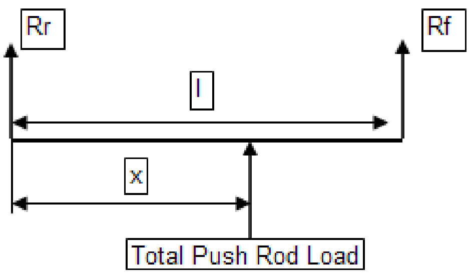
Race Brake Actuation System Set Up.

Balance Bar Systems.

There are a variety of systems available on the market all of them mechanically allow the adjustment of the pedal load bias from one master cylinder to another. Usually one cylinder feeds the front brakes and the other the rear brakes.

Most systems operate as a simple beam where the load input position is varied by changing dimension x as shown in Fig 1.



$$Rf = \frac{\text{Total Push Rod Load} * \text{Dimension } x}{\text{Dimension } l}$$

$$Rr = \text{Total Push Rod Load} - Rf$$

Fig 1.

1. Spherical Bearing in Tube.

For many years the most common type of balance bar system was a spherical bearing in a tube in the pedal and a clevis attached to the end of each master cylinder push rod. (Fig 2.). The balance bar is fixed axially but free to rotate the centre or within the centre of the spherical bearing and threaded into the push rod clevises. By rotating the balance bar the spherical bearing moves back and forth within the tube.

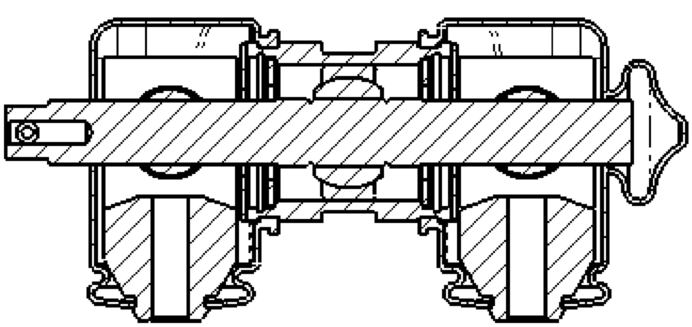


Fig 2.

AP Racing Limited
Registered in England No. 3794633
Registered Office : Wheler Road,
COVENTRY, CV3 4LB
VAT Registration No. GB 747 8871 70

Tel : +44 (0) 24 7663 9595
Fax : +44 (0) 24 7663 9559
E-mail : sales@apracing.co.uk
Internet : www.apracing.com

This type of system is probably still the most common but there are now more efficient systems.

2. Centre Trunnion.

In this type the spherical bearing is replaced by a centre trunnion which is usually fixed in position midway between the two master cylinders. The centre of the trunnion is threaded. The balance bar rotates within clevises attached to the master cylinder push rods but is not threaded within them. Rotating the balance bar causes the master cylinder trunnions to move over relative to the centre trunnion. Fig 3. The master cylinder trunnion that moves closer to the centre trunnion has its load increased. So in Fig. 3 turning the balance bar clockwise increases the load on the right hand cylinder.

Because the centre trunnion type angles over the cylinders more as it is adjusted further away from the mid position this should be kept to a minimum. Once the adjustment is greater than 2 or 3 turns it is better to move to the next size cylinder to bring the adjustment back near mid position.

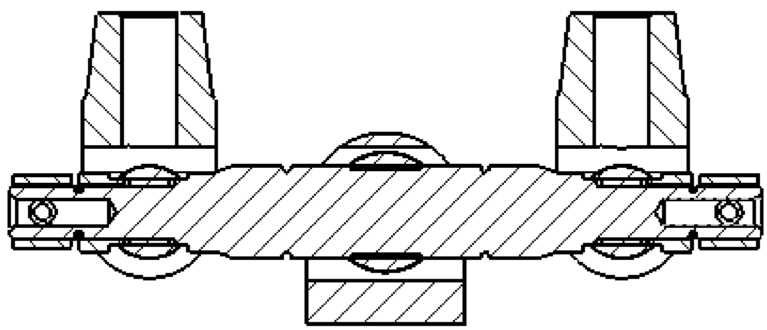


Fig 3.

Traditionally the balance bar is in the pedal with the clevis' or spherical bearings fitted to the master cylinder push rods but it can be fitted at the end of the master cylinders with clevis' or spherical bearings in the cylinder bodies. The latter method allows better packaging and means the balance bar does not travel through an arc moved by the pedal. The latter systems must be used with cylinders having rigid push rod / pistons whereas the former can be used with articulating push rods and a rigidly mounted cylinder body.

System Efficiency.

Many brake problems can be traced to actuation system inefficiencies. As with any system care should be taken not to damage any movable parts. Parts designed to rotate or articulate must be free to do so and should be adequately lubricated and free of debris. Spherical bearings used in the balance bar centre must be a loose fit, typically metal to metal type of good quality, lubricated.

Parts should be set up so that everything is square under the usual maximum braking load not at rest. The different systems require a different balance bar rest position to achieve this. (Fig 4).

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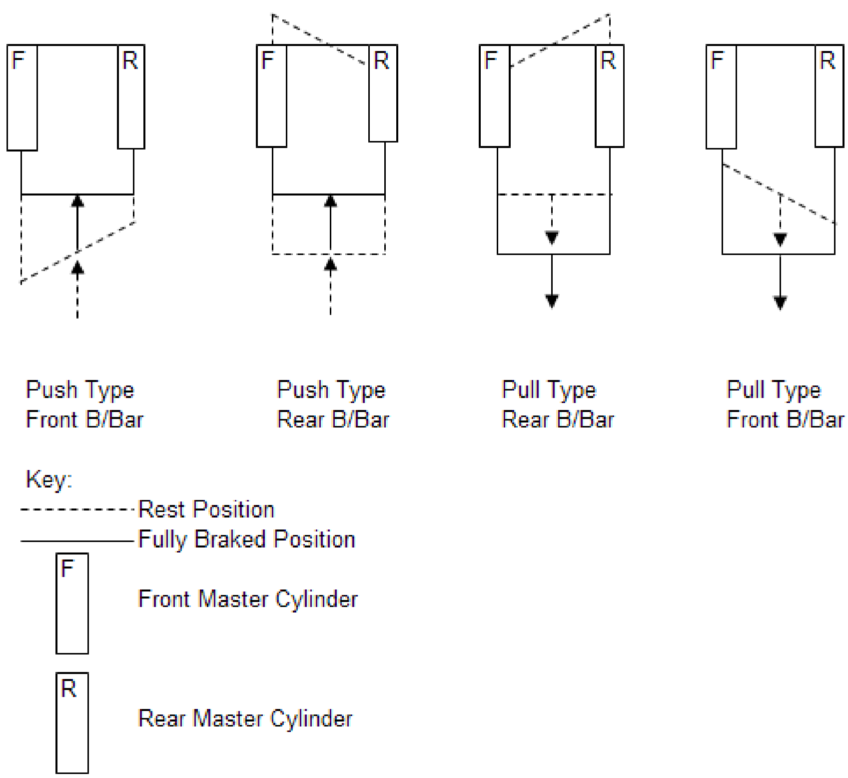
Balance Bar Setting Various Systems:



All assume more front displacement than rear.

Fig 4.

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Viewed from the side the pedal should be square to the master cylinder centreline under the usual maximum braking load. (Fig 5).

Lastly again under the usual maximum braking load the driver should be pushing at his most advantageous point square onto the pedal. (Fig 5).

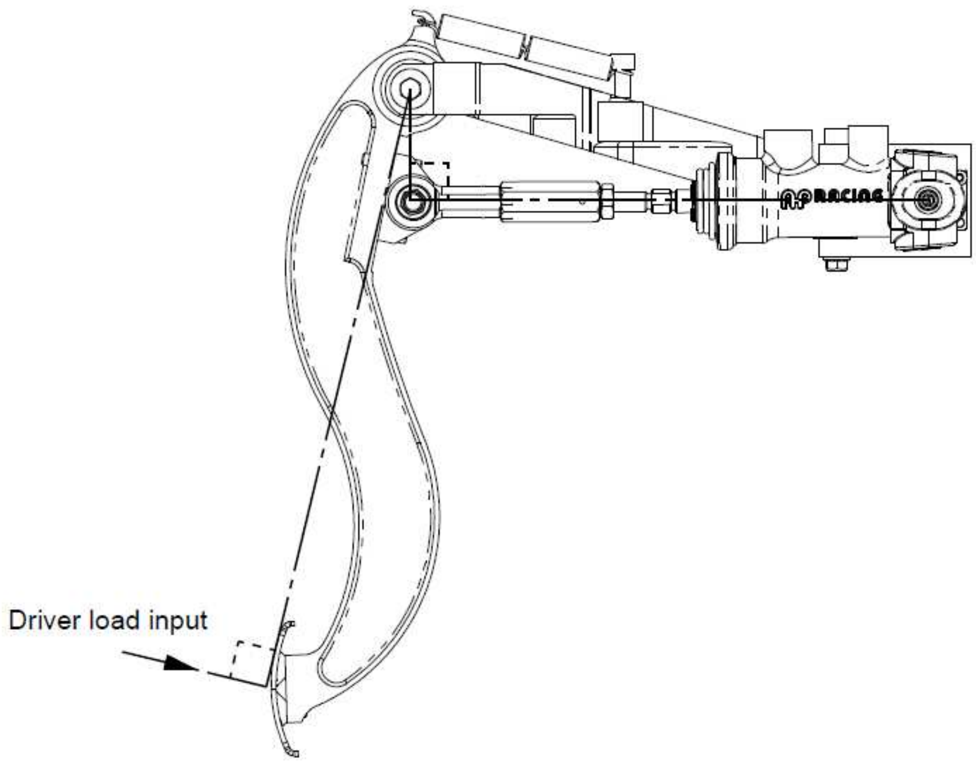

Fig 5. Condition under maximum braking.

All systems should have a limit to how far the balance bar can articulate. The reason for this is should there be a hydraulic failure in one circuit once the balance bar reaches the limit of its articulation the other circuit will then generate pressure. It is not a perfect failsafe as the whole system is loaded on one side and liable to bending but gives at least some braking to help drive the car to a safe position. **Under no circumstances should partially failed systems be used to continue racing.**

The older spherical bearing balance bar articulation was limited by the amount of clearance between the clevis and the tube in the pedal. The problem with this type of system is the clevis can touch one side of the tube under normal operation causing losses. Sometimes a large washer is positioned between clevis and tube to limit such losses.

Trunnion systems are usually not limited in this way. Once the balance bar reaches the pre-designed limit of its travel it meets a hard stop. Up until that point there is no possibility of parts touching.

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Types of Master Cylinder.

1. Rigidly mounted body articulating push rod, push type. E.g. CP2623.
   For:
   a. Relatively cheap.
   b. Fits older, cheaper pedal boxes.
   Against:
   a. Articulating push rod can load piston sideways.
   b. Cannot be used with end mounted balance bars.

2. One piece push rod / piston, spherical bearing end mounting, push type. E.G. CP5855.
   For:
   a. Less chance of side loading cylinder.
   b. Can be used with rear mounted balance bars.
   Against:
   c. More expensive.

3. One piece push rod / piston, end trunnion, pull type. E.g. CP6465.
   For:
   a. Side loading virtually eliminated.
   b. Uses rear mounted balance bar.
   Against:
   c. More expensive.

Other types are available refer to AP Racing catalogue or web.
http://www.apracing.com/info/index.asp?section=Master+Cylinders_2350

Step by Step Actuation System.

1. Decide on the master cylinder type. Pick the best you can afford it will pay dividends.
2. Preferably pick and fit one of the APR pedal boxes depending on the installation as to which type.
3. Decide on the size of cylinders. There are a number of ways APR can assist with this up to a full RM.
4. If it is adjustable ensure that the front and rear master cylinder push rods and bodies are parallel to one another. If clearance between clevis' and pedal tube set the limit of articulation this must be set to recommended limits at the same time.
5. Fit the system and set up "all square" under the usual maximum braking load.
6. Ensure that nothing touches or binds during the whole stroke of the system, unless it is designed to do so. If cylinder bodies are of the type that move during operation, ensure that all pipes and adjuster cables have sufficient free play to not load the cylinders over the full range of operation. Remote reservoirs are recommended for this type of master cylinder.
7. The cylinders must be under no load when at rest, ensure the push rod is in its free position.
8. When bleeding the system open a bleed front and rear at the same time so that both cylinders stroke more or less equally to avoid overloading one side of the balance bar.
9. Fit pressure transducers front and rear. Record and plot say % front balance from zero to maximum pressure.
   % front balance = front pressure/(front + rear pressure)*100.

   Ignoring low pressure values say < 5bar look at the variation in front balance %. For a good spherical bearing system < 5% variation should be the target and for the best pull type system < 2% variation. If you have more than this it is likely something is wrong.

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10. Run the car and re-check the balance variation on the circuit with telemetry or data logging. The balance variation should remain within the limits above.
11. Should the driver need to consistently have the balance bar more than 3 turns away from mid position a change of master cylinder size may be required.

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