Fundamentals of Automotive Systems
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Module No # 10
Lecture No # 49
Air Brake System Part - 01

So greeting so welcome to today's class so let's quickly recap where we were we discuss the hydraulic brake system and we were just starting the air brake system. As we discussed an air brake system uses compressed air as the energy transmitting medium and if you look at road vehicles by and large used in heavy commercial road vehicles trucks, buses, tracker trailer, units and so on.

And if you look a broad schematic of an air brake system you know like one can visualize an air brake system in this manner we going to also going to draw a simple schematic shortly. So what happens is that like that the driver presses what is called as Treadle valve. The Treadle valve is the one which is actuated when the driver presses the brake pedal and once again there are 2 circuits we can see that as mandated you know we need what is called as a dual circuit brake system.

So there are 2 circuits in the air brake system and as opposed to an hydraulic brake system. In an air brake system the driver's pedal effort does not pressurized the air it in facts meters out compressed air from a source of compressed air which is in the where compressed air is essentially stored in the storage reservoir. And when the driver applies the brake pedal that compressed air is taken from the reservoir and given to the brakes on the wheels.

And how does it happen? Typically the Treadle valve which is controlled by the driver is placed towards the front of the vehicle right. So in typical if you visualize a typical truck or a bus but the rear wheels are far behind so please note that the compressed air as to travel a longer distance through hose brake hoses or pipes to reach the rear. So for that reason the primary circuit of the Treadle valve provides air to what is called as a relay valve okay near the rear brakes okay.

So we will shortly look at what is the function of a relay valve? But the relay valve receives the signal from the primary circuit of the treadle valve and then the relay valve as it is own supply from the storage reservoirs and the signal from the treadle valve only triggers the relay valve okay. Just tells the relay valve okay provide compressed air to the brakes on the rear wheels. So the relay valve then meters out it is own supply what to say supply of compressed air from a reservoir and provides the compressed air to what are called as rear service brake chambers okay.

We will see what brake chambers are now what is meant by you know like a service brake chamber what is a spring brake chamber and all shortly okay. So that is something which we will look at now what happens is that when this relay valve is acting in this fashion one can obviously understand that there is going to be a significant time lag or what is called as transportation lag in this case for the air to travel that distance to the rear and then signal the relay valve to meter out air from a reservoir to the brakes on the rear wheels right.

So that is why the front brakes which are closer to the treadle valve are actuated by the secondary circuit. So in a typical air brake system the split is a front sorry this the primary circuit actuates the rear the secondary circuit actuates the front okay so this is the front rear split okay in a typical air brake system. So the front brakes

being closer to the treadle valve get actuated from the secondary circuit of the treadle valve and the air from the corresponding reservoir it metered out to the; what are called as the front service brake chambers right.

So that is those are the front brakes right so we will see what a brake chamber is shortly alright. And one can observe that there is something called a quick release valve near the front brakes the function of the quick release valve is to enable the quick release or enable the quick exhaust of air okay from the front brake chambers once the brake is released okay so that is the function of a quick release valve.

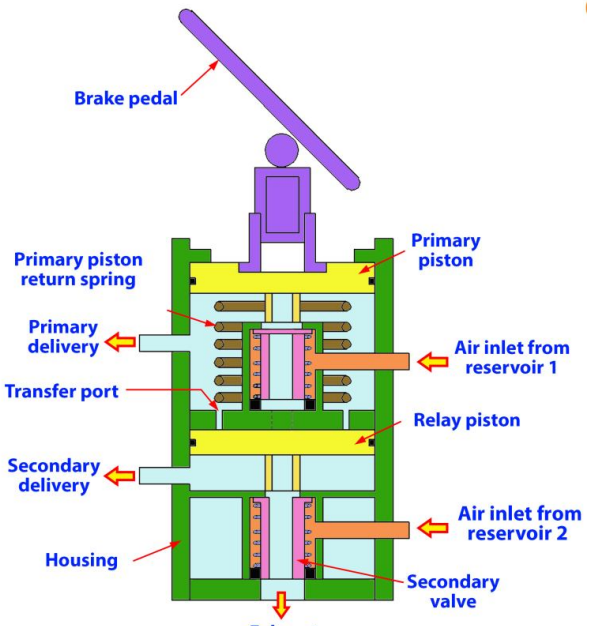
So once the brake application is completed and the driver releases the brake pedal so we need essentially the front brakes to be released fast. So that is why we have a valve which is closer to the front brakes and that is the reason why it is called as the quick release valve. Please note that air being a compressible fluid we need to pump in lot of air to pressurize a chamber right. So essentially even if we look at the ideal gas equation of state right you look at PV = MRT.

Let us say we keep even like volume constant for the sake of argument let us say we keep time sorry temperature constant right. So the way to increase the pressure would be pump in more fluid or more air right increase M. So that is what happens here so the brakes get pressurized because more air is pumped into a chamber that is a mechanics of this brake application. Similarly when you want to exhaust the, or release the brake the opposite action should take place right.

So essentially air should be now release from the chamber to the atmosphere even that takes time that is the reason why we have the quick release. In the rear the air is going to be exhausted from the relay valve itself which is closer to the rear

brakes okay. So that is why we do not the relay valves in the rear serves to both apply the brakes faster and also release the brakes faster okay. So, that is the function of a relay valve on the near the rear brakes okay.

So even you can pictorialize let us say a cycle what to say tyre right. So when we want to release the air let us say we open up with valve what it is going to happen it is going to take some time right for the air to exhaust because that is how you know that is the mechanics of the process right. So we see that we have some response times which are significant in air brake systems both for apply and exhaust okay.



TREADLE VALVE

So that is why we have these valves which enable us to reduce this response times and also ensure that all the brakes are applied and exhausted at about the same time right is it not? See we do not want one set of breaks to be applied earlier than the other and conversely released earlier than the other right. So that is why we have these mechanisms okay. So we look at all these components in detail. So the

compressed or the pressurized air in the storage reservoir is supplied through an air compressor which takes air from the atmosphere pressurizes it and stores at in this, reservoirs or tanks okay.

So the relay valve essentially helps in faster application and release of the rear brakes okay. So that is the what to say one important function of the relay valve okay so the adjective service you can see service relay valve or front service brake chamber okay adjective service in this context is to indicate that particular component is used during normal brake application that is what is used when the brake system is normal we will see what happens when there is fault or when there is some issue in the brake system as we go along right okay.

So let us take a look at each component one by one you know in the air brake system so let us first look at the treadle valve. So this is the treadle valve which is applied by the driver which is under the control of the driver. So what happens you know that driver's pedal input force you know like is given to this treadle valve and that generates a force right and actuation force. So once again we have 2 circuits the primary circuit and the secondary circuit.

So each of the circuits has an air inlet coming from corresponding reservoirs right so that is what happens right. So now when you have the brake pedal being applied the pedal displaces what is called as a primary piston. So one can observe what is called as primary piston, the primary piston gets displaced okay. So this is what is called as the supply port okay S stands for supply port okay in this case.

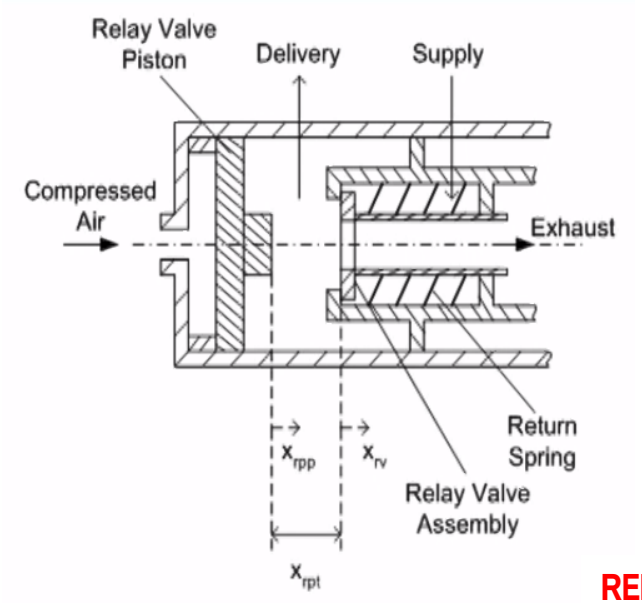
So you see that there is a supply port which provides air to the primary circuit of the relay valve sorry treadle valve input. So this is control mechanism or this is the control primary control valve which then starts delivering compressed air to the

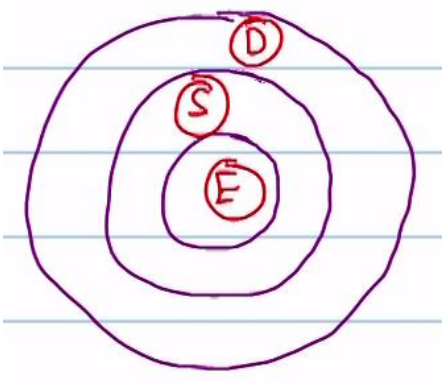
relay valve in the following fashion. So initially when the brake is not applied you can see that the central part of the treadle valve is connected to the atmosphere.

So which we call as exhaust so E refers to the exhaust port okay and D refers to the delivery port. So the delivery port is one which takes the air from the relay valve to the corresponding brakes on either to the relay valve or the front brakes okay depending on the circuit. Now we can see that these are the 3 main ports when the brake is not applied the exhaust port and the delivery port are in connection with one another so you can see that the exhaust port is essentially connected to the delivery so that is what happens when the brake is not applied okay so this is in connection.

So when brake is not applied the delivery port is connected to the exhaust port so it is open to the exhaust port. So what does it mean? That means that there is no there is no compressed air is transferred to the delivery port and in that manner to the brake chambers on the wheels. So, all the brakes are at atmospheric pressure so the brakes are not applied. So now what will happen is that when the treadle valve is applied when the driver presses the brake pedal this primary piston moves and then what happens is that you can see a projection here right.

That will go and sit here alright it will first close the connection between the delivery port and the exhaust port then it will push this valve you can see this valve right that will be pushed down and in opening will be created through which this air from the supply will go to the delivery okay. So that is the way in which air will be transmitted.





RELAY VALVE

So when the brake is applied the primary piston closes the connection between D and E that is the delivery port and the exhaust port right. Then if the primary piston will move further it is moved further motion of the primary piston opens the primary control valve and air flows from the supply port to the delivery port okay that is the way in which air flows in the primary circuit. So you can see that air starts flowing once this primary control valve is open right so in fact an easier visualization of this entire mechanism is to look at it from this side.

So if you look at a cross section of this treadle valve from this end it will look something like this you know like you can picturize I am just drawing a very simple schematic let me may be draw it here alright. So you can picturize the entire treadle valve as having 3 annular regions okay. The center, most region being the exhaust the middle being the supply the outer most being the delivery.

So when the brake pedal is not pressed the delivery and the exhaust are connected okay supply is not connected to delivery right. So when the brake pedal is pressed the primary piston goes and closes the connection between the delivery and

exhaust in the primary circuit and then opens the connection between supply and delivery okay that is a easier visualization of what is happened.

Now as pressure starts increasing in the primary circuit you will see that there is going to be a force which acts on the other face of the primary piston right pressurized air is flowing so there is going to be a force or pressure which is going to act upon this side of the primary piston. Now after sometime depending on the pedal input by the driver there may come, an instant of time where the net force on the primary piston is such that the primary piston will close the connection between supply and delivery and also at the same time it will close the connection between the delivery and the exhaust.

So that means the pressure would have reached a steady state okay so that is how the control valve reaches a steady state pressure okay. So it depends on the amount of force which is provided by the driver and the design of this valve okay. So the pressure if you look at it will from the initial point of time there may be a time delay and then it will go and reach a steady state in this manner okay it will have a transient region and then it will reach a steady state okay.

So that is how the primary circuit works now what happens to the secondary circuit? So now you can see that there are, what are called the transfer ports. So once the pressure in the primary circuits starts building not only as starts flowing through the delivery port to relay valve in the rear but there is a transfer port in the body of the treadle valve. Now air starts going through a transfer port it acts on what is called as a relay piston and then the relay piston is moved down it does the same sequence of action in the secondary circuit.

So the relay piston moves down and it closes this connection between the secondary delivery and the secondary exhaust then opens up the connection between the secondary supply and the secondary delivery same action okay that is why it is called as relay piston. So this is like a relay race right the primary piston pressure builds up then the secondary circuit is actuated by the relay piston right okay. So that is the treadle valve or the brake application valve right in an air brake system.

So now let us look at the relay valve so the relay valve is also something very similar in construction and operation okay just like the one of the circuits of the treadle valve. So if you look at the relay valve a simple schematic of the relay valve is here so compressed air from the primary circuit right of the treadle valve enters through this inlet port of the relay valve right. Now pressurized air as starts acting on this right what is going to happens to the relay valve piston it will go and close the connection between the exhaust and the delivery and this is a supply right.

So same story right so the relay valve piston will first go and close the connection between delivery and exhaust of the relay valve then it will move the relay valve relay control valve and then the air from the supply port will go will start going to the delivery port okay so that is how the relay valve will work. So now once again depending on the pressure in this delivery circuit there may come a time when the force is balanced on the relay valve that means that the net force acting on the relay valve is such that the relay valve will just close the exhaust but it also close the connection between the supply and the delivery.

So that is when we reach a steady state suppose if the driver slams the brake pedal right so for example you know like the magnitude the maximum air pressure which is available in most air brake systems used in road vehicles today is of the order of 10 bars right. So typically 9 bar or 10 bars is the maximum operating pressure right. So if the driver slams the brake pedal then what is going to happen is that if the maximum pressure in the storage reservoir it is going to be 9 or 10 bar that is what we are going to get in the brakes on the wheels right is not it?

See we are going to only get as much pressure as the input source which is compressed air right then this openings between supply and delivery will remains slightly open so that the equilibrium between the reservoir pressure and the brake chamber pressure is reached okay so that is how we get the maximum operating pressure right in these systems. So that is how the relay valve works okay now if we look at the overall schematic.

We have discussed the treadle valve the relay valve and what happens when the brake is released when the brake is released please note that this pressure is dumped right from the primary circuit exhaust but there is a pressure acting on this side right due to the pressure in the delivery side that is going to push back the relay valve and then the air will start exhausting from the brake chamber to the exhaust port right so that is how the release application will okay.

So these are the 3 ports once again and that is how the relay valve works or so essentially the relay valve has what to say a control port that receives the compressed air from the primary circuit of the treadle valve okay and this is how it acts right so essentially this is how it connects the it provides pressurized air to the rear brakes.