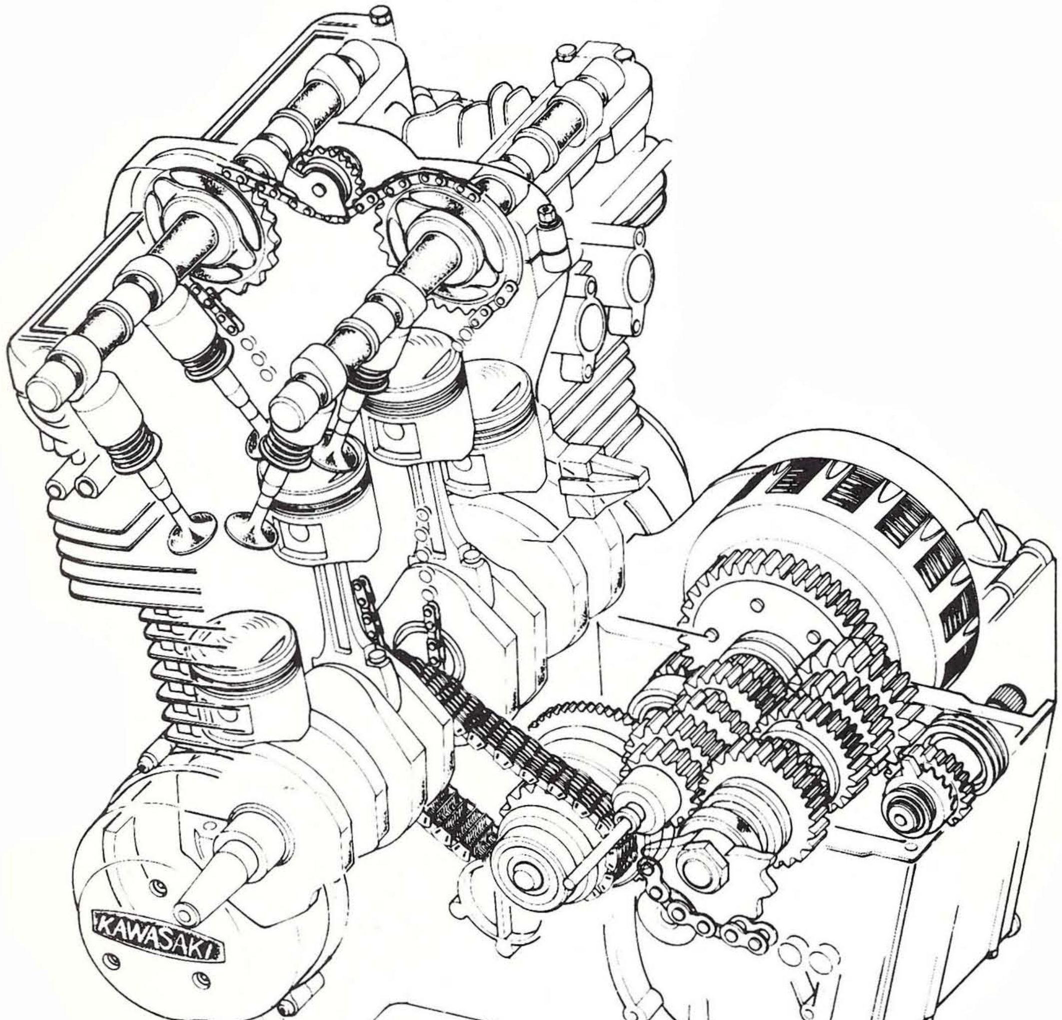
Kawasaki

TRAINING CENTRE



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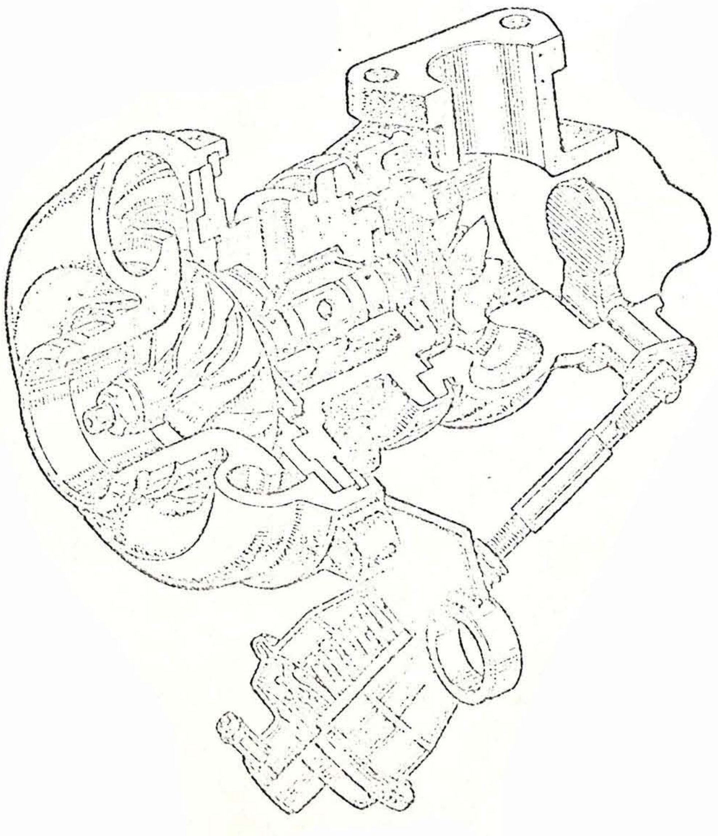
ADVANTAGES OF KAWASAKI TURBO SYSTEM

The purpose of a turbocharger is to make use of the large amount of energy carried away by exhaust gas. This energy, readily available when an engine is under load and exhaust flow high, is used to force a higher volume of air through the engine, increasing its effective displacement. Thus turbocharging delivers extra power from an engine in the middle and high rpm ranges.

The general advantages of this are obvious: a given amount of power can be extracted from a relatively small, light engine. When extra power isn't needed, the engine can be run economically at relatively low rpm.

Japan's motorcycle factories have applied turbocharging in different ways -- from simple to ultra-complex -- with mixed results. Two makers place turbos behind their in-line Four engines, which makes routing of the exhaust pipes relatively easy but increases response time because the turbo is far from exhaust ports. Another company places the turbo near the exhaust ports of its V-Twin but high in the frame, which contributes to an already high center of gravity.

To combat turbo lag, some makers use reed intake valves to bypass the turbo until boost pressure surpasses atmospheric pressure. The intention is to let the engines run efficiently without boost, but because of relatively low compression ratios power output is still less than it would be with non-turbocharged engines.



1. OUTLINE

Unlike the other turbocharged motorcycles on the market, the ZX750-E1 has its turbocharger mounted low and in front of the engine. The combination of this unique placement of the turbocharger and Kawasaki's own DFI (Digital Fuel Injection) system makes the ZX750-E1 the fastest and quickest production turbo-bike ever built.

A turbocharger is a device which uses the high temperature of the exhaust gases coming out of the engine to push more air into the engine. A turbine is driven by the exhaust gases, and it in turn drives a compressor which pushes air into the cylinders at greater than atmospheric pressure. More air means more power and torque from the engine.

The advantages of a turbocharger system are:

1. Higher horsepower and torque can be achieved without increasing engine displacement or operating speed.
2. Lower specific fuel consumption can be achieved by turning the engine slower and by using "low-speed" camshafts (less duration and overlap). The result is that a turbocharged engine can get better fuel economy than a "normally aspirated" engine with the same power output.
3. Intake and exhaust noise is reduced because the turbocharger acts as a silencer.

The intake and especially the exhaust paths of the Kawasaki Turbocharger System are made as short as possible by placing the turbocharger low and in front of the engine and the air cleaner near the engine sprocket. As a result, the Kawasaki Turbocharger System offers these extra advantages:

1. Better throttle response is the result of minimal "turbo lag."
   "Turbo lag" is the time the turbine/compressor assembly needs to speed up enough to raise the intake pressure above atmospheric when the throttle is suddenly opened.
2. Minimal loss of exhaust gas heat energy increases overall efficiency. The very short distance from the exhaust valves to the turbocharger is responsible.
3. The relatively low center of gravity means good stability.
4. The hottest parts of the system are placed well away from the rider for comfort.

(1) Turbine

The turbine extracts the heat energy of the exhaust gases, changing it to rotational energy to drive the compressor.

The turbine is made up of the turbine wheel and a surrounding snail-shell-shaped housing. The housing directs the flow of exhaust gas at the turbine wheel, allowing it to expand and cool. The expansion of the exhaust gases turns the turbine wheel through its blades. The shape of the blades forces the gas flow to spin the turbine wheel. The turbine wheel and its housing are made of highly heat resistant alloys.

(2) Compressor

The compressor is a centrifugal-type compressor which pumps air into the engine at greater-than-atmospheic pressures.

The compressor is made up of a compressor wheel and a surrounding snail-shell-shaped housing. The compressor wheel has 12 specially shaped blades on it, which push the air as the wheel turns. The housing shape allows the speed of the air to drop as it comes off the compressor wheel blades. The drop in speed increases the air pressure as the air flows toward the engine. A special casting method has been used to shape the compressor wheel blades.

(3) Center Housing

The center housing supports the shaft connecting the turbine and compressor wheels as it turns at speeds as high as 200,000 rpm. A floating bearing, which also turns, is mounted in the center housing, and it carries the shaft on two films of oil, absorbing the minute vibration caused by the tiny imbalance present in even the most precisely manufactured parts. The shaft rides on an oil film inside the bearing shell, and the bearing shell rides on another oil film inside the center housing. The bearing turns at about 30% the speed of the shaft. Thus the bearing speeds between the shaft and the floating bearing and between the bearing and the center housing are much less than the bearing speed of a fixed bearing would be. Lower bearing speeds decreases the possibility of cooling and lubrication problems.

Fig. 1 Structure of Kawasaki Turbo System

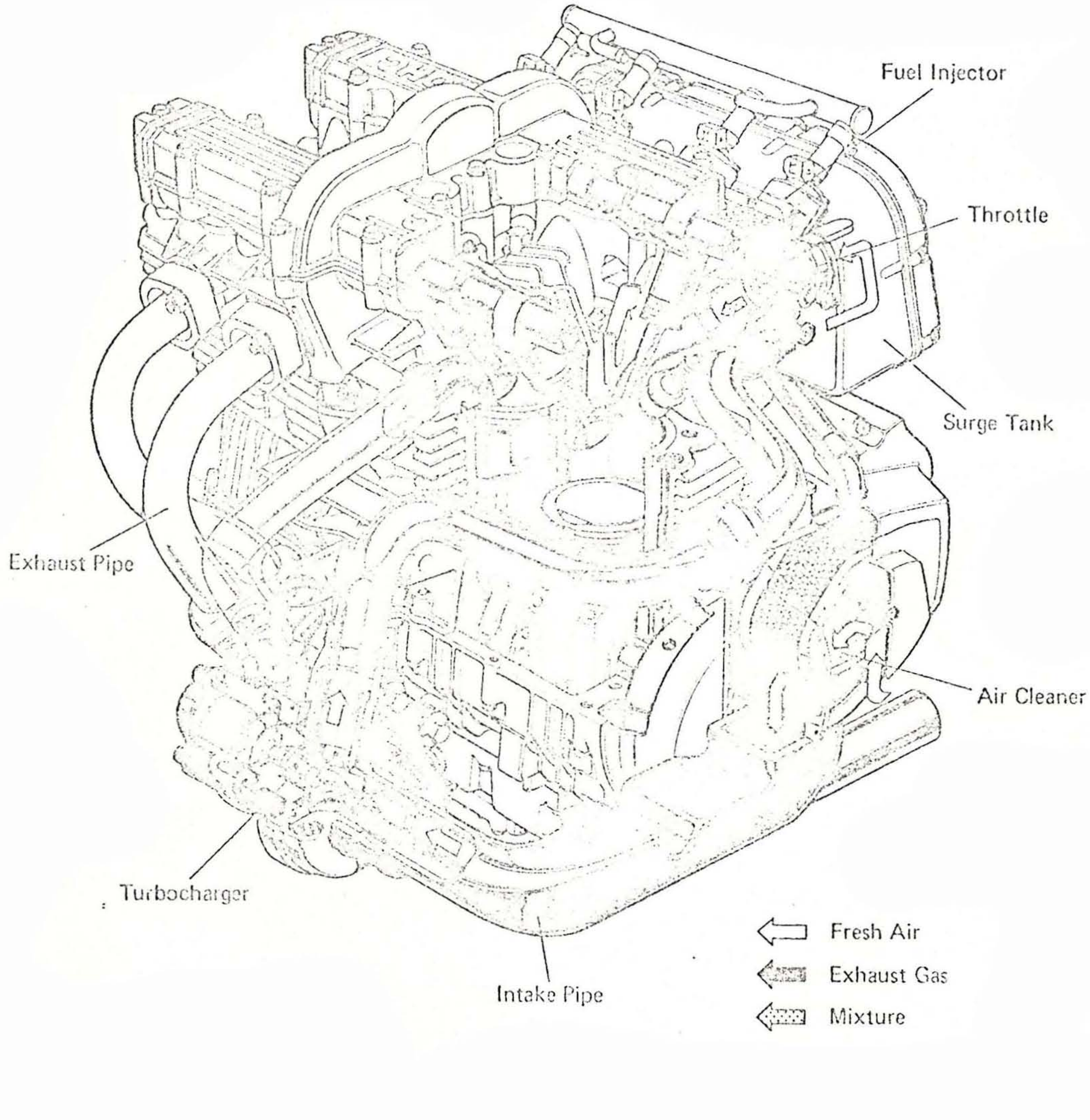
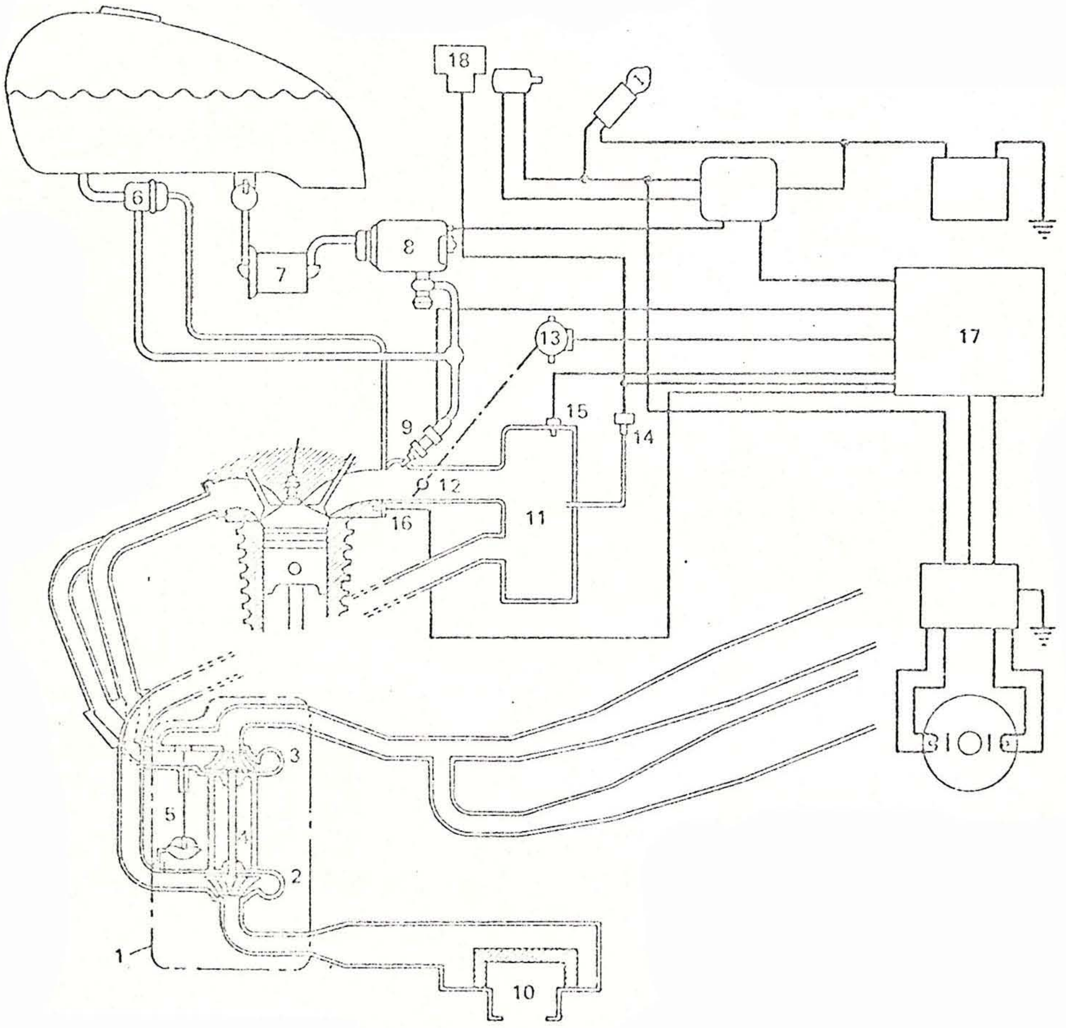


Fig. 6 Turbo/D.F.I. System



1. Turbocharger
2. Compressor
3. Turbine
4. Center Housing
5. Boost Control
6. Fuel Pressure Regulator
7. Fuel Filter
8. Fuel Pump
9. Injector
10. Air Cleaner
11. Surge Tank
12. Throttle Valve
13. Throttle Sensor
14. Air Pressure Sensor
15. Air Temperature Sensor
16. Engine Temperature Sensor
17. D.F.I. Control Unit
18. Boost Meter

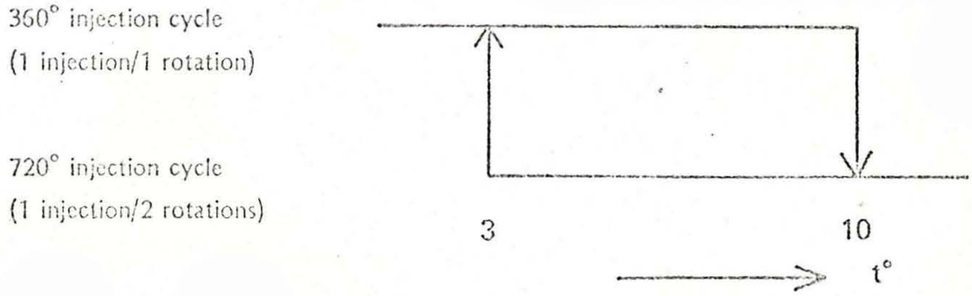
① Injector Driver Circuit

a. Injection Timing

The injection timing is changed from a 360° injection cycle (1 injection/1 rotation) to a 720° injection cycle (1 injection/2 rotations). Because the range of the injection fuel quantity which the turbocharged engine needs is wider than that which the conventional engine does, it is necessary to elongate the injection time at high engine rpm and improve the accuracy of the injection fuel quantity at idle.

During cold starting only, the 360° injection cycle is used. Injection timing is changed in accordance with cylinder head temperature as shown below.

Injection Timing



b. One-Shot Accelearation Enrichment

The one-shot acceleration enrichment feature is added. It injects a specified fuel quantity at the instance the throttle is snapped open.

This eliminates any "time lag". If the throttle is snapped open in the interval between injections in the old DFI system, the fuel quantity is not enriched until the next closest normal injection point.

② Boost and Atmospheric Pressure Sensor

a. Sensor

The boost sensor is installed in the surge tank. Besides monitoring the boost pressure, this sensor measures atmospheric pressure at idling rpm's and light loads. The atmospheric pressure sensor mounted in the ZX1100-A1 control unit is not needed.

The boost sensor sends signals not only to the DFI control unit but also to the boost meter, which shows the boost pressure of the turbocharger.

b. Fuel Cut

The turbocharger itself controls the boost pressure with the wastegate and its actuator. As a further safety measure, the DFI system cuts off fuel supply to the engine if the boost pressure monitored by the boost pressure sensor exceeds the preset maximum.

③ Air Temperature Sensor

The air temperature sensor in the air cleaner case has been replaced with a new air temperature sensor in the surge tank which can react to changes in air temperature caused by boost pressure much more quickly so that the optimum fuel injection quantity can be determined sooner.

Fig. 9 Air Temperature Sensor

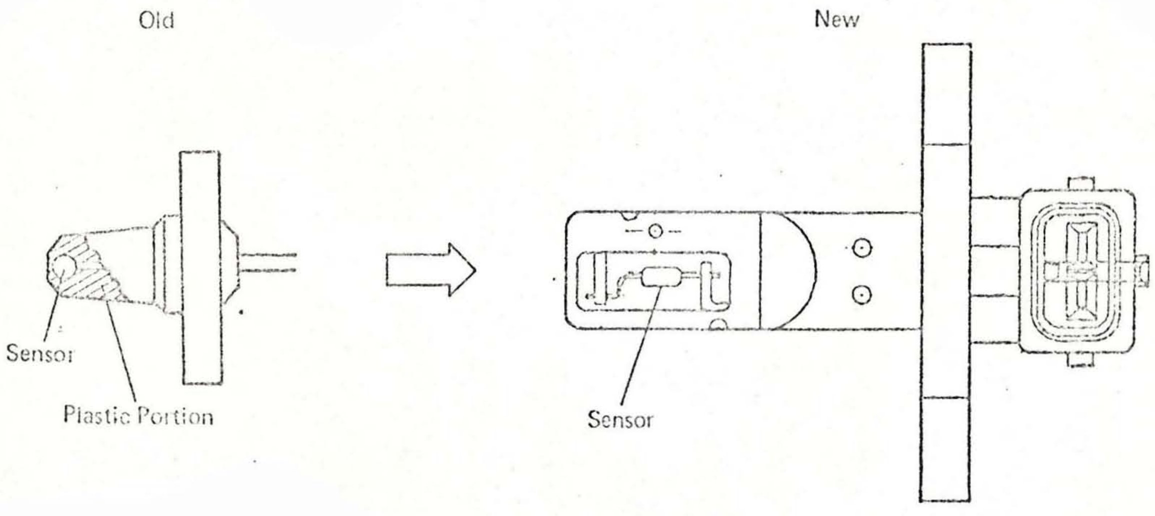
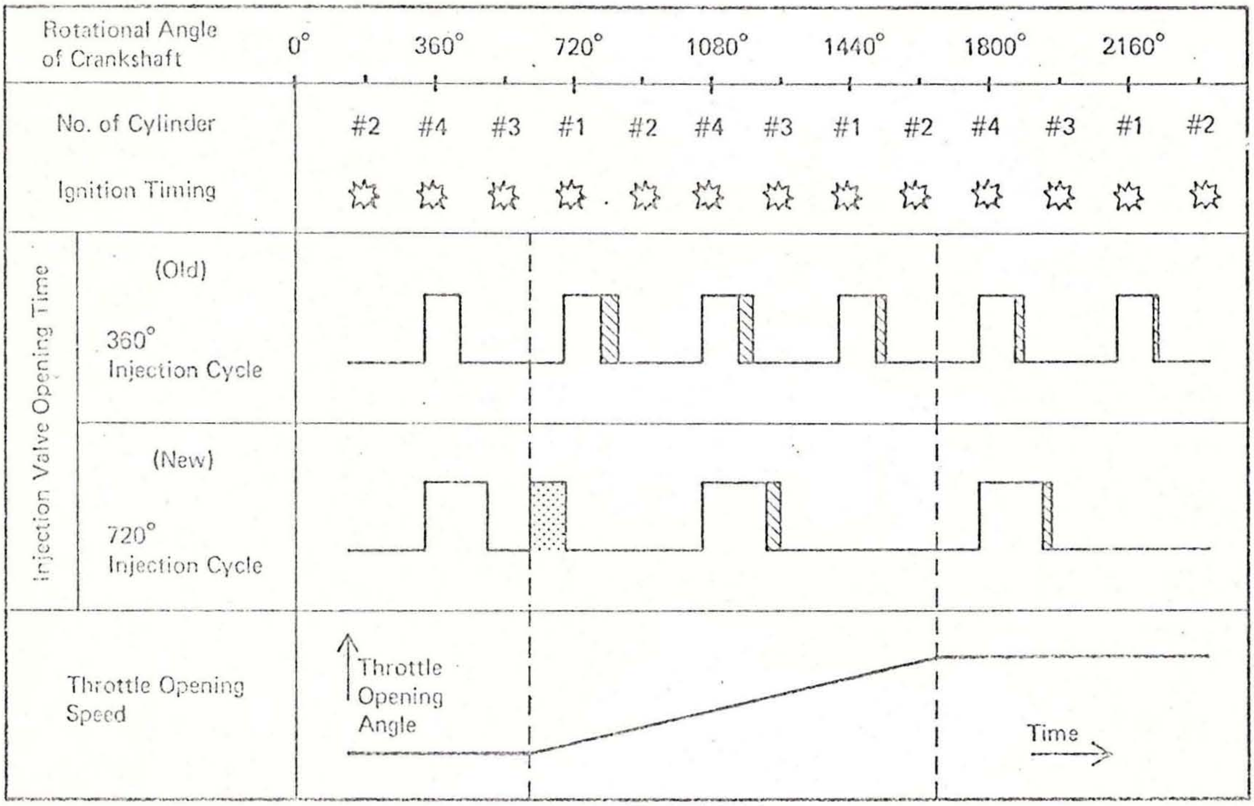


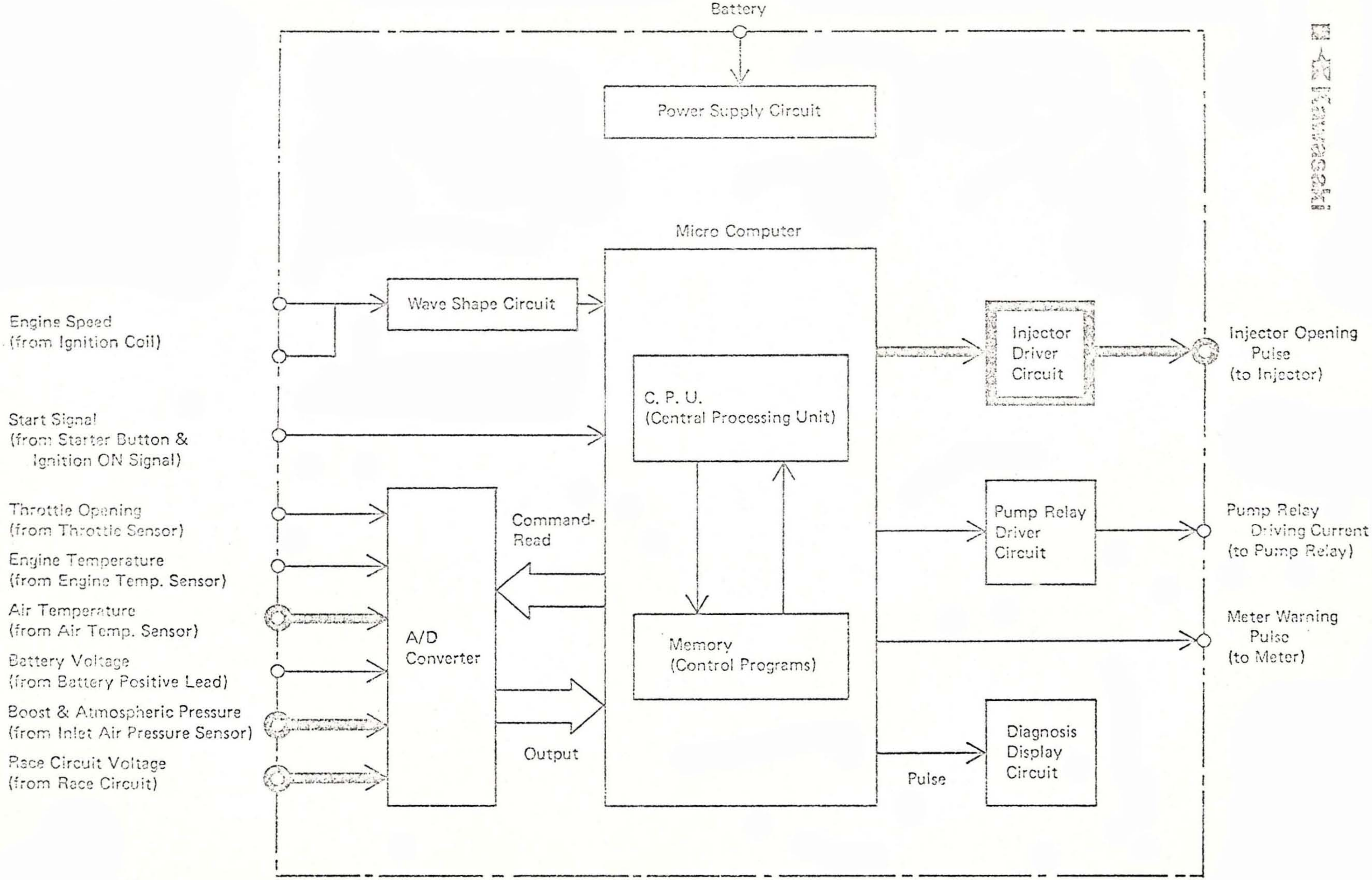
Fig. 8 One-Shot Acceleration Enrichment



- : Instance of Ignition
- : Fuel Injection Time
- : Duration of Acceleration Enrichment
- : Duration of One-shot Acceleration Enrichment

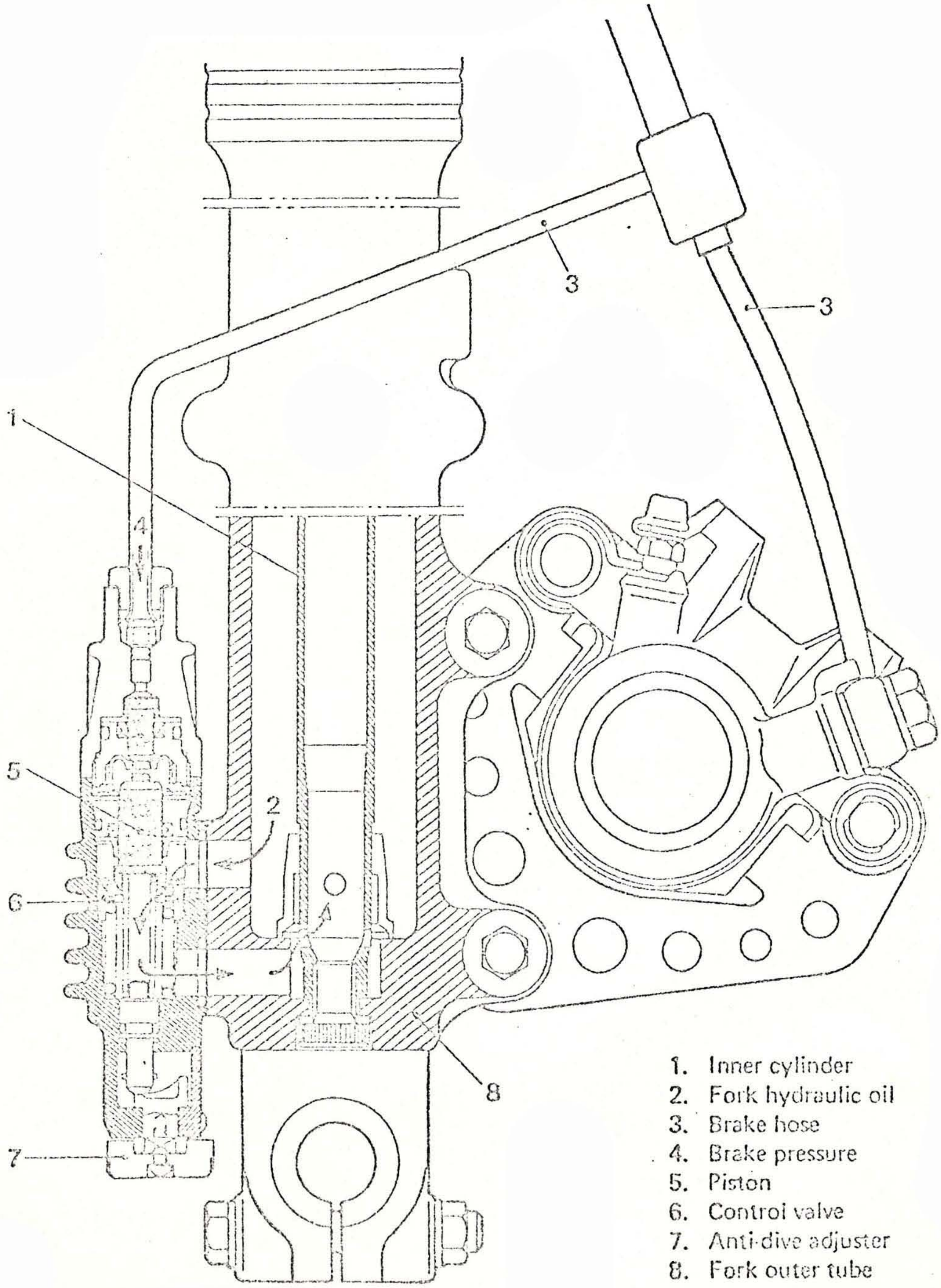
NOTE: The acceleration enrichment enriches the mixture only when the engine is cold. On the other hand, one-shot acceleration enrichment works not only before but also after the engine is warm-up whenever the throttle opening speed becomes greater than a predetermind level.

Fig. 7 Control Unit Internal Circuit



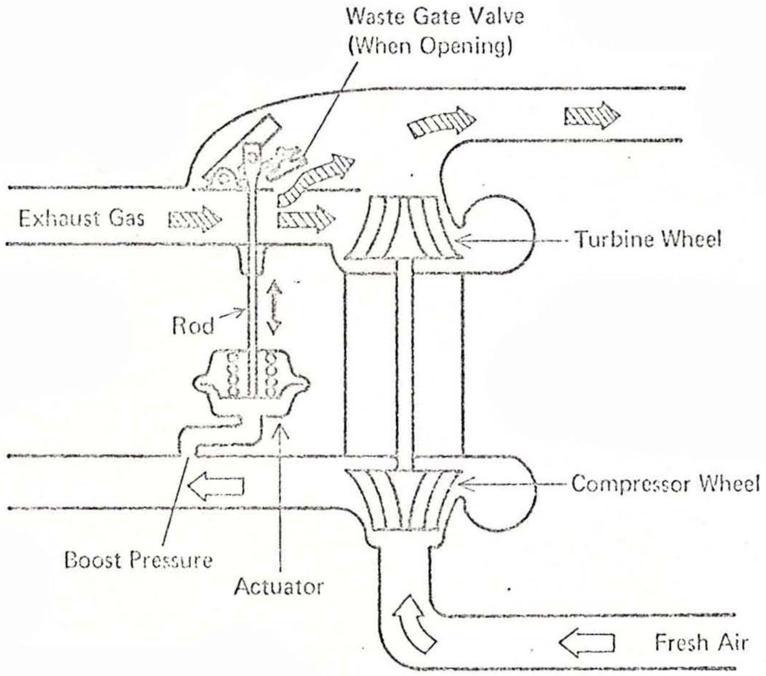
NOTE: The broad-pointed lines showes the difference between 1983 ZX1100A1 and 1984 ZX750E1.

Anti-Dive



1. Inner cylinder
2. Fork hydraulic oil
3. Brake hose
4. Brake pressure
5. Piston
6. Control valve
7. Anti-dive adjuster
8. Fork outer tube

Fig. 5 Boost Control



3. TURBOCHARGER SYSTEM OPERATION

(1) TURBO/DFI SYSTEM

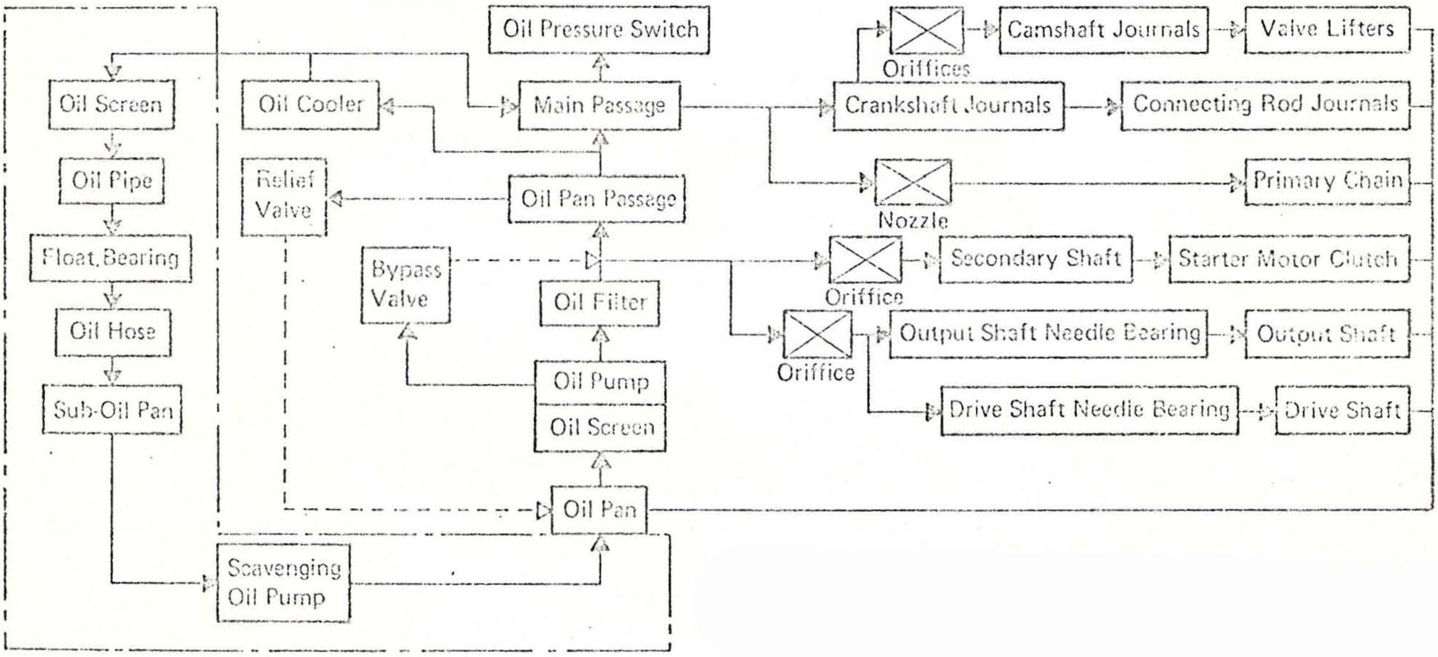
The DFI (Digital Fuel Injection) system used on the ZX750-E1 TURBO is based upon that of 1983 ZX1100-A1.

The DFI system computes the optimum fuel injection quantity according to the program stored in the memory of the control unit, acting upon the information collected by various sensors which detect engine operating conditions such as boost pressure, throttle position, engine rpm, engine temperature, intake air temperature and atmospheric pressure. The following are the differences from the ZX1100-A1 DFI system.

(2) Lubrication

① The lubrication system of ZX750-E1 is based on that of ZX750-A1. The differences between the two are that a new oil flow passage is added, which is routed from the oil cooler through the turbocharger, the sub-oil pan and the scavenging oil pump to the oil pan.

Fig. 10 Engine Oil Flow Chart



NOTE: The oil flow passage is added, which is encircled by the line of "——— · ———".

② The oil automatically flows down into the sub-oil pan after lubricating the turbocharger.
From there, the oil is pumped up to the oil pan by the scavenging pump, which is mounted on the left end of the secondary shaft.

NOTES OF IMPORTANCE

1) Do not overfill engine unit with engine oil.

2) Do not use a low octane of fuel as deterioration or severe knocking will occur causing engine damage.

3) After harsh riding conditions do not stop engine, allow the machine to idle for a while. This allows the turbine to reduce its temperature.

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Fig. 11 Turbocharger Lubrication System (1)

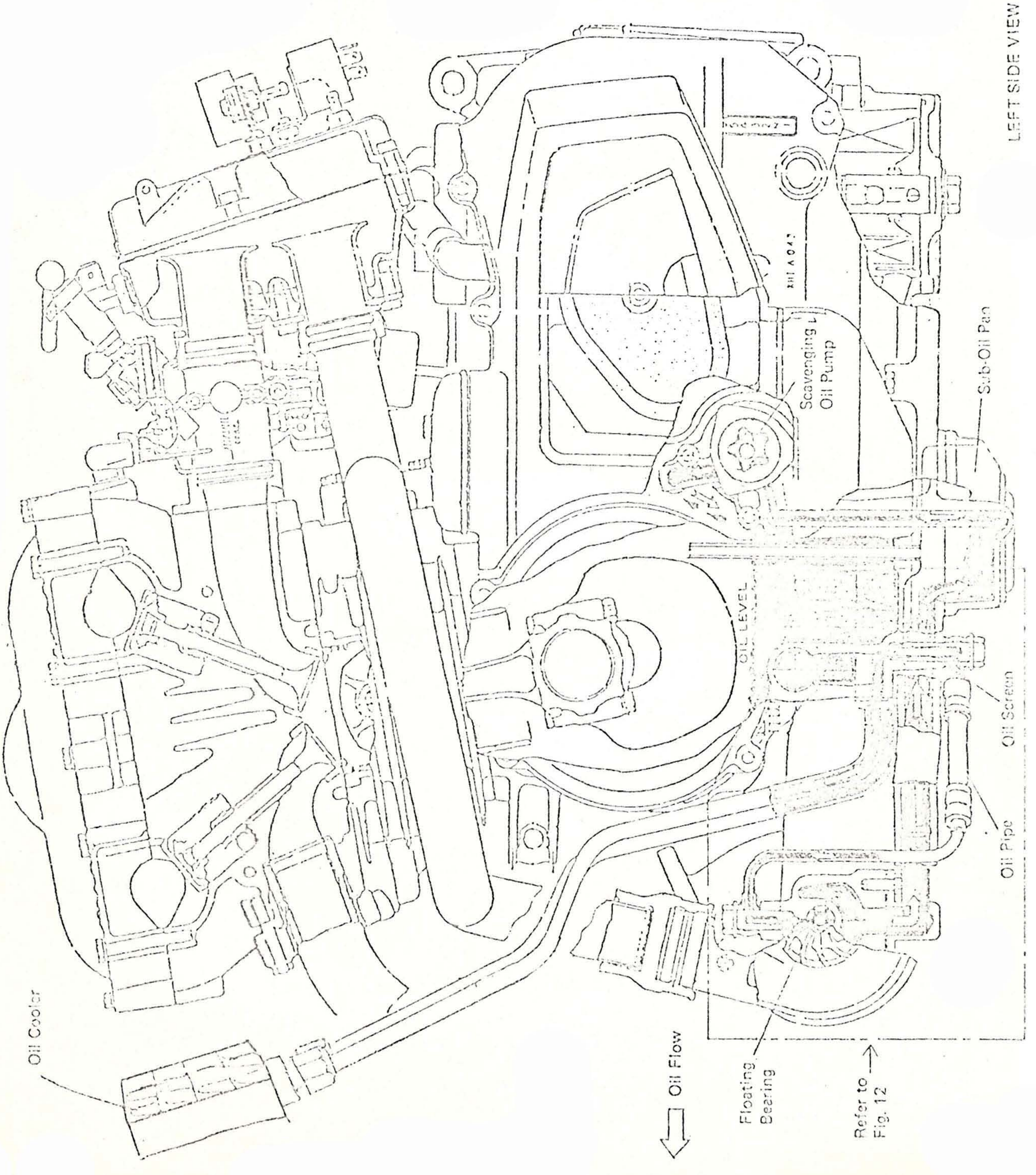


Fig. 12 Turbocharger Lubrication System (2)

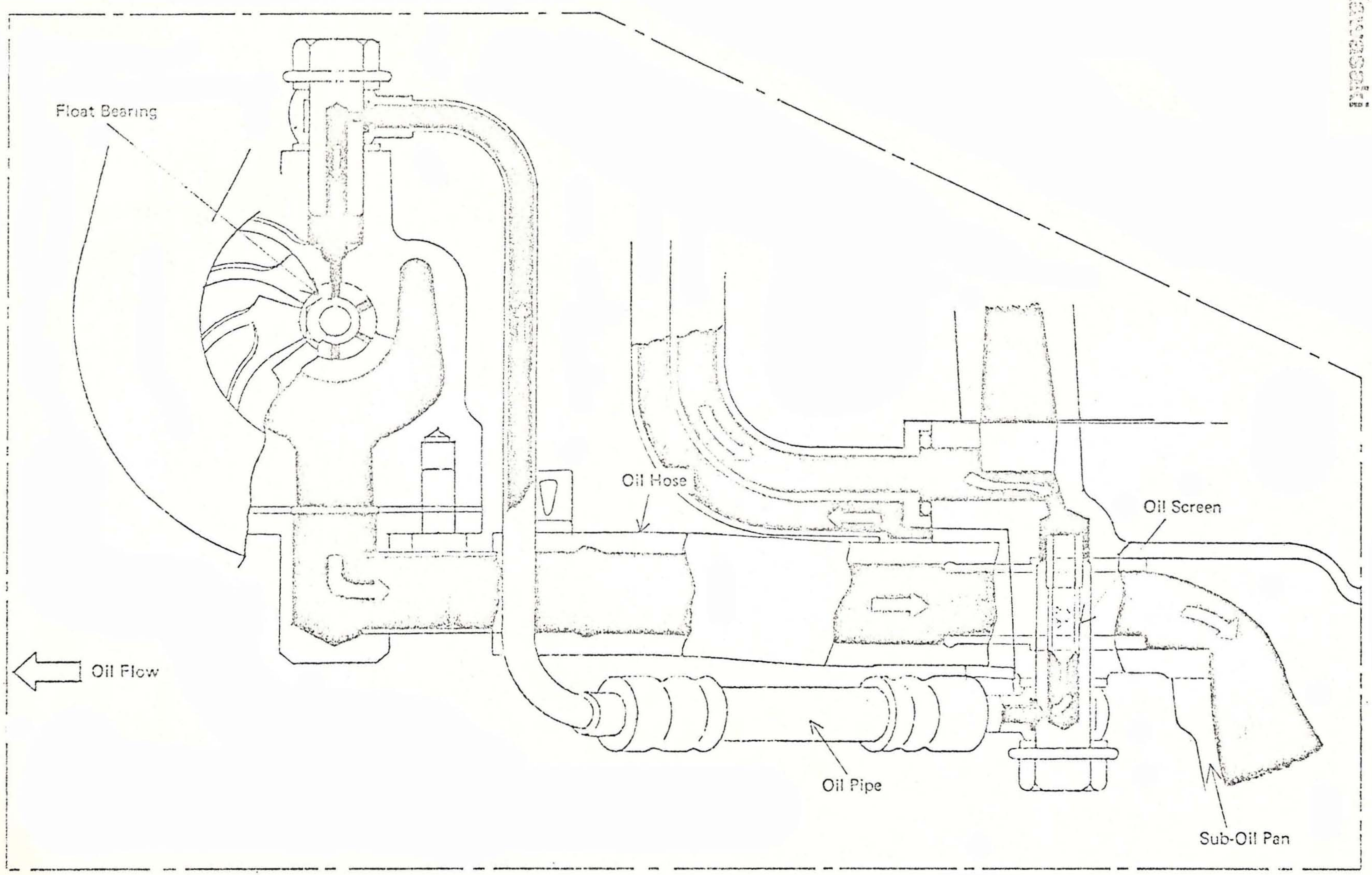
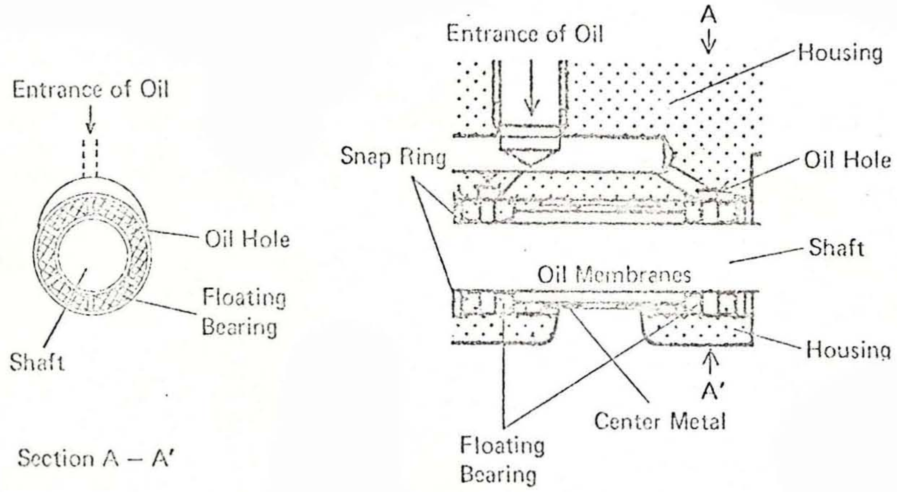


Fig. 4 Floating Bearing

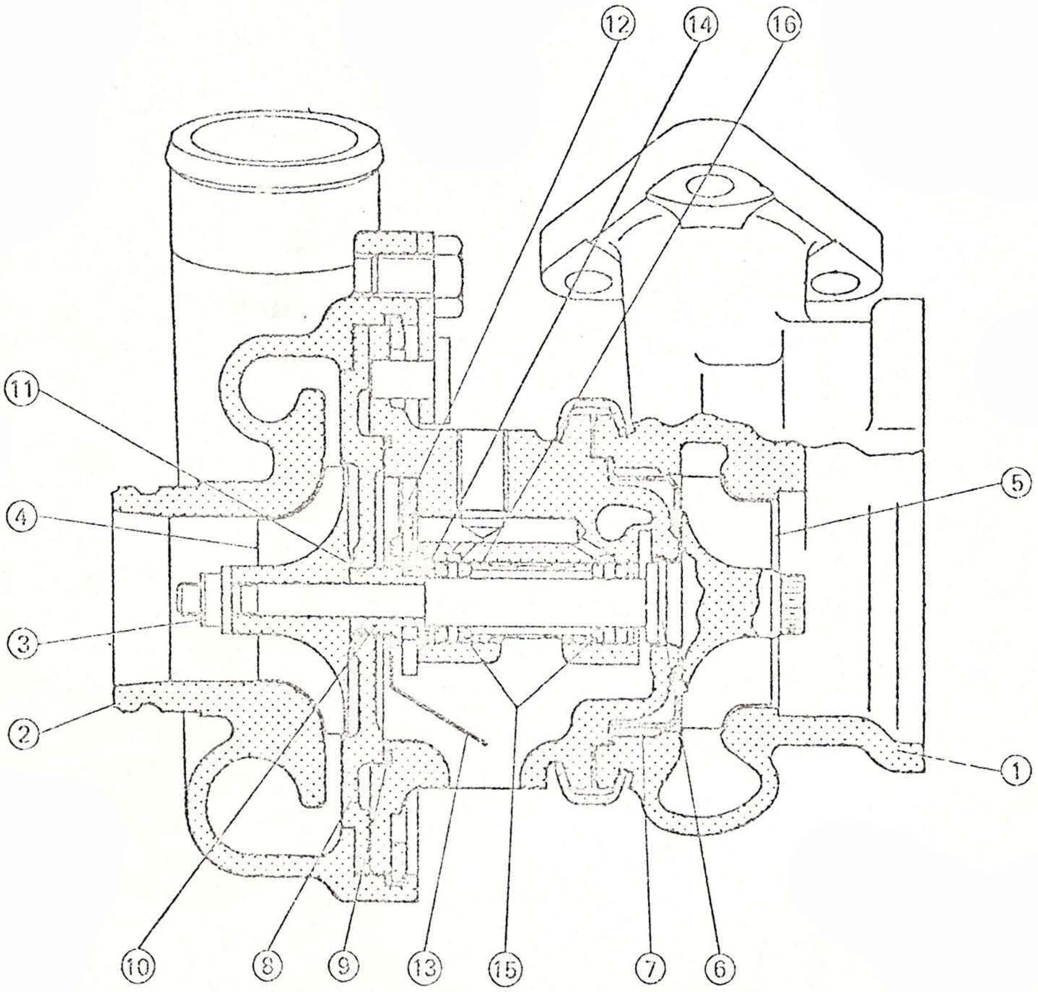


(4) Boost Control

Two components working together control the boost pressure. The waste gate allows some of the exhaust gas to bypass the turbine when the pressure approaches the design limit. The actuater is a pressure sensing diaphragm in the pressurized part of the intake tract which opens the waste gate when necessary.

If the boost pressure were left uncontrolled, it would rise as long as the throttle was held open until the engine exploded. It is very important to keep the boost pressure under control.

Fig. 3 Components of Turbocharger



1. Turbine Housing
2. Compressor
3. Locknut
4. Compressor Wheel
5. Turbine Wheel
6. Piston Ring
7. Heat
8. Backing Plate
9. Seal Ring
10. Thrust Collar
11. Piston Ring
12. Thrust Bearing
13. Oil Separator
14. Retainning Ring
15. Floating Bearing
16. Center Metal

2. STRUCTURE OF TURBOCHARGER UNIT

The turbocharger unit basically has four parts: the turbine, which extracts the heat energy of the exhaust gases; the compressor, which compresses the incoming air; the center housing, which carries the shaft between the turbine and compressor; and the boost control.

Fig. 2 Structure of Turbocharger

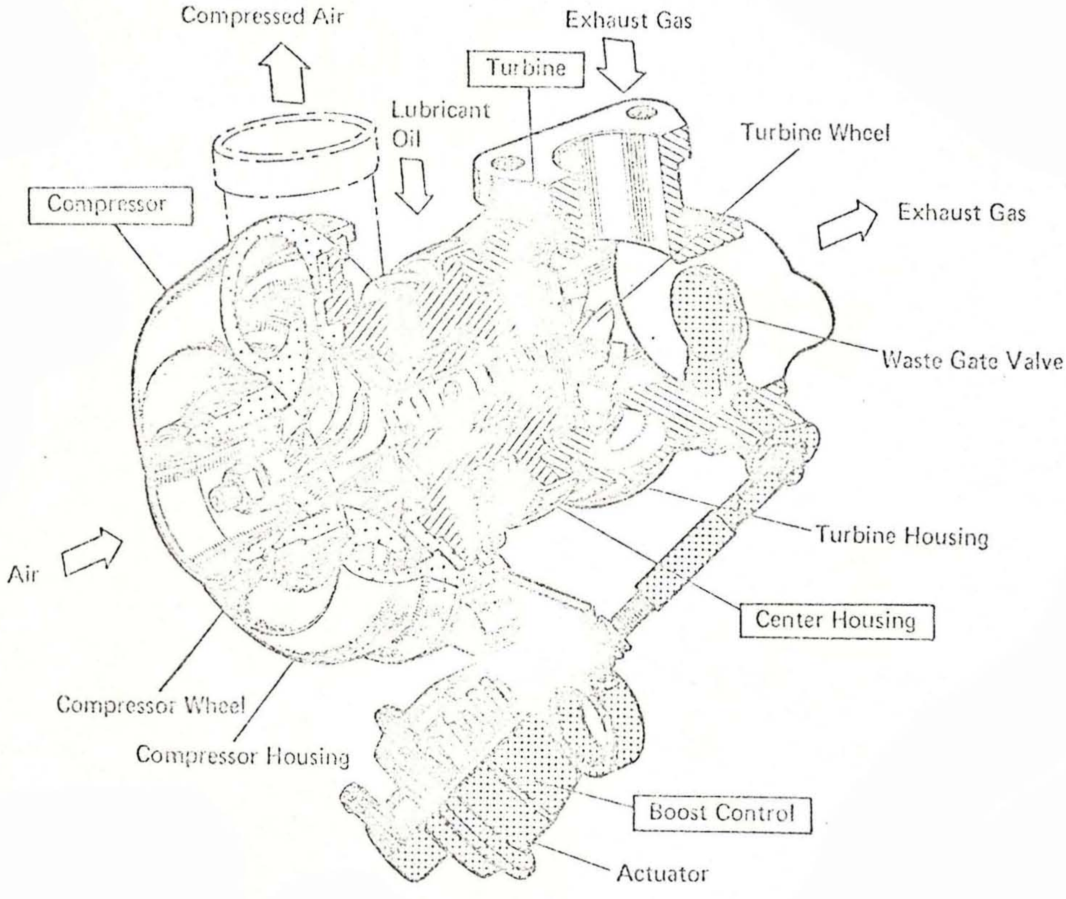
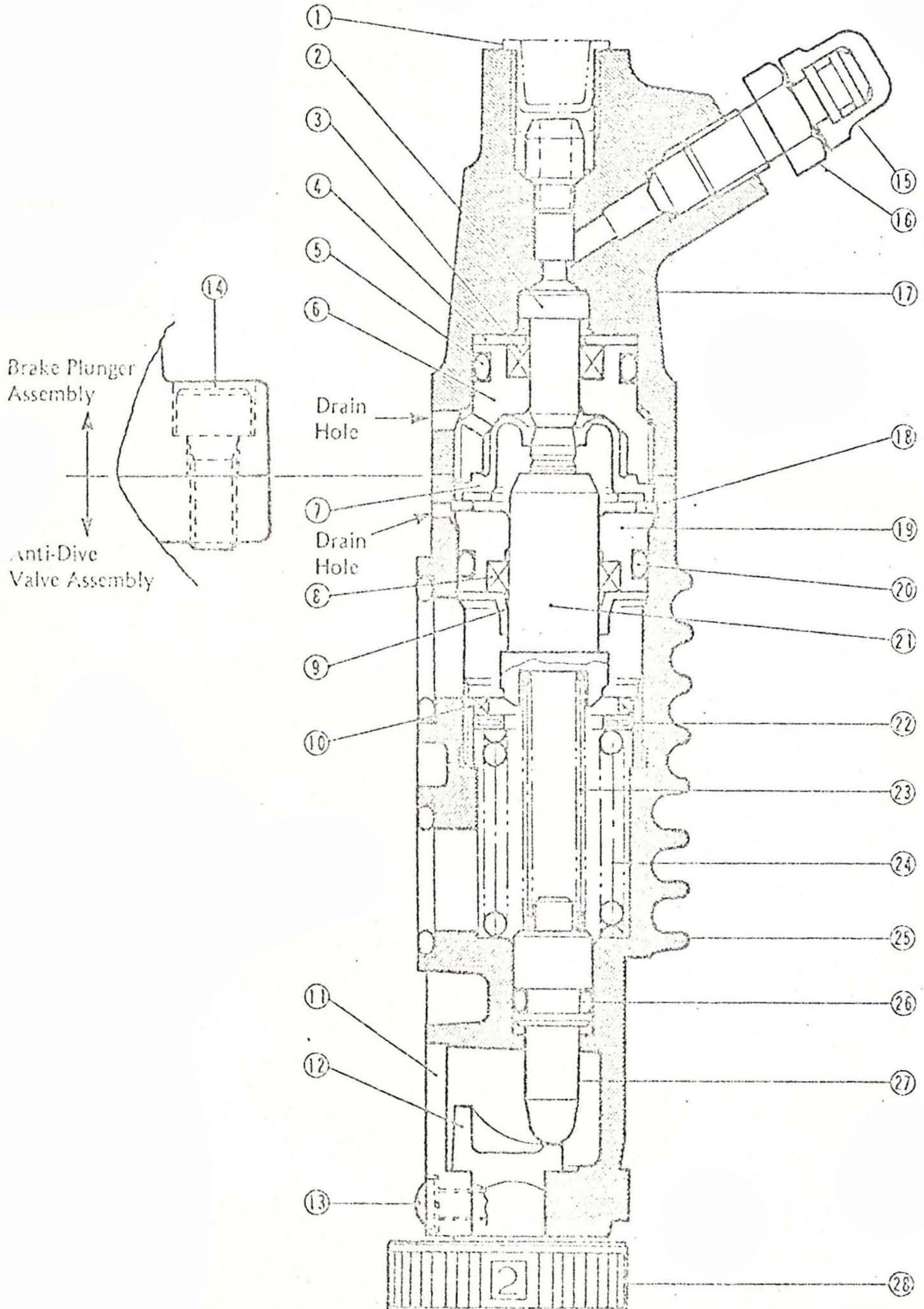


Fig. 2 Construction of Anti-Dive Unit



1. Shipping Plug
2. Brake Plunger
3. Seal Ring
4. Washer
5. O-Ring
6. Seal Case
7. Separator
8. Seal Ring
9. Rod Guide
10. Valve Seat
11. Cover
12. Adjuster Cam
13. Cover Mounting Screw
14. Brake Plunger Assembly Mounting Screw
15. Rubber Cap
16. Air Bleed Valve
17. Plunger Body
18. Retaining Ring
19. Rod Bearing
20. O-Ring
21. Valve Rod
22. Anti-Dive Valve
23. Rod Return Spring
24. Valve Spring
25. Valve Body
26. O-Ring
27. Adjuster Rod
28. Adjuster

Fig. 3 Anti-Dive System Not Working—
Compression Stroke (With Brake Released)

- The brake line is not pressurized.
- The brake plunger and valve rod are in their uppermost positions by rod spring tension.
- The anti-dive valve allows the fork oil to flow freely through the anti-dive valve assembly.
- Damping force in this case is relatively low.

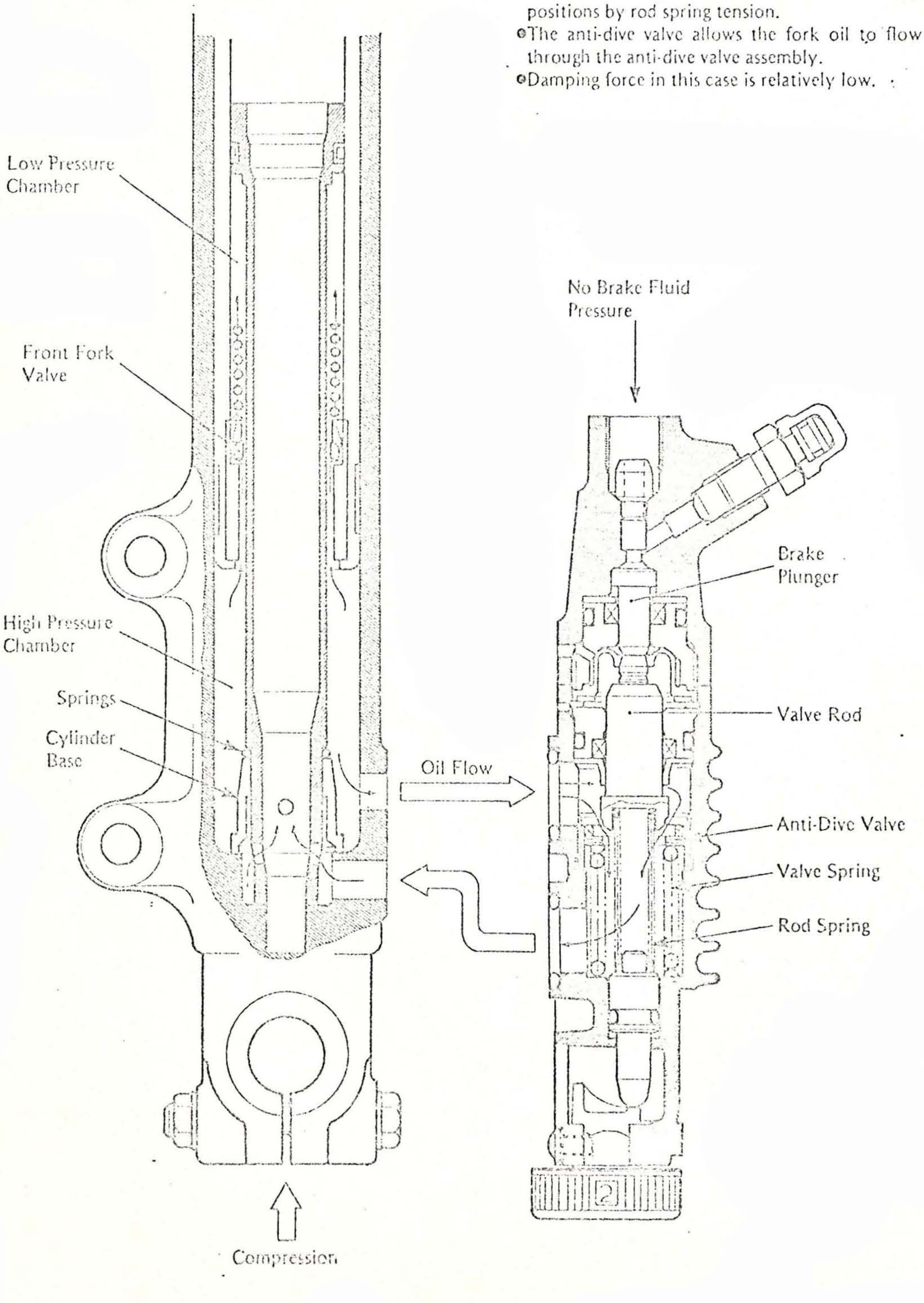


Fig. 4 Anti-Dive System Not Working–
Extension Stroke (With Brake Released)

- The brake line is not pressurized.
- The brake plunger and valve rod are in their uppermost positions by rod spring tension.
- The front fork valve restricts the oil flow from the high pressure chamber to the low pressure chamber. This provides the extension stroke damping force.
- The cylinder base acts as a check valve, that is, it opens during extension stroke to supply the low pressure chamber with fork oil.

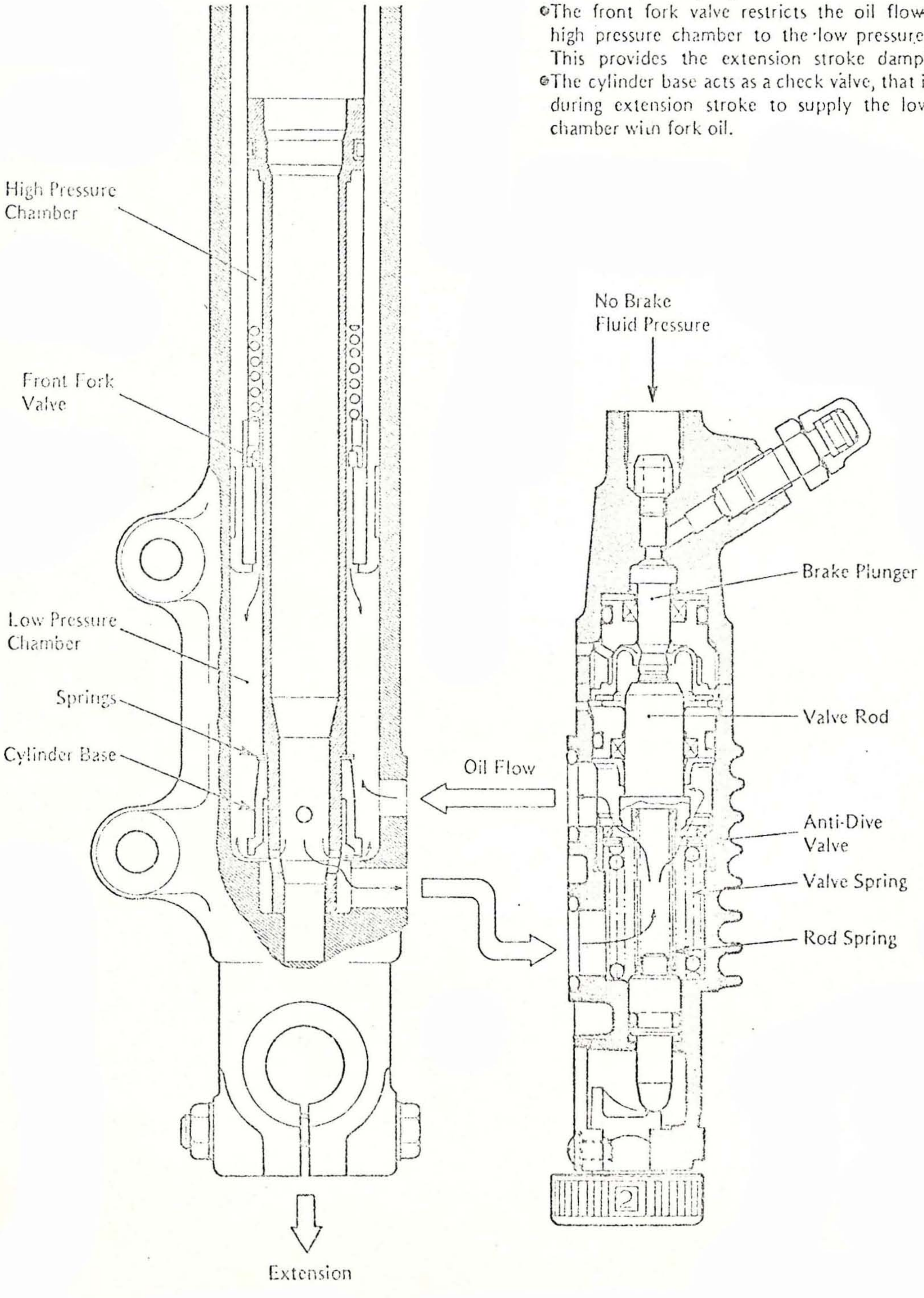


Fig. 5 Anti-Dive System Working – Preventing Excessive Compression (With Brake Applied)

- Brake pressure exerted on the top of the brake plunger pushes down the valve rod to close the anti-dive valve.
- This stops the oil to flow through the anti-dive valve assembly, preventing front fork over-reaction. This is true when the rise in oil pressure in the high pressure chamber is less than the valve spring tension.
- Pre-load of the rod spring can be adjusted by turning the adjuster so that individual riders se the anti-dive unit to suit road conditions and their own riding style.

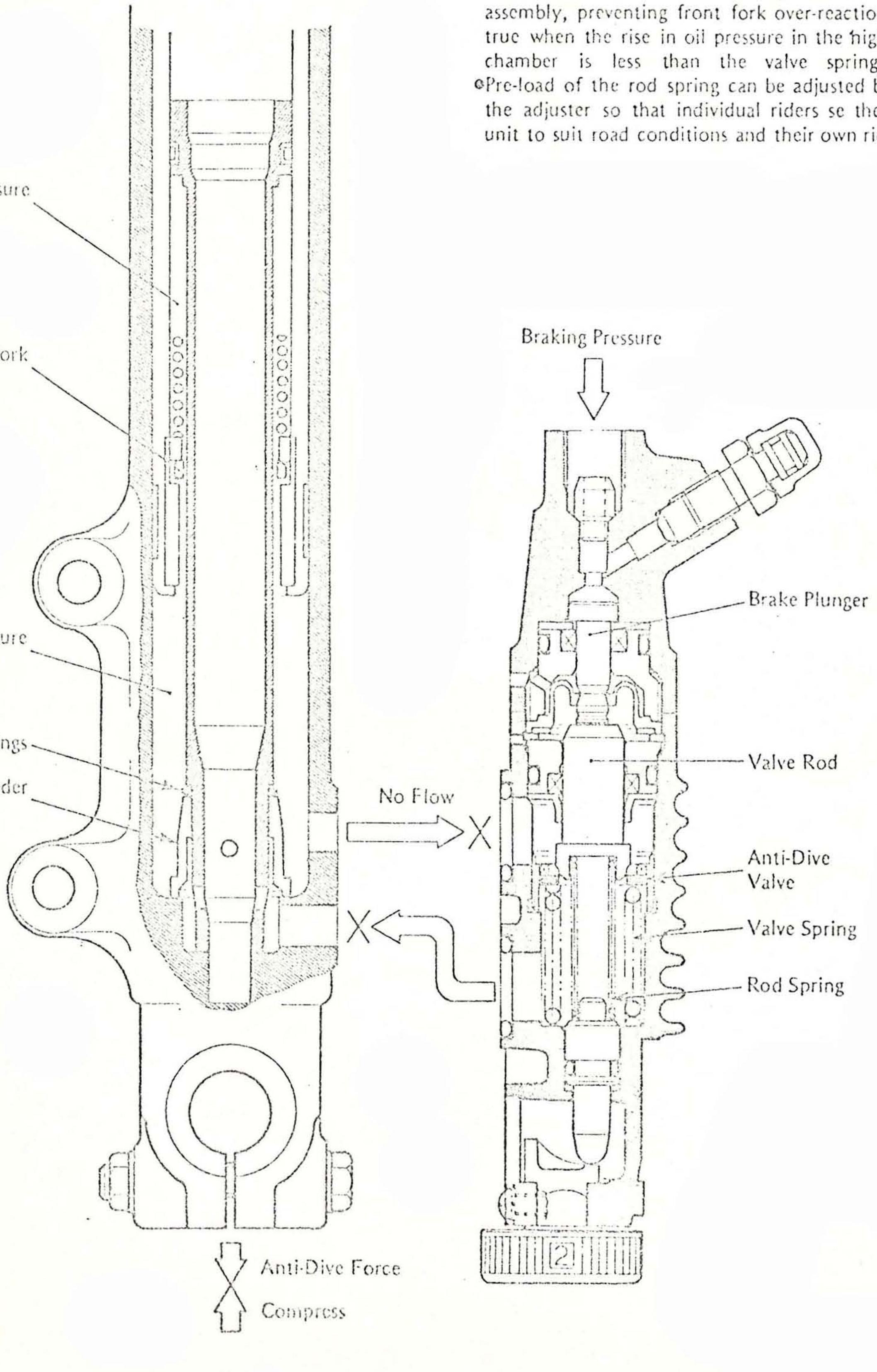


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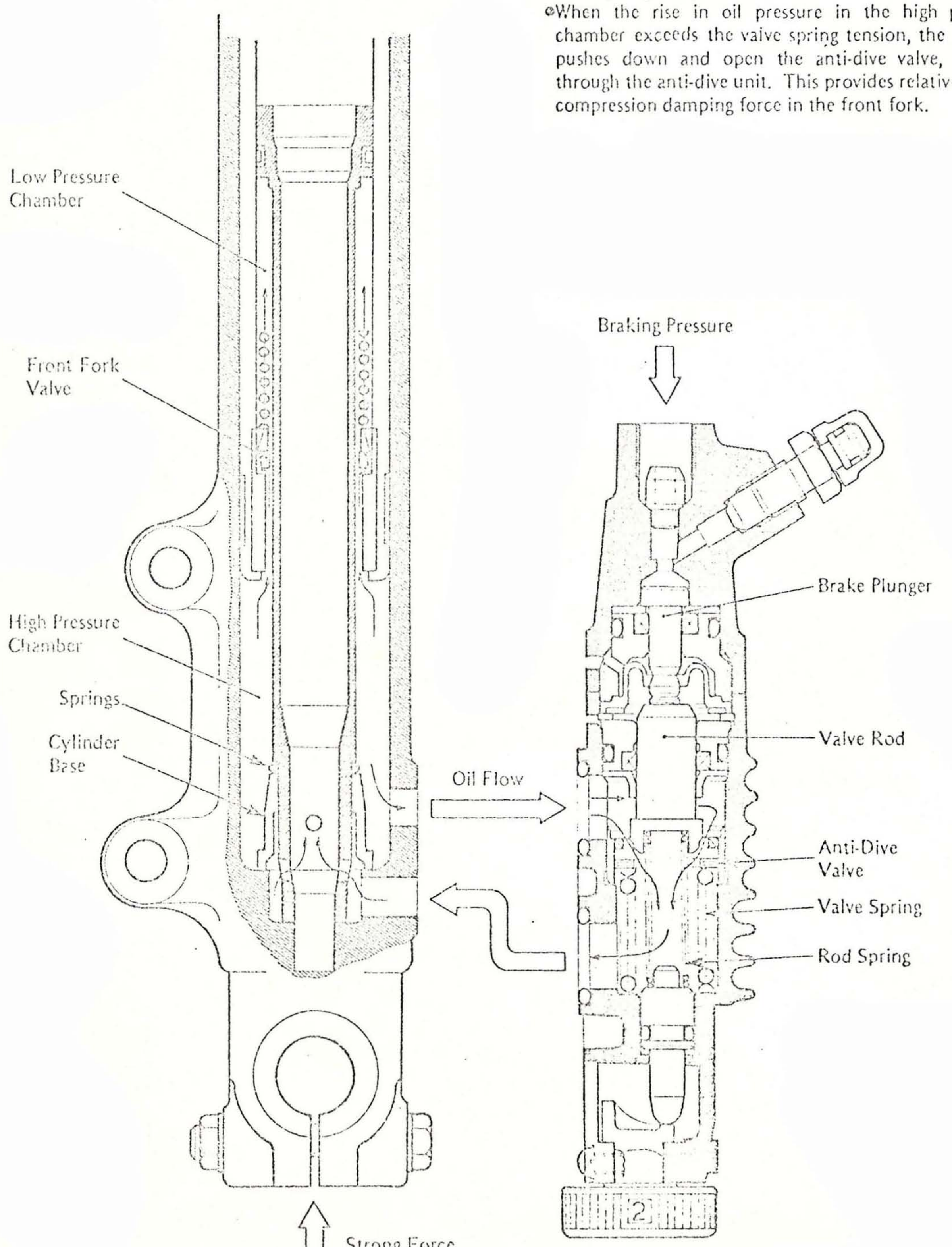
Fig. 6 Anti-Dive System Working — Receiving Strong Compression Force (With Brake Applied)

- The brake plunger and valve rod are in their lowermost positions by the brake line pressure applied to the brake plunger top.
- When the rise in oil pressure in the high pressure chamber exceeds the valve spring tension, the fork oil pushes down and open the anti-dive valve, flowing through the anti-dive unit. This provides relatively high compression damping force in the front fork.



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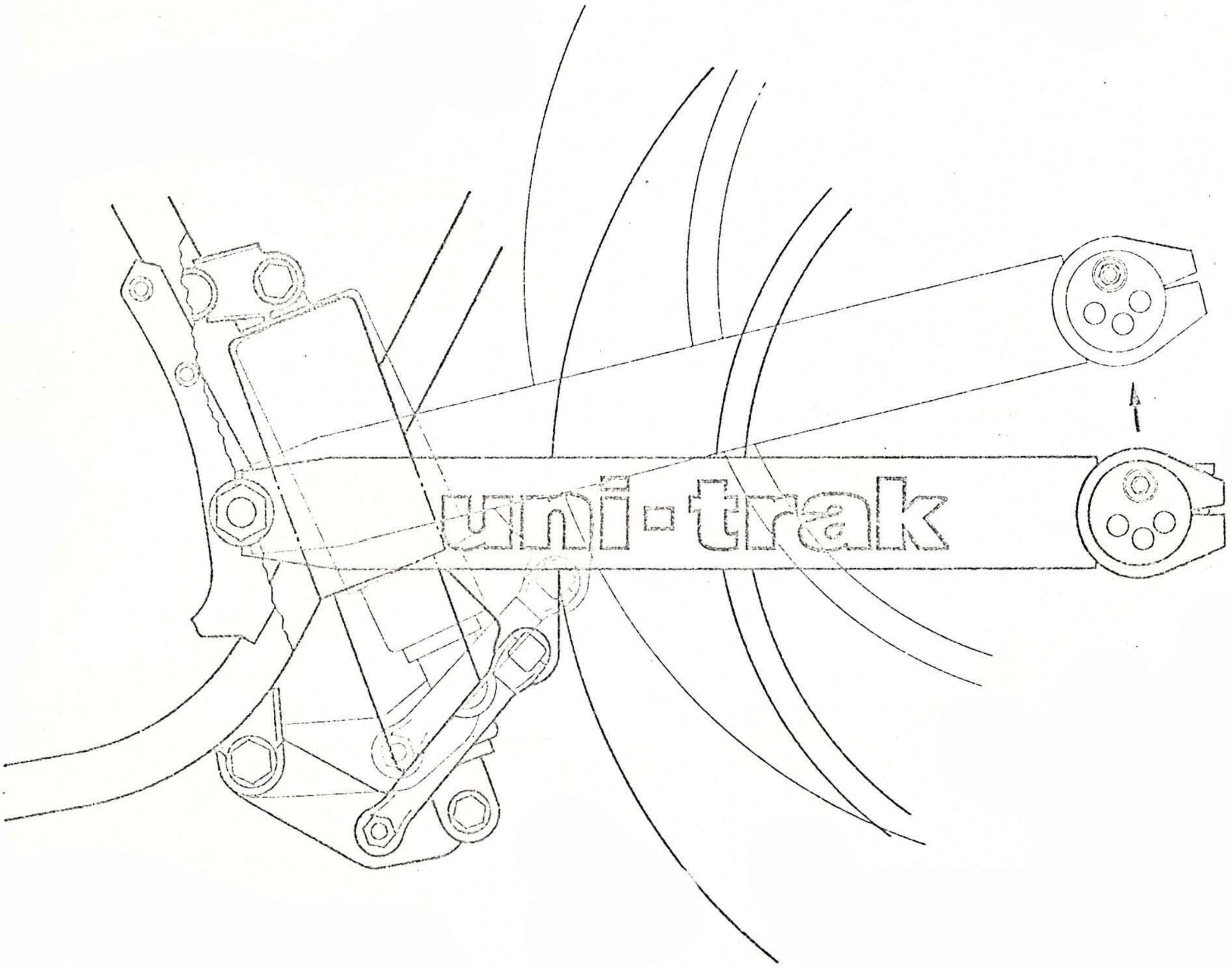


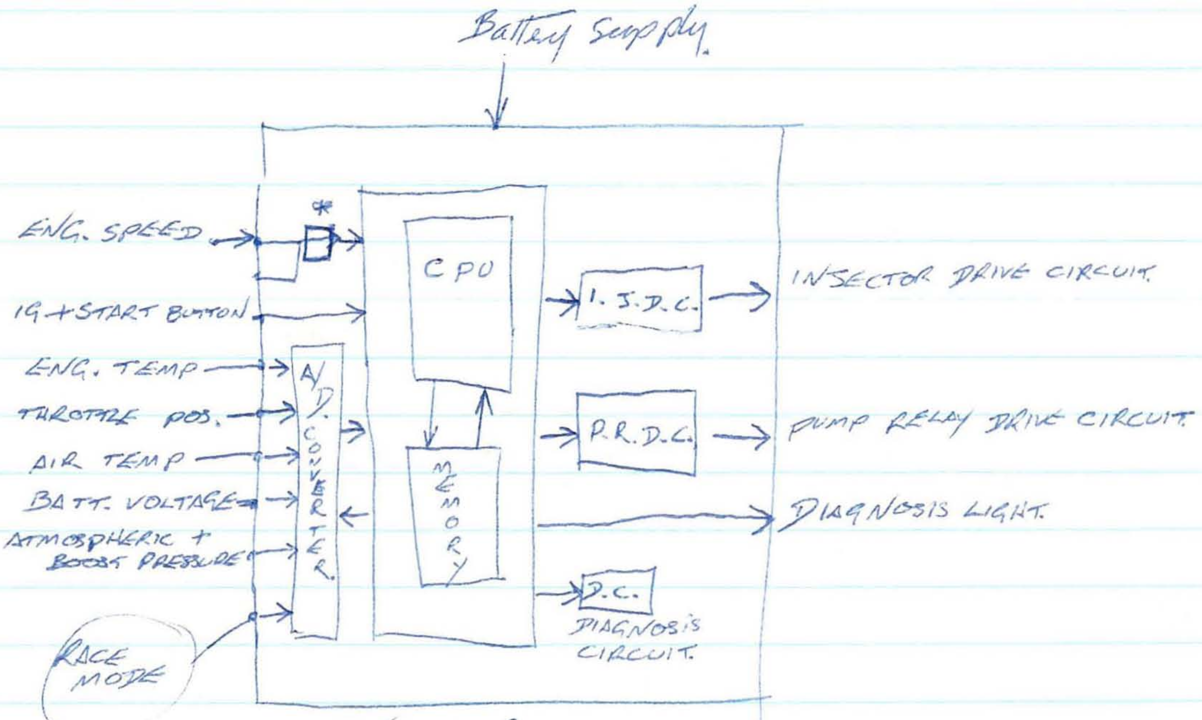
BENEFITS

- Sophisticated tyre/road adhesion under widely varying conditions
- Improved adhesion allows later, heavier braking
- Superior stability
- Increased safety
- Greater comfort.

ZX750E1/2. TURBO.

Valve timing is the same as Z650.
Std valve clearance :- IN. 0.13 - 0.23.
Ex. 0.08 - 0.18.

TURBINE - Snail shape. Blades 70% Nickel IN/CO7133. Blade & shaft 1 unit. (500-800°C)
COMPRESSOR - Snail Shape. Ali-silicon alloy. ALCOAC355.
CENTRE HOUSING. - Oil feed. 200,000RPM. 2. Floating bearings.
BOOST CONTROL - Diaphragm & spring 7.1 - 10.0 psi. to open Wastegate



* = Wave Shape circuit.
IJDC. Injector drive circuit
PRDC. Pump relay drive circuit.
DC. Diagnosis circuit.

Unsolder Brown from Blue/Red from Air temperature sensor; this gives no fuel cut. & 5 - 6% extra fuel injected.
Remove exhaust baffles.
Remove air filter (or better, cut pipe from air filter to turbo & point forward into air stream)

GENERAL SPECIFICATIONS

Items	ZX750E1/2
Dimensions:	
Overall Length	2,220mm (87.4in)
Overall Width	740mm (29.1in)
Overall Height	1,260mm (49.6in)
Road Clearance	155mm (6.10in)
Dry Weight	2,290N (233Kg, 514lb)
Performance:	
Minimum Turning Radius	2.7m (106.3in)
Braking Distance	12.5m from 50Km/h (41ft from 31mph)
Engine:	
Type	DOHC, 4 Cylinder, 4-Stroke
Cooling System	Air-Cooled
Bore & Stroke	66.0 x 54.0mm (2.60 x 2.13in)
Displacement	738ml (45.02 cu in)
Compression Ratio	7.8:1
Maximum Horsepower	Max 82.4K2 (112ps) @ 9,000 R/Min (Rpm)
Maximum Torque	99.1N-m (10.1Kg-m, 73.1ft.lb) @ 6,500 R/Min (Rpm)
Carburation System	Digital Fuel Injection, Turbo
Starting System	Electric Starter
Ignition System	Battery & Coil (Transistorised)
Timing Advance	Electronically Advanced
Ignition Timing	10° BTDC @ 1,050 R/Min (Rpm) 30° BTDC @ 3,300 R/Min (Rpm)
Spark Plugs	NGK BR9EV
Cylinder Numbering Method	Left to Right 1-2-3-4
Firing Order	1-2-4-3
Lubrication System	Forced Lubrication (wet sump with cooler)
Engine Oil:	
Grade	SE Class
Viscosity	SAE 10W40, 10W50, 20W40 or 20W50
Capacity	3.5L (3.7 US QT)
Drive Train:	
Primary Reduction System:	
Type	Gear
Reduction Ratio	1.935 (23/23 x 60/31)
Clutch Type	Wet, Multi-Disc
Transmission: Type	5-Speed, Constant Mesh, Return Shift
Gear Ratio: 1st	2.285 (32/14)
2nd	1.647 (28/17)
3rd	1.272 (28/22)
4th	1.045 (23/22)
5th	0.833 (20/24)

Items	ZX750E1/2
Final Drive System:	
Type	Chain Drive
Reduction Ratio	3.066 (46/15)
Overall Drive Ratio	4.946 @ Top Gear
Frame:	
Type	Tubular, Cradle
Castor (Rake Angle)	28^{o}
Trail	117mm (4.60 in)
Front Tyre: Type	Tubeless
Size	110/90 V18
Rear Tyre : Type	Tubeless
Size	130/80 V18
Front Suspension: Type	Telescopic Fork (Pneumatic)
Wheel Travel	130mm
Rear Suspension : Type	Swing Arm (Uni-Trak)
Wheel Travel	105mm
Brake Type: Front	Dual Disc
Rear	Single Disc
Electrical Equipment:	
Battery	12V 14AH
Headlight: Type	Semi-Sealed Beam
Bulb	12V 60/55W (Quartz-Halogen)
Tail/Brake Light	12V 5/21W x 2
Alternator: Type	Three-Phase AC
Rated Output	20A @ 8,000 R/Min (Rpm), 14V
Voltage Regulator: Type	Short-Circuit