The Brake System

Job No.
42 — 0

A. General

The efficacy and dependability of the brake system of a vehicle are of particular importance for traffic safety. The chief function of the brakes is to absorb the kinetic energy of the moving vehicle. The kinetic energy is converted into heat. The efficacy of a brake system is judged by the mean deceleration attainable. In the relevant German road traffic law the following values are laid down for passenger cars:

Specified mean deceleration
for the service brake: = 2.5 m/sec/sec
for the hand brake: = 1.5 m/sec/sec

The mean deceleration can be computed from the initial velocity of the vehicle and the stopping distance. The stopping distance is the distance the vehicle travels from the moment the brakes are applied until it comes to a stop.

The mean deceleration can, however, also be determined from the initial velocity and the stopping time.

For any given vehicle the stopping distance is dependent on the following factors (assuming that the pedal force applied remains constant):

1. Type and condition of the brake
2. Weight of the vehicle
3. Speed at the moment of brake application (Initial velocity)
4. Condition of the tires
5. Condition of the road surface

Computation of the Stopping Distance

In accordance with basic mechanical formulae, the stopping distance is given by the following equation:

$$s = \frac{v \times t}{2} = \frac{b \times t^2}{b} = \frac{v^2}{2 \times b} \text{ (m)}$$

where

s = stopping distance in m
v = velocity in m/sec
t = stopping time in sec
b = deceleration in m/sec/sec

If the velocity is to be expressed in km/h, the equation is

$$s = \frac{v^2}{26 \times b} \text{ (m)}$$

or for the mean deceleration

$$b = \frac{v^2}{26 \times s} \text{ (m/sec/sec)}$$

The mean deceleration can be determined from the initial velocity and the stopping time by means of the basic equation

$$b = \frac{v}{3.6 \times t} \text{ (m/sec/sec)}$$

The best method of determining the mean deceleration is to measure the stopping distance and to measure the initial velocity with the help of a calibrated speedometer. However, the stopping distance cannot be measured with sufficient accuracy by measuring the tire marks since at the beginning of the braking operation there are no visible tire marks on the road surface. For accurate measurements, therefore, paint markers are used which mark the road surface with a spot of paint at the beginning and at the end of the braking operation.

For practical purposes it is sufficient to determine the mean deceleration by means of a commercial decelerometer. The decelerometer, however, does not indicate the mean deceleration but the maximum deceleration attained during the braking opération. As a rule it can be assumed that when the brakes are fully applied at medium speed (approx. 70—80 km/h), the mean deceleration is roughly 0.8 times that of the maximum deceleration indicated by the decelerometer, which means that the indicated value must by multiplied by 0.8.

The specified deceleration values must be attained on a dry level road, at normal pedal load, with the vehicle fully loaded and the brake drums warmed up, (also at maximum speeds) without the vehicle beginning to skid.

Stopping Distance "s" (in m) and Stopping Time "t" (in sec)

on dry concrete roads (freeways) exclusive of the "scare second"

Deceleration	Speed in km/h																					
	40		50		60		70		80		90		100		110		120		130		140	
	s	t	s	t	s	t	s	t	s	t	s	t	s	t	s	t	s	t	s	t	s	t
1.5	41	7.46	64.1	9.3	92.3	11.19	125.6	13	164	14.92	207.7	16.8	256.4	18.6	310.2	20.5	369.2	22.38	433.3	24.2	502.5	26
2	30.8	5.6	48.1	7	69.3	8.4	94.2	9.8	123.2	11.2	156.6	12.6	192.4	14	232.7	15.4	277.2	16.8	325	18.2	376.8	19.6
2.5	24.8	4.48	38.5	5.6	55.8	6.72	75.4	7.6	99.2	8.96	125.1	10.08	154	11.2	186.2	12.3	223.2	13.44	260	14.6	301.6	15.2
3	20.4	3.72	32.1	4.7	45.9	5.58	62.8	6.5	81.6	7.44	103.5	8.4	128.4	9.4	155.1	10.3	183.6	11.16	216.6	12.1	251.2	11.2
3.5	17.6	3.2	27.5	4	39.6	4.8	53.8	5.6	70.4	6.4	89.1	7.2	110	8	133	8.8	158.4	9.6	185.7	10.4	215.2	13
4	15.2	2.8	24	3.5	34.2	4.2	47.1	4.9	60.8	5.6	77.4	6.3	96	7	116.3	7.7	136.8	8.4	162.5	9.1	188.4	9.8
4.5	13.6	2.48	21.4	3.1	30.6	3.72	41.9	4.4	54.4	4.96	69.3	5.58	85.6	6.2	103.4	6.8	122.4	7.44	144.4	8	167.6	8.8
5	12.4	2.24	19.2	2.8	27.9	3.36	37.7	3.9	49.6	4.48	62.1	5.04	76.8	5.6	93.1	6.2	111.6	6.72	130	7.3	150.8	7.8
5.5	11.2	2.04	17.4	2.54	25.2	3.06	34.2	3.6	44.8	4.08	56.7	4.59	69.6	5.08	84.6	5.6	100.8	6.12	118.1	6.6	136.8	7.2
6	10.4	1.86	16	2.3	23.4	2.79	31.4	3.3	41.6	3.72	53.1	4.2	64	4.6	77.6	5.1	93.6	5.58	108.3	6.1	125.6	6.6
6.0	9.6	1.72	14.8	2.15	21.6	2.58	28.9	3	38.4	3.44	48.6	3.87	59.2	4.3	71.6	4.7	86.4	5.16	100	5.6	115.6	6
7	8.8	1.6	13.7	2	19.8	2.4	26.9	2.8	35.2	3.2	44.1	3.6	54.8	4	66.5	4.4	79.2	4.8	92.9	5.2	107.6	5.6

In computing the stopping distances given in the above table, the "scare second" has not been taken into account. Many tests have confirmed the general experience that the driver of a motor vehicle needs just about one second, the so-called "scare second", until he is in a position effectively to brake his vehicle. The "scare second" comprises the recognition time, the reaction time proper, the brake actuating time, and the brake response time. During the whole of this one second the vehicle travels on at undiminished speed. For this reason the actual stopping distance is much longer when the "scare second" is taken into consideration. In the following diagram the stopping distances are given on the basis of one "scare second".

Stopping Distance (Including 1 Scare Second)

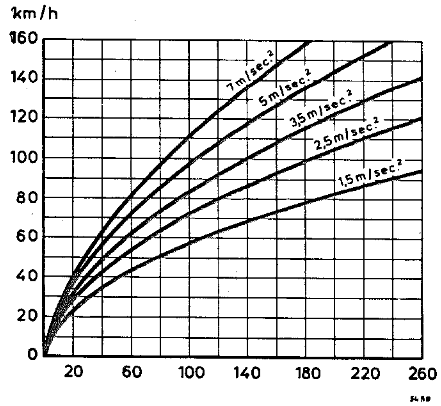


Fig. 42 — 0/1

The deceleration values attained by modern vehicles are considerably higher than the legal minimum values when the cars are braked at medium speeds.
Under very favorable conditions ,the following mean deceleration values can be expected:

dry concrete (freeways)	7 m/sec/sec
dry asphalt and macadam	5 m/sec/sec
wet asphalt and macadam	3.5 m/sec/sec
icy roads	1.5 m/sec/sec

B. Description of the Brake System

a) Vehicle without ATE Power Brake A 50

General:

The service brake is of the hydraulic type. It consists of a brake master cylinder which produces the hydraulic pressure,

the brake wheel cylinders inside the brake drums which transmit this pressure and press the brake shoes against the brake drums,

the network of brake lines and brake hoses which provide the connection between brake master cylinder and brake wheel cylinders, and

the fluid reservoir which maintains a constant volume of brake fluid.

The hydraulic brake operates in accordance with Pascal's Law which states that the pressure exerted on an enclosed liquid is transmitted equally in all directions.

When the brake pedal is depressed, the piston in the brake master cylinder is pushed forward and the displaced brake fluid passes through the brake lines and brake hoses to the brake wheel cylinders. The brake fluid enters the brake wheel cylinders, pushing their pistons outward against the brake shoes and thus forcing these shoes against the brake drums. (For a diagrammatic illustration of the brake system see Fig. 42 — 0/2).

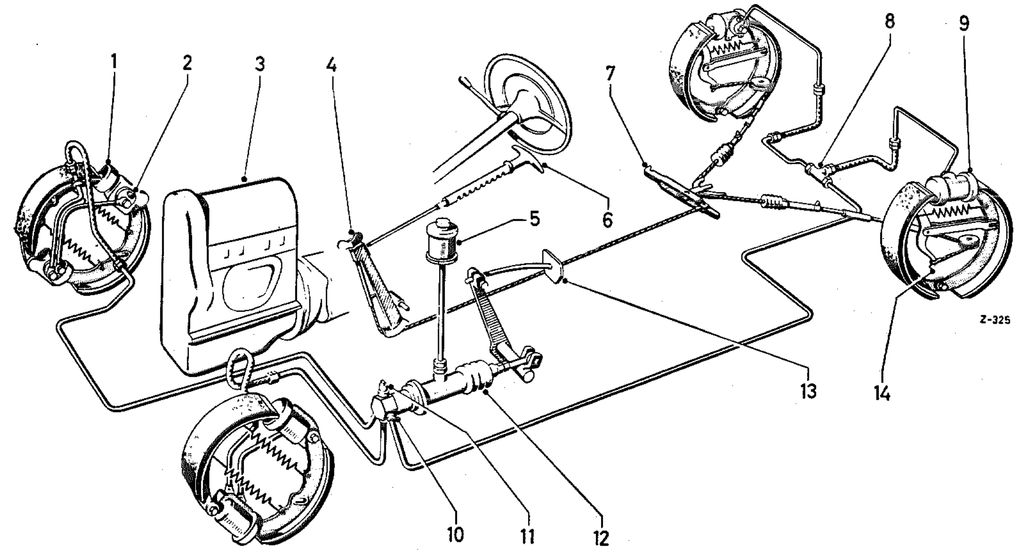


Fig. 42 — 0/2

1 Brake wheel cylinder	4 Brake lever	7 Equalizer	10 Distributor fitting, front	13 Brake pedal
2 Bleed screw	5 Fluid reservoir	8 Distributor fitting, rear	11 Stop light switch	14 Brake lever
3 Engine	6 Hand brake	9 Brake wheel cylinder	12 Brake master cylinder	

When the pedal load is increased, the pressure within the brake wheel cylinders is also increased and consequently also the force acting on the brake shoes. The pressure is transmitted in accordance with the pedal load applied.

When the brake pedal is released, the return springs pull the brake shoes and the pistons of the brake wheel cylinders back into their initial position and force the brake fluid back to the brake master cylinder.

However, to ensure instant response of the brake, a small residual pressure of 0.4 — 0.8 atm. is left in the line system even when the brake is released.

On the front wheels the brakes have two leading shoes in each drum, and each brake shoe has its own brake wheel cylinder (Duplex brake) (Fig. 42 — 0/3). This arrangement of two leading shoes, each actuated by a brake wheel cylinder, results in a high degree of self-energization of the brakes, which is produced by the rotating brake drum which tends to drag the brake shoes along with it; as a result, the brake shoes are forced against the brake drum.

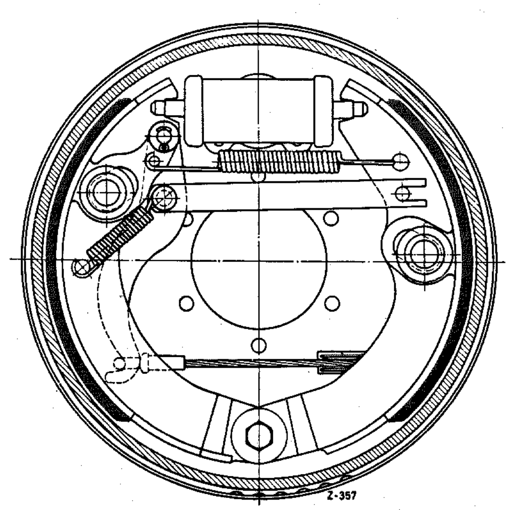


Fig. 42 — 0/3

Front wheel brake left

On the rear wheels, the two brake shoes have a common brake wheel cylinder with two pistons (Simplex brake) (Fig. 42—0/4). In this case the brake shoe which rotates about its pivot in the same sense as the brake drum is the leading or primary shoe, which is pressed against the brake drum when the brake is applied, and consequently exerts an additional force as in the case of the front wheel brake.

The braking force of the second brake shoe, the trailing or secondary shoe, which is moved inward by the sense of rotation of the drum, is considerably smaller.

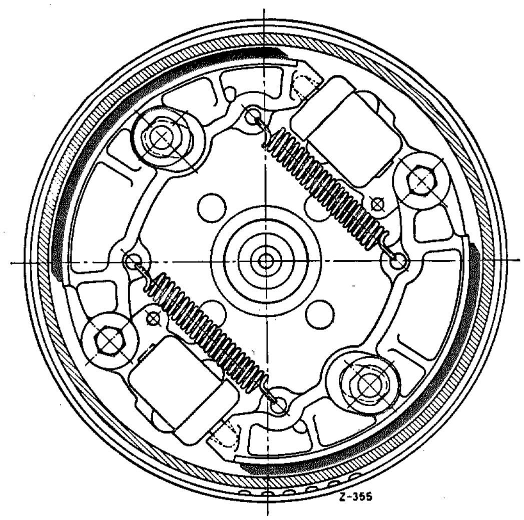


Fig. 42—0/4

Rear wheel brake left

Brake Master Cylinder

The brake master cylinder refills automatically, that is, it contains an automatic control device which ensures constant fluid volume and constant pressure in the brake lines.

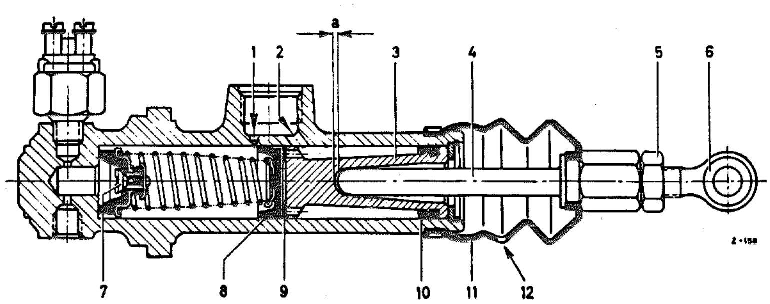
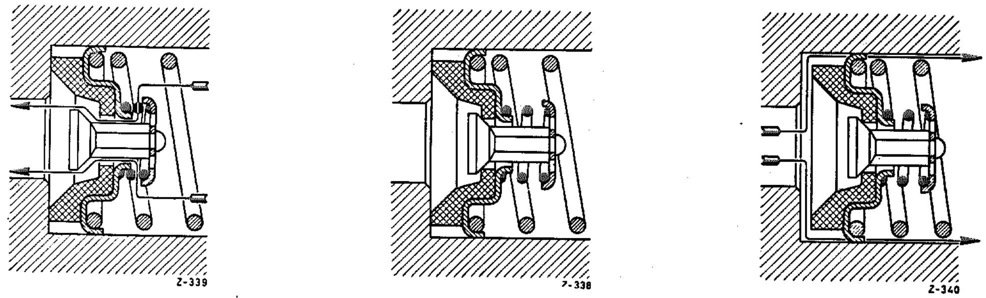


Fig. 42—0/5

a = 1 mm
1 Compensating port
2 Connecting port
3 Piston
4 Piston push rod
5 Hexagon nut
6 Piston push rod end
7 Check valve
8 Primary cup
9 Piston cup washer
10 Secondary cup
11 Boot
12 Vent hole

The fluid contained in the brake master cylinder, in the brake lines, and in the brake wheel cylinders is subject to temperature influences, with the result that the enclosed brake fluid expands under the influence of heat and contracts under the influence of cold. Volume compensation is effected via the compensating port (1). When the fluid volume expands, the excess can flow back from the pressure chamber of the brake master cylinder into the fluid reservoir; on the other hand, if the fluid volume is deficient, fluid can flow from the fluid reservoir via the compensating port (1) into the pressure chamber of the brake master cylinder. **In order to ensure that the compensating port can fulfil its highly important task, the compensating port must always be kept open when the brake is in its non-applied position.** When the brake pedal is adjusted, it is therefore very important to ensure that there is a clearance of a = approx. 1 mm between the piston push rod (4) and the piston (3) (see

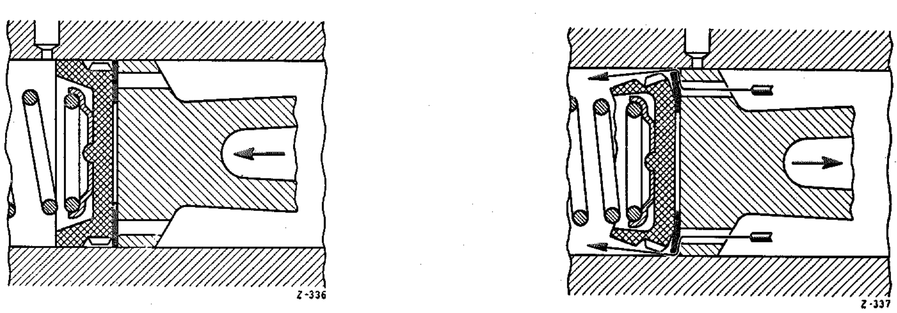
Fig. 42—0/5). If the compensating port is closed, the brake fluid cannot flow back when it expands under the influence of heat. The result would be drum-shoe contact and a constant dragging of the brake shoes.
In addition to the compensating port, a check valve (7) in the brake master cylinder is necessary to provide for the fluid exchange between fluid reservoir, brake master cylinder, and the brake line system (Fig. 42—0/5 and Fig. 42—0/6).



Applied position — Non-applied position — Release position

Fig. 42—0/6

The check or relief valve is arranged at the bottom of the brake master cylinder, that is, between the pressure piston of the brake cylinder and the line system.
Its function is to provide for pressure equalization between brake master cylinder and the line system when the brake fluid expands or contracts. In addition, it maintains a slight residual pressure of 0.4—0.8 atm. in the line system when the brake is released. This ensures that the line system is always completely filled with fluid, so that the brake can respond evenly and quickly.
During the braking operation or if, because of fluid contraction, the pressure in the line system is lower than in the pressure chamber, the inner valve opens and admits brake fluid (Fig. 42—0/6, Applied position).
When the brake is released, or if, because of fluid expansion, the pressure in the line system is higher than in the pressure chamber, the check valve lifts from its seat so that brake fluid can flow back to the fluid reservoir through the pressure chamber of the brake master cylinder (Fig. 42—0/6, Release position).
The pressure spring in the brake master cylinder is so designed that the check valve lifts when the pressure reaches 0.4—0.8 atm.; this ensures the maintenance of the required residual pressure in the line system (Fig. 42—0/6, Non-applied position).
In order to prevent air from being sucked in when the brake cylinder piston returns to its initial position quickly, a ring-shaped fluid chamber is arranged behind the primary piston cup which is supplied with brake fluid via the connecting port (2) (see Fig. 42—0/5).



Applied position — Releasse position

Fig. 42—0/7

When the brake is applied, the sealing lip of the primary cup seals off the pressure chamber, the piston cup washer presses against the bores which are arranged in a circle around the piston, thus preventing damage to the primary cup by the connecting ports (Applied position, Fig. 42—0.7). When the brake is released, the primary cup folds up, and the piston cup washer moves away from the piston head. Thus, the brake fluid can flow from the fluid chamber in the piston through the connecting ports into the pressure chamber (Release position, Fig. 42—0/7).

The interaction of compensating port, check valve, and primary cup definitely prevents the entrance of air into the brake system.

Brake Wheel Cylinders

It is the function of the brake wheel cylinders, which are attached to the brake anchor plates, to transmit to the brake shoes the pressure produced in the brake master cylinder.

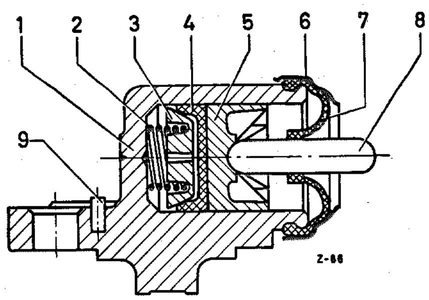


Fig. 42—0/8

Front wheel brake cylinder

1 Brake wheel cylinder
2 Stop spring
3 Piston cup expander
4 Cup
5 Piston
6 Metal boot
7 Rubber boot
8 Actuating pin
9 Notched pin

The front wheel brake cylinder contains the piston (5), the cup (4), the cup expander (3), and the stop spring (2). The stop spring together with the cup expander serves to press the cup against the cylinder wall. The contact between the piston and the brake shoe is established by the actuating pin (8). In order to prevent dirt and moisture from entering the bore of the brake wheel cylinder, a rubber boot (7) covers the brake wheel cylinder and the actuating pin. An additional metal boot (6) is added in order to protect the rubber boot from hot abrasive particles.

When the brake is applied, the brake fluid displaced in the brake master cylinder is pressed into the brake wheel cylinders. The pressure of the brake fluid moves the cup and the piston outward and the actuating pin forces the brake shoe against the brake drum.

A bleed screw is mounted at the highest point of the brake wheel cylinder. This bleed screw is opened when the brake system is filled and bled in order to provide an escape for any air that may have entered. For this purpose, the bleeder valve is so arranged that it is not covered by the cup even when the brake is released.

The rear wheel brake cylinder (Fig. 42—0/9) is designed on the same principle with the difference that it has two pistons, two cups, and two cup expanders. The contact between pistons and brake shoes is again provided by two actuating pins. Metal boots are not required on the rear wheel brake because it is subject to less strain than the front wheel brake.

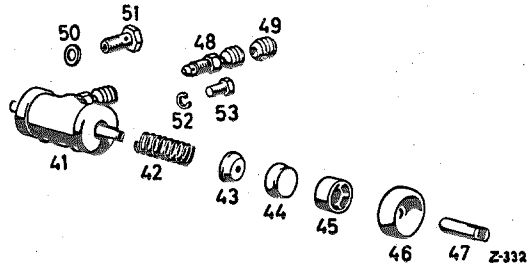


Fig. 42—0/9

Rear wheel brake cylinder

41 Brake wheel cylinder
42 Stop spring
43 Piston cup expander
44 Piston cup
45 Piston
46 Rubber boot
47 Actuating pin
48 Bleed screw
49 Rubber boot
50 Sealing ring A 10×14 copper
51 Hollow screw
52 Lock washer
53 Hexagon screw

Brake shoes

The arrangement of the brake shoes, the brake wheel cylinders, and the return springs is shown in Figs. 42—0/10 and 42—0/11.

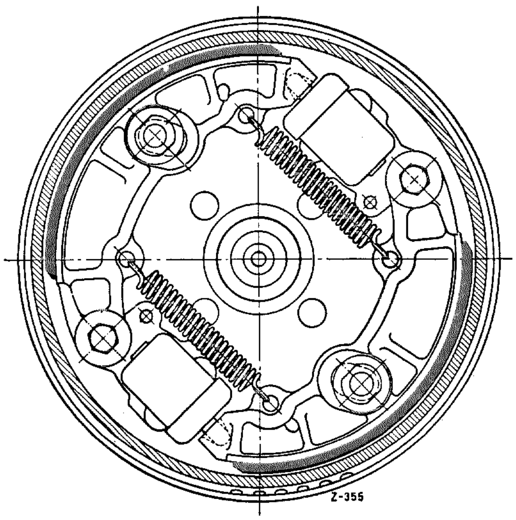


Fig. 42—0/10

Front wheel brake left

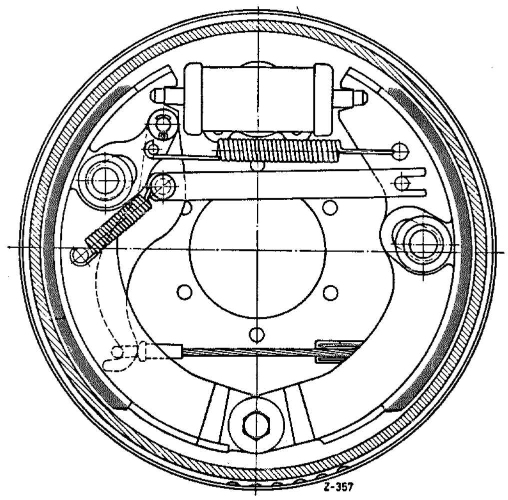


Fig. 42—0/11

Rear wheel brake left

The brake linings are bonded to the brake shoes by a special process. This bonding of the brake linings has the advantage that the brake lining snugly fits the brake shoe without any hollow spots. Since rivets are not used, the effective brake area is larger than in the case of a riveted lining of equal size. An additional advantage is that because of the absence of rivets the brake lining can be worn down to a thickness of approx. 1.5 mm.

Automatic Brake Adjustment

Both the front wheel brakes and the rear wheel brakes adjust themselves automatically to the degree of wear of the linings.

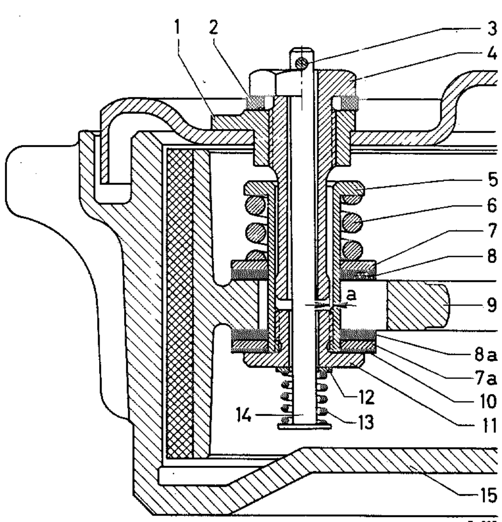


Fig. 42—0/12

Front wheel brake

1 Collar bushing
2 Lock washer
3 Cotter pin 3 × 15
4 Pin
5 Adjusting sleeve
6 Pressure spring
7 and 7 a Thrust washer (steel)
8 and 8 a Friction washer
9 Brake shoe
10 Washer
11 Tensioning screw
12 Washer
13 Pressure spring
14 Guide pin
15 Brake drum
a = clearance

The automatic adjustment operates as follows:

The adjusting sleeve (5), together with the tensioning screw (11), is arranged in the slotted hole of the brake shoe (Fig. 42—0/12). The pressure spring (6) presses the two friction washers (8 and 8a) against the web of the brake shoe. The pin (4), which is screwed into the brake anchor plate, projects into the adjusting sleeve (5). The guide pin (14) which passes through the hollow pin (4) and is secured at the brake anchor plate by means of a cotter pin, provides an axial guide for the brake shoe. The pressure spring (13) presses the brake shoe against the contact plates of the brake anchor plate.

Between the adjusting sleeve (5) and the pin (4) there is a radial clearance of 0.8 mm in the case of the front wheel brake and of 1 mm in the case of the rear wheel brake (Fig. 42—0/12).

When the brake is released, the return spring pulls the brake shoe inward to the point where the adjusting sleeve comes to rest against the pin. On account of the available clearance, the brake wheel cylinder can easily press the brake shoe against the drum when the brake is applied. If in the course of time the brake lining is worn down, the adjusting sleeve rests against the pin before the brake shoe comes to rest against the drum.
The pressure exerted by the brake wheel cylinder now overcomes the pressure of the friction washers and thus readjusts the brake shoe where it contacts the brake drum. When the brake shoe is thus automatically adjusted, the adjusting sleeve, which is held by the pin, shifts in the slotted hole of the brake shoe.

The contact pressure of the friction washers must be kept within limits so that it can be overcome by the braking pressure, whereas the return spring must not be able to pull the brake shoe inward beyond the specified clearance.

Hand Brake

The hand brake is a conventional cable brake, acting on the rear wheels. The hand brake is adjusted by means of a wing nut at the brake lever which is arranged at the chassis base panel under the engine hood.

The hand brake must be so adjusted that braking begins when the hand brake lever is pulled out to the third or fourth notch.

b) Vehicles with ATE Power Brake T 50

In order to reduce the pedal force required for braking, the vehicle can be provided with an ATE Power Brake T 50 as an optional extra. The power brake is a vacuum-assisted hydraulic braking device which utilizes the pressure difference between engine intake manifold vacuum and atmospheric pressure for its operation. The power unit increases the pressure created physically in the brake master cylinder so that the same braking effect can be produced with considerably less expenditure of effort. With the Power Brake T 50 installed, the pedal force required for braking is about half the force otherwise required. However, it is not possible to obtain a greater mean deceleration. The power unit is mounted in the hydraulic line between the brake master cylinder and the brake wheel cylinders. A vacuum hose connection is made from the power brake unit to the engine intake manifold (Fig. 42—0/13).

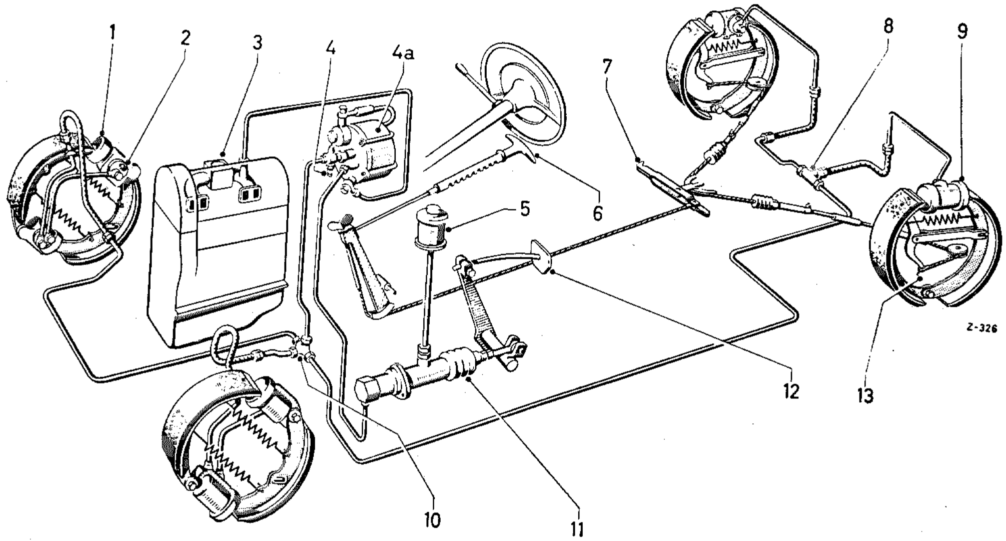


Fig. 42—0/13

1 Brake wheel cylinder
2 Bleed screw
3 Intake manifold
4 Stop light switch
4a ATE Power Brake
5 Fluid reservoir
6 Hand brake
7 Equalizer
8 Distributor fitting, rear
9 Brake wheel cylinder
10 Distributor fitting, front
11 Brake master cylinder
12 Brake pedal
13 Brake lever

Description and Operation of the ATE Power Brake T 50

The ATE Power Brake consists of the following three main sections:

1. Vacuum power cylinder
2. Hydraulic slave cylinder
3. Hydraulically actuated control valve

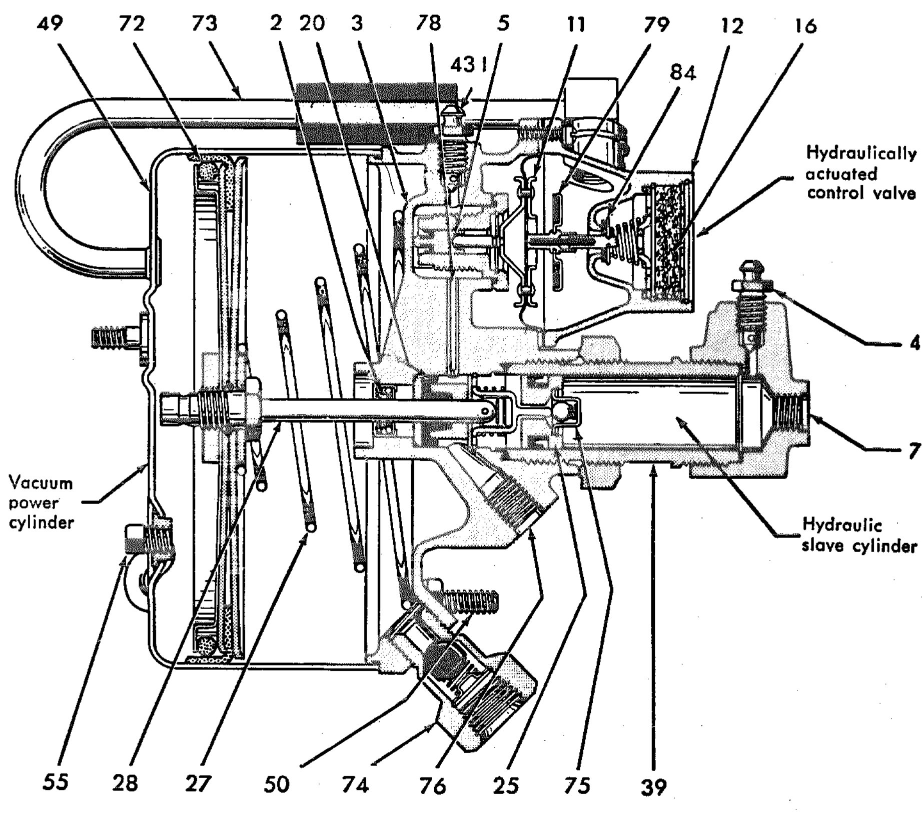


Fig. 42—0/14

Cross-Section of Power Brake ATE 50

2 Vacuum seal
3 End-plate assembly
5 Control valve piston
11 Valve diaphragm
12 Control valve cover
16 Air cleaner element
20 Rubber cup (push rod)
25 Hydraulic slave cylinder piston
27 Power piston return spring
28 Push rod
39 Cylinder tube
43 Bleeder valve
49 Vacuum cylinder (metal shell)
50 Hook bolt (4 fitted)
55 Plug
72 Vacuum power piston
73 Control tube
74 Vacuum connection with check valve
76 Threaded union (intake)
75 Ball check valve in hydraulic slave piston
77 Threaded union (output)
78 Connecting passage
79 Vacuum poppet
84 Atmosphere poppet

Vacuum Power Cylinder

The vacuum power cylinder consists of the cylinder shell (49) with piston (72), piston return spring (27), and push rod (28), and is clamped to the end plate (3) by means of four hook bolts (50) (Fig. 42—0/14).

The control tube (73) connects the left chamber of the vacuum power cylinder with the right side of the diaphragm assembly (11) of the control valve, while the right chamber of the vacuum power cylinder is connected with the vacuum inlet and the check valve (74), and the check valve is connected with the intake manifold. The right chamber of the vacuum power cylinder is also connected with the left chamber of the diaphragm assembly (11).

Hydraulic Slave Cylinder

The hydraulic slave cylinder consists of a cylinder tube (39) and a piston (25) which is pinned to the push rod (28) and is provided with a ball check valve (75).
A hydraulic rubber cup (20) and a vacuum seal (2) are provided in the end plate to seal the push rod. The hydraulic line from the brake master cylinder is attached at (76) and the hydraulic line to the wheel cylinders at (77). The passage (78) in the end plate connects the slave cylinder chamber at the left of the piston (25) with the left side of the control valve piston (5).

Control Valve

The control valve contains the piston (5) which is in contact with the diaphragm (11). The valve cover (12) contains the vacuum poppet (79) and the atmosphere poppet (84) together with the air cleaner (16).

For bleeding purposes, one bleed screw each (43) is placed at the top of the end plate (3) and in the slave cylinder end cap. The vacuum power cylinder is lubricated through an opening at the end of the vacuum power cylinder which is provided with a plug (55).

Principle of Operation

The hydraulic line from the brake master cylinder is attached at (76) (Fig. 42—0/15). Brake fluid passes through the passage (78) behind the valve piston (5) of the control valve, and past the ball check valve (75) of piston (25) into the slave cylinder chamber (80). Vacuum is transmitted through the vacuum check valve (74) to the cylinder chamber (81) and the valve chamber (82) on the one hand, and via the diaphragm (11) and the vacuum poppet (79) to the valve chamber (83) on the other hand. The atmosphere poppet (84) is held on its seat by the spring (13) and by the atmospheric pressure, thus shutting off the valve chamber (83) from the atmosphere. The valve chamber (83) is connected to the cylinder chamber (85) by the control tube (73) so that there is an equal degree of vacuum on both sides of the piston (72).

In the release position (Fig. 42—0/15) the piston (72) is held to the left in the vacuum cylinder by the piston return spring (27). In this position the yoke (86) of the hydraulic slave piston (25) is against the piston stop washer, and the ball of the check valve (75) is lifted from its seat. The valve piston (5) is at its extreme left position, thus separating the poppet (79) from its seat at the diaphragm (11).

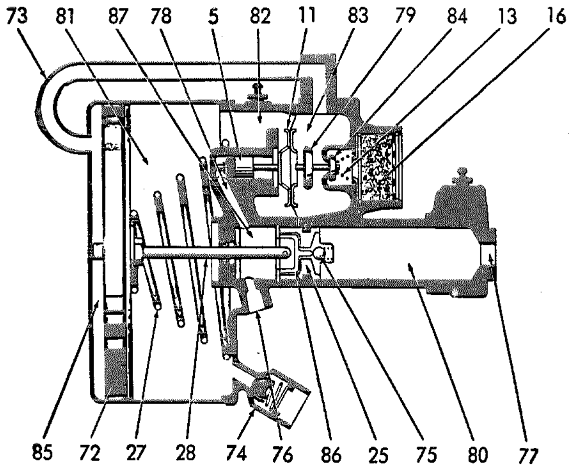


Fig. 42—0/15

Power Brake T 50 in release position

5 Control valve piston
11 Valve diaphragm
13 Atmosphere poppet spring
16 Air cleaner element
25 Hydraulic slave cylinder piston
27 Vacuum power piston return spring
28 Push rod
72 Vacuum power piston
73 Control tube
74 Vacuum connection with check valve
75 Ball check valve in hydraulic slave piston
76 Threaded union (intake)
77 Treaded union (output)
78 Connecting passage
79 Vacuum poppet
80 Cylinder chamber in front of hydraulic slave piston
81 Cylinder chamber in front of power piston
82 Valve chamber behind diaphragm
83 Valve chamber in front of diaphragm
84 Atmosphere poppet
85 Cylinder chamber behind vacuum power piston
86 Yoke for piston check valve
87 Cylinder chamber behind hydraulic slave piston

When the brake pedal is applied, fluid under pressure by-passes the ball check valve (75) and is transmitted to the slave cylinder chamber (80) and to the brake wheel cylinders. At the same time pressure is built up at the left of the valve piston (5), moving the piston to the right. As a result, the piston (5) presses against the diaphragm (11) and moves the diaphragm to the right until it comes to rest against the vacuum poppet (79). Any further movement to the right opens the atmosphere poppet (84) (Fig. 42—0/16).

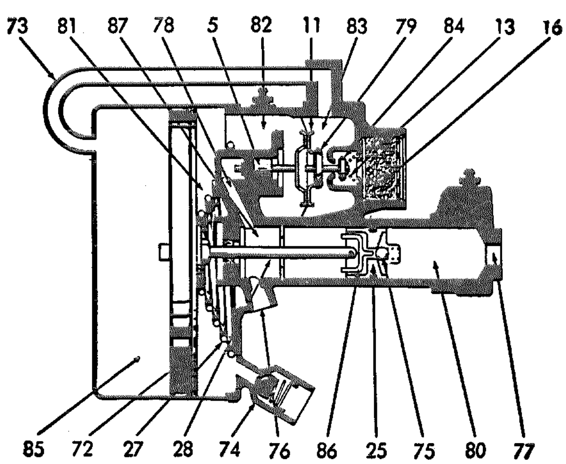


Fig. 42—0/16

Power Brake T 50 in applied position

5 Control valve piston
11 Valve diaphragm
13 Atmosphere poppet spring
16 Air cleaner element
25 Hydraulic slave cylinder piston
27 Vacuum power piston return spring
28 Push rod
72 Vacuum power piston
73 Control tube
74 Vacuum connection with check valve
75 Ball check valve in hydraulic slave piston
76 Threaded union (intake)
77 Threaded union (output)
78 Connecting passage
79 Vacuum poppet
80 Cylinder chamber in front of hydraulic slave piston
81 Cylinder chamber in front of power piston
82 Valve chamber behind diaphragm
83 Valve chamber in front of diaphragm
84 Atmosphere poppet
85 Cylinder chamber behind vacuum power piston
86 Yoke for piston check valve
87 Cylinder chamber behind hydraulic slave piston

Atmosphere now enters the valve chamber (83) through the air cleaner (16) past the opened poppet (84) and through the control tube (73), enters the cylinder chamber (85), moving the power piston (25) to the right, compressing the return spring (27). With this movement of the slave cylinder piston (25) the ball of the check vale (75) can be pressed onto its seat by the valve spring because the yoke (86) is then at the left, with the result that the brake fluid is trapped in the cylinder chamber (80) and pressure is transmitted to the brake wheel cylinders.

The vacuum differential (difference between the pressure in the right and the left chamber) across the piston (72) is the same as that across the diaphragm (11). The diaphragm is balanced by the master cylinder pressure on the left side of the valve piston (5). The pressure produced in the slave cylinder chamber (80) is equal to that produced by the piston (72) plus the pressure produced by the brake master cylinder.

After the desired degree of brake application has been obtained, the control valve part of the Power Brake T 50 will reach a "lap" or "holding" position in which the vacuum poppet (79) rests against the diaphragm (11) and at the same time the atmosphere poppet (84) rests against the valve cover. The hydraulic pressure at the left of the valve piston (5) is balanced by the vacuum differential across the diaphragm (11).
Any increase or decrease of the pedal pressure at the brake master cylinder will cause a corresponding increase or decrease in the vacuum differential and consequently in the hydraulic pressure in the brake wheel cylinders.

When the Power Brake T 50 is fully applied (see Fig. 42—0/16), the valve piston (5) is completely to the right against its stop and the atmosphere poppet (84) is lifted from its seat. The cylinder chamber (85) is then completely exposed to atmospheric pressure and the maximum possible differential exists across the vacuum power piston. Any further increase in the pressure existing in the brake wheel cylinders can only be obtained by increasing the pedal pressure.

When the pressure is released from the left side of the piston (5), the piston moves to the left (Fig. 42—0/15). The atmosphere poppet (84) is seated and the vacuum differential pushes the seat on the diaphragm (11) away from the vacuum poppet (79). Vacuum is again transmitted to cylinder chamber (85) through the control tube (73) and the valve chamber (83). The spring (27) then returns the piston (72) and the slave cylinder piston (25) to the release position. The yoke (86) lifts the ball of the check valve (75) from its seat, opening chamber (80) to chamber (87), thus allowing for any fluid expansion or contraction to be compensated for via the brake master cylinder.

If for any reason there should be a vacuum failure,the vehicle can still be braked since in this case the hydraulic pressure is directly transmitted from the brake master cylinder via the open ball check valve (75) to the brake wheel cylinders. However, in this case, a larger pedal force is required corresponding to the force normally applied in a vehicle not provided with a power brake.

When the engine is switched off, the brakes can still be applied several times with power brake assistance since a certain vacuum is stored in the unit by the check valve (74);however, power assistance decreases with every brake application.

c) Hints on Maintenance and Repair of the Brake System

Maintenance and repair of the brake system require very particular care. High standards should be applied in judging the serviceability of all parts.

Particular attention should be paid to the following points:

1. Before starting any work on the brake system, carefully clean your hands to remove all traces of grease and oil. **Grease or oil must on no account get into the line system of the brake.**

2. The brake system must only be filled with the prescribed blue ATE Brake Fluid or in foreign countries with Lockheed Brake Fluid. These two fluids can be mixed with one another.

   Caution! Brake fluid attacks the car finish. The brake linings must not come into contact with the brake fluid. If brake fluid gets into the eyes, they should be immediately rinsed out with water.

3. If through an oversight the brake system is filled with any brake fluid other than those prescribed above, all rubber parts including the brake hoses and the stop light switch must be replaced. To do this, remove the whole brake system, clean according to instructions and flush out.

4. **Only brake fluid or alcohol may be used for cleaning the various parts of the brake system. Do not use gasoline, kerosene, or trichloroethylene!** Mineral oils or related fluids swell the rubber cups and thus render the whole brake system completely inoperative in a very short time.

5. When the brake cylinders are assembled, the cylinder walls and the rubber parts should only be coated with the prescribed brake fluid or with ATE Brake Paste.

   Note: The brake paste may harden if stored too long.

6. The rubber parts can only be stored for a limited period of time. For reasons of brake safety, the rubber cups may not be stored for more than six months and rubber cups installed in brake cylinders for not more than twelve months.

7. The brake system should be checked for correct functioning, leakage, and rubbed spots at the intervals laid down in the 'Service Book Sheets.' Brake hoses should be replaced whenever they show traces of rubbed spots. In addition, the cause of rubbing must be removed. It is imperative that all brake hoses that have become hard, cracked or swollen, should be replaced even if they show no sign of leakage.

   The brake hoses must be carefully covered during any spraying job; care must be taken to ensure that they do not come into contact with gasoline, grease or mineral oil.

8. Regularly check the brake lines for corrosion and rubbed spots. Highly corroded or rubbed lines must always be replaced (see also Job No. 42—2, Paragraph 3).

9. The brake lining surface on both front and rear brakes should be smoothed at regular intervals with emery cloth and the abrasive dust should be blown out with compressed air. Check the lining thickness on the brake shoes. Brake shoes whose linings are worn down to approx. 1.5 mm should, for safety reasons, be replaced. Whenever brake linings are replaced, all linings on the left and on the right should be replaced together.

10. Do not omit to check the rubber boots of the brake wheel cylinders.

11. It is advisable to replace the brake fluid after twelve months of operation. When this is being done, the whole brake system should be flushed out with ATE Blue Brake Fluid or with alcohol.

12. The air cleaner element in the valve cover of the ATE Power Brake T 50 should be replaced every 16 000 km.

    When the vehicle is being driven in very dusty country, it is advisable to check the cleaner element more often. The element must not be clogged or dirty, since otherwise the response of the power brake is retarded.

    The cleaner element must not be washed in gasoline, kerosene, or trichloroethylene, since there is a danger that small particles of the washing fluid may be carried into the power unit by the air and may destroy the rubber parts and cups. In an emergency the cleaner element can be washed with alcohol. In that case it should be thoroughly cleaned with compressed air and allowed to dry completely before it is reinstalled.