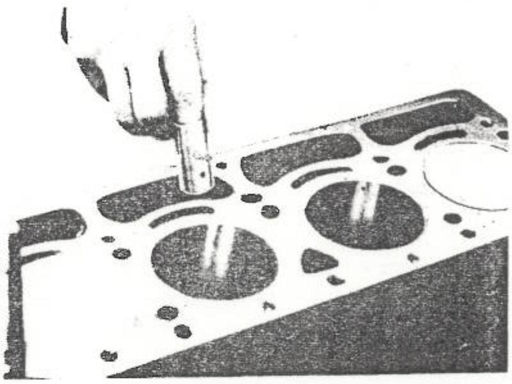


Fig. 4-15

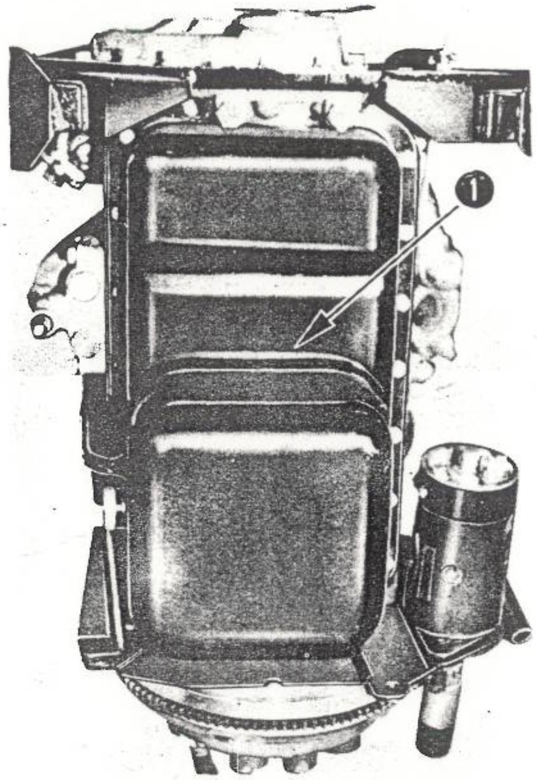


Fig. 4-16 Dismantling (22)~(23)

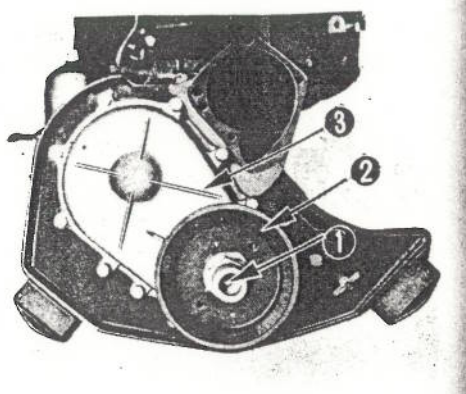


Fig. 4-17 Dismantling (25)~(26)

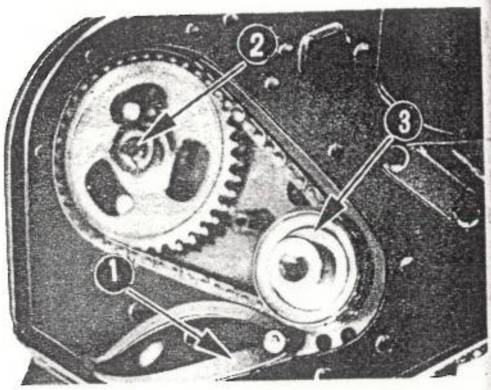


Fig. 4-18 Dismantling (27)~(29)

(23) Remove the oil pan (1).

(24) Remove the oil pan assembly.

(25) Turn loose the starting claw (1) and then remove the crank pulley (2).

(26) Remove the timing cover (3).

(27) Remove the chain tensioner (1).

(28) Remove the camshaft bolt (2) and take the lock washer and plain washer off the position.

(29) Remove the crankshaft oil thrower (3).

(30) With the timing chain fitted on the camshaft and crankshaft timing wheels, pull out both the camshaft and crankshaft timing wheels with the aid of the puller (8521-0074) (8521-0062).

(31) Remove the camshaft thrust plate (1) and then pull out the support plate (3).

(32) Scrape off carbon deposit from the upper portion of the cylinder walls.

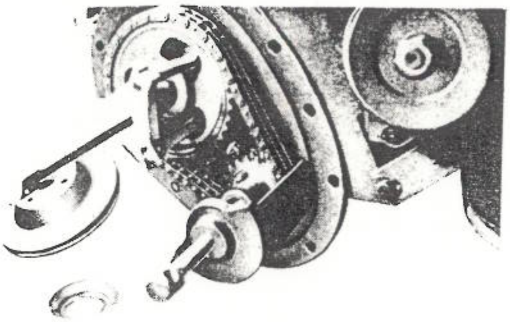


Fig. 4-19

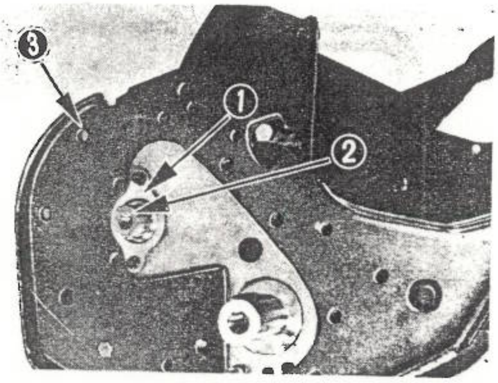


Fig. 4-20 Dismantling (31)

(33) Carefully turn the crankshaft so as to bring the pistons in the 2nd and 3rd cylinders (or 1st and 4th) into their bottom dead centers.

(34) Remove the bearing caps (1) and (2) from the connecting rods in the 2nd and 3rd cylinders.

(35) With finger pressure applied onto piston heads in the 1st and 4th cylinders, carefully turn the crankshaft so as to bring the 2nd and 3rd pistons to the T.D.C.

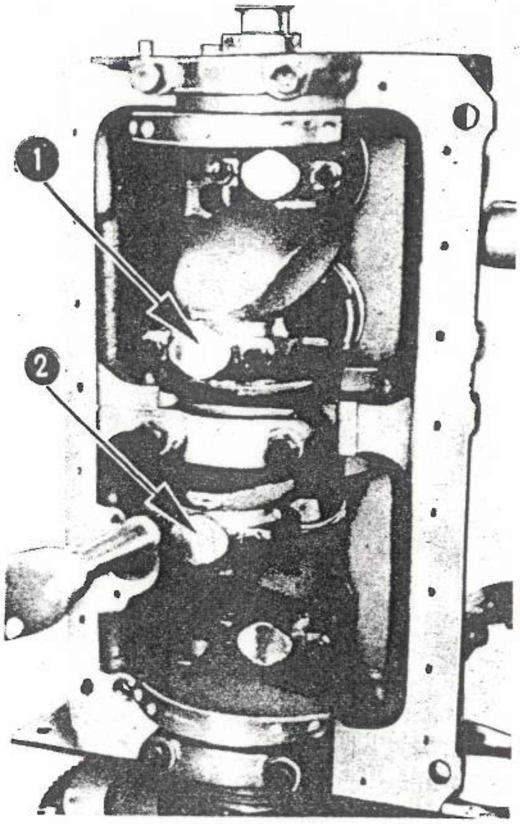


Fig. 4-21 Dismantling (31)

(36) Pull out the pistons to the cylinder side by depressing the connecting rods in the 1st and 4th cylinders.

Note: In order to avoid interchanging the parts, temporarily fasten the cap with the respective connecting rod.

(37) Apply the same dismantling procedure to the 1st and 4th (or 2nd and 3rd) cylinders for removing the pistons and their pertinent parts.

(38) Remove the piston rings with the aid of piston ring expander.

Note: In order to avoid interchanging these parts, the pistons and their rings should be stored separately.

Fig. 4-22 Dismantling (38)

(39) Disconnect the connecting rod from the piston.

1) Remove the piston pin snap ring.

2) Pull out the piston pin after the piston is heated to 50-60°C with use of piston heater.

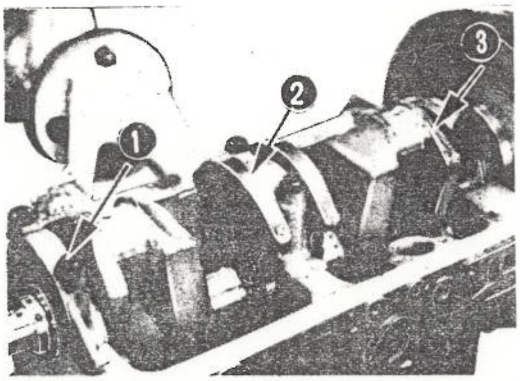


Fig. 4-23

(40) Turn the engine block up side down to bring its head down.

(41) Remove the crank bearing caps (1), (2) and (3).

(42) Remove the crankshaft together with the flywheel in position.

(43) Remove the valve and the valve spring from the cylinder head with the aid of the valve replacer (8523-1415).

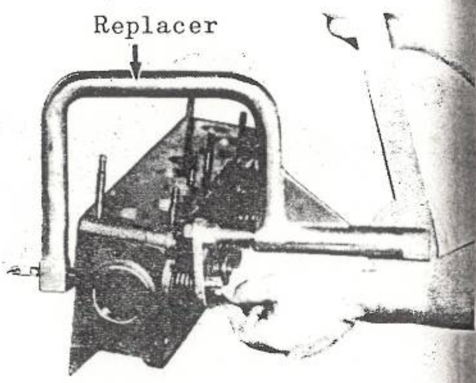


Fig. 4-24

Note: All the valves and their springs should be identified with suitable marking.

(44) Further dismantle the valve rocker arm shaft assembly.

First remove the clips on both ends of the valve rocker arm shaft assembly and then, take out the spring, rocker arm and rocker arm bracket from the shaft.

4-3 REASSEMBLING

4-3-1 Cautions for reassembling the engine

(1) All the parts needed for reassembling should be clean and dry. Particular attention should be invited to the oil port, bearing, piston and cylinder walls.

(2) The cylinder, piston, bearing and all other parts subjected to friction should be lubricated with engine oil before being reassembled.

(3) All the gaskets and packings should be replaced with new ones and to prevent oil leakage, suitable bonding compound should be applied to the gaskets and packings as necessary.

(4) All the lock washers should be replaced with new ones.

(5) Even though all the parts are preadjusted to provide with adequate clearances, careful attention should be invited for fitting these parts in positions with optimum clearances given.

4-3-2 Reassembling

(1) Connect the connection rod with the piston.

1) Heat the piston and its connecting rod to 50° - 60°C with use of the piston heater.

2) Properly fasten the connecting rod with the piston.

Note: The piston and the connecting rod should be properly aligned with their front sides faced frontward.

(2) Mount the piston rings on the piston with the aid of the piston ring expander.

(3) Mount the rocker arms in positions.

(4) Mount the valve system properly on the cylinder head.

Reassembling the rokerarm

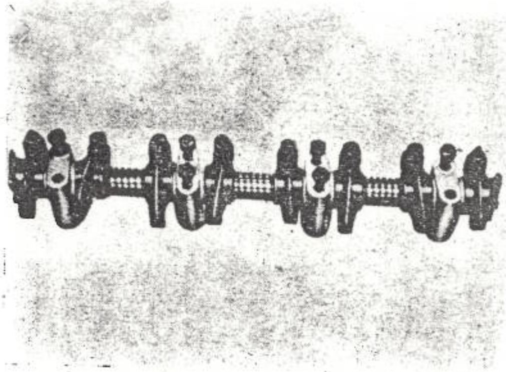


Fig. 4-25

Insert the valve into the valve guide, refit the valve spring and spring seat in position and depress the valve spring with the aid of valve spring replacer. With the valve spring held depressed, mount the sealing ring and secure it in position with the split cotter.

(5) Refit the crankshaft rear oil seals into the grooves in the cylinder block and in the rear bearing cap.

Note: The oil seal should be fitted in position with its both edges protruded about 0.5mm from the contacting faces of the bearing caps.

Mounting the rear oil seall

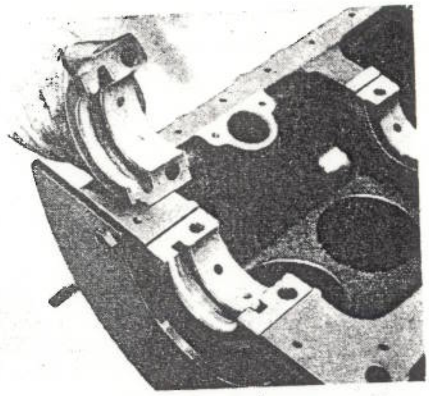


Fig. 4-26

(6) Mount the main bearings (upper front), (center) and (rear) in the cylinder block.

(7) Mount the crankshaft thrust bearing on the both sides of the center bearing upper in the cylinder block.

Note: The thrust bearing should be mounted in place with its oil groove faced against the mounting face.

(8) Mount the crankshaft in the cylinder body.

(9) Refit the crankshaft bearing lower half into the bearing cap and then mount the cap in the cylinder block.

The bearing cap clamp bolts should be tightened with specified torque given below in the sequence of center bearing. rear bearing and front bearing.

The clamping torques are standard at:

9-10 m-kg for model G150
9-10 m-kg for model G130 and
9-10 m-kg for model C180

(1) The front bearing cap should be tightened in such a manner that the face of the cap is properly aligned with the front face of the body.

(2) After the bearing caps are tightened, the crankshaft should be carefully turned with hand to make sure that it rotates freely.

(10) Refit the flywheel in place if it has been removed.

The clamping torques are standard at:

4.5 - 6.5 m-kg for model G150
4.5 - 6.5 m-kg for model G130
and
4.5 - 6.5 m-kg for model C180

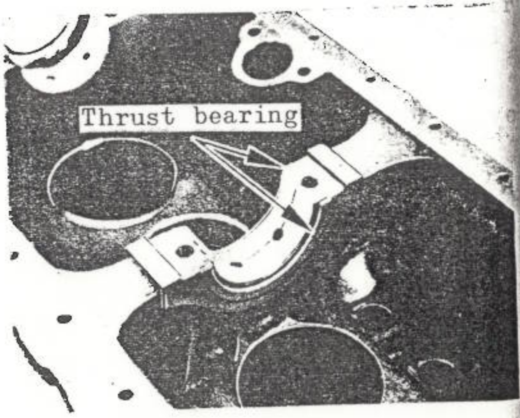


Fig. 4-27

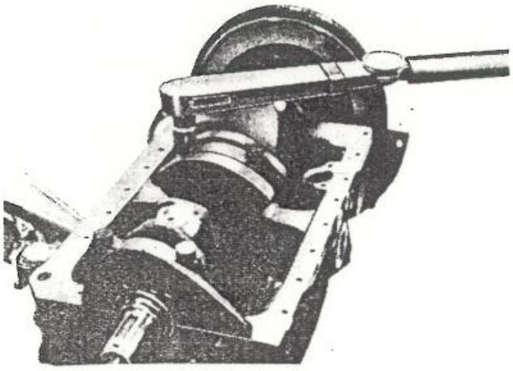


Fig. 4-28

(11) Mount the bearings on the connecting rod and the cap.

Note: The bearing and the face of the engine block in which the bearing is mounted should be cleaned.

(12) Insert the piston with the connecting rod mounted in position into the cylinder from the upper part thereof with the aid of the piston ring setting tool. (8522-1169)

Inserting the piston into cylinder with an aid of setting tool

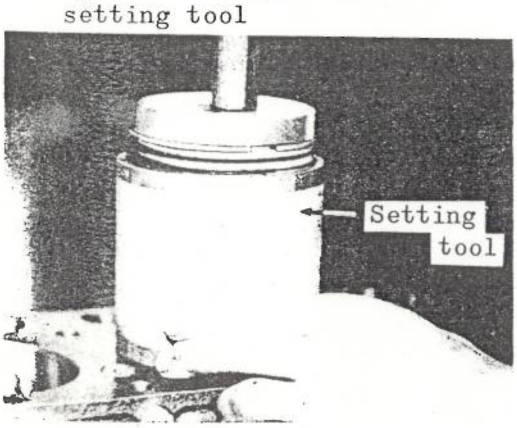


Fig. 4-29

(1) The piston should be mounted in position together with the connecting rod with the face of the connecting rod with the cylinder number marking faced toward the camshaft side.

(2) The piston rings should be so arranged on the piston that their gaps are properly aligned (The gaps of the compression rings should be at 180° or 120° on the circumference of the piston). The piston ring gap should not be held in line with the piston pin.

(13) The bearing should be mounted on the connecting rod. The torque required for clamping the bearing is 2.4 - 2.9 m-kg.

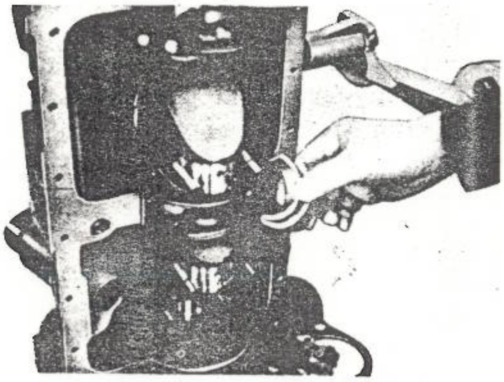


Fig. 4-30

(1) The connecting rod should be checked to see if it is provided with optimum thrust clearances. The thrust clearance is standard at 0.2 - 0.33mm.

(2) The crankshaft should be turned with hand to make sure that it rotates freely without any restriction.

(14) Mount the support plate in position.

(15) Mount the camshaft in place and refit the thrust plate in the cylinder body.

(16) Refitting the timing chain.

Rotate the crankshaft carefully so as to bring the pistons in the 1st and 4th cylinders to their T.D.C. Put the crankshaft timing wheel through the crankshaft and hold it in position about 30mm aparted from the outer end of the crankshaft. Place the timing chain over the crankshaft timing wheel and camshaft timing wheel after their notched markings are properly sligned. Carefully turn the camshaft to bring the key grooves on the timing wheel and on the shaft in correct line. With the aid of the hide mallet, refit the crankshaft timing wheel and the camshaft timing wheel properly into position. Keep the timing chain away from undue strains.

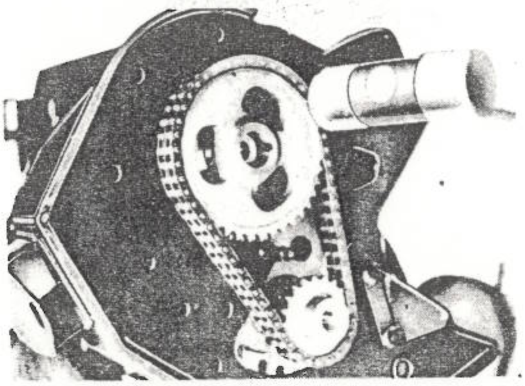


Fig. 4-31

Note: The camshaft should be held with a screwdriver to prevent it from being decentralized. When a strong force is applied, the camshaft tends to deviate from its normal position and causes the end plug provided at the rear part of the camshaft to slip off the position.

(17) Mounting the oil pump

(1) Hold the piston in the first cylinder at T.D.C. in the compression stroke. (When the timing marks on the crankshaft and camshaft timing wheels are properly aligned, the piston in the 4th cylinder is held at T.D.C. in the compression stroke.)

(2) Insert the oil pump shaft into position with a smaller half of the oil pump drive pinion end devided into two portions by a groove faced frontward. The oil pump shaft is driven by the helical gear on the camshaft. The pump shaft should be so arranged that when viewed from the position of the distributor the smaller half of the pinion end appears to be held within the angle of 47°-49° against the engine.

(3) Connect the feed pipe to the cylinder body.

(18) Mount the blade on the chain tensioner and further fit the tensioner into the cylinder block and secure it in position with the pivot pin.

Note: The crankshaft should be turned with hand to make sure that it rotates freely.

Fitting the felt ring into position

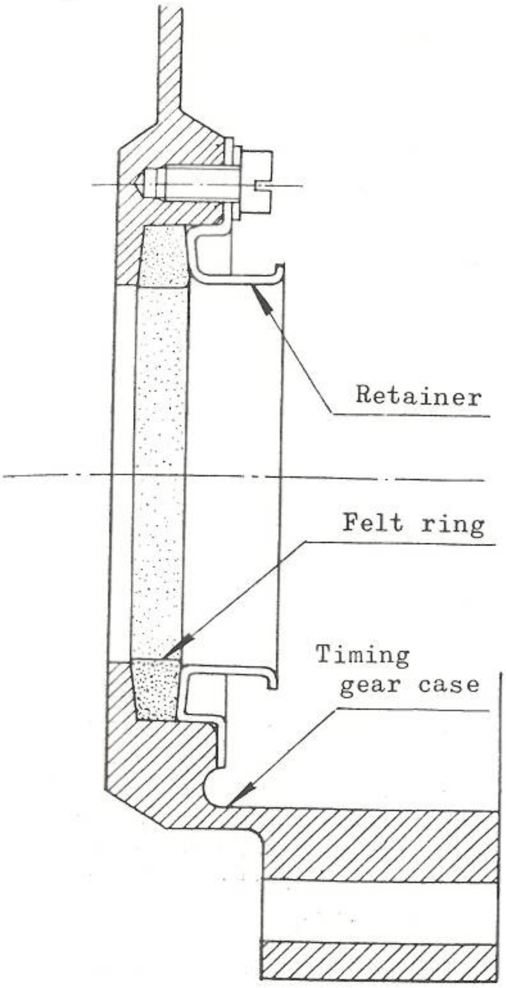


Fig. 4-32

Before the "O" ring is fitted

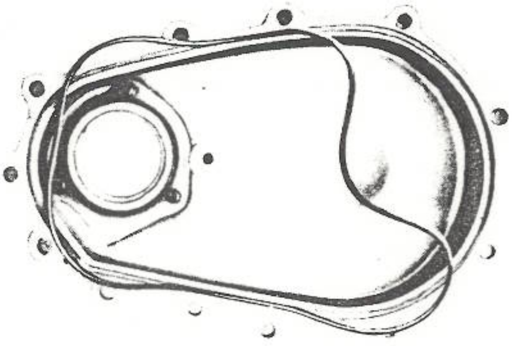


Fig. 4-33

After the "O" ring is fitted

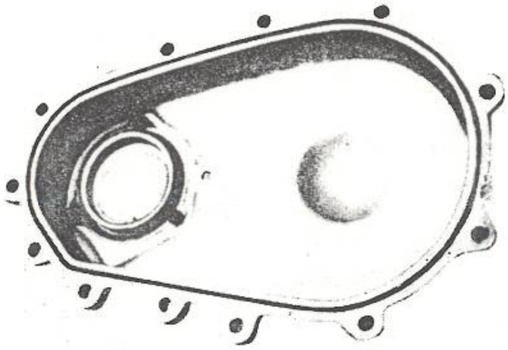


Fig. 4-34

(19) Fit the felt ring into the crank pulley hole on the timing cover.

huopa kampi hihnapyörä

(20) Fit the "O" ring packing into the groove on the inside face of the timing wheel cover.

(21) Fit the oil thrower over the crankshaft timing wheel.

(22) Mount the timing wheel cover on the cylinder body with the aid of the timing wheel cover aligner. (8524-1701)

Mounting the timing wheel cover

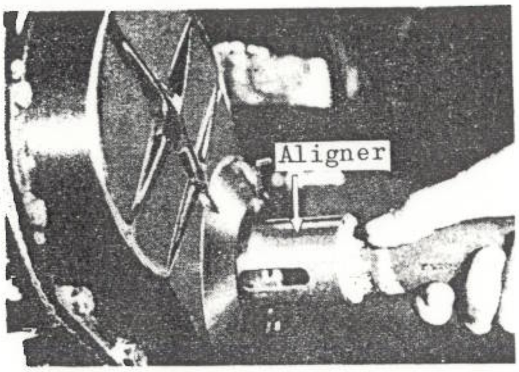


Fig. 4-35

Reassembling the oil thrower, crank pulley and timing gear case

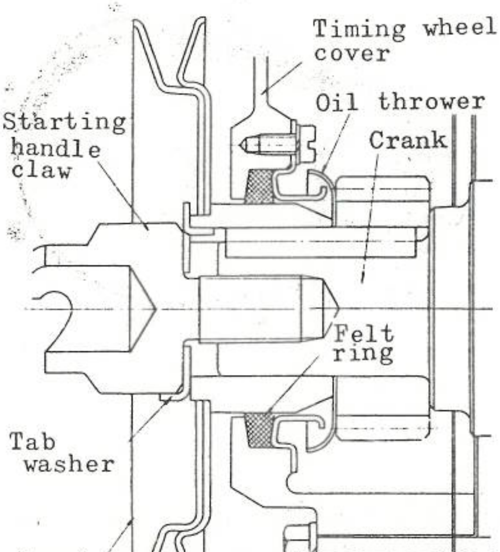


Fig. 4-36

(23) After the crank pulley is mounted on the crank shaft and the tab washer fitted into position, secure these parts to the crank shaft with the starting handle claw. Lock the starting handle claw from turning loose by bending the tab washer as necessary.

(24) Mounting the oil pan

(1) Coat the face of the cylinder body to which the oil pan is mounted with jointing compound and then, fit the new oil pan packing over the coated area. The front and rear edges of the oil pan packing should be properly fitted into the bearing packing grooves in the front and rear bearing caps, respectively.

(2) Coat the bearing packing with jointing compound and fit this into the bearing cap groove. The front and rear edges of the packing should be properly fitted into the grooves in the bearing caps and held in position with the edges of the oil pan packing.

(3) Coat the oil pan packing with jointing compound and fit this into place together with the oil pan. Secure the oil pan tightly to the cylinder body by applying even clamping torque to the oil pan fixing bolts.

Note: The oil pan should be mounted in place with its flat side faced frontward.

Fitting the oil pan packing in position

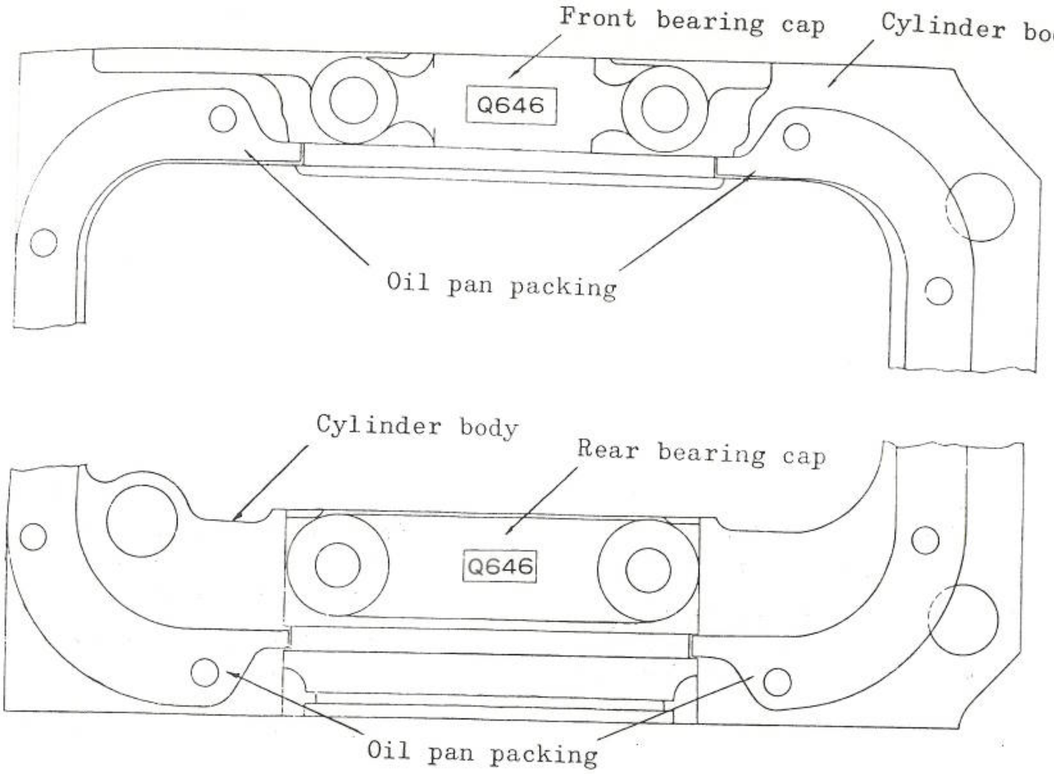


Fig. 4-37

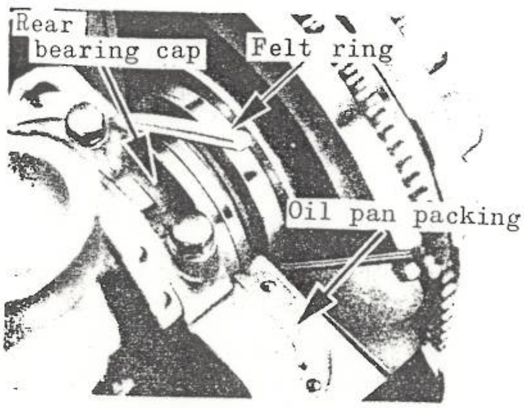


Fig. 4-38

Fitting the bearing packing in position

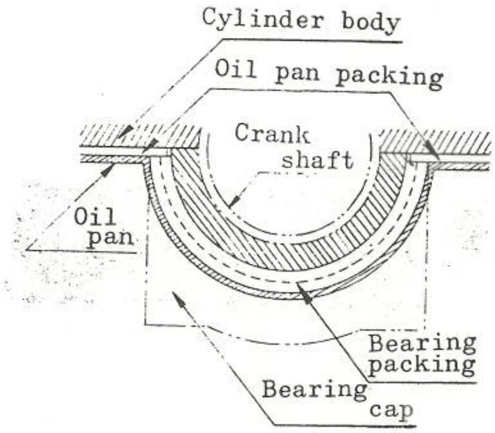


Fig. 4-39

venttiilin nosto

(25) Inserting the tappet into position

Fully coat the tappet with engine oil before it is mounted in position.

(26) Mounting the cylinder head in position

(1) Fully coat the both sides of the cylinder head gasket tiiviste with jointing compound and fit the gasket to the cylinder body and then mount the cylinder head over the gasket.

(2) The cylinder head clamping bolts should be tightened in the sequence illustrated in Fig. 4-40 in the following manner.

First apply clamping torques of up to 2 - 3 m-kg evenly to the bolts and gradually increase the clamping torque. Repeat the clamping operation several times and finally apply torque of up to 6-7 m-kg.

työntötanko

(3) Insert the push rod into position.

keinuvipu

(27) Mounting the rocker shaft assembly in position

(1) Put the rocker shaft assembly through the two (2) stud protruded on the cyl--inder head and clamp it in position with two (2) nuts and 6 clamping bolts by applying torques carefully to keep the rocker shaft free from undue strain, and finally apply torque of up to 1.7 - 2.3 m-kg.

Note: All the clamping bolts and studs should be provided with plain aluslevy washers before they are tightened.

(2) After the rocker shaft is mounted in position, adjust the tappet clearance.

The tappet clearances are standard at:

Intake valve ... 0.3mm (cold) 0.25

Exhaust valve ... 0.35mm(cold) 0.35

Minulla: kuumana

(28) Mount the head cover assembly in position.

(29) Mount the water pump in place.

(30) Refit the fan into position in the following manner.

Fasten the fan pulley, spacer and fan to the fan center with four (f) clamping bolts.

Cylinder head clamping bolts tightening sequence and clamping torques

Kannen pulttien kiristysjärjestys:

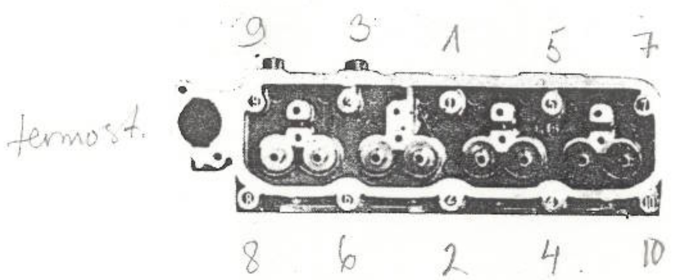


Fig. 4-40

(31) Mounting the manifolds assembly in place.

Mount the manifold assembly in position through the gasket.

Note: The two (2) guide tubes should be fitted to the cylinder head side of the intake manifolds before mounting the manifolds in place.

(32) Mounting the carburetor assembly in place

The carburetor assembly should be mounted in place through the heat protector and heat insulator.

(33) Refit the thermostat and the thermostat housing into position.

(34) Mount the generator bracket and its adjusting plate on the cylinder block and temporarily fasten the generator to the bracket.

(35) Refitting the fan belt into position.

Refit the fan belt over the pulleys and adjust its tentioning by pivotting the generator about the bracket mounting bolts. When the fan belt gives lateral deflection of about 15mm at centering portion between the water pump and generator, secure the generator in that position by clamping the generator bracket bolts and adjust plate clamping bolts.

(36) Mount the breather assembly in place.

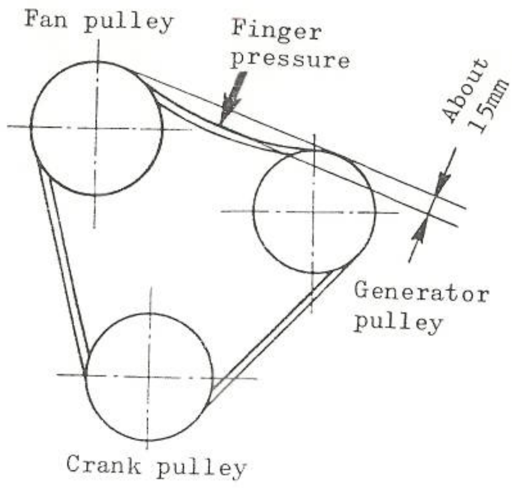


Fig. 4-41

(37) Mount the oil filter assembly in position.

(38) Mount the distributor assembly in place in the following manner. Carefully insert the distributor shaft into position with its boss properly fitted into the slot on the oil pump shaft and then, secure the distributor in position by clamping the timing adjust plate to the cylinder block.

(39) Mount the fuel pump in position.

(40) Connect the fuel pipe, vacuum pipe and oil pipe to their respective positions.

(41) Refit the spark plugs to the cylinder head.

(42) Put the ignition cable back into place.

(43) Mount the engine hanger on the cylinder head.

(44) Mount the water drain pipe in place.

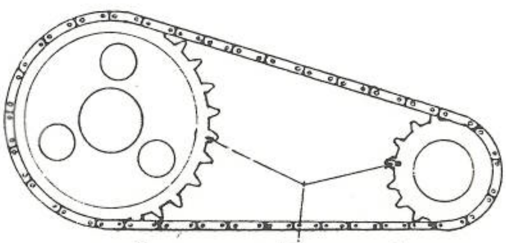
(45) Refit the dipstick into position.

(46) Refit the right and left stiffener into position

4-3-3 Reassembling the oil pump

Note: The method for reassembling the oil pump introduced in subparagraph (17) on page 4-18 is corrected as follows:

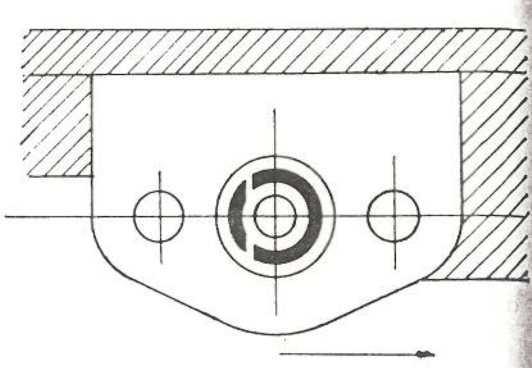
(1) Bring the piston in the 4th cylinder into T.D.C. in the compression stroke. (The corresponding marks on the timing sprockets come in line with the shaft center line against each other)



Corresponding marks

Fig. 4-42

(2) Mount the oil pump in place with a smaller half of the oil pump drive pinion end devided into two portions by a groove faced frontward. (See Fig. 4-43)



Toward the front part of of engine

Fig. 4-43

(3) The pinion gear comes into engagement with the helical gear on the camshaft and should be so arranged that when viewed from the distributor mounting hole, the smaller half of the pinion end appears slightly turned toward the right handside with the groove in the pinion end facing the cylinder wall at an angle of 30°. (See Fig. 4-44)

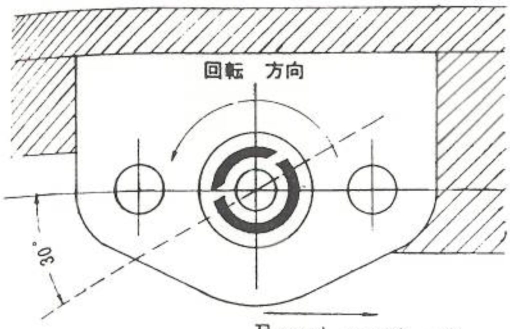


Fig. 4-44

PART 5 INSPECTING, REPAIRING AND ADJUSTING

CONTENTS

PART 5 INSPECTING, REPAIRING AND ADJUSTING

Preparations:

(1) All pertinent parts should be thoroughly cleaned to remove carbon deposit, grease rust, scale and the like before they are inspected and repaired as necessary.

(2) The oil port should be cleaned and checked with compressed air to see if the port is free from being clogged.

(3) Carbon deposit on the piston head, cylinder head and valve should be carefully removed.

(4) In order to avoid interchanging the parts, the valve, bearing, piston and connecting rod should be provided with suitable marking and stored separately.

5-1 CYLINDER HEAD AND ITS ASSOCIATED PARTS

5-1-1 Cylinder head

(1) Removing the carbon deposit

Carbon deposit should be removed from the cylinder head carefully to prevent the valve seats from being scratched with tools.

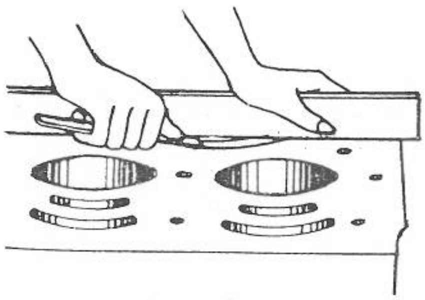


Fig. 5-1

(2) Crack or damage

The cylinder head should be carefully inspected for crack or damage with the aid of damage detector. The cylinder head should be replaced if necessary.

(3) Inspecting the cylinder head for distortion

The cylinder head should be carefully inspected for distortion using a thickness gage with a straight edge held against the lower face of the cylinder head as illustrated in Fig. 5-2.

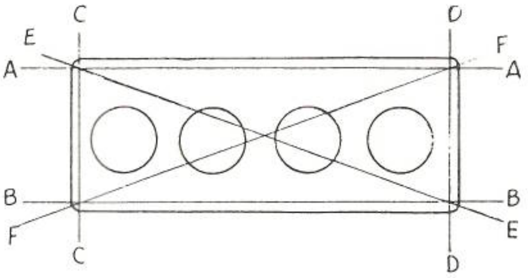


Fig. 5-2

(4) Rectifying the distorted cylinder head

If distortion of the cylinder head should exceeds 0.2mm, the lower face of the cylinder head should be touched upon with a surface grinder to hold the distortion to 0.05mm at the maximum.

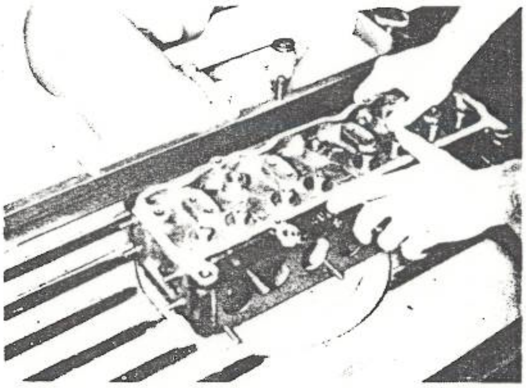


Fig. 5-3

5-1-2 Valve Guide

(1) Inspection

The clearance between the valve stem and the valve guide should be measured, and if the clearance of the intake valve and that of the exhaust valve should exceed 0.20mm and 0.25mm, respectively, these valves together with their valve guides, should be replaced.

Measuring the clearance between the valve stem and valve guide.

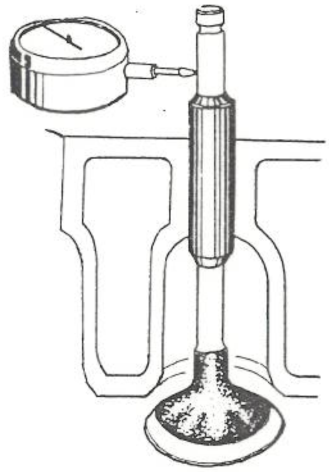


Fig. 5-4

Measurement of the valve guide as mounted in position.

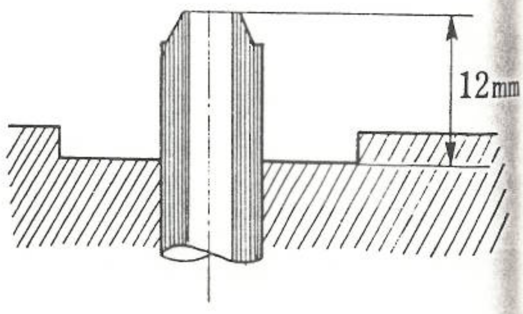


Fig. 5-5

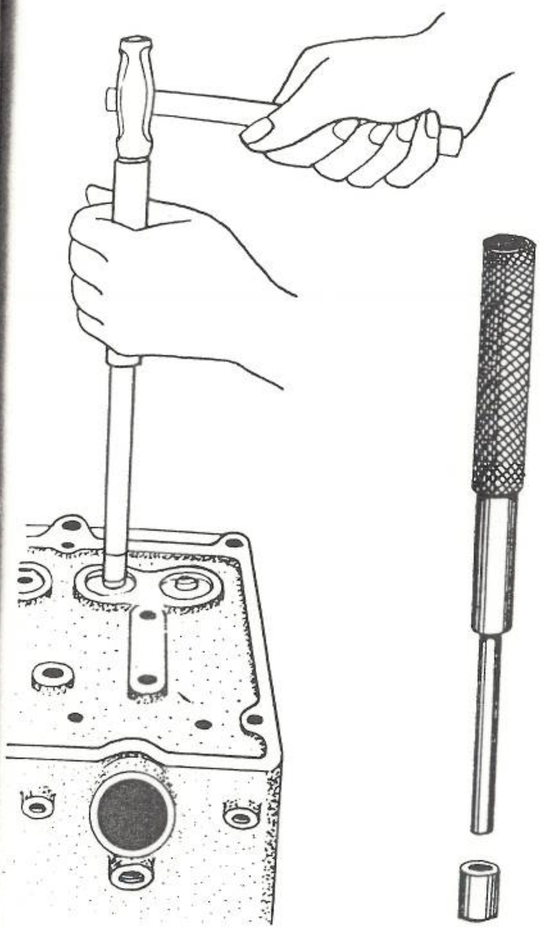


Fig. 5-6

(2) Replacement

The valve guide should be replaced in the following manner with the aid of the valve guide replacer (8523-1212). The valve guide should be removed and refitted into position through the upper part of the cylinder head. (See fig. 5-6)

The valve guide should be refitted into position with its upper tip end protruded from the cylinder head level as illustrated in Fig. 5-5.

5-1-3 Valve Seat

(1) Inspecting

The valve seat in the cylinder head should be carefully checked for wear or damage on the contacting face and rectified as necessary.

(2) Rectifying

The valve seat may be rectified with the aid of valve seat cutter or a valve seat grinder. If the valve guide is worn beyond the serviceability, the contacting face of the valve seat should be rectified after the valve guide is replaced.

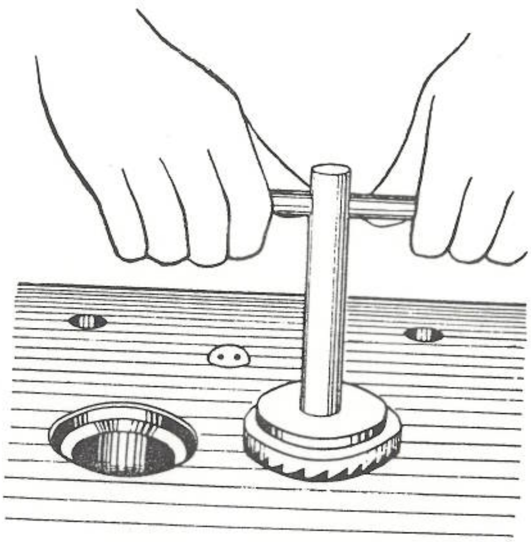


Fig. 5-7

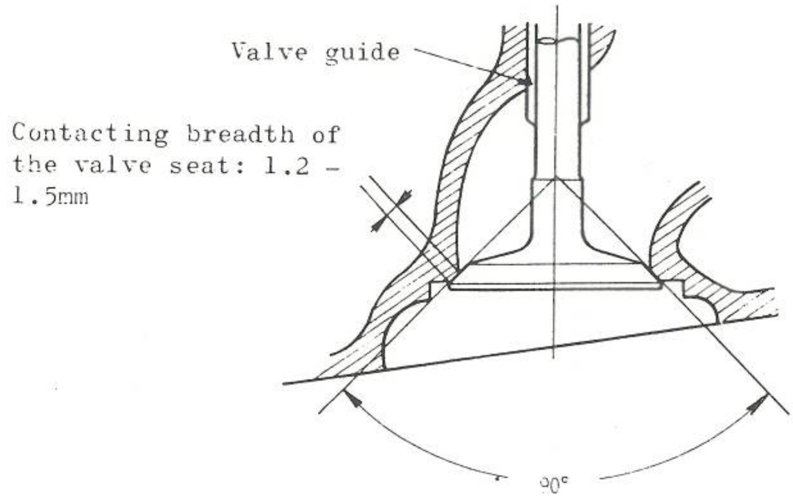


Fig. 5-8

The contacting face of the valve seat should be rectified to hold contacting breadth of 1.2 - 1.5mm with the use of the valve seat cutters having cutting angles of 60°, 90° and 120°.

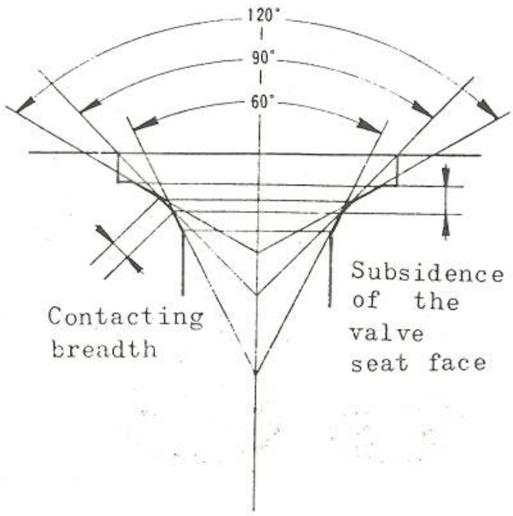


Fig. 5-9

If the subsidence of the valve seat face exceeds 2.5mm, it should be rectified after the seat ring is fitted in.

5-1-4 Valve

(1) Inspecting

The valve should be carefully checked for seizure, wear or deformation and replaced as necessary.

(2) The contacting face of the valve and the tip end of the valve stem should be rectified with the valve grinder as necessary.

(3) Service limit of the valve

If the thickness of the valve head is less than 1mm, the valve should be replaced.

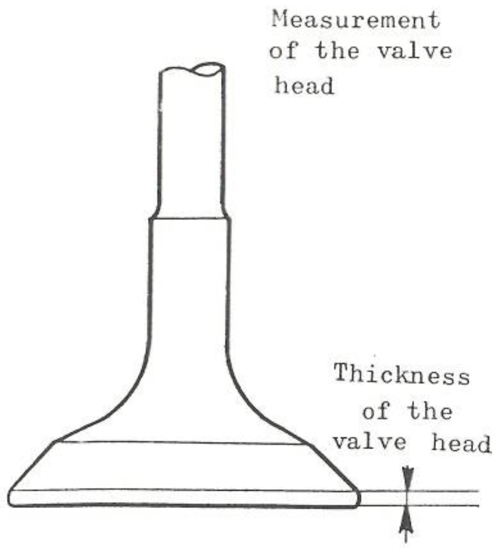


Fig. 5-10

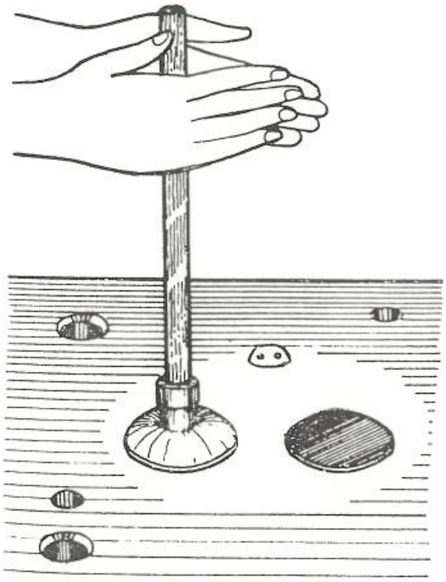


Fig. 5-11

(4) Valve grinding

The valve seat should be coated with grinding paste and then, the valve is ground into its valve seat.

Note: Close attention should be invited so as to keep the valve stem free from grinding paste. As the valve heads for models G130, G150 and G160 engines are finished with alminizing treatment, these valves should be ground with application of light pressure.

5-1-5 Valve spring

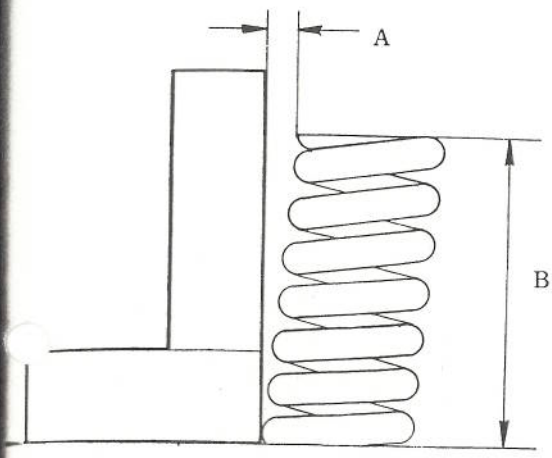
(1) Measurement of the valve spring

( ) denotes "service limit"

	For models G130 & G150		For models G150C & G150D		For model G160		For model C180	
	Inner spring	Outer spring	Inner spring	Outer spring	Inner spring	Outer spring	Inner spring	Outer spring
Free length mm	48.4 (47.0)	53.0 (51.4)	52.5 (50.9)	54.3 (52.7)	50.4 (48.9)	55.0 (53.4)	48.4 (47.0)	53.0 (51.5)
Outside diameter of the steel wire mm	2.9	4.0	2.9	4.0	2.9	4.8	2.9	4.0
Number of coils	6.0	5.0	7.0	5.5	6.0	5.0	6.0	5.0
Length as fitted mm	38.0	40.0	38.0	40.0	38.0	40.0	38.0	40.0
Valve spring load for fitting into position kg	10.8 (9.2)	26.0 (22.1)	12.9 (11.0)	26.0 (22.1)	12.9 (11.0)	30.0 (25.5)	10.8 (9.2)	2.6 (22.1)

(2) Inspecting

The dimensions of the valve spring should be measured after it is carefully inspected for damage.



A: Deviation to right angle
B: Free length

Fig. 5-12

Deviation of the valve spring from the right angle should be measured in the manner illustrated in Fig. 5-12 and if deviation exceeds 1mm, the spring should be replaced.

(3) Measuring

A slide calipers should be used for measuring the valve spring. The valve spring load at fitted length should be measured with the spring tester in the manner as illustrated in Fig. 5-13.

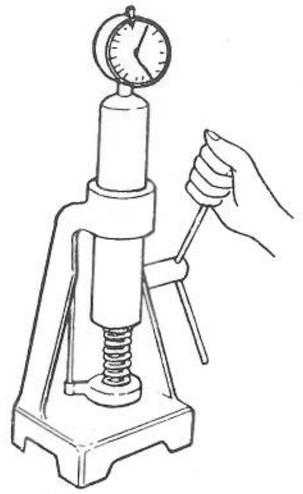


Fig. 5-13

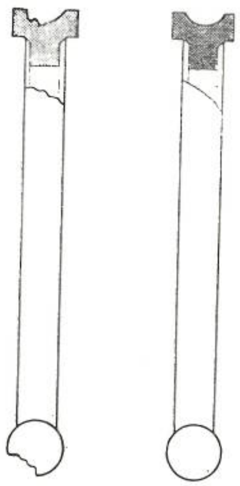


Fig. 5-14

5-1-6 Push rod

(1) Inspecting

The push rod should be inspected for bend or wear in the upper and lower ends and replaced as necessary.

5-1-7 Tappet

(1) Inspecting

The tappet has a large spherical contact with the cam and the contact face of the cam has a tapered portion. The tappet freely rotates and slides with rotation of the camshaft. The tappet should be visually inspected for wear on the sphere (Fig. 5-17) and the condition of contacting face (Fig. 5-16).

Cam Shaft and Tappet

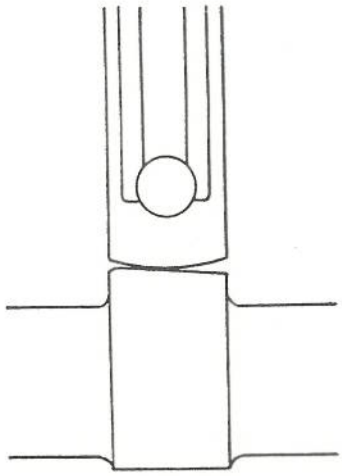
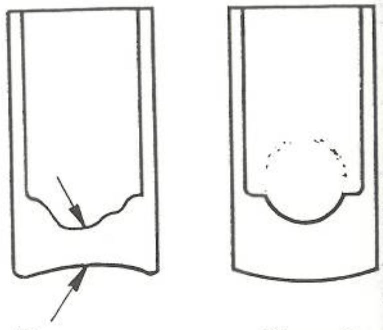


Fig. 5-15

(2) Wear in the circumference of the tappet

The outside diameter of the tappet should be measured with a micrometer and if the wear is in excess of 21.95ø, the tappet should be replaced.



Condition of the spherical portion

Fig. 5-17

Measuring the rocker shaft bending

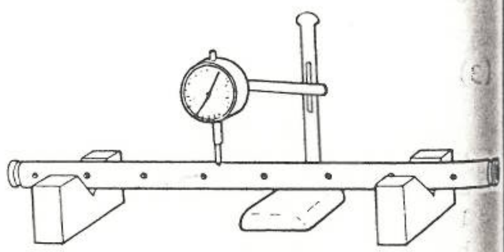


Fig. 5-18

Condition of the contacting face of the tappet

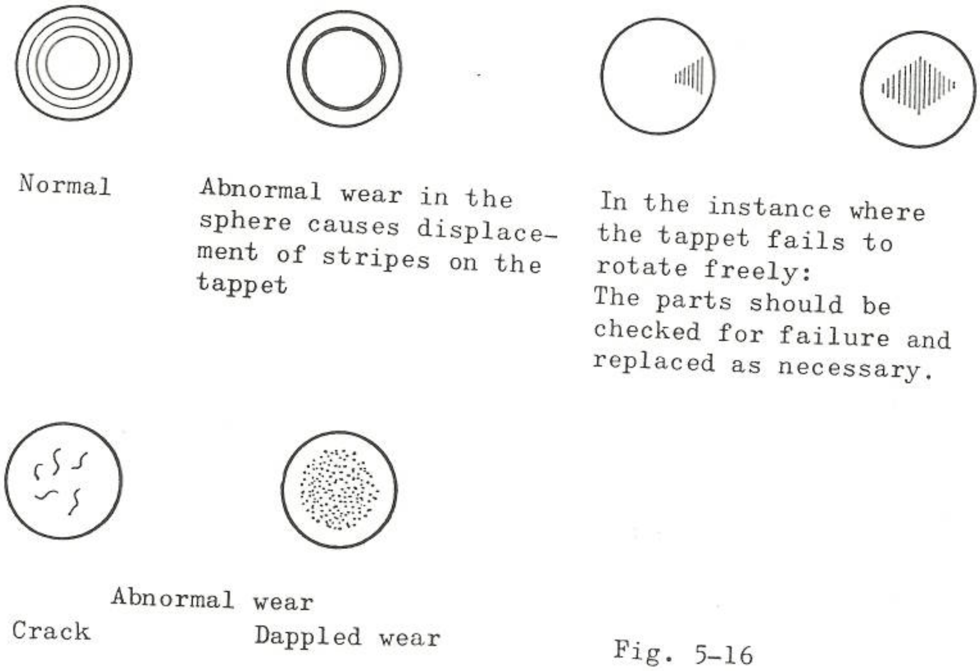


Fig. 5-16

5-1-8 Rocker shaft

(1) Inspecting

1) External portion

If there is considerable wear or damage in the sliding portion of the rocker arm, this should be replaced.

2) Measurement

The outside diameter of the rocker shaft is standard at 19ø but if it does not retain 18.85ø for wear, the rocker shaft should be replaced. The rocker shaft should be further inspected for bend with the aid of a dial gage and a V-block. Appreciable bending of the rocker shaft may be rectified with a press machine but if the bending is beyond correction, the shaft should be replaced.

3) Adjusting

If the clearance between the inner circumference of the rocker arm and the outer circumference of the rocker shaft is in excess of 0.2mm, it should be adjusted by replacing the pertinent parts to adjust this clearance to less than 0.04mm.

5-1-9 Rocker arm

(1) Inspecting and adjusting

The inner circumference of the rocker arm is standard at 19ø, and if the clearance between the outer circumference of the rocker shaft and the rocker arm is in excess of 0.2mm, the clearance should be adjusted to 0.04mm by replacing the pertinent parts as necessary. If there is considerable wear in the portion that comes in contact with the valve stem end, the rocker arm should be replaced. Appreciable wear in the rocker arm may be rectified with the aid of an abrasive stone.

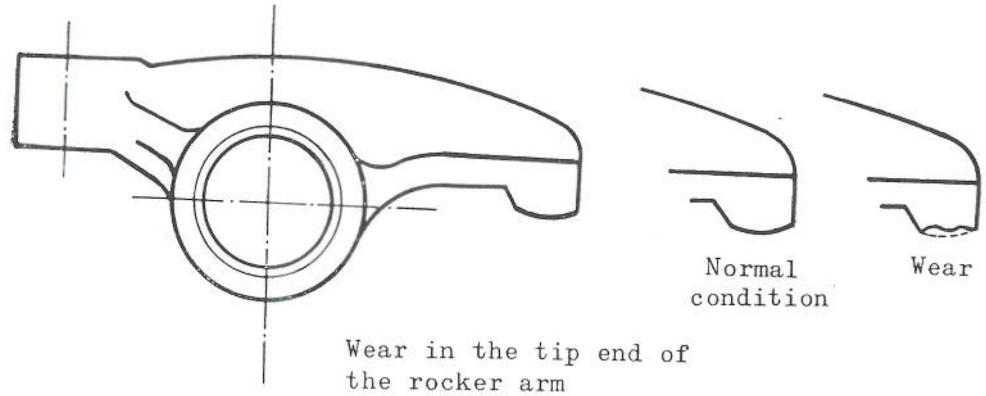


Fig. 5-19

5-2 MANIFOLDS

(1) Inspecting

1) The intake and exhaust manifolds should be inspected for distortion with all the associated parts fastened in the face directly fastened to the cylinder head. If the distortion in the mounting face is in excess of 0.4mm, it should be rectified with a surface grinder.

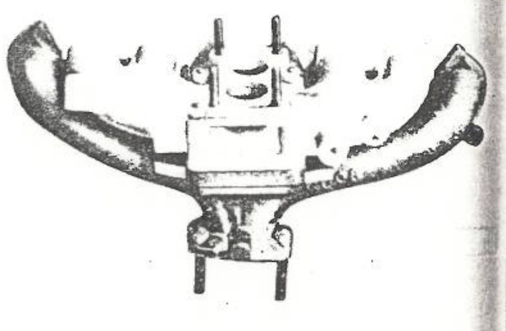


Fig. 5-20

2) The intake and exhaust manifolds should also be inspected for corrosion, damage or crack and the faulty parts replaced as necessary.

5-3. EXHAUST PIPE AND MUFFLER

(1) Inspecting

1) The entire exhaust system should be checked for crack, wear or damage and rectified or the faulty parts replaced as necessary.

(1) - Exhaust muffler assembly
(2) - Exhaust pipe front
(3) - Exhaust pipe rear
(4) - Exhaust pipe mounting flange at engine side
(5) - Flange packing

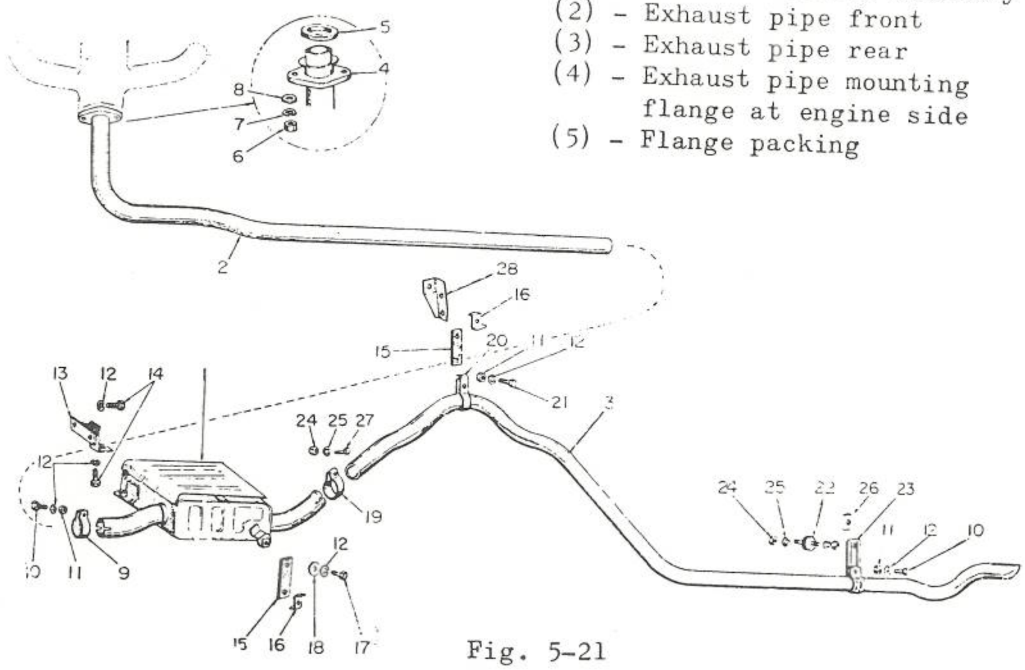


Fig. 5-21

(6) - Nut
(7) - Spring washer
(8) - Plain washer
(9) - Exhaust pipe clamp
(10) - Bolt
(11) - Nut
(12) - Spring washer
(13) - Muffler body mounting rubber
(14) - Bolt
(15) - Exhaust muffler hanger belt
(16) - Plate
(17) - Bolt
(18) - Plain washer
(19) - Tail pipe clamp
(20) - Tail pipe hanger
(21) - Bolt for fastening the tail pipe to the differential carrier

5-4 CYLINDER BODY

5-4-1 Inspecting the cylinder block

(1) Inspecting the cylinder block for crack or damage:

The cylinder block should be checked visually and with the aid of a detector and rectified or replaced as the situation calls for.

(2) Measuring the distortion of the upper face of the cylinder block.

With a straight edge attached in six different ways A, B, C, D, E and F as illustrated in Fig. 5-22, the upper face of the cylinder block should be inspected for distortion. If the distortion is in excess of 0.2mm, it should be rectified to 0.05mm or below with a surface grinder. The maximum rectifying margin is 0.4mm.

Portions of the cylinder block to which the straight edge is attached for measuring distortion

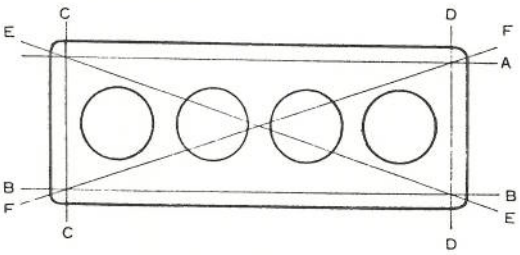


Fig. 5-22

Illustration showing the method of measuring the distortion of the cylinder block.

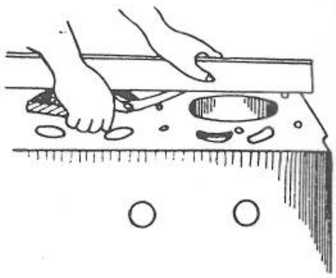


Fig. 5-23

(3) Hydraulic test

With the hydraulic pressure of 5 kg/cm^2 applied, the cylinder block should be carefully checked for water leakage. If the leak is beyond the repair, the cylinder block should be replaced.

(4) Measuring the cylinder bore wear

Wear of the cylinder walls should be measured in each cylinder in the axial direction of the crankshaft and in a direction across the axis of the crankshaft. The measurement should be taken at three portions, upper, center and lower part of each cylinder wall. The portion of the cylinder wall where the first piston ring comes in contact when the piston is held at its T.D.C. should be regarded as "upper portion of the cylinder bore". This is equal to a portion 7.5mm (12mm for the model C180) below the top level of the cylinder block. The portion where the piston skirt comes in contact when the piston is held at its B.D.C. should be regarded as "lower portion of the cylinder bore". The upper portion of the cylinder wall is mainly subjected for wear whilst the wear in the lower portion is considerably small, the actual wear on the cylinder wall may be obtained by deducting the measured value of the lower portion from the measured value of the upper portion. If the wear is in excess of 0.2mm (0.4mm for model C180), the cylinder wall should be rectified by boring. Wear in the cylinder wall should be measured with a cylinder gage (inside dial gage) by attaching the gage to the

Measuring the Cylinder bore

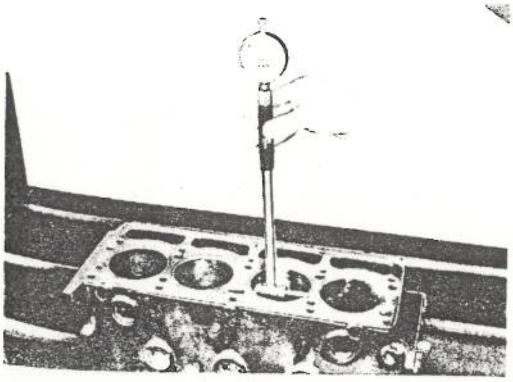


Fig. 5-24

cylinder wall in the right angle. If only one of the cylinder fails to meet with the specified value, the entire cylinder walls should be regarded as due for correction.

(5) Rectifying the cylinder wall

1) At the time when the engine is dismantled, the stepped wear in the upper portion of the cylinder wall should be rectified with a ridge reaming machine even if the wear or tapered wear is less than 0.2mm (0.4mm for model C180).

Measuring the outside diameter of piston

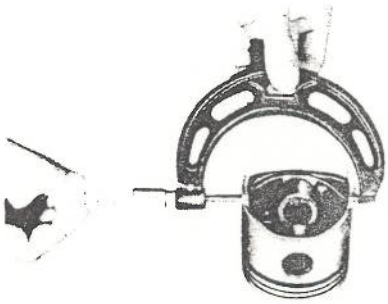


Fig. 5-25

2) Boring the cylinder wall

If the cylinder wall is considered as due for rectification, the size of the over-sized piston for replacement should be predetermined by selecting the cylinder whose wear is largest. The outside diameter of the piston should be measured at the piston skirt using an outside micrometer. Then, the desired inside diameter of the cylinder wall should be obtained by the following formula:

Desired inside diameter as finished by boring and honing:

(mm) = P + C − H ± E

P = Outside diameter of piston (mm)

C = Clearance between piston and cylinder wall 0.045 ± 0.01 (± 0.07mm for model C180)

H = Excessive margin for honing: Less than 0.02mm

E = Allowable error of boring finish (mm)

* The measurement should be taken while the parts are held at normal temperature.

3) Honing finish and measuring

The cylinder wall should be further treated with honing every after it is rectified by boring. Honing serves to smoothen out the cylinder wall thereby removing the trace of the cutting tool. Therefore, an excessive margin given to the cylinder wall for honing often leads to improper finish. Upon completion of the honing, the inside diameter of the cylinder should be measured in the manner introduced in Paragraph (4) above, and the tolerance of inside diameter when measured at the upper, center and lower portion of the cylinder wall should be held to 0.02mm or less.

Homing the cylinder wall

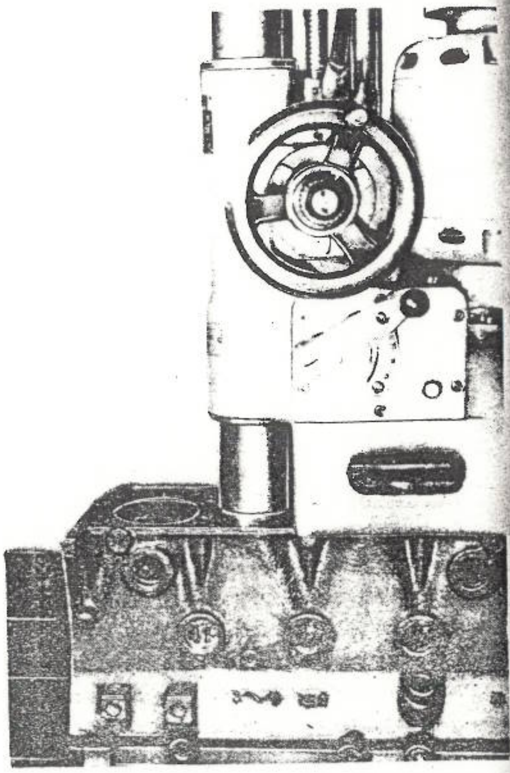


Fig. 5-26

4) The clearance between the piston and the cylinder wall

With a thickness gage inserted in the cylinder wall, the piston should be turned upside down and inserted into the cylinder wall until the

Honing the cylinder wall

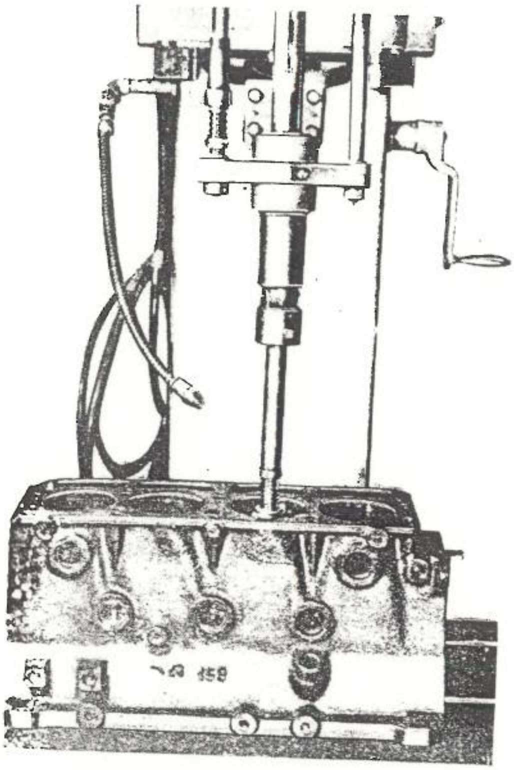


Fig. 5-27

Measuring the clearance between the piston and cylinder

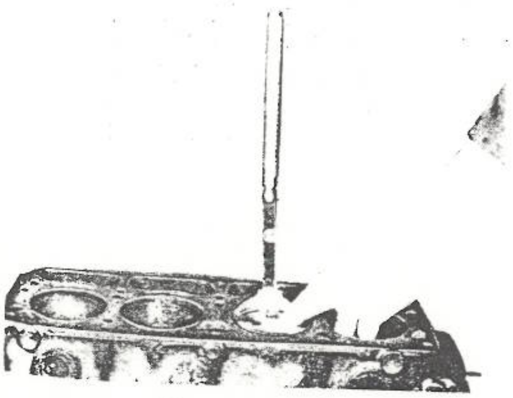


Fig. 5-28

piston skirt comes in level with the top face of the cylinder block. Then, the piston should be slid up and down in the cylinder bore while pressed onto the cylinder wall in a direction opposite to the thickness gage. Judgement should be exercised to determine the clearance therebetween by feeling the friction imposed on the sliding piston. The clearance may be correctly measured with the aid of a spring balancer by pulling the piston out of the cylinder bore upward. If the tensile strength required for pulling the piston is 0.5 - 1.0 kg common to the cylinder bores, the cylinder should be considered as in normal condition.

A list of the dimensions of the pistons by grade

Piston size (dimensions of over-size pistons)	Piston grade	Length of piston skirt (mm)		
		G-130 D=75ϕ	G-150 D=79ϕ	C-180 D=79ϕ
S. T. D	A	-0.035 -0.025	-0.035 -0.025	-0.060 -0.070
	B	-0.024 -0.015	-0.024 -0.015	-0.050 -0.060
	C	-0.014 -0.005	-0.014 -0.005	-0.040 -0.050
	D	-0.004 -0.005	-0.004 -0.005	-0.030 -0.040
O. S 0.25 " 0.50 " 0.75 " 1.00 " 1.25 " 1.50	The tolerance in dimensions is held same as above			

A list of the dimensions of the cylinder bores by grade

Size of the cylinder bore	Cylinder bore grade	Inside diameter of the cylinder bore (mm)		
		G-130 D=75ϕ	G-150 D=79ϕ	G-180 D=79ϕ
S. T. D	A	+0.01 0	+0.01 0	+0.01 0
	B	+0.02 +0.01	+0.02 +0.01	+0.02 +0.01
	C	+0.03 +0.02	+0.03 +0.02	+0.03 +0.02
	D	+0.04 +0.03	+0.04 +0.03	+0.04 +0.03
O. S 0.25 " 0.50 " 0.75 " 1.00 " 1.25 " 1.50	The tolerance in measurement of the cylinder bore is held same as above			

5-5 PISTON AND ITS ASSOCIATED PARTS

5-5-1 Piston

(1) Inspecting the piston

The piston should be visually inspected for crack, scratch or seizure and carbon deposits should be removed from the ring grooves. If the chafing or scuffing is significant, the piston should be replaced.

(2) Measuring the piston

The largest diameter of the piston skirt should be taken for measurement by bringing a slide caliper to the piston in the direction across the axial line of the piston pin.

(3) Over-sized piston

When the cylinder bore is rectified by boring, the over-sized piston should be fitted into the cylinder as necessary. The over-sized pistons are available in six sizes giving every 0.25mm of difference between adjacent pistons in the diameter. The over-size synbol is stamped on the piston crown.

(4) Clearance between the circumference of the piston and the cylinder bore

Excessive clearance will result in the compression leak and further lead to power loss. If the clearance is too small, it would often invite piston seizure and other troubles; therefore, it is necessary to keep the correct clearance as specified.

5-5-2 Piston ring

Every engine overhauling should be followed by the replacement of the piston rings. When the over-sized piston is used, the over-sized piston rings relative to the over-size piston should be utilized.

5-5-3 Inspecting the piston rings

The piston rings should be carefully checked for rupture, damage or wear and replaced as necessary.

5-5-4 Measuring the clearance between piston ring and its groove

The clearance between the piston ring and the groove should be measured with the aid of the thickness gage at several optional portions on the circumference of the piston ring.

Measuring the clearance between piston ring and ring groove

Fig. 5-29

Measuring the piston ring gap

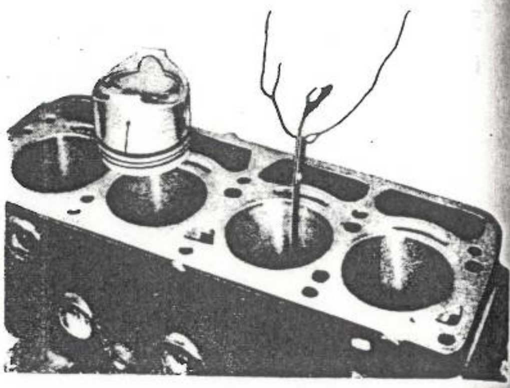


Fig. 5-30

Clearance between the piston ring and upper and lower face of the ring groove (mm)

	Standard value	Service limit
Compression ring	0.036 - 0.074	0.3
Oil control ring	0.040 - 0.082	0.15

(1) Measuring the piston ring gap

With the piston ring inserted in the cylinder bore (the piston ring should be pushed into the cylinder with the piston head to align the ring at right angle to the cylinder wall), a thickness gage should be inserted into the ring gap for measuring the ring gap. When replacing the piston rings without rectifying the cylinder bore, the piston ring gap should be measured by inserting the piston ring into the portion (normally the lower part of the cylinder wall) of the cylinder in which the wear is smallest.

(2) Rectifying the piston ring gap

If the piston ring gap is excessively small, it should be rectified to provide specified clearance and the opposed tip ends properly aligned with the aid of file or the piston ring filing tool.

Piston ring gap (mm)

			Standard value	Service limit
Compression ring	No.1	for models G130, G150	0.23 - 0.36	1.5
		C180	0.20 - 0.40	
	No.2	G130, G150 C180	0.23 - 0.36	
	No.3	C180		
Oil control ring	No.1	C180	0.10 - 0.30	1.0
	No.2	G130, G150 C180	0.20 - 0.40	

Rectifying the piston ring gap

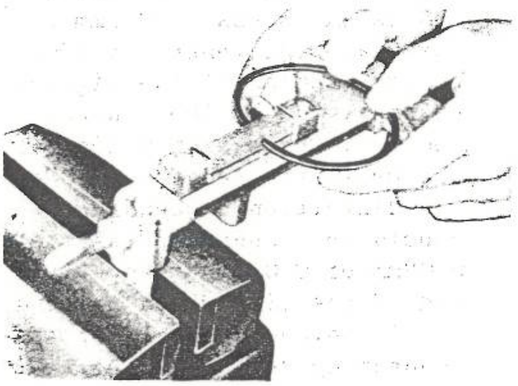


Fig. 5-31

5-5-4 Inspecting and rectifying the connecting rod small-end bush

(1) The connecting rod bushing should be visually inspected and replaced if wear or damage is serious.

(2) The bush should be removed and replaced with new one with the aid of the connecting-rod small-end bushing replacer (8523-1369).

(3) When replacing the bushing, the inner circumference of the bushing should be touched upon with a pin hole grinder or a reaming machine to provide the correct clearance between the piston pin and the bushing.

5-5-5 Inserting the piston pin into the piston

The piston should be replaced together with the piston pin. The clearance between the piston and the piston pin is standard at 0.004mm (0-0.013mm for the model C180) and if this clearance is too large, it

Measuring the piston pin (mm)		
	Nominal dimension	Service limit
Piston pin G130 G150	22ϕ	21.97ϕ
Piston pin C180	24ϕ	23.965ϕ

would often cause tapping noise while the engine is running. If a correct clearance is provided between the piston and its pin, the piston pin can be smoothly pushed into the piston when the piston is heated to about 70–100°C.

5-5-6 Inspecting and rectifying the connecting rod

The connecting rod should be carefully inspected for bending or distortion with the aid of connecting rod aligner.

Measuring the connecting rod bending

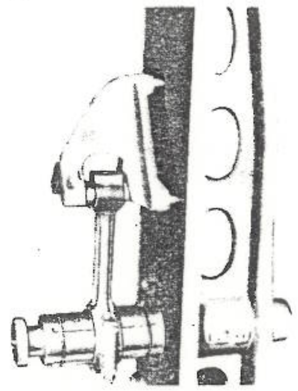


Fig. 5-32

This inspection is directed to the big-end and small-end bearings readily mounted on the connecting rod and hence, the bearings should be absolutely free from excessive wear.

With the piston pin put through the bushing on the small-end of the connecting rod, a measuring tripod should be placed over the piston pin to see if the legs of the tripod come in even contact with the connecting rod aligner. If any of the three legs fails to come in contact with the aligner, a thickness gage should be inserted under the leg to measure the bending or distortion thereof. If the distortion at the big-end or the small-end of the connecting rod is in excess of 0.2mm at the measuring length of 100mm, or the bending at the big-end or small-end of the connecting rod is in excess of 0.15mm at the measuring length of 100mm, the distortion or bending should be reduced to less than 0.08mm or 0.05mm, respectively, and if the distortion or bending is beyond correction, the connecting rod should be replaced.

Rectifying the connecting rod bush

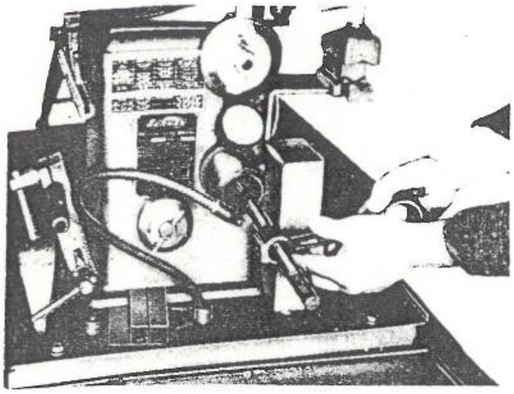


Fig. 5-33

5-5-7 Inserting the piston pin into the bushing

When the correct clearance is provided between the piston pin and bushing, the piston pin can be pushed into the bushing with thumb after the piston pin is well lubricated with engine oil.

Clearance between the bush and piston pin (mm)		
Standard value	G130 G150	less than 0.011
	C180	less than 0.02
Service limit	above 0.05	

5-5-8 Inspecting the connecting rod bearing

(1) The connecting rod bearing should be visually inspected and replaced if the bearing is applicable to any of the following:

1) Excessively worn
2) Separation
3) Crack or dent
4) Corrosion or damage

(2) Measuring the oil clearance

Oil clearance (mm)	
Optimum clearance (standard value)	0.03 - 0.06
Service limit	0.1

If the oil clearance on the connecting rod bearing is in excess of the service limit, it tends to give excess oil flow which results in a decrease of oil pressure and further in abnormal engine operating noise. If the oil clearance is too small, it will often lead to over-heating of the bearings and further to bearing seizure.

(3) The oil clearance may be checked in the following manner with use of a press gage.

1) Oil and dust should be throughly removed from the bearing and crankshaft pin.

2) The press gage (with the measuring range of 0.025 - 0.075mm) should be cut in the same size as the bearing width and placed over the crank pin located in the axial direction of the crankshaft (the oil port should be avoided from being covered with the press gage) and then, the connecting rod bearing cap should be clamped back in by applying a clamping torque of 2.4 - 2.9 m-kg. (6.5 - 7.0 for model C180). During this measurement, the crankshaft should be held from being turned. The bearing cap should then be removed a few minutes later.

Measuring the oil clearance. Before pressure is applied.

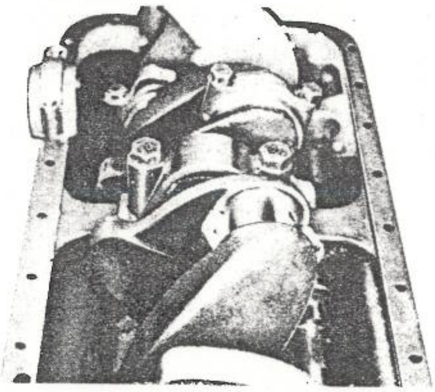


Fig. 5-34

3) After the bearing cap is released, the press gage should be taken out and its width is measured with a

Measuring the oil clearance. After pressure is applied.

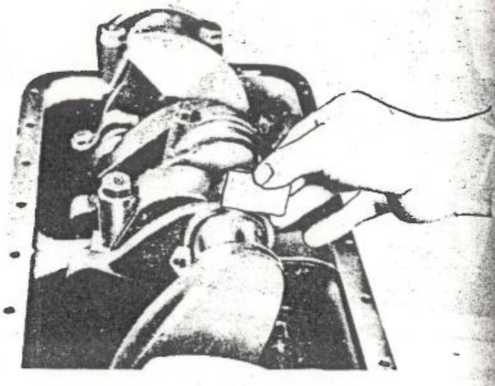


Fig. 5-35

scale printed on the container of the gage. The narrowest and widest portion of the press gage should be carefully measured for determining the serviceability of the crank pin and the bearing.

4) If the clearance is too large due to worn crank pin and bearing, the crank pin should be rectified by grinding and the connecting rod bearing of small-size should be fitted in. If the crankshaft has been replaced, a standard-size bearing should be fitted in.

5) Where the smaller-size bearing is used for the rectified crankshaft pin, or the crankshaft is replaced, or a standard-size bearing is mounted, the oil clearance should be

checked before the bearing is mounted on the crankshaft pin.

(4) Inspecting the clamping margin of the bearing

The clamping margin (clash) of the bearing should be measured with the aid of a height measuring gage or by mounting the bearing on the bearing cap and with 800 kg of pressure applied to the bearing, the clearance between the lower face of the big-end bearing cap and the opposed ends of the bearing half should be measured. The clearance (may be termed as bearing clash or clamping marging) is standard at 0. - 0.02mm.

Note: If excessive clearance is found between the bearing cap and the opposed ends of the bearing half (clamping margin is too small), the bearing tends to shrink innerward during service and often leads to exfoliation.
If the clamping margin is too large, the reverse side of the bearing does not come in direct contact with the bearing cap and the connecting rod and hence, the heat conductivity is limited and lead to bearing seizure.
If the clamping margin is excessively large, the inner face of the bearing tends to distort causing poor contact with the connecting rod and also leads to bearing seizure.

Measuring the clamping margin on the bearing

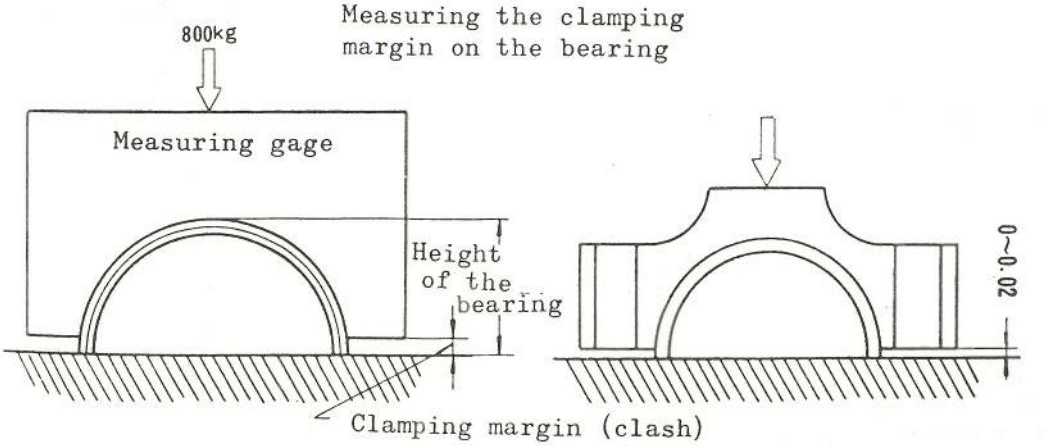


Fig. 5-36

5-6 CRANKSHAFT

5-6-1 Inspecting the crankshaft

The crankshaft journal and the crankpin should be inspected for wear using a micrometer.
Measurement should be taken at least three different portions of the joint in the axial direction,

Measuring the jaurnal and crankpin

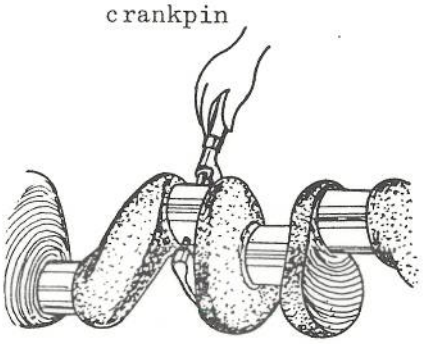


Fig. 5-37

Wear of the crankshaft (mm)		
	Nominal dimensions	Service limit
Wear of the crank journal	G130 G150 56 ø	55 ø
	C180 60 ø	58.93ø
Wear of the crank pin	G130 G150 49 ø	48 ø
	C180 51 ø	49.93ø

and at least two portions on the circumference of the shaft should be checked for wear in a direction across the shaft. The difference in the measured valve between the two portions or the difference between the measured and the specified value may be regarded as wear.

Note: The taper on the fillet portions on the crank pin and on the crank journal should be held at an angle of 3.5 and if the tapered wear of the crank journal or the crank pin is in excess of 0.05mm, it should be regarded as due for rectification.

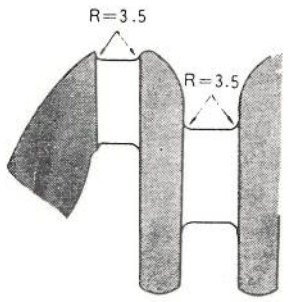


Fig. 5-38

5-6-2 Measuring the distortion of the crankshaft

With the outer journals of the crankshaft mounted on the V-block, the dial gage should be attached to the center journal and the crankshaft is carefully turned to measure the distortion.
(See Fig. 5-39)
Distortion or slight bending may be corrected using a crankshaft grinder but, if the distortion or

bending is in excess of 0.1mm, the crankshaft should be rectified to give a maxium distortion or bending of 0.05mm with use of a press machine. The crankshaft should be replaced if the distortion or bending is serious. An undersized bearing should be used where the crankshaft has been rectified by grinding. The undersized main bearings are available in the following four (4) different sizes.

Size mm	0.25	0.50	0.75	1.00

Measuring the distortion of the crankshaft

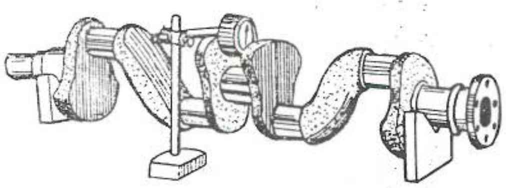


Fig. 5-39

5-6-3 Measuring the play of the crankshaft in the axial direction

The clearance between the thrust bearing and the crankshaft should be measured using a thickness gage, (See Fig. 5-40) and if it is in excess of 0.3mm, the thrust bearing should be replaced. If the clearance is within 0.05 - 0.10mm, the crankshaft play should be regarded as normal. The thrust bearing should be mounted in place with its oil slotted face toward the thrust face of the crankshaft.

Measuring the journal and crankpin

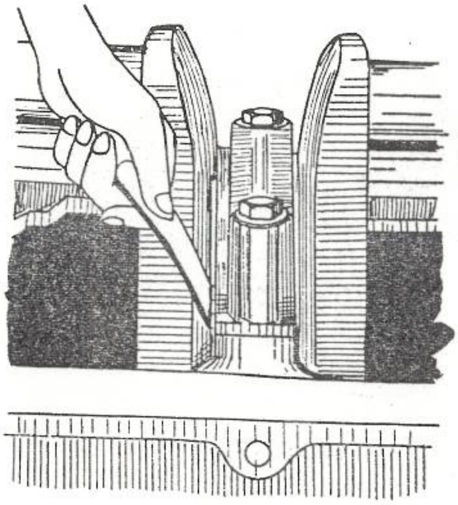


Fig. 5-40

5-6-4 Inspecting the crankshaft bearing

The crankshaft bearing should be inspected in the same manner as inspecting the connecting rod bearing.

If the crank journal is excessively worn, it should be rectified by grinding and an undersized bearing is fitted into position. The big-end bearing cap should be clamped by applying a torque of 9-10 m-kg to the clamping bolts. The bearing caps should be clamped in the order of center, front and rear by applying even torque repeatedly up to 9-10 m-kg.

Note: The engine dismantling should always be followed by the replacement of felt rings and gaskets.

Removing the crankshaft bushing

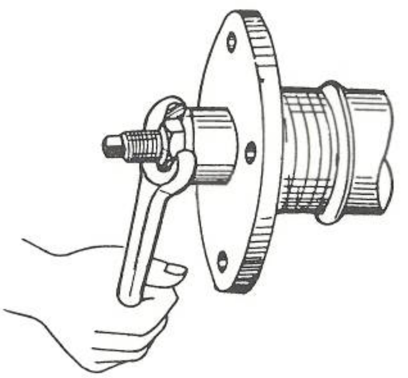


Fig. 5-41

5-6-5 Inspecting the crankshaft bushing

If there is wear or damage on the crankshaft bushing, it should be replaced. The crankshaft bushing should be removed and refitted into place in the following manner with the aid of the crankshaft bushing replacer (8523-1366).

With a tap cutter screwed into the bushing, an adapter should be put through the tap cutter and turned clockwise to pull out the bushing. (See Fig. 5-41). The bushing should be put into the crankshaft with a setting tool (8522-0020) by lightly hitting the tool head.

5-6-6 Inspecting the flywheel and gear ring.

1) The clutch driven plate of the flywheel should be carefully inspected for proper contact and flatness. If the wear, distortion or damage is significant, the parts should be replaced.

2) Distortion of the contacting face of the clutch driven plate should be measured with the aid of dial indicator and if this distortion is in excess of 0.1 mm, it should be rectified.

3) The flywheel to gear ring engagement should be carefully checked and if the gear ring is loosened or slanted, the trouble should be rectified.

4) The gear ring should be visually inspected for wear or damage. If the wear or damage is serious the gear ring should be replaced but if the wear or damage is slight, the gear ring may be put back into service by remounting on the flywheel with 90° turned either way. The gear ring should be removed and refitted in place after it is adequately heated for expansion.

5-7 CAMSHAFT

The camshaft should be dismantled and visually inspected for wear or abnormal condition. If the wear is considerable the camshaft should be regarded as due for replacement.

1) Measuring the effective height of the cam

The effective height of the cam on the camshaft should be measured with a micrometer, (See Fig. 5-42) and if it is in excess of service limit, the cam together with the camshaft should be replaced.

Measuring the effective height of the cam

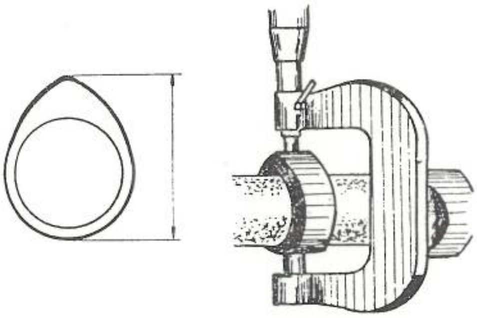
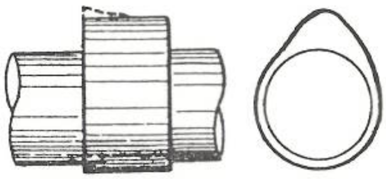


Fig. 5-42

	Height of the cam (mm)	Service limit (mm)
G130 · G150 C180	35.50	35.00
G150C·G150D	36.07	35.60

2) Measuring the camshaft journal

If the wear is significantly great, the camshaft should be replaced. If the wear is slight, it may be rectified with a crankshaft grinder. When the distorted wear on the camshaft journal is in excess of 0.05mm, it should be rectified or the parts replaced.



Tapered wear Stepped wear

Fig. 5-43

Diameter of the camshaft journal (mm)	
Nominal dimensions	Service limit
45 ⌀	44.6 ⌀

3) Distortion of the camshaft

Distortion of the camshaft should be measured by the journal gage with the outer journals mounted on a V-block. (See Fig. 5-44). If the deflection or distortion of the camshaft is in excess of 0.1 mm, it should be rectified with a crankshaft grinder and the shaft with serious bending should be replaced.

Measuring the camshaft bending

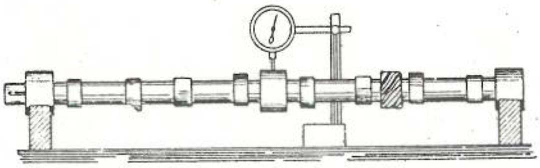


Fig. 5-44

4) Inspecting the oil pump and drive gear

The oil pump drive gear should be visually inspected for wear or damage and further carefully checked for trouble by engaging it with the counter gear.

5) Inspecting the camshaft bearing

The inner circumference of the camshaft bearing and outer diameter of the camshaft journal should be measured for checking the clearance therebetween. The clearance is normally 0.05mm and if there is provided a clearance in excess of 0.12mm, it should be rectified by replacing the bearing with trouble. If the clearance is too large, the camshaft journal should be rectified with a grinder and an undersized bearing of 0.25mm is fitted thereto.

6) The camshaft bearing should be removed and refitted into position with the aid of a camshaft bearing replacer. (8523-1360) (See Fig. 5-45)

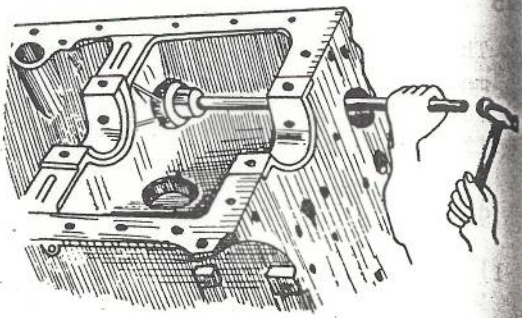


Fig. 5-45

7) Inspecting the play of the camshaft in the axial direction

The play of the camshaft in the axial direction should be measured by inserting a feeler gage (thickness gage) into the clearance between the sprocket on the camshaft and thrust plate.

Play of the camshaft in the axial direction

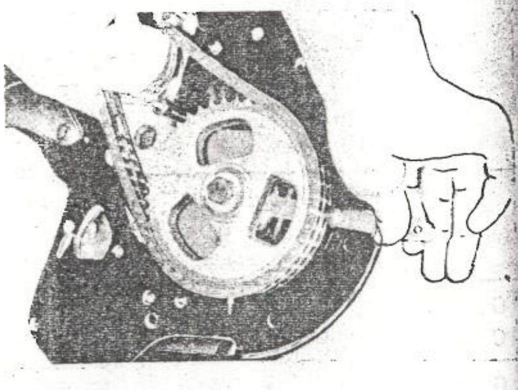


Fig. 5-46

The play is standard at 0.05 - 0.1mm but if it exceeds 0.2mm, the play should be adjusted by replacing the trust plate. (See Fig. 5-46) The method for inspecting the camshaft play in the axial direction on the model C180 is as follows: The play of the camshaft in the axial direction may be measured with a feeler gage by mounting the camshaft timing wheel on the camshaft and with the thrust plate slid all the way to the cam gear side. Then the feeler gage is inserted into the clearance between the thrust plate and journal. The play is standard at 0.05 - 0.1mm, but if it exeeds the standard value, it should be adjusted by replacing the thrust plate.

5-8 TIMING WHEEL

5-8-1 Dismantling

The timing wheel (cam and crankshaft) should be dismounted with the use of the timing wheel puller.

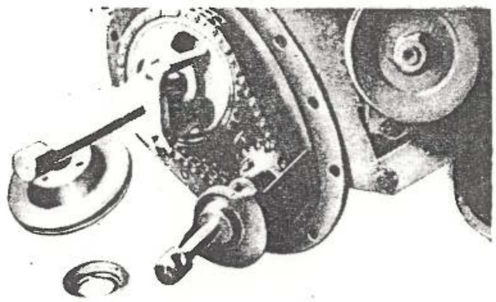


Fig. 5-47

5-8-2 Inspecting the timing chain and tensioner blade

The timing chain and the tensioner should be checked for wear or damage, and both parts should be replaced if the wear or damage is significant. The camshaft sprocket and the crankshaft sprocket should also be checked for wear or damage at the portion normally held in contact with the timing chain.

5-8-3 Inspecting the timing gear

The arrangement of the timing gears:

The crank gear, idling gear, camgear and pump gear are provided with setting marks X, Y and Z respectively so that they can be properly refitted into their positions.

Timing gears arrangement

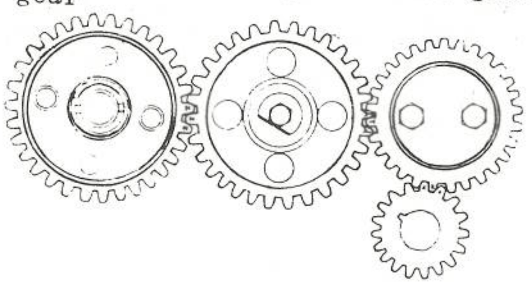


Fig. 5-48

5-8-4 Measuring the backlash of the gears

The backlash on the gears should be carefully measured with a thickness gage or a steel wire. If a suitable narrow thickness gage (feeler gage) or steel wire is not available, a piece of fuse may be inserted between the gears and rotated to detect the backlash by measuring the thickness of the fuse dent. The gear should be regarded as due for replacement if the backlash thereof is in excess of 0.3mm. If any of the gears is excessively worn, all the associated gears should be replaced at the same time. The backlash should normally be held less than 0.1mm.

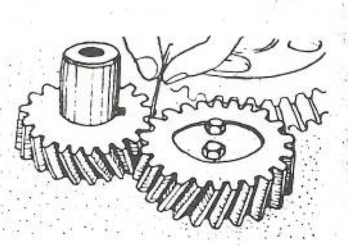


Fig. 5-49

5-8-5 Inspecting the clearance on the idle gear shaft

The inner diameter of the idle gear should be measured and if the clearance is in excess of 0.2 mm, it should be adjusted to retain 0.05mm by replacing the gear bushing or the idle gear shaft.

If the tapered wear of the idle gear shaft is in excess of 0.1mm, it should be considered due for replacement, but it may be put back in service by shifting its mounting angle. If wear of the idle gear shaft is beyond adjustment or rectification, it should be replaced.

PART 6 LUBRICATING SYSTEM

CONTENTS

PART 6 LUBRICATING SYSTEM

6-1 INTRODUCTION

A forced oil circulating system is employed in the Bellett engines. The oil pump serves to feed the lubricating oil to the oil port on the cylinder block through the oil filter element thereby lubricating the entire moving parts of the engine. If the oil filter element is clogged or its filteration is decreased, or the oil pressure is excessively increased to produce a difference of oil pressure between the portions separated by the oil filter, the high pressure oil supplied by the oil pump causes the overflow valve to open on the oil filter and flows directly to the oil port in the cylinder block without going through the oil filter.

In such manner, the lubricating system is so arranged that the oil pressure is automatically controlled by a relief valve on the oil pump and by the overflow valve in the oil filter. The releaf valve on the oil feed pump automatically operates as the oil pressure increases in excess of the specified value and feeds the oil partially back into the oil pan bypassing the lubricating system of the engine thereby regulating the oil pressure. A trochoid type of oil pump is employed for the Bellett engines. The lubricating oil is fed to the valve rocker through the camshaft bearing, oil feed pipe, oil port in the rear part of the cylinder block, oil port in the rocker shaft bracket to the rocker shaft and further fed to the valve rockers.

6-2 SPECIFICATIONS OF THE LUBRICATING SYSTEM

	Model G150	Model G130	Model C180
Lubricating system	Forced circulating system	Same as left	Same as left
Type of oil pump	Trochoid type	"	
Maximum feed ltr/min. (at 1,400 r.p.m. 4kg/cm^2) (at oil temperature 50^{o}C)	Above 8.25	"	Above 10.16
Type of oil filter	Paper filter element type	"	Same as left

Relief valve opening pressure kg/cm^2	3.2 - 3.5	"	"
Overflow valve opening pressure kg/cm^2	0.8 - 1.2	"	"

6-3 TROUBLE-SHOOTING

Cause	Correction
1. Excessive oil consumption	
(1) Use of unsuitable engine oil	Replace with specified oil
(2) Oil leakage	Repaired
(3) Excessively low pressure	Rectify piston ring, piston and cylinder bore or replace the part
(4) Over-heating	Refer Cooling system 3) "Over-heating"
(5) Worn valve guide	Replace valve guide
(6) Wear in the piston ring groove	Replace piston or piston ring
(7) Worn cylinder wall.	Rectify the cylinder bore by inserting liner
(8) Piston ring sticking	Replace piston ring
(9) Excessive use of engine braking effect	Use correct manner of operation
2. Reduced oil pressure	
(1) Use of unsuitable engine oil	Replace with specified engine oil
(2) Relief valve sticking	Replace the parts
(3) Clogged oil pump strainer	Clean the strainer
(4) Excessive play caused by the worn oil pump parts	Replace the parts as necessary
(5) Crack, break or leak in the oil pump feed pipe connection	Rectify or replace the parts as necessary
(6) Oil pump failure	Rectify or replace the parts as necessary

(7) Pressure gage failure	Rectify or replace
(8) Crankshaft or connecting rod bearing wear	Fit under-sized bearing
3. Contaminated engine oil	
(1) Clogged oil filter	Replace filter element
(2) Fuel mixture leakage	Rectify piston, cylinder bore or replace the parts as necessary
(3) Failure of the breather system	Rectify or replace the parts
(4) Use of unsuitable engine oil	Replace with the specified engine oil
(5) Unsuitable oil-changing period (intervals)	Replace the engine oil at intervals as specified
4. Engine oil fails to reach the valve system	
(1) Clogged rocker feed pipe	Clean or rectify as necessary
(2) Clogged rocker shaft	Same as above
(3) Clogged rocker bracket port	"
(4) Clogged rocker arm oil port	"
(5) Clogged camshaft oil communicating port	Rectify as necessary

6-4 OIL PUMP

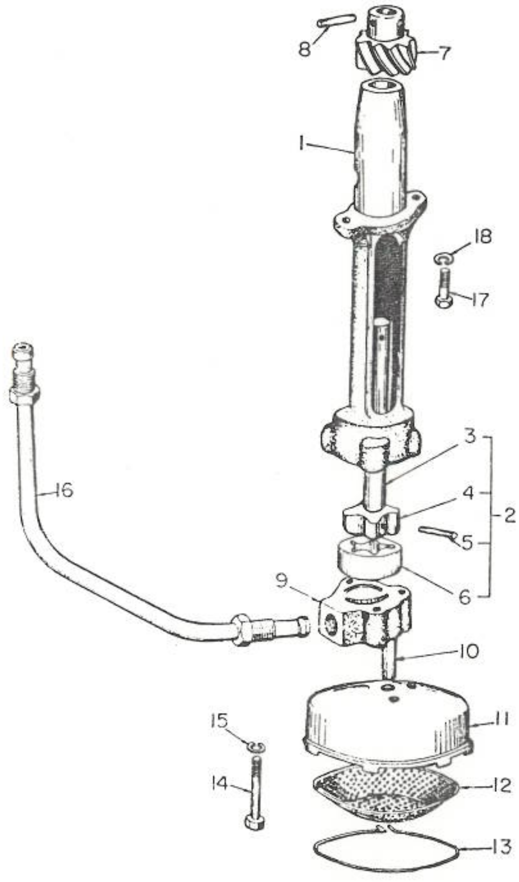
6-4-1 Specifications

	Model G150	Model G130	Model C180
Type	Trochoid type	Same as left	Same as left
Amount of oil delivery (pump revolution 1,400r.p.m. $4kg/cm^2$ at 50^oC)	Above 8.25	"	Above 10.16
Tip clearance between rotor and vane (mm)	0 - 0.14	"	0.005 - 0.14

Clearance between the vane rotor and cover	0.014 - 0.056	"	0.02 - 0.07
Clearance between vane and pump body	0.20 - 0.27	"	Same as left
Clearance between pump shaft and pump body	0.04	"	0.014 - 0.057

6-4-2 Component parts of the oil pump

Component parts of the oil pump



(1) Body
(2) Gear assembly
(3) Shaft
(4) Rotor
(5) Pin
(6) Vane
(7) Oil pump pinion
(8) Pin
(9) Cover
(10) Pipe
(11) Oil strainer case
(12) Gauze
(13) Snap ring
(14) Bolt
(15) Spring washer
(16) Oil pipe assembly
(17) Bolt
(18) Spring washer

Fig. 6-1

6-4-3 Removing

1) Remove the oil pan

2) Remove the oil pan assembly

3) Remove the oil pump clamping bolt and take out the oil pump assembly.

6-4-4 Dismantling

1) First remove the snap ring and strainer case fixing bolts and then dismantle the strainer case, oil pump cover and vane.

2) Disconnect the pipe assembly from the pump cover.

3) The rotor and the pinion are mounted on the rotor shaft with a knock pin so that they cannot be dismantled.

6-4-5 Inspecting and repairing

All the pertinent parts should be cleaned before they are inspected and repaired as necessary.

Measuring tip clearance

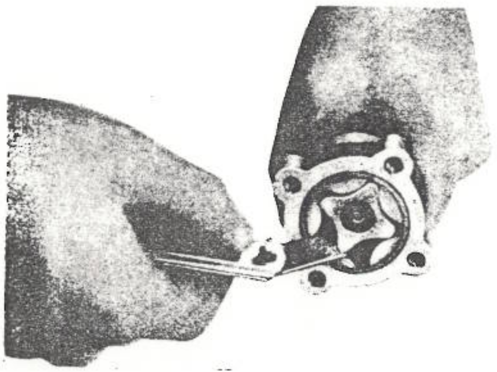


Fig. 6-2

1) Inspecting the clearance between the rotor shaft and the pump body. The rotor shaft is not removable from the pump body so that the clearance between the rotor shaft and the pump body should be checked with the shaft put through the pump body. If the clearance is more than 0.2mm, the assembly should be replaced.

2) If there is considerable wear in the teeth of the rotor and the vane, the assembly should be replaced.

Measuring the clearance between vanelotor and cover

Fig. 6-3

3) If the clearance between the vane, the rotor and the cover is in excess of 0.15mm, either the cover or the assembly should be replaced.

4) If the clearance between the vane and the pump body is in excess of the specified value, the assembly should be replaced.

Measuring the clearance
between vane and pump body

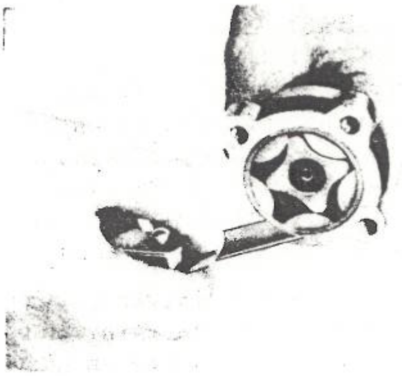


Fig. 6-4

5) If the vane, rotor or gear is worn or damaged, the assembly should be replaced.

6-4-6 Reassembling

(1) Reverse the procedure for dismantling

6-5 OIL FILTER

6-5-1 Specifications

	Model G150	Model G130	Model C180
Type	Paper filter element	Same as left	Same as left
Relief valve opening pressure kg/cm^2	3.2 - 3.5	"	"
Over-flow valve opening pressure kg/cm^2	0.8 - 1.2	"	"

6-5-2 Construction and the component parts of the filter

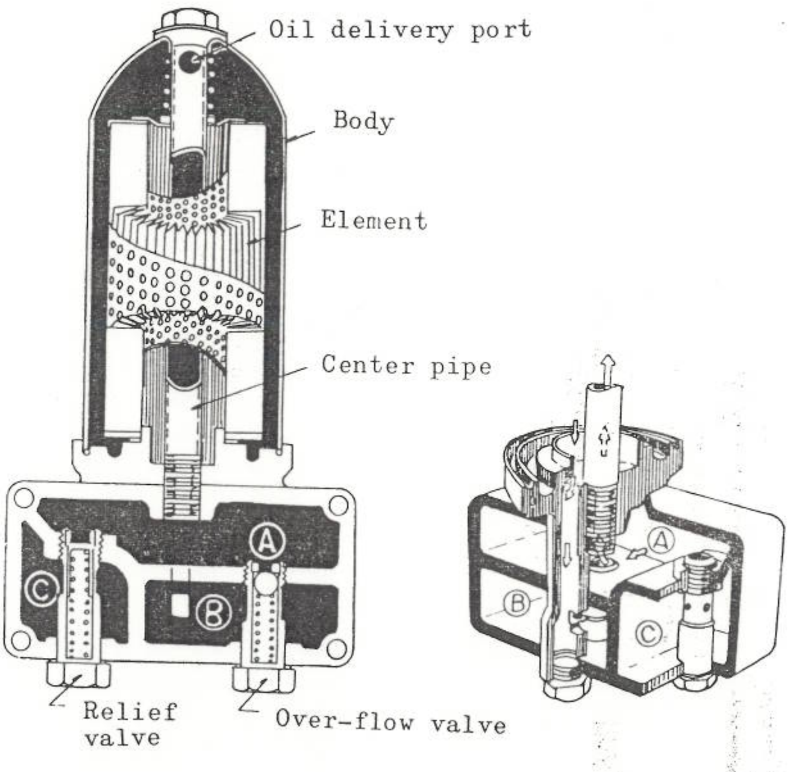
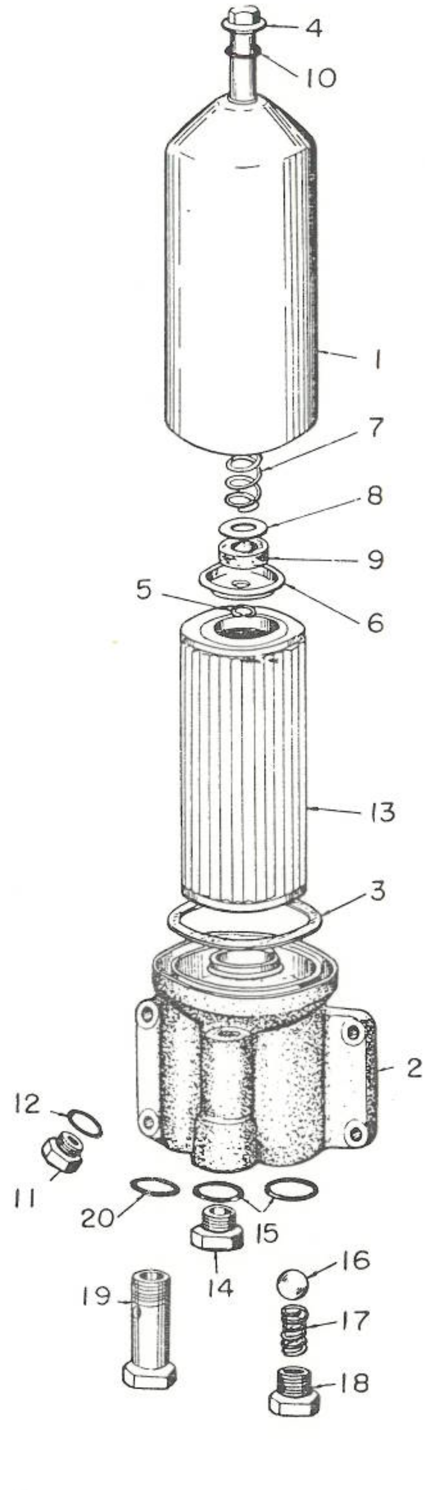


Fig. 6-5

Component parts of the oil filter



(1) -- Body
(2) -- Cover
(3) -- Element packing
(4) -- Center pipe
(5) -- Snap ring
(6) -- Element holder
(7) -- Spring
(8) -- Spring seat
(9) -- Felt ring
(10) -- Center pipe packing
(11) -- Drain plug
(12) -- Drain plug packing
(13) -- Element
(14) -- Adapter
(15) -- Plug packing
(16) -- Ball
(17) -- Spring
(18) -- Cap
(19) -- Relief valve assembly
(20) -- Relief valve packing

Fig. 6-6

6-5-3 Dismantling

The four clamping bolts should be removed before dismantling the oil filter assembly.

1) Remove the relief valve assembly (19)

2) Remove the cap (18) from the over-flow valve and then dismantle the spring (17) and ball (19)

3) Remove the center pipe (4) and then, take out the filter element. (See Fig. 6-6)

6-5-4 Cleaning and inspecting

1) Carefully clean the filter element in gasoline or clean detergent oil and replace those torn or contaminated.

2) Replace the filter body if it is deformed or seriously damaged.

3) Replace the over-flow valve and ball if they are worn or damaged beyond the correction

4) Check to make sure that the relief valve opening pressure is 3.2 - 3.5 kg/cm^2.

6-5-5 Reassembling

Reverse the procedures for dismantling but the following should be carefully noted.

1) All the packings and gaskets should be replaced with new ones.

2) Center pipe of the filter body should be clamped by applying the torque of up to 3.0 m-kg.

6-5-6 Procedures for replacing the oil filter element

1) Drain the engine oil entirely from the oil filter through the drain plug.

2) Disconnect the center pipe from the filter body and remove the oil filter element together with the oil filter body.

3) For refitting the filter, refer the subparagraph 6-5-5 "Reassembling".

PART 7 COOLING SYSTEM

CONTENTS

PART 7 COOLING SYSTEM

7-1 INTRODUCTION

1) Component part of the cooling system

The cooling system comprises radiator, water pump, cooling fan, fanbelt, thermostat, by-pass pipe, rubber joint and the like.

2) Cooling water circulation

The forced water circulating method has been employed in the Bellett engine. As the thermostat valve is held closed, the cooling water is not forced to circulate irrespective of water pump operation until the cooling water reaches as high as 76.5°C. Thus, the cooling water temperature raise quickly thereby bringing the engine into optimum operating temperature after a short period of driving.

As the cooling water reaches the thermostat valve opening temperature, the valve is forced to open and the cooling water is taken into the water jacket from the lower tank in the radiator. The water is then, forced to return to the radiator through the upper hose and cooled by the cooling fan.

7-2 SPECIFICATIONS OF THE COOLING SYSTEM

	Model G150	Model G130	Model C180
Cooling method	Pressurized circulation system	Same as left	Same as left
Cooling system capacity (ltr)	6	"	"
Water pump type	Impeller type	"	"
Maximum delivery(ltr/min) at 3,000 r.p.m. total lift 2.5m or above	Above 50	"	Above 55
Type of thermostat	Wax pellet type with by-pass	"	Same as left
Thermostat valve opening temperature	7.65 ± 1.5	"	"

Thermostat valve fully opening temperature	90	"	"
Valve opening stroke (mm) at water temperature 90°C	8.5	"	"
Radiator type	Pressurized colling	"	"
Type of water tube and fin	Corrugated fin with flat tube	"	"
Number of piping arrangement	2	"	"
Number and diameter of the cooling fan	4 x 350	"	4 x 370
Fan belt	Model A	"	Same as left

7-3 TROUBLE-SHOOTING

Cause	Correction
1. Over-heating	
(1) Insufficient cooling water	Water replenished and cooling system checked for leakage
(2) Loosened or worn fan belt	Fanbelt tension adjusted or replace the fan belt
(3) Oil or grease on the fan belt	Replace the fan belt
(4) Thermostat failure	Replace thermostat as necessary
(5) Water pump operating failure	Rectify or replace
(6) Clogged water transfer port	Clean the radiator and water passage preferably with radiator chemicals
(7) Improper ignition timing	Readjust ignition timing

(8) Contaminated or clogged radiator core	Clean external part of the radiator
(9) Mixture leaks into the water jacket due to worn cylinder head gasket	Replace cylinder head gasket

2. Over-cooling

(1) Thermostat operating failure	Replace thermostat
(2) Extremely low ambient temperature	Reduce cooling area by covering the radiator

3. Reduction of cooling water

(1) Leakage in the radiator	Rectify or replace the radiator
(2) Loosened or damaged rubber joint	Retighten the clamping or replace the hose
(3) Water pump leaking	Rectify or replace the parts
(4) Loosened or damaged heater hose connection	Tighten or replace the hose
(5) Water leaking from the cylinder head gasket	Retighten cylinder head clamping bolts or replace the gasket
(6) Cracked cylinder block or cylinder head	Rectify or replace the parts

4. Noise arises from the cooling system

(1) Worn water pump bearing	Replace water pump
(2) Loosely mounted blade or bent fan blade	Retighten or replace the fan blades
(3) Worn fan belt	Replace the fan belt

7-4 WATER PUMP

7-4-1 Specifications

	Model G150	Model G130	Model C180
Type	Impeller type with 6 blades	Same as left	Same as left
Amount of delivery ltr/min (at 3,000 rpm. total lift 2.5m or above)	Above 50	"	55
Diameter of the pulley	132 ϕ	"	120 ϕ
Gear ratio to the crank-shaft	1.04	"	1.14
Water sealant	Mechanical sealing	Same as left	Same as left
Bearing type	Ball bearing	"	"
Pump impeller and pump Clearance between the body (mm)	1	"	1.2 - 1.3

7-4-2 Construction and the component parts of the water pump

Construction of the water pump

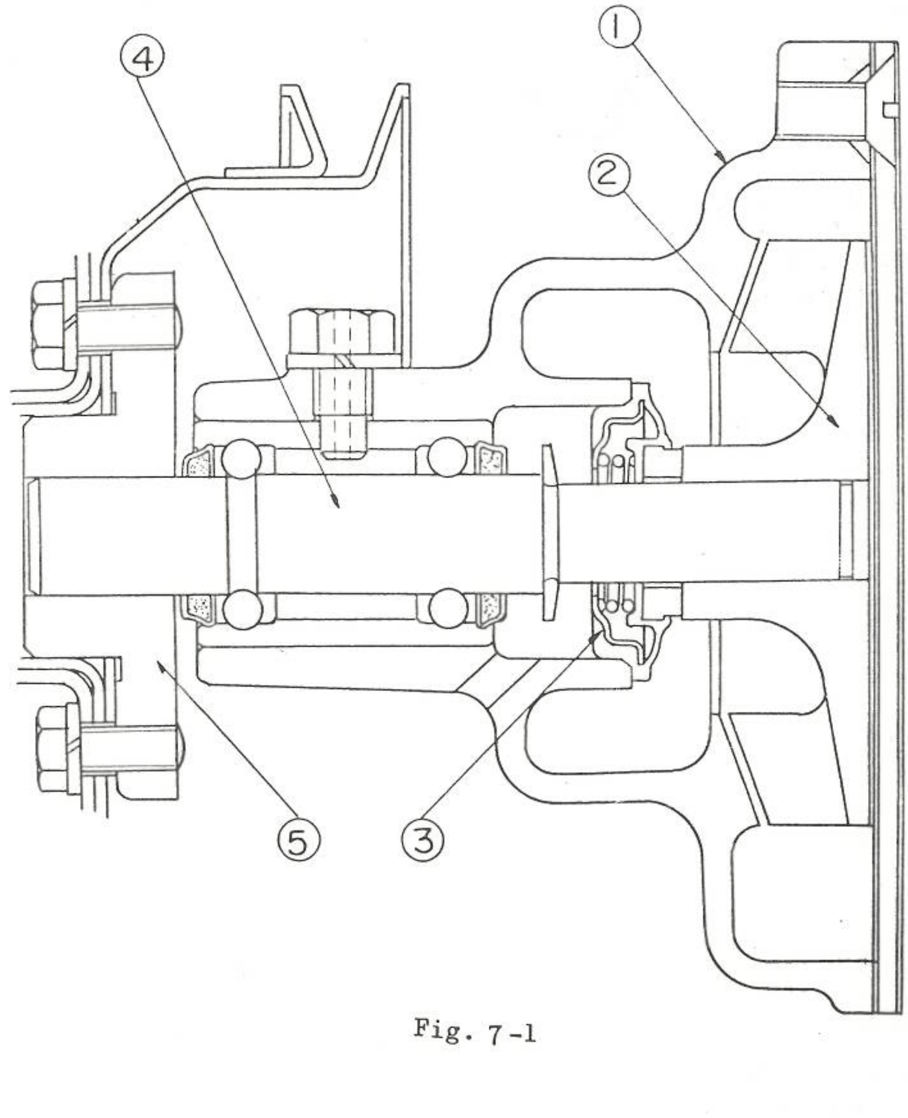
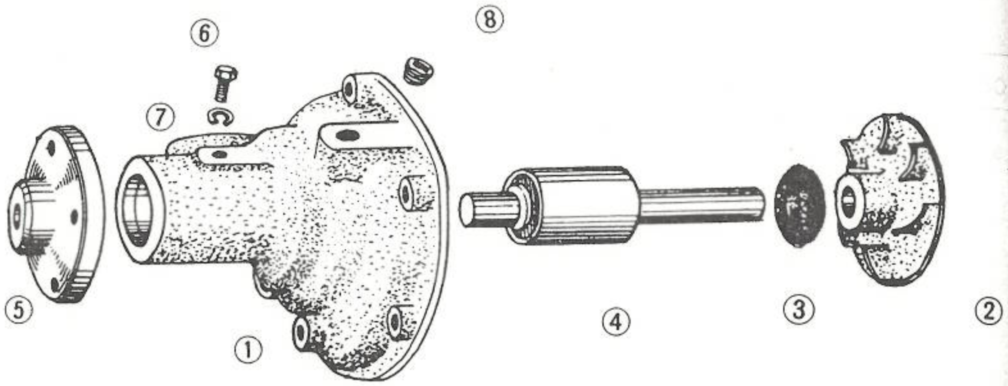


Fig. 7-1

Component parts of the water pump



(1) Water pump body
(2) Impeller
(3) Sealing unit
(4) Bearing unit
(5) Fan center
(6) Setting screw
(7) Spring washer
(8) Heater plug

Fig. 7-2

7-4-3 Removing

The parts should be removed in the following order.

(1) Drain the cooling water

(2) Disconnect the intake hose and outlet hose

(3) Remove the fan belt

(4) Remove the pump from the cylinder body

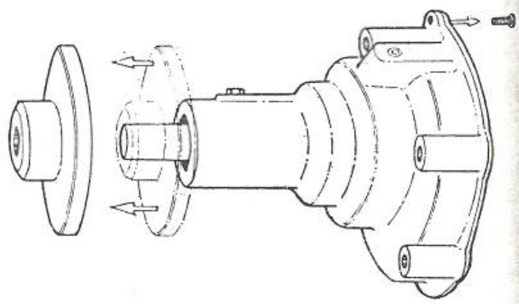


Fig. 7-3

7-4-4 Dismantling

The parts should be dismantled in the following order.

(1) Remove the water pump cover.

(2) Remove the fan center with the aid of puller. (See Fig. 7-3)

(3) Loosen the setting screws on the bearing unit and then pull out the shaft with the impeller. (See Fig. 7-4)

Note: The shaft should be pulled out with the aid of press machine.

(4) Remove the impeller from the shaft. (See Fig. 7-5)

(5) Remove the seal unit and thrower from the shaft.

(6) The bearing unit is provided with sealed-in grease and integrally connected with the shaft and hence it can not be dismantled.

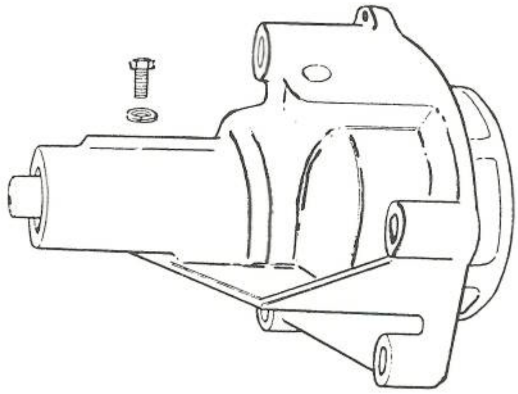


Fig. 7-4

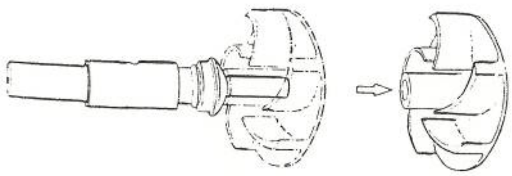


Fig. 7-5

7-4-5 Inspecting and adjusting

The parts should be cleaned before they are inspected.

(1) Bearing unit

1) Check the bearing unit to see if they are damaged or bent.

2) Replace the bearing unit if it is provided with above 0.2mm of excessive play in the direction across to the shaft.

(2) Water pump body

1) Check the drain hole on the pump body for clogging.

2) Check the pump body for cracking or damage.

3) Check the contacting face of the seal unit for wear.

(3) Impeller

1) Replace the impeller if it is corroded or damaged.

2) Check the contacting face of the sealing unit for wear, irregular contact and damage and replace the parts as necessary.

(4) Seal unit

1) Replace the parts if the carbon bakelite seal is excessively worn or damaged and no longer gives proper contact.

2) Check the rubber boot and replace the seal unit if damage is serious.

7-4-6 Reassembling

The water pump should be reassembled in the following order.

1) With the setting hole of the bearing unit agreed with the setting screw on the pump body, the bearing unit should be inserted into the pump body.

2) The bearing unit should be mounted in the pump body with the setting screw.

3) Refit the impeller to the bearing unit with the aid of press machine. Check the clearance between the cylinder body and the impeller by holding a straight edge right against the mounting face of the body and inserting a feeler gage into the clearance between the straight edge and the impeller. To avoid the impeller from coming into contact with the body, adequate clearance should be given therbetween. The clearance is standard at 0.3 ± 0.1mm.

4) Refit the fan center into position with the aid of the press machine.

Measuring the clearance in the back of the Impeller

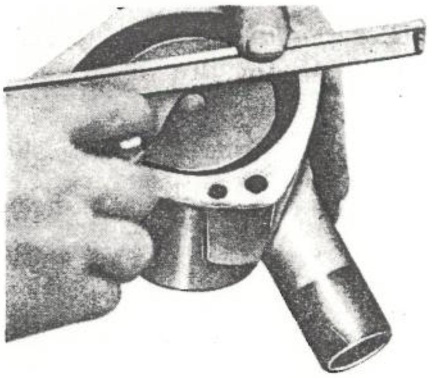


Fig. 7-6

7-5 FAN AND FAN BELT

7-5-1 Specifications

	Model G150	Model G130	Model C180
Type of the fan	Axial flow air-intake	Same as left	Same as left
Number and diameter of the fan blade mm	4 x 350	"	4 x 370
Diameter of the pulley	132 ∅	"	120 ∅
Gear ratio to the crankshaft	1.04	"	1.14
Type of the fan belt	A-type	Same as left	Same as left

7-5-2 Removing the fan belt

1) Remove the four (4) clamping bolts fastening the fan blades and then, remove the fan, fan pulley and spacer.

2) Slacken the clamping bolts fastening the adjust plate and generator bracket and the pivot the generator all the way to the engine for removing the fan belt.

7-5-3 Refitting and adjusting the fan belt

After the fan belt is refitted into the pulleys, pivot the generator about the clamping bolts on the generator bracket for adjusting the tension of the fan belt. Tighten the clamping volts on the adjusting plate and generator bracket after the fan belt is properly tensioned.

7-5-4 Inspecting

1) Check the fan blades for crack or bending and replace as necessary.

2) Check the fan belt for wear, separation or cracking and replace as necessary.

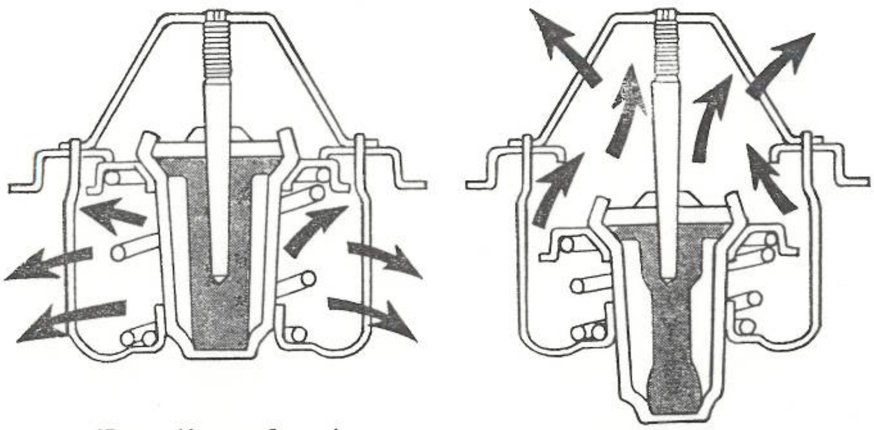
7-6 THERMOSTAT

7-6-1 Specifications

	Model G150	Model G130	Model C180
Type	Wax pellet type with by-pass	Same as left	Same as left
Valve opening temperature	$76.5^{o} \pm 1.5^{o}$	"	"
Temperature for fully opening the valve ^{o}C	90	"	"
Valve lifting stroke (mm) at $90^{o}C$	8.5	"	"

7-6-2 Construction

Construction and function of the wax pellet type thermostat



When the valve is fully closed

The valve at full open

Fig. 7-7

The wax pellet type thermostat relies upon the expansion of the element for the valve operation.

7-6-3 Removing

Drain the cooling system entirely and disconnect the water outlet pipe and then take out the thermostat.

7-6-4 Inspecting

1) Replace the thermostat if it fails to close when disposed in a water at normal temperature.

2) Check the valve operating temperature in the following manner.

With the thermostant held in water, gradually raise the water temperature and measure the temperature at which the valve of the thermostant started opening and held fully open.

3) The maximum valve opening stroke is standard at 8.5mm.

4) Replace the thermostat as necessary.

7-7 RADIATOR

7-1 Specifications

	Model G150	Model G130	Model C180
Type	Pressurized cooling system	Same as left	Same as left
Type of cooling pipes and fins	Flat cooling pipes with corrugated fins	"	"
Number of cooling pipes	2	"	3
Pressure valve operating pressure	0.04 - 0.50	"	Same as left
Valve opening pressure kg/cm^2			
Operating of vacuum pressure valve	0.04 - 0.50	"	"
Valve opening pressure kg/cm^2			

7-7-2 Removing

1) Drain the cooling system.
2) Disconnect upper and lower water hoses.
3) Remove four (4) radiator clamping bolts and then dismantle the radiator.

7-7-3 Inspecting and repairing

1) Check the radiator and core for water leakage in the upper and lower water reservoir and repair the water leakage as necessary.
2) Check the radiator core for clogging and if clogged area is in excess of 80 percent of the entire area of the core, replace the radiator assembly.
3) Check the pressure valve on the radiator cap for weakened spring and faulty packing and replace the cap if necessary.

7-7-4 Refitting

Reverse the procedure for removing. After it is refitted to position, fill the coolant with water and operate the engine and check to see if water is allowed to leak from hose connections.

PART 8 FUEL SYSTEM (GASOLINE ENGINE)

CONTENTS

PART 8 FUEL SYSTEM (GASOLINE ENGINE)

8-1 FUEL SYSTEM

The fuel system of the Bellett gasoline engine comprises a fuel tank, fuel filter, fuel pump and a carburetor, and all the component parts are in common with the model G150 (1500cc) and model G130 (1300cc) except the carburetor.

A diagram illustrating the fuel system of the Bellett gasoline engine

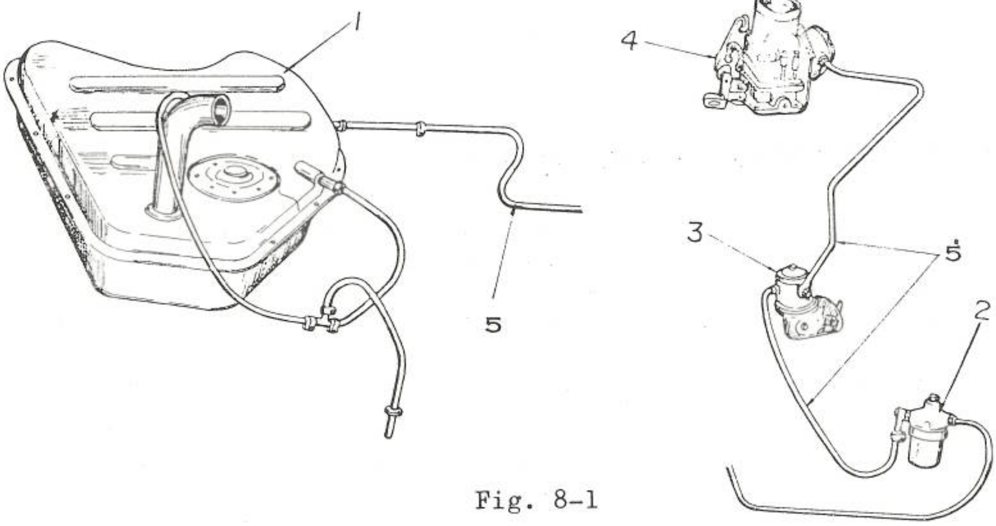


Fig. 8-1

(1) Fuel tank (2) Fuel strainer (3) Fuel pump
(4) Carburetor (5) Fuel pipe

(1) Carburetor

The difference of the carburetors between the model G150 and G130 is that the model G150 employs the strongburgh type carburetor manufactured by the NIHON KIKAKI whilst the model G130 is equipped with solex type carburetor manufactured by the HITACHI.

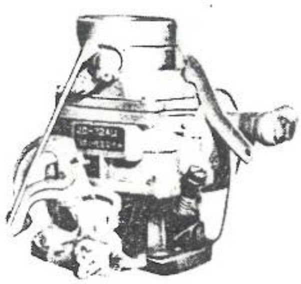


Fig. 8-2

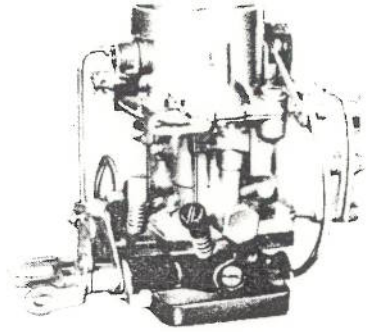


Fig. 8-3

8-2 SPECIFICATIONS OF THE CARBURETOR

The letters P and S represent "primary" and "secondary" respectively

Type of the engine	For model G150	For model G130
Manufacturer	Nihon Kikaki	Hitachi
Type	Strongburgh type twin down-draught 2D-32AU-2	Solex type twin down-draught DAB-308-5A
Parts number	8110-0071	8110-0080
Diameter of the bore (intake)	Inner diameter 57.5ϕ Outer diameter 63ϕ	Inner diameter58ϕ Outer diameter63ϕ
Diameter of the bore (outlet)	P=30ϕ S=32ϕ	P=28ϕ S=30ϕ
Venturi diameter	P=21ϕ, 8ϕ S=27ϕ, 14ϕ, 7ϕ	P=22ϕ S=28ϕ
Fuel level (from the top level of the body) (mm)	19	23
Fuel level (from the main nozzle)(mm)	13	10

Fuel feed pressure (kg/cm2)	0.22	0.13 - 0.16
Diameter of the [illegible] jet part		
Main jet	P=0.96ø, S=1.4ø	P=0.95ø, S=1.6ø
Slow jet	0.45ø	P=0.50ø, S=1.05ø
Power jet	0.45ø	0.45ø
Main air bleed	P=10.8ø, S=0.8ø (dynamic pressure)	P=2.0ø, S=20ø (dynamic pressure)
Emulsion hole	P=0.6øx12, S=0.6o/x2	P=1.6øx16, S=1.0øx16
First slow air bleed	0.8ø	P=1.9ø, S=0.7ø
Second slow air bleed	1.5ø	
Slow econostat	1.4ø	
Idle port	1.5ø	1.5ø
Slow port	0.8ø, 1.2ø	1.2øx2
Acceleration pump nozzle diameter	0.6ø	0.4ø
Maximum delivery of the acceleration pump (cc)	0 - 0.2, 0.28 - 0.56, 0.42 - 0.78	0.45, 0.35, 0.3, 0.25
Main nozzle inner diameter	P=2.5ø S=2.8ø	P=1.8øx8, S=1.8øx8
Power valve operating angle	50°	Start operating at boosting 60mmHg
Throttle valve fully closing angle	P=10° S=20°	P=10° S=18°
Secondary throttle valve operating angle	50°	49°
Choke valve fully closing angle	10°	15°
Opening angle of the throttle valve when the choke valve is fully closed	$12.5^{\circ}\ ^{+2^{\circ}}_{-1^{\circ}}$	14°

8-3 CARBURETOR FOR MODEL G150

(1) Construction of the carburetor

Construction of the carburetor for model G150

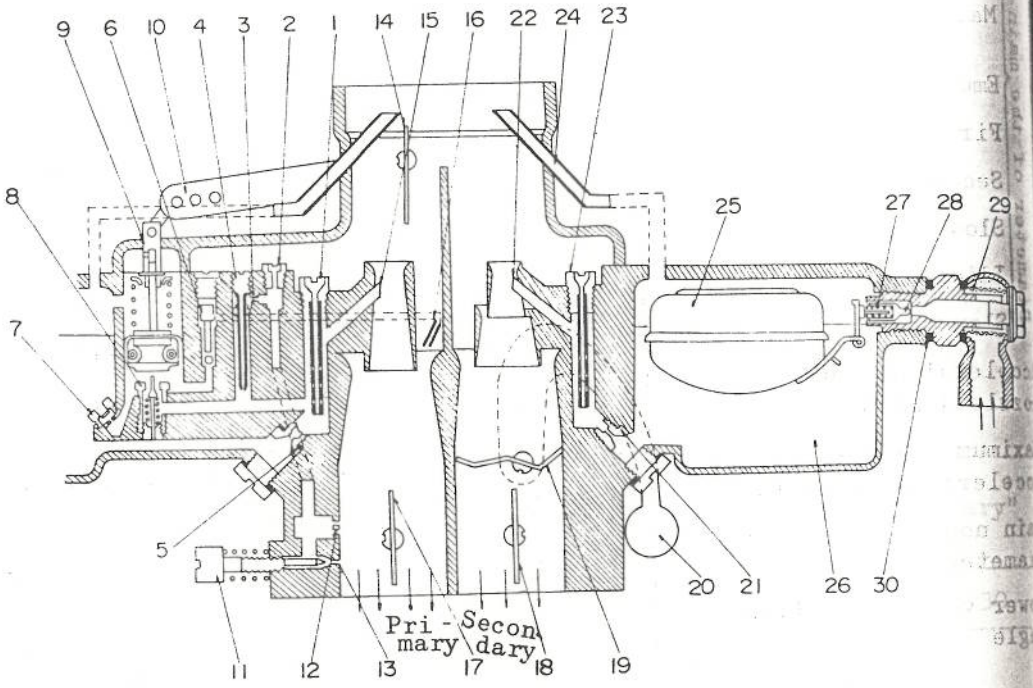


Fig. 8-5

1. Primary main air bleed
2. Slow air bleed
3. Slow econostat
4. Slow jet
5. Primary main jet
6. Outlet check valve
7. Inley check valve
8. Power jet valve
9. Acceleration pump piston
10. Acceleration pump arm
11. Idle adjusting screw
12. Slow port
13. Idle port
14. Choke valve
15. Primary main nozzle
16. Acceleration pump nozzle
17. Primary throttle valve
18. Secondary throttle valve
19. Auxiliary throttle valve
20. Auxiliary throttle valve weight
21. Secondary main jet
22. Secondary main nozzle
23. Secondary main air bleed
24. Air vent
25. Float
26. Float chamber
27. Valve spring
28. Float valve
29. Strainer
30. Gasket

Component parts of the carburetor for model G150

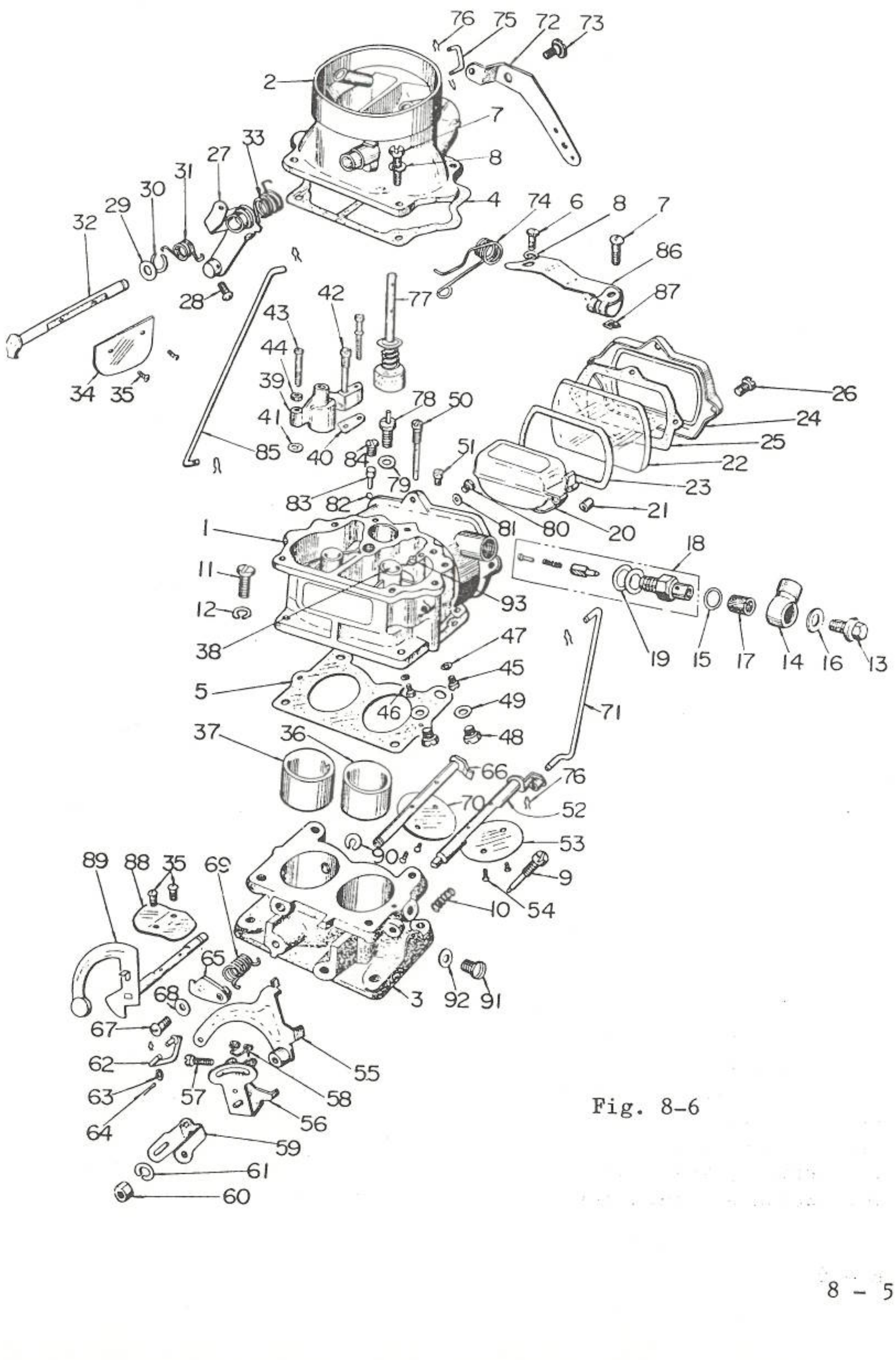


Fig. 8-6

1. Body assembly
2. Air horn assembly
3. Flange
4. Gasket body
5. Gasket flange
6. Screw choke wire holder
7. Screw choke wire holder fixing
8. Spring washer
9. Idle adjust screw
10. Spring idle adjust screw
11. Screw flange fixing
12. Spring washer
13. Union bolt
14. Union nipple
15. Gasket for union nipple
16. Gasket for union bolt
17. Strainer inlet
18. Float valve assembly
19. Float valve arm
20. Float
21. Collar float pin
22. Window glass
23. Window glass gasket
24. Retainer
25. Retainer gasket
26. Screw
27. Choke lever
28. Screw wire terminal
29. Collar choke valve shaft
30. Choke lever ring
31. Choke valve return spring
32. Shaft
33. Choke valve arm spring
34. Choke valve
35. Screw valve
36. Primary venturi large
37. Secondary venturi large
38. Primary small venturi
39. Secondary small venturi
40. Venturi gasket
41. Venturi gasket
42. Secondary main air bleed
43. Venturi screw
44. Spring washer
45. Primary main jet
46. Secondary main jet
47. Main jet gasket
48. Main passage plug
49. Plug gasket
50. Slow jet assembly
51. Slow air bleed
52. Primary throttle shaft
53. Primary throttle valve
54. Screw for throttle valve
55. Throttle valve starting
56. Primary throttle shaft arm
57. Throttle adjust screw
58. Adjust spring
59. Throttle lever
60. Throttle shaft nut
61. Spring washer
62. Throttle shaft link assembly
63. Washer
64. Split pin
65. Secondary throttle valve lever
66. Throttle valve shaft (secondary)
67. Secondary throttle shaft screw
68. Secondary throttle shaft washer
69. Secondary throttle shaft valve spring
70. Secondary throttle valve
71. Pump connecting rod
72. Pump arm
73. Pump arm screw
74. Pump arm return spring
75. Pump link
76. Snap ring
77. Pump plunger assembly
78. Power jet valve assembly
79. Valve seat gasket
80. Check valve assembly for pump
81. Check valve gasket
82. Check valve discharge
83. Pump weight
84. Pump passage plug
85. Starting connecting rod
86. Choke holder wire
87. Wire holder nut

58. Dumper valve
59. Dumper valve shaft
60. Clip
61. Slow port plug
62. Slow port plug gasket
63. Primary main air bleed

8-3-2 Construction and function of the carburetor

The twin carburetor employed in the Bellett engine comprises a pair of single barrel carburetors and so designed that only one of the carburetors operates when the automobile is travelling at low speeds or with light load. The two of the carburetors are arranged to operate simultaneously when high-speed operation or maximum performance is called for and the operation of two-carburetors will result in a marked increase in the mixture intake effect. Each unit of the carburetors for low speeds and high speeds are referred to as primary carburetor and secondary carburetor respectively.

(1) Float chamber

The fuel fed by the fuel pump is maintained at a constant level and transmitted to the primary and secondary carburetor in common. The fuel is transmitted to the float chamber through the fuel pump, fuel strainer and float valve.

A detachable glass cover with the mark "level" is provided on the side of the float chamber through which the fuel level can

Float chamber

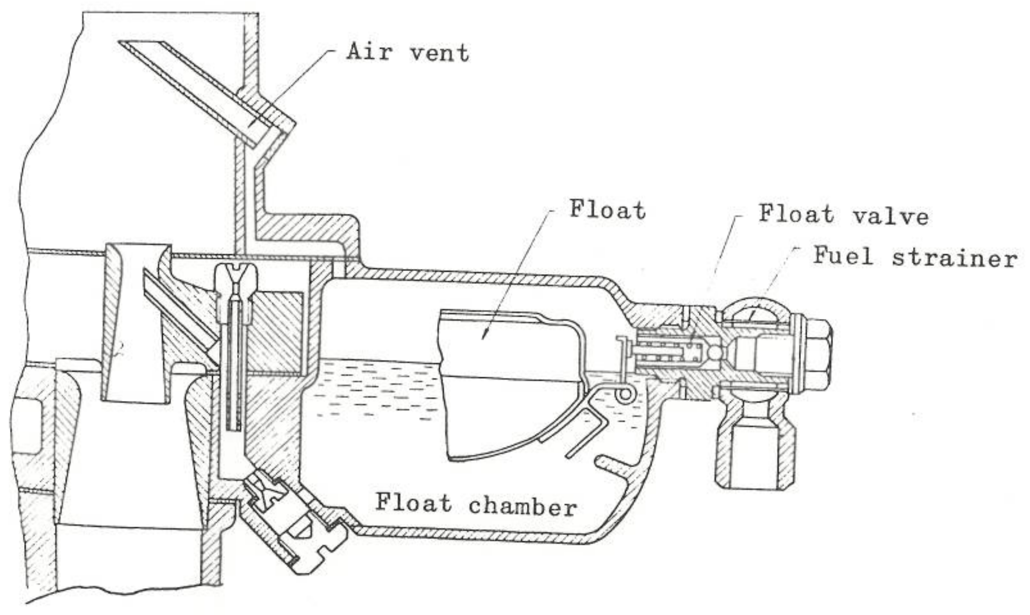


Fig. 8-7

be checked. The air ventilation pipe serves to communicate the dynamic pressure in the primary and secondary carburetors with the float chamber.

(2) Idling and slow running system

Both idling and slow running devices are provided in the primary carburetor, and when the engine is held running at idling speed, the primary throttle valve is held open about 2-3° while the secondary throttle valve is held fully closed. The fuel is supplied to the engine through the idle port. When the engine is accelerated from the idling condition, the fuel is supplied through the slow port. When the engine is hels running at low speeds, the fuel is initially controlled by the primary main jet and further by the slow jet. The fuel is then, readjusted by the slow jet and mixes with the air supplied from the slow air bleed and fed through the slow port.

Slow running system

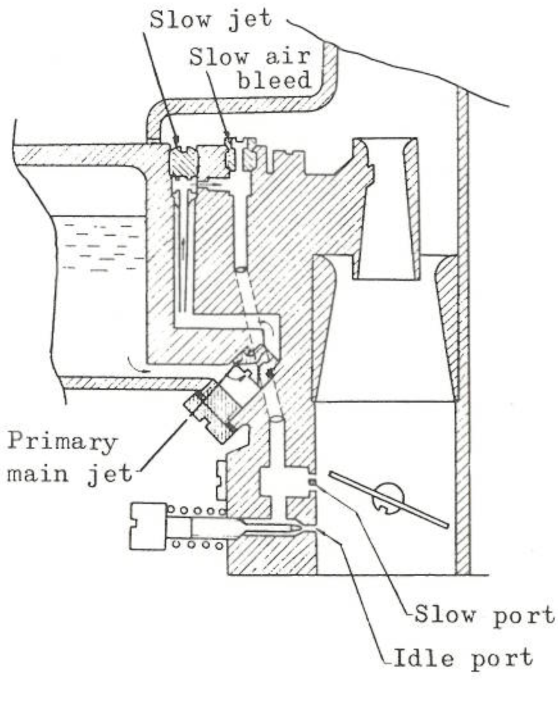


Fig. 8-8

Primary main supply system

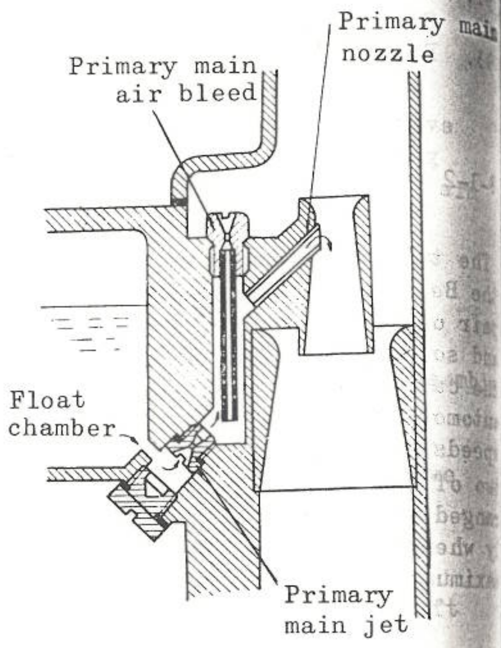


Fig. 8-9

(3) Primary main fuel supply system

When the engine is further accelerated and the throttle valve is held open at ablut 6-7°C, the fuel is supplied to the engine through the main fuel supply system. As illustrated in figure, the fuel in the main fuel supply system is primarily controlled by the main jet and mixes with the air supplied from the main air bleed and then fed to the engine through the main nozzle.

(4) Acceleration and power system

The acceleration system is provided in the primary carburetor and directly linked with the throttle valve. When the engine is suddenly accelerated, the acceleration system serves to open the throttle valve widely and, increasing the air intake, the acceleration pump plunger goes down and sprays the mixture through the pump jet therby compensating for the delay of mixture injection by the main and power nozzle, improving the acceleration.

The operation of the acceleration system is as follows: When the piston of the acceleration pump goes down, it closes the intake check valve positioned in the bottom of the float chamber and opens the discharge check valve (nylon ball) in the acceleration fuel transfer port thereby making the pump jet to spray the mixture against the inner wall of the venturi to give a vaporizing effect. When

Acceleration and power system

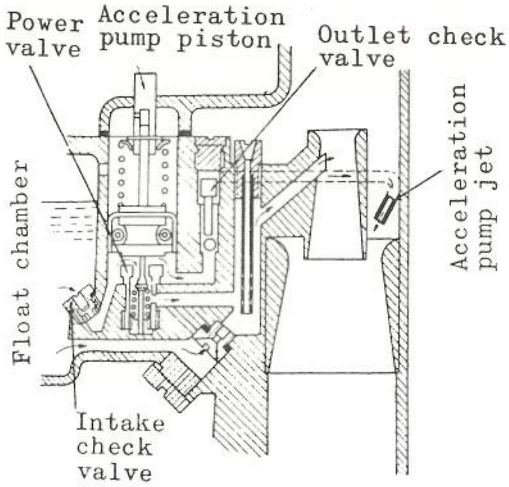


Fig. 8-10

the throttle valve is further opened to 50°, the tip end of the piston in the acceleration pump causes the power jet valve to open permitting the fuel to flow through the power jet valve to open permitting the fuel to flow through the power jet thereby supplying the main system with greater fuel. When the throttle valve is held closed, the piston of the acceleration pump goes up and closes the outlet check valve thereby opening the intake check valve for taking the fuel in the float chamber into the acceleration pump.

(5) Choke system

The choke system is installed in the primary carburetor for use in starting and idling the engine. The choke lever is held by the damper spring and when it is held partially open, the choke valve automatically operates in response to the engine speed and serves to keep the engine idling smooth. The carburetor is also provided with a fast idling device

Construction of choke system linkage

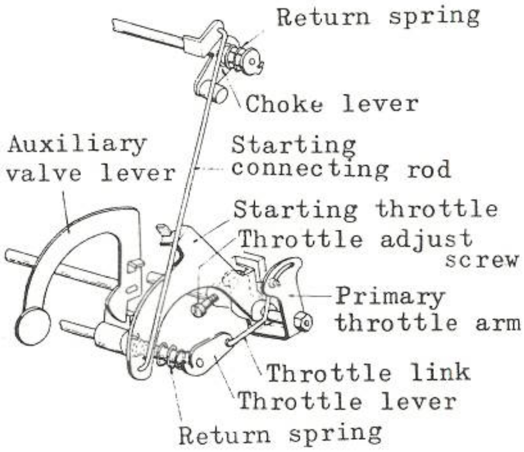


Fig. 8-11

which serves to open the throttle valve in the primary carburetor for easier starting and gives an ideal idling speed when the choke lever is held open. To prevent the air leaking from the secondary carburetor from going into the engine while the choke lever is operated, the carburetor is so arranged that the starting throttle lever serves to lock the auxiliary valve and hold it from being operated while the choke valve is fully closed.

(6) Secondary main supply system

As the primary throttle valve is opened to 50° or so, the secondary throttle valve which is directly linked with the primary throttle valve also started to open and both the primary and secondary throttle valves fully opens simultaneously. Both of the valves are forced to return to their close position by the return spring mounted on the secondary throttle valve shaft. To obtain the greater air-tightness, the secondary throttle valve is fabricated with material 2mm thicker than that of the primary throttle valve. The carburetor is so arranged that only the function of the primary carburetor will suffice the fuel delivery while the engine is operated at low speeds even when the accelerator pedal is pressed all the way down thereby causing the secondary throttle valve to open.

The secondary carburetor is so arranged that it is put into operation only when the operation of the primary carburetor is not sufficient to supply the fuel required for the engine performance. The auxiliary valve serves to control this operation automatically. The auxiliary valve is a butterfly valve having a corrugated section and arranged eccentrically on a shaft. A dumper valve lever integrally combined with a weight is fixedly mounted on the shaft.

On account of the weight, the auxiliary valve is always held closed and not brought into operation even if the throttle valve is fully opened as the low pressure side of the secondary carburetor is independently operable. And hence, the velocity of the

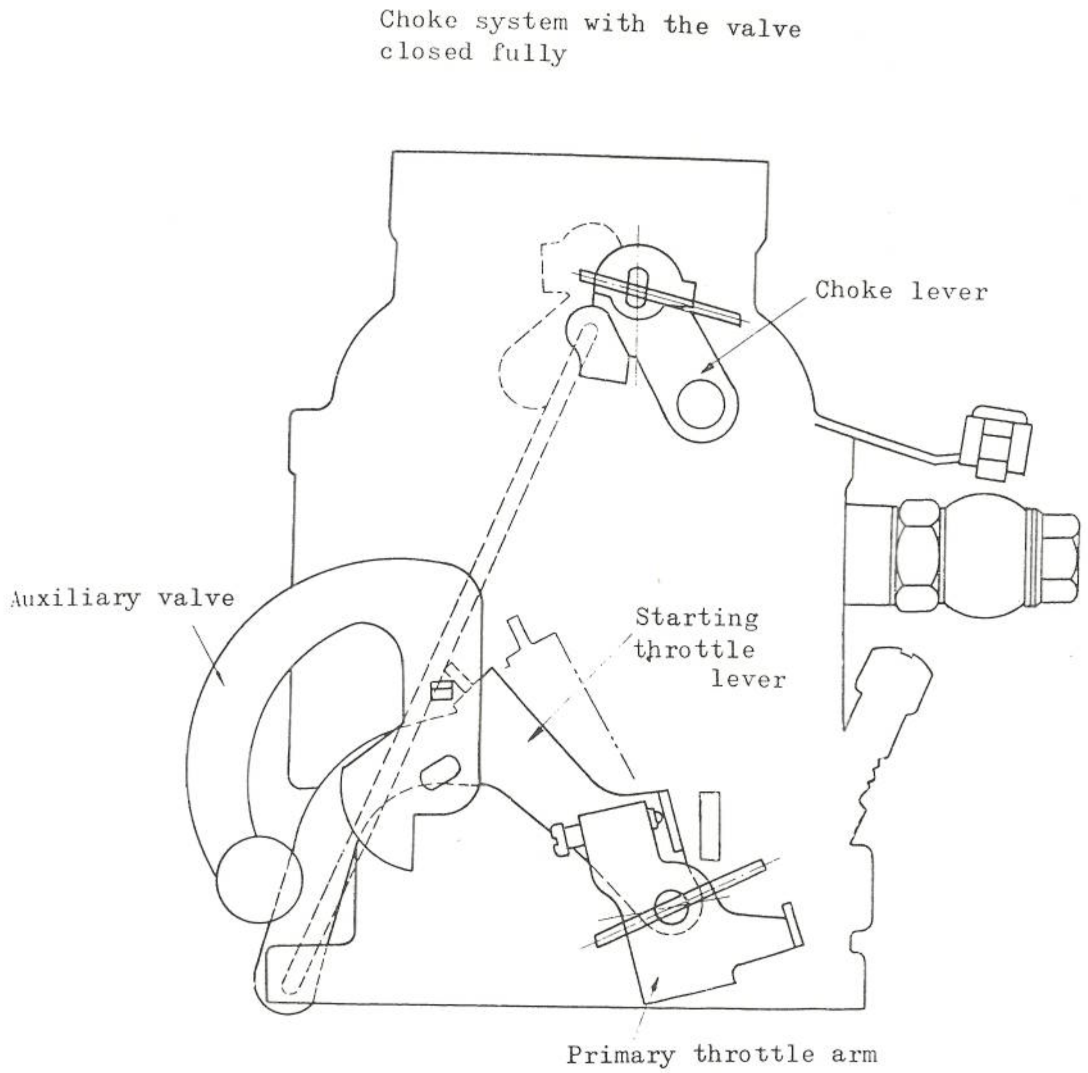


Fig. 8-12

air intake is held from being deaccelerated and provide the engine with optimum fuel mixture and thus ensures the engine of maximum performance particularly in slope-ascending and accelerating mode of operation. As the revolution of the engine increases with the throttle valve opening and the air intake pressure overcomes the weight of the auxiliary valve, the valve is forced to move toward opening side by the eccentrical force acting upon the weight and finally led to full open when the

Secondary main fuel
supply system

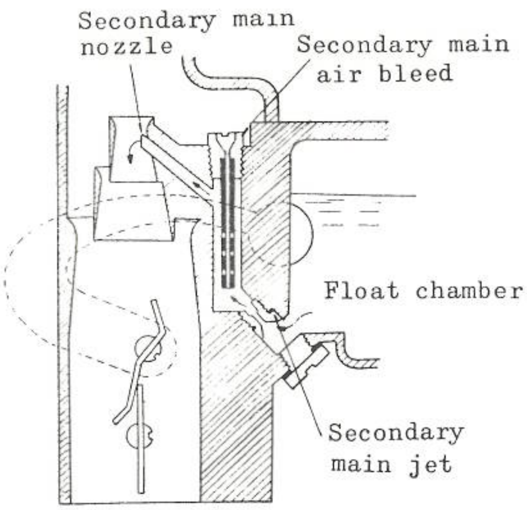


Fig. 8-13

Medium speed operation
(200 - 3,000 rpm)

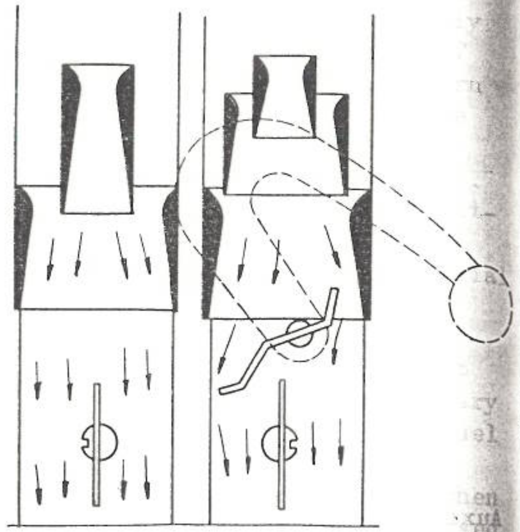


Fig. 8-15

Slow speed operation

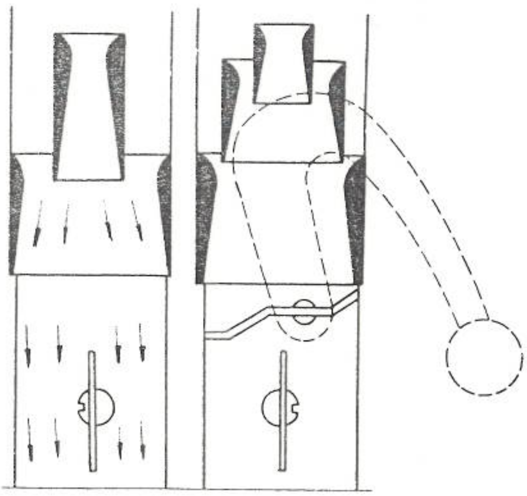


Fig. 8-14

engine speed increases as high as 3,000 rpm. The engine is accelerated smoothly as the auxiliary valve serves to hold the air intake pressure constant. The secondary carburetor is brought into full operation after the auxiliary valve is fully opened. The main fuel supply system in the secondary carburetor serves to control the fuel supplied from the float chamber with the secondary main jet and mixes the fuel with the air supplied by the secondary main air bleed and further lead the mixture to the narrowest portion in the tripple venturi through the main nozzle. As the secondary carburetor is designed to provide the engine with power, the fuel system is equipped only with the main fuel supply system. The

High speed operation

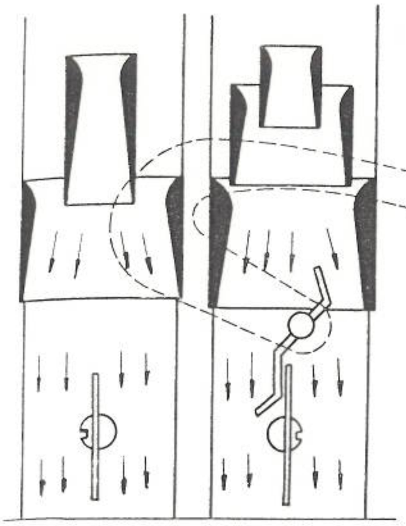


Fig. 8-16

secondary carburetor is equipped with a venturi far larger than that of the primary carburetor, and the venturi is provided with thripple channels and so arranged that it generates negative pressure and gives air intake effect sufficient to the engine operation and thus ensures the engine of smoothest operation.

7) Others

The carburetor is provided with a vacuum pressure ejector device on the upper portion of the throttle valve in the primary carburetor for operating a vacuum ignition timing control mounted on the distributor. The vacuum ignition timing starts operating when the throttle valve opens nearly 6^{0} from its closed position and held from working when the engine is held idling.

8-3-3 Dismantling the carburetor

1) Cautions for the work

A wrench and a screwdriver of proper size should be used for dismantling the carburetor to prevent the nut, bolt and screw from being damaged and the carburetor parts should be carefully treated and kept from dust or other foreign particles.

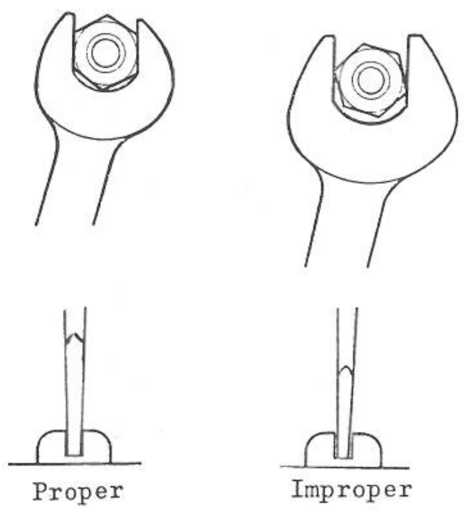


Fig. 8-17

The dismantled parts should be disposed separately by each system and protected from being interchanged. Careful attention each system and protected from being interchanged. Careful attention should be invited to the parts in common with the primary and secondary carburetor. The parts should be thoroughly cleaned with gasoline and compressed air may be used for cleaning small hole on the parts. A wire and the like should not be used for cleaning the delicate parts as jets as the wire and the like may ruin nor enlarge the port of the jet and may often lead to engine trouble.

2) Removing the carburetor

(1) Remove the air cleaner

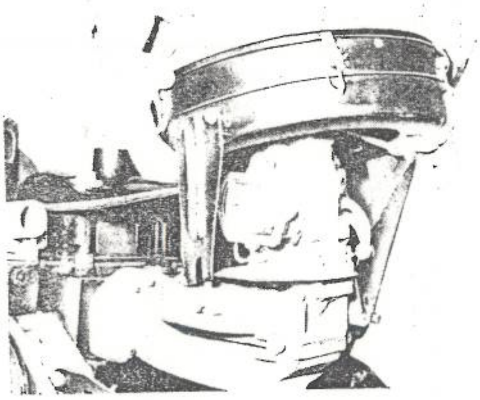


Fig. 8-18

(2) Disconnect the choke contol wire
(3) Disconnect the vacuum piping
(4) Remove the split pin on the operating shaft and then disconnect the linkage between the carburetor and the operating shaft.

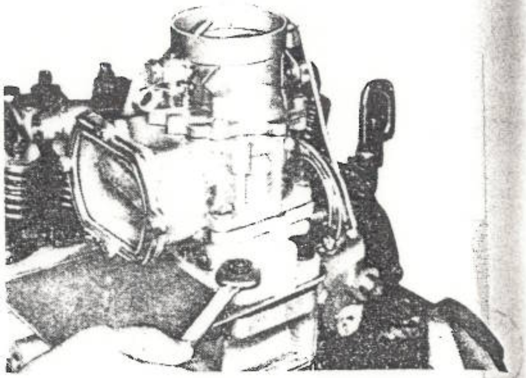


Fig. 8-19

(5) Disconnect the fuel pipe
(6) Remove the four(4)clamping nuts on the manifolds and dismount the carburetor from the manifold.

3) Dismantle the air horn and its associated parts

(1) First remove the spring clip and then remove the starting connecting rod serves to connect the choke lever with the starting throttle lever.

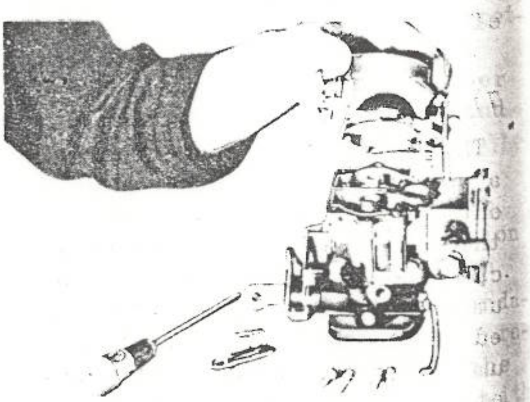


Fig. 8-20

(2) First remove the spring clip and then remove the connecting rod linking the acceleration pump arm with the primary throttle shaft.

(3) Remove the air horn by removing the four (4) screws and dismount the choke wire holder and gasket.

(4) Remove the plunger from the acceleration pump
First depress the dumper spring on the plunger and pull out the knock pin on the reverse side of the spring seat and then remove the plunger, dumper spring and spring seat.

Fig. 8-21

(5) Check the operation of the choke valve and remove the choke valve and the shaft by removing the two (2) screws fixing the choke valve to the shaft as necessary. Carefully remove the valve to prevent the choke valve return spring from missing.

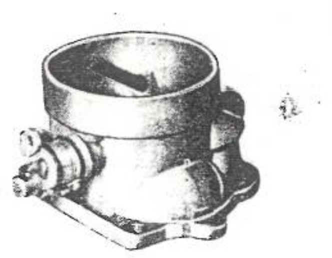


Fig. 8-22

(6) As the choke lever is secured to the air horn body with a ring, it should not be dismantled unless absolutely necessary.

4) Float chamber and its associated parts

(1) Pull out the union bolt on the side of the float chanber and remove the union nipple and intake strainer.

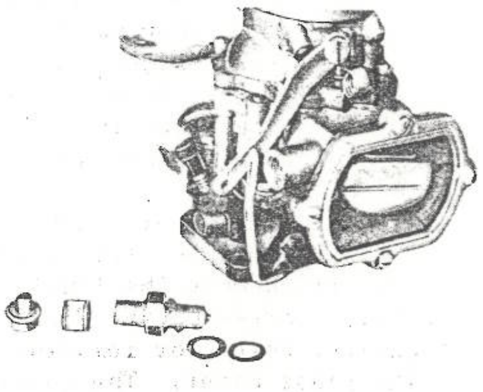


Fig. 8-23

Remove the float needle valve assembly. The needle valve can be taken out easily if the main body is tilted and the valve assembly is pulled out downwardly. Then remove the needle valve, needle valve spring and spring retainer from the valve seat.

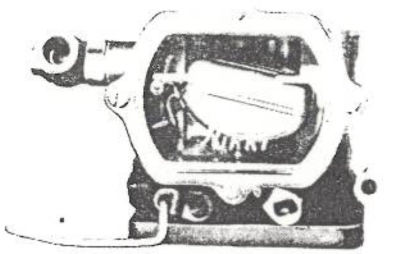


Fig. 8-24

(2) Note the number of copper packings provided between the main body and the needle valve seat as they may be required for reassembling. The fuel level rises as the number of packings increased and lowers with the packings increased.

(3) The float chamber can be dismantled in the following manner: Remove the four(4) fixing screws on the float chamber cover for removing the glass cover. The cover should be carefully removed to prevent the packing from being damaged. Then take out the float and check it carefully for damage. Shake the float with finger to see if it contains gasoline. Ruptured or leaky float should be replaced.

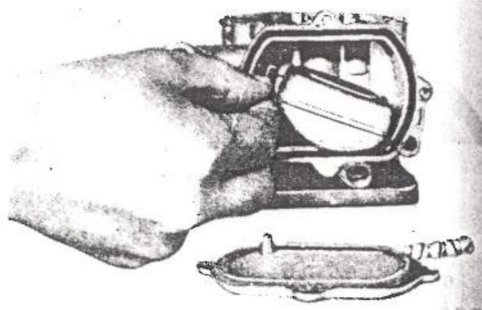


Fig. 8-25

(4) Remove the acceleration pump check valve from the bottom of the float chamber together with the packing.

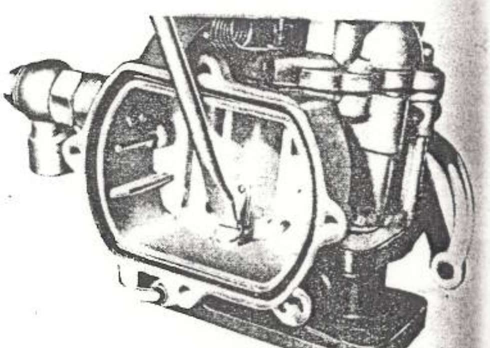


Fig. 8-26

5) Main body and its associated parts

(1) Remove the slow air bleed, slow jet and main air bleed on the upper part of the main body.

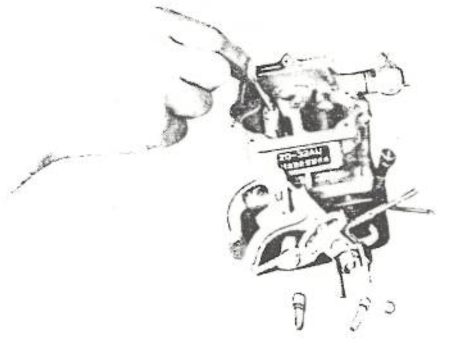


Fig. 8-27

(2) Remove the plug on the upper part of the main body and hold the body upside down for removing the pump weight and outlet check valve.

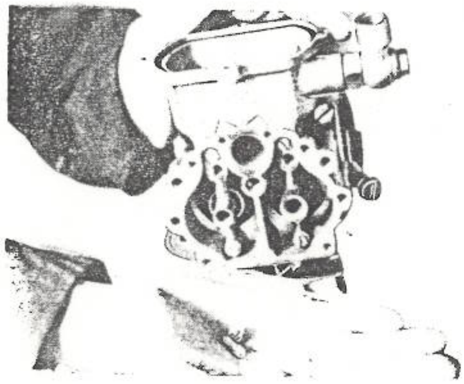


Fig. 8-28

(3) Remove the power jet valve from the bottom of the acceleration pump cylinder. Insert a screwdriver edge properly into the groove in the pump cylinder to prevent the valve rod from being damaged.

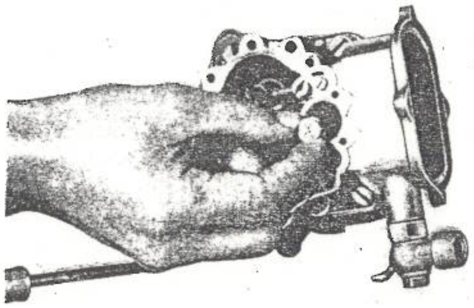


Fig. 8-29

(4) Hold the main body upside down and remove the plug from the primary and secondary main jet provided on the lower part of the body and then remove the main jet. Both the primary and secondry main jets are indistinguishable from their external appearance except the chamferred portion of the secondary main jet is smaller than that of the primary main jet.

(5) Remove the small venturi and their packings from the primary and secondary carburetor if absolutely necessary. The small venturi can be removed when the two (2) fixing screws are removed

Fig. 8-30

but it is normally held in trouble-free condition and therefore, dismantling is not necessary and loosened screws may be re-tightened on detection.

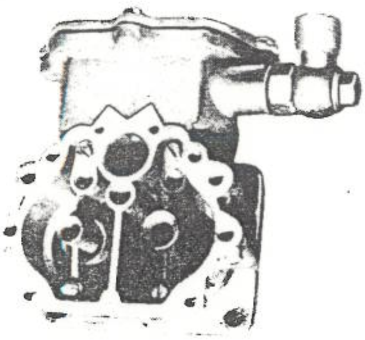


Fig. 8-31

6) Body flange and its associated parts

(1) Remove the four (4) fixing bolts from the main body and main body flange and then remove the main body.

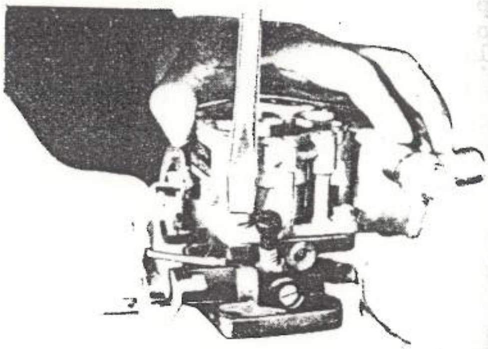


Fig. 8-32

(2) Remove the idle adjusting screw and its spring and also remove the slow port plug. When the above parts are removed, the slow port and the idle port can be easily cleaned.

(3) Remove the lock nut on the throttle lever and disconnect the throttle linkage by removing the split pin and then remove the primary throttle arm and starting

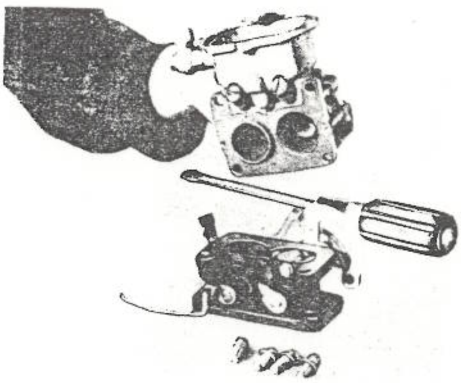


Fig. 8-33

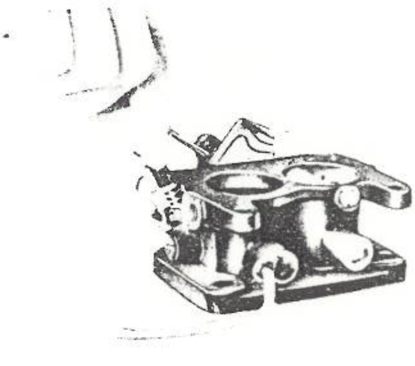


Fig. 8-34

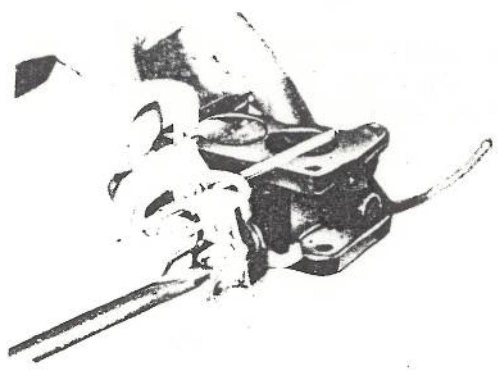


Fig. 8-36

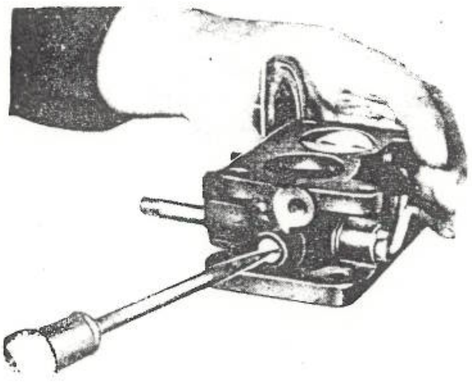


Fig. 8-35

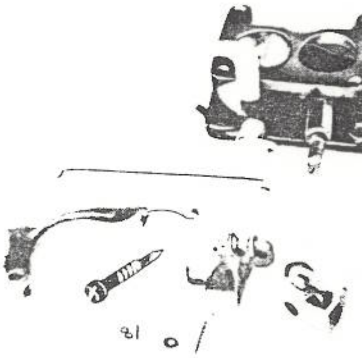


Fig. 8-37

throttle lever. Protect the return spring from being deformed.

(4) As the screws fastening the primary, secondary and auxiliary valves are carefully clamped and hermetically sealed to prevent the air leakage, they should be held from being turned loose but the carbon deposits may be carefully removed.

8-3-4 Inspecting the parts

When the carburetor is completely dismantled check the entire parts for trouble paying special attention to the following.

1) Air horn

(1) Crack or damage on the air horn particularly the damage on the contacting face.

(2) Wear on the joints on the shafts.

(3) Operation of the choke valve (The operation of the choke valve is often restricted by the carbon deposits).

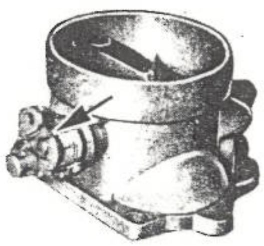


Fig. 8-38

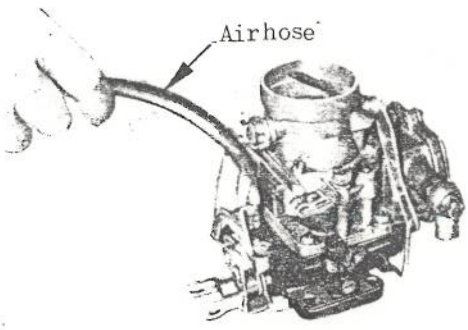


Fig. 8-39

2) Main body

(1) As the internal part of the body is normally subjected to carbon deposits, clean the parts carefully to remove the carbon deposits. As the slow air bleed is directly bored through the body side of the primary carburetor, clean this carefully with the aid of the compressed air.

(2) The outlet check valve located in the bottom of the float chamber is susceptible to corrosion by the water segimented in the bottom of the float chamber and also tends to lead to operating failure in contact with foreign particles and hence, the parts with any signs of trouble should be replaced.

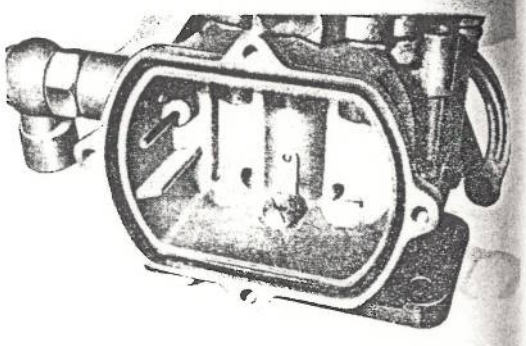


Fig. 8-40

(3) The bottom of the acceleration pump cylinder should be carefully cleaned as the foreign particles tend to accumulate on this part and causes the jet clogging.

(4) If the needle valve, particularly the portion where comes in direct contact with the valve seat is worn and

(5

Fig. 8-41

no longer provide desired sealing effect, it should be replaced as it often invite over-flowing and other troubles. The float valve spring should also be checked for weakened tensile force.

Fig. 8-42

(5) The float should be shaken to see if there is gasoline inventory inside. Leaking float should be immediately replaced. If the float pin inserting hole is worn the float should be replaced as loosely inserted pin would often result in over-flowing

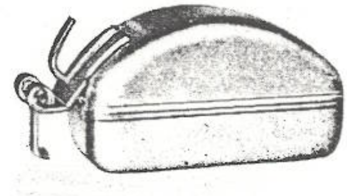


Fig. 8-43

Check the strainer in the union nipple for rust or damage. The tensile force of the dumper spring provided between the pump rod and the piston is acting on the acceleration pump plunger but the operation of the

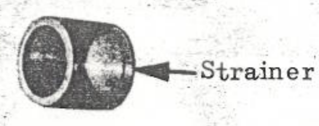


Fig. 8-44

pump plunger may be restricted if the piston rod fails to slide freely with the pump rod for rust. The leather boot should be checked for deformation. After the plunger is refitted into the cylinder, check to make sure that the plunger is allowed to slide freely.

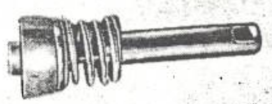


Fig. 8-45

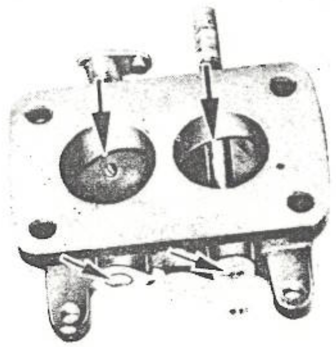


Fig. 8-46

3) Body flange

(1) Check the slow port and idle port for clogging.
(2) Check the throttle valve for carbon deposit and wear.
(3) Check the jointing portion of the throttle shaft for wear.
(4) Check the tip end of the idle adjusting screw where comes in contact with the seat for tapered wear, stepped wear or damage in the threaded portion.

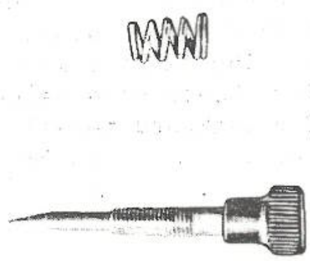


Fig. 8-47

(5) Reassembling and adjusting the carburetor
The carburetor should be reassembled in the sequence converse to dismantling and the following should be carefully noted.

1) After the carburetor is reassembled, move the primary throttle lever to see if the linking secondary throttle lever smoothly operate. Check

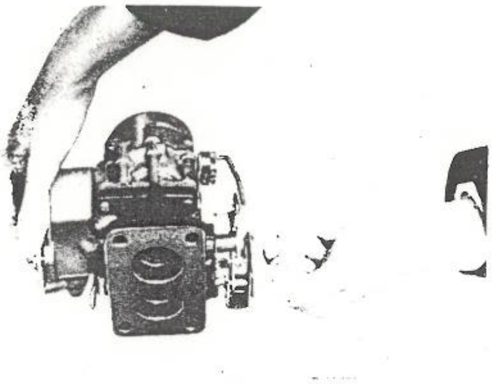


Fig. 8-48

to see if the primary and secondary throttle valve open fully at the same time. If the throttle valves fails to open fully simultaneously, readjust the valve operation by bending or stretching the linkage.

2) The main jet for the primary and the secondary carburetor should be kept from being interchanged. The packing should be replaced with that of good quality and the parts are firmly secured in position to prevent fuel leakage.

3) The power jet valve should be carefully mounted to prevent the valve rod from bending and carefully tightened to prevent fuel leakage. If the valve is not properly tightened, the fuel may be allowed to leak-off and increases the fuel consumption.

4) The small venturis may not have to be dismantled unless absolutely necessary but once they are removed, they should be provided with new gasket. Before fastening the small venturi to the body make sure to refit the new packings to the two (2) clamping bolts.

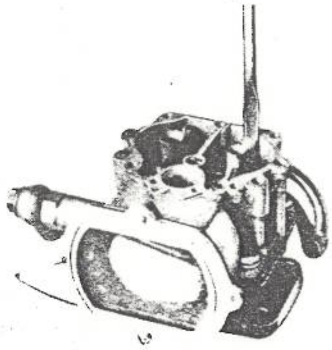


Fig. 8-49

5) The fuel level in the float chamber may be adjusted by reducing or increasing the number of copper gasket for the float valve seat. Increasing the number of gasket increases the fuel level and less gasket reduces the fuel level. The fuel level is standard at 19mm below the upper part of the body but since the glass cover is provided with level marks, the fuel level may be adjusted to retain within the markings. The level marks should be used as references for adjusting the fuel level only when the engine is held stationary. The float cover should be carefully checked for a sign of fuel leakage.

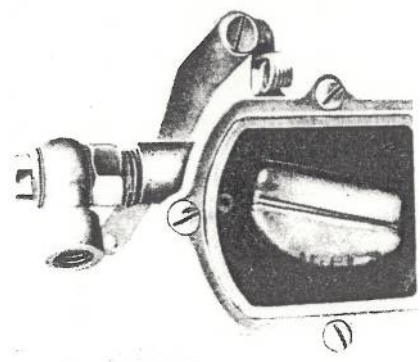


Fig. 8-50

6) When the acceleration pump is reassembled, fill it with gasoline and check to make sure that the fuel for acceleration is smoothly injected. As the pump piston also serves to operate the power jet valve, the connecting rod should be carefully treated to prevent it from being bent.

7) Check the fast idling system to see if the primary throttle valve opens to the specified angle (12.50) when the choke valve is held fully closed. The opening angle of the primary throttle valve may be adjusted by controlling the effective length of the connecting rod. The primary throttle valve opening angle may be adjusted while the idle adjust screw is held screwed all the may in so as to hold the primary throttle valve fully closed when the choke valve is opened fully.

8-4 CARBURETOR FOR MODEL G130

8-4-1 Construction of the carburetor

The carburetor for the model G130 engine has the construction substantially same to that for the model G150 except the carburetor for the model G130 is equipped with Solex type main fuel supply system. The acceleration pump similar to that on the model G150 equipped with the engine for the model G130 ensures the engine of maximum accelerating efficiency.

Construction of the carburetor

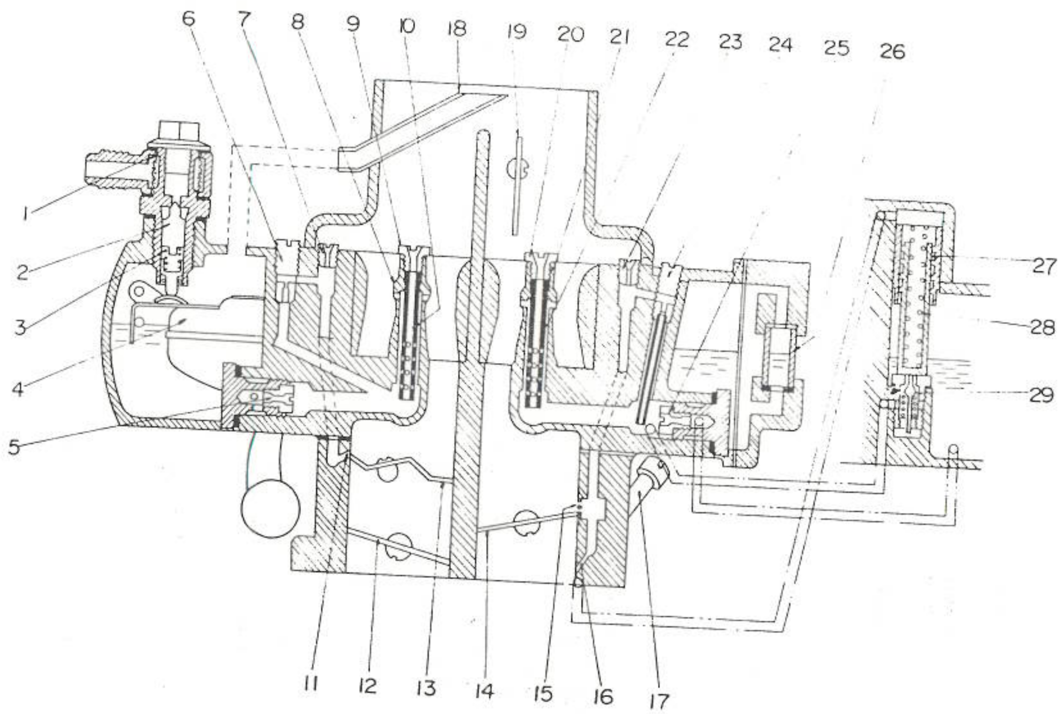


Fig. 8-51

1. Strainer
2. Needle valve
3. Valve spring
4. Float
5. Secondary main jet
6. Secondary slow jet
7. Secondary slow air bleed
8. Secondary main nozzle
9. Secondary main air bleed
10. Secondary emulsion tube
11. Step port
12. Secondary throttle valve
13. Auxiliary valve
14. Primary throttle valve
15. Slow port
16. Idle port
17. Idle adjusting screw
18. Air vent
19. Choke valve
20. Primary main air bleed
21. Primary main nozzle
22. Primary emulsion tube
23. Primary slow air bleed
24. Primary slow jet
25. Primary main jet
26. Fuel level gage
27. Vacuum piston
28. Vacuum piston spring
29. Power valve

Component parts of the carburetor for model G130

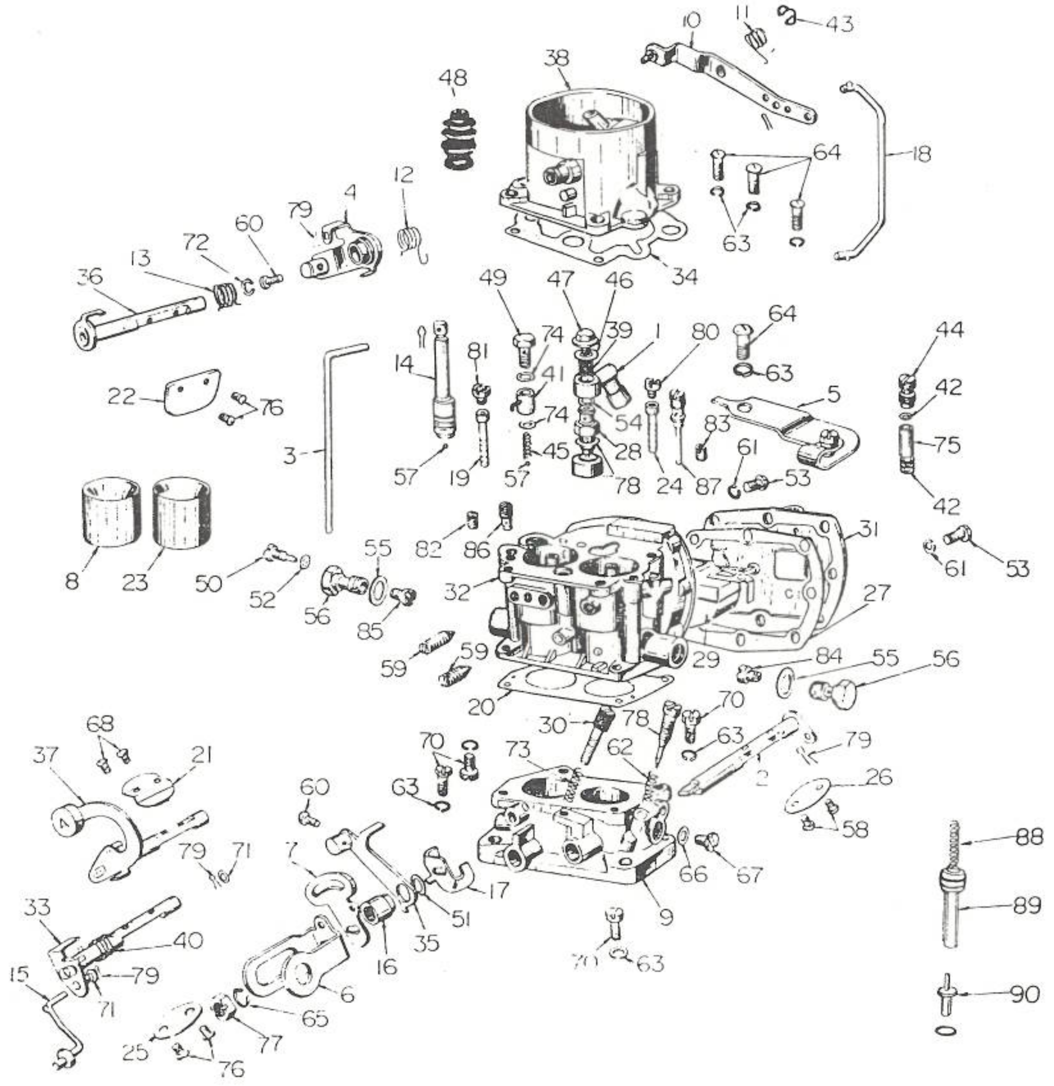


Fig. 8-52

1. Nipple
2. Throttle shaft
3. Connecting rod
4. Choke lever
5. Choke wire guide
6. Throttle lever
7. Connecting lever
8. Venturi (S)
9. Throttle chamber
10. Pump lever
11. Pump lever spring
12. Choke lever spring
13. Choke valve spring
14. Piston
15. Connecting rod
16. Sleeve
17. Adjust plate
18. Pump rod
19. Emulsion tube
20. Throttle chamber gasket
21. Auxiliary valve
22. Choke valve
23. Venturi (P)
24. Emulsion tube
25. Throttle valve (S)
26. Throttle valve (P)
27. Float chamber gasket
28. Needle valve
29. Float
30. Throttle adjust screw
31. Float chamber cover assembly
32. Float chamber
33. Throttle shaft (S)
34. Choke chamber gasket
35. Connecting lever
36. Choke valve shaft
37. Counter lever assembly
38. Choke chamber
39. Filter
40. Throttle spring
41. Pump injector
42. Packing
43. Shaft clip
44. Gage set screw
45. Pump injector spring
46. Washer
47. Filter setting screw
48. Pump cover
49. Injector set screw
50. Ball lock screw
51. Washer
52. Packing
53. Screw
54. Packing
55. Washer
56. Main jet carrier
57. Ball
58. Screw
59. Venturi stop screw
60. Screw
61. Spring washer
62. Idle adjust spring
63. Spring washer
64. Screw
65. Spring washer
66. Packing
67. Slow port plug
68. Screw
69. Washer
70. Bolt
71. Washer
72. Clip
73. Throttle adjust spring
74. Washer
75. Fuel level gage
76. Screw
77. Nut
78. Idle adjust screw
79. Cotter pin
80. Main air bleed (P) (#200)
81. Main air bleed (S) (#200)
82. Slow air bleed (P) (#190)
83. Slow air bleed (S) (# 70)
84. Main jet (P) (# 95)
85. Main jet (S) (#160)
86. Slow jet (S) (# 50)
87. Slow jet (P) (#105)
88. Power piston spring
89. Power piston
90. Power valve (# 45)

8-4-2 Construction and function of the carburetor

As the construction of the carburetor for model G130 is substantially same to that of the model G150 engine, the component parts of the carburetor in common with that of the model G150 are omitted from further description.

1) Main fuel supply system

The main fuel supply system has a construction similar to solex type and the fuel in the float chamber is fed to the venturi through the main jet and main nozzle through which the fuel is vaporized by the air supplied from the main air bleed through the emulsion tube. The main nozzle is provided with multi-hole and gives exellent fuel vaporizing effect.

2) Stop port fuel supply system

This system serves as the slow system in the primary carburetor and the secondary carburetor is also equipped with the step port fuel supply system. This system is provided for communicating the fuel between the primary and secondary carburetors and the delivery port of which is situated at the position close to the auxiliary valve when held closed.

3) Float chamber

The construction of the float chamber differs from that of the model G150. The cover of the float chamber is fabricated with aluminum and is provided with a fuel level gage. If the fuel level is such that the projected portion on the cover provided on both sides of the fuel level gage is filled with the fuel, the fuel level may be regarded as properly maintained.

4) Acceleration system

The acceleration pump is provided with the piston fabricated with metal and its arrangement facilitates the maintenance work.

5) Power fuel supply system

The power valve system of this carburetor relies upon the boost and is operated by the air intake pressure generated in the lower part of the throttle valve.

Acceleration system

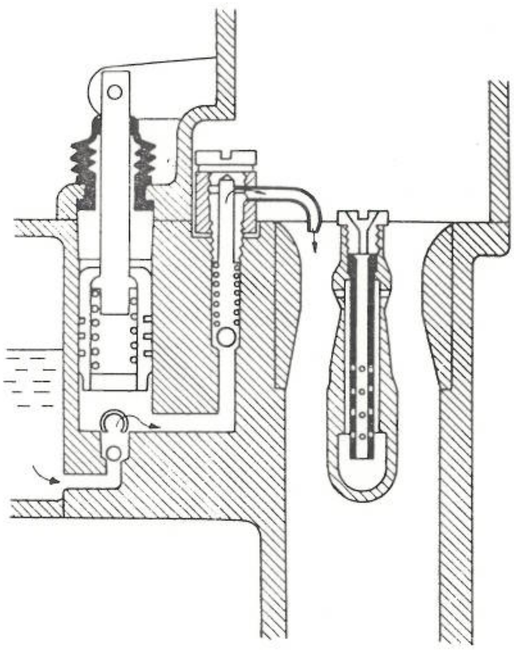
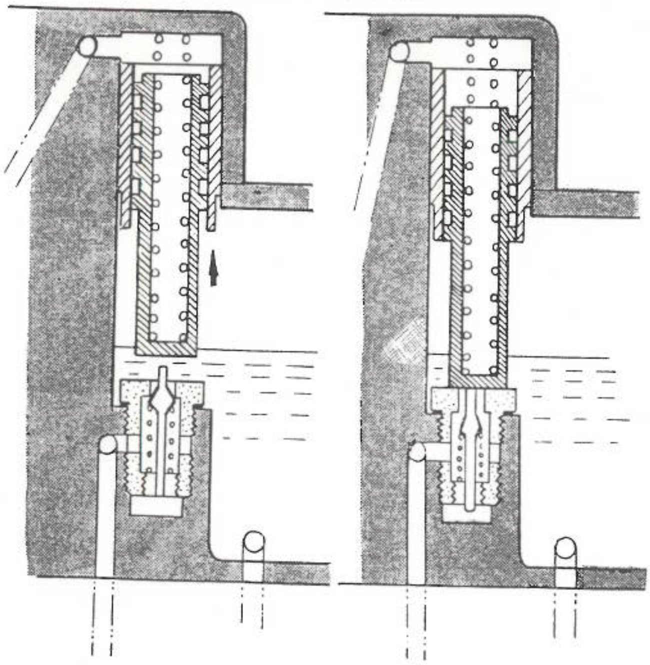


Fig. 8-53

Power system



When Light-load is applied

When heavy-load is applied

Fig. 8-54

When the engine is operated with light load, the throttle valve opening angle is considerably small and hence, strong negative pressure is generated in the lower part of the venturi and the vacuum piston is forced to move upward against the tensile force of the spring while the power valve is held closed.

However, when the engine is operated with heavy load or the engine is accelerated, the throttle valve is held open widely and the negative pressure in the lower part of the venturi is decreased and hence the vacuum piston is forced to move downwardly by the return spring and causes the power valve to open thereby supplying the fuel as necessary.

8-4-3 Dismantling, reassembling and adjusting

1) Float and its associated parts

For adjusting the fuel level, remove the float chamber cover by removing eight (8) fixing screws from the cover and then dismout the float. The fuel level may be controlled by adjusting the float seat. The effective stroke of

Fig. 8-55

the needle valve is standard at 1.5mm. This may be checked by holding the carburetor upside down and lift the float all the way up and see if 1.5mm of clearance is provided between the tip end of the needle valve and the float seat. Adjust the clearance to 1.5mm by adjusting the float stopper as necessary.

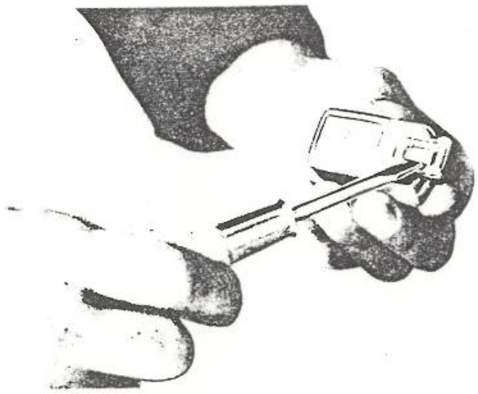


Fig. 8-56

Fig. 8-57

2) Interlocking system

When reassembling the interlocking linkage, the proper adjustment may be easily made by aligning the notched line on the choke connecting rod with the arrow marking on the post of the choke connecting lever.

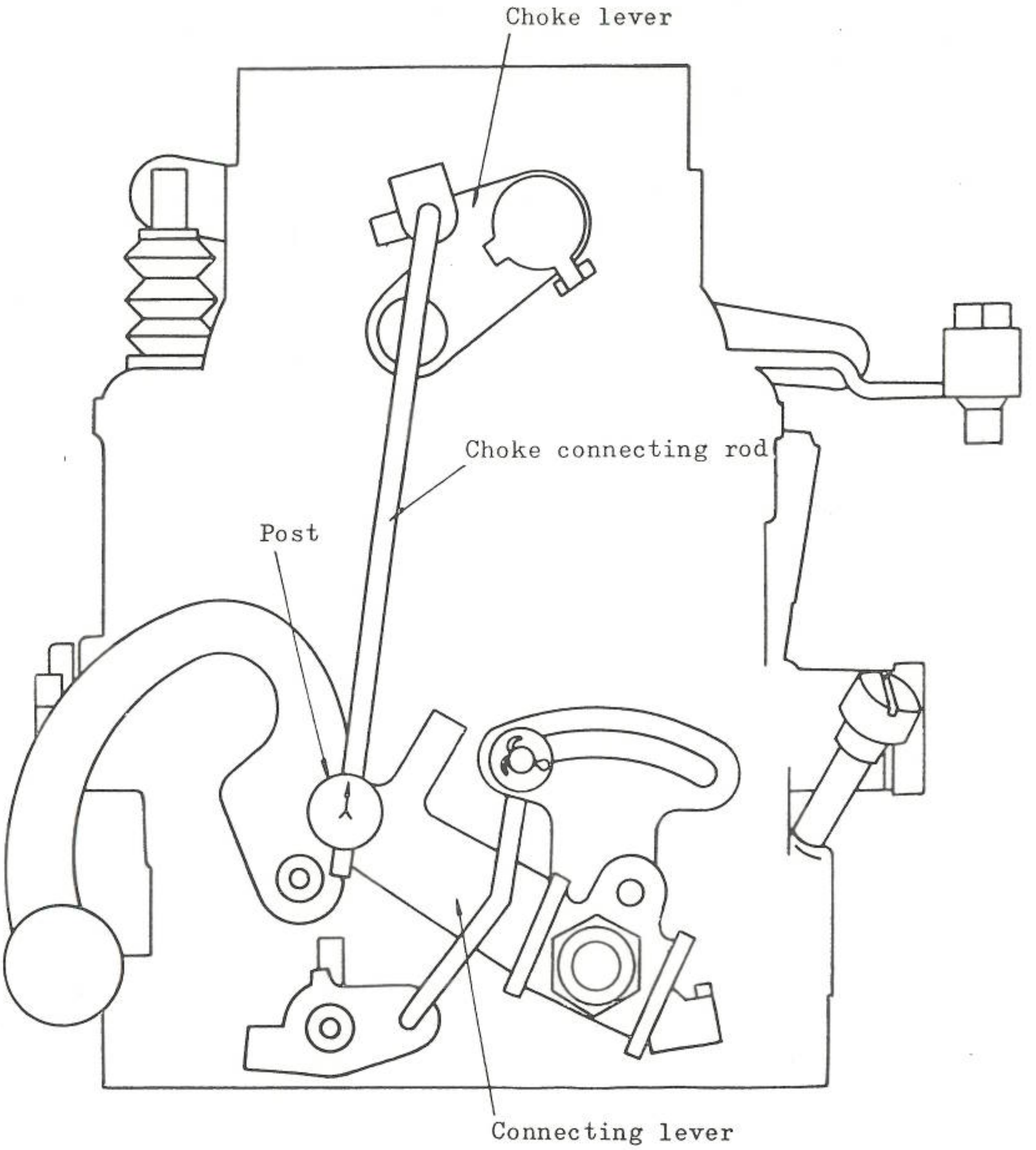


Fig. 8-58

8-5 TROUBLE-SHOOTING CARBURETOR SERIES

To provide for prompt services where the automobile has trouble with the carburetor, the following trouble-shooting and correction procedures should be followed. Engine performance failures may be attributed to various sources of trouble including carburetor failure, but the carburetor is often regarded as the cause of such trouble even when the electrical equipment and fails to work properly and therefore, the electrical equipment should be thoroughly checked before inspecting and adjusting the carburetor performance.

Trouble	Cause	Correction
(1) Overflow	Leaking float	Replace the parts as necessary
	Poor sealing effect of the needle valve to valve seat	Reface the contacting portion of the valve or replace the parts
	Foreign particle on the needle valve	Clean
	Excessive play between the float pin and inserting hole	Rectify or replace
	Excessively high pressure in the fuel pump	Repair the pump as necessary
	Misadjusted fuel level	Readjust
(2) Float chamber is not provided with the fuel	Strainer clogging	Clean or replace
	Trouble in the fuel system except the carburetor	Inspect and rectify as necessary
(3) Engine fails to start	Same as (4)	
	Same as (17)	
	Improper throttle valve opening angle when the choke valve	Adjust
	Excessive clearance between the throttle valve shaft and the boss	Replace

	Operating failure of the secondary throttle valve	Clean and rectify
(4) Poor engine idling performance	Same as (4)	
	Same as (17)	
	Same as (26)	
	Operating failure of the secondary throttle valve	
	Loosely mounted carburetor	Retighten
	Clogged slow jet	Clean
(5) Excessive fuel consumption	Over-flow (Check 1) through 6)	Clean
	Clogged main air bleeds or clogged emulsion tube	
	Enlarged main jet bore	Replace
	Choke valve fails open fully	Readjust
	Excessively advanced power open timing	Readjust
	Poor sealing effect of the outlet valve	Reface the contacting faces of the parts
	Power valve is held open	Clean or replace the parts
(6) Power failure	Same as (4)	
	Same as (44)	
	Clogged main jets	Clean
	Throttle valves do not operate (open) properly	Readjust
	Fuel pump operating failure	Rectify the pump as necessary
	Same as (18)	
	Auxiliary valve operating failure	Clean and adjust
	Clogged air cleaner	Clean or replace

(7) Engine fails to operate smoothly when accelerated	Auxiliary valve is held open	Clean and adjust
	Operating failure of the acceleration pump (Excessively retarted fuel injection timing, insuffi- cient fuel injection, insuffi cient fuel injecting intervals)	Clean and adjust
	Excessive play in the accelera- tion pump linkage	Adjust or replace the parts as necessary
	Operating failure of the intake and outlet valves	Clean or replace
	Poorly adjusted idling	Adjust
	Same as (37)	
	Same as (57)	
(8) Engine fails to operate smoothly at high speed	Same as (57)	
	Plugged power valve	Clean

8-6 JET AND AIR BLEED

As the jet and the air bleed are the most important parts of the carburetor which have direct effects on the engine performance and hence, all the parts incorpo- rated in the carburetor are manu- factured in the most careful man- ner. The jet and the air bleed should be therefore, cleaned carefully with gasoline and dried with compressed air. As the num- ber marking on the jet increases, the size of the bore increases and thus, with increased numbers on the main jet or slow jet, the mixture becomes heavier and with the mark number reduced, the mixture gets thinner. Converse- ly, the main or slow air bleed with larger numbers provide more air and hence, the mixture gets thinner with the main or slow air bleed with increased numbers. In such instance if the jet is replaced with that of different marks, the following should be carefully noted.

For the practical purpose of economizing the fuel consumption even sacrificing the power loss, the main jet or the slow jet with smaller bore or the main air bleed or the slow air bleed with larger bore may be put to use in place of the parts presently used.

For the purpose of improving the engine output regardless of the fuel consumption, the main jet or the slow jet with larger bore and the main air bleed or the slow air bleed with smaller bore may be used in place of the specified parts.

8-7 FUEL PUMP

The fuel pump for the Bellett engine is equipped with a diaphragm and operated on the principle of cam rotation. The rotation of the eccentric cam on the camshaft is shifted into reciprocative motion and transmitted to the diaphragm which serves to intake and deliver the fuel into the carburetor. The diaphragm is specially finished to prohibit the penetration of the fuel. The fuel pump is also equipped with a manually operable lever so that it may be readily operated for feeding the fuel to carburetor when necessary.

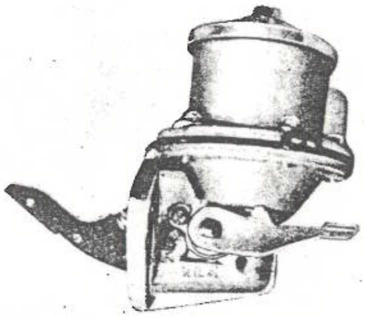


Fig. 8-59

8-7-1 Specifications of the fuel pump

Name of the manufacturer	NIHON KIKAKI
Type	Mechanically operated diaphragm PD-56Q
Parts number	15100-029
Valve closing pressure	0.2 - 0.25kg/cm^2
Maximum amount of delivery	Above 300cm^3/min
Number of cam rotation	1000r.p.m

Construction of the fuel pump

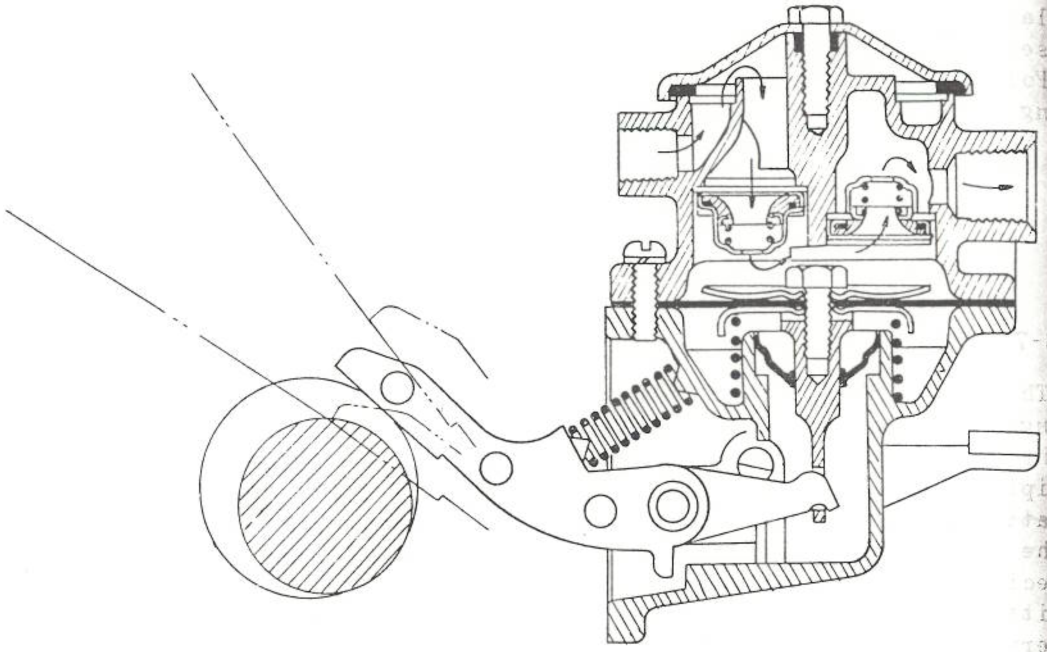


Fig. 8-60

Component parts of the fuel pump

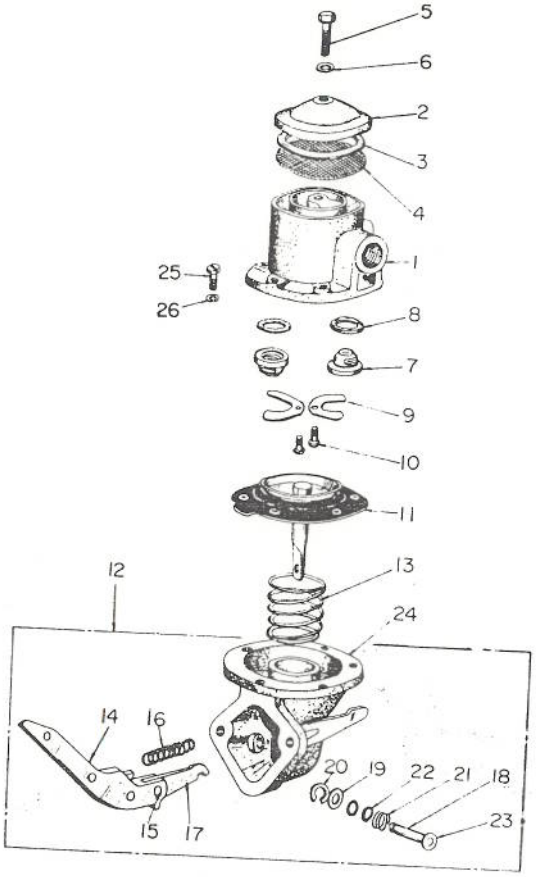


Fig. 8-61

1. Vlave chamber body
2. Valve chamber packing
3. Packing body
4. Strainer screen
5. Bolt and cap set
6. Packing bolt
7. Valve assembly
8. Valve packing
9. Valve retainer
10. Valve retainer screw
11. Diaphragm assembly
12. Rower body assembly
13. Diaphragm spring
14. Rocker arm
15. Rocker arm shaft
16. Return spring
17. Link arm
18. Rocker arm pin
19. Washer
20. Snap ring
21. Spring
22. "O" ring
23. Washer
24. Body
25. Body set screw
26. Spring washer

8-7-2 Removing

1) Remove the inlet and outlet pipe from the pump

2) Remove the fixing bolts and then dismount the pump assembly.

8-7-3 Dismantling

1) Wash the pump with detergent oil and dry it with compressed air before it is dismantled.

2) Remove the valve chamber cap and take out the strainer screen inside.

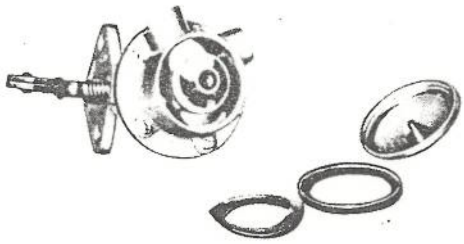


Fig. 8-62

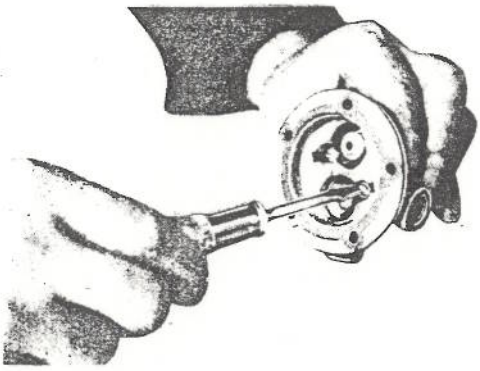


Fig. 8-63

3) Remove the upper body by removing the five (5) fixing screws.

4) Remove the screws from the retainer valve and then remove the valve.

5) Hit the rocker arm shaft lightly with a hide mallet for removing and then, remove the rocker arm, diaphragm, diaphragm spring and return sprin

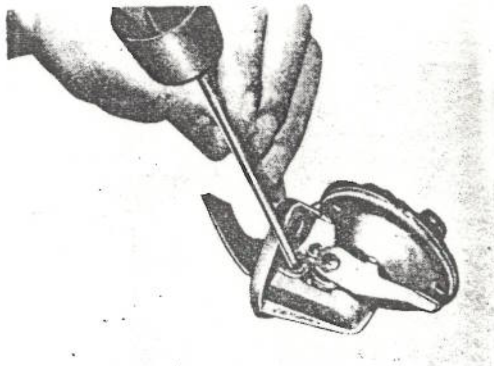


Fig. 8-64

Fig. 8-65

7-4 Insp

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8-7-4 Inspecting

1) Carefully check the cap and body for crack or deformation and body pin hole for wear.

2) Check the diaphragm for breakage and diaphragm push rod hole for wear.

3) Check the operation of the valve and also check the valve spring for weakening or rust accumulation.

4) Check the rocker arm pin for wear.

5) Check the contacting face of the rocker arm to the cam for wear.

6) Check the diaphragm spring for weakened tensile force.

Fig. 8-66

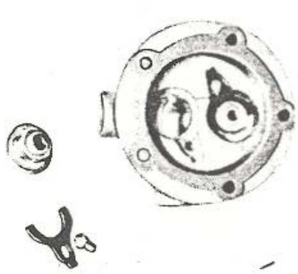


Fig. 8-67

8-7-5 Reassembling and refitting

1) Refit the intake and outlet valve to their respective positions with new gaskets.

2) Refit the diaphragm assembly to its position and press the diaphragm lightly upward and then, put the link arm through the hole on the push rod.

3) Put the rocker arms through the holes on the rocker arm, link arm and the body.

4) Refit the upper body.

5) Refit the strainer screen and then mount the valve chamber cap. The packing should be replaced before the parts are refitted to their positions.

6) All the parts should be fitted to their positions with new gasket attached. The pump should be carefully checked for fuel and oil leakage after it is reassembled.

PART 10 ELECTRICAL SYSTEM

CONTENTS

PART 10 ELECTRICAL SYSTEM

10-1 ALTERNATOR (HITACHI)

The model LT 123-16 is a 3-phase alternator comprises a rotor with the field coil and is not equipped with a commutator. The alternator is provided with a silicone diode which serves to rectify the current generated by the alternator automatically. It has been skillfully designed to provide maximum of service life with the minimum of maintenance. Compactly built alternator readily provides the stabilized charging current in various operating conditions from low-speeds to high-speeds and hence, it is best suited for use in automobiles subjected to stop-and-go operation. Fig. 10-1 illustrates the external view of the alternator model LT 123-16.

LT 123-16 ALTERNATOR AND
TLIZ-08 VOLTAGE REGULATOR

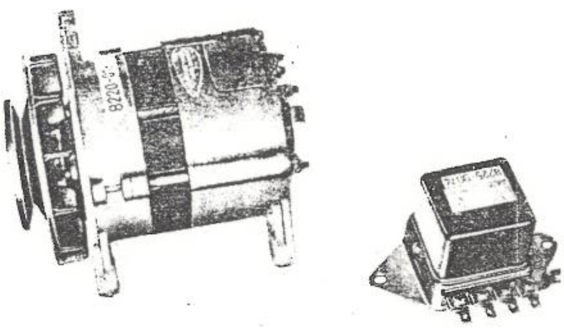


Fig. 10-1

10-1-1 Specifications

The alternator is used in combination with a tirril type voltage regulator, the details of which are given below.

Specifications

Parts name	Type	Battery voltage (V)	Ground polarity	Output	Weight (kg)	Remarks
AC Alternator	LT123-16	12	–	300W	5.3	Clockwise rotation as viewed from the side of the pulley
Voltage regulator	TLIZ-08	12	–	Above 23A	0.5	

Performance

Operating speed (rpm)	Rated rotating speed (rpm)	Non-load voltage (V)	Output current (A)
1,000~12,000	2,500	14 ± 0.5 (at 2,500 rpm)	Above 23 (at 2,500 rpm with the voltage held to 13V)

Note: The output speed characteristic curve is shown in Fig. 10-2.

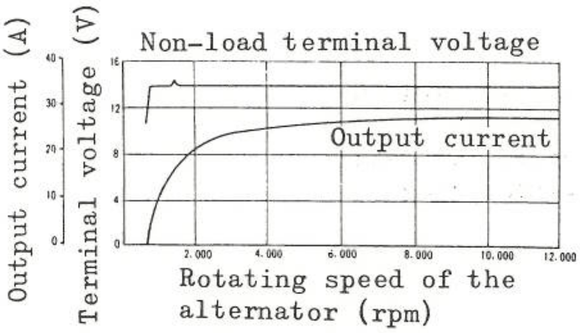


Fig. 10-2

10-1-2 Construction

(1) Alternator

The construction of the alternator model LT 123-16 is illustrated in Fig. 10-6. The alternator comprises a rotor, a stator, a front cover, a rear cover and a pulley. The rear cover is provided with six (6) silicone diodes which serves to rectify the current generator by the alternator to DC.

(2) Voltage regulator

The voltage regulator serves to control the voltage generated by the alternator and holds it in constant irrespective of the travel speed of automobile. The Bellett engine is equipped with a tirril type voltage regulator having a pair of contact points as illustrated in Fig. 10-3. The model TLIZ-08 voltage regulator is provided with a field relay. Figs. 10-3 and 10-4 illustrate the construction of the voltage regulator and field relay, respectively, whilst Fig. 10-5 is showing the appearance of the model TLIZ-08.

Construction of the voltage regulator

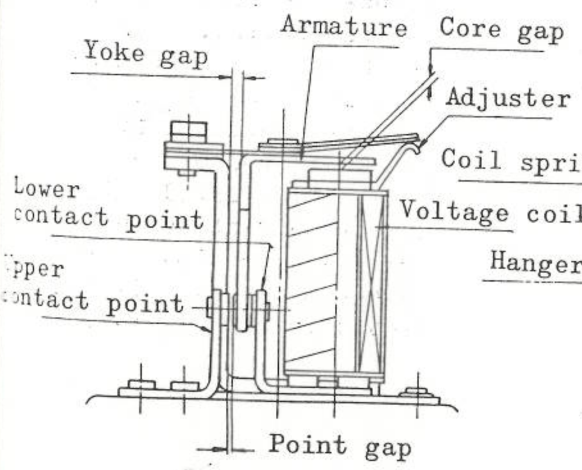


Fig. 10-3

Construction of the field relay

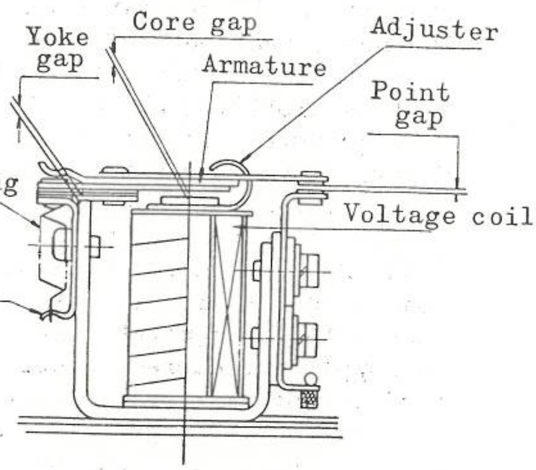


Fig. 10-4

Voltage regulator
model TLIZ-08

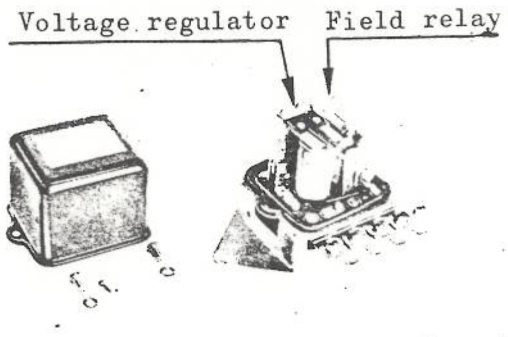


Fig. 10-5

10-1-3 Function and operating principle

(1) Alternator

The operation of the alternator is substantially same to that of the DC generator on the point that both of them serve to charge the battery as well as providing the electrical equipment with power. However, the alternator differs entirely from the DC generator as far as the function and the construction are concerned. As it is well known, the DC generator serves to supply the current generated by the armature to electric circuit through the commutator and carbon brushes, whereas, in the alternator, the magnet is excited through the slip ring and rotated to induce the current in the stator coil held statically around the rotor, the operating principle of which is illustrated in Fig. 10-7.

The conductors C. and C' would on the stator are held statically and the rotor provided with N. and S. is rotated in direction indicated by an arrow marking. As the rotor is turned, the current induced flows through the conductor in a direction indicated by arrow and reaches the battery via the diode. When the rotor is turned half a way, the induced current tends to flow in a counter-clockwise direction as represented by the dotted line in Fig. 10-7-(b) in the conductor, however, it is held from flowing in a reverse direction by the inherent characteristic of the diode and thus, only the rectified current having the waveform of DC current is allowed to reach the battery The theoretical waveform of which is as illustrated in Fig. 10-8-(a), however, the current generated by the 3-phase alternator is practically rectified into the direct current by the six (6) silicone diodes, the waveform of which is illustrated in Fig. 10-8-(b).

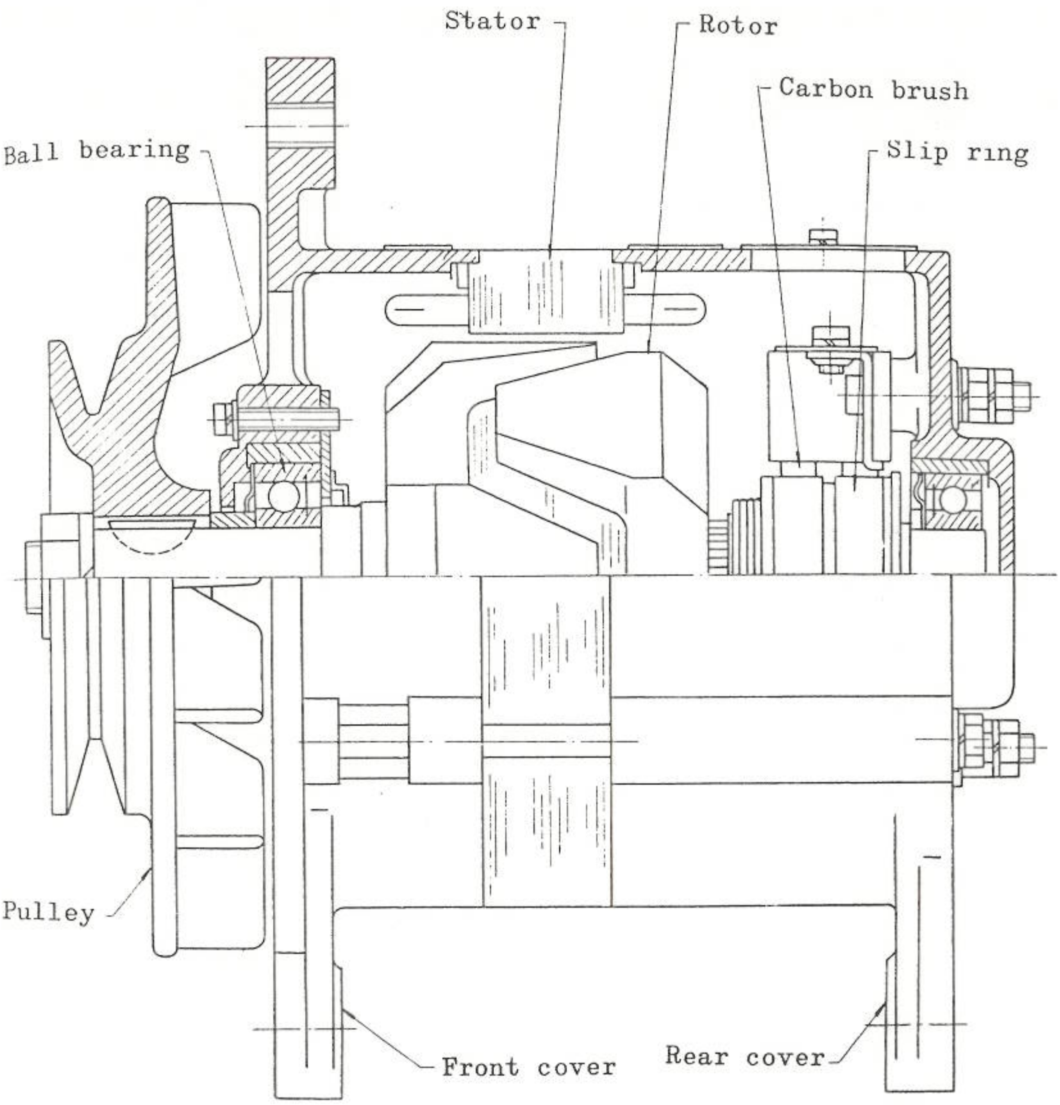

Stator
Rotor
Carbon brush
Slip ring
Ball bearing
Pulley
Front cover
Rear cover

Fig. 10-6

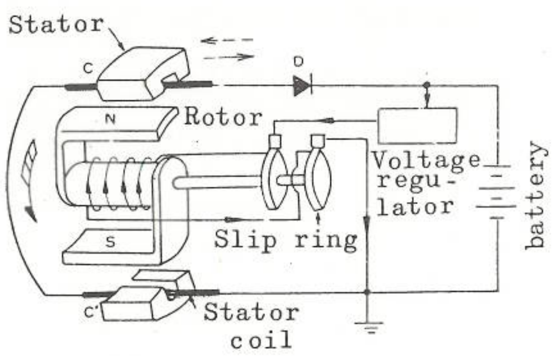


Fig. 10-7

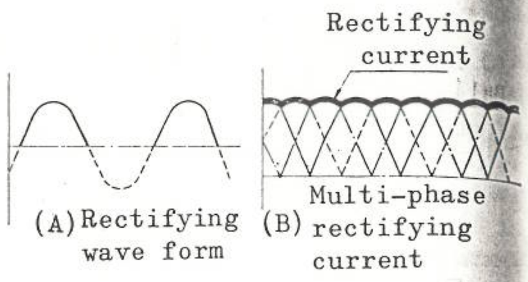
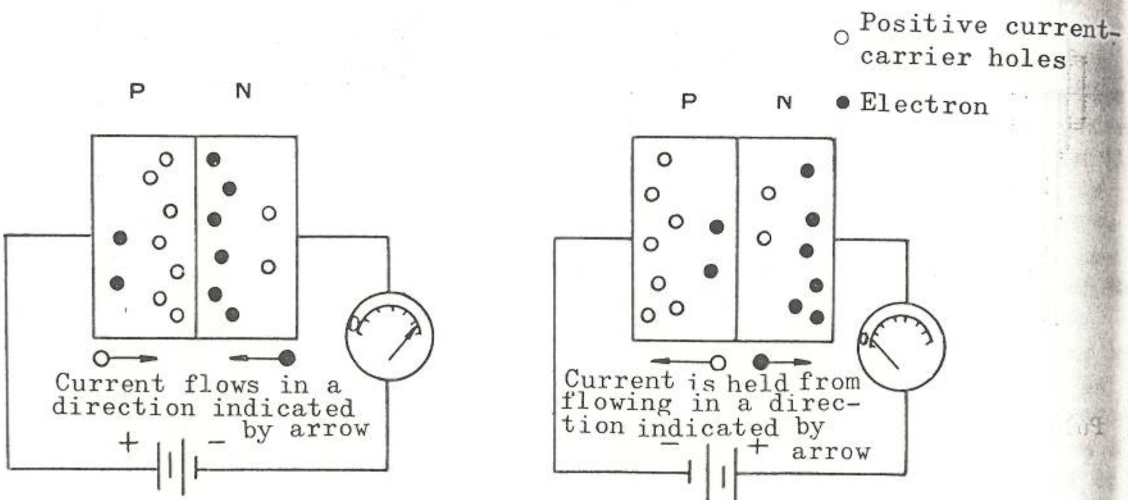


Fig. 10-8



When positive current is applied to P

When negative current is applied to P

Fig. 10-9

(2) Silicone diode

The silicone diode has an inherent characteristic that it permits the current to flow therethrough in a certain direction but blocks the current which tends to flow in reverse direction and thus, it serves as an ordinary cut-out relay. As may be understood from Fig. 10-9, the silicone diode comprises a P-type semi-conductor having positive current-carrier holes and N-type semi-conductor having negative current-carrier electrons.

When positive current is applied to P and negative current to N as illustrated in Fig. 10-9-(a), the positive current-carrier holes and the electrons flow in a direction indicated by arrow and gather around the junction between P and N and facilitate flow of current.

Conversely, if negative current and positive current are applied to P and N side, respectively, positive current carriers are drawn toward the negative current whilst the electrons are drawn toward the positive current and thus the resistance in the junction is increased and flow of current is restricted. Conductivity of the silicone diodes are identified with color marking as illustrated in Fig. 10-10.

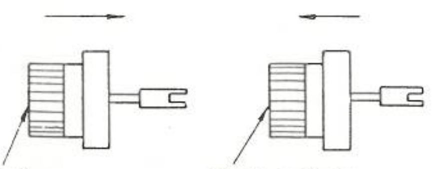


Fig. 10-10

(3) Voltage regulator

The voltage regulator comprises a rotor coil (field coil) having a resistance RF inserted in series thereto through a contact which serves to cut-in and out the resistance RF for controlling the current in the rotor coil thereby holding the regulator voltage in constant. The operating principle of the voltage regulator is illustrated in Fig. 10-11.

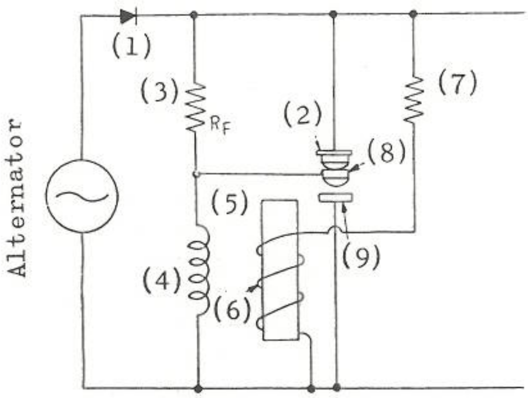


Fig. 10-11

(1) - Silicone diode
(2) - Lower contact
(3) - Rotor (field) coil
(4) - Inserted resistance (rotor field coil)
(5) - Magnet
(6) - Voltage coil
(7) - Compensating resistance
(8) - Moving contact
(9) - Upper contact

1) When the voltage in the generator increases beyond the rated voltage, the force of the magnet in the regulator overcomes the tensile force of the spring and attract the armature as the voltage coil in the voltage regulator is provided with

the current proportional to the voltage generated by the generator. When the armature is attracted by the magnet, the moving contact releases from the lower contact thereby inserting the resistance RF into the rotor coil (field coil) in the generator circuit and thus, the current flown into the rotor coil is minimized resulting in a reduction of the voltage in the generator.

As the voltage generated by the generator becomes lower than rated voltage, the current in the voltage coil reduces with the reduction in the attracting force of the magnet. Thus, the armature is released from the magnet by the tensile force of the return spring and brings the moving contact into engagement with the lower contact. Then, the resistance RF is short-circuitted with the result of increased current in the rotor coil and the voltage in the generator being allowed to increase. When the rotation of the generator is not sufficiently high or it is subjected to excess load, this operation is automatically repeated to hold the voltage constant.

2) When the rotation of the generator further increases, the voltage is allowed to increase irrespective of the resistance RF inserted as the capacity of the resistance is considerably small. Thus, the current in the voltage coil also increases and strongly attracts the armature and closes the moving contact and upper contact. Thence, the rotor coil is short-circuitted and the voltage in the generator circuit is reduced. When the generator is rotated at high speeds, this operation is repeated to hold the voltage from being increased.

3) Field relay

The field relay serves to minimize the current flown into the rotor coil when the ignition key is held turned on whilst the engine operation is stopped. As the contact points of the field relay are held open whilst the generator is not operated, the rotor coil is provided with the field resistance connected in series and thence, the current flown into the rotor coil is held to a minimum. When the voltage generated by the generator reaches as high as 4-6V when measured at N terminal, the field relay points are held closed putting the rotor coil circuit back into normal operating condition.

10-1-4 Connection

The internal connections of the generator, regulator and their associated parts are illustrated in Fig. 10-12 while the method of connection for adjustment is illustrated in Fig. 10-13. All the terminals should be tightly fastened to their corresponding leads noting their marks.

Connections (for generator model LT123-16)

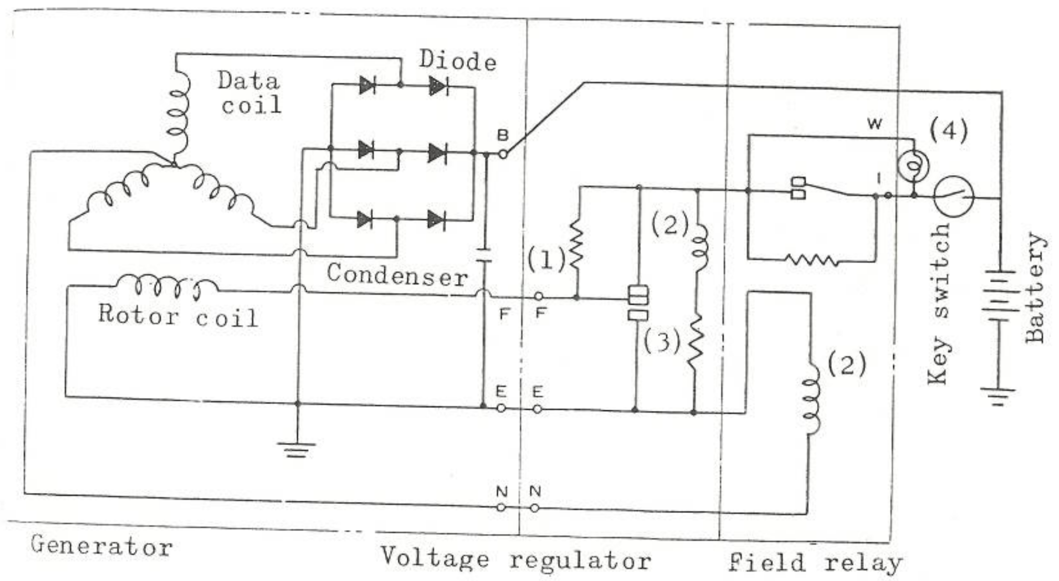


Fig. 10-12

(1) - Rotor coil inserting resistance
(2) - Voltage coil
(3) - Compensating resistance
(4) - Charge warning lamp

10-1-5 Adjusting method

(1) Voltage regulator

The voltage regulator should be adjusted in the following manner with the aid of DC voltmeter, ammeter and tachometer.

1) Dismantle the regulator from the automobile and check the contact points for fouling. The contaminated contact points may be cleaned and rectified with use of fine abrasive paper.

Connections for adjustment
(for model TLIZ-08)

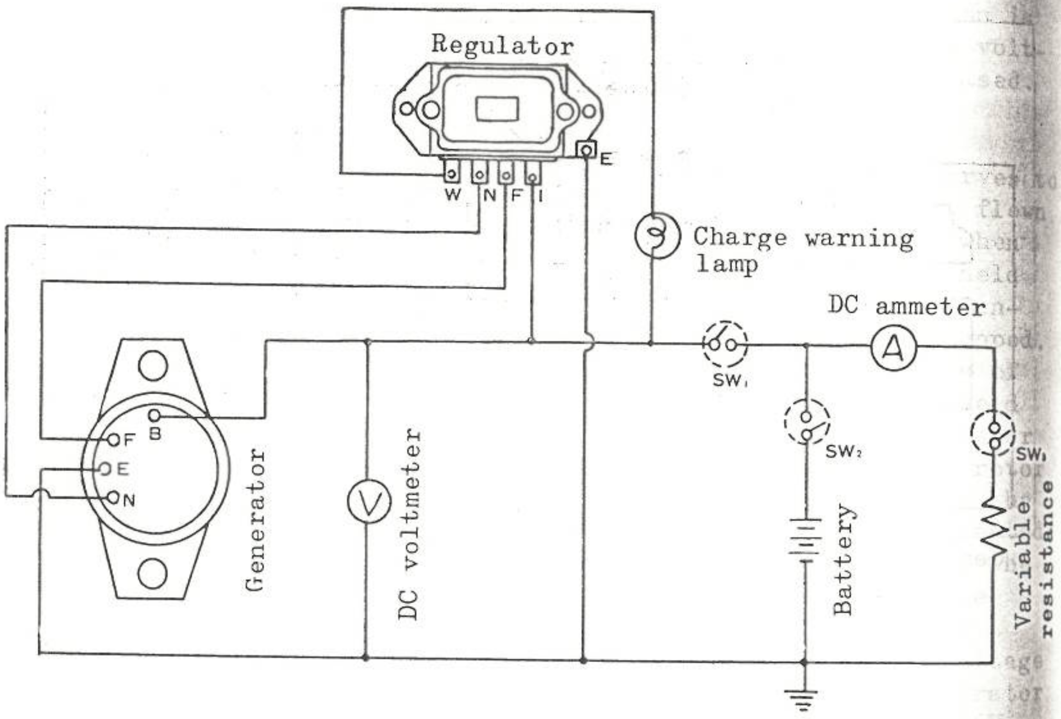


Fig. 10-13

2) Check the point gaps and if necessary adjust them according to "maintenance Standard" (See Figs. 10-14 through 10-16). The adjustment should be made in the sequence of Yoke gap, core cap and point gap.

Measuring the yoke gap

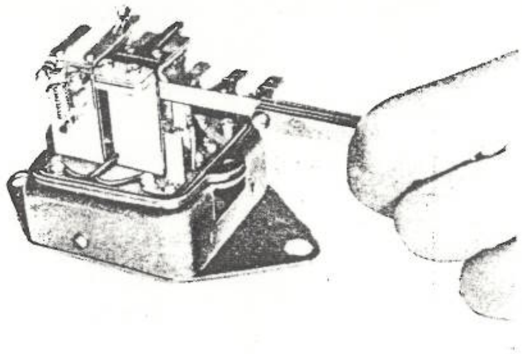


Fig. 10-14

Adjusting the core gap

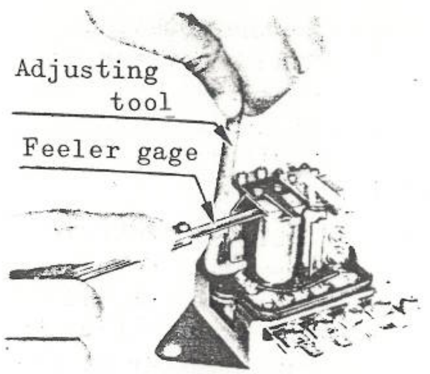


Fig. 10-15

3) Make the necessary connections as illustrated in Fig. 10-13 upon completion of the adjustment of gaps.

4) For adjusting the non-load voltage, turn-on the switches SW1 and SW2 and then apply exciting current to the rotor coil in the generator from the battery and increase the rotation of the generator. Cut-off the switch SW1 when the rotation of the generator increases as high as about 1,000 rpm. (Also cut-off the switches SW2 and SW3).

Note: For DC generator, the output voltage increases with the increase in the rotating speed of the generator but, for alternator, the voltage fails to increase as rated unless the rotor coil is initially excited by the

Adjusting the contact point gap

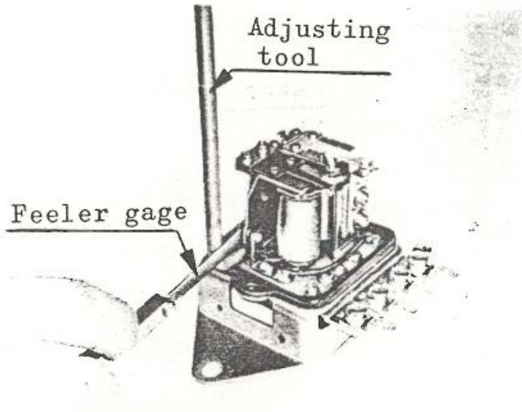


Fig. 10-16

current supplied from the battery. When the generator is once brought into a stop and again operated, the switch SW1 should be turned-on and turned-off after the generator started generating the rated current, then check the non-load voltage.

5) Increase the rotating speed of the generator as high as specified and then adjust the non-load voltage by adjusting the regulator.

6) If the non-load voltage fails to meet the rated value which is 13.5V, adjust it to hold rated voltage by bending the adjuster upward.

7) If the non-load voltage is in excess of rated voltage of 14.5V, bring it down to rated level by bending the adjuster downward. (See Fig. 10-17)

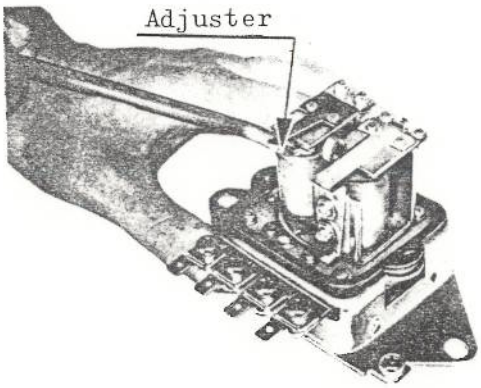


Fig. 10-17

8) The above adjustments will suffice the necessary adjustment required on the voltage regulator, but to make sure that it is properly adjusted, bring the generator to a full stop and again operate it at rated speed and check to see if the output voltage comes within the rated value.

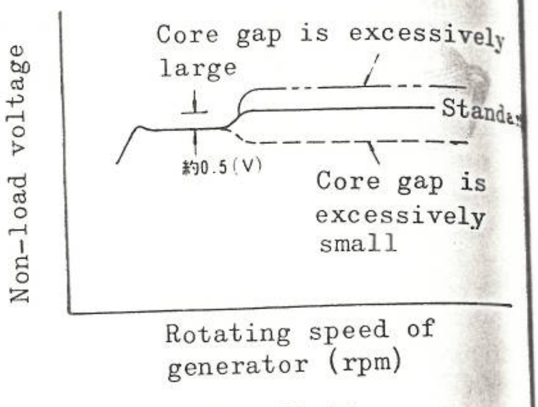


Fig. 10-18

9) When the generator is properly adjusted, the output voltage becomes as illustrated in Fig. 10-18.

The output voltage tends to vary when the rotating speed of the generator increases and the operation of the contact is shifted from lower contact to upper but this is not detrimental to normal charging operation. The adjustment should preferably be made in such a manner that the output voltage increases by some 0.5V when the rotating speed of the generator is increased.

10) If the output voltage increases beyond 0.5V or tends to drop when the generator rotating speed is

increased recheck and adjust the core gap. Excessively large core gap will result in undue increase in the output voltage and excessively small core gap leads to voltage drop.

(2) Field relay

1) Check and adjust the gap with reference to subparagraph (1)-1) and 2).

2) Apply voltage to the regulator terminals N and E, and check the armature attracting voltage.

3) If the armature attracting voltage is maladjusted, readjust it by adjusting the tension of the coil spring as illustrated in Fig. 10-19.

Adjusting the armature attracting voltage of the field relay

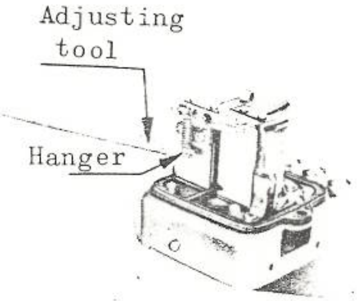


Fig. 10-19

10-1-6 Cautions for handling

As the alternator comprises silicone diode, the following should be carefully noted.

(1) The alternator should never be connected to the wrong polarity of the battery. If the alternator is connected to the battery with the leads fastened to wrong polarity, the battery is short-circuitted by the silicone diodes allowing excessive current to flow through the alternator and results in damaged silicone diode and burnt-down wire harnesses.

Alternators for use in automobile with positive polarity connected to ground is provided with the silicone diode having the polarity differs from those installed in the alternators for use in automobile with the negative polarity connected to ground and hence, the alternator provided with identification plate in which the positive polarity connected to ground is specified should be prepared for use in automobile with positive polarity connected to ground.

(2) The terminals should be properly connected to their corresponding leads.

(3) Avoid rotating the alternator at high speed with the terminal B disconnected, as the silicone diodes may be damaged by the high tension generated by the alternator.

(4) Disconnect the terminal B from the alternator, before the battery is connected to the battery charger for recharging.

10-1-7 Inspecting

(1) The alternator should be mounted securely in position with the nuts and bolts. The fan belt tension should be properly adjusted to give extended service life to the fan belt and the ball bearing in the alternator. When the fan belt gives lateral deflection of about 20mm on its longest portion when depressed by the finger, the fan belt tension may be regarded as normal.

(2) Check the carbon brush in the brush holder for operating failure and fouling after every 6,000 km of travel distance and make necessary cleaning or rectification. The slip ring should also be checked and cleaned after every 6,000 km of travel.

(3) Check the regulator for non-load voltage after every 12,000 km of travel distance and adjust it in the manner introduced in the foregoing paragraph if the voltage is less than 13.5V.

(4) The alternator is provided with ball bearing which does not often require lubrication. It is recommended that the ball bearings should be checked after every 24,000 km of travel distance and replenished with "HITACHI generator grease" if necessary.

(5) Wear of the carbon brushes is considerably small when compared with ordinary DC generator but they should be regarded due for replacement if their length is less than 6.5mm.

(6) Failure of the silicone diode may be checked in the following manner. Disconnect the lead from the stator coil in the alternator from the silicone diode and check the conductivity of the silicone diode both in positive and negative direction with use of a tester. If the test results show that the diode has good conductivity in the positive direction, the diode may be regarded as normal.

Note: The use of Megger should be definitely avoided for the silicone diode is susceptible to damage due to high voltage developed by the tester.

The conduction test of diode

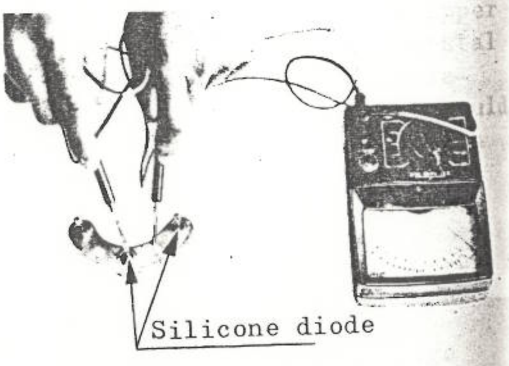


Fig.10-20

(7) The rotor coil should be checked for insulation. The tester may be connected between the slip ring and the shaft or the core to see if conduction takes place. If so, it is that the slip ring or the coil is grounded. (See Fig. 10-21) If conduction does not takes place between two slip rings, the coil is disconnected. For its resistance, refer the paragraph "Maintenance Standard".

The earth test of rotor coil

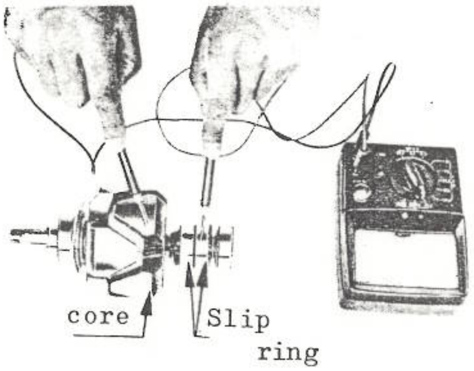


Fig. 10-21

(8) The stator coil should be checked for proper connection. Conduction test may be made between the stator coil and the core, and if conduction takes place, the coil is grounded. If the conduction does not takes place between the three terminals, the trouble may be regarded to disconnection.

(9) If the capacity gage is not available, the condenser may be tested in the following manner. Shift the dial on the tester to the range for measuring large capacity and check the gage pointer. If the pointer of the tester deflects and gradually moves to the extreme and of the division in which the capacity increases to maximum, the condenser may be regarded as normal. If the pointer is held deflecting or held still, the condenser should be replaced.

10-1-8 Dismantling and reassembling

The alternator should be disassembled in the following manner.

Removing the pulley

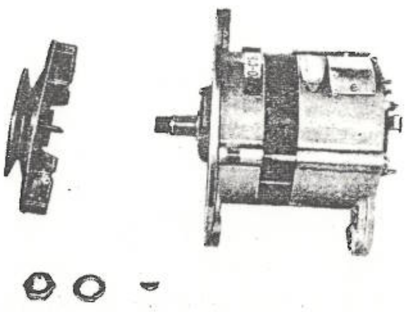


Fig. 10-22

(1) Remove the pulley clamping nut and then remove the pulley. Remove the brush cover on the rear cover and take out the brush. (See Fig. 10-22)

(2) Remove the through bolts and then remove the front cover. (See Fig. 10-23)

Removing the front cover

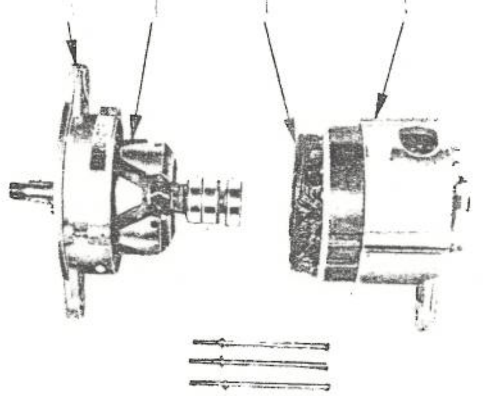


Fig. 10-23

(3) Remove the bearing retainer nut from the front cover and then, remove the rotor. (See Fig. 10-24)

(4) Disconnect the wiring between the stator coil and the silicone diode and then remove the stator and rear cover (See Fig. 10-26)

Removing the rotor

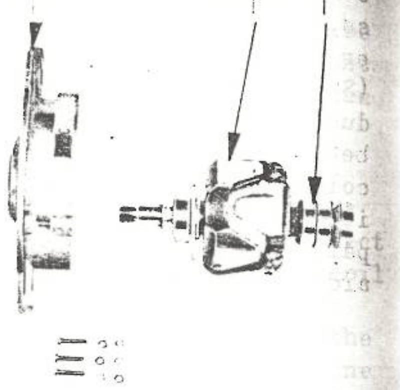


Fig. 10-24

Removing the stator

Fig. 10-25

(5) The alternator may be reassembled in the sequence converse to dismantling.

Operation of the carbon brushes and thrust on the rotor should be carefully checked before the component parts are put together.

Parts of the alternator as dismantled

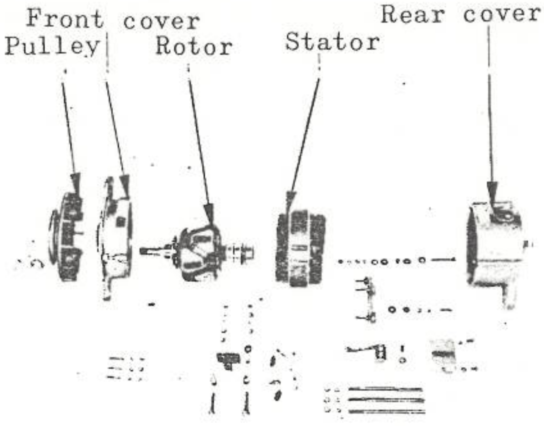


Fig. 10-26

10-1-9 Standards for correction and repair

(1) Alternator

All the values are given in the metric system

Carbon brush		Standard height Limit of reduction in height	14.5 5
Brush spring		Standard tensile strength (kg)	0.3
Shaft	Front side	Standard measurement of bearing	17ø 6203ZN
	Rear side	Standard measurement of bearing	15ø 6202ZN
Rotor coil (field coil) resistance value (ohm)			5.2 (at 20°C)
Stator coil resistance value (single phase)			0.17 (at 20°C)

(2) Regulator	All the values are given in the metric system
Yoke gap	0.9~1.0
Core gap	0.8~1.2
Point gap	0.4~0.5
Voltage coil resistance (ohm)	9.9 (at 20°C)
Rotor coil (field coil inserting resistance) (ohm)	10
Compensating resistance (ohm)	25

(3) Field relay	All the values are given in the metric system
Yoke gap	0.2
Core gap	0.5~0.6
Point gap	0.4~0.5
Attracting voltage (V)	4 6 (Terminal A)
Field resistance (ohm)	18
Voltage coil resistance (ohm)	21.7 (at 20°C)

10-1-10 Alternator trouble-shooting

(1) Charging current is not generated

Trouble	Cause	Correction
Wiring and ammeter	Disconnection, short-circuitted or loosened connection	Rectify or replace
Generator (Alternator)	1. Coils disconnected, short-circuitted or grounded	Replace
	2. Terminal short-circuitted	Rectify
	3. Faulty silicone diode	Replace
	4. Faulty condenser	Replace
Regulator	1. Short-circuitted or disconnected lead wire	Rectify or replace
	2. Non-load voltage is lower than rated voltage	Readjust

:) Battery is discharging due to insufficient charging

Trouble	Cause	Correction
Wiring	Loosened joint or short-circuitted wiring	Rectify or retighten
Alternator	1. Short-circuitted rotor coil layer (Check conductivity by making conduction test with a tester)	Replace
	2. Short-circuitted stator coil layer	Replace
	3. Disconnected stator coil phase (primary phase)	Replace
	4. Slip ring fouling	Clean or replace and rectify by grinding
	5. Poorly contacted carbon brush	Rectify
	6. Silicone diode failure	Replace
Regulator	1. No-load voltage is lower than rated voltage	Readjust
	2. Contact point fouling or foreign particle deposit	Clean or regrind
	3. Short-circuitted coil or condenser	Replace
Battery	1. Insufficient battery electrolyte	Top-up with distilled water
	2. Faulty plates	Replace

(3) Over-charging

Trouble	Cause	Correction
Wiring	Alternator operate as "shunt generator" due to B and F terminal circuit short-circuitted	Rectify
Battery	Short-circuit in cell	Replace
Voltage regulator	1. Abnormally elevated non-load voltage	Rectify
	2. Poorly grounded regulator	Properly connect it to ground
	3. Disconnected field coil	Repair or replace
	4. Field relay points fails to close. Attracting voltage is excessively high	Readjust

(4) Irregular charging current

Trouble	Cause	Correction
Wiring	Named wire causes short-circuit due to travel shock, or disconnected wire sometimes comes in contact on account of vibration	Replace or rectify
Alternator	1. Short-circuitted layer (Primary state of short-circuitting between layers)	Replace
	2. Worn or broken brush spring	Replace
	3. Slip ring fouling	Replace
Regulator	1. Disconnected coil	Rectify or replace
	2. Disordered adjusting voltage	Readjust
	3. Ignition switch failure	Replace
	4. Contact points fouling	Clean

10-1-11 Parts numbers

Serial numbers for major component parts are given below

(1) Alternator

Parts name	Parts number
Rotor assembly	LT123-2100
Stator assembly	L 123-2200
Rear cover assembly	L123I-1300
SR holder assembly	L123B-1303
Brush assembly	L 123-1326
Front cover	L 123-1401
Pulley	L123I-1501

(2) Regulator

Parts name	Parts number
Voltage regulator coil	TL131-1100
Voltage regulator yoke	T 111-1200
Voltage regulator armature	T115H-1300
Lower regulator contact	T115H-1601
Upper regulator contact	T115H-1602
Field relay coil	TL131-1101
Field relay yoke	TL115-1201
Field relay armature	TL131-1301
Field relay contact	TL115-1802
Base Assembly	TL1Z-4600

10-1-12 Interchangeability of the parts

Alternator model LT 123-16 has no other parts available which can be interchanged with the parts of this alternator.

The regulator model TLIZ-08 is same in specification and dimension to the regulator model TL 131-05.

10-2 STARTER (HITACHI)

10-2-1 Specifications

Model		S114-54
Voltage		12
Output (KW)		1.0
Weight (kg)		4.8
Direction of rotation as viewed from the pinion side		right
Pinion	D P	10/12
	Pressure angle (°)	20
	Number of teeth	9
	Pitch diameter (mm)	22.86ϕ
	Tooth tip diameter (mm)	29.6ϕ
	Amount of shift	1.27
	Hardness (RC)	52 56

Performance

Performance	No-load	Terminal voltage (V)	12
		Current (A)	below 40
		Revolution (rpm)	Above 7,000
	Load	Terminal voltage (V)	6.3
		Current (A)	below 420
		Torque (m-kg)	Above 1.0
Pinion sliding-out voltage			8
Dumper			2-stages

Starter

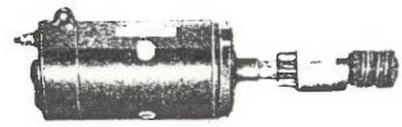


Fig. 10-27

Hold the brush lifted

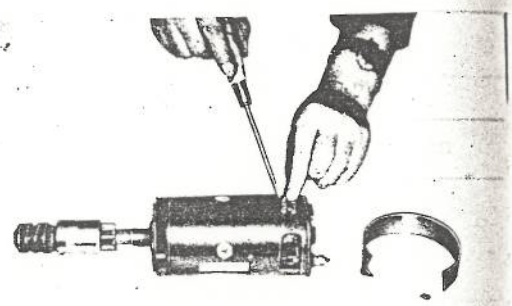


Fig. 10-28

10-2-2 Dismantling

The starter should be dismantled in the following sequence.

(1) Remove the brush cover and hold the carbon brushes lifted to prevent them from

being damaged while the starter is dismantled.

(2) Pull out the split pin as illustrated in Fig. 10-29 and remove the spring stopper nut and then dismount the pinion assembly.

Removing the pinion assembly

Fig. 10-29

(3) The pinion assembly should be dismantled after the clip is removed. Fig. 10-30 illustrates the pinion assembly as dismantled.

(4) Pull out the through bolts and remove the front cover and armature assembly.

(5) Remove the carbon brushes and nut clamping the terminal screw. Then the rear cover assembly and yoke assembly can be dismantled as illustrated in Fig. 10-31.

Pinion as dismantled

Fig. 10-30

Removing the rear cover

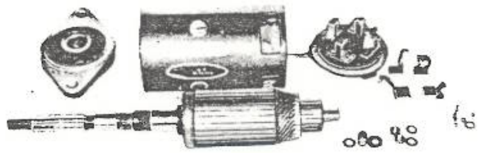


Fig. 10-31

10-2-3 Inspecting and repairing

(1) Testing the armature for short-circuit

Mount the armature on the tester and hold a piece of hacksaw blade right against the armature and then turn the armature with finger.

If the armature is short-circuitted, the hacksaw is either magnetized or vibrates. Replace the armature as necessary. (Fig. 10-32)

Testing the armature for short-circuit

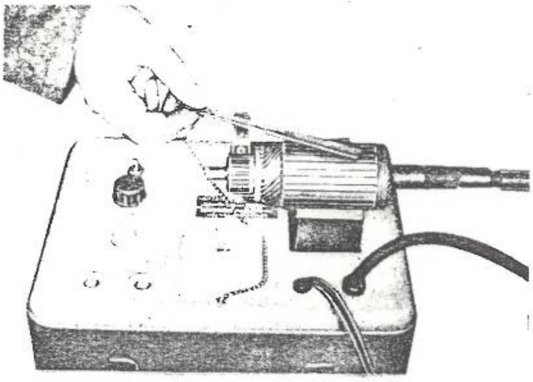


Fig. 10-32

(2) Testing the armature coil for grounding

Mount the armature on the tester and check to see if conduction takes place between the commutator and core. The pilot lamp on the tester lights as the conduction takes place. Rectify or replace the armature is faulty. (See Fig. 10-33)

(3) Checking the armature coil for disconnection

Mount the armature on the tester, and measure the current induced in the coils with use of ammeter. If the induced current tends to

Testing the armature coil for grounding

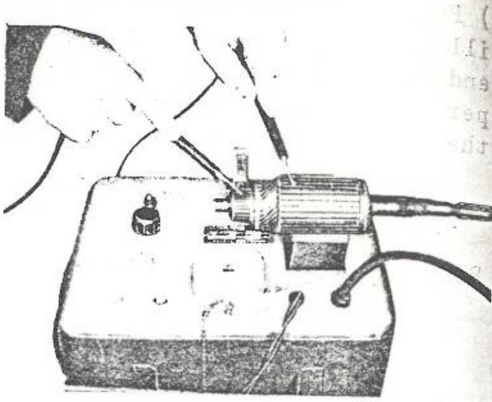


Fig. 10-33

decrease suddenly when the test nozzle comes to a certain point on the armature, the trouble may be regarded as attributed to poor conduction, short-circuitted or disconnected. In such instance, the armature should be rectified or replaced. (See Fig. 10-34)

Checking the armature coil for disconnection

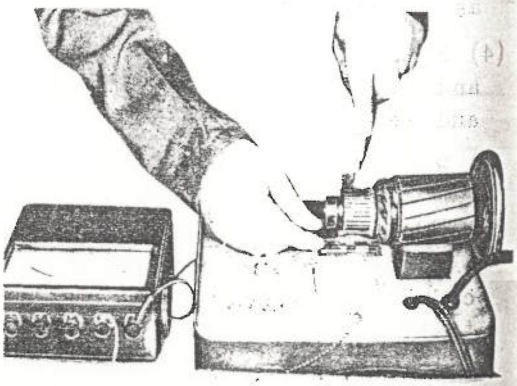


Fig. 10-34

(4) Field coil

1) Test the field coil for grounding

If conduction takes place between one end of the field coil and yoke, check the coil for grounding and rectify as necessary.

Testing the field coil for grounding

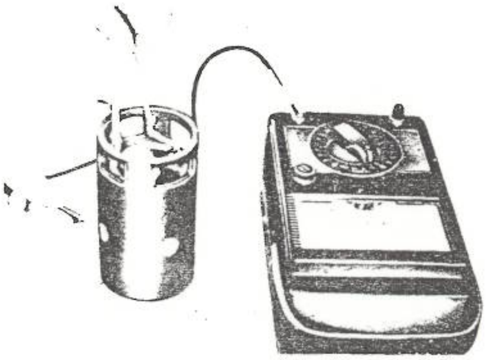


Fig. 10-35

Checking the armature shaft for bending

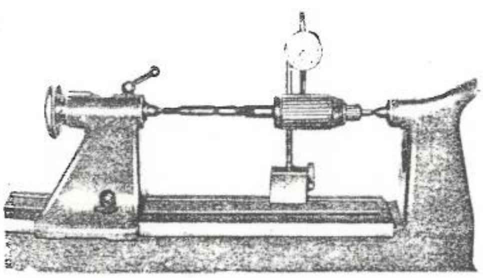


Fig. 10-36

(5) Armature shaft

Hold the both ends of the armature in a suitable support, check the shaft for distortion or bending with the aid of a dial gage. Rectify with a press machine if the bending is in excess of 0.08.

(6) Commutator

If the deflected wear of the commutator is in excess of 0.4mm, or reduction in the depth of mica is in excess of 0.2mm, the commutator should be regarded as due for correction or repair. Allowable reduction in the outside diameter of the commutator is 2mm. Fouling or foreign particle deposit on the commutator may be removed and cleaned with fine abrasive paper by turning the commutator with fingers.

(7) Brush

1) Replace the carbon brush if it becomes shorter than 9.5mm. (The original length is standard at 14mm)

2) Measuring the tensile strength of the brush spring

Measure the tensile strength of the brush spring with use of spring tension tester. The tensile strength is normal at 0.8kg. (See Fig. 10-37)

Measuring the tensile strength of the brush spring

Fig. 10-37

10-2-4 Lubrication

(1) Front and rear cover are provided with oilless bearings. Lubricate the front cover bearing, sliding part of the pinion and rear cover bearing with spindle oil. Grease the rear cover bearing preferably with HITACHI motor grease or MARUZEN No. 29 grease. Apply engine oil 10W-30W to the sliding part of the pinion and helical spline at the time of dismantling or reassembling.

10-2-5 Starter troubleshooting

As the operation of the starter relies upon the power of the battery, the trouble may be classified into the following.

1) Charging operation failure

2) Disconnected wiring

3) Loosened terminal connections

4) Starter failure

5) Starter switch and starter relay failure

10-2-6 Inspecting the starter as mounted in position

(1) Turn on the head-lights or room lamp and turn the starter switch to see if starter fails to operate and the power of the head-lights or room lamp tends to drop temporarily. This indicates that the current is supplied to the starter. In the event of such trouble, check the battery failure (measuring the specific gravity of the electrolyte) and wiring for loosened connections. If the battery and the wiring are free of trouble, the starter may be regarded as source of trouble.

(2) If the power of the head-lights or the room lamp fail to drop as the starter switch is turned, it may be understood that the current is not supplied to the starter. In the event of such failure, check the starter switch for operating failure and wiring for loosened connection. If the starter switch is free

of trouble, hold the starter switch turned and check the starter circuit commencing with the part close to the battery. The trouble spot may be detected as the voltmeter fails to indicate the current when the voltmeter lead is brought into contact with the wiring with trouble. If the starter switch and the wiring are free of trouble, dismantle the starter motor and check for failure.

10-2-7 Inspecting the starter after dismounted

(1) Turn the pinion with finger to see if it operates smoothly.

(2) Mount the starter on the bench and connect it to 12V-battery, and then apply the rotary current to make sure that it operate smoothly at the speed of above 7,000 r.p.m., at which time the current should be held less than 40A.

10-2-8 Trouble-shooting

(1) Pinion fails to come into engagement with the ring gear when the ignition switch is turned on.

Trouble	Cause	Correction
Wiring	Disconnected battery connection or loosened switch terminals	Retighten or rectify
Starter switch	Current fails to flow due to poor contact	Rectify or replace the parts
Starter	Foreign particle deposit on the sliding portion of the pinion on the armature shaft or the operation of the pinion is restricted due to lack of lubricant	Clean or lubricate

(2) The starter fails to stop when the starter switch is turned-off after the engine is started.

Trouble	Cause	Correction
Starter switch	Current still flows after the switch is turned-off	Rectify or re-place the parts
Magnetic switch	Contactor is decentralized and held in contact with the corresponding contacting piece	Rectify or replace

10-2-9 Maintenance standard

The maintenance standard and the standard measurements are given below

(All the numerical values are presented in metric system)

Carbon brush		Standard height	14
		Limit of reduction in height	4.5
Brush spring		Standard tensile strength (kg)	0.8
Commutator	Outside diameter	Standard measurement	23ø
		Limit of reduction	2
	Difference between maximum and minimum diameter	Correction limit	0.4
		Correction accuracy	0.05
	Depth of insulating mica	Correction limit	0.2
		Correction accuracy	0.5~0.8
Clearance between the shaft and bearing		Correction limit	0.2
		Correction accuracy	0.03~0.1
Limit of reduction in shaft diameter			0.1
Limit of correcting the bending of the shaft			0.08

Brush side	Outside diameter of the shaft	11.5ø e7
	Inside diameter of the bore	$11.5\phi^{+0.021}_{0}$
Pinion side	Diameter of the shaft	$20\phi^{+0.021}_{0}$
	Diameter of the bore	$20\phi^{+0.025}_{0}$
Sliding portion of the pinion	Outside diameter of the shaft	$16\phi^{-0.100}_{-0.111}$
	Inside diameter	16ø H7

Component part of the starter

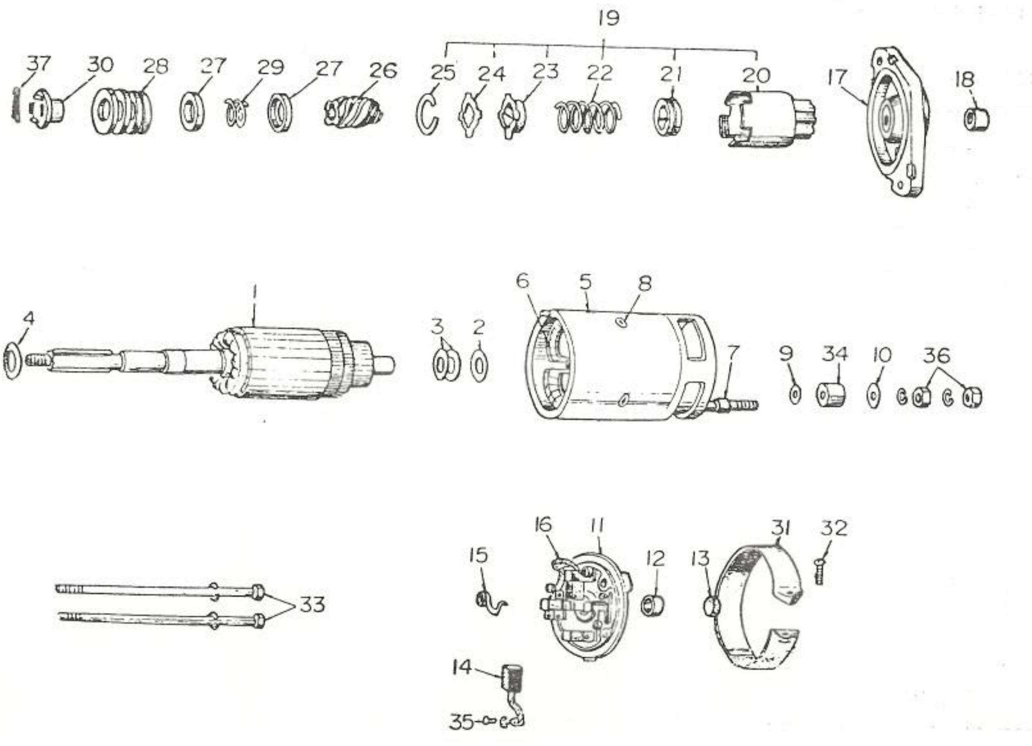


Fig. 10-38

(1) - Armature assembly
(2) - Thrust washer
(3) - Thrust washer
(4) - Thrust washer
(5) - Yoke assembly
(6) - Field coil assembly
(7) - Terminal screw
(8) - Pole core set screw
(9) - Washer
(10) - Washer
(11) - Rear cover assembly
(12) - Gear case metal
(13) - Bearing cover
(14) - Brush (Negative)
(15) - Brush spring
(16) - Brush (Positive)
(17) - Front cover
(18) - Bearing metal
(19) - Pinion assembly
(20) - Pinion
(21) - Spring stopper
(22) - Return spring
(23) - Pinion guide
(24) - Pinion washer
(25) - Pinion clip

10-3 GENERATOR AND VOLTAGE REGULATOR (HITACHI)

10-3-1 Specifications

Type	Alternator	GT123-08
	Voltage regulator	T 123-07
Conti performance		Continuous operation
Battery voltage (V)		12
Nominal output (W)		300
Rated revolution (rpm)		2,500
Normal operating speed (r.p.m.)		1,300 6,000
Direction of rotation as viewed from pulley side		right

Alternator

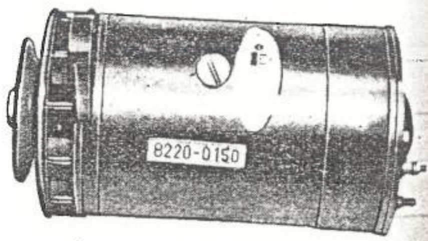


Fig. 10-39

Non-load voltage (V)	14～15 at 1,700 rpm
	13.5～15.5 at 2,500 rpm
Output current (A)	24～27
Cut-in voltage (V)	12.7～13.7
Cut-in speed (rpm)	Below 1,300
Reverse Current (A)	Below 8
Polarity of the battery	Negative (-) polarity connected to ground
Weight of alternator (kg)	9
Weight of voltage regulator (kg)	0.9

10-3-2 Principal values (alternator)

Outside diameter of yoke (mm)	113ø
Outside diameter of armature (mm)	71ø
Field coil resistance (at 20°C)	6.6
Number of field coils	2
Carbon brush material	GH-45
Type of pulley drive belt	M single
Reduction ratio of pulley	1.71

Voltage regulator

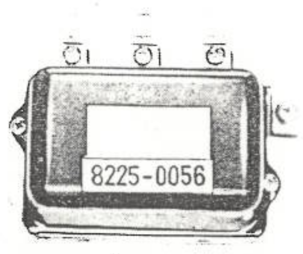


Fig. 10-40

10-3-3 Principal values

(Voltage regulator)

Voltage coil resistance (at 20°C)	9.85
Inserted resistance for rotor coil	10
Compensating resistance	12.5
Current limiter	

Inserted resistance for field coil (at 20°C)	20
Cut-out relay	
Voltage coil resistance (at 20°C)	9.85
Compensating resistance	12.5

Interior of the voltage regulator

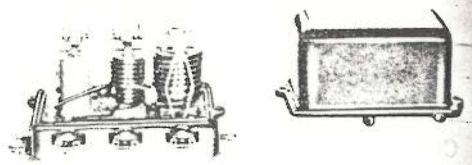


Fig. 10-41

10-3-4 Inspecting and repairing

Driving test

Performance of the alternator, voltage regulator and their associated parts should be tested by driving the automobile before the parts are dismantled.

(1) With use of fully charged 12V battery, short-circuit the terminals F and A and then, connect the ammeter between the terminal A and the battery. The alternator and its associated parts may be regarded as normal if the alternator operates smoothly without abnormal operating noise and measurements indicate between 4A - 6A when the alternator is rotated at speeds within 750 rpm to 950 rpm. (See Fig. 10-42)

(2) If the charging current is in excess of specified value, the trouble may be attributed to the following.

1) Mechanical trouble (undue friction)

2) Internal short-circuit

(3) Unsmooth operation

1) Short-circuitted armature

(4) If the operation is not fast enough

1) Short-circuitted field coil

(5) If the charging current is insufficient to the specified value.

1) Poor internal contact

2) Poorly soldered armature coil

3) Resistance is excessively high

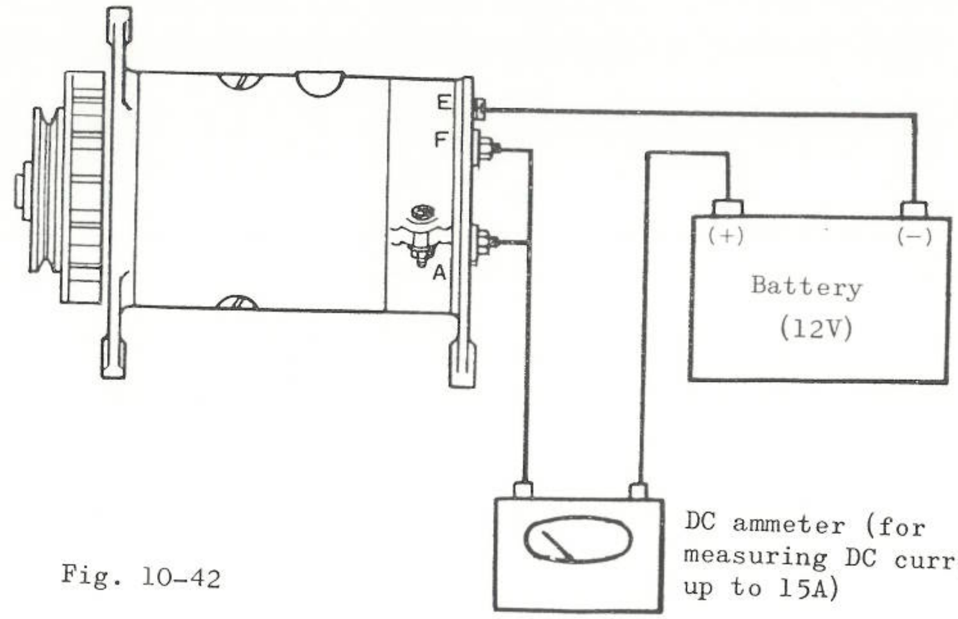


Fig. 10-42

Operating test

10-3-5 Dismantling

(1) Remove the brush cover and then take out the carbon brushes. (See Fig. 10-43)

Remove the carbon brush

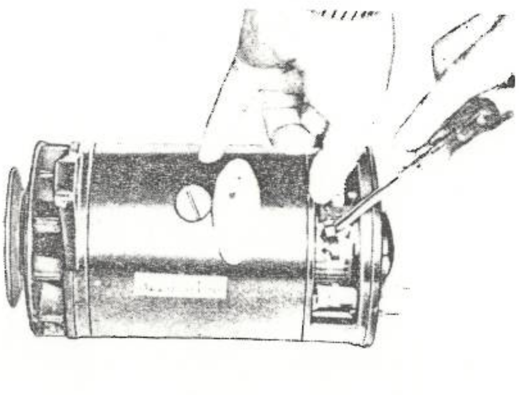


Fig. 10-43

(2) Remove all the through bolts fastening the front and rear cover to the body.

(3) Remove the front cover and armature together with the pulley by lightly hitting the front cover with wooden hammer or hide mallet. (See Fig. 10-44)

(4) Remove the screw on the joint portion of the field coil to the carbon brush and then slacken the nuts on the terminal. Then remove these parts from the yoke by lightly hitting the end cover with a wooden hammer or hide mallet. (See Figs. 10-45 and 10-46)

Remove the through bolts

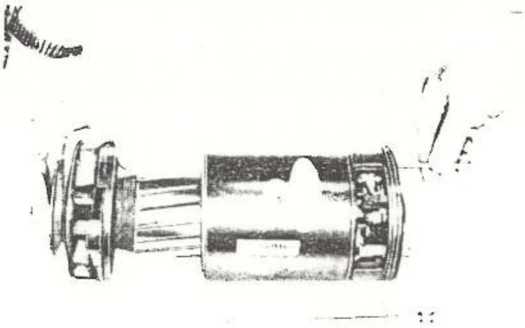


Fig. 10-44

Disconnect the joint between field coil and carbon brush

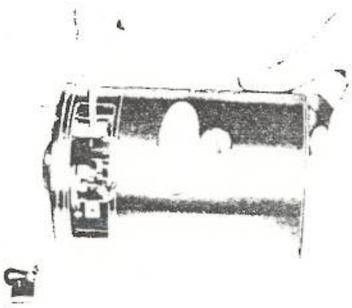


Fig. 10-45

(5) Remove the pulley nut and then remove the pulley.

(6) Remove the key and then dismount the front cover from the armature shaft with the aid of puller or press machine. (See Fig. 10-47)

Remove the end cover

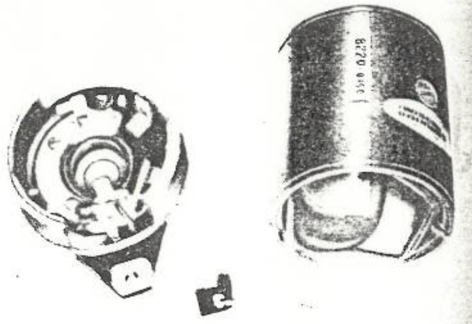


Fig. 10-46

Remove the front cover

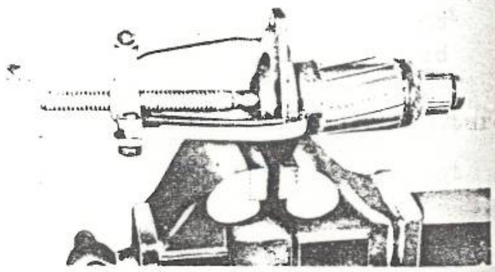


Fig. 10-47

(7) Remove the stopper ring from the bearing on the front cover and then remove the bearing. (See Fig. 10-48)

(8) Remove the pole core setting bolt and then take out the field coil.

Component parts of the alternator as dismantled

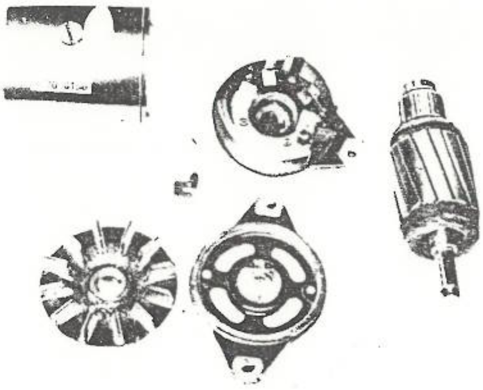


Fig. 10-48

Testing the field coil for grounding

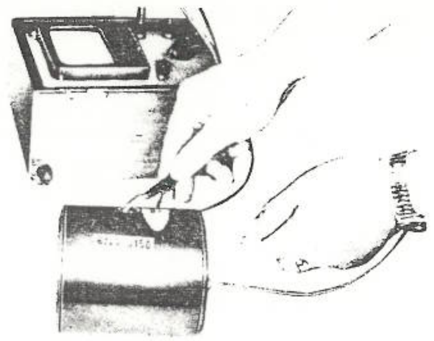


Fig. 10-49

10-3-6 Testing method

(1) Testing the field coil

Check to see if conduction takes place between the field coil and the yoke. The field coil may be regarded as due for rectification or replacement if short-circuitting is indicated. (See Fig. 10-49)

(2) Connect the coil and ammeter in series between the positive and negative polarity of the battery. Short-circuitting is indicated by excessive current flow and disconnection in the coil may be known as the ammeter fails to give any response as it is connected to the battery. In either cases, the coil may be regarded due for repair or replacement.

(3) Testing the armature circuit

Mount the armature on the tester and turn it with fingers while a piece of hacksaw blade is held right against the armature core. If the armature is short-circuitted, the steel piece is either magnetized or vibrates. In the event of short-circuit, the armature coil may be repaired or replaced. (See Fig. 10-50)

(4) Grounding test

Check to see if conduction takes place between the core in the armature and commutator. Conduction takes place only when the armature coil is short-circuitted. (See Fig. 10-51)

Testing the armature circuit

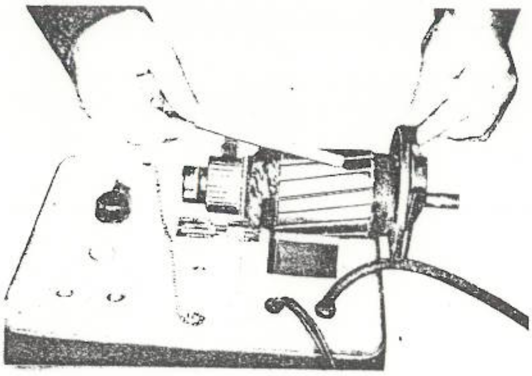


Fig. 10-50

Testing the armature coil for grounding

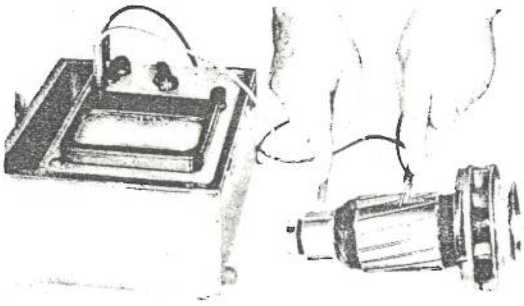


Fig. 10-51

10-3-7 Inspecting and repairing

(1) Commutator

If the partial wear on the commutator face is in excess of 0.3mm or the depth of mica insulator in the commutator exceeds 0.2mm, the commutator should be regarded due for repair. The limit of reduction in the outside diameter of the commutator is 2mm. Fouled or scuffed commutator face may be cleaned with fine abrasive paper while the commutator is turned with fingers.

(2) Carbon brush

If the carbon brush is worn and no longer gives 11mm in length, it should be replaced. (It is 16mm in length when new).

(3) Measuring the tensile strength of the brush spring

This may be tested with use of spring tension tester. The tensile strength is standard at 0.7kg

(4) Checking the armature shaft bending

Hold the both ends of the armature shaft in suitable support as illustrated in Fig. 10-52 and measure the bending on the shaft with a dial gage. If bending is in excess of 0.08mm, the shaft should be regarded due for repair.

Measuring the armature shaft for bending

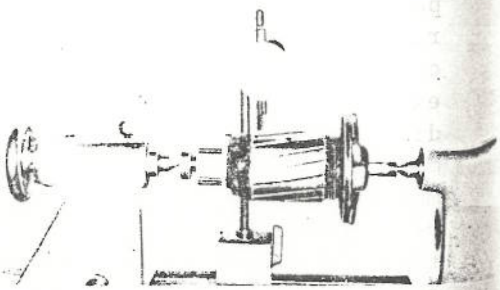


Fig. 10-52

(4) Checking the armature shaft bending

Hold the both ends of the armature shaft in suitable support as illustrated in Fig. 10-52 and measure the bending on the shaft with a dial gage. If bending is in excess of 0.08mm, the shaft should be regarded due for repair.

10-3-8 Maintenance standard

Alternator

Shunt voltage		Voltage (V) Rotating speed (rpm)	Above 10 1,000
Motoring test		Current (A) Rotating speed (rpm)	4 - 6 750 - 950
Tensile strength of the brush spring at standard (kg)			0.7
Carbon brush		Standard height Limit for reduction	16 5
Commutator	Outside diameter	Standard measurement Limit for reduction	45ø 2
	Difference between maximum and minimum diameter	Correction limit Correction accuracy	0.3 Below 0.05
	Depth of the mica insulator	Correction limit Correction accuracy	0.2 0.5 - 0.8
Shaft	Pulley side	Standard measurement Ball bearing	17 6203
	Carbon brush side	Standard measurement Ball bearing	15 6202Z

10-3-9 Trouble-shooting

(1) No charging takes place

Trouble	Cause	Correction
Carbon brush	Poor contact due to wear	Rectify or replace
Brush spring	Brush floating due to insufficient spring force	Rectify or replace
Commutator	Poor brush contact due to worn commutator face	Rectify
	Short-circuitted segments	Rectify
	Grounded	Rectify
Armature	Poor soldering on the riser	Rectify
	Short-circuitted layer	Rectify
	Grounded	Rectify
Field coil	Grounded	Rectify
	Disconnection	Rectify
	Demagnetized	Flow current for a short period of time
Terminal	Grounded	Rectify
Brush holder	Grounded brush holder	Rectify
Wiring	Disconnected	Replace
	Cut-out relay point fails to close or coil is not provided with attracting force	Replace

Voltage regulator	Cut-in voltage is higher than non-load voltage	Readjust relay
	Non-load voltage is lower than rated cut-in voltage	Readjust
	Current fails to flow even while the contact points are held closed	Rectify
	Fouled contact points or foreign particle on the points	Grind
	Others	

(2) Battery is discharging due to insufficient charging

Trouble	Cause	Correction
Carbon brush	Poor contact due to wear	Replace
Brush spring	Brush floating due to insufficient spring force	Replace
Armature coil	Short-circuitted layer	Rectify or replace
Commutator	Roughened commutator face or poorly soldered risers	Rectify
Field coil	Coil is partially disconnected	Rectify or replace
External wiring	Partially disconnected	Replace
Belt	Loosened tension	Readjust
Voltage regulator	Cut-out relay points fouling	Grind
	Reduction in the non-load voltage	Adjust

10-3-10 Method for measuring the voltage regulator

Tachometer, volt meter, ammeter and a complete set of adjusting tools should be prepared for adjusting the voltage regulator.

DC voltmeter		DC ammeter	
Battery voltage	Measurable range of volt meter	Cut-out current	Measurable range of ammeter
12V	0 ~ 30V	0 ~ 30A	0 ~ 50A

10-3-11 Voltage regulator

(1) Check the contact points and clean them with fine abrasive paper if fouling is notable.

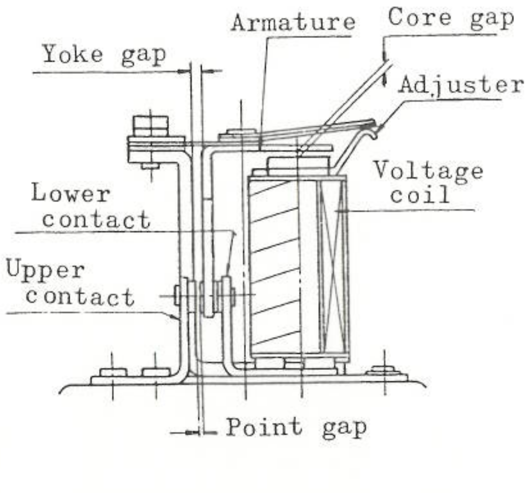


Fig. 10-53

(2) Check and adjust all the contact points gaps in the sequence of 1) yoke gap, 2) core gap and 3) points gap. (See Fig. 10-53)

(3) Yoke gap

The screw 3ø should be turned loose for adjusting the yoke gap.

Adjusting the yoke gap

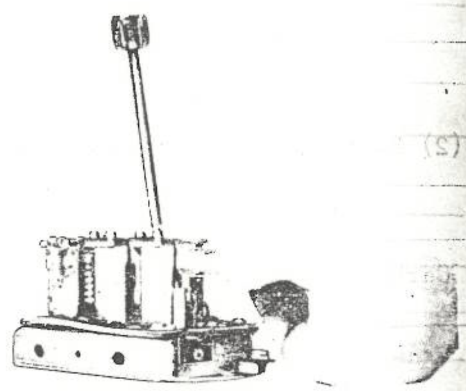


Fig. 10-54

(4) Core gap

Core gap may be adjusted by bending the lower contact in the manner illustrated in Fig. 10-55.

(5) Point gap

Point gap may be adjusted by bending the upper contact in the manner illustrated in Fig. 10-56.

Adjusting the core gap

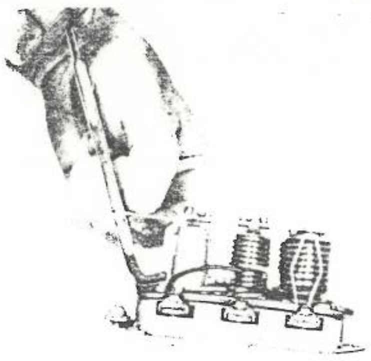


Fig. 10-55

Adjusting the point gap

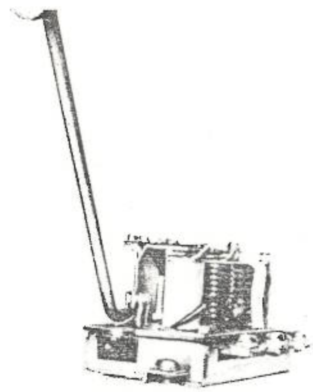


Fig. 10-56

Voltage regulator	Yoke gap	0.9～1.0mm
	Core gap	0.9～1.0mm
	Point gap	0.4～0.5mm

When the gaps are adjusted, rotate the alternator at the rated speed (See specifications).

Connections of the Meters for Adjusting the Non-load Voltage

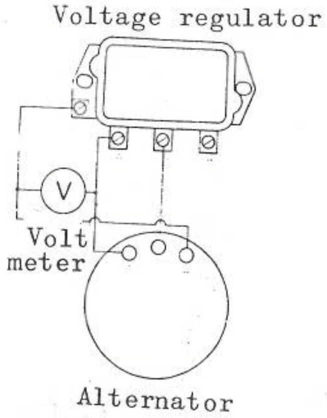


Fig. 10-57

10-3-12 Adjusting the non-load voltage

1. Wiring

Connections of the meters for adjusting the voltage are illustrated in Fig. 10-57. Connect the alternator terminals to corresponding terminals on the voltage regulator. Hold the terminal B on the voltage regulator free of load and connect DC volt meter to the line between terminals A and E.

(1) Check to make sure that the non-load voltage falls within the specified value

and if it is lower than specified value, adjust it by bending the adjuster upward as illustrated in Fig. 10-58. Bending the adjuster downward if the non-load voltage is higher than specified value.

Adjusting the Non-load Voltage

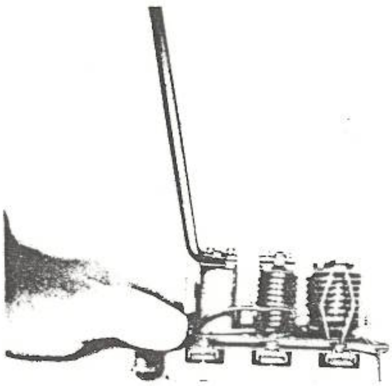


Fig. 10-58

(2) If the deformation of the yoke is serious and bending the adjuster no longer adjusts the non-load voltage, rectify the angle of the yoke with the aid of a tool in the manner illustrated in Fig. 10-59. When the parts is replaced, readjust the gaps before adjusting the voltage. Adjustment on the voltage regulator may be considered complete when the above adjustments are made however, to make double sure that the ad-

Adjusting the Angle of the Yoke

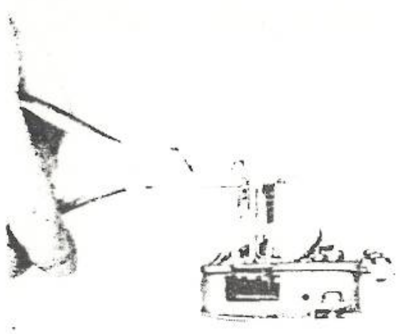
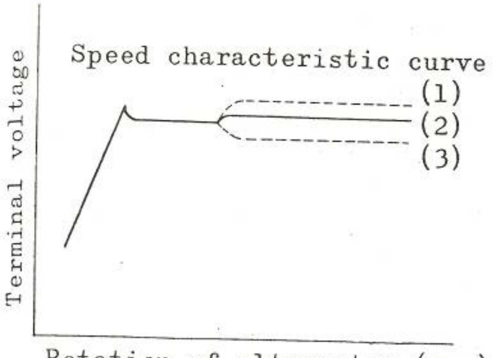


Fig. 10-59

justments are properly made, stop the rotation of the alternator and again operate it at rated speed to see if the voltage regulator holds the non-load voltage within the specified value.

(3) If the adjustment is correctly made, the alternator voltage should appear as depicted in Fig. 10-60. The voltage may slightly vary when changing the speed from low to high: i.e., from the lower contact to the upper contact operation, but this is not detrimental to normal charging operation. Some increase in the voltage when switching the operation to high speed are rather desirable. In the event if the voltage varies over 0.5V or more,

or decreases when the rotation of the alternator is increased, the core gap should be rechecked and readjusted. If the core gap is greater, the voltage increases and similarly, the voltage decreased with smaller core gap.



Speed characteristic curve

Fig. 10-60

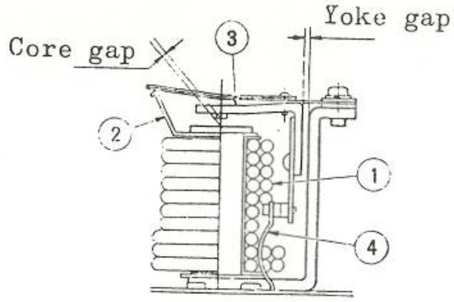
(1) - Core gap is excessively large
(2) - Normal
(3) - Core gap is excessively small

(4) As the voltage regulator may become maladjusted when the cover is put back into place, make double check after the cover is refitted.

10-3-13 Current controller

(1) Adjust the gaps in the same manner as applied for adjusting the voltage regulator. (See Fig. 10-61)

Construction of the Current Controller



(1) - Current coil
(2) - Adjuster
(3) - Armature
(4) - Current contact

Fig. 10-61

When gaps are adjusted, connect the meters as illustrated in Fig. 10-62.

Current controller	Yoke gap	0.9 ~ 1.0mm
	Core gap	0.6 ~ 0.7mm

Connections for adjusting the output current

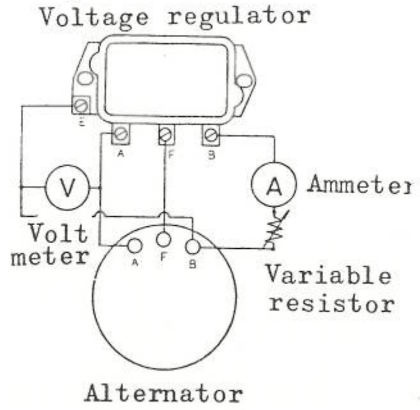


Fig. 10-62

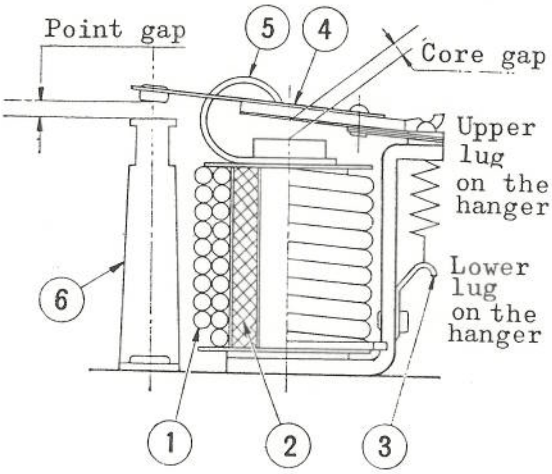
(2) Operate the alternator at rated speed and check to see if the output current meets the specified value.

10-3-14 Cut-out relay

If the points fails to close when the rated cut-in voltage is applied, adjust the relay in the following manner.

(1) If the points are fouled, clean and grind them with fine abrasive paper.

Construction of cut-out relay



(1) - Voltage coil
(2) - Current coil
(3) - Hanger
(4) - Armature
(5) - Stopper
(6) - Cut-out relay contactor

Fig. 10-63

(2) Adjust the gaps in the sequence of core gap and point gap.

Cut-out relay	Yoke gap	0.2~0.3mm
	Core gap	0.9~1.0mm
	Point gap	0.6~0.7mm

(3) Adjust the relay by carefully moving the upper lug on the hanger with the coil spring held disconnected to allow the points to close when 10 - 12 volt is applied. Voltage increases with the hanger lifted up and decreases with it bent down.

(4) Refit the coil spring into place and adjust the hanger to bring the cut-in voltage within the rated value. If the cut-in voltage is lower than rated value, strengthen

Adjusting the Current

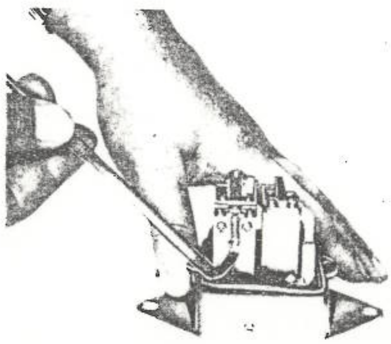


Fig. 10-64

the tensile force of the coil spring by bending the hanger downward and in the similar manner, bend the hanger upward to weaken the spring force if the cut-in voltage is higher than the rated value.

(5) Adjust the point gap by adjusting the cut-out relay contactor. (See Fig. 10-65)

Adjusting the Point Gap

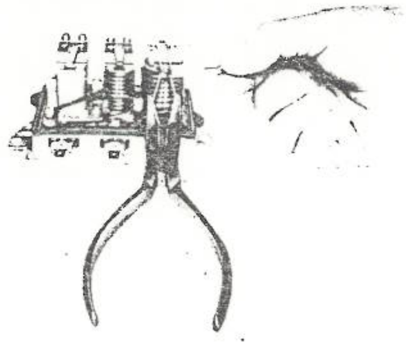


Fig. 10-65

(6) Over-charging

Trouble	Cause	Correction
Wiring	Short-circuitted armature and field coil	Rectify
	Undue increase in the non-load voltage	Adjust
Voltage regulator	Poorly grounded voltage regulator	Properly fasten the ground lead
	Disconnected lead for voltage coil	Rectify or replace

(7) Irregular charging current

Trouble	Cause	Correction
Wiring	Naked wire causes short-circuit due to travel shock, or disconnected wire sometimes comes in contact on account of vibration	Rectify or replace
Armature and field coil	Partially short-circuitted layer	Rectify or replace
Brush spring	Broken	Replace
Commutator	Mica insulator	Rectify
Voltage regulator	Fouled cut-out relay points or partially disconnected coil	Rectify or replace
	Unstable voltage in the regulator	Readjust
	Disconnected stabilizing resistance	Replace

10-4 IGNITION COIL (HITACHI)

10-4-1 Specifications

12V, C1Z-14 (-) Ground

Primary voltage: 12V

Secondary voltage:
1,500 r.p.m. 15,000V

Primary resistance: 3.5Ω

Secondary resistance: 10KΩ

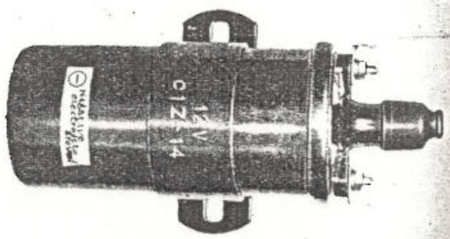


Fig. 10-66

10-4-2 Testing method

(1) Primary conduction test

With use of a tester check to see if conduction takes place between primary terminals on the ignition coil. Replace if conduction does not takes place. The resistance for primary coil is between 3.5 ohms - 4.5 ohms.

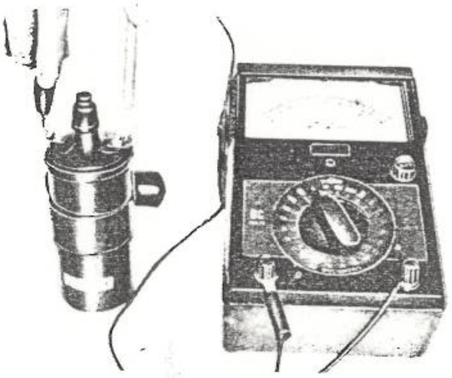


Fig. 10-67

(2) Sparking test

The secondary coil should be tested using a triple-pole needle gap tester. In this test, a nickle piece should be used as an electrode. With the ignition coil disposed in a constant-temperature oven, both internal and external temperatures should be elevated to 80°C and then, the oven is mounted on the testing bench, and high-tension power should be then applied to the ignition coil by operating the distributor at 1,800 - 2,000 r.p.m. to see if sparks exceed 6mm. If the constant temperature oven is not available, the distributor should be operated for about thirty minutes at 200 - 300 r.p.m. so that temperature of the ignition coil increases to 80°C. The ignition coil temperature should be by any means held as close as to 80°C for testing.

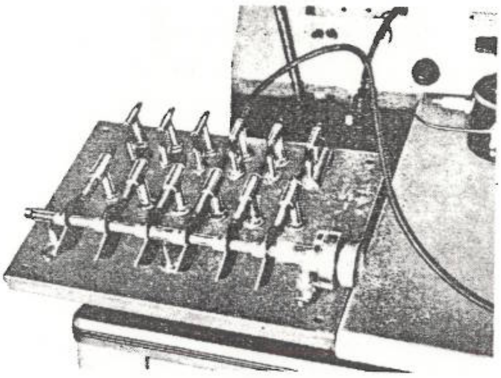


Fig. 10-68

(3) On-the-Spot trouble-shooting

The ignition coil mounted on the engine should be tested in the following manner. With the high-tension cord pulled out, the ignition switch should be turned on and the tip of the high-tension cord should be borne against the engine block keeping a distance of about 6mm, and then, the engine should be rotated by the starter, or the contact breaker point should be operated with hand to see if sparks takes place. The test should be conducted with the ignition switch, battery wiring and contact points all held in their respective portion.

This method may sometimes fail to pick out defective point correctly and the ignition coil may fail to operate properly as the ambient temperature increases. (See Fig. 10-69)

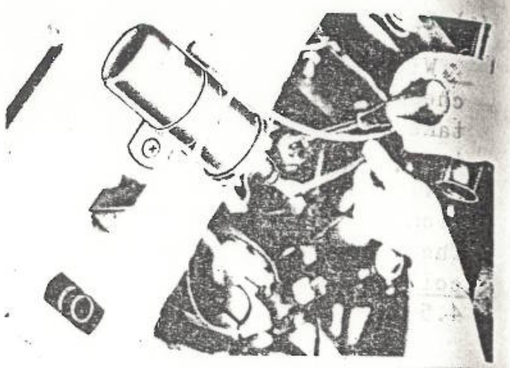


Fig. 10-69

10-5 DISTRIBUTOR (HITACHI)

10-5-1 Specifications

Distributor

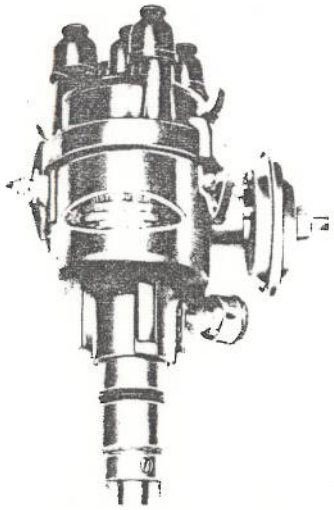


Fig. 10-70

Engine type			PR20, G150
Type			D415-70
Direction of rotation as viewed from the drive side			Right
Weight (kg)			1.3
Drive			Male coupling
Angle advancing characteristic	Centrifugal type	Start operating speed rpm	400
		Medium °/rpm	8/1,000
		Maximum °/rpm	15/1,900
	Vacuum type	Start operating -mmHg	50
		Maximum °/-mmHg	8/250

10-5-2 Dismantling

(1) Remove the cap and take out the rotor. (Fig. 10-71)

Remove the Cap and Take Out the Rotor

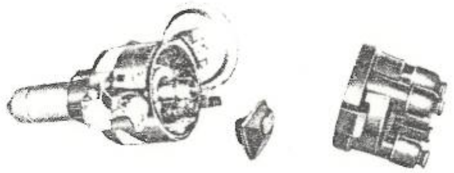


Fig. 10-71

(2) Remove the vacuum controller.

(3) Disconnect primary terminal and then, remove the contact breaker bracket.

(4) For disassembling the contact breaker, the moving plate should be held downward and then, the fixed plate is removed. As small steel ball is provided between the plates, they should be kept from being lost.

(5) The coupling should be removed and then, the edge of the kay groove in the main shaft should be smoothened by a file before removing the rotating parts. Before

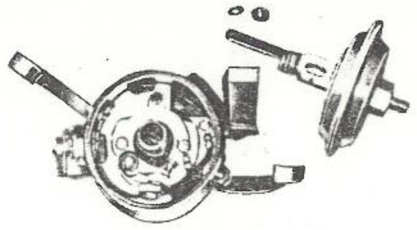


Fig. 10-72

the coupling is removed, the corresponding marks should be applied to the pertinent portions of the coupling and the main shaft or the pertinent positions of the rotor grooves in the camshaft, thus the direction of the coupling may be memorized.

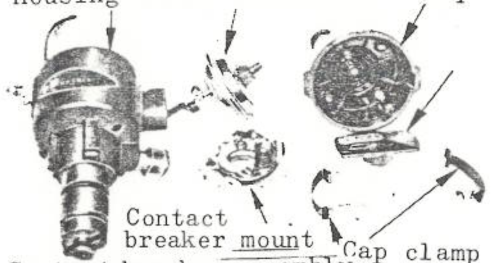


Fig. 10-73

(6) A screw should be removed before removing the cam. Similar marks should be applied to corresponding posi-

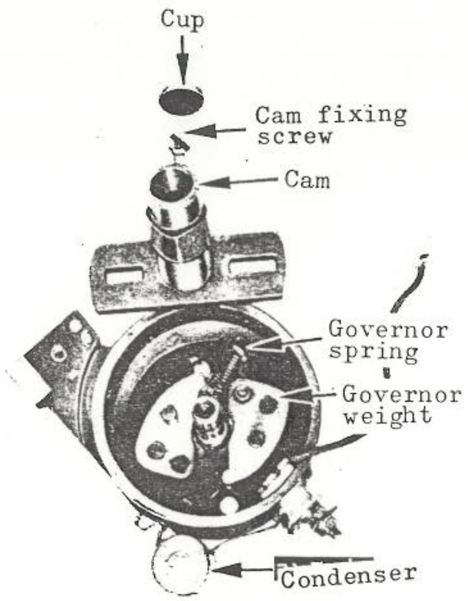


Fig. 10-74

tions of the flyweight mount plate and the camshaft so that the relations of the parts may be memorized.

(7) The governor weight and spring should be removed. The above shows the sequence for disassembling the parts but they may be changed at will to fit the necessary repair.

10-5-3 Inspecting

The parts should be cleaned for inspection and replaced if necessary. The vacuum timing control (diaphragm) and condenser should not be cleaned.

(1) The shaft and the housing should be checked for wear, and if bend of the shaft is in excess of 0.05mm, it should be replaced.

(2) The governor weight-to-pin contact and the governor spring mount should be checked for wear.

(3) The cam should be checked for wear or damage. Cam-to-camshaft meshing should be checked for wear.

(4) The contact point should be checked for wear or graze, and corrected with an abrasive oil stone or abrasive paper if necessary.

(5) The distributor cap and the rotor should be checked for crack, damage, rust or corrosion.

(6) If the distributor cap carbon is worn in excess of 2mm, the cap should be replaced.

(7) The ignition cord should be checked for tear or damage.

(8) The diaphragm in the vacuum timing control should be checked for wear.

10-5-4 Testing

(1) Contacting pressure of the breaker arm

The actuating pressure of the breaker arm should be tested with a spring tension tester. (The pressure of the spring acting on the breaker arm is 500gr - 650gr for HITACHI and 415gr ± 15% DENSO).

With the tension tester hung onto the tip of the breaker arm and pulled in a direction right-angle to the breaker arm, and the scale should be read when the contact point is opened.

Measuring the Contacting Pressure of the Breaker Arm

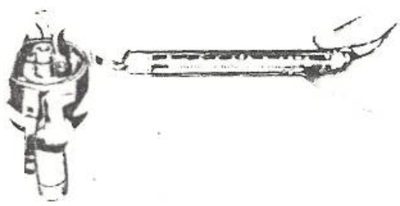


Fig. 10-75

(2) The cam angle should be tested with use of a distributor tester. Adjusting value is: 48° - 53° for HITACHI and 52° ± 3° for DENSO.

Cam angle

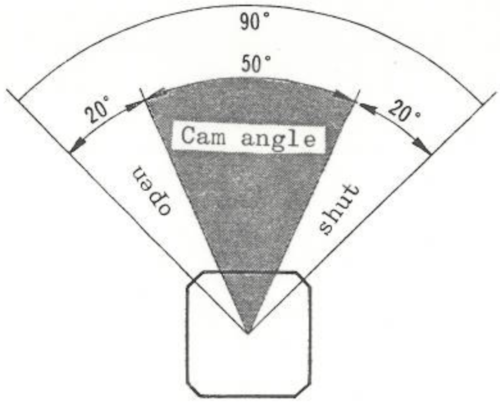


Fig. 10-76

(3) If the cam angle exceeds the rated value when the point gaps are properly adjusted, the trouble may be attributed to:

A Worn breaker arm heel
B Improperly mounted arm
C Worn cam
D Deformed cam

(4) Adjusting method

The cam angle should be adjusted after the point gap is corrected.

Cam angle	Point gap
Too large	Widen
Too small	Bring closer

Adjusting the Point Gap

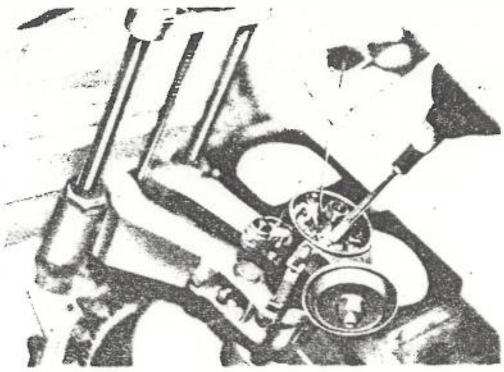


Fig. 10-77

(5) Point gap

The contact point is provided with the maximum gap at the breaker arm heel that comes in contact with the tip of the cam. With the breaker arm held in this position, the gap should be adjusted to 0.45mm.

(6) Angle advancing characteristic

The angle advancing characteristic of the governor and the vacuum control should be measured with use of a distributor tester in the manner illustrated in Figs. 10-78 and 10-79.

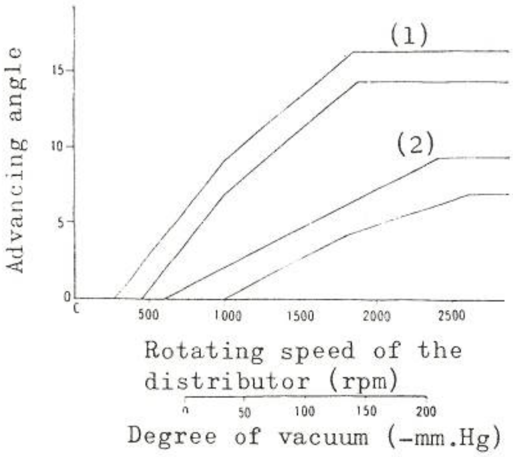


Fig. 10-78

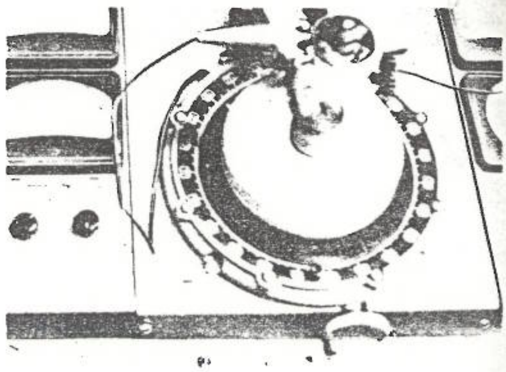


Fig. 10-79

(1) - Centrifugal angle advancing characteristic

(2) - Vacuum controlled angle advancing characteristic

10-6 CONDENSER

10-6-1 Specifications

Condenser capacity:
$0.22 \pm 0.02\mu F$

Insulation resistance
(at normal temperature):
$15M\Omega$

Condenser

Fig. 10-80

(1) If insufficient sparking is due to condenser failure, the condenser should be tested by comparing it with a new one.

(2) One of the light-tester terminals should be connected to the condenser lead and the other terminal should be attached to the condenser body to see if the light-tester lights. The condenser should be regarded as short-circuitted if the light-tester lights on contact with the condenser body.

(3) DC or AC 200V should be instantly applied to the lead wire and the body of the condenser. 1 - 2 minutes later the edge of the lead should be held close to the body and if sparks occur when the lead is held 2mm apart from the body, the condenser may be regarded as normal.

(4) Capacity and insulation resistance of the condenser should be measured with use of a condenser tester or Megger.

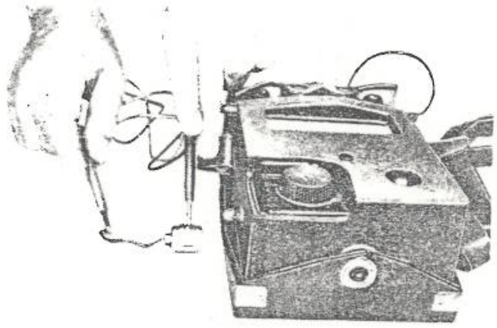


Fig. 10-81

10-7 SPARK PLUG (HITACHI)

10-7-1 Type HGK BGE

HITACHI L46J
Size 14mm P=1.25

Ignition plug

10-7-2 Inspecting

(1) The insulator should be checked for crack.

(2) The electrodes should be checked for wear.

(3) The internal portion, threaded portion and electrode of the plug should be checked for wear or carbon deposit.

(4) The insulator should be checked for fouling

If the electrode turned white, the spark plug should be replaced with a spark plug of cold type. If the insulator turned black on account of the carbon deposit, a spark plug of hot type should be used.

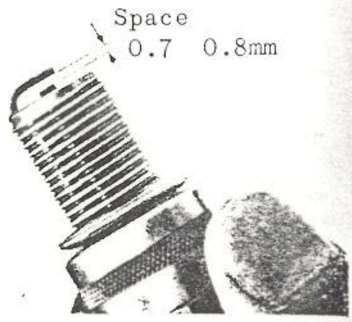


Fig. 10-82

10-7-3 Adjusting and cleaning

(1) The spark gap should be adjusted to 0.7 - 0.8mm.

(2) The spark plug should be regularly checked after every 3,000km of travel distance. For cleaning the spark plug, a spark plug cleaner or a wire brush should be used.

Parts of distributor

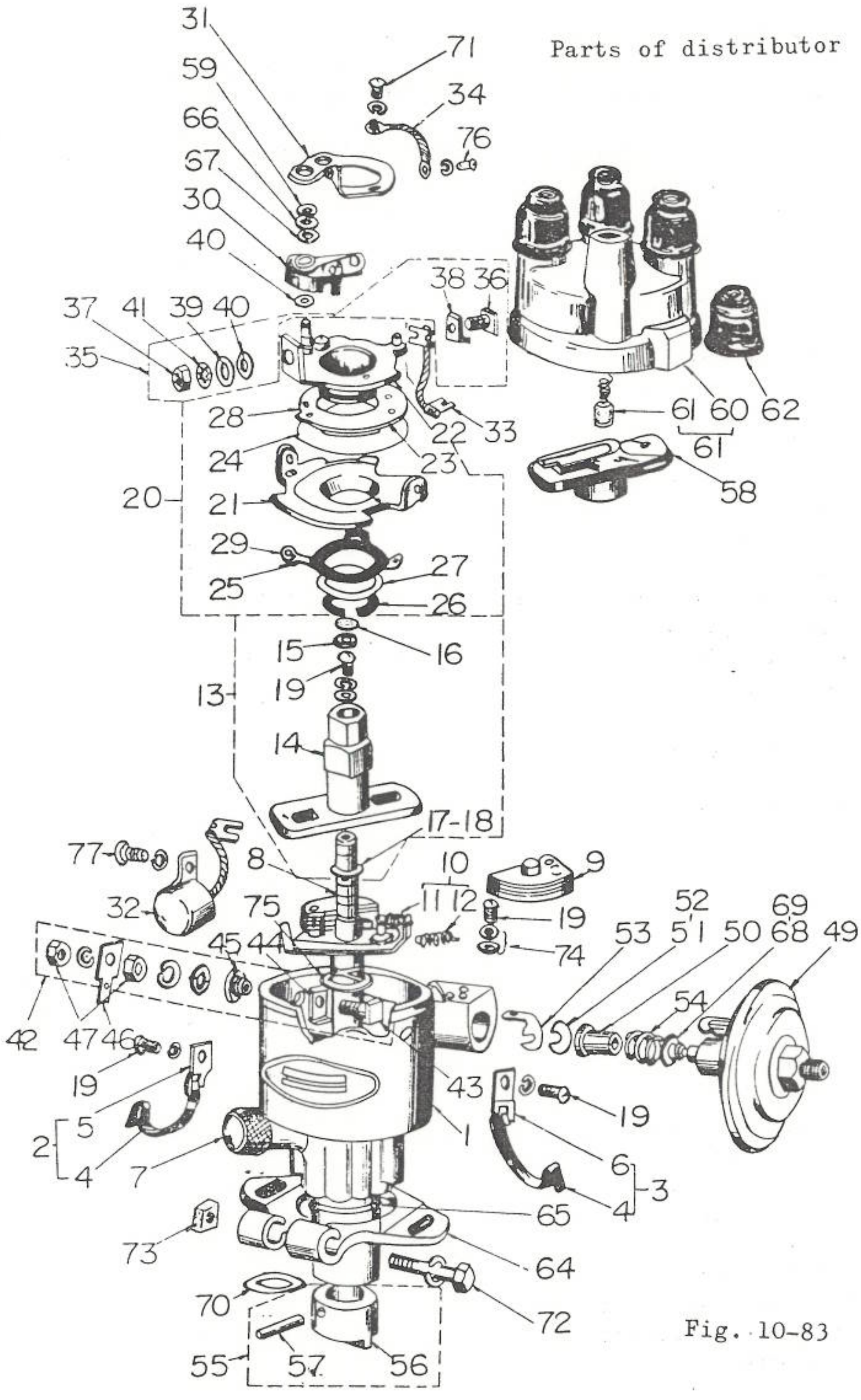


Fig. 10-83

(1) - Housing
(2) - Cap clamp assembly
(3) - Cap clamp assembly
(4) - Cap clamp
(5) - Clamp hinge plate
(6) - Clamp hinge plate
(7) - Grease cup
(8) - Shaft assembly
(9) - Governor weight
(10) - Governor spring assembly
(11) - Governor spring
(12) - Governor spring
(13) - Cam assembly set
(14) - Cam assembly
(15) - Felt disk
(16) - Packing ring
(17) - Thrust washer
(18) - Thrust washer
(19) - Screw
(20) - Contact breaker assembly
(21) - Breaker plate
(22) - Breaker plate
(23) - Ball guide
(24) - Ball contact plate
(25) - Breaker spring
(26) - Breaker clip
(27) - Thrust washer
(28) - Steel ball
(29) - Steel ball
(30) - Contact arm
(31) - Contact point
(32) - Condenser
(33) - Lead wire assembly
(34) - Grounding wire assembly
(35) - Terminal assembly
(36) - Terminal screw
(37) - Terminal nut
(38) - Terminal insulator
(39) - Thrust washer
(40) - Insulating washer
(41) - Teeth washer
(42) - Terminal assembly
(43) - Terminal screw
(44) - Terminal insulator
(45) - Terminal insulator
(46) - Terminal
(47) - Nut
(48) - Vacuum control assembly
(49) - Vacuum case assembly
(50) - Spring guide
(51) - Adjusting washer
(52) - Adjusting washer
(53) - Vacuum advance hinge
(54) - Vacuum spring
(55) - Coupling assembly
(56) - Coupling
(57) - Knock pin
(58) - Rotor head
(59) - Stopper
(60) - Cap assembly
(61) - Carbon point assembly
(62) - Rubber cap
(63) - Fixing plate assembly
(64) - Fixing plate
(65) - "O" ring
(66) - Thrust washer
(67) - Insulating washer
(68) - Adjusting washer
(69) - Adjusting washer
(70) - Thrust washer
(71) - Screw
(72) - Bolt
(73) - Nut
(74) - Thrust washer
(75) - Thrust washer
(76) - Screw
(77) - Screw

10-8 BATTERY

10-8-1 Specifications and construction

Models N30Z (for PR-D10) and NS40 (for PR-20) are used, the construction of which is illustrated in Fig. 10-84 while the specifications are given in Table 10-1.

Construction

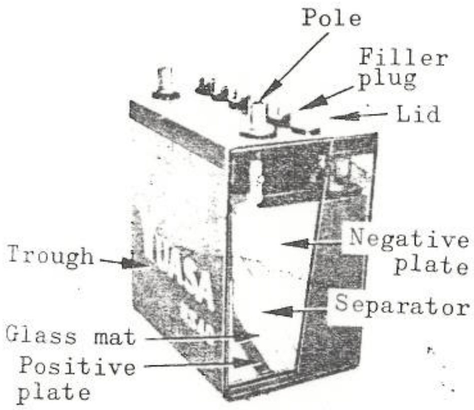


Fig. 10-84

10-8-2 Daily care

(1) The upper portion of the battery is apt to get contaminated and the battery tends to leak and hence, it should be washed with water and dried. If the carrier is corroded, clean it with water and apply black anti-corrosive paint.

(2) Topping-up

Check the electrolyte every once a week and top-up with distilled water until the top level of the electrolyte comes as high as upper level marking.

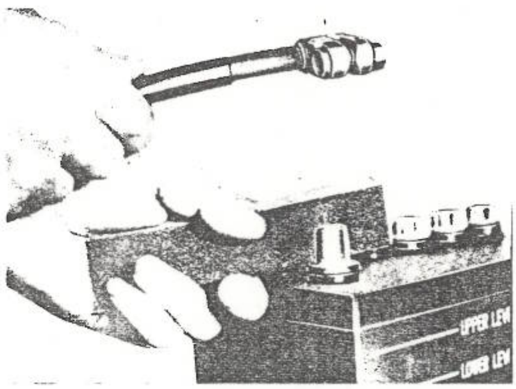


Fig. 10-85

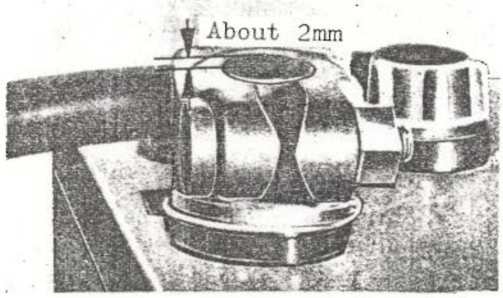


Fig. 10-86

(3)

Type		NS40	N30Z
Voltage (V)		12	12
Capacity per 20 hours		32	35
Number of positive plate per cell		4	4
-15°C 150A Discharge	Hours continued	Above 2.5 min.	Above 2.12 min.
	Voltage after 5 seconds	Above 8.4V	Above 7.3V
Dimensions (Maximum mm)	Over-all height	227	232
	Height of trough	203	207
	Width	128	135
	Length	196	204
Gross weight		11 kg	13 kg
Specific gravity of the electrolyte (20°C)		1.260±0.01	1.260±0.01

Table 10-1

* J.A.S.O. is the abbreviation of Japanese Automobile Standard Organization.

If the pole and lead terminals of the battery are found corroded, wash them with water and clean them with use of abrasive paper or wire brush and then, retighten the nuts and smear all external surfaces of the nuts and battery holding down bolts with grease or petroleum jelly. (See Fig. 10-85 and Fig. 10-86)

(4) Storing

The battery should be stored as installed in the automobile or removed from the automobile after it is fully charged. The battery tends to self-discharge as much as 1% of capacity per day in summer and at 0.5% per day in winter. Hence the battery should be recharged once a month in summer and once in every three months in winter regardless of use. (See paragraph "charging")

Measuring the specific gravity

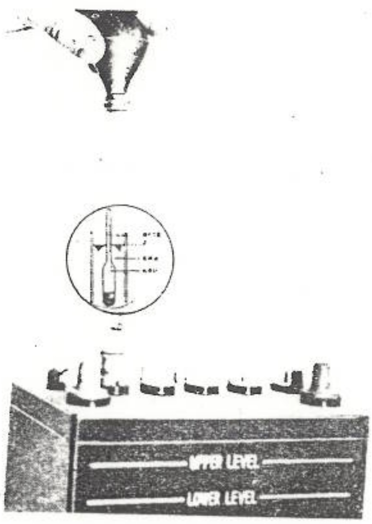


Fig. 10-87

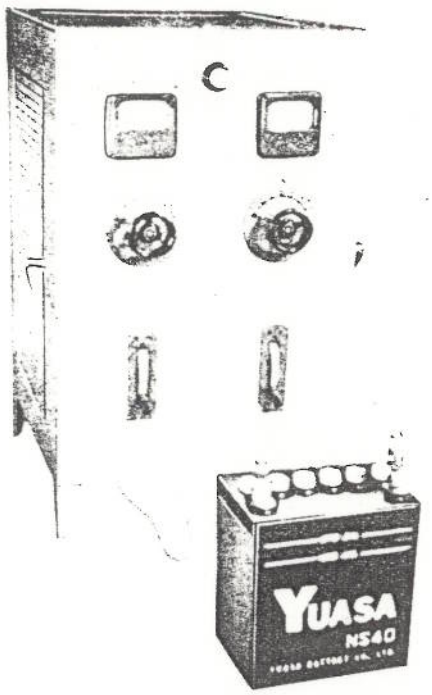


Fig. 10-88

10-8-3

When the automobile is operated normally, the specific gravity of the battery electrolyte is normal at 1.260 (at 20°C) and if measured value is less than 1.200 (at 20°C), the battery should be re-charged in the following manner.

(1) Normal charging

Connect the battery with the battery charger as illustrated in Fig. 10-88 and apply charging current rated at 1/10 of the battery capacity to the battery. The rated charging current for N-30Z is 3.2A and 3.2A for NS40. As the charging proceed, the voltage and specific gravity of the electrolyte increases and comes to a certain point where the voltage and specific gravity are held from further increase (At which time the voltage will be 15 - 16V and specific gravity at 1.260 at 20°C) and the charging may be regarded complete after the battery is held in this condition with the charging current supplied for continuous 2 hours. Fully discharged battery (specific gravity is less than 1.110) can be re-charged within 13 hours and partially discharged battery (50% dis-

Power Remains in the Battery

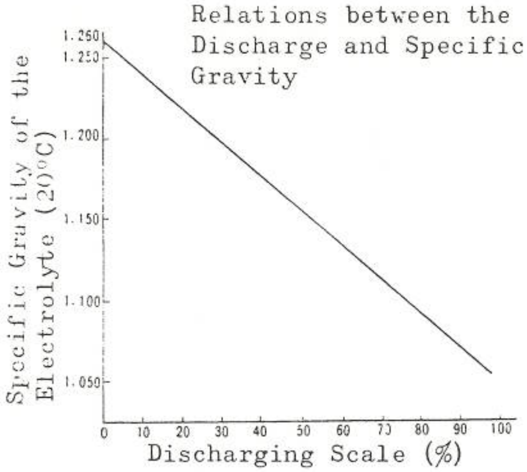


Fig. 10-89

charged, specific gravity is about 1.180) may be re-charged within 6 hours or so. The time required for re-charging the battery may be reduced or increased according to the charging current applied to the battery. The temperature of the electrolyte increases during charging operation, and if it exceeds 50°C, the current should be reduced to about half or the charging should be suspended until the temperature falls. During the charging operation, the battery should be kept away from flame.

(2) Quick-charging

When charging the battery while it is installed in automobile, the charging current should only be applied only after the ground cord is disconnected. The charging current is 32A for model NS40 and 32A for model N30Z. Fully-discharged battery may be re-charged in one hour and partially discharged battery for 30 minutes. This charging operation re-charges the battery at 85% of its full capacity. In quick-charging operation, the battery electrolyte should also be held on or lower than 50°C.

10-8-4 Service life of the battery and relations between the temperature and performance

(1) Service life of the battery

If the battery is used in a correct manner it should normally operate satisfactorily for about 2 years for personal automobile. Measure the specific gravity of each cell and if any or the cells fails to give specified value (less than 1.100) while others meet the rated value, or the specific gravity of the electrolyte or the voltage fails to increase as the normal charging current is applied, the battery may be regarded as out of the service life.

(2) Relations between the temperature and operating efficiency

The efficiency of the battery tends to decrease with

Relations between Electrolyte Temperature and Battery Capacity

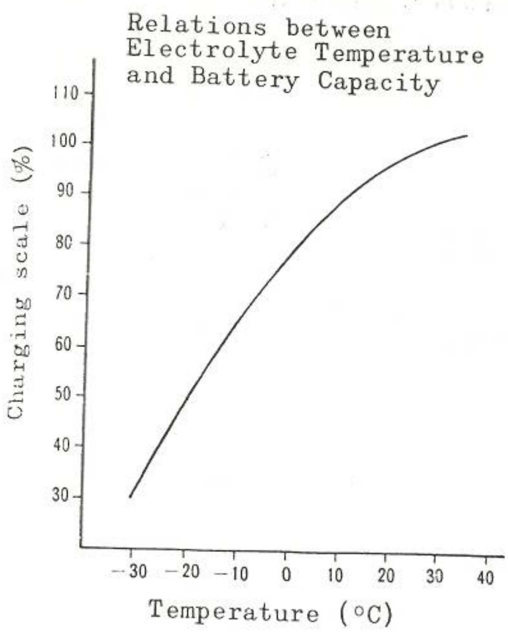


Fig. 10-90

reduction in the temperature of the electrolyte as the chemical reaction gets inactive. The relation between the temperature and efficiency of the battery is illustrated in Fig. 10-90.

10-9 STARTER, CHANGE-OVER SWITCH AND PREHEATING SYSTEM (HITACHI)

10-9-1 Construction

The Bellett diesel engine is equipped with 12-V electrical system except the starter is operated with 24V through the change-over switch.

Construction

(1) 24V starter (See Fig. 10-91)
(2) Change-over switch (See Fig. 10-92)
(3) Seized glow plug (See Fig. 10-93)
(4) Glow plug relay (See Fig. 10-92)

The above parts are connected as illustrated in Fig. 10-95.

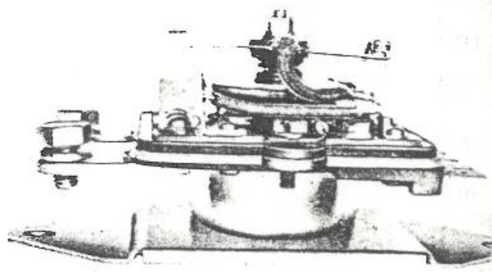


Fig. 10-92

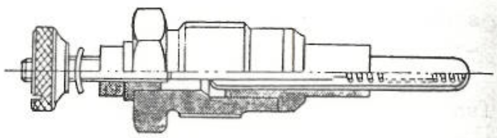


Fig. 10-93

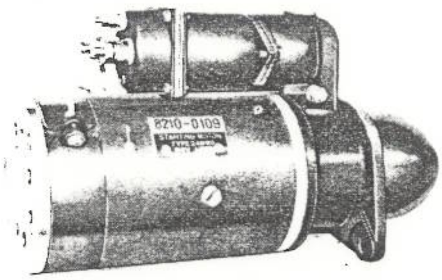


Fig. 10-91

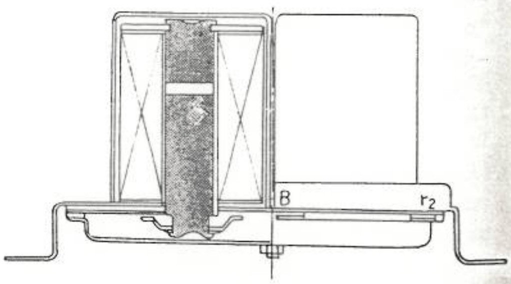


Fig. 10-94

Starter circuit

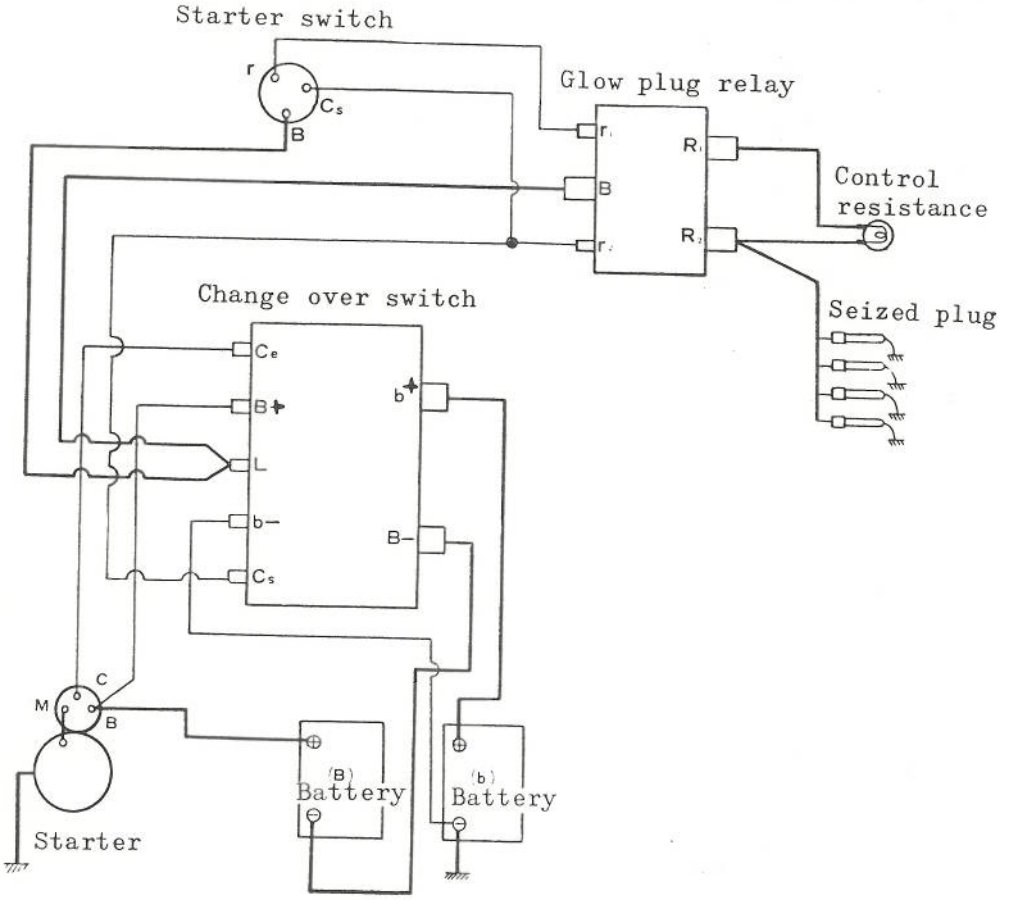


Fig. 10-95

10-9-2 Specifications of the starter

Type	24MW-A
Rated output (seconds)	30
Nominal power output (KW)	1.5
Direction of rotation as viewed from the pinion side	Right
Weight (kg)	12
Clutch	Spring type
Pinion operating voltage (V)	Below 18
Meshing	Magnetic shifting

Non-load	Terminal voltage (V)	21
	Current (A)	Below 60
	Speed of rotation	Above 7500
With-load	Terminal voltage (V)	4.5
	Current (A)	Below 450
	Torque (m-kg)	Above 1.8

Table 10-3

10-9-2 On the spot trouble-shooting

If the operating speed of the starter is considerably slow or if fails to operate when the starting current is applied, check the battery for charging, circuit for disconnection and poor contact of the terminal connections before dismantling the starter for repair.

(1) Inspecting the battery

Measure the specific gravity of the battery electrolyte and if the measured value is less than 1.200 (at 20°C), remove the battery from the automobile and recharge as necessary. The specific gravity is standard at 1.260 (at 20°C).

(2) Inspecting the starter circuit

Turn the head lights on and then turn the starter switch and check the following.

1) If the head lights goes out as the starter switch is turned: Check to make sure

that the cables are properly connected to the battery terminals. Loosened terminal connections may be detected by touching the cable with finger. The terminal tends to get heated if it is provided with undue resistance for poor connection. In the event if the trouble is attributed to poorly connected cables, clean the terminal and retighten the clamping bolts.

2) If the head light power reduces as the starter switch is turned

Such trouble may be attributed to insufficiently charged battery or the starter failure. The starter failure may often be caused by the armature shaft bending, loosened pole connections, burnt-out armature coil or burnt-out commutator. The maintenance procedure of the starter is described in subparagraph 10-9-5.

3) The starter fails to operate and give no influence on the head light as the starter switch is turned.

By connecting the volt meter to the starter circuit in the manner illustrated in Fig. 10-12, check the voltage drop in the circuits. The volt meter required for this check-up is: DC volt meter having measurable range of 1-5V.

The voltage drop in the circuit when the starter switch is turned on should be less than 0.2V. If the voltage drop is in excess of 0.2V, check the connections and retighten the clamping bolts as necessary. If the starter failure is detected by the above check-up, remove the starter from the engine for repairing.

10-9-3 Inspecting the pre-heating system

Meters used for inspection: DC volt meter having measuring range up to 15V and circuit tester.

If the control resistance fails to get red-heated after the current is continuously supplied for more than 30 seconds, check the system in the following manner.

(1) Inspecting the circuit

After the check up is made to make sure that the terminal switch and the glow plug relay are provided with the current, turn the starter switch for pre-heating.

1) Measure the voltage between the terminal r_1 of the glow plug relay and the ground. If the volt meter fails to give response when it is connected to the circuit or the voltage differential between the glow plug relay and the terminal B is more than 0.2V, replace the

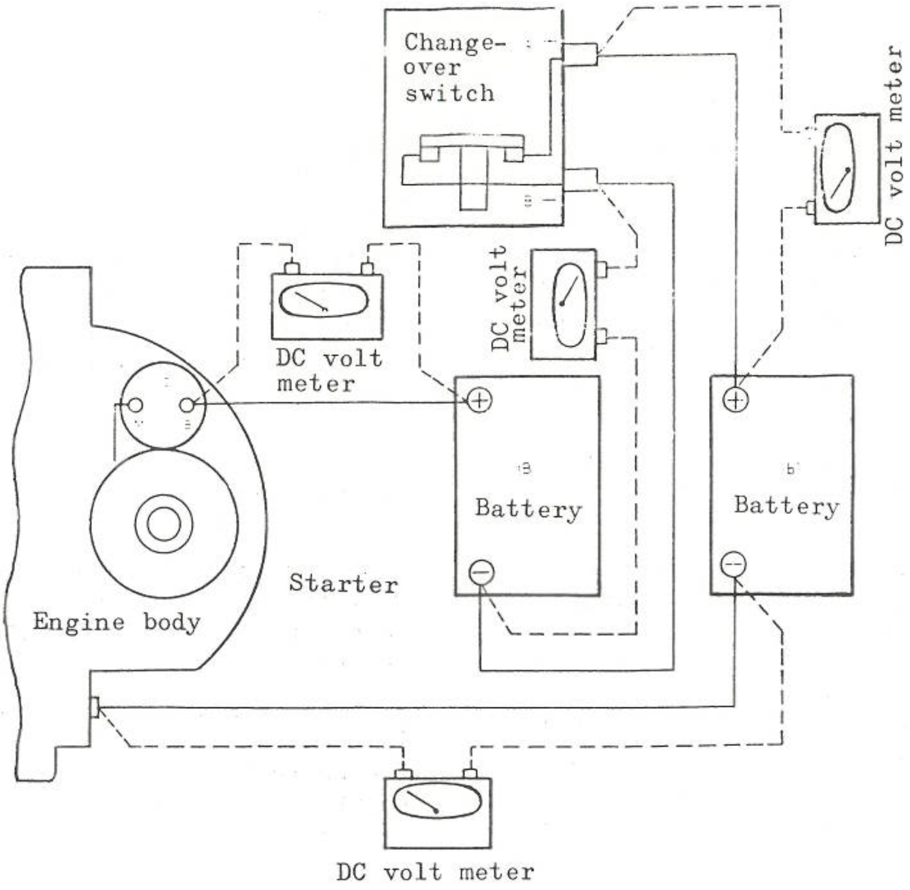


Fig. 10-96

glow plug. Then, insert lead of the terminal r_1 into the terminal r_1 and inspect the circuit for voltage drop in the same manner. (See Fig. 10-97)

2) Connect DC volt meter in the circuit between the terminals R_1 and R_2 of the glow plug relay for measuring the voltage thereof. If the measured value is 0 or above 0.8V, the trouble may be attributed to disconnected control resistance, disconnected circuit or loosened connections. (See Fig. 10-97)

(2) Inspecting the seized glow plug

Remove the connecting plate from the seized glow plug and then, connect the circuit

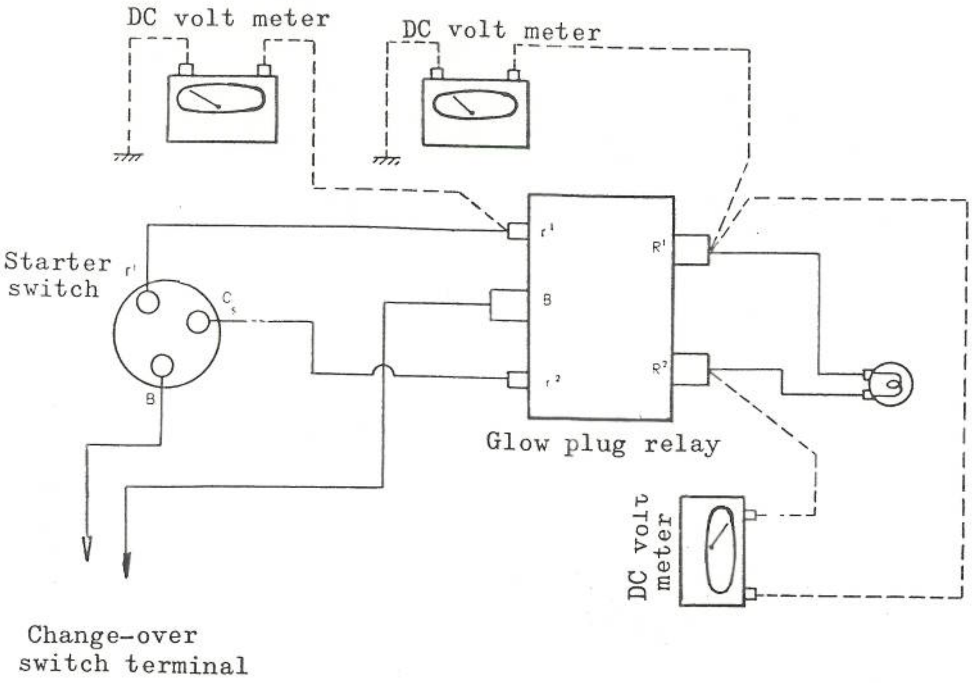


Fig. 10-97

tester in the circuit between the seized glow plug and the engine body for checking the resistance thereof.

1) If the tester indication is 0, the trouble is attributed to internal short-circuit.

2) If the tester pointer indicate the maximum, the trouble is caused by disconnection.

3) If the tester pointer indicate 1.2 ohms. the glow plug may be regarded as normal.

10-9-4 Dismantling the starter

(1) Turn loose the terminal nut on the terminal M of the magnet switch and then, remove the connecting plate from the starter. Then slacken the two bolts fastening the magnetic switch to the gear case. (See Fig. 10-98)

(2) Remove the brush band and lift the brush spring and then remove the carbon brush from the brush box. (See Fig. 10-99)

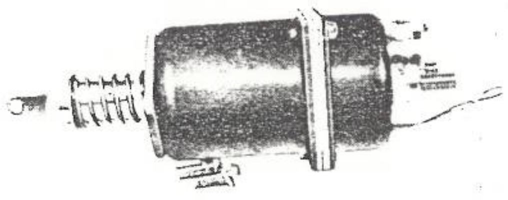


Fig. 10-98

Removing the Brush

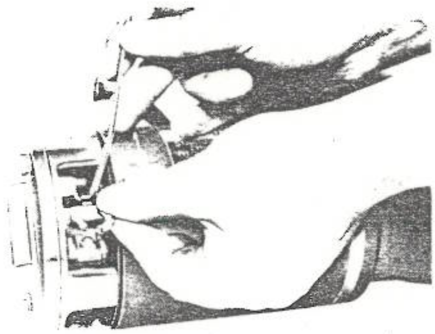


Fig. 10-99

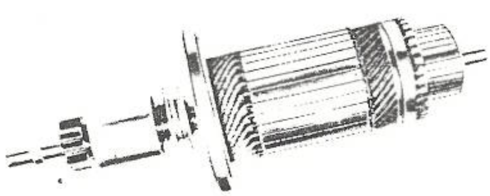


Fig. 10-100

(3) Remove the through bolts from the rear cover and then pull out the armature. (See Fig. 10-100)

(4) Remove the brush terminal fixing screw and then remove the rear cover from the yoke. (Fig. 10-101)

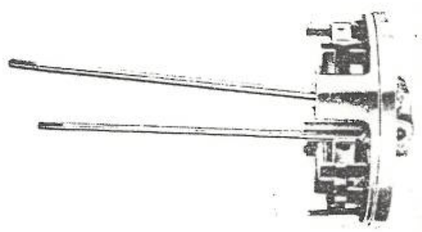


Fig. 10-101

(5) Remove the Stopper ring on the armature shaft end and then dismount the clutch assembly.

10-9-5 Maintenance and inspection

(1) Inspecting the armature

1) Armature shaft bending

Check the armature shaft bending with use of a dial gage. If the bending is in excess of 0.1mm, the shaft should be rectified. (See Fig. 10-102)

Measuring the Shaft Bending

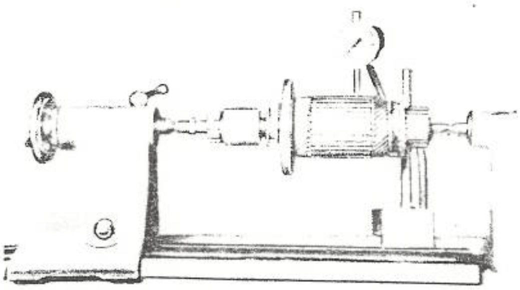


Fig. 10-102

Conduction Test on Armature

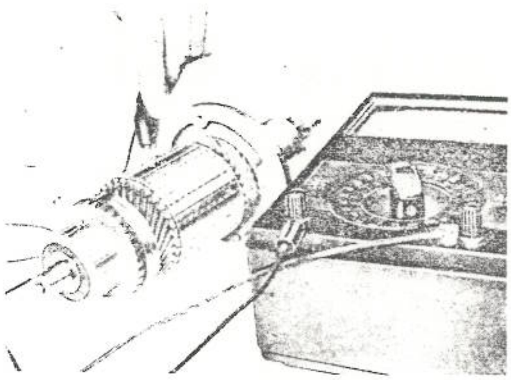


Fig. 10-103

2) Inspecting the commutator

If the commutator face is fouled or glazed, rectify with abrasive paper. If the deflected wear is in excess of 0.4mm or the subsidence of the mica insulator is below 0.2mm rectify the commutator in a lathe to hold the deflection within 0.05mm and to make the depth of mica insulator to 0.5 - 0.8mm. The limit for reduction in the commutator diameter is 2mm.

3) Conduction test between the commutator and shaft

Contact one of the tester nozzle to armature shaft and another to commutator as illustrated in Fig. 10-103. If conduction takes place therebetween, the armature is short-circuitted and hence, it should be regarded due for replacement.

4) Testing the armature

Mount the armature on the tester and carefully turn the armature with finger while the hacksaw blade is held right against the armature. If the armature is short-circuitted, the hacksaw blade is either magnetized or vibrates. The armature should then be replaced. (See Fig. 10-104) At which time check to make sure that the soldered portion on the commutator is normal.

5) Inspecting the yoke

Check the insulation between the field coil and yoke with use of a tester. If conduction takes place therebetween, check the terminal connections for insulating effect and if this part is free of trouble, the trouble may

Testing the Armature

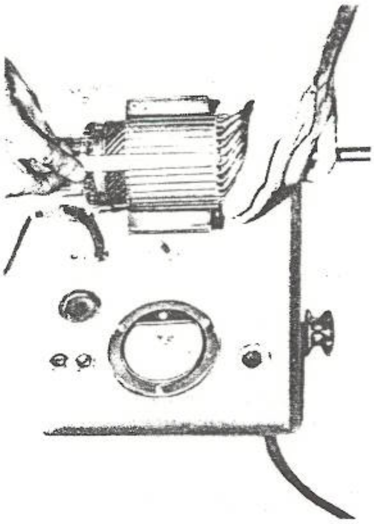


Fig. 10-104

be attributed to short-circuitted layer in the field coil. In the event of such trouble, turn loose the screw on the pole core and replace the field coil. (See Fig. 10-105)

Checking the Yoke

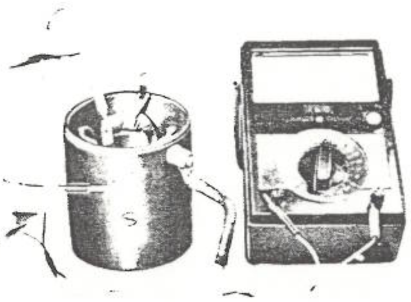


Fig. 10-105

6) Inspecting the rear cover

a) Check the height of the carbon brush if it retains 14mm.

b) The brush spring tip should be hooked with a spring balance thereby checking its pressure as illustrated in Fig. 10-106. The balance should be pulled in parallel with the brush to measure the force required for the spring to release from the brush. The brush strength is normally of the order of 0.9 - 1.1 kg.

(2) Inspecting the gear case

Put the gear case metal through the armature shaft. If the clearance is in excess of 0.2mm, the metal should be replaced. For inserting a new metal, the inside diameter of which should be finished to 14ϕ.

After the metal is finished, smear it with engine oil SAE 10-20#.

(3) Inspecting the over-running clutch

Clamping interference is provided between the driving spring and sleeve. This is normal at 0.25-0.5mm. If the clamping margin is reduced due to wear, bend the edge of the spring inner ward to adjust the inner diameter to 0.7mm in the manner illustrated in Fig. 10-107 and smear it with engine oil and then, as-

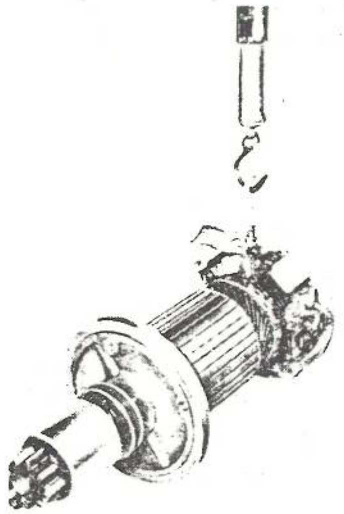


Fig. 10-106

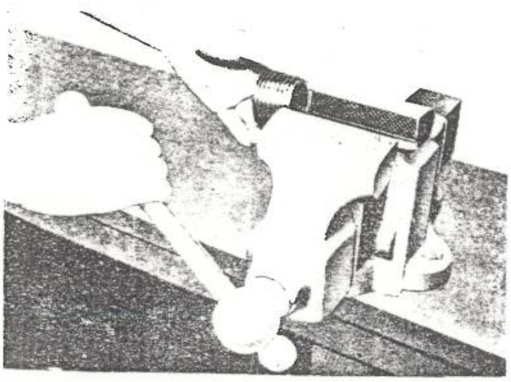


Fig. 10-107

semble it. The method for removing the drive spring is illustrated in Fig. 10-108. For inserting the drive spring back into place, see Fig. 10-109.

(4) Inspecting the engagement

Remove the solder from the terminal and remove the nut

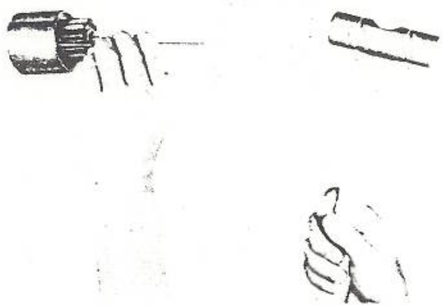


Fig. 10-108

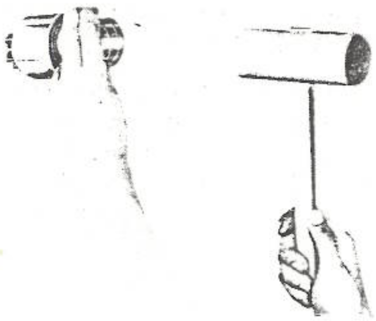


Fig. 10-109

and washer from the terminal C and then, dismount the switch cover. Slacken the lock nut on the adjust screw and then dismantle the adjust screw and return spring. Fig. 10-110 illustrates the magnet switch as dismantled. Fouled contactor face should be cleaned with use of abrasive paper.

1) Check to see if there is provided a clearance of 15± 0.1mm between the switch

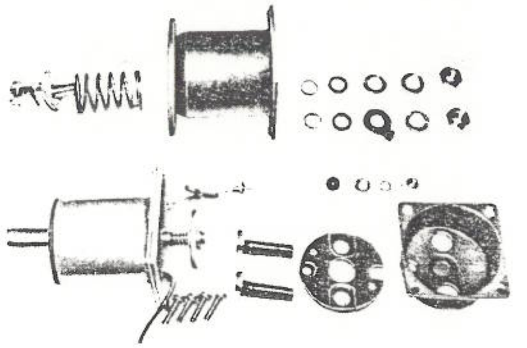


Fig. 10-110

cover and the terminal bolt when the terminal bolt is clamped to the switch cover. (See Fig. 10-111)

2) After all the parts are reassembled, adjust the distance represented by L in Fig. 10-112 to 56.5mm and secure parts with the lock nut. Then mount the switch on the starter and make necessary adjustment in the following sequence.

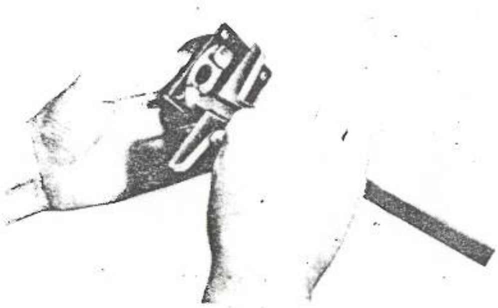


Fig. 10-111

a) Fasten the engage securely to the body.

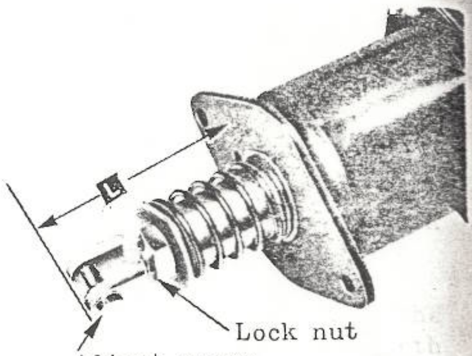


Fig. 10-112

b) Carefully move the pin reciprocally to see if there is provided an excessive play. Play of 0.3-0.5mm is rather desirable and if there is no play, remove the engage from the body and slacken the adjust nut and then, screw in the adjust screw a little. If the play is in excess of 0.5mm, turn loose the adjust screw and fix it with the lock nut.

c) Connect the tester in the circuit between the terminals B and M on the engage.

d) Remove the rubber cap on the upper part of the gear case and then insert a screwdriver through the hole and press the pinion. Check to see if the pinion comes in contact with the pinion stopper and further travel innerward thereby giving the tester response.

e) Retract the pinion until it comes in contact with the pinion stopper and check to see if conduction takes place between the terminals B and M on the engage. (See Fig. 10-114)

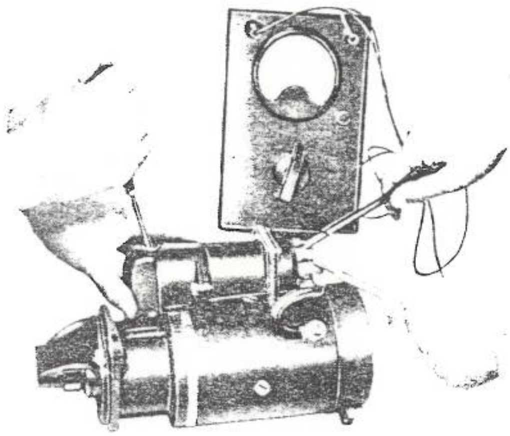


Fig. 10-113

Conduction should not take place if the engage is properly adjusted. If conduction takes place between the said terminals, the starter may often fail to stop when the starter switch is turned off after the engine is started.

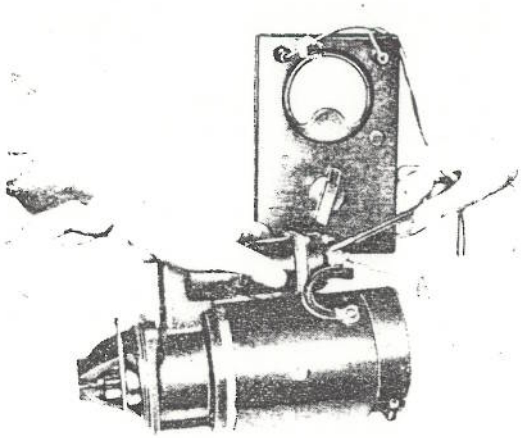


Fig. 10-114

10-9-6 Inspecting the change-over switch

(1) Clean the contact point with abrasive paper if it is fouled.

(2) Upper contactor gap is 1mm +0 -0.2 and main contactor gap is 2mm +0.2 -0.

(3) Measure the pressure of the upper contact. This is standard at 200-300gr.

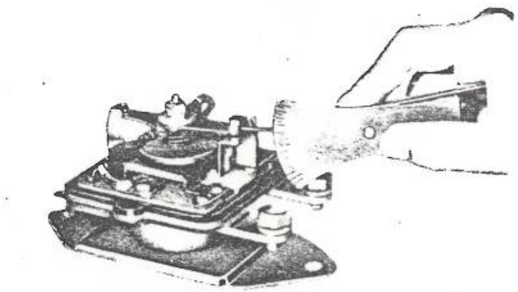


Fig. 10-115

(4) Pressure on the contact point held in contact with the terminal Ce is standard at 300-400gr. Replace the contact point is pressure is excessively low.

For measuring the point pressure, read the value on the pressure when the point opens.

Maintenance Standard

Unit (mm)

Check spot			Due for correction	Standard value for assembling	Service limit	Correction	Remarks
Armature shaft	Clearance between shaft and bearing	Gear case bearing	Above 0.2	0.016～0.052		Replace the bearing	Gear case bearing 14ϕ
		Rear cover bearing	Above 0.2	0.016～0.052		Replace the bearing	Rear cover bearing 16ϕ
		Center bearing	Above 0.25	0.070～0.141		Replace the bearing	Center bearing 25ϕ
	Wear and bending of the shaft		Above 0.1		0.05	Replace the shaft Rectify	
Commutator	Wear in the commutator diameter				3.0	Replace	Nominal dimension 49ϕ
	Deflected wear in the commutator diameter		Above 0.4	Below 0.05		Rectify	
	Depth of the mica insulator in the commutator		Below 0.2	0.5～0.8		Rectify	
	Commutator face					Rectify with abrasive paper if fouled or scuffed	
Carbon brush	Brush and brush spring				Length of the brush to 14mm	If the contacting face of the brush to commutator is not correct, or the tensile force of the brush spring is not even or the tension is too wear or too strong, the wear of the brush is accelerated. If the brush bracket is not normal, correct it.	Nominal length of the carbon brush 25. Tensile strength of the carbon brush as mounted in place is 0.9 1.1kg.
Pinion						If the wear is serious, rectify or replace it.	
Clearance between the pinion bearing and shaft			Above 0.2	0.032～0.068		Replace the bearing	Shaft 14ϕ

10-10 ALTERNATOR AND VOLTAGE REGULATOR (NIKKO)

10-10-1 Specifications

Alternator		Voltage regulator	
Type	12AGY	Type	12AR
Rated capacity	12V/400W	Adjusting method	
Power output	13V/31A (3000 rpm)	Non-load adjusting voltage	14±0.50V (2500 rpm)
Direction of rotation	Right (as viewed from pulley side)	Field relay operating speed	Below 1100 rpm
Pulley diameter	80ϕ	Ground polarity	⊖
Ground polarity	⊖	Weight	0.58 kg
Rectification	three phase all-wave rectification		
Brush	2 (Two) 7x7x14 (mm)		
Bearing	Front 6204VV Rear 6203VV		
Weight	6.5 kg		
Field coil resistance	4		

Table 10-4

10-10-2 On-the-spot trouble-shooting

On detection of charging failure, check the fan belt tension, circuit disconnection, short-circuitting, incorrect wiring, loosened terminal connection and contact point failure before dismantling the alternator and voltage regulator.

(1) Measuring the circuit resistance

Meters used for this test

Ammeter ... having maximum division of 15-30A

Volt meter ... having maximum division of 1-5V

1) PR20 series (with single battery)

a) Connect ammeter and volt meter into circuit illustrated in Fig. 10-116.

b) Start the engine and check to make sure that the charging current is generated and then, hold the engine at idling speed. Then connect the terminals B and F on the alternator in jumper and disconnect the terminal lead F from the voltage regulator.

c) Disconnect the leads from the meter.

d) Gradually increase the engine speed and adjust the engine speed to hold the charging current to 10A.

e) Then, connect the volt meter in circuit as illustrated in Fig. 10-117 and measure the voltage drop in the negative side. Check to make sure that the voltage difference is within 0.4V.

2) PR-D10 series (with two-battery)

Measure the voltage drop in the individual charging circuit as illustrated in Fig. 10-118. For diesel engine, turn the starter switch off instead of disconnecting the meter connections.

a) B side of the battery regarded as normal if the addition of volt meter reading (3) (4) and (2) comes lower than 0.4V when the ammeter (1) reading is at 10A. If the voltage drop is more than 0.4V, check the charging circuit and make necessary corrections.

(2) Inspecting the alternator output

Meters used:

Ammeter ..... having divisions of 50A

Volt meter .. having divisions of 20-30V

Tachometer .. Hone or hustler

Variable resistor ... Maximum load 50A

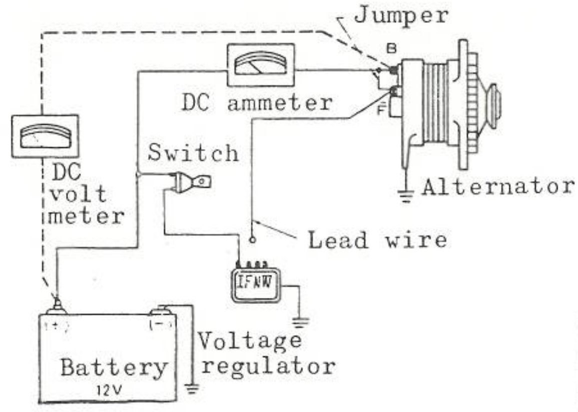


Fig. 10-116

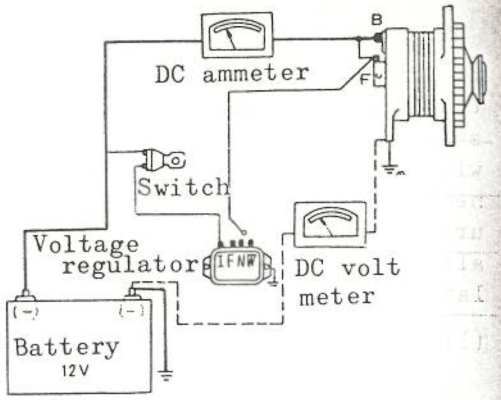


Fig. 10-117

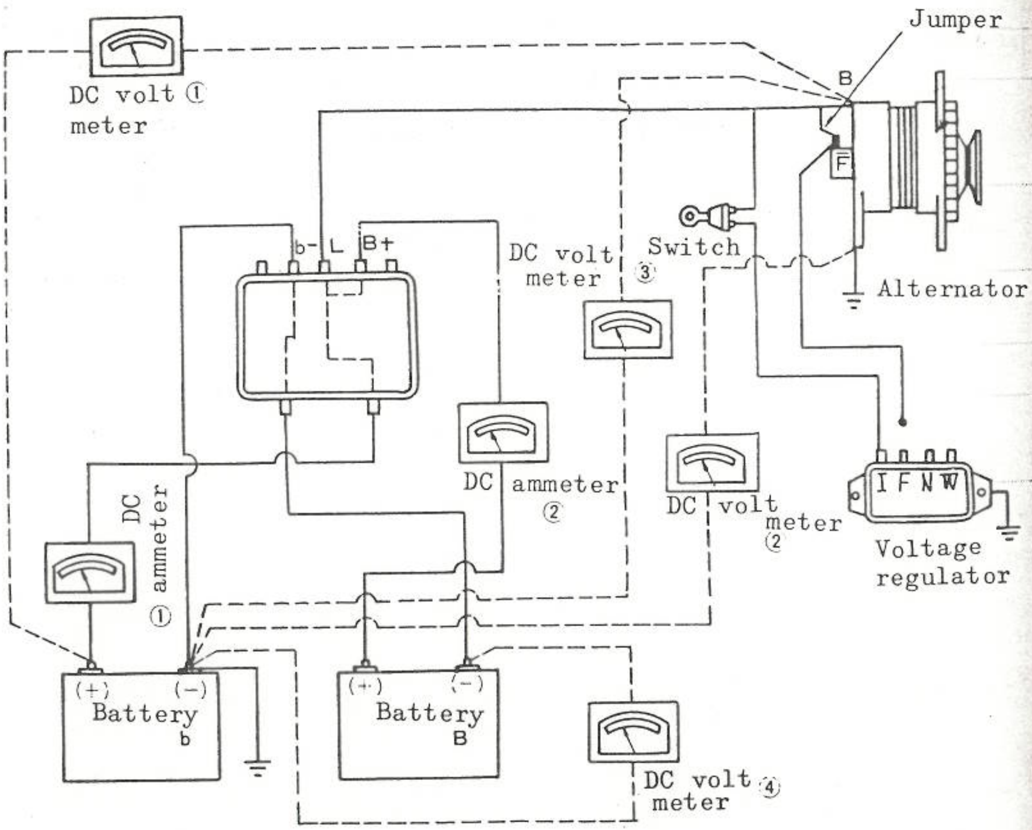


Fig. 10-118

1) Connect the volt meter, ammeter and variable resistor in the manner illustrated in Fig. 10-119.

2) Start the engine and check to make sure that the charging current is generated and then hold the engine at idling speed.

3) Connect the terminals B and F of the alternator in jumper and then, disconnect the voltage regulator terminal lead F.

4) Gradually increase the engine speed and when the volt meter indicate 13V, turn on the variable resistor switch and adjust the rotation of the alternator to 3,000 r.p.m. Hold the voltage from increasing beyond 15V and set the engine speed while adjusting the voltage with use of variable resistor.

5) Adjust the load with variable resistor to hold the volt meter reading to 13V, then read the ammeter indication and compare it with the output given in the Table 10-3. If the meter reading is excessively lower than the specified value, dismantle the alternator and make necessary correction.

6) For models PR-D10, connect the variable resistor into position as illustrated in Fig. 10-120 and test the charging circuit for failure.

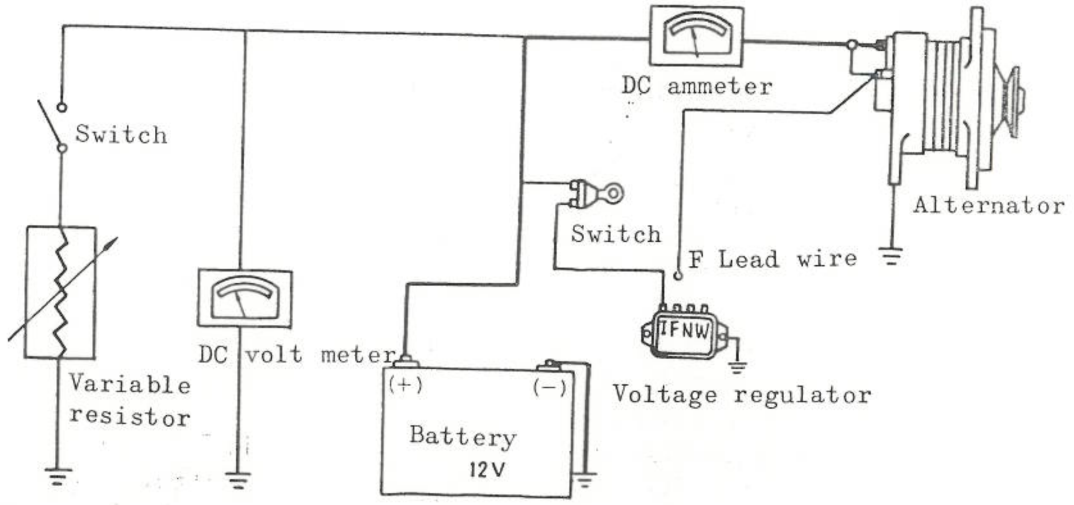


Fig. 10-119

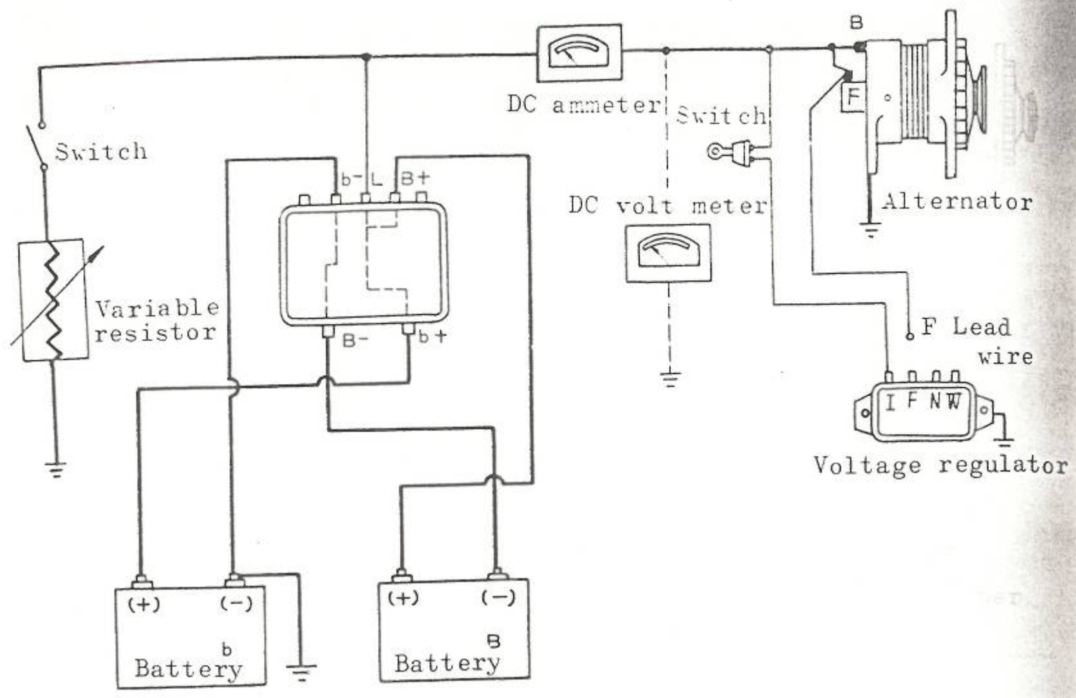


Fig. 10-120

(3) Measuring the regulator voltage

Meters used:
Volt meter .....
having measuring range of 20-30V

Volt meter .....
having measuring range of 10-15V

1) Connect the volt meters as illustrated in Fig. 10-121, and turn off all the load other than battery. Start the engine and keep charging the battery by operating the alternator

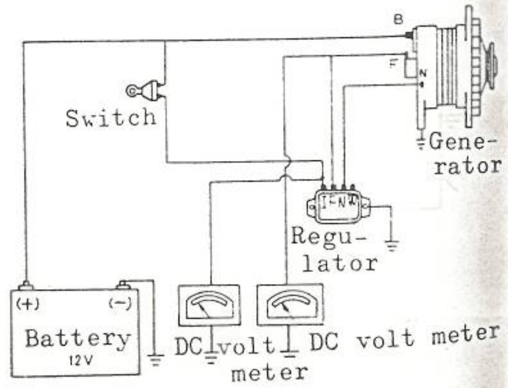


Fig. 10-121

at 3,000 r.p.m. until the voltage measured by connecting the volt meter between the terminal F of the alternator and ground indicates 4V or above.

2) Stop the engine and again start it to see if charging current measured at position between the terminal (1) of the voltage regulator and ground comes between 13.5 - 14.0V when the engine speed is increased from idling.

10-10-3 Dismantling the alternator for inspection

(1) Dismantling

1) Remove the pulley clamping nut and then dismount the pulley. Also remove the brush and brush cover from the rear cover. (See Fig. 10-122)

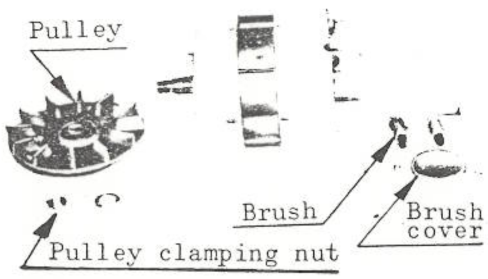


Fig. 10-122

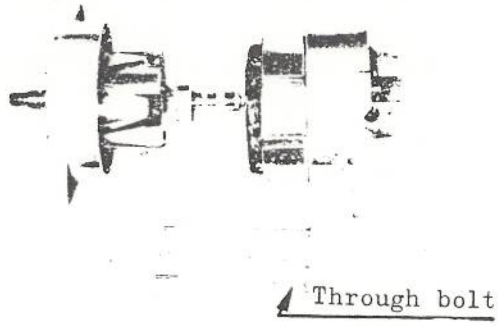


Fig. 10-123

2) Remove the through bolt and then, remove the front cover. (Fig. 10-123)

3) Remove the bearing retainer fixing bolt from the front cover and then, remove the rotor from the front cover. (Fig. 10-124)

4) Disconnect the joint between stator coil and diode and remove the stator and

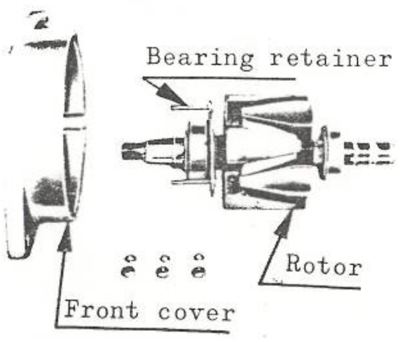


Fig. 10-124

rear cover. Then, remove the (+) diode base. Dismantling work is all complete when the above work is done. (See Figs. 10-125 and 10-126).

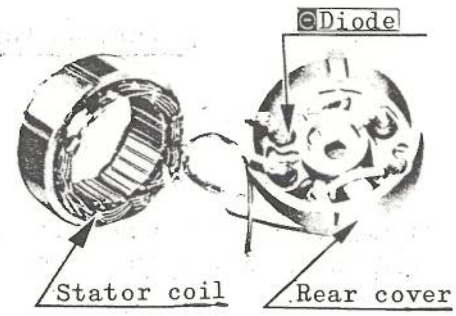


Fig. 10-125

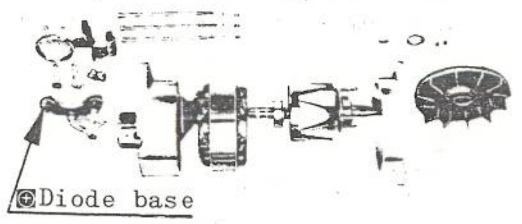


Fig. 10-126

(2) Inspecting and repairing

1) Check to see if the carbon brush operates freely in the brush holder. Replace the brush if it is worn and no longer gives 7mm. (See Fig. 10-127)

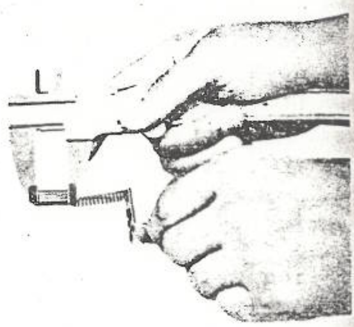


Fig. 10-127

2) The tensile strength of the brush spring is standard at 0.2 kg when it is compressed to 12mm. Weakened spring should be replaced.

3) Check the slip ring for roughened sliding face or deflected wear. Replace the slip ring if it fails to give 15mmø.

4) Check the bearing after every 24,000 km of travel distance and apply high temperature grease as necessary. If the bearing fails to rotate smooth or

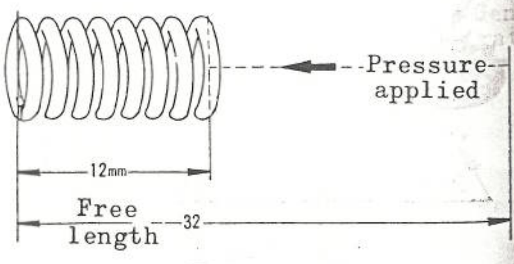


Fig. 10-128

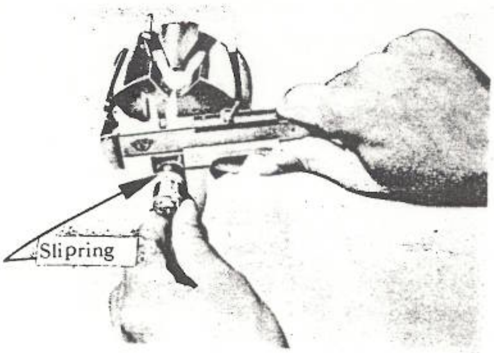


Fig. 10-129

the clearance of the bearing in the direction across to the shaft is in excess of 0.1mm, replace the bearing.

5) Measure the resistance of the field coil by holding tester nozzles right against the slip rings. The resistance of the field coil may be regarded as normal if the measured value is between 4-5 ohms. If the value is lower than 4 ohms, the trouble may be attributed to internal short-circuit. Greater resistance may be provided if the field coil is disconnected. (Fig. 10-131)

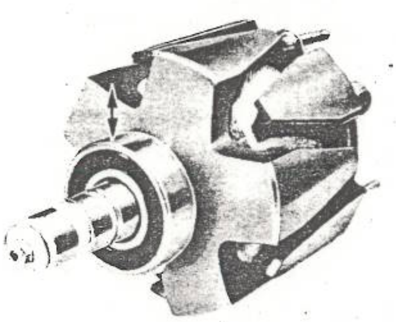


Fig. 10-130

6) For checking the stator coil, disconnect the circuit between the stator coil and diode and then, connect the tester between the lead of the coil and the core, if conduction takes plate therebetween, the trouble may be attributed to short-circuit. (See Fig. 10-132)

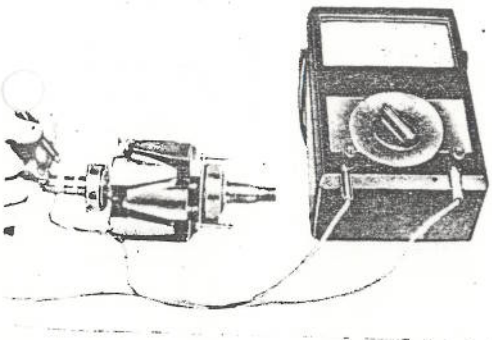


Fig. 10-131


Fig. 10-132

The stator coil may be regarded as normal if the resistance measured between three of the lead wires is almost close to 0 and if conduction does not take plate between lead wires, the trouble may be attributed to disconnection. (Fig. 10-133)

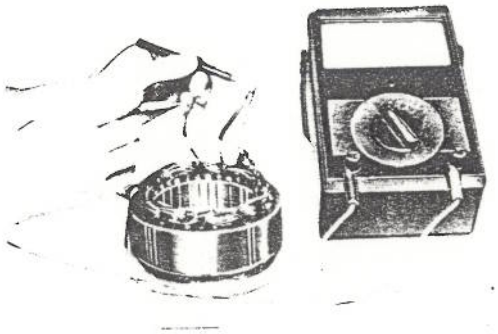


Fig. 10-133

Trouble with the stator coil can easily be detected in the manner similar to diode failure, as the fan belt vibrates and abnormal noise arises when the alternator is put into operation.

7) For inspecting the silicone diode, remove the connections between the stator coil and silicone diode and leads of the diode. The use of megger should be definitely avoided for the silicone diode is susceptible to damage due to high voltage developed by the tester. For checking the

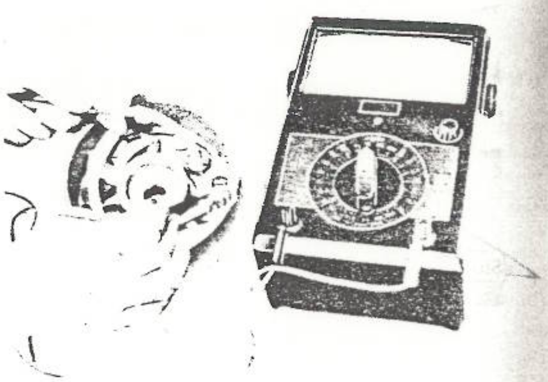


Fig. 10-134

positive side of the diode (identified with blue color), connect the positive lead of the tester to terminal B of the alternator and negative lead of the tester to outlet of the diode and then, check to see if conduction takes place therebetween. Conduction does not take place if wrong connections are made. (See Figs. 10-134 and 10-135) If conduction does

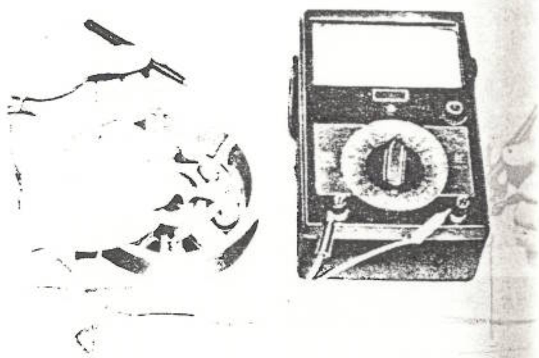


Fig. 10-135

not take place or the resistance is extremely low, the trouble may be caused by faulty diode.

For checking the negative side of the diode (identified with red color), connect the positive lead of the tester to outlet of the diode and negative lead of the tester to rear cover and check to see if conduction takes place.

(3) Reassembling

For reassembling the alternator, reverse the procedure for dismantling. Check the operation of the carbon brush, thrust bearing of the rotor and then, turn the rotor with finger to see if it rotate smoothly.

10-10-4 Dismantling and reassembling the voltage regulator

(1) Dismantling

1) Remove the voltage regulator cover.

2) Remove the resistors on the rear side of the voltage regulator. (See Fig. 10-136)

3) Remove the point retainer and armature plate from the yoke. (See Fig. 10-137)

4) Remove clamping nuts on the reverse side of the regulator and then remove the yoke and coil from the voltage regulator base. (Fig. 10-138)

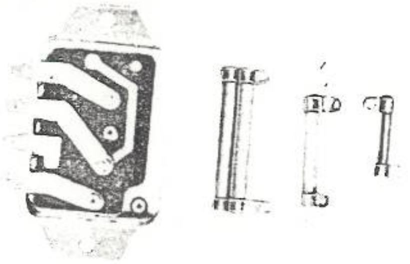


Fig. 10-136

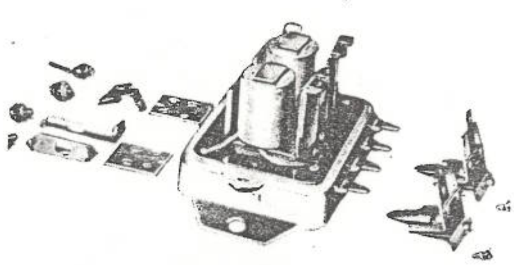


Fig. 10-137

(2) Inspecting and repairing

1) Fouled contact points should be cleaned with abrasive paper and wiped with clean cloth. Replace the contacts points if the wear is significant. (Fig. 10-139)

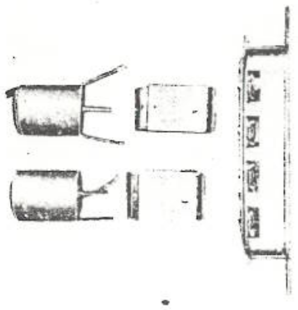


Fig. 10-138

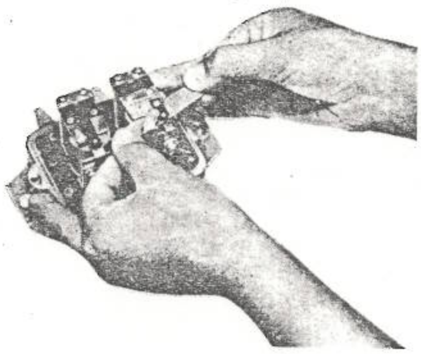


Fig. 10-139

2) For checking the pressure coil circuit in the voltage regulator, connect the tester between the terminal W and base. The coil may be regarded as normal if it is provided with 76 ohms of resistance. If conduction does not take place or the resistance is extremely low, the trouble may be attributed to disconnected or short-circuitted pressure coil or compensating resistor (55 ohms) and hence, the voltage regulator should be replaced. (See Fig. 10-140)

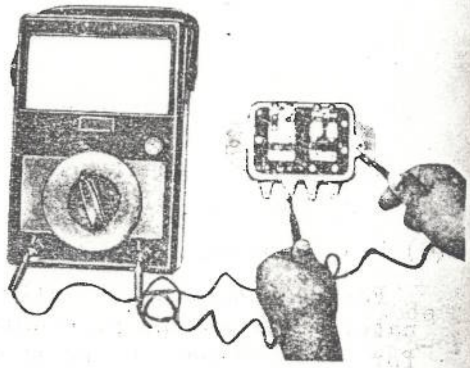


Fig. 10-140

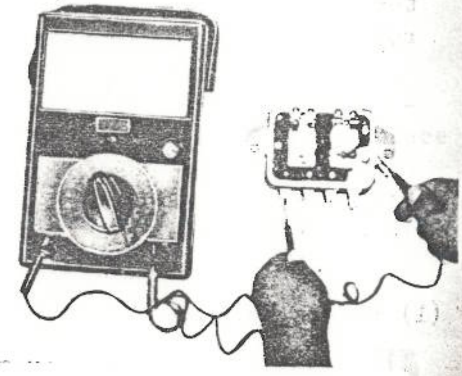


Fig. 10-141

3) For checking the pressure coil circuit in the field relay, connect the tester between the pressure coil terminal N and base. The coil may be regarded as normal if it is provided with resistance of 41 ohms. If conduction does not take

place or the resistance is extremely low, the trouble may be attributed to short-circuitted or disconnected pressure coil. The voltage regulator with faulty coil should be replaced. (Fig. 10-141)

(3) Reassembling

For reassembling the voltage regulator, reverse the procedure for dismantling.

1) Voltage regulator

(a) Mount the magnet yoke and coil on the voltage regulator base and then insert a gap gage (0.7mm) in the clearance between the yoke and armature plate. Then mount the armature plate on the yoke with plain screw. (The clearance between the yoke and armature plate is 0.7mm) (See Fig. 10-142)

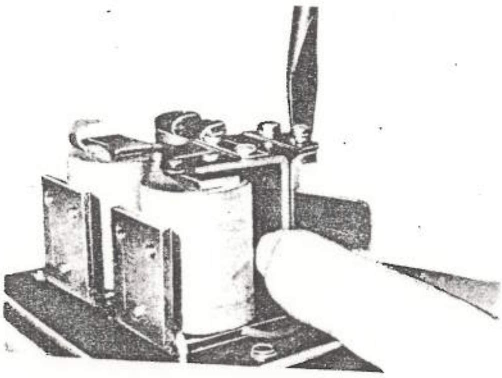


Fig. 10-142

(b) Insert a gap gage (1.1 mm) between the armature plate and magnet core and bring the lower contact point in light contact with the corresponding contact point and then fasten the lower contact point retainer in place with plain screw. (The points gap is 1.1mm) (Fig. 10-143)

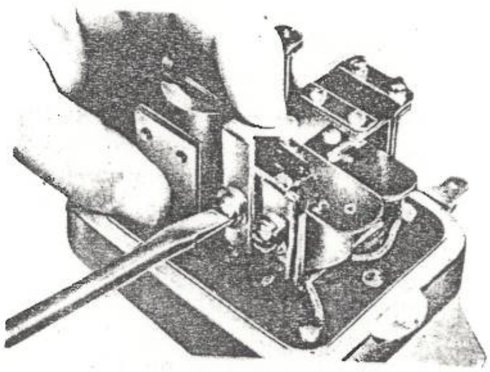


Fig. 10-143

(c) With the lower point held in contact with the corresponding point, insert a gap gage (0.3mm) into clearance between the upper points and fasten the upper point retainer to the body with plain screw. (Fig. 10-144)

(d) Adjust the clearance between the armature plate and adjust spring to 0.3-1.0mm by turning the adjust screw as necessary.

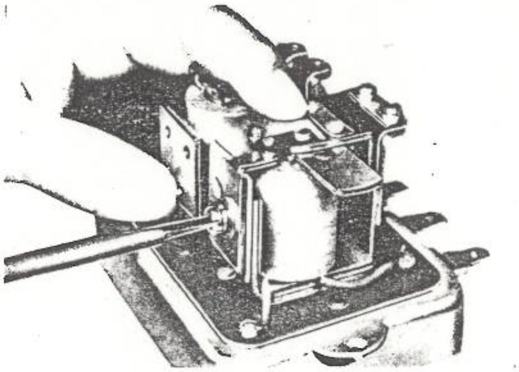


Fig. 10-144

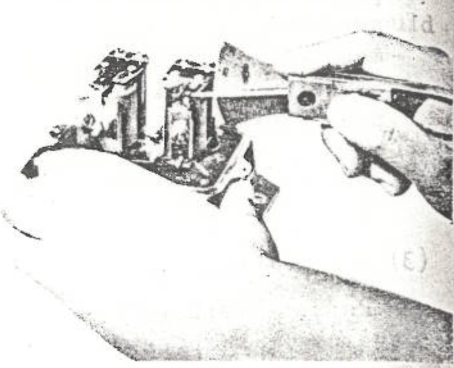


Fig. 10-146

(e) With use of tension gage, measure the low speed side point opening pressure as illustrated in Fig. 10-146. This is standard at 120gr - 130gr. If the point opening pressure is out of adjustment, adjust it by bending the lug on the yoke with use of an adjuster.

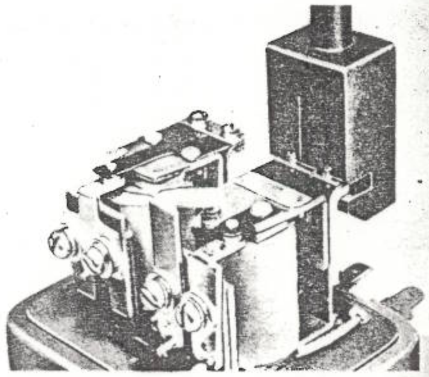


Fig. 10-147

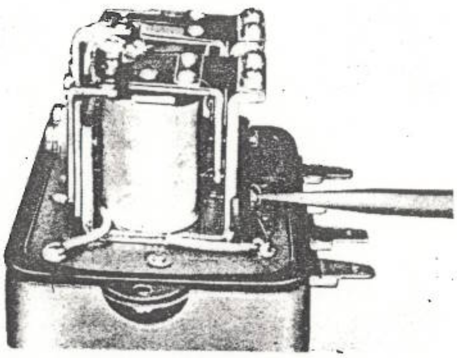


Fig. 10-145

2) Field relay

(a) Insert a gap gage (0.9 mm) into the clearance between the yoke and armature plate is 0.9mm) (Fig. 10-148)

(b) Insert a gap gage (0.9 mm) into the clearance between the armature plate and magnet core and bring the lower point into light contact with the corresponding point and then

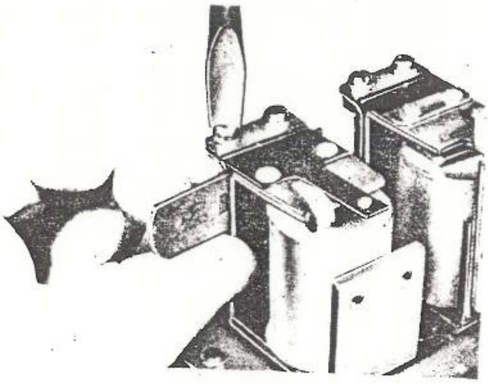


Fig. 10-148

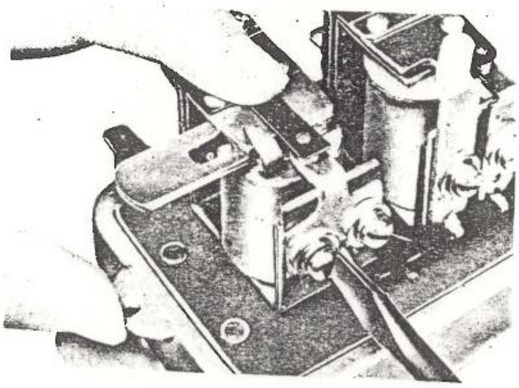


Fig. 10-149

fasten the lower point retainer to the base with plain screw. (Fig. 10-149)

(c) Insert a gap gage (0.5 mm) into the clearance between the lower and upper point and then, bend the stopper point to bring it in light contact with the armature plate. (The point gap is 0.5mm) (Fig. 10-150)

(d) Further turn the adjust screw in after it has reached the adjust plate.

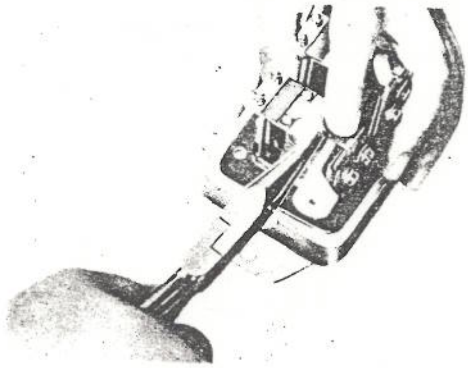


Fig. 10-150

(4) Adjusting

1) Voltage regulator

In the same manner as introduced in subparagraph 10-10-2 above, charge the battery until the voltage measured between terminals F and E becomes below 4V.

2) Stop the engine and again start it and accelerate the speed to vary the voltage between the terminals I and E. If the adjusting voltage comes between 13.5 - 14.0V (at normal operating temperature) within the range of low and high speed, the voltage regulator may be regarded as normal. If the voltage thereof is in excess of 13.5 - 14.0V turn the adjust screw counterclockwise to reduce the voltage and turn it clock-

wise to increase the voltage.

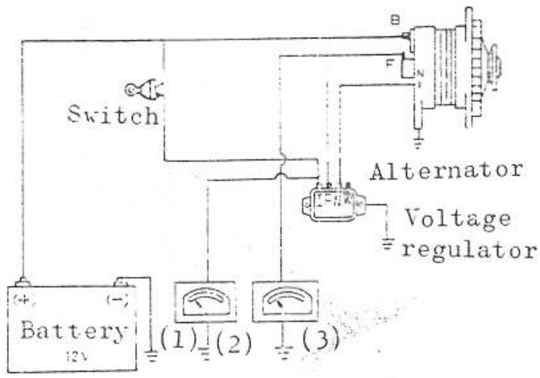


Fig. 10-151

(1) - DC voltmeter
(2) - DC voltmeter
(3) - DC voltmeter

3) Variation in the voltage in the circuit between the terminals I and E when the engine speed is increased is not detrimental to normal charging operation, but if the voltage thereof

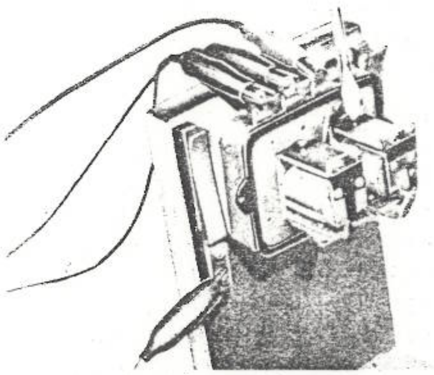


Fig. 10-152

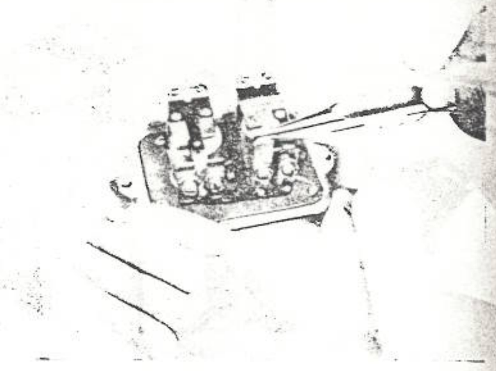


Fig. 10-153

tends to increase beyond 5V, adjust the voltage regulator by bending the point retainer downward in the manner illustrated in Figs. 10-153 and 10-154.

If the voltage tends to drop when the engine speed is increased, also adjust the voltage by adjusting the voltage regulator by bending the point retainer upward.

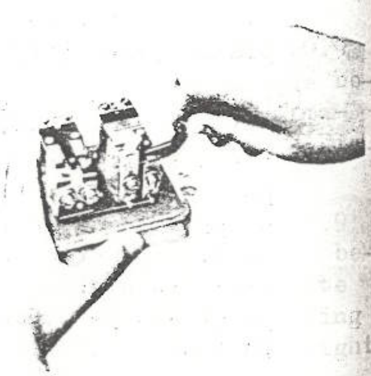


Fig. 10-154

4) If the adjusting screw fails to adjust the voltage, adjust the voltage regulator by bending the lug on the yoke with use of adjuster as illustrated in Fig. 10-147.

5) The adjustment of the voltage regulator is complete when the above adjustments are all done. But to make double-check, stop the engine and again start it and increase the speed to see if the charging voltage comes within 13.5 - 14.0V (at normal operating temperature).

(2) Field relay

Increase the operating speed of the alternator and check to see if the field relay point closes and the ammeter indication increases to 2.8A when the voltage in the circuit between the terminals N and E becomes 3.0 - 4.0V. If the points closes only when the voltage increases beyond 3.0 - 4.0V, adjust the voltage by turning the adjusting screw counter-clockwise. If the points closes with the voltage lower than 3.0 - 4.0V, turn the adjusting screw clockwise to adjust the voltage. (See Fig. 10-156)

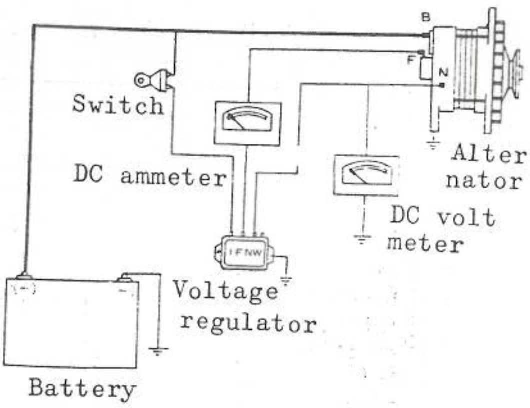


Fig. 10-155

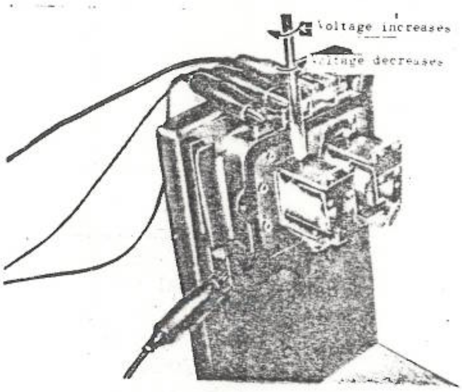


Fig. 10-156

10-10-5 Maintenance standard

The maintenance standards for alternator and voltage regulator are listed in Tables 10-5 and 10-6, respectively.

Maintenance Standard

For Alternator (The values are represented in metric system)

Item		Nominal dimension	Value requiring service	Standard value as assembled	Service limit	Correction
Rotor shaft	Shaft bending		Above 0.07mm			Rectify or replace
	Clearance between the rotor shaft and ball bearing		Above 0.1mm	Maximum 0.05mm		Replace the bearing
Slip ring	Diameter	17mm			15mm	15mm
	Deflected wear of the diameter		Above 0.4mm	Below 0.05mm		Replace
	Contacting face of the slip ring					Fouling or scuffing on the face may be cleaned with emery cloth
Length of carbon brush		14mm			7mm	
Tensile strength of the brush spring		Torque required to compress the spring to 20mm should be about 0.2kg				

Table 10-5

Maintenance Standard for Voltage Regulator

(The values are represented in metric system)

	Voltage regulator	Field relay
Operating clearance	1.1~1.2	0.9
Fixed clearance	0.7	0.9
Point clearance	0.3	0.5
Control resistor	10 (Ω)	—
Compensating resistor	55 (Ω)	—
Field resistor	—	17 (Ω)
Pressure coil	About 21 (Ω)	About 41 (Ω)

Table 10-6

10-11 RADIO RECEIVER (NATIONAL ELECTRIC COMPANY)

10-11-1 Specifications
(See Fig. 10-7)

Circuit: RF single stage
IF 2-stage amplification
6 transistors

Tuning: u-tuning, manual push button

Range of cycles:
535KC - 1605KC

Sensitivity:
20μV (20dB) or less (at output 0.5W)

Intermediate cycle:
455KC

Selectibility:
Above 18dB (±10KC)

AGC characteristic:
Above 40dB

Maximum output:
Above 2.5W
(Maximum output without strain above 2W)

Output impedance: 8 ohms

Fidelity

	High tone	Low tone
100c/s	Within ±4dB	Within ±4dB
400c/s	0dB	0dB
2000c/s	—	Above -10dB
4000c/s	Within -15dB	—

Voltage of power source:
DC11~ 16V (Standard voltage 13.2V)

Power consumption:
About 9.9W (13.2V x 0.75A at maximum output)

Table 10-7

10-11-2 Construction

1. Radio receiver:
   Weight about 2 kg
   (Fig. 10-157)

2. Speaker:
   Weight about 500gr
   (Fig. 10-156)

3. Antenna:
   Weight about 400gr
   over-all length
   1060mm
   (Fig. 10-157)

10-11-3 Operating method

(1) Combination dial for power and volume (Fig. 10-157)

1) The power turns-on when the button is pushed and turns-off with another pushing.

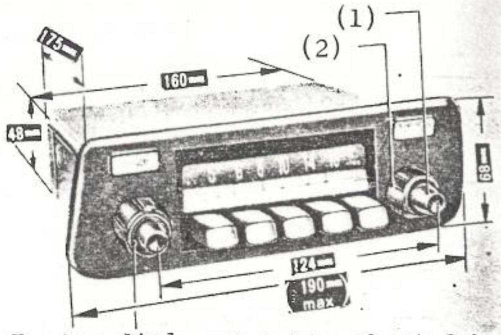


Fig. 10-157

(1) - Combination dial for power and volume
(2) - Tone control dial

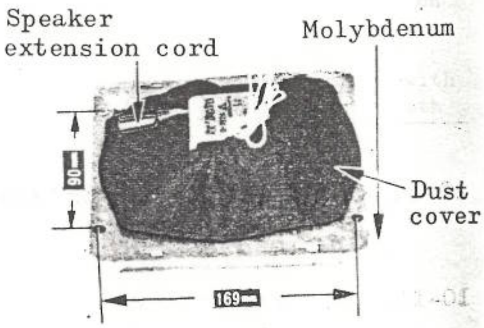


Fig. 10-158

2) The volume increases as the dial is turned clockwise.

(2) Tone control dial (Fig. 10-157)

1) Tone rises with the dial turned clockwise and lowers with it turned counter-clockwise.

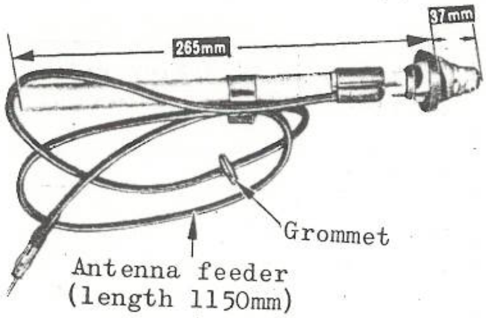


Fig. 10-159

(3) Tuning dial (Fig. 10-157)

This is for use in selecting the frequency without using the push botton control. This may also be used for setting the push botton.

(4) Method for adjusting the push botton

Pull the push botton all the way out and select the frequency with use of tuning dial and then, push the button all the way in.

10-11-4 Arrangement of the component parts

10-11-5 Method for adjusting

(1) The following preparations should be made prior to adjustment.

1) Power source: DC 13.2V

2) Volume: Volume control turned to maximum and tone control also turned to maximum

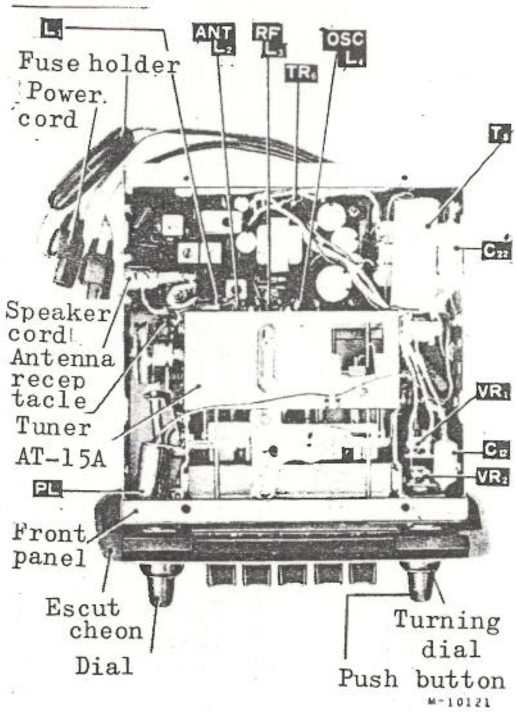
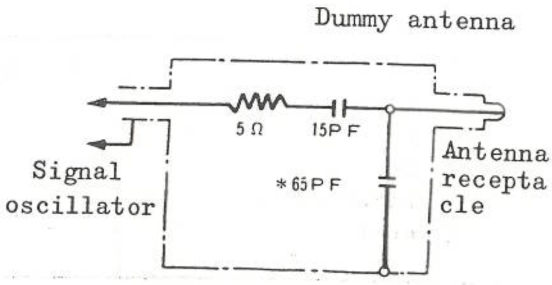


Fig. 10-160

Dummy antenna



*65PF include capacity of the feeder

Fig. 10-161

Procedure for adjustment

Sequence of adjustment	Adjusting spot		Signal frequency	Position of frequency pointer	Adjusting method
1	IFT adjustment	IFM_1 (Black)	455 KC	Set the pointer in right end	Make the adjustment several times to provide maximum output
2		T_3 (White)	"	"	
3		T_2 (Blue)	"	"	
4		T_1 (Pink)	"	"	
5	OSC adjustment	L_4 (Red)	525 KC	Point at which the frequency is lowest (left)	Calibrate to control so as to receive signal at any point within range of all frequency bound
6		TC_3	1650 KC	Point at which the frequency is highest (right)	
7	RF, ANT. Matching adjustment	TC_2	1400 KC	1400 KC point	Make the adjustment several times to provide maximum output
		TC_1	1400 KC	1400 KC point	

Table 10-8

3) Signal oscillator output:
Modulation frequency 400c/s
Modulation 30%

4) Signal supply: Antenna receptacle

5) Dummy antenna: Refer Fig. 10-161

(2) Sequence of adjustment

Adjustment should be made in the sequence given in Table 10-8 with reference to Fig. 10-162.

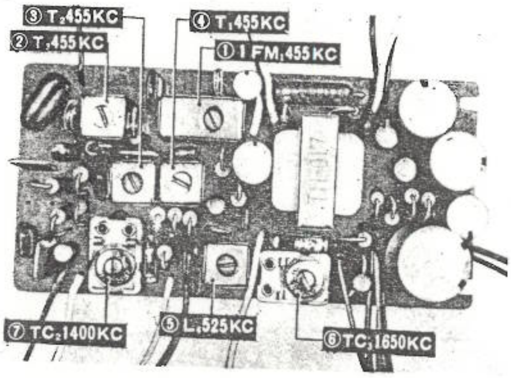


Fig. 10-162

(3) After the radio is installed in automobile, select the frequency for broadcast where the power is greatest and then, make readjustment on the antenna matching trimmer (TC_1) to make the output maximum.

10-11-6 Noise interference

Noise of the radio may be classified into: 1. Noise caught by the antenna and 2. transmitted from the power circuit.

(1) Noise arises from the high tension cord and distributor

1) Check to see if engine hood hinges are provided with jointing compound. Such noises may be practically killed by inserting noise supressor or condenser into circuits as illustrated in Figs. 10-163 and 10-164.

(2) Noise arises from the alternator

Alternator is readily equipped with the condenser and hence, further treatment is not required. For DC generator, insert a condenser in the circuit as illustrated in Fig. 10-165.

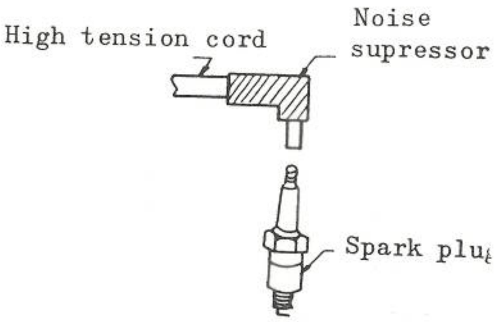


Fig. 10-163

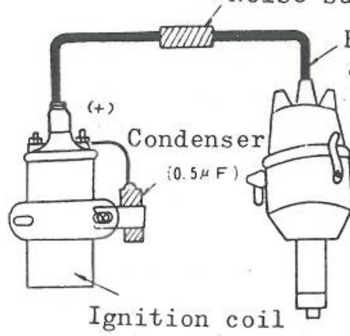


Fig. 10-164

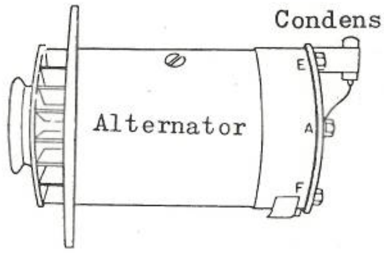


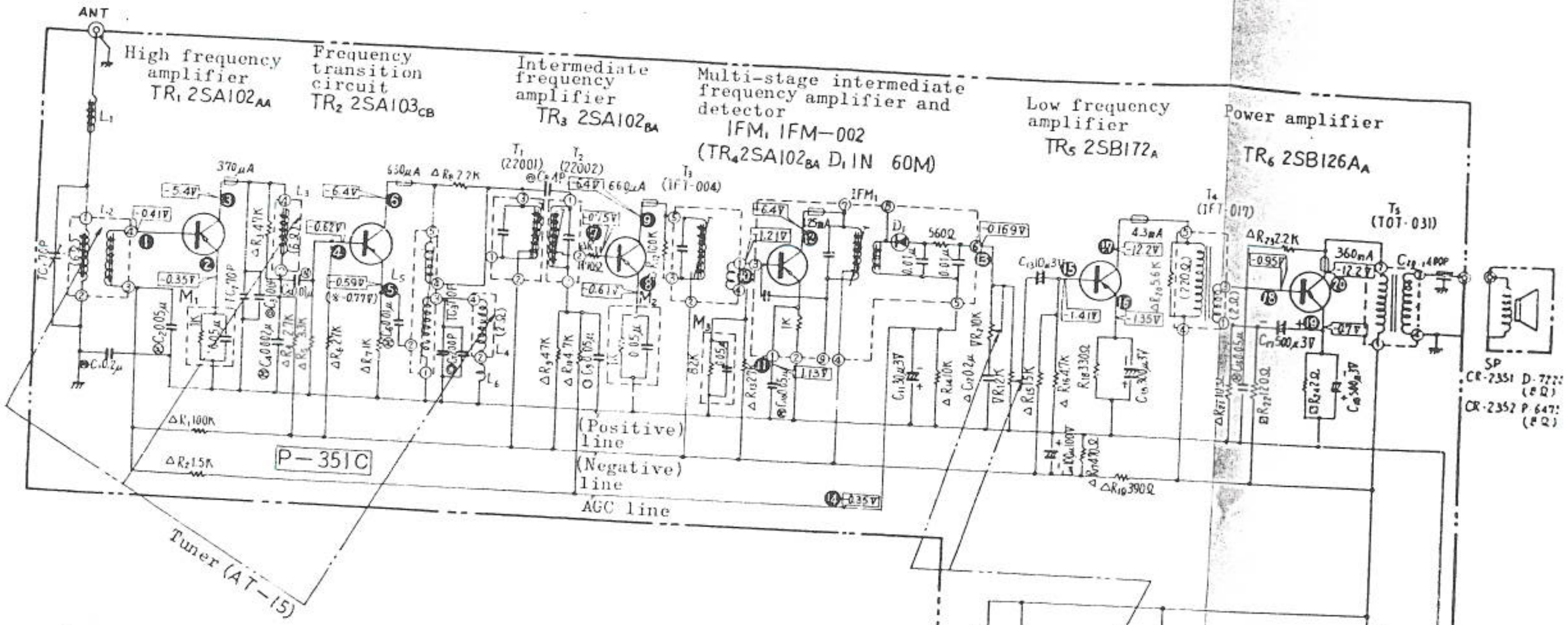
Fig. 10-165

(3) Noise arises from the voltage regulator

Insert a condenser between the terminal B of the voltage regulator and ground.

(4) Noise arises from the windshield wiper motor

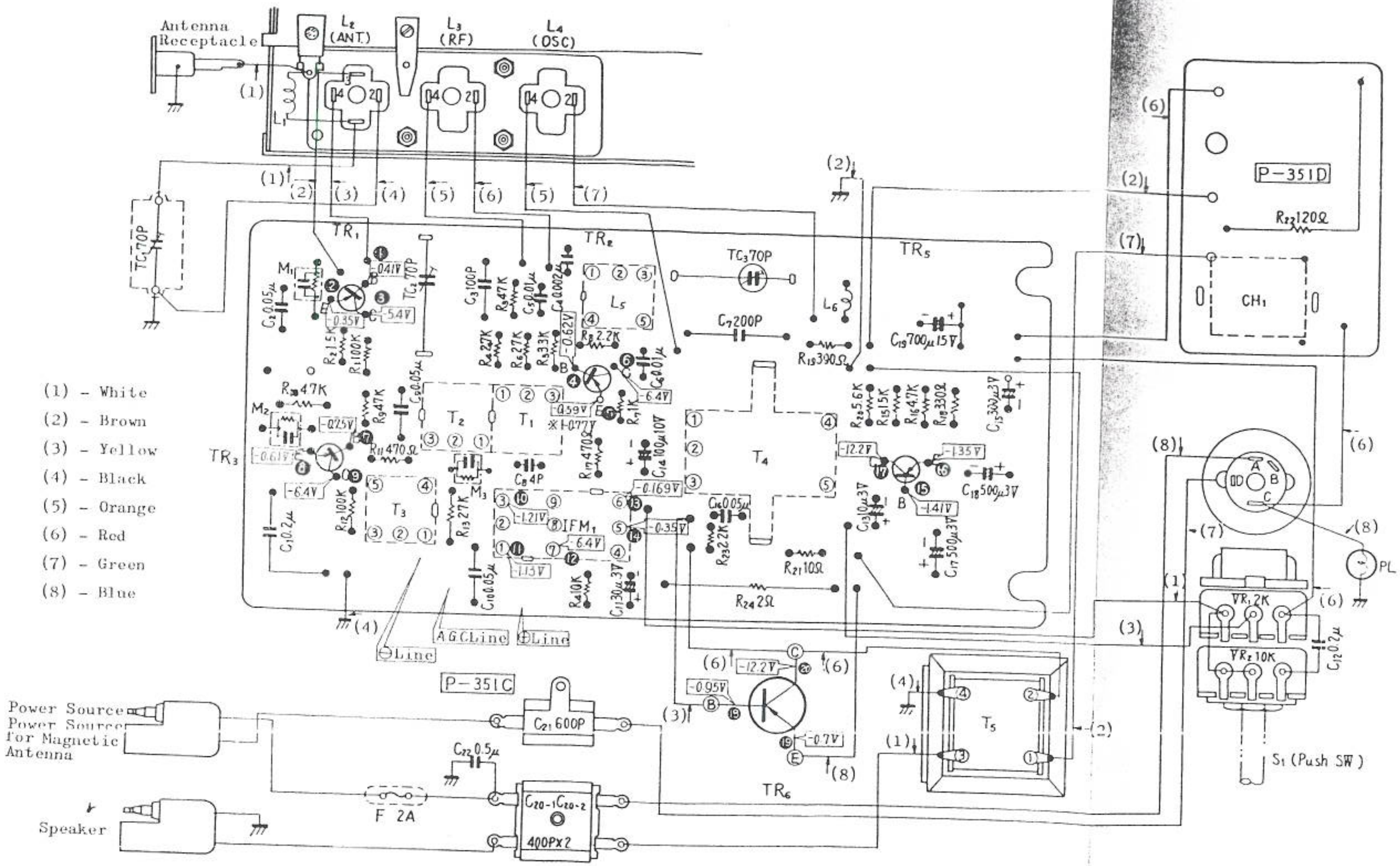
Insert a condenser between wiper motor power cord (identified with blue color 0.5) and ground.



Identification symbol

Resistance:
- △ Solid resistance
- ○ Carbon film resistance
- □ Coil resistance
- ⊘ Resin resistance
- ⊠ Laminated resistance

Condenser:
- ⊠ Paper condenser
- ⚠ MP condenser (MPBS)
- △ MP condenser (MPAR)(MPOR)
- ▲ Mica condenser
- ○ Titanium variable condenser
- ◎ Titanium condenser (parallel)
- ● Titanium condenser (For compensating the temperature)
- Ⓢ Styrol
- Ⓜ Miller
- Ⓣ Tantalum



Antenna Receptacle
L_2 (ANT.)
L_3 (RF)
L_4 (OSC)
L_1
TC_1 70P
TR_1
TR_2
TR_3
TR_5
TR_6
T_1
T_2
T_3
T_4
T_5
L_5
L_6
IFM₁
C_7 200P
TC_3 70P
R_{19} 390Ω
C_{19} 700μ 15V
R_{24} 2Ω
R_{21} 10Ω
P−351C
P−351D
R_{22} 120Ω
CH_1
PL
VR_1 2K
VR_2 10K
C_{12} 0.2μ
S_1 (Push SW)
C_{21} 600P
C_{22} 0.5μ
C_{20-1} C_{20-2} 400P×2
F 2A
AGC Line
⊖Line
⊕Line
(1) − White
(2) − Brown
(3) − Yellow
(4) − Black
(5) − Orange
(6) − Red
(7) − Green
(8) − Blue
Power Source
Power Source for Magnetic Antenna
Speaker

PART 11 SPECIAL TOOLS

CONTENTS

PART 11 SPECIAL TOOLS

Parts Number 8523-1212

Parts Name

Valve Guide Replacer

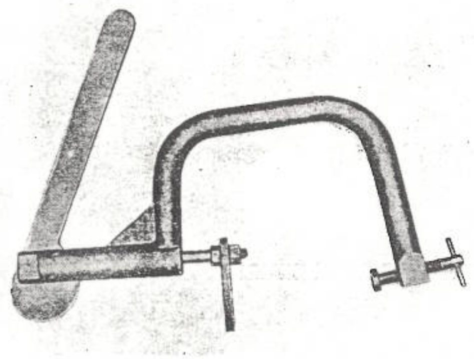
* For Models G150, G130 and C180 in common

Parts Number 8523-1415

Parts Name

Valve Spring Replacer

* For Models G150, G130 and C180 in common

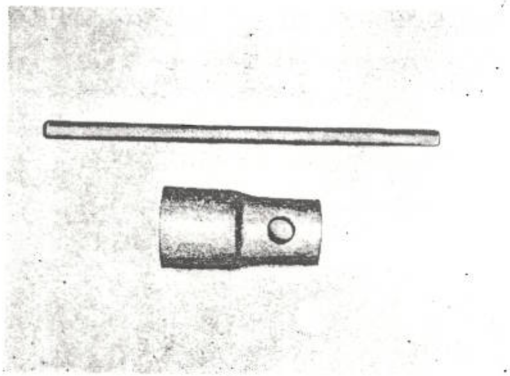


Parts Number 8511-1340

Parts Name

Starting Handle Claw Wrench

* For C180

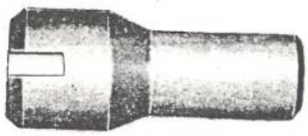


Parts Number 8524-1701

Parts Name

Timing Cover Aligner

* For Models G150, G130
and C180 in common



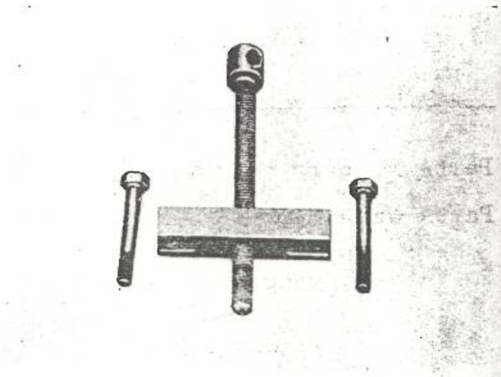
Parts Number 8521-0063

Parts Name

Crankshaft Pulley

Puller Assembly

* For Models G150, G130
and C180 in common

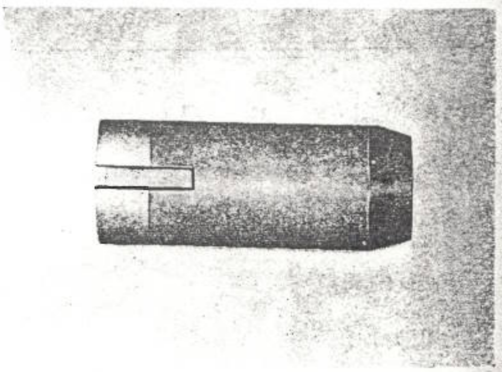


Parts Number 8522-0021

Parts Name

Timing Wheel Setting Tool

* For Models G150, G130
and C180 in common



Parts Nur

Parts Nam

Timing
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Timing
(Crank:

* For Moc
and C18

Parts Numb

Parts Name

Piston

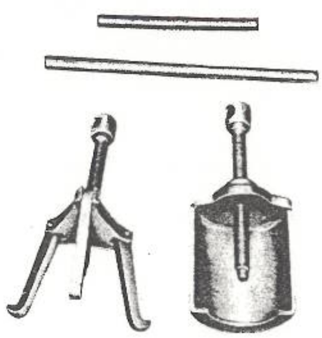
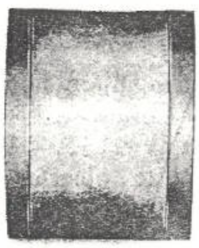
* For Mod

Parts Numbe

Parts Name

Cranksha

* For Mode
and C180

Parts Number 8521-0062 8521-0074 Parts Name Timing Wheel Puller (Camshaft Gear) Timing Wheel Puller (Crankshaft Gear) * For Models G160, G130 and C180 in common	
Parts Number 8522-1169 Parts Name Piston Ring Setting Tool * For Model G150	
Parts Number 8522-0020 Parts Name Crankshaft Bush Setting Tool * For Models G150, G130 and C180 in common	

Parts Number 8523-1360

Parts Name

Camshaft Bearing Replacer Set

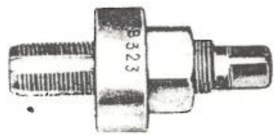
* For Models G150, G130 and C180 in common

Parts Number 8523-1366

Parts Name

Crankshaft Bush Replacer

* For Models G150, G130 and C180 in common

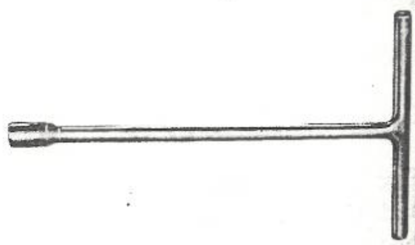


Parts Number 8511-3503

Parts Name

Oilpan Wrench

* For Models G150, G130 and C180 in common



Parts Number 8511-1343
8511-1930

Parts Name

Injection Pump Camshaft Wrench

Injection Pump Camshaft Retainer

* For Model C180

Parts Number 8511-3701

Parts Name

Injection Pump Wrench

* For Model C180

Parts Number 8521-0069

Parts Name

Automatic Timing Control

Puller Assembly

* For Model C180

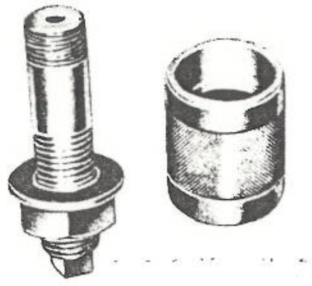
Parts Number 8521-0076

Parts Name

Pre-Combustion Chamber

Replacer

* For Model C180



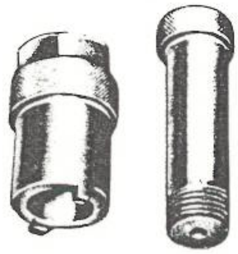
Parts Number 8521-0075

Parts Name

Pre-Combustion Chamber

Wrench

* For Model C180



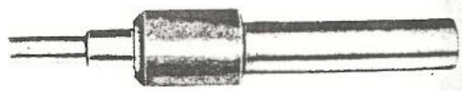
Parts Number 8524-1204

Parts Name

Pre-Combustion Chamber

Aligner

* For Model C180



CONVERSION TABLES

CONVERSION TABLES

MILLIMETERS TO INCHES

mm.	Inches	mm	Inches
1	0.0394	51	2.0079
2	0.0787	52	2.0472
3	0.1181	53	2.0866
4	0.1575	54	2.1260
5	0.1968	55	2.1653
6	0.2362	56	2.2047
7	0.2756	57	2.2441
8	0.3150	58	2.2835
9	0.3543	59	2.3228
10	0.3937	60	2.3622
11	0.4331	61	2.4016
12	0.4724	62	2.4409
13	0.5118	63	2.4803
14	0.5512	64	2.5197
15	0.5905	65	2.5590
16	0.6299	66	2.6984
17	0.6693	67	2.6378
18	0.7087	68	2.6772
19	0.7480	69	2.7165
20	0.7874	70	2.7559
21	0.8268	71	2.7953
22	0.8661	72	2.8346
23	0.9055	73	2.8740
24	0.9449	74	2.9134
25	0.9842	75	2.9527
26	1.0236	76	2.9921
27	1.0630	77	3.0315
28	1.1024	78	3.0709
29	1.1417	79	3.1102
30	1.1811	80	3.1496
31	1.2205	81	3.1890
32	1.2598	82	3.2283
33	1.2992	83	3.2677
34	1.3386	84	3.3071
35	1.3779	85	3.3464
36	1.4173	86	3.3858
37	1.4567	87	3.4252
38	1.4961	88	3.4646
39	1.5354	89	3.5039
40	1.5748	90	3.5433
41	1.6142	91	3.5827
42	1.6535	92	3.6220
43	1.6929	93	3.6614
44	1.7323	94	3.7008
45	1.7716	95	3.7401
46	1.8110	96	3.7795
47	1.8504	97	3.8189
48	1.8898	98	3.8583
49	1.9291	99	3.8976
50	1.9685	100	3.9370

INCHES TO MILLIMETERS

Inches	mm.
1/64	0.3969
1/32	0.7937
3/64	1.1906
1/16	1.5875
5/64	1.9844
3/32	2.3812
7/64	2.7781
1/8	3.1750
9/64	3.5719
5/32	3.9687
11/64	4.3656
3/16	4.7625
13/64	5.1594
7/32	5.5562
15/64	5.9531
1/4	6.3500
17/64	6.7469
9/32	7.1437
19/64	7.5406
5/16	7.9375
21/64	8.3344
11/32	8.7312
23/64	9.1281
3/8	9.5250
25/64	9.9219
13/32	10.3187
27/64	10.7156
7/16	11.1125
29/64	11.5094
15/32	11.9062
31/64	12.3031
1/2	12.7000
33/64	13.0969
17/32	13.4937
35/64	13.8906
9/16	14.2875
37/64	14.6844
19/32	15.0812
39/64	15.4781
5/8	15.8750
41/64	16.2719
21/32	16.6687
43/64	17.0656
11/16	17.4625
45/64	17.8594
23/32	18.2562
47/64	18.6531
3/4	19.0500
49/64	19.4469
25/32	19.8437
51/64	20.2406
13/16	20.6375
53/64	21.0344
27/32	21.4312
55/64	21.8281
7/8	22.2250
57/64	22.6219
29/32	23.0187
59/64	23.4156
15/16	23.8125
61/64	24.2094
31/32	24.6062
63/64	25.0031

FAHRENHEIT & CENTIGRADE

°F	°C	°C	°F
-20	-28.9	-30	-22
-15	-26.1	-28	-18.4
-10	-23.3	-26	-14.8
-5	-20.6	-24	-11.2
0	-17.8	-22	-7.6
1	-17.2	-20	-4
2	-16.7	-18	-0.4
3	-16.1	-16	3.2
4	-15.6	-14	6.8
5	-15.0	-12	10.4
10	-12.2	-10	14
15	-9.4	-8	17.6
20	-6.7	-6	21.2
25	-3.9	-4	24.8
30	-1.1	-2	28.4
35	1.7	0	32
40	4.4	2	35.6
45	7.2	4	39.2
50	10.0	6	42.8
55	12.8	8	46.4
60	15.6	10	50
65	18.3	12	53.6
70	21.1	14	57.2
75	23.9	16	60.8
80	26.7	18	64.4
85	29.4	20	68
90	32.2	22	71.6
95	35.0	24	75.2
100	37.8	26	78.8
105	40.6	28	82.4
110	43.3	30	86
115	46.1	32	89.6
120	48.9	34	93.2
125	51.7	36	96.8
130	54.4	38	100.4
135	57.2	40	104
140	60.0	42	107.6
145	62.8	44	112.2
150	65.6	46	114.8
155	68.3	48	118.4
160	71.1	50	122
165	73.9	52	125.6
170	76.7	54	129.2
175	79.4	56	132.8
180	82.2	58	136.4
185	85.0	60	140
190	87.8	62	143.6
195	90.6	64	147.2
200	93.3	66	150.8
205	96.1	68	154.4
210	98.9	70	158
212	100.0	75	167
215	101.7	80	176
220	104.4	85	185
225	107.2	90	194
230	110.0	95	203
235	112.8	100	212
240	115.6	105	221
245	118.3	110	230
250	121.1	115	239
255	123.9	120	248
260	126.6	125	257
265	129.4	130	266

FEET TO METERS

ft	0	1	2	3	4	5	6	7	8	9	ft
	m	m	m	m	m	m	m	m	m	m	
—		0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743	
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791	10
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839	20
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887	30
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935	40
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983	50
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031	60
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079	70
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127	80
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175	90
100	30.480	30.785	31.090	31.394	31.699	32.004	32.309	32.614	32.918	33.223	100

MILES TO KILOMETERS

mile	0	1	2	3	4	5	6	7	8	9	mile
	km	km	km	km	km	km	km	km	km	km	
—		1.609	3.219	4.828	6.437	8.047	9.656	11.265	12.875	14.484	—
10	16.093	17.703	19.312	20.921	22.531	24.140	25.750	27.359	28.968	30.578	10
20	32.187	33.796	35.406	37.015	38.624	40.234	41.843	43.452	45.062	46.671	20
30	48.280	49.890	51.499	53.108	54.718	56.327	57.936	59.546	61.155	62.764	30
40	64.374	65.983	67.593	69.202	70.811	72.421	74.030	75.639	77.249	78.858	40
50	80.467	82.077	83.686	85.295	86.905	88.514	90.123	91.733	93.342	94.951	50
60	96.561	98.170	99.779	101.39	103.00	104.61	106.22	107.83	109.44	111.04	60
70	112.65	114.26	115.87	117.48	119.09	120.70	122.31	123.92	125.53	127.14	70
80	128.75	130.36	131.97	133.58	135.19	136.79	138.40	140.01	141.62	143.23	80
90	144.84	146.45	148.06	149.67	151.28	152.89	154.50	156.11	157.72	159.33	90
100	160.93	162.54	164.15	165.76	167.37	168.98	170.59	172.20	173.81	175.42	100

SQUARE INCHES TO SQUARE CENTIMETERS

in^2	0	1	2	3	4	5	6	7	8	9	in^2
	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	
—		6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064	—
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580	10
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096	20
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612	30
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128	40
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644	50
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160	60
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676	70
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192	80
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708	90
100	645.160	651.612	658.063	664.515	670.966	677.418	683.870	690.321	696.773	703.224	100

CUBIC INCHES TO CUBIC CENTIMETERS

in^3	0	1	2	3	4	5	6	7	8	9	in^3
	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	
—		16.387	32.774	49.161	65.548	[illegible].935	98.322	114.709	131.097	147.484	—
10	163.871	180.258	196.645	213.032	229.419	24[illegible]	262.193	278.580	294.967	311.354	10
20	327.741	344.128	360.515	376.902	393.290	409.677	426.064	442.451	458.838	475.225	20
30	491.612	507.999	524.386	540.773	557.160	573.547	589.934	606.321	622.708	639.095	30
40	655.483	671.870	688.257	704.644	721.031	737.418	753.805	770.192	786.579	802.966	40
50	819.353	835.740	852.127	868.514	884.901	901.289	917.676	934.063	950.450	966.837	50
60	983.224	999.611	1015.998	1032.385	1048.772	1065.159	1081.546	1097.933	1114.320	1130.707	60
70	1147.094	1163.482	1179.869	1196.256	1212.643	1229.030	1245.417	1261.804	1278.191	1294.578	70
80	1310.965	1327.352	1343.739	1360.126	1376.513	1392.200	1409.288	1425.675	1442.062	1458.449	80
90	1474.836	1491.223	1507.610	1523.997	1540.384	1556.771	1573.158	1589.545	1605.932	1622.319	90
100	1638.706	1655.093	1671.481	1687.868	1704.255	1720.642	1737.029	1753.416	1769.803	1786.190	100

METERS TO FEET

m	0	1	2	3	4	5	6	7	8	9	m
	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	
—		3.2808	6.5617	9.8425	13.1234	16.4042	19.6850	22.9659	26.2467	29.5276	—
10	32.8084	36.0892	39.3701	42.6509	45.9318	49.2126	52.4934	55.7743	59.0551	62.3360	10
20	65.6168	68.8976	72.1785	75.4593	78.7402	82.0210	85.3018	88.5827	91.8635	95.1444	20
30	98.4252	101.7060	104.9869	108.2677	111.5486	114.8294	118.1102	121.3911	124.6719	127.9528	30
40	131.2336	134.5144	137.7953	141.0761	144.3570	147.6378	150.9186	154.1995	157.4803	160.7612	40
50	164.0420	167.3228	170.6037	173.8845	177.1654	180.4462	183.7270	187.0079	190.2887	193.5696	50
60	196.8504	200.1312	203.4121	206.6929	209.9738	213.2546	216.5354	219.8163	223.0971	226.3780	60
70	229.6588	232.9396	236.2205	239.5013	242.7822	246.0630	249.3438	252.6247	255.9055	259.1864	70
80	262.4672	265.7480	269.0289	272.3097	275.5906	278.8714	282.1522	285.4331	288.7139	291.9948	80
90	295.2756	298.5564	301.8373	305.1181	308.3990	311.6798	314.9606	318.2415	321.5223	324.8032	90
100	328.0840	331.3648	334.6457	337.9265	341.2074	344.4882	347.7690	351.0499	354.3307	357.6116	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	km
	mil	mil	mil	mil	mil	mil	mil	mil	mil	mil	
—		0.621	1.243	1.864	2.486	3.107	3.728	4.350	4.971	5.592	—
10	6.214	6.835	7.457	8.078	8.699	9.321	9.942	10.562	11.1 5	11.805	10
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.776	17.399	18.019	20
30	18.641	19.263	19.884	20.506	21.127	21.748	22.370	22.990	23.613	24.233	30
40	24.855	25.477	26.098	26.720	27.341	27.962	28.584	29.204	29.827	30.447	40
50	31.069	31.690	32.311	32.933	33.554	34.175	34.797	35.417	36.040	36.660	50
60	37.282	37.904	38.525	39.147	39.768	40.389	41.011	41.631	42.254	42.874	60
70	43.497	44.118	44.739	45.361	45.982	46.603	47.225	47.845	48.468	49.088	70
80	49.711	50.332	50.953	51.575	52.196	52.817	53.439	54.059	54.682	55.302	80
90	55.924	56.545	57.166	57.788	58.409	59.030	59.652	60.272	60.895	61.515	90
100	62.138	62.759	63.380	64.002	64.623	65.244	65.866	66.486	67.109	67.729	100

SQUARE CENTIMETERS TO SQUARE INCHES

cm^2	0	1	2	3	4	5	6	7	8	9	cm^2
	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	
—		0. 55	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395	—
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945	10
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495	20
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045	30
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595	40
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145	50
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695	60
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245	70
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795	80
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345	90
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.385	16.740	16.895	100

CUBIC CENTIMETERS TO CUBIC INCHES

cm^3	0	1	2	3	4	5	6	7	8	9	cm^3
	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	
—		0.0610	0.1220	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492	—
10	0.6102	0.6713	0.7323	0.7933	0.8543	0.9154	0.9764	1.0374	1.0984	1.1595	10
20	1.2205	1.2815	1.3425	1.4035	1.4646	1.5256	1.5866	1.6476	1.7087	1.7697	20
30	1.8307	1.8917	1.9528	2.0138	2.0748	2.1358	2.1969	2.2579	2.3189	2.3799	30
40	2.4409	2.5020	2.5630	2.6240	2.6850	2.7461	2.8071	2.8681	2.9291	2.9902	40
50	3.0512	3.1122	3.1732	3.2343	3.2953	3.3563	3.4173	3.4784	3.5394	3.6004	50
60	3.6614	3.7224	3.7835	3.8445	3.9055	3.9665	4.0276	4.0886	4.1495	4.2106	60
70	4.2717	4.3327	4.3937	4.4547	4.5158	4.5768	4.6378	4.6988	4.7599	4.8209	70
80	4.8819	4.9429	5.0039	5.0650	5.1260	5.1870	5.2480	5.3091	5.3701	5.4311	80
90	5.4921	5.5532	5.6142	5.6752	5.7362	5.7973	5.8583	5.9193	5.9803	6.0414	90
100	6.1024	6.1634	6.2244	6.2854	6.3465	6.4075	6.4685	6.5295	6.5906	6.6516	100

CONVERSION TABLES

CUBIC FEET TO CUBIC METERS

ft³	0	1	2	3	4	5	6	7	8	9	ft³
	m³	m³	m³	m³	m³	m³	m³	m³	m³	m³	
—		0.0283	0.0566	0.0850	0.1133	0.1416	0.1699	0.1982	0.2265	0.2549	—
10	0.2832	0.3115	0.3398	0.3681	0.3964	0.4248	0.4531	0.4814	0.5097	0.5380	10
20	0.5663	0.5947	0.6230	0.6513	0.6796	0.7079	0.7362	0.7646	0.7929	0.8212	20
30	0.8495	0.8778	0.9061	0.9345	0.9628	0.9911	1.0194	1.0477	1.0760	1.1044	30
40	1.1327	1.1610	1.1893	1.2176	1.2459	1.2743	1.3026	1.3309	1.3592	1.3875	40
50	1.4159	1.4442	1.4725	1.5008	1.5291	1.5574	1.5858	1.6141	1.6424	1.6707	50
60	1.6990	1.7273	1.7557	1.7840	1.8123	1.8406	1.8689	1.8972	1.9256	1.9539	60
70	1.9822	2.0105	2.0388	2.0671	2.0955	2.1238	2.1521	2.1804	2.2087	2.2370	70
80	2.2654	2.2937	2.3220	2.3503	2.3786	2.4069	2.4353	2.4636	2.4919	2.5202	80
90	2.5485	2.5768	2.6052	2.6335	2.6618	2.6901	2.7184	2.7468	2.7751	2.8034	90
100	2.8317	2.6800	2.8884	2.9167	2.9450	2.9733	3.0016	3.0300	3.0583	3.0866	100

GALLONS (U. S.) TO LITERS

U.S. gal	0	1	2	3	4	5	6	7	8	9	U.S. gal
	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	
—		3.7854	7.5709	11.3563	15.1417	18.9271	22.7126	26.4980	30.2834	34.0638	—
10	37.8543	41.6397	45.4251	49.2105	52.9960	56.7814	60.5668	64.3523	68.1377	71.9231	10
20	75.7085	79.4940	83.2794	87.0648	90.8502	94.6357	98.4211	102.2065	105.9920	109.7774	20
30	113.5528	117.3482	121.1337	124.9191	128.7045	132.4899	136.2754	140.0608	143.8462	147.6316	30
40	151.4171	155.2025	158.9879	162.7734	166.5588	170.3442	174.1296	177.9151	181.7005	185.4859	40
50	189.2713	193.0568	196.8422	200.6276	204.4131	208.1985	211.9839	215.7693	219.5548	223.3402	50
60	227.1256	230.9110	234.6965	238.4819	242.2673	246.0527	249.8382	253.6236	257.4090	261.1945	60
70	264.9799	268.7653	272.5507	276.3362	280.1216	283.9070	287.6924	291.4779	295.2633	299.0487	70
80	302.8342	306.6196	310.4050	314.1904	317.9759	321.7613	325.5467	329.3321	333.1176	336.9030	80
90	340.6884	344.4738	348.2593	352.0447	355.8301	359.6156	363.4010	367.1864	370.9718	374.7573	90
100	378.5427	382.3281	386.1135	389.8990	393.6844	397.4698	401.2553	405.0407	408.8261	412.6115	100

GALLONS (IMP.) TO LITERS

IMP gal	0	1	2	3	4	5	6	7	8	9	IMP gal
	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	
—		4.5460	9.0919	13.6379	18.1838	22.7298	27.2758	31.8217	36.3677	40.9136	—
10	45.4596	50.0055	54.5515	59.0975	63.6434	68.1894	72.2354	77.2813	81.8275	86.3732	10
20	90.9192	95.4652	100.0111	104.5571	109.1030	113.6490	118.1950	122.7409	127.2869	131.8328	20
30	136.3788	140.9248	145.4707	150.0167	154.5626	159.1086	163.6546	168.0005	172.7465	177.2924	30
40	181.8384	186.3844	190.9303	195.4763	200.0222	204.5682	209.1142	213.6601	218.2061	222.7520	40
50	227.2980	231.8440	236.3899	240.9359	245.4818	250.0278	254.5738	259.1197	263.6657	268.2116	50
60	272.7576	277.3036	281.8495	286.3955	290.9414	295.4874	300.0334	304.5793	309.1253	313.6712	60
70	318.2172	322.7632	327.3091	331.8551	335.4010	340.9470	345.4930	350.0389	354.5849	359.1308	70
80	363.6768	368.2223	372.7687	377.3147	381.8606	386.4066	390.9526	395.4985	400.0445	404.5904	80
90	409.1364	413.6824	418.2283	422.7743	427.3202	431.8662	436.4122	440.9581	445.9041	450.0500	90
100	454.5960	459.1420	463.6879	468.2339	472.7798	477.3258	481.8718	486.4177	490.9637	495.5096	100

POUNDS TO KILOGRAMS

lb	0	1	2	3	4	5	6	7	8	9	lb
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—		0.454	0.907	1.361	1.814	2.26[illegible]	2.722	3.175	3.629	4.082	—
10	4.536	4.990	5.443	5.897	6.350	6.804	7.257	7.711	8.165	8.618	10
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154	20
30	13.608	14.061	14.515	14.969	15.422	15.876	16.329	16.783	17.237	17.690	30
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226	40
50	22.680	23.133	23.587	24.040	24.494	24.948	25.401	25.855	26.308	26.762	50
60	27.216	27.669	28.123	28.576	29.030	29.484	29.937	30.391	30.844	31.298	60
70	31.751	32.205	32.659	33.112	33.566	34.019	34.473	34.927	35.380	35.834	70
80	36.287	36.741	37.195	37.648	38.102	38.555	39.009	39.463	39.916	40.370	80
90	40.823	41.277	41.730	42.184	42.638	43.092	43.545	43.998	44.453	44.906	90
100	45.359	45.813	46.266	46.720	47.174	47.627	48.081	48.534	48.988	49.442	100

CUBIC METERS TO CUBIC FEET

m^3	0	1	2	3	4	5	6	7	8	9	m^3
	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	
—		35.3	70.6	105.9	141.3	176.6	211.9	247.2	282.5	317.8	—
10	353.1	388.5	423.8	459.1	494.4	529.7	565.0	600.3	635.7	671.0	10
20	706.3	741.6	776.9	812.2	847.5	882.9	918.2	953.5	988.8	1024.1	20
30	1059.4	1094.7	1130.1	1165.4	1200.7	1236.0	1271.3	1306.6	1341.9	1377.3	30
40	1412.6	1447.9	1483.2	1518.5	1553.8	1589.2	1624.5	1659.8	1695.1	1730.4	40
50	1765.7	1801.0	1836.4	1871.7	1907.0	1942.3	1977.6	2012.9	2048.2	2083.6	50
60	2118.9	2154.2	2189.5	2224.8	2260.1	2295.4	2330.8	2366.1	2401.4	2436.7	60
70	2472.0	2507.3	2542.6	2578.0	2613.3	2648.6	2683.9	2719.2	2754.5	2789.8	70
80	2825.2	2860.5	2895.8	2931.1	2966.4	3001.7	3037.0	3072.4	3107.7	3143.0	80
90	3178.3	3213.6	3248.9	3284.2	3319.6	3354.9	3390.2	3425.5	3460.8	3496.1	90
100	3531.4	3566.7	3602.0	3637.3	3672.7	3708.0	3743.3	3778.6	3813.9	3849.2	100

LITERS TO GALLONS (U. S.)

ℓ	0	1	2	3	4	5	6	7	8	9	ℓ
	gal	gal	gal	gal	gal	gal	gal	gal	gal	gal	
—		0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775	—
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2267	4.4909	4.7551	5.0192	10
20	5.2834	5.5476	5.8118	6.0759	6.3401	6.6043	6.8684	7.1326	7.3968	7.6610	20
30	7.9251	8.1893	8.4535	8.7176	8.9818	9.2460	9.5102	9.7743	10.0385	10.3027	30
40	10.5668	10.8310	11.0952	11.3594	11.6235	11.8877	12.1519	12.4160	12.6802	12.9444	40
50	13.2086	13.4727	13.7369	14.0011	14.2652	14.5294	14.7936	15.0577	15.3219	15.5861	50
60	15.8503	16.1144	16.3786	16.6428	16.9069	17.1711	17.4353	17.6995	17.9636	18.2278	60
70	18.4920	18.7561	19.0203	19.2845	19.5487	19.8128	20.0770	20.3412	20.6053	20.8695	70
80	21.1337	21.3979	21.6620	21.9262	22.1904	22.4545	22.7187	22.9829	23.2470	23.5112	80
90	25.7754	24.0396	24.3037	24.5679	24.8321	25.0962	25.3604	25.6246	25.8888	26.1529	90
100	26.4171	26.6813	26.9454	27.2096	27.4738	27.7380	28.0021	28.2663	28.5305	28.7946	100

LITERS TO GALLONS (IMP.)

ℓ	0	1	2	3	4	5	6	7	8	9	ℓ
	gal	gal	gal	gal	gal	gal	gal	gal	gal	gal	
—		0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5398	1.7598	1.9798	—
10	2.1998	2.4197	2.6397	2.8597	3.0797	3.2996	3.5196	3.7396	3.9596	4.1795	10
20	4.3995	4.6195	4.8395	5.0594	5.2794	5.4994	5.7194	5.9394	6.1593	6.3793	20
30	6.5993	6.8193	7.0392	7.2592	7.4792	7.6992	7.9191	8.1391	8.3591	8.5791	30
40	8.7990	9.0190	9.2390	9.4590	9.6789	9.8989	10.9189	10.3389	10.5588	10.7788	40
50	10.9988	11.2188	11.4388	11.6587	11.8787	12.0987	12.3187	12.5386	12.7586	12.9786	50
60	13.1986	13.4185	13.6385	13.8585	14.0785	14.2984	14.5184	14.7384	14.9584	15.1783	60
70	15.3983	15.6183	15.8383	16.0582	16.2782	16.4982	16.7182	16.9382	17.1581	17.3781	70
80	17.5981	17.8181	18.0380	18.2580	18.4780	18.6980	18.9179	19.1379	19.3579	19.5779	80
90	19.7978	20.0178	20.2378	20.4578	20.6777	20.8977	21.1177	21.3377	21.5576	21.7776	90
100	21.9976	22.2176	22.4376	22.6575	22.8775	23.0975	23.3175	23.5374	23.7574	23.9774	100

KILOGRAMS TO POUNDS

kg	0	1	2	3	4	5	6	7	8	9	kg
	lb	lb	lb	lb	lb	lb	lb	lb	lb	lb	
—		2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.842	—
10	22.046	24.251	26.455	28.660	30.865	33.069	35.274	37.479	39.683	41.888	10
20	44.092	46.297	48.502	50.706	52.911	55.116	57.320	59.525	61.729	63.934	20
30	66.139	68.343	70.548	72.752	74.957	77.162	79.366	81.571	83.776	85.980	30
40	88.185	90.389	92.594	94.799	97.003	99.208	101.41	103.62	105.82	108.03	40
50	110.23	112.44	114.64	116.84	119.05	121.25	123.46	125.66	127.87	130.07	50
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12	60
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17	70
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21	80
90	198.42	200.62	202.83	205.03	207.23	209.44	211.64	213.85	216.05	218.26	90
100	220.46	222.67	224.87	227.08	229.28	231.49	233.69	235.89	238.10	240.30	100

POUNDS PER SQUARE INCHES TO KILOGRAMS PER SQUARE CENTIMETERS

lb/in²	0	1	2	3	4	5	6	7	8	9	lb/in²
	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	
—		0.0703	0.1406	0.2100	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328	—
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358	10
20	1.4062	1.4765	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389	20
30	2.1092	2.1795	2.2498	2.3202	2.3905	2.4608	2.5311	2.6014	2.6717	2.7420	30
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1639	3.2342	3.3045	3.3748	3.4451	40
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0072	4.0779	4.1482	50
60	4.2185	4.2888	4.3591	4.4294	4.4997	4.5700	4.6403	4.7106	4.7809	4.8512	60
70	4.9216	4.9919	5.0622	5.1325	5.2028	5.2731	5.3434	5.4137	5.4840	5.5543	70
80	5.6246	5.6949	5.7652	5.8356	5.9059	5.9762	6.0465	6.1168	6.1871	6.2574	80
90	6.3277	6.3980	6.4683	6.5386	6.6089	6.6793	6.7496	6.8199	6.8902	6.9605	90
100	7.0308	7.1011	7.1714	7.2417	7.3120	7.3823	7.4526	7.5229	7.5933	7.6636	100

KILOGRAMS PER SQUARE CENTIMETERS TO POUNDS PER SQUARE INCHES

kg/cm²	0	1	2	3	4	5	6	7	8	9	kg/cm
	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	
—		14.22	28.45	42.67	56.89	71.12	85.34	99.56	113.78	128.01	—
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.02	270.24	10
20	284.46	298.69	312.91	327.13	341.36	355.58	369.80	384.03	398.25	412.47	20
30	426.70	440.92	455.14	469.36	483.59	497.81	512.03	526.26	540.48	554.70	30
40	568.93	583.15	597.37	611.60	625.82	640.04	654.27	668.49	682.71	696.94	40
50	711.16	725.38	739.61	753.83	768.05	782.28	796.50	810.72	824.94	839.17	50
60	853.39	867.61	881.84	896.06	910.28	924.51	938.73	952.95	967.18	981.40	60
70	995.62	1009.8	1024.1	1038.3	1052.5	1066.7	1081.0	1095.2	1109.4	1123.6	70
80	1137.8	1152.1	1166.3	1180.5	1194.7	1209.0	1223.2	1237.4	1251.6	1265.9	80
90	1280.1	1294.3	1308.5	1322.7	1337.0	1351.2	1365.4	1379.6	1393.9	1408.1	90
100	1422.3	1436.5	1450.8	1465.0	1479.2	1493.4	1507.7	1521.9	1536.1	1550.3	100

FOOT POUNDS TO KILOGRAMETERS

ft-lb	0	1	2	3	4	5	6	7	8	9	ft-lb
	kgm	kgm	kgm	kgm	kgm	kgm	kgm	kgm	kgm	kgm	
—		0.138	0.276	0.415	0.553	0.691	0.829	0.967	1.106	1.244	—
10	1.382	1.520	1.658	1.796	1.934	2.073	2.211	2.349	2.487	2.625	10
20	2.764	2.902	3.040	3.178	3.316	3.455	3.593	3.731	3.869	4.007	20
30	4.146	4.284	4.422	4.560	4.698	4.837	4.975	5.113	5.251	5.389	30
40	5.528	5.666	5.804	5.942	6.080	6.219	6.357	6.495	6.633	6.771	40
50	6.910	7.048	7.186	7.324	7.462	7.601	7.739	7.877	8.015	8.153	50
60	8.292	8.430	8.568	8.706	8.844	8.983	9.121	9.259	9.397	9.535	60
70	9.674	9.812	9.950	10.088	10.227	10.365	10.503	10.641	10.779	10.918	70
80	11.056	11.194	11.332	11.470	11.609	11.747	11.885	12.023	12.161	12.300	80
90	12.438	12.576	12.714	12.855	12.991	13.129	13.267	13.405	13.544	13.682	90
100	13.820	13.958	14.096	14.235	14.373	14.511	14.649	14.787	14.925	14.064	100

KILOGRAMETERS TO FOOT POUNDS

kgm	0	1	2	3	4	5	6	7	8	9	kgm
	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	
—		7.23	14.47	21.70	28.93	36.17	43.40	50.63	57.87	65.10	—
10	72.33	79.57	86.80	94.03	101.27	108.50	115.74	122.97	130.20	137.43	10
20	144.67	151.90	159.13	166.37	173.60	180.84	188.08	195.30	202.54	209.77	20
30	217.00	224.23	231.46	238.70	245.93	253.17	260.41	267.63	274.87	282.10	30
40	289.34	296.57	303.79	311.04	318.27	325.50	332.75	339.98	347.21	354.44	40
50	361.66	368.89	376.12	383.36	390.59	397.82	405.07	412.30	419.53	426.76	50
60	434.00	441.23	448.45	455.70	462.93	470.17	477.41	484.64	491.87	499.10	60
70	506.34	513.57	520.80	528.04	535.27	542.50	549.75	556.98	564.21	571.44	70
80	578.68	585.91	593.14	600.38	607.61	614.85	622.09	629.41	636.55	643.78	80
90	651.00	658.23	665.46	672.70	679.93	687.17	694.41	701.63	708.87	716.10	90
100	723.34	730.57	737.80	745.04	752.27	759.51	766.75	774.07	781.21	788.44	100

CONVERSION TABLES

CONVERSION TABLES

MILLIMETERS TO INCHES

mm.	Inches	mm	Inches
1	0.0394	51	2.0079
2	0.0787	52	2.0472
3	0.1181	53	2.0866
4	0.1575	54	2.1260
5	0.1968	55	2.1653
6	0.2362	56	2.2047
7	0.2756	57	2.2441
8	0.3150	58	2.2835
9	0.3543	59	2.3228
10	0.3937	60	2.3622
11	0.4331	61	2.4016
12	0.4724	62	2.4409
13	0.5118	63	2.4803
14	0.5512	64	2.5197
15	0.5905	65	2.5590
16	0.6299	66	2.6984
17	0.6693	67	2.6378
18	0.7087	68	2.6772
19	0.7480	69	2.7165
20	0.7874	70	2.7559
21	0.8268	71	2.7953
22	0.8661	72	2.8346
23	0.9055	73	2.8740
24	0.9449	74	2.9134
25	0.9842	75	2.9527
26	1.0236	76	2.9921
27	1.0630	77	3.0315
28	1.1024	78	3.0709
29	1.1417	79	3.1102
30	1.1811	80	3.1496
31	1.2205	81	3.1890
32	1.2598	82	3.2283
33	1.2992	83	3.2677
34	1.3386	84	3.3071
35	1.3779	85	3.3464
36	1.4173	86	3.3858
37	1.4567	87	3.4252
38	1.4961	88	3.4646
39	1.5354	89	3.5039
40	1.5748	90	3.5433
41	1.6142	91	3.5827
42	1.6535	92	3.6220
43	1.6929	93	3.6614
44	1.7323	94	3.7008
45	1.7716	95	3.7401
46	1.8110	96	3.7795
47	1.8504	97	3.8189
48	1.8898	98	3.8583
49	1.9291	99	3.8976
50	1.9685	100	3.9370

INCHES TO MILLIMETERS

Inches	mm.
1/64	0.3969
1/32	0.7937
3/64	1.1906
1/16	1.5875
5/64	1.9844
3/32	2.3812
7/64	2.7781
1/8	3.1750
9/64	3.5719
5/32	3.9687
11/64	4.3656
3/16	4.7625
13/64	5.1594
7/32	5.5562
15/64	5.9531
1/4	6.3500
17/64	6.7469
9/32	7.1437
19/64	7.5406
5/16	7.9375
21/64	8.3344
11/32	8.7312
23/64	9.1281
3/8	9.5250
25/64	9.9219
13/32	10.3187
27/64	10.7156
7/16	11.1125
29/64	11.5094
15/32	11.9062
31/64	12.3031
1/2	12.7000
33/64	13.0969
17/32	13.4937
35/64	13.8906
9/16	14.2875
37/64	14.6844
19/32	15.0812
39/64	15.4781
5/8	15.8750
41/64	16.2719
21/32	16.6687
43/64	17.0656
11/16	17.4625
45/64	17.8594
23/32	18.2562
47/64	18.6531
3/4	19.0500
49/64	19.4469
25/32	19.8437
51/64	20.2406
13/16	20.6375
53/64	21.0344
27/32	21.4312
55/64	21.8281
7/8	22.2250
57/64	22.6219
29/32	23.0187
59/64	23.4156
15/16	23.8125
61/64	24.2094
31/32	24.6062
63/64	25.0031

FAHRENHEIT & CENTIGRADE

°F	°C	°C	°F
-20	-28.9	-30	-22
-15	-26.1	-28	-18.4
-10	-23.3	-26	-14.8
-5	-20.6	-24	-11.2
0	-17.8	-22	-7.6
1	-17.2	-20	-4
2	-16.7	-18	-0.4
3	-16.1	-16	3.2
4	-15.6	-14	6.8
5	-15.0	-12	10.4
10	-12.2	-10	14
15	-9.4	-8	17.6
20	-6.7	-6	21.2
25	-3.9	-4	24.8
30	-1.1	-2	28.4
35	1.7	0	32
40	4.4	2	35.6
45	7.2	4	39.2
50	10.0	6	42.8
55	12.8	8	46.4
60	15.6	10	50
65	18.3	12	53.6
70	21.1	14	57.2
75	23.9	16	60.8
80	26.7	18	64.4
85	29.4	20	68
90	32.2	22	71.6
95	35.0	24	75.2
100	37.8	26	78.8
105	40.6	28	82.4
110	43.3	30	86
115	46.1	32	89.6
120	48.9	34	93.2
125	51.7	36	96.8
130	54.4	38	100.4
135	57.2	40	104
140	60.0	42	107.6
145	62.8	44	112.2
150	65.6	46	114.8
155	68.3	48	118.4
160	71.1	50	122
165	73.9	52	125.6
170	76.7	54	129.2
175	79.4	56	132.8
180	82.2	58	136.4
185	85.0	60	140
190	87.8	62	143.6
195	90.6	64	147.2
200	93.3	66	150.8
205	96.1	68	154.4
210	98.9	70	158
212	100.0	75	167
215	101.7	80	176
220	104.4	85	185
225	107.2	90	194
230	110.0	95	203
235	112.8	100	212
240	115.6	105	221
245	118.3	110	230
250	121.1	115	239
255	123.9	120	248
260	126.6	125	257
265	129.4	130	266

FEET TO METERS

ft	0	1	2	3	4	5	6	7	8	9	ft
	m	m	m	m	m	m	m	m	m	m	
—		0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743	
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791	10
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839	20
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887	30
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935	40
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983	50
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031	60
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079	70
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127	80
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175	90
100	30.480	30.785	31.090	31.394	31.699	32.004	32.309	32.614	32.918	33.223	100

MILES TO KILOMETERS

mile	0	1	2	3	4	5	6	7	8	9	mile
	km	km	km	km	km	km	km	km	km	km	
—		1.609	3.219	4.828	6.437	8.047	9.656	11.265	12.875	14.484	—
10	16.093	17.703	19.312	20.921	22.531	24.140	25.750	27.359	28.968	30.578	10
20	32.187	33.796	35.406	37.015	38.624	40.234	41.843	43.452	45.062	46.671	20
30	48.280	49.890	51.499	53.108	54.718	56.327	57.936	59.546	61.155	62.764	30
40	64.374	65.983	67.593	69.202	70.811	72.421	74.030	75.639	77.249	78.858	40
50	80.467	82.077	83.686	85.295	86.905	88.514	90.123	91.733	93.342	94.951	50
60	96.561	98.170	99.779	101.39	103.00	104.61	106.22	107.83	109.44	111.04	60
70	112.65	114.26	115.87	117.48	119.09	120.70	122.31	123.92	125.53	127.14	70
80	128.75	130.36	131.97	133.58	135.19	136.79	138.40	140.01	141.62	143.23	80
90	144.84	146.45	148.06	149.67	151.28	152.89	154.50	156.11	157.72	159.33	90
100	160.93	162.54	164.15	165.76	167.37	168.98	170.59	172.20	173.81	175.42	100

SQUARE INCHES TO SQUARE CENTIMETERS

in^2	0	1	2	3	4	5	6	7	8	9	in^2
	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	
—		6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064	—
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580	10
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096	20
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612	30
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128	40
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644	50
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160	60
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676	70
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192	80
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708	90
100	645.160	651.612	658.063	664.515	670.966	677.418	683.870	690.321	696.773	703.224	100

CUBIC INCHES TO CUBIC CENTIMETERS

in^3	0	1	2	3	4	5	6	7	8	9	in^3
	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	
—		16.387	32.774	49.161	65.548	[illegible].935	98.322	114.709	131.097	147.484	—
10	163.871	180.258	196.645	213.032	229.419	[illegible]	262.193	278.580	294.967	311.354	10
20	327.741	344.128	360.515	376.902	393.290	409.[illegible]	426.064	442.451	458.838	475.225	20
30	491.612	507.999	524.386	540.773	557.160	573.547	589.934	606.321	622.708	639.095	30
40	655.483	671.870	688.257	704.644	721.031	737.418	753.805	770.192	786.579	802.966	40
50	819.353	835.740	852.127	868.514	884.901	901.289	917.676	934.063	950.450	966.837	50
60	983.224	999.611	1015.998	1032.385	1048.772	1065.159	1081.546	1097.933	1114.320	1130.707	60
70	1147.094	1163.482	1179.869	1196.256	1212.643	1229.030	1245.417	1261.804	1278.191	1294.578	70
80	1310.965	1327.352	1343.739	1360.126	1376.513	1392.200	1409.288	1425.675	1442.062	1458.449	80
90	1474.836	1491.223	1507.610	1523.997	1540.384	1556.771	1573.158	1589.545	1605.932	1622.319	90
100	1638.706	1655.093	1671.481	1687.868	1704.255	1720.642	1737.029	1753.416	1769.803	1786.190	100

METERS TO FEET

m	0	1	2	3	4	5	6	7	8	9	m
	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	
—		3.2808	6.5617	9.8425	13.1234	16.4042	19.6850	22.9659	26.2467	29.5276	—
10	32.8084	36.0892	39.3701	42.6509	45.9318	49.2126	52.4934	55.7743	59.0551	62.3360	10
20	65.6168	68.8976	72.1785	75.4593	78.7402	82.0210	85.3018	88.5827	91.8635	95.1444	20
30	98.4252	101.7060	104.9869	108.2677	111.5486	114.8294	118.1102	121.3911	124.6719	127.9528	30
40	131.2336	134.5144	137.7953	141.0761	144.3570	147.6378	150.9186	154.1995	157.4803	160.7612	40
50	164.0420	167.3228	170.6037	173.8845	177.1654	180.4462	183.7270	187.0079	190.2887	193.5696	50
60	196.8504	200.1312	203.4121	206.6929	209.9738	213.2546	216.5354	219.8163	223.0971	226.3780	60
70	229.6588	232.9396	236.2205	239.5013	242.7822	246.0630	249.3438	252.6247	255.9055	259.1864	70
80	262.4672	265.7480	269.0289	272.3097	275.5906	278.8714	282.1522	285.4331	288.7139	291.9948	80
90	295.2756	298.5564	301.8373	305.1181	308.3990	311.6798	314.9606	318.2415	321.5223	324.8032	90
100	328.0840	331.3648	334.6457	337.9265	341.2074	344.4882	347.7690	351.0499	354.3307	357.6116	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	km
	mil	mil	mil	mil	mil	mil	mil	mil	mil	mil	
—		0.621	1.243	1.864	2.486	3.107	3.728	4.350	4.971	5.592	—
10	6.214	6.835	7.457	8.078	8.699	9.321	9.942	10.562	11.1 5	11.805	10
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.776	17.399	18.019	20
30	18.641	19.263	19.884	20.506	21.127	21.748	22.370	22.990	23.613	24.233	30
40	24.855	25.477	26.098	26.720	27.341	27.962	28.584	29.204	29.827	30.447	40
50	31.069	31.690	32.311	32.933	33.554	34.175	34.797	35.417	36.040	36.660	50
60	37.282	37.904	38.525	39.147	39.768	40.389	41.011	41.631	42.254	42.874	60
70	43.497	44.118	44.739	45.361	45.982	46.603	47.225	47.845	48.468	49.088	70
80	49.711	50.332	50.953	51.575	52.196	52.817	53.439	54.059	54.682	55.302	80
90	55.924	56.545	57.166	57.788	58.409	59.030	59.652	60.272	60.895	61.515	90
100	62.138	62.759	63.380	64.002	64.623	65.244	65.866	66.486	67.109	67.729	100

SQUARE CENTIMETERS TO SQUARE INCHES

cm^2	0	1	2	3	4	5	6	7	8	9	cm^2
	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	
—		0. 55	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395	—
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945	10
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495	20
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045	30
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595	40
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145	50
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695	60
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245	70
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795	80
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345	90
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.385	16.740	16.895	100

CUBIC CENTIMETERS TO CUBIC INCHES

cm^3	0	1	2	3	4	5	6	7	8	9	cm^3
	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	
—		0.0610	0.1220	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492	—
10	0.6102	0.6713	0.7323	0.7933	0.8543	0.9154	0.9764	1.0374	1.0984	1.1595	10
20	1.2205	1.2815	1.3425	1.4035	1.4646	1.5256	1.5866	1.6476	1.7087	1.7697	20
30	1.8307	1.8917	1.9528	2.0138	2.0748	2.135[illegible]	2.1969	2.2579	2.3189	2.3799	30
40	2.4409	2.5020	2.5630	2.6240	2.6850	2.7461	2.8071	2.8681	2.9291	2.9902	40
50	3.0512	3.1122	3.1732	3.2343	3.2953	3.3563	3.4173	3.4784	3.5394	3.6004	50
60	3.6614	3.7224	3.7835	3.8445	3.9055	3.9665	4.0276	4.0886	4.1495	4.2106	60
70	4.2717	4.3327	4.3937	4.4547	4.5158	4.5768	4.6378	4.6988	4.7599	4.8209	70
80	4.8819	4.9429	5.0039	5.0650	5.1260	5.1870	5.2480	5.3091	5.3701	5.4311	80
90	5.4921	5.5532	5.6142	5.6752	5.7362	5.7973	5.8583	5.9193	5.9803	6.0414	90
100	6.1024	6.1634	6.2244	6.2854	6.3465	6.4075	6.4685	6.5295	6.5906	6.6516	100

CUBIC FEET TO CUBIC METERS

ft³	0	1	2	3	4	5	6	7	8	9	ft³
	m³	m³	m³	m³	m³	m³	m³	m³	m³	m³	
—		0.0283	0.0566	0.0850	0.1133	0.1416	0.1699	0.1982	0.2265	0.2549	—
10	0.2832	0.3115	0.3398	0.3681	0.3964	0.4248	0.4531	0.4814	0.5097	0.5380	10
20	0.5663	0.5947	0.6230	0.6513	0.6796	0.7079	0.7362	0.7646	0.7929	0.8212	20
30	0.8495	0.8778	0.9061	0.9345	0.9628	0.9911	1.0194	1.0477	1.0760	1.1044	30
40	1.1327	1.1610	1.1893	1.2176	1.2459	1.2743	1.3026	1.3309	1.3592	1.3875	40
50	1.4159	1.4442	1.4725	1.5008	1.5291	1.5574	1.5858	1.6141	1.6424	1.6707	50
60	1.6990	1.7273	1.7557	1.7840	1.8123	1.8406	1.8689	1.8972	1.9256	1.9539	60
70	1.9822	2.0105	2.0388	2.0671	2.0955	2.1238	2.1521	2.1804	2.2087	2.2370	70
80	2.2654	2.2937	2.3220	2.3503	2.3786	2.4069	2.4353	2.4636	2.4919	2.5202	80
90	2.5485	2.5768	2.6052	2.6335	2.6618	2.6901	2.7184	2.7468	2.7751	2.8034	90
100	2.8317	2.6800	2.8884	2.9167	2.9450	2.9733	3.0016	3.0300	3.0583	3.0866	100

GALLONS (U. S.) TO LITERS

U.S. gal	0	1	2	3	4	5	6	7	8	9	U.S. gal
	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	
—		3.7854	7.5709	11.3563	15.1417	18.9271	22.7126	26.4980	30.2834	34.0638	—
10	37.8543	41.6397	45.4251	49.2105	52.9960	56.7814	60.5668	64.3523	68.1377	71.9231	10
20	75.7085	79.4940	83.2794	87.0648	90.8502	94.6357	98.4211	102.2065	105.9920	109.7774	20
30	113.5528	117.3482	121.1337	124.9191	128.7045	132.4899	136.2754	140.0608	143.8462	147.6316	30
40	151.4171	155.2025	158.9879	162.7734	166.5588	170.3442	174.1296	177.9151	181.7005	185.4859	40
50	189.2713	193.0568	196.8422	200.6276	204.4131	208.1985	211.9839	215.7693	219.5548	223.3402	50
60	227.1256	230.9110	234.6965	238.4819	242.2673	246.0527	249.8382	253.6236	257.4090	261.1945	60
70	264.9799	268.7653	272.5507	276.3362	280.1216	283.9070	287.6924	291.4779	295.2633	299.0487	70
80	302.8342	306.6196	310.4050	314.1904	317.9759	321.7613	325.5467	329.3321	333.1176	336.9030	80
90	340.6884	344.4738	348.2593	352.0447	355.8301	359.6156	363.4010	367.1864	370.9718	374.7573	90
100	378.5427	382.3281	386.1135	389.8990	393.6844	397.4698	401.2553	405.0407	408.8261	412.6115	100

GALLONS (IMP.) TO LITERS

IMP gal	0	1	2	3	4	5	6	7	8	9	IMP gal
	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	
—		4.5460	9.0919	13.6379	18.1838	22.7298	27.2758	31.8217	36.3677	40.9136	—
10	45.4596	50.0056	54.5515	59.0975	63.6434	68.1894	72.2354	77.2813	81.8275	86.3732	10
20	90.9192	95.4652	100.0111	104.5571	109.1030	113.6490	118.1950	122.7409	127.2869	131.8328	20
30	136.3788	140.9248	145.4707	150.0167	154.5626	159.1086	163.6546	168.0005	172.7465	177.2924	30
40	181.8384	186.3844	190.9303	195.4763	200.0222	204.5682	209.1142	213.6601	218.2061	222.7520	40
50	227.2980	231.8440	236.3899	240.9359	245.4818	250.0278	254.5738	259.1197	263.6657	268.2116	50
60	272.7576	277.3036	281.8495	286.3955	290.9414	295.4874	300.0334	304.5793	309.1253	313.6712	60
70	318.2172	322.7632	327.3091	331.8551	335.4010	340.9470	345.4930	350.0389	354.5849	359.1308	70
80	363.6768	368.2223	372.7687	377.3147	381.8606	386.4066	390.9526	395.4985	400.0445	404.5904	80
90	409.1364	413.6824	418.2283	422.7743	427.3202	431.8662	436.4122	440.9581	445.9041	450.0500	90
100	454.5960	459.1420	463.6879	468.2339	472.7798	477.3258	481.8718	486.4177	490.9637	495.5096	100

POUNDS TO KILOGRAMS

lb	0	1	2	3	4	5	6	7	8	9	lb
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—		0.454	0.907	1.361	1.814	2.26[illegible]	2.722	3.175	3.629	4.082	—
10	4.536	4.990	5.443	5.897	6.350	6.804	7.257	7.711	8.165	8.618	10
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154	20
30	13.608	14.061	14.515	14.969	15.422	15.876	16.329	16.783	17.237	17.690	30
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226	40
50	22.680	23.133	23.587	24.040	24.494	24.948	25.401	25.855	26.308	26.762	50
60	27.216	27.669	28.123	28.576	29.030	29.484	29.937	30.391	30.844	31.298	60
70	31.751	32.205	32.659	33.112	33.566	34.019	34.473	34.927	35.380	35.834	70
80	36.287	36.741	37.195	37.648	38.102	38.555	39.009	39.463	39.916	40.370	80
90	40.823	41.277	41.730	42.184	42.638	43.092	43.545	43.998	44.453	44.906	90
100	45.359	45.813	46.266	46.720	47.174	47.627	48.081	48.534	48.988	49.442	100

CUBIC METERS TO CUBIC FEET

m^3	0	1	2	3	4	5	6	7	8	9	m^3
	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	ft^3	
—		35.3	70.6	105.9	141.3	176.6	211.9	247.2	282.5	317.8	—
10	353.1	388.5	423.8	459.1	494.4	529.7	565.0	600.3	635.7	671.0	10
20	706.3	741.6	776.9	812.2	847.5	882.9	918.2	953.5	988.8	1024.1	20
30	1059.4	1094.7	1130.1	1165.4	1200.7	1236.0	1271.3	1306.6	1341.9	1377.3	30
40	1412.6	1447.9	1483.2	1518.5	1553.8	1589.2	1624.5	1659.8	1695.1	1730.4	40
50	1765.7	1801.0	1836.4	1871.7	1907.0	1942.3	1977.6	2012.9	2048.2	2083.6	50
60	2118.9	2154.2	2189.5	2224.8	2260.1	2295.4	2330.8	2366.1	2401.4	2436.7	60
70	2472.0	2507.3	2542.6	2578.0	2613.3	2648.6	2683.9	2719.2	2754.5	2789.8	70
80	2825.2	2860.5	2895.8	2931.1	2966.4	3001.7	3037.0	3072.4	3107.7	3143.0	80
90	3178.3	3213.6	3248.9	3284.2	3319.6	3354.9	3390.2	3425.5	3460.8	3496.1	90
100	3531.4	3566.7	3602.0	3637.3	3672.7	3708.0	3743.3	3778.6	3813.9	3849.2	100

LITERS TO GALLONS (U. S.)

ℓ	0	1	2	3	4	5	6	7	8	9	ℓ
	gal	gal	gal	gal	gal	gal	gal	gal	gal	gal	
—		0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775	—
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2267	4.4909	4.7551	5.0192	10
20	5.2834	5.5476	5.8118	6.0759	6.3401	6.6043	6.8684	7.1326	7.3968	7.6610	20
30	7.9251	8.1893	8.4535	8.7176	8.9818	9.2460	9.5102	9.7743	10.0385	10.3027	30
40	10.5668	10.8310	11.0952	11.3594	11.6235	11.8877	12.1519	12.4160	12.6802	12.9444	40
50	13.2086	13.4727	13.7369	14.0011	14.2652	14.5294	14.7936	15.0577	15.3219	15.5861	50
60	15.8503	16.1144	16.3786	16.6428	16.9069	17.1711	17.4353	17.6995	17.9636	18.2278	60
70	18.4920	18.7561	19.0203	19.2845	19.5487	19.8128	20.0770	20.3412	20.6053	20.8695	70
80	21.1337	21.3979	21.6620	21.9262	22.1904	22.4545	22.7187	22.9829	23.2470	23.5112	80
90	25.7754	24.0396	24.3037	24.5679	24.8321	25.0962	25.3604	25.6246	25.8888	26.1529	90
100	26.4171	26.6813	26.9454	27.2096	27.4738	27.7380	28.0021	28.2663	28.5305	28.7946	100

LITERS TO GALLONS (IMP.)

ℓ	0	1	2	3	4	5	6	7	8	9	ℓ
	gal	gal	gal	gal	gal	gal	gal	gal	gal	gal	
—		0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5398	1.7598	1.9798	—
10	2.1998	2.4197	2.6397	2.8597	3.0797	3.2996	3.5196	3.7396	3.9596	4.1795	10
20	4.3995	4.6195	4.8395	5.0594	5.2794	5.4994	5.7194	5.9394	6.1593	6.3793	20
30	6.5993	6.8193	7.0392	7.2592	7.4792	7.6992	7.9191	8.1391	8.3591	8.5791	30
40	8.7990	9.0190	9.2390	9.4590	9.6789	9.8989	10.9189	10.3389	10.5588	10.7788	40
50	10.9988	11.2188	11.4388	11.6587	11.8787	12.0987	12.3187	12.5386	12.7586	12.9786	50
60	13.1986	13.4185	13.6385	13.8585	14.0785	14.2984	14.5184	14.7384	14.9584	15.1783	60
70	15.3983	15.6183	15.8383	16.0582	16.2782	16.4982	16.7182	16.9382	17.1581	17.3781	70
80	17.5981	17.8181	18.0380	18.2580	18.4780	18.6980	18.9179	19.1379	19.3579	19.5779	80
90	19.7978	20.0178	20.2378	20.4578	20.6777	20.8977	21.1177	21.3377	21.5576	21.7776	90
100	21.9976	22.2176	22.4376	22.6575	22.8775	23.0975	23.3175	23.5374	23.7574	23.9774	100

KILOGRAMS TO POUNDS

kg	0	1	2	3	4	5	6	7	8	9	kg
	lb	lb	lb	lb	lb	lb	lb	lb	lb	lb	
—		2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.842	—
10	22.046	24.251	26.455	28.660	30.865	33.069	35.274	37.479	39.683	41.888	10
20	44.092	46.297	48.502	50.706	52.911	55.116	57.320	59.525	61.729	63.934	20
30	66.139	68.343	70.548	72.752	74.957	77.162	79.366	81.571	83.776	85.980	30
40	88.185	90.389	92.594	94.799	97.003	99.208	101.41	103.62	105.82	108.03	40
50	110.23	112.44	114.64	116.84	119.05	121.25	123.46	125.66	127.87	130.07	50
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12	60
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17	70
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21	80
90	198.42	200.62	202.83	205.03	207.23	209.44	211.64	213.85	216.05	218.26	90
100	220.46	222.67	224.87	227.08	229.28	231.49	233.69	235.89	238.10	240.30	100

POUNDS PER SQUARE INCHES TO KILOGRAMS PER SQUARE CENTIMETERS

lb/in²	0	1	2	3	4	5	6	7	8	9	lb/in²
	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	kg/cm²	
—		0.0703	0.1406	0.2100	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328	—
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358	10
20	1.4062	1.4765	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389	20
30	2.1092	2.1795	2.2498	2.3202	2.3905	2.4608	2.5311	2.6014	2.6717	2.7420	30
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1639	3.2342	3.3045	3.3748	3.4451	40
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0072	4.0779	4.1482	50
60	4.2185	4.2888	4.3591	4.4294	4.4997	4.5700	4.6403	4.7106	4.7809	4.8512	60
70	4.9216	4.9919	5.0622	5.1325	5.2028	5.2731	5.3434	5.4137	5.4840	5.5543	70
80	5.6246	5.6949	5.7652	5.8356	5.9059	5.9762	6.0465	6.1168	6.1871	6.2574	80
90	6.3277	6.3980	6.4683	6.5386	6.6089	6.6793	6.7496	6.8199	6.8902	6.9605	90
100	7.0308	7.1011	7.1714	7.2417	7.3120	7.3823	7.4526	7.5229	7.5933	7.6636	100

KILOGRAMS PER SQUARE CENTIMETERS TO POUNDS PER SQUARE INCHES

kg/cm²	0	1	2	3	4	5	6	7	8	9	kg/cm
	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	lb/in²	
—		14.22	28.45	42.67	56.89	71.12	85.34	99.56	113.78	128.01	—
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.02	270.24	10
20	284.46	298.69	312.91	327.13	341.36	355.58	369.80	384.03	398.25	412.47	20
30	426.70	440.92	455.14	469.36	483.59	497.81	512.03	526.26	540.48	554.70	30
40	568.93	583.15	597.37	611.60	625.82	640.04	654.27	668.49	682.71	696.94	40
50	711.16	725.38	739.61	753.83	768.05	782.28	796.50	810.72	824.94	839.17	50
60	853.39	867.61	881.84	896.06	910.28	924.51	938.73	952.95	967.18	981.40	60
70	995.62	1009.8	1024.1	1038.3	1052.5	1066.7	1081.0	1095.2	1109.4	1123.6	70
80	1137.8	1152.1	1166.3	1180.5	1194.7	1209.0	1223.2	1237.4	1251.6	1265.9	80
90	1280.1	1294.3	1308.5	1322.7	1337.0	1351.2	1365.4	1379.6	1393.9	1408.1	90
100	1422.3	1436.5	1450.8	1465.0	1479.2	1493.4	1507.7	1521.9	1536.1	1550.3	100

FOOT POUNDS TO KILOGRAMETERS

ft-lb	0	1	2	3	4	5	6	7	8	9	ft-lb
	kgm	kgm	kgm	kgm	kgm	kgm	kgm	kgm	kgm	kgm	
—		0.138	0.276	0.415	0.553	0.691	0.829	0.967	1.106	1.244	—
10	1.382	1.520	1.658	1.796	1.934	2.073	2.211	2.349	2.487	2.625	10
20	2.764	2.902	3.040	3.178	3.316	3.455	3.593	3.731	3.869	4.007	20
30	4.146	4.284	4.422	4.560	4.698	4.837	4.975	5.113	5.251	5.389	30
40	5.528	5.666	5.804	5.942	6.080	6.219	6.357	6.495	6.633	6.771	40
50	6.910	7.048	7.186	7.324	7.462	7.601	7.739	7.877	8.015	8.153	50
60	8.292	8.430	8.568	8.706	8.844	8.983	9.121	9.259	9.397	9.535	60
70	9.674	9.812	9.950	10.088	10.227	10.365	10.503	10.641	10.779	10.918	70
80	11.056	11.194	11.332	11.470	11.609	11.747	11.885	12.023	12.161	12.300	80
90	12.438	12.576	12.714	12.855	12.991	13.129	13.267	13.405	13.544	13.682	90
100	13.820	13.958	14.096	14.235	14.373	14.511	14.649	14.787	14.925	14.064	100

KILOGRAMETERS TO FOOT POUNDS

kgm	0	1	2	3	4	5	6	7	8	9	kgm
	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	ft-lb	
—		7.23	14.47	21.70	28.93	36.17	43.40	50.63	57.87	65.10	—
10	72.33	79.57	86.80	94.03	101.27	108.50	115.74	122.97	130.20	137.43	10
20	144.67	151.90	159.13	166.37	173.60	180.84	188.08	195.30	202.54	209.77	20
30	217.00	224.23	231.46	238.70	245.93	253.17	260.41	267.63	274.87	282.10	30
40	289.34	296.57	303.79	311.04	318.27	325.50	332.75	339.98	347.21	354.44	40
50	361.66	368.89	376.12	383.36	390.59	397.82	405.07	412.30	419.53	426.76	50
60	434.00	441.23	448.45	455.70	442.93	470.17	477.41	484.64	491.87	499.10	60
70	506.34	513.57	520.80	528.04	535.27	542.50	549.75	556.98	564.21	571.44	70
80	578.68	585.91	593.14	600.38	607.61	614.85	622.09	629.41	636.55	643.78	80
90	651.00	658.23	665.46	672.70	679.93	687.17	694.41	701.63	708.87	716.10	90
100	723.34	730.57	737.80	745.04	752.27	759.51	766.75	774.07	781.21	788.44	100