EVOLUTION
OF THE
AIR BRAKE.
[Signature]
The original of this book is in the Cornell University Library.

There are no known copyright restrictions in the United States on the use of the text.

http://www.archive.org/details/cu31924022793818
EVOlUTION
OF THE
Air-BRAKe

A BRIEF BUT, COMPREHENSIVE HISTORY
OF THE
DEVELOPMENT OF THE MODERN RAILROAD BRAKE, FROM THE EARLIEST CONCEPTION CONTAINED IN THE SIMPLE LEVER, UP TO, AND INCLUDING, THE MOST APPROVED FORMS OF THE PRESENT DAY.

BY
PAUL SYNNESTVEDT
AUTHOR OF "DISEASES OF THE AIR BRAKE SYSTEM."

PUBLISHED BY
"LOCOMOTIVE ENGINEERING"
256 BROADWAY, NEW YORK
1895
PREFACE.

Upwards of two years ago the author of this book began the publication, in the "Railway Engineering and Mechanics," of a series of articles treating of the history of the railroad brake. Favorable comment from many readers has encouraged him to believe that the subject is of sufficient interest to warrant the preservation of the matter contained in the articles referred to in a more permanent form. It has therefore been revised and corrected; and, together with some additional material, brought together to form the basis of this work.

To the author himself, the labor involved in collecting and arranging the data contained in these pages, has proven of great benefit in aiding him to secure a clear and comprehensive knowledge of the art of which he treats; and it is his sincere hope, that, to the reader as well, this record of the past will prove of practical value.

Paul Synnestvedt.

Chicago, 1895.—126.
## CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory</td>
<td>7</td>
</tr>
<tr>
<td>Power Brakes in General</td>
<td>12</td>
</tr>
<tr>
<td>Compressed Air Brake</td>
<td>26</td>
</tr>
<tr>
<td>Hose Coupling</td>
<td>31</td>
</tr>
<tr>
<td>Air Pump</td>
<td>37</td>
</tr>
<tr>
<td>Governor</td>
<td>51</td>
</tr>
<tr>
<td>Engineer's Valve</td>
<td>62</td>
</tr>
<tr>
<td>Equalizing Discharge Valve</td>
<td>67</td>
</tr>
<tr>
<td>Triple Valve</td>
<td>75</td>
</tr>
<tr>
<td>Quick Action Brakes</td>
<td>83</td>
</tr>
<tr>
<td>Wenger Brake</td>
<td>91</td>
</tr>
<tr>
<td>Quick Action Brakes (Continued)</td>
<td>98</td>
</tr>
</tbody>
</table>
## LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Fig.</th>
<th>Illustration</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Early Lever Brake</td>
<td>8</td>
</tr>
<tr>
<td>2.</td>
<td>&quot;Le Caan&quot; Brake</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>Modified Lever Brake</td>
<td>9</td>
</tr>
<tr>
<td>4.</td>
<td>Example of Improper Leverage</td>
<td>9</td>
</tr>
<tr>
<td>5.</td>
<td>Defective Lever Brake</td>
<td>10</td>
</tr>
<tr>
<td>6.</td>
<td>Stevenson Driver Brake</td>
<td>11</td>
</tr>
<tr>
<td>7.</td>
<td>Steam Driver Brake</td>
<td>12</td>
</tr>
<tr>
<td>7a.</td>
<td>Loughridge Chain Brake</td>
<td>13</td>
</tr>
<tr>
<td>8.</td>
<td>Hydraulic Brake</td>
<td>16</td>
</tr>
<tr>
<td>9.</td>
<td>Eames Vacuum Brake</td>
<td>17</td>
</tr>
<tr>
<td>10.</td>
<td>Eames Ejector</td>
<td>18</td>
</tr>
<tr>
<td>11.</td>
<td>Eames Ejector</td>
<td>19</td>
</tr>
<tr>
<td>12.</td>
<td>English Vacuum Brake</td>
<td>20</td>
</tr>
<tr>
<td>13.</td>
<td>English Vacuum Brake</td>
<td>20</td>
</tr>
<tr>
<td>14.</td>
<td>Sanders Vacuum Brake</td>
<td>22</td>
</tr>
<tr>
<td>15.</td>
<td>Vacuum Brake used at Burlington</td>
<td>23</td>
</tr>
<tr>
<td>16.</td>
<td>Vacuum Valve used at Burlington</td>
<td>24</td>
</tr>
<tr>
<td>17.</td>
<td>Westinghouse Straight Air Brake</td>
<td>26</td>
</tr>
<tr>
<td>18.</td>
<td>First Auxiliary Reservoir</td>
<td>29</td>
</tr>
<tr>
<td>19.</td>
<td>Automatic Brake with Triple Valve</td>
<td>29</td>
</tr>
<tr>
<td>20.</td>
<td>First Westinghouse Triple Valve</td>
<td>29</td>
</tr>
<tr>
<td>21.</td>
<td>Early Westinghouse Coupling</td>
<td>31</td>
</tr>
<tr>
<td>22.</td>
<td>Modified Westinghouse Coupling</td>
<td>32</td>
</tr>
<tr>
<td>23.</td>
<td>Original Form of Present Coupling</td>
<td>32</td>
</tr>
<tr>
<td>24.</td>
<td>Flat Back Coupling</td>
<td>33</td>
</tr>
<tr>
<td>25.</td>
<td>Jackson Coupling</td>
<td>33</td>
</tr>
<tr>
<td>26.</td>
<td>Beery Coupling</td>
<td>34</td>
</tr>
<tr>
<td>27.</td>
<td>Eames Vacuum Coupling</td>
<td>34</td>
</tr>
<tr>
<td>28.</td>
<td>Welsh Coupling Cover</td>
<td>35</td>
</tr>
<tr>
<td>29.</td>
<td>Westinghouse Combined Coupler and Valve</td>
<td>35</td>
</tr>
<tr>
<td>30.</td>
<td>Modified Westinghouse Coupling and Valve</td>
<td>36</td>
</tr>
<tr>
<td>31.</td>
<td>Harris Automatic Coupling</td>
<td>36</td>
</tr>
<tr>
<td>32.</td>
<td>First Westinghouse Pump</td>
<td>37</td>
</tr>
<tr>
<td>33 and 34.</td>
<td>Details of Westinghouse Pump</td>
<td>39</td>
</tr>
<tr>
<td>35.</td>
<td>Improvement in Westinghouse Reversing Gear</td>
<td>40</td>
</tr>
<tr>
<td>36.</td>
<td>Second Improvement in Westinghouse Reversing Gear</td>
<td>41</td>
</tr>
<tr>
<td>37.</td>
<td>Third Improvement in Westinghouse Reversing Gear</td>
<td>42</td>
</tr>
<tr>
<td>38.</td>
<td>Westinghouse Old Style Standard Pump</td>
<td>43</td>
</tr>
<tr>
<td>40.</td>
<td>Barrett Valve Motion</td>
<td>45</td>
</tr>
<tr>
<td>41.</td>
<td>Cameron Pump</td>
<td>45</td>
</tr>
<tr>
<td>42.</td>
<td>Harlow Pump Head</td>
<td>46</td>
</tr>
<tr>
<td>43.</td>
<td>Boyden Pump</td>
<td>47</td>
</tr>
<tr>
<td>44.</td>
<td>Lansberg Pump</td>
<td>48</td>
</tr>
<tr>
<td>44a.</td>
<td>New York Pump</td>
<td>49</td>
</tr>
<tr>
<td>45.</td>
<td>Breitenstein Pump</td>
<td>50</td>
</tr>
<tr>
<td>Fig.</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>46 and 47. Illustrative Governor</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>48. First Westinghouse Governor</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>49. Second Westinghouse Governor</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>50. Third Westinghouse Governor</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>51. Double Westinghouse Governor</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>52. Boyden Governor</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>53. New York Governor</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>54. Westinghouse Improved Governor</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>55. Mason Regulator</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>56. Three Way Cock</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>57. Westinghouse 1879 Engine Valve</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>58. Paradise Engineer's Valve</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>59. Independent Driver Brake Valve</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>60. Cosgrove Engineer's Valve</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>61. First Westinghouse Equalizing Valve</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>62. 1889 Westinghouse Equalizing Valve</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>63. Boyden Equalizing Valve</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>64. Massey Equalizing Valve</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>65. New York Equalizing Valve</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>66. Vaughn &amp; McKee Equalizing Valve</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>67. Howard Equalizing Valve</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>68. 1873 Westinghouse Triple Valve</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>69. Perkins Triple Valve</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>70. Westinghouse 1875 Triple Valve</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>71. Prince Automatic Brake</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>72. Westinghouse Standard Plain Triple</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>73. Westinghouse '87 Quick-Action Triple</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>74. Ford &amp; Welsh Relief Valve</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>75. Sanders Relief Valve</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>76. Westinghouse '79 Relief Valve</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>77. Westinghouse '81 Relief Valve</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>78. Boyden 1883 Triple</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>79. Fives' Lille Brake</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>80. Duval Regulator</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>81. Duval Regulator and Triple</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>82. Westinghouse Standard Quick Action Triple</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>83. Westinghouse Independent Quick Action Valve</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>84. New York Quick Action Valve No. 1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>85. New York Quick Action Valve No. 2</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>86. New York Quick Action Valve No. 3</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>87. New York Quick Action Valve No. 4</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>88. Boyden Quick Action Valve No. 1</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>89. Boyden Quick Action Valve No. 2</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>90. Crane Quick Action Valve</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>91. Lansberg Quick Action Valve No. 1</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>92. Lansberg Quick Action Valve No. 2</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>93. Haberkorn Quick Action Valve</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>94. Dixon Quick Action Valve</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>95. Park Quick Action Valve</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>96. Howe Quick Action Valve</td>
<td>111</td>
<td></td>
</tr>
</tbody>
</table>
EVOLUTION OF THE AIR BRAKE.

INTRODUCTORY.

It is easy to conceive that with the invention of wheeled vehicles, there was felt the necessity of a brake to stop them in cases of emergency, and that this need became greater as the running gear of such vehicles was perfected and friction eliminated. But with the introduction of the tramway and steam railway the brake became an absolute necessity, and its importance has grown with the development of the railway and the increased speed and weight of the trains hauled, until at the present day there is hardly a part of the rolling stock equipment which is deserving of more care and study than the brake. The evolution of the railway brake therefore becomes a matter of unusual interest at the present day, and in the pages of this book its progress and development will be briefly outlined.

In no place or manner has the early history of the railway brake been more perfectly portrayed than in the "world's railway" exhibit of the Baltimore & Ohio Railroad at the World's Columbian Exposition. A long line of drawings, illustrative of the above subject, proved an interesting and instructive collection to anyone at all familiar with such things, and the author made free-hand sketches of a number of them, a few of which are here reproduced.
Fig. 1 was the first one in the set and is about as simple a form of brake as could possibly be designed. There is nothing to it in fact except a single wooden lever, pivoted at one end to the body of the car and supported at the other by a short chain. This chain was slipped off the end of the lever and a downward pressure exerted when it was desired to bring the brake into action. Here is an excellent lesson in simplicity for designers of brakes at the present day. Shoe, beam, tie rod, lever and cylinder are all in one, and a little muscle is all that is necessary to bring them into operation. Attention is called to the fact that the lever, practically as it is used most generally to-day, was used in this brake of 1630, the fulcrum at one end, the shoe in the middle, and the power at the other end.

Fig. 2 shows what is called the "Le Caan" brake, which was used in England about 1796. It was attached to a kind of road cart and, as will be clearly seen by a glance at the cut, was put into operation
automatically. By merely dropping the shafts the point of the curved arm wedged itself in between the wheel and the ground. The author must confess to not having had any experience with such a brake, but is inclined to think it must have been very effective.

Fig. 3—Modified Lever Brake.

Fig. 3 shows what might be called a modified form of the device shown in Fig. 1, with the difference that it has shoes applied to both wheels instead of one.

Fig. 4—Example of Improper Leverage.

Fig. 4 shows a wooden lever brake used in England, but this lever was not pivoted to the car at all, what might be called the fulcrum
point bearing against one of the wheels and the power point against the other. This is a very good sample of unequal braking power, or a poorly equalized brake, as the wheel to the right in the cut evidently has to stand more pressure than the other. It seems a remarkable fact that this same mistake has been repeated hundreds, perhaps thousands of times in designs made since this style of brake was in use. Every brake which has no dead lever on one end of the truck is just as faulty in construction as this one.

![Diagram](image)

**Fig. 5—Defective Form of Lever Brake.**

Fig. 5 shows still another lever brake which, while it looks as if it might be very effective, contains also a mistake which has been repeated innumerable times in modern construction. It is that of placing two weight points on the same lever, one on each side of the fulcrum. If one shoe has a little more slack than the other the one that has the least will receive nearly all the braking force while the other gets little or nothing. Without compensating devices of some kind (springs or equalizers) a lever can no more act properly with two weight points than it can with two fulcrum. Any one can see that with two fixed points in a lever any movement is impossible.

Fig. 6, the last cut shown, is perhaps to railroad men the most interesting. It contains all the elements of the present driver brake; cylinder, toggle-joint and suspension links. This is the first power brake shown in this set and was operated by steam from a valve near the dome. Attention is called to the fact that the method of arranging the cylinder made it unnecessary to use any stuffing box around the piston rod, one of the great points of the present push-
down brake. The fact that this brake was used on one side of the engine only was of course a great objection, as it must have produced a very severe torsional strain on the driving axles. But there is much food for reflection in the fact that as early as 1833 Stephenson had in use a driver brake so nearly like the best practice of the present day.

**Fig. 6—Stephenson Driver Brake (1833).**
POWER BRAKES IN GENERAL.

Stephenson’s driver brake, shown in Fig. 6, serves very appropriately to introduce the subject which, in a general way, we shall consider next, namely, the early forms of the power brake. These were many in number and of great variety. Among them may be mentioned steam brakes, chain brakes, hydraulic brakes, vacuum brakes, and a number of primitive air brakes.

Fig. 7—Steam Driver Brake.
Evoi,uTioN OF THE Air Brake.

STEAM BRAKES.

The steam brake for obvious reasons made practically no headway at all beyond its use on the engine and tender. In this limited field, however, it has been and is at present extensively used on account of its simplicity, requiring only the cylinder and the operating valve. One of the earlier arrangements of it is shown in Fig. 7. The objections to it are the liability to freeze, and the escape of steam from leakage obscuring the view of the engineer in very cold weather.

BUFFER BRAKE.

There were a number of different forms of this brake designed during the period when air was coming into general favor, all dependent for their operation on the strains on the draw-bars, but as this style of brake became most prominent at the Burlington brake tests in 1886, we shall treat of it more fully in that connection.

Fig. 7a—Loughridge Chain Brake.

CHAIN BRAKES.

One of the best known of these was the "Loughridge" which was in actual use on a number of roads for some time, just about the period when "air" was in its infancy. This form of brake, or a modification of it, is still in service on some street car lines, on trains of two or three cars (notably on some of the large cable systems).

As the name indicates, a chain was utilized in the transfer of power, there being chain connections between the cars. We illustrate it in Fig. 7a, quoting a description written by W. de Sanno, of Indianapolis.
"There was a friction wheel or sheave like A, Figs. 1 and 2, on a three inch shaft, B; this shaft was hung in hangers, one of which swung loose. This loose hanger was connected to a lever passing up through the foot board and in such a position as to be easily handled by the engineer. To apply the brake the lever was pulled back, which brought the friction wheel A in contact with the driving wheel flange on the right side of the engine; this would revolve the shaft B and wind up the chain. Under the center of each car was the frame D swinging on the pivot E. Running loose in the frame D were the two sheaves F - F. The chain was the length of the train, but the end of it was secured to the back end of the rear coach. When the brake was applied, in winding around the shaft the tendency of the chain was to assume a straight line, and in doing so it would swing the frame D around in the direction of the arrows, which in turn would pull on the two rods H H which were connected to the brake levers. By the time the brakes were set (and it was quick) about all the chain belonging to the first car would be wound around the shaft. On the shaft B was a ratchet wheel and dog or pawl that would hold the brakes set. The lever spoken of set the brakes and the ratchet held them set; but the contact between the friction wheel and flange was controlled by a weighted bell crank also under the foot board. If the tension of the chain became too severe it would pull the friction wheel away from the flange by overcoming the weight on the bell crank. To release the brake the engineer would raise the pawl from the ratchet and throw the lever forward, when the chain would unwind. One great trouble with this brake was the friction wheel would get flat spots cut in it by the flange."

The Clark chain brake was another form of this idea which was tried very persistently in England. It was automatic, being arranged so that it would apply in case of a separation of the train.

To accomplish this it was made so that a constant tension on the chain held the brakes off and a relaxation of this tension caused them to set from force stored in compressed springs. Concerning this brake, Mr. Reynolds, in a work published in England in 1882, on "Continuous Railway Brakes," makes the following criticism:

"It has the great defects of all chain brakes: 1. That it can only be used on short trains, or portions of trains, so that it is practically a sectional brake rather than a continuous brake. 2. The action cannot be controlled; that is to say, when applied, the action is in full
force, because the friction between the pulleys cannot be graduated. On account of this, chain brakes will at all times be very rough brakes. 3. It is influenced by changes in the weather, and it very commonly happens that drums and pulleys become coated with ice in winter. The friction pulleys, under such circumstances, lose their grip entirely, and the brake is rendered powerless. 4. It not infrequently happens that in winter the chain gets frozen fast on its guiding pulleys. In this case, the brakes cannot be either applied to or taken off the wheels.

"It may be added that the chain brake is very old, and that it has been tried more than any other brake."

**Hydraulic Brakes.**

Classed under this head are all those brakes which were worked by any liquid stored under pressure in an accumulator. One of the forms is shown in part in Fig. 8.

Most of them were operated by a continuous pipe carried along the train, with cylinders for applying the force under the cars. The pressure was generally obtained by a direct acting steam pump on the engine; and in the cases of those which were automatic water under pressure was stored in receptacles under the cars. On a separation of the train and consequent disconnection of the pipe, those of the automatic class would set in a manner quite similar to the automatic air brake, the stored water being forced into the brake cylinders by springs. Several modifications, some of them very elaborate, were made of this general principle, but none were ever perfected so as to be satisfactory in practice.

Lack of compressibility, and susceptibility to cold are the characteristics which form the main objections to the use of liquids in the operation of train brakes.

**Vacuum Brakes.**

There are two general forms of this brake, the plain vacuum, and the automatic vacuum. Both have been and in some places are now extensively used. In fact the vacuum brake is the only form of train brake which can be considered in any sense a competitor of the compressed air brake. The plain and the automatic vacuum have each a distinct field of usefulness. In service similar to that on elevated roads, where the trains are short and the stops frequent, the plain
The brake has given great satisfaction, having the very strong recommendation of simplicity, while on trains of moderate length and light cars the automatic vacuum has had many admirers because of two advantages which it possesses over the automatic air brake. There are possibilities of accurately graduating the release as well as the application, in other words making a partial release; and second, the

![Diagram of Eames Vacuum Brake, Engine and Tender](image)

**Fig. 9—Eames Vacuum Brake, Engine and Tender.**

fact that repeated applications in rapid succession do not reduce the available braking force in the auxiliary reservoir, except of course what little may be lost by leakage.

Fig. 9 shows the application of the Eames plain vacuum brake to an engine and tender. It comprises the following parts: An ejector
for producing the vacuum; a continuous line of pipe; couplings between the cars; and diaphragms, (generally substituted for cylinders as a means of applying the force.)

Outside and sectional views of the ejector are given in figures 10 and 11 respectively. This is similar in construction to an injector, with the difference that instead of the flow of the steam through the cones acting to draw water from the tank and force it into the boiler, it operates to draw the air out of the train pipe, thereby applying the brake. By simply re-admitting the atmospheric pressure the brake is released.

**Fig. 10.—Eames Ejector.**
With this form of brake the parting of a train has no effect and the engine is the only place where it can be applied. When the ejector is put into operation it must take air from the entire train pipe and all the diaphragms to set the brakes. This it does readily in short trains, and this brake has a remarkable record of efficiency and freedom from accident on the elevated roads of New York and Brooklyn.

**AUTOMATIC VACUUM BRAKE.**

This was a natural outgrowth from the plain vacuum, and most of the earlier forms were exceedingly simple. Nearly all of them
employed diaphragms or pistons having air tight chambers on both sides and mechanism so arranged that when the vacuum in the pipe (which was maintained constantly while running) was destroyed by the admission of air from the atmosphere, this air so admitted entered the chamber on one side of the diaphragm, but was prevented from entering the chamber on the other side. This of course moved the diaphragm, with the force of the atmospheric pressure admitted,

towards the chamber in which the vacuum was still maintained, and so applied the brakes. The pressure was removed by drawing the air out of the pipes again with the ejector.

**ENGLISH VACUUM.**

One form of this general type of brake which is still extensively used in England, was exhibited at the fair and is shown in Figs. 12 and 13. The train pipe is indicated by $A$, the cylinder by $D$, the piston by $C$, and the piston rod by $B$. The piston rod is large in diameter, hollow, and attached rigidly to the floor of the car. The cylinder $D$, is attached to the brake lever, $E$, and moves up and down on the piston as the brakes are operated. Both the cylinder and piston are of pressed steel, and very light. A release valve, $F$, is provided for releasing the brakes by hand when necessary. The piston packing is rubber and so attached to the piston that air pressure admitted above the piston forces the packing out in contact with the cylinder and
Evolution of the Air Brake.

shuts off communication with the lower side of the piston. Air admitted below the piston easily pushes past the packing and passes to the upper side. When the train is running a vacuum exists in the train pipe, and also on both sides of the piston; the cylinder of its own weight takes the position shown in Fig. 12. When the brakes are to be applied, atmospheric pressure is admitted to the train pipe, A, whereupon it passes through the piston rod B, into the space above the piston, C, and forces the cylinder up into the position shown in Fig. 13, applying the brakes through the lever E. Gages are placed on the engine and also in the guards' compartments, and the instructions are that when the trains are running they shall show not less than 20 nor more than 25 inches of vacuum. In order to apply the brakes simultaneously on all wheels a valve or brake setter is provided in each guards' compartment, so constructed that any sudden increase of pressure in the train pipe will instantly cause the valve to open automatically and admit a supply of air, after which it closes again by its own weight. A handle is attached to this brake setter, by the use of which the guard can, in case of emergency, apply the brakes to the entire train.

The engine equipment comprises an air pump attached to the cross-head for maintaining the vacuum while the train is in motion, and a combined ejector and engineer's valve. This device has several offices to perform, all controlled by one lever. One position of this lever puts into operation a steam ejector which creates a vacuum in the train pipe and cylinders before the train starts. Another position of the lever admits air to the train pipe and at the same time admits steam to the cylinders of the steam brake. When the brakes are to be released, a movement of the handle will throw the ejector into action if the train is at rest. If not, the vacuum is created by the air pump. The cylinder of this pump is five inches in diameter, and the stroke coincides with that of the locomotive piston.

Sander's Vacuum.

Fig. 14 illustrates an automatic vacuum brake patented in 1879. It was very similar to the one just described, but embodies, in a form better suited to purposes of illustration, the idea spoken of above, that of making the application of the brakes throughout the train as nearly simultaneous as possible, by the automatic opening of a local admission valve under each car, whereby atmospheric pressure gained
Evolution of the Air Brake.

entrance to the train pipe at or near each cylinder in turn, when a quantity of air was admitted at the engineer's valve.

The operation of this device is as follows: When the vacuum is equal on both sides of the piston a, it is forced inwards into the position represented, by the pressure of the atmosphere acting on the closed and external end of the piston rod b. In this position the brakes are held out of action. On the admission of air into the continuous pipe on the train and to the non-piston rod side of the piston a, for the purpose of applying the brakes, the piston moves outwards and the valve e is opened by the action of the enlarged end g-2 of the rod g on the lever e-2 of the said valve e. A sudden inrush of air then takes place and the brakes are rapidly applied by the vacuum, which is retained on the other side of the piston and in the reservoir by the check valve p.

Automatic Vacuum Brake Used at Burlington.

Fig. 15 shows the general arrangement of the Eames automatic vacuum brake tested at Burlington in 1886. It required the use of a
Evolution of the Air Brake.

Fig. 15—Automatic Vacuum Brake Used at Burlington in 1886.
double ejector, and in addition to the other parts used with the plain vacuum it comprised a storage reservoir of some kind under each car, in which the force of a constant vacuum could be maintained, and a valve, corresponding to the triple in the compressed air brake. The double ejector was simply a combination of a large ejector for exhausting the air from the train rapidly, and a small ejector for maintaining a constant vacuum throughout the apparatus while running.

Fig. 16 is a sectional view of the valve which takes the place of the triple in the compressed air brake. The valve is placed between the diaphragms and the reservoir, the reservoir being exhausted through it. Its functions are to control the passage of air from the brake diaphragms to the reservoir, and partially or wholly apply the brakes; also to admit air to the brake diaphragms, and partially or wholly release the brakes. This is accomplished by the valves $M$ and
Evoi,u*ioN

OF

The Air Brake.

These valves are moved by the bell crank levers shown in the cut, which are controlled by the flexible diaphragms $F$ and $N$ connected with them by links.

Amongst other kinds of vacuum brake made and tested at different times may be mentioned Smith's, Hardy's and Aspinall's, but in spite of the fact of there being so many different forms, the same general principle obtains in them all.

None of them have been made to fully meet the requirements of railway service where very long trains and heavy cars are used. The greatest force that can be obtained with a vacuum is necessarily limited to less than atmospheric pressure (about 15 pounds), so that to get a total piston power equivalent to that of the compressed air brake (which averages 70 pounds) necessitates the use of proportionately larger apparatus in every part or an abnormal increase of power through levers. The first alternative makes the vacuum brake fully twice as heavy, and the second makes frequent adjustment of slack necessary. The vacuum brake is also slower in application, and, as will be seen in a subsequent chapter, produces in consequence very violent shocks on the rear of long trains.
EVOLUTION OF THE AIR BRAKE.

COMPRESSED AIR BRAKE.

From the manifest uncertainty or insufficiency of the apparatus previously described, it would seem to us now as if the whole railroad world would have turned with eagerness to anything which promised better service, and welcomed it with outstretched arms. Such was not the case, however. The early days of the air brake afford a striking record of a hard struggle for recognition, and some roads did not adopt it until years after it had been proven to be a pronounced success.

The first form of air brake put into successful operation was what is known as the "straight air" brake. In service the operation was as follows:

Air compressed by the pump was stored in the reservoir under the engine. When it was desired to set the brake, the engineer's valve was turned so as to allow the air from the drum to go back through the pipe and fill the cylinders under the cars, forcing out the pistons, which through the levers and rods brought the shoes against the wheels. To release the brake, the handle of the engineer's valve was turned so as to cut off the supply of air from the drum to the train pipe, and allow the pressure in the train pipe and cylinders to escape to the atmosphere.

WESTINGHOUSE STRAIGHT AIR BRAKE.

Mr. Geo. Westinghouse, Jr., was the first inventor to make this brake a practical success. The foundation patent on it was issued
April 13, 1869, and re-issued July 29, 1873. Fig. 17 is a general view of the apparatus shown in this patent. The main drum is marked d, the engineer's valve h, the train pipe i, and the cylinder under the car m. The pump, c, it will be noticed, had three cylinders, one for steam, one for pumping the air, and the third for supplying water to the boiler. By this it will be seen that the air brake antedated the use of the injector. The specification of this patent dwells very emphatically on the advantages of being able to pump up the boiler without the necessity of cutting the engine loose from the train and running it back and forth.

From a catalogue issued in 1872 I have taken the following interesting items, testifying to the remarkable efficiency of this pioneer air brake, though it is to be noted that the results given were taken from trials with short trains.

At Chicago, November 26, 1869, tests were made on the C. & N. W. Railway, with the following results: A train of six cars running at the rate of 32 miles per hour was stopped in 19 seconds, or seven car lengths. The same train at a speed of nearly 40 miles was stopped in 10 seconds, running a distance of only 370 feet.

At Altoona a train of six cars was stopped in less than its own length, in 11 seconds, from a speed of about 30 miles per hour. Another train on the P. R. R. running at a speed of 45 miles per hour, was suddenly flagged and brought up in nine car lengths.

Although this brake was such a great step in advance over the chain brakes and similar devices used in the early days, it lacked several of the elements which are essential to a perfect brake. It was still too slow, particularly in releasing, as all the air in both pipe and cylinders had to be exhausted through the engineer's valve. The longer the train the slower it was, on account of the increased number of cylinders and length of pipe. The storage capacity of the main drum was necessarily limited, and this on long trains, reduced the effective power on the pistons. To illustrate: With an initial pressure in the main drum of 90 lbs. the braking force at full equalization on one or two cars would probably be about 85 lbs., while on 10 cars it might not be 70.

Another great objection to this brake was the fact that if a hose or pipe burst the brake was thereby rendered useless on the entire train, and if the train broke in two the brake on the rear portion was not available, although the use of a valve in the coupling enabled the
engineer to stop the forward section—something which was often done with disastrous results, collisions between the divided sections being not at all uncommon.

These defects or shortcomings were rendered all the more serious and dangerous because of the fact that trouble was most liable to occur just at the time when the brake was most badly needed, i.e., when a very heavy pressure was put into the pipes to make an emergency stop.

Experience with the straight air brake soon developed the fact that a brake, in order to be satisfactory, should be adapted to be set from the train as well as from the engine, for occasions frequently arose (as when passengers attempted to get on or off the train while in motion), in which accidents could have been averted had the trainmen been able to stop the train quickly without the loss of time incident to signalling the engineer to apply the brake.

It also soon became apparent that a brake in order to be reliable must be perfectly automatic, that is, it should be so constructed that any defect would operate to set it. Such action would necessitate immediate investigation and repair of the defective part.

It finally became evident that, to secure such a result from the air brake, the force for applying the brake must be stored on each car, and held out of action by a constant pressure carried in the train pipe. The most primitive conception of this idea was a design in which a spring was used as the operative force, so arranged that it was held under compression by the air in the pipe, and brought into action when the air escaped. Many of the uninitiated at the present day have the idea that such is the action of the modern air brake.

**AUTOMATIC AIR BRAKE.**

The first step towards a practical solution of the problem of storing the braking power on the cars was to use a reservoir, auxiliary to that on the engine. This idea was embodied in a patent issued to Mr. Westinghouse, March 5, 1872, the principal cut of which is shown in Fig. 18. Here the auxiliary reservoir is open to one train pipe and hence in communication with the main reservoir, while by means of the other pipe the brakes were applied as in regular straight air. But if the train parted the brakes were to be set by the couplings pulling apart and thereby turning the valves shown at diagonally opposite
Fig. 18—First Auxiliary Reservoir (1872).

Fig. 19—Automatic Brake with Triple Valve (1872).

Fig. 20—First Westinghouse Triple Valve.
corners of the car, thus admitting the air from the auxiliary reservoir into the cylinder.

The next move in this progressive march was to provide a mechanism so arranged that the stored pressure in the auxiliary reservoir would be automatically admitted to the brake cylinder whenever the pressure in the train pipe escaped. Such a device is shown in another patent issued to Mr. Westinghouse on the same day as the preceding one, and from it we have taken Figs. 19 and 20, Fig. 20 being a large sectional view of the valve $D$ of Fig. 19.

In Fig. 19 $A$ is the auxiliary reservoir, $A$ the cylinder, and $D$ the triple valve, or what, to speak more accurately, formed the beginning of the triple valve. We shall not endeavor to describe the operation of the parts in Fig. 20, for (as a glance at the cut will show) it was a device so "fearfully and wonderfully made" that considerable time and space would be required to make it clear. It will be sufficient to say that it was for the purpose of opening communication from the auxiliary reservoir $A$ to the cylinder $A$, when the pressure in the train pipe $B$ escaped.
HOSE COUPLING.

As it was in the development of the straight air brake that the hose coupling was perfected, and as that device has played a very important part in the evolution of the air brake, before we proceed further with the general subject, we shall here give a brief sketch of the history of the hose coupling.

Between the years 1867 and 1874 (the date of the invention of the present well known form) there were ten different patents on hose couplings taken out or assigned to the Westinghouse Air Brake Co. alone. Many others were patented during the same period by other inventors, and the total number issued to date is very large.

Fig. 21 shows a good specimen of what, for convenience, we shall term the direct type, which was the general form of nearly all the designs. They came together end for end, and were held in contact by snap springs and lugs. Sometimes, as shown in the cut, they were made with check valves, inserted in such a way as to close when they were pulled apart; for in use with the straight air brake this was necessary to keep the brakes on the first section of the divided train in operative condition. From the very first, rubber rings or washers were used to keep the joint at the point of contact air tight.

One great difficulty with many of these direct couplers was that they would not couple without alteration if the cars were turned end for end. In other words, the couplers on the two ends of a car were not duplicates. This necessitated placing two hose and half couplings on each end of each car. As a step in the direction of overcoming
this difficulty the design shown in Fig. 22, having a male and female part cast together in each half coupling, was made and tried for a time.

These attempts were so unsatisfactory, however, that an entirely new departure was made by Mr. Westinghouse in 1874, when he brought out the coupler shown in Fig. 23, with the passage at right angles to the axis. It is safe to say that there have been very few mechanical contrivances ever designed which so completely and fully met all the requirements of the case; interchangeability, simplicity, convenience, non-liability to leakage, and detachability in case of forcible separation of the train. The essential form of this last described coupler is the same as that in general use to-day. The principal changes made in it have had reference to the method of retaining the rubber gasket in place, or additions in the shape of auxiliary devices of some kind which have not affected the general construction. Two of the first mentioned modifications are shown in Figs. 24 and 25, the
first from a patent issued to T. W. Welsh, and the second from a patent granted to A. W. Jackson, both improvements being of recent date.

In Fig. 24 the gasket is held in place simply by its own elasticity causing the flange to bind in the groove, which is made of a taper form for the purpose.

Fig. 25 shows the gasket held in place by an adjustable retainer, which can be operated by a tool thrust through the opening. Both of the above designs were made for the purpose of making it possible to renew a worn or defective gasket without the necessity of removing the hose from the car.

One complaint made against the common form of coupling is that the cup shape of the end forms a pocket in which dirt collects when the hose is allowed to hang down. With this idea in mind Mr. S. M. Beery designed the coupling shown in Fig. 26, making the casting of such a form that the passage through it would be of practically the same diameter at all points, and least liable to afford a lodgment for dirt. This was patented in November, 1893.

The peculiar angular construction shown in Fig. 27 is illustrated in a patent issued to Eames in 1877, and was designed for use with vacuum brakes, the atmospheric pressure holding the two halves to-
gether with sufficient force to keep the connection air tight. That this form was a success is evidenced by the fact that it has been and is still extensively used, practically without material modification.

In Fig. 28 we return again to the usual construction, with the addition of a clapper or cover to keep out the dirt. This was patented by T. W. Welsh in 1879. Others, to whom the same idea occurred later, have been surprised to find that it was not novel, and we are forced to confess that the author was one of the number.

The remaining cuts illustrate various schemes for doing away with the "deadly" angle cock.

Those shown in Figs. 29 and 30 were patented by Westinghouse in 1879. Fig. 29 shows a semi-spherical rotary valve adapted to be opened automatically by the lug $H$ in the act of coupling. Fig. 30 shows an adaptation of the idea to the usual style of coupling, the valve in this case being a rotary ported disc $E$, operated by engagement of the outside arm $G$ with a lug on the opposite half coupling. In several devices in this line a plug cock is inserted in the back of
coupling and operated in some such manner as the disc valve in Fig. 30. Some of these are wholly impractical, while others possess more or less merit, but none of them have seen extensive use.

Fig. 28—Welsh Coupling Cover (1879).

Fig. 29—Westinghouse Combined Coupler and Valve (1879).

Many inventors have tried and are still trying to perfect a coupler which will not need to be coupled by hand. Fig. 31 shows one of this class patented by W. A. and L. S. H. Harris, Feb. 20, 1894. It pro-
vides for both brake and signal connections. Frequent attempts have been made to combine the brake coupling with the signal and steam connections, and even to combine it with the M. C. B. car coupler.

So far as our information goes, no automatic hose coupler, either alone or in combination with other couplers, has proven satisfactory. In fact, the great majority of them are entirely impracticable, and even if one shall be designed which will meet all the requirements, its introduction will be a matter of great difficulty because of the lack of interchangeability.

**Fig. 30**—Westinghouse Coupling and Valve, Modified (1879.)

**Fig. 31**—Harris Automatic Coupling (1894.)
AIR PUMPS.

Having in the last chapter considered the development of the hose coupling up to the present date, let us begin now the history of another detail of the apparatus,

THE AIR PUMP.

Fig. 32 is an isometric view of the first Westinghouse pump, patented August 30, 1870. It will, no doubt, have a very familiar appearance to many of the older generation of railroad men, so many of whom operated the "first one ever put on the X. X. & X. R. R."

The reversing cylinder on top, the outside crank and moving piston, and the handle for starting it when stopped, are very clearly shown.
Many times the writer has heard stories of engineers operating the pump for a round trip over the road by means of a string tied to the reversing piston, giving it a pull every time the pump took a stroke; for it is to be noted that this pump had a very peculiar habit, whenever it took a bad spell, of always stopping at one end of the stroke, when a pull on the string would be necessary to get it to make another move. All these old timers are agreed, however, that, for those days, this pump was a wonderful piece of mechanism, and it is reported to have done very effective work as long as it was properly adjusted and cared for.

In Fig. 32 the upper cylinder and head only is shown. Fig. 33 shows the whole pump, except the top head, in section, the section being taken, however, too far back to show the main piston and rod. In this cut we wish to call attention particularly to the air cylinder, in which, it will be noted, the arrangement of air valves is practically the same as that used in the standard 6-inch pump for many years afterward.

The familiar stop pin above the lower discharge valve is clearly shown, as well as the bothersome bushing in which the upper discharge valve works.

The valve motion in the steam cylinder of this pump comprised a main valve $C$ (Fig. 34); a reversing piston, the rod and cross head $E^2$ of which are seen in Fig. 32; and a reversing valve and stem $A$, shown in Fig. 34. The main valve $C$, Fig. 34, stood vertically, on the side of the cylinder, with the crank arm sticking out through a packing nut on the top, and the valves proper were in the shape of conical plugs, one on the lower end of the stem, and the other a little above the middle, opposite the top end of the cylinder. This valve was adapted to be adjusted vertically by means of two set screws $I$ in Fig. 33 and $P$ in Fig. 32. Of course, if the upper one of these got screwed down too far it resulted in a binding of the valve in its bearing, making it very hard to move at all, and if the lower set screw were set up too tightly, the valves would leak.

The reversing piston was operated by steam admitted alternately to the outer ends by the reversing valve $A$ (Fig. 34). As shown, this valve had a stem adapted to project into a hollow made in the upper part of the main piston, through an oblong slot in the reversing plate, shown as $B$ (Fig. 34). The stem was twisted at its upper and lower ends so that as the main piston moved to the top or bottom of the
Evolution of the Air Brake.

39

cylinder a rotary motion was imparted to the conical reversing valve $g$, the main piston rod itself being made *square* in cross section to prevent it from turning. The stuffing boxes used for packing the piston were set in horizontally, as shown in $D$ (Fig. 34), and were adapted to be drawn together by two set screws or bolts.

![Figures 33 and 34 - Details of First Westinghouse Pump.](image)

Anyone at all familiar with the operation of air pumps will see at once that there were, in this design of valve motion, two very weak points, certain to give trouble. One of them was the square piston rod which it was impossible to keep tightly packed, and the other
was the reversing valve arrangement. Imagine the amount of frictional resistance that would be encountered in moving the conical valve $g$, and how far the main piston would have to travel to secure full movement, or, in other words, how far from the end of the stroke the pump would have to begin to reverse. We can imagine, also, how rapid would be the wear of the rod, and the oblong slot in the reversing plate in which it worked.

The patent itself was valuable, because it contained a broad claim to the combination of a reversing rod operating in a hollow piston, but that the mechanism was unsatisfactory in practical operation is shown by the fact that this patent had not been issued a year before

![Diagram](image)

**Fig. 35—Improvement in Westinghouse Reversing Gear (1870).**

application was made by Mr. Westinghouse for another on an improvement in the reversing valve gear.

This improvement is shown in Fig. 35, which is a sectional view taken through the center of the reversing piston cylinder and reversing valves. In place of the conical rotary valve with its twisted stem there were substituted two poppet valves $e$ and $c$ which were held to their seats by the pressure of steam in the chamber between them. The lower one was unseated by being struck by the reversing plate when the main piston reached the upper end of its stroke. The upper one was unseated by the plate striking the bottom on the lower end of the rod when the main piston reached the lower end of its stroke. These valves had two large double concentric seats and gave
considerable trouble in service because of the difficulty of keeping these seats tight. An endeavor was made to compensate for slight leakage by drilling a small leak port into the exhaust, but this was a sort of makeshift and did not fully overcome the objections. In this pump, as will be readily seen, it was possible to do away with the square piston rod, and this was a great step in advance. The reversing movement was still imperfect, however, and another alteration was made in it inside of a year, as shown by a patent issued in 1872, from which we have taken Fig. 36.

In this design a return was made to the rotary conical plug of the first construction, but it was set in a vertical position, with its axis horizontal, and operated by a rod similar to the one used in the form shown in Fig. 35. The cut (Fig. 33) shows only the valve, the bushing and the top of the rod, but the manner in which the rotary motion was imparted to the valve, is clearly illustrated in the elevation on the left.

Although this seemed to meet the requirements a little better, it was superseded by another form brought out in 1873.

In this arrangement, shown in Fig. 37, the rotary valve was still retained, but a kind of crank shaft, or rocker arm, was substituted for the direct connection of valve and stem of the preceding figure, and the upper end of the rod was slotted, or made with a slotted eye, shown in the main part of the figure, this eye being adapted to slip over the pin $i^1$ of the crank shaft $g^1$, shown at the top of the figure. By this time there were a great number of air brakes in use and quite a large number of the pumps last described above were kept in service for several years, although it was only a little over a year after this that Mr. Westinghouse practically abandoned the old construction ex-
Except the hollow piston rod, and adopted the design shown in Fig. 38, which is taken from a patent issued in 1875. The construction shown is practically the same as that used in all the 6-inch pumps and later in the standard 8-inch pump and at the present day in service on thousands of locomotives all over the world.

Such differences as exist are matters of detail only. Instead of two packing rings in each valve piston head a single broad ring is shown. The bushings are inserted in exactly the same manner and position.

![Diagram](image)

**Fig. 37—Third Improvement in Westinghouse Reversing Gear (1873).**

The reversing valve, rod and plate are substantially identical, except that the upper end of the rod projects through a stuffing-box at the top. This was probably designed to obviate the difficulty sometimes caused by inadvertent movement of the reversing valve, which results in what is generally called "giggling." or "fluttering."

In concluding this chapter the writer desires to call attention to a very interesting fact that is revealed by one of the patents to which we have referred. It will be noted that most of the changes above
described had relation to the reversing valve mechanism; all of the designs shown up to Fig. 33 evidently having been unsatisfactory. First a horizontal rotary valve was used, then a double poppet valve, then a vertical rotary valve, and finally a simple slide valve; and yet there is a suggestion as to the use of a slide valve contained in the very first patent, which is as follows: "A sliding valve of short throw might be made to do the same work (as the rotary valve used)

by means of the valve stem entering the hollow of the piston head and stem, and the two being so constructed that at any desired part of the stroke of the piston head it shall engage some fixed point in, or part of, the valve stem." With our knowledge of the experience of the past and of what actually has proven suitable in air pump construction, it certainly seems as if it was a strange error in mechanical judgment to adopt a rotary or plug valve in a mechanism for which a slide valve was manifestly superior, and especially so when, as shown
by the quotation above cited, the use of a slide valve had been con-
considered.

From the figure last above illustrated (which shows the valve motion used in the Westinghouse 6 and 8-inch pumps) we naturally pass to the latest design furnished by that company, two sectional views of the upper head being given in Fig. 39. But little explanation of its operation will be necessary, as it is already pretty well known among air brake men. There are two important points to be noted, in which it differs from the one shown in Fig. 38.

First—instead of the piston valve shown in the latter, a slide valve (23) is used to control the main ports, the movement of the slide valve being effected by a differential piston.

Second—All the valve motion is on the top head, so that if it becomes necessary a new head can be substituted while the old one is being repaired.

The outer end of the smaller one of the valve piston heads (28) is in constant communication with the exhaust, and the outer end of the larger head (29) is connected alternately with live steam and exhaust by means of a slide valve (8) operated by a reversing rod (7), a mechanism practically identical with that formerly used.

The advantages of such construction are obvious. It embodies, in combination, features shown in various prior devices found in what might be called the "ancient history" of the art.

In 1858 Mr. E. D. Barrett secured a patent on the pump shown in Fig. 40, this being one of the earliest patents in this class of direct acting steam valves.

The main valve B was similar to the slide valve on any ordinary engine. It received its motion, however, from a double headed piston, controlled in its movements by a smaller slide valve, supplementary to the main valve. This supplementary valve was actuated by the rocker shaft F; whenever the main piston reached either end of its stroke, the arrangement of the parts being clearly illustrated in the cut.

In 1865, a patent was issued to A. S. Cameron for a "steam slide valve," the essential features of which are still used in the well known Cameron water pump. From this patent we have taken Fig. 41.

This is perhaps the simplest direct acting valve motion ever designed, and is a model which may be very profitably studied by any ambitious mechanical designer. The main valve (C) is adapted to be
FIG. 39—WESTINGHOUSE LATEST DESIGN.

FIG. 40—BARTLETT VALVE MOTION (1858).

FIG. 41—CAMERON PUMP (1865).
Evolution of the Air Brake.

Moved back and forth by a double-headed piston ($FF_1$) whenever the main piston $B$, at either end of its stroke, unseats the exhaust valve ($I_1$ or $I_1'$) and thus relieves the pressure from the corresponding end of the valve piston. As leak ports ($d_1 d_1$) are provided to allow live steam to equalize on both ends of the double piston, it is very manifest that it is not necessary to have the piston heads a tight fit; in other words, no packing rings are necessary. All the parts in the design illustrated are readily accessible, a very desirable feature in any mechanical contrivance. In the figure shown the exhaust valves are held to their seats by springs ($h h_1$), but this was changed some time after the issue of the patent, by the substitution of an arrangement whereby live steam pressure was used in place of these springs, making the apparatus even simpler than that shown.

In 1884 a patent was issued to M. S. Harlow for a valve mechanism of this same general class (having a slide valve and double piston), but in which all the operative mechanism was placed in the top head.

This we have illustrated in Fig. 42.

In 1888, Mr. G. A. Boyden patented a pump in which a double piston and slide valve are used, but having their functions reversed.
That is, the piston is used for the main valve, and the slide valve for reversing. This arrangement is shown in Fig. 43.

The double piston is really a quadruple one, for it has four heads, the upper two being larger than the others. The movement of the main piston is imparted to the reversing valve (28) through the instrumentality of the tappet rods (34). This mechanism while not arranged in the top head, is still so designed that it can be completely removed from the cylinder in case it becomes necessary to do any work upon it.

In 1889 Mr. F. Lansberg patented the valve mechanism shown in Fig. 44.

This differs from prior constructions in the fact that, in place of a valve piston with two heads of the same size, a differential piston is
used to move the main slide valve, this part of the construction being practically identical with the one first above described. It differs from that, however, in the form of reversing gear used. When live steam first enters at (7) it forces the valve to the position shown, because the upper piston is larger than the lower one. This admits steam to the under side of the main piston (2), and the upper side, being open to the exhaust, through passage (8a and 9), forces the main piston to the top of the cylinder. When it strikes the tappet (25) the rotary valve (23) opens a passage to admit live steam to the upper side of the piston (12), and, forcing it down, reverses the pump.

At the bottom of the stroke the tappet (21) reverses the movement by turning valve (23) so as to exhaust the steam from above piston (12). The under side of the piston (13) is at all times connected with the exhaust through the port (35).

As shown, this arrangement was not as readily accessible as some of the others, being placed at the side of the cylinder, instead of in the top head.
The New York pump, shown in Fig. 44\(a\), seems to have been the first attempt of any moment to utilize the duplex principle in air brake construction. Some years ago the Westinghouse company made extensive experiments with a four cylinder compound pump, and it was our privilege at that time to witness some tests made with that pump at their shops at Wilmerding. We have no record of the results, though it is our recollection that high efficiency and great economy were obtained. The design was finally abandoned, however, in favor of the 91/2 inch type, because of excessive liability to heat, and unwarranted complication of parts. What resembles in some respects a combination of the 91/2-inch pump with the New York
duplex, is shown in Fig. 45, taken from a patent issued to H. Breitenstein, November 21, 1893.

As will be seen by reference to the drawing, the opposite ends of the cylinder are connected in such a way that both pistons will move at the same time, but in opposite directions, this being an evident attempt to overcome the objection incident to any construction in which one piston has to stand still until the other has completed its stroke. What the operation of the device illustrated would be in practice is problematical.
GOVERNOR.

Shortly after the introduction of the automatic brake it became manifest that to secure the most satisfactory results in the operation of the apparatus, some means must be devised whereby the air in the train could be maintained at a uniform pressure without attention from the engineer. In the use of the straight air brake it was not so essential to keep the stored pressure uniform, and little difficulty was experienced by the engineer in satisfactorily regulating the supply by occasional manipulations of the pump throttle.

In itself the problem was a simple one. There was a valve to be moved and pressure to do it. A plug cock might do for a valve and a piston as a means for supplying the force. As the movement had to take place when the pressure reached a certain predetermined amount some yielding resistance to the movement of the piston had to be provided, which would permit action only when such predetermined pressure had been reached. At first glance the solution seemed easy enough. Let us demonstrate by illustration.

In Figs. 46 and 47 is shown, in simple form, what seemed to meet the requirements. It was, as far as the general plan was concerned, nearly identical with many that have been sketched out by aspiring inventors who have endeavored to simplify the form in use. Air entered the cylinder $A$ at the air inlet, pressed the piston $B$ to the left against the spring $C$ and thus through the lever $D$ turned the valve $E$ until, when a sufficient number of pounds had accumulated, the passage $F$ was completely closed (as shown in Fig. 47) shutting off the steam from the pump. As the pressure reduced the spring $C$ forced back the piston $B$, reopened the passage $F$, and allowed the pump to start again.

It will be evident on a moment's reflection, that when the passage $F$ was nearly closed, the pump would run so slowly that the accumulation of sufficient pressure to move the piston $B$ further would require some time. Herein lay the defect of this device. Just as the pressure increased, the speed of the pump reduced, in consequence of
which the accumulation of the last five or ten pounds below the limit was prolonged almost indefinitely. It, therefore, became manifest that some auxiliary or supplementary device would have to be added to overcome this defect. A diaphragm valve held shut by a spring under adjustable tension, and adapted when opened to admit pressure to the piston, so as to effect full closure of the steam valve when the desired limit was reached, seemed best suited to the purpose. Such

![Diagram of diaphragm valve and steam valve](image)

**FIGS. 46 AND 47—ILLUSTRATIVE GOVERNOR.**

an arrangement also permitted the steam supply passage to remain unobstructed until the full pressure was obtained.

As a plug cock was not as well adapted to the purpose as a common poppet valve, the latter was substituted for the former in all the constructions which have been used in practical service.

Various different modifications of this general idea have been or are now in use, and we shall next proceed to consider them in detail.
E V O L U T I O N  O F  T H E  A I R  B R A K E.
The pioneer is shown in Fig. 48. It was patented by Mr. Westinghouse in 1881, and may be found in the earlier catalogues issued by the Westinghouse Company.

$B^1$ is the connection from the boiler, $B^2$ leads to the pump, and a balanced steam valve of the usual construction controls the flow of steam from the former to the latter. This steam valve is held open by the spring which bears against the piston $D$, until sufficient pressure has accumulated in the train pipe or receptacle connected at $B^1$ to unseat the diaphragm valve $v$, when the air pressure flows through the passage $s^1$ to the upper side of the piston $D$, moving it downwards, and allowing the spring $a^3$ to seat the balanced valve and cut off further supply of steam to the pump. The method of operation of this governor was very little different from the best ones now in use, but the details of construction were too complicated and delicate to be satisfactory in the long run. These objections resulted in an altered form, brought out in 1883, in which what might be called a more negative principle of operation was adopted. Fig. 49 is a sectional view of this device.

In this construction steam entered at $B$ from the boiler; the pump was connected at $B^1$ and the valve $C$ controlled the passage from one to the other. When the hand wheel on the spindle $R$ was unscrewed the steam that leaked around the cup piston $c^3$ and through leakage groove $a^1$ caused an accumulation of pressure at $a$ (valve $d^1$ being normally closed), and operated to open free passage to the pump. As soon, however, as the accumulated pressure in the train pipe or drum (connected at $H^1$) became sufficient to move the diaphragm $e$ against the resistance of spring 1, the small valve $d^1$ unseated and permitting the escape of the accumulated pressure that was holding the valve $C$ open, allowed the back pressure on the pump side of the valve $C$ to close it. In the last clause of the sentence just above is the key note to the failure of this device. The "back pressure" was a varying and uncertain quantity, and could not be depended on to seat the valve as described, and the consequence was that of the large number of these governors put into service very few were of any account.

The need of a good governor finally became so urgent that in 1889 Mr. Westinghouse brought out another form, more nearly resembling the one patented in 1881, and which forms the basis of the construction that company is now using. It is shown in Fig. 50, in which 2 is the connection from the boiler, 3 to the pump, and the passage be-
Evolution of the Air Brake.

Fig. 49—Second Westinghouse Governor (1883).
Evolution of the Air Brake.

tween them is controlled by a single valve 4, held open by the steam pressure until the air unseats the diaphragm valve and flowing in on top of piston 8, which is of larger area than the steam valve, forces valve 4 to its seat. A modification of this construction, taken from the same patent, is shown in Fig. 51, the design being simply a dupli-

Fig. 50—Third Westinghouse Governor (1889).
cation of the upper or diaphragm part, in order to provide independent regulation for both the drum and train pipe.

In 1891 Mr. G. A. Boyden designed a governor which differed from that shown in Fig. 50, principally in having, instead of a dia-

**Fig. 51—Double Governor.**
phragm, a kind of a safety valve, the construction being clearly shown in Fig. 52.

In 1893 Mr. Massey of the New York Company secured a patent on the style of governor shown in Fig. 53, which, while on the same general plan as those shown in Figs. 50 and 52, contained several modifications in detail. A small spring was introduced for the purpose of unseating the diaphragm valve, in order to insure more sensitive action, for without such a provision the least amount of lost motion between the diaphragm and its valve interfered considerably with the certainty of always securing prompt starting of the pump when the pressure was slightly reduced.
Finding the construction shown in Fig. 50 a little too light, the Westinghouse Company introduced an improved form, now known as their standard, and which is shown in Fig. 54, but which is too well known to require further description.

In addition to the various ones already described we call attention to the one shown in Fig. 55. It is the Mason regulator, which began
to be very generally known quite a number of years ago, but as to the exact date of the first introduction of which we are uncertain.

In this device steam from the boiler passing through passages $X$ and $Z$ (valve 8 being held normally open by the tension of spring 5) acts on the underside of piston 19, moving it upward and holding main valve 21 open; until the air pressure accumulated in the train pipe or drum (connected at $O$ with the cavity under the diaphragm 24) reaches the limit at which spring 5 is set, when valve 8 seats, the steam under piston 19 escapes by leakage and allows valve 21 to seat from the action of the spring 22 and steam pressure above it.

![Fig. 54—Westinghouse Improved Governor.](image)
FIG. 55—MASON REGULATOR.
The first form of engineer's valve used with an air brake was nothing more or less than a plain three-way cock, i.e., a valve with three openings controlled by one rotary plug, conical in shape. It was illustrated in the 1872 catalogue of the Westinghouse Air Brake Company, from which we take figure 56. This, the foundation idea, (having three connections controlled by one valve) has been retained in all of the engineer's valves since designed. The complications found in later constructions are merely additions to this general scheme. The valve shown in the cut was the form used with the straight air brake, but it is to be noted that when the automatic brake was first introduced, the same valves were used for a time simply by reversing the motion, something which was made possible by the fact that the position of the handle that would apply a straight air brake would release an automatic brake, and vice versa.

With the straight air brake, and also with the automatic brake, as long as it was limited to short trains, the operation of such a plain valve was quite satisfactory, but as soon as the number of brake equip-
ments increased materially difficulty began to be experienced in getting the brakes to release properly, because of the insufficiency of the air supply carried in the main drums. In order to overcome this difficulty it became apparent that, either the size of the drum must be increased, or else the air stored in it must be maintained at a higher pressure than that in the train pipe. This was the beginning of "excess" pressure. It seems to have been first put into practical use in the valve shown in Fig. 57 on which what is known as the "running position" first appeared. In this construction (patented in 1879) a

![Diagram](/resources/diagram.png)

**Fig. 57—Westinghouse Engineer's Valve of 1879.**

rotary valve $C$ was substituted for the former plug valve and in the center of the casting forming this rotary valve was arranged a small poppet valve $J$ held shut by a spring of just sufficient strength to hold back the desired surplus pressure in the main reservoir, the ports in the rotary valve being so arranged as to shut off, in running position, all passage of air from the drum to the train, except such as forced its way by this excess pressure valve and through the small port $L$.

In order to make it possible to more accurately gage the amount of train pipe reduction made in applying the brakes an exhaust or discharge valve $E$, held shut by a spring, was arranged in such a manner as to permit the escape of train pipe pressure when the handle $D$ was
moved so as to lighten the tension on the spring. This was also designed to assist in closing the exhaust easily, which, as we shall see presently, was quite a desirable feature.

Although this valve was very extensively introduced, experience developed defects in its construction which frequently caused much inconvenience. The spring on top of the discharge valve \( E \) would sometimes weaken so as to permit the escape of air from the train while the handle was still in the running position, which of course made it impossible to carry it anywhere except in the position for full release of the brakes, under which circumstances no excess pressure could be carried. The spring on top of the excess pressure valve \( J \)

![Diagram](image)

**Fig. 58—Paradise Engineer's Valve (1882).**

also caused frequent trouble, and the small port \( L \) above this valve often became obstructed with gum so as to prevent entirely the passage of air, which of course cut off all feed to the train, allowed the train pressure to reduce, sometimes dragging the brakes, and at the same time causing the accumulation of an abnormal pressure in the main reservoir, the amount of this being only limited under such conditions by the capacity of the pump.

In Fig. 58 is shown an arrangement in which the excess pressure valve of Fig. 57 is combined with a common three-way cock. The cut is taken from a patent issued to Mr. N. J. Paradise in 1882 and is practically the same as the valve which was once used quite extensively on the Chicago, Burlington & Quincy Railway.
The next idea which seemed to develop in the improvement of engineer's valves had relation to the driver brake. In some cases, especially on mountain roads, it was considered advisable to arrange the driver brake so it could be operated independently of the brakes on the train. Fig. 59 shows an independent engineer's valve provided for this purpose, the arrangement shown being a modification of a device which was patented in 1879. The idea was that by setting the handle at a certain point, a predetermined amount of pressure could be maintained in the driver cylinders through the operation of the piston (9) and valve (12) in a manner that will be clear from examination of the drawing.

In Fig. 60, from a patent issued to E. J. Cosgrove in 1885, we illustrate an attempt to combine the driver brake valve with the regular
brake valve. It was so arranged as to bring the former into operation only in case of emergency, the position of the handle marked 3 being the position for emergency applications in which it will be noted the handle strikes the added valve, and, by connections not clearly shown, admits air from the main reservoir to the driver cylinders.

Shortly after the date of the last named patent conditions began to develop which resulted in the introduction of what is known as the equalizing discharge valve, but consideration of this we must defer until the next chapter.

**Fig. 60—Cosgrove Combination Engineer's Driver Brake Valve (1885).**
EQUAlIZING DISCHARGE VALVE.

In the operation of all the engineer’s valves previously described, difficulty was experienced on long trains from the brakes on the head cars releasing when they should remain set, because of a violent recoil of the air in the train pipe, which resulted from any sudden closure of the exhaust opening. As long as the number of air brake cars in a train was limited to a few, this difficulty was of little moment, but with the large increase in the number of equipments that took place about 1885 or 1886 it became evident that some automatic means would have to be provided to overcome this objection, or the loss of braking power through such a release on extremely long trains would largely reduce the benefits to be derived from investments in continuous brakes. An idea prevails with many that the equalizing valve was an outgrowth of the quick action triple, adopted for the purpose of preventing unnecessary emergency application through definite limitation of the size of the service discharge opening, but this is a mistake. The equalizing valve antedates the celebrated Burlington brake tests, besides which, if all that was wanted was a limited discharge opening, a smaller hole in the regular rotary valve would have answered every purpose.

Fig. 61, taken from a catalogue issued by Westinghouse in 1888, is the earliest form of equalizing valve the writer has been able to find. It seems to have all the elements of the present construction, but contains in addition some springs, the use of which is not very clearly defined. Possibly they were considered necessary to aid in moving the slide valve. Briefly described the operation was as follows: A slight quantity of air being exhausted from the cavity above the piston 18, allowed the pressure in the train pipe underneath to raise the piston and hold the valve on the bottom of stem 22 open until the same degree of reduction had taken place throughout the train, when the valve would gradually close the exhaust as the pressure below the piston became slightly less than that above. The valve as shown is in the release position, and it is to be noted that in this position air from the main drum passed directly through the equalizing piston by un-
seating valve 20, and thence to the train pipe (as shown by the arrows), an arrangement which might have been more satisfactory if it had been possible to make the valve 20 in some way such as would insure its seating absolutely tight at all times. It is apparent that any lodg-
ment of dirt on this seat which would hold the valve open would entirely destroy its equalizing function, because the preliminary exhaust port through which air was exhausted from the small cavity above the piston being of necessity quite small, could not discharge pressure sufficiently fast to raise the piston, if air from the train pipe were at the same time flowing into the cavity past the valve 20.

In Fig. 62 we have illustrated a modification of the primitive valve shown in Fig. 62, the cut having been taken from a patent issued to Westinghouse & Moore in 1839. The principle of operation of the two was almost identical, but the latter form was considerably simpler and is now, with the addition of a feed valve, the standard of the Westinghouse Company. The discharge valve 21 is formed on the end of the piston 19, and the train pipe exhaust is in the shape of an elbow, marked 23.
A short time after the issue of this patent Mr. George A. Boyden devised an invention shown in Fig. 63, in which the same end was accomplished, i.e: the cushioning of the exhaust closure, by means of an overflow reservoir substituted for the piston. The principle of operation of this valve is well described by the second claim of the patent, which was issued in January of 1891. It is as follows: "A device to gradually stop the forward movement of compressed air in the train pipe, comprising the combination of a train pipe (H), an engineer's brake valve (A), an air receiver (J), and means to discharge the train pipe air into the air receiver when the discharge from the train pipe to the atmosphere is cut off." The cut shows a brake valve of the form of the old three-way cock, but the same equalizing arrangement was subsequently used by Mr. Boyden in conjunction with an improved valve of the rotary type.

The next equalizing valve to make its appearance was designed by Mr. A. P. Massey, of the New York Air Brake Company, in 1892, and this we have illustrated in Fig. 64. In this also the main controlling valve was of the plug type, marked 5 in the cut. The principle of operation of the valve in closing was similar to that of Figs. 61 and 62, but it was opened by a positive mechanical pressure of the lever 15 instead of a reduction of the pressure on the upper side of the diaphragm.

Fig. 63—Boyden Equalizing Engineer's Valve (1891).
In other words, when it was desired to apply the brake lightly, the handle and controlling valve were moved to such a position as would (through a cam on the lower edge of the plug 5) push down on the lever 15 and thereby raise the diaphragm 13 and discharge valve 12, permitting the escape of not only train pipe pressure but also the pressure in the cavity on top of the diaphragm, for in the application position ports 8 and 11 were open, as shown in the cut, and the pressure in cavity 10 reduced coincidently with that in the train until such time as the handle was moved to the lap position, when the opening from the cavity was closed and the air remaining in it would begin to exert a downward pressure on the diaphragm and close the discharge as soon as the pressure in the train became equalized.

Another valve was made by the New York Company, and designed, we believe, by A. P. Massey, about the same time as the preceding one, is shown in Fig 65. It is practically the same as the one now furnished by them as standard. The cut given shows the equalizing part of the valve, combined with their arrangement of excess pressure valve as designed by H. G. Manning. In this equalizing mechanism the automatic closure of the discharge opening from the train pipe was accomplished by a balance between, or rather an opposition, of the pressures in train pipe and main drum exerted on opposite sides of a piston 19. To make an application, the handle was moved to such a position as would cause the lever 17 to open the valve 27 by
means of the eccentric 13, then as the pressure in the train pipe, which is on the upper side of the piston, became reduced the air in the main drum, which acts on the under side of the piston, would raise the piston and permit the valve 27 to close. The bell crank lever 21, with its co-acting spring 24, was for the purpose of exerting a retarding force against the too sudden closure of the discharge valve, such as might take place without some such provision, in case the piston moved a little stiffly.

Fig. 65 shows an equalizing discharge valve patented by Messrs. Vaughn & McKee, of St. Paul, in August, 1893. The distinctive feature of this device lay in the use of an expansion cavity which had a certain proportionate size as compared to the cylinder in which the
equalizing piston operated. Referring to the cut, it will be seen that a slight movement of the handle to the right would move the slide valve, $b$, to a position which would allow air to escape from the train pipe out of the exhaust. This escape of air reduced the pressure on the train pipe side of the piston and through the lever $c$ (as the air in the cavity $a$ expanded), caused a return movement of the small slide valve $c$ which automatically closed the exhaust as the train

![Diagram](image)

**Fig. 66—Vaughn & McKee Equalizing Engineer’s Valve (1893).**

pressure became equalized. The notches in the quadrant marked "service positions" represent various degrees of reduction, as the further the lever is moved the greater must be the reduction in the train pipe before the valve $c$ will be closed.

In Fig. 67 is shown an equalizing valve patented by L. E. Howard in July, 1894. This construction seems to be exactly the reverse of the device shown in Figs. 61 and 62. That is, instead of opening the equalizing valve by reducing the pressure on the upper side of the
piston, the valve is opened by putting pressure underneath it. To accomplish this result it was necessary to use two pistons, the lower one to open the valve and the upper one to close it. In applying the brake, the handle is moved to admit train pipe pressure underneath the lower piston. The upper piston at this time being in equilibrium of course, offers no resistance to the unseating of the discharge valve 8, and this, when open, allows train pipe pressure to escape out of the port 13 from the under side of piston 6. To illustrate, if five pounds of air is admitted below the piston 7, valve 8 will open and stay open until a little more than five pounds has been exhausted from the under side of piston 6 (the train pipe side) and then the pressure on the upper side of the upper piston will begin to exert a downward pressure on the valve 8, which will close it as soon as the pressure throughout the train is equalized.

When we contemplate the array of devices shown above, all designed to accomplish the same result, we cannot help feeling very strongly the force of the teaching that the fact that we know of but one way to do a thing is no reason to suppose that some one else may not discover another method.
TRIPLE VALVE.

In the last few chapters we have considered the development of the pump, engineer’s valve, governor and auxiliary parts. Let us now return to the subject of the triple valve, the consideration of which we left sometime ago at the point where the “triple valve” first appeared on the scene.

The form of “triple valve” device, shown in Fig. 21, was not (as can be easily imagined when reference is had to the cut) a very successful one. It did not take long to discover that to be satisfactory in all the conditions of practical railroad service something much better would have to be designed. The problem engaged the attention of a number of inventors, but Mr. George Westinghouse, Jr., seems to have been the first to get one which came anywhere near doing what necessity demanded of it. His invention, like nearly all inventions of a mechanical nature, passed through several stages, embodying numerous minor changes in detail of construction, but the main elements of it are shown in a patent issued to him May 13, 1873, from which we have taken the view shown in Fig. 68.

Referring to the cut, it will be seen that the casing had three pipe connections, and these I have marked to indicate the parts of the apparatus to which they are attached. The exhaust is also marked on the cut.

In operation, air enters the valve at D, feeds through the ports x-l to the reservoir, and by pressure on the upper side of the diaphragm m-l holds shut the valve b leading to the cylinder, and the exhaust or escape to the atmosphere open, the valve c, which controls the exhaust, being, as shown, raised from its seat. To apply the brakes a reduction is made in the train pipe. This closes the opening from the reservoir to the train pipe and from the cylinder to the atmosphere, and then opens the communication from the reservoir to the cylinder. Reservoir pressure then flows into the cylinder and sets the brakes. To let the brakes off all that is necessary is to increase the pressure again in the train pipe, which returns all the parts to the position shown. If a partial or service application is desired, only a
slight reduction is made in the train pipe, this in turn only allows a small quantity of air to flow from the reservoir to the cylinder, the communication being cut off by the return of the valve \( b \) to its seat when the reservoir pressure reduces a trifle below that in the train pipe.

In Fig. 69 (taken from a patent to C. H. Perkins, issued in 1875) we have illustrated an interesting modification of a device embodying the same general ideas, but using very different mechanical constructions. The parts as shown are in the release position. As the names
of the different connections are marked, no further explanation will be necessary.

In Fig. 70 is illustrated what may be called the father of almost all of the triple valves of the present day. The cut is taken from a patent issued to Mr. George Westinghouse, Jr., October 5, 1875. Crude though the device be in appearance, it marks the beginning of the remarkable advance made in the brake business since that date. This patent introduced two valuable and important improvements over that shown in Fig. 68, i.e., a four-way cock (marked $B^1$), provided for the purpose of changing the brakes from straight air to automatic or vice versa, and a slide valve $H$ is substituted for the poppet valves of the earlier form. The necessity which compelled the introduction of the four-way cock arose from the fact that at the time this triple valve was invented quite a large number of cars had already been equipped with the straight air brake. As the principle on which this operated was directly opposite to that on which the automatic operated, it was of course impossible to use the two conjointly. The whole train had to be either straight air or automatic. Letting air out of the pipe would set the automatic and release the straight air; and restoring the pressure resulted in the release of the automatic and the application of the straight air.

During the transition period much confusion arose as the result of a misunderstanding on the part of many of the brakemen as to the
proper position in which to place the triple valve handle. However the four-way cock was a necessary evil, for it is obvious that all the equipment could not be changed at once, and it is also obvious that it would not do to abandon the use of the brakes entirely pending the completion of the change. Even up to a very recent date the four-way cock continued to fill a use on mountain roads, for until the intro-
Evolution of the Air Brake.

duction of the pressure retaining valve it was not considered safe to use the automatic brake on very heavy grades, because of the danger of the stored air in the reservoirs under the train becoming exhausted through repeated applications of the brake without proper recharging. On such lines it was customary to use the automatic brake going up hill and then change to straight air before beginning the descent.

On this drawing also (Fig. 70), the connections have been marked for convenience of reference. The piston and slide valve are shown in the release position. Air from the train pipe is feeding into the reservoir through the small port $s$, and the cylinder is open to the atmosphere through the recessed cavity $h^2$ in the seat of the slide valve $H$. When the pressure in the train pipe is reduced the piston $G$ moves down, closing the port $s$ from the train pipe to the reservoir, cutting off communication between the cylinder and the exhaust, and (the slide valve $H$ continuing its downward movement), uncovering the port $e$, leading from the reservoir to the cylinder, thus applying the brakes. Restoration of the pressure in the train pipe moves the parts back to the position shown, and thus releases the brakes.

Up to this point we have confined our consideration of the automatic brake almost entirely to those forms which use a triple valve. Another form which should not be passed without some mention belongs to a class which was so constructed that no triple valve was necessary. One of these is embodied in a patent issued to S. F. Prince, Jr., in June, 1878, and as this is one of the earliest ones of the kind, we have selected from that patent the illustration marked Fig. 71.

In apparatus of this class a reservoir and cylinder were generally used, but the piston in the cylinder was so arranged that it was balanced between train pipe and reservoir pressures, the reservoir being charged through a small port or passage through or around the piston and as generally arranged, covered by a non-returning check valve. In Fig. 71 this valve is marked $K$. To apply the brake the pressure was reduced in the train pipe $J$, which caused a movement of the piston to the left because of the expansion of the air in the reservoir $F$ and the seating of the check valve $K$. When pressure was restored in the train pipe the piston was forced back to the position shown, and thus the brakes were released.

This arrangement, or some modification of it, has been patented in
Evolution of the Air Brake.

several countries, and times almost without number, and came into quite extensive use in several of the foreign countries under various different names. It is open to several serious objections, however, especially in service on long trains, and on this account has in the last few years been largely superseded by more modern forms.

In Fig. 72 is illustrated the last of this series of plain triple valves, for in that device the development reaches its greatest perfection. The valve shown in that cut was designed by Mr. George Westinghouse, Jr., in the year 1879, and in all essential particulars forms the basis of nearly all the triple valves since made. It is made on the same general plan as the valve shown in Fig. 70, but contains in addi-

![Fig. 71—Prinze Automatic Brake (1878).](image-url)

tion, the small graduating valve $c\ldots$, which makes the engineer's control of his brake so perfect in all classes of service application.

A careful study of the sketch will be necessary to thoroughly understand the operation of this additional feature. In Fig. 70, as stated, the brakes are applied by the slide valve moving down and uncovering the port leading to the cylinder, and the flow of air to the cylinder is cut off by a slight backward movement of the slide valve (just sufficient to close the opening) caused by the reservoir pressure reducing to a point a little below the pressure in the train pipe. Now
in practice it was soon discovered that with the device as shown in Fig. 70 there was a tendency for the slide valve to move clear back to the release position instead of stopping just at the point where the graduating port was covered, but the exhaust not yet open. This was due in part to the fact that the amount of force necessary to start the valve upward was more than enough to carry it to the end of its
stroke after it started. It is a general and well known law that it takes more force to start a body in motion than it requires to keep it moving after it is started, and this case was but one instance of that law. To overcome this, then, the slide valve was given a slight range of motion independent of the piston stem, and the small grading valve was so inserted that after the slide valve had uncovered the port to the cylinder, a slight upward movement of the piston would seat the small valve e-l, and without moving the slide valve cut off communication from the reservoir to the brake cylinder, the resistance afforded by the friction of the slide valve itself acting to stop the upward movement of the piston and prevent any unintentional release during the service application.

The extreme nicety with which this device operates must be seen to be appreciated.
QUICK ACTION BRAKES.

What constitutes a quick action brake is, just at this particular time, a much disputed point. The pending litigation, arising from actions brought by the Westinghouse Company against a number of competitors for alleged infringement of quick-action patents held by that company, has given to the subject extended prominence and great interest.

In 1886, a committee appointed by the Master Car-Builders' Association, conducted a number of exhaustive tests at Burlington, for the purpose of determining, if possible, which of the several different continuous brakes then on the market was best suited to use on long freight trains. Prior to the date above mentioned, the plain automatic brake had proven quite sufficient, for the reason that only short trains were commonly used. As the motive power was constantly being made heavier, the number of cars which could be used in a train was correspondingly increased.

Amongst the brakes entered for trial in 1886, were momentum or buffer brakes and compressed air brakes. All were tested on trains of 50 cars. All failed to meet the requirements. The momentum or buffer brakes proved erratic, unreliable and insufficient, and the vacuum and compressed air brakes produced too great shocks in the rear of the trains, caused by the cars behind crowding into those ahead because the head brakes set some time before those in the rear.

In May, 1887, the tests were repeated, the competing designs comprising an electric brake, an electric air brake, a vacuum brake, and what is known as the Westinghouse, 1837, quick action brake. In these tests the electric air brake patented by J. F. Carpenter made the quickest stops and with practically no shock. The vacuum brake was unsatisfactory and the Westinghouse new valve, while it made much quicker stops than was made the year before, produced at first such severe shocks that it was deemed unsafe to use it except in combination with electric relief valves. Subsequent investigation revealed the fact that this result was due partly to the emergency port in the valve.
being too small, but mainly to an improper proportioning of the accessory parts, such as the train pipe, hose cocks, etc.

This invention was patented by Mr. Westinghouse in March, 1887, and as it clearly exemplifies the class to which it belongs, we reproduce a sectional view of it (Fig. 73) as introductory to this article.

As to the part of the mechanism which is for use in ordinary or service stops, the construction is practically identical with the older, plain triple valve (shown in Fig. 72 in our last article). The additional parts, which were used for emergency applications only, included a slide valve 41, a check valve 40, and a passage 46, the valves in the cut being shown in open position the better to illustrate their functions. The train pipe connection, marked on the figure, is at all times in open communication (through a passage parallel with passage 46, but not shown in the cut) with the drain cup chamber in

![Fig. 73—Westinghouse '87 Quick Action (patent 360,070).](image)

which Fig. 39 stands and should therefore be considered the same as if the pipe connection were made directly into the drain cup itself.

In ordinary or graduation applications of the brakes, the piston 12 travels just far enough to touch the stem of the valve 41, but not sufficient to move the valve itself, the spring 39 stopping it at that point. On a sudden and extreme reduction in the train pipe pressure, all parts move to the position shown, and then port 42, being uncovered, air from the train pipe passes by the check valve 40, and through passage 46 directly to the brake cylinder, at the same time that reservoir pressure is flowing into the cylinder through ports 35, 33 and 22. This local venting of the pressure in the pipe under the first car
served to hasten the application of the brake on the next succeeding car, and so on in turn throughout the train. In the first experimental devices of this kind made by Mr. Westinghouse these vents discharged directly to the atmosphere. This resulted in considerable waste of air, in view of which fact they were subsequently connected to the brake cylinder.

Examination of the state of the art prior to the date of this patent reveals a number of devices which show the use of a local vent as a means of quickening the discharge from a long pipe. One of the first is shown in a patent (No. 162,565) issued in 1875 to Ford, Westinghouse and Welsh, from which we have taken Fig. 74.

It was arranged to be put in the main train pipe, at such intervals as were deemed desirable. The passages marked \( a' \) opening to the atmosphere were adapted to be closed by valve \( c \) when air was admitted to the train pipe. When the pressure in the pipe was reduced, the air with which the reservoir \( B \) had been charged, reacted against the diaphragm \( b \), and unseating the valve \( c \), opened the vent from the train pipe, discharging the air locally to the atmosphere. This patent was set up by the New York Air Brake Co, in their defense in the suit recently decided, but was declared by the court to fail as an anticipation, because it was used for hastening the release of a straight air brake, and not for quickening the action of an automatic brake.

Following this invention, a patent was taken out in England in 1879, by a man named Sanders, for a device of a similar nature, but used as an emergency relief valve in an automatic brake. From this (British patent 980 of 1879) we have taken Fig. 75.

Several variations are illustrated and described in the patent, but we shall confine our remarks here to this one. The pipe connection shown, leading into the bottom, is for the train pipe attachment. The emergency valve \( a \) is normally held shut by the air pressure and spring \( d \). A movable diaphragm \( b \), with a small feed port through it at \( c \), is so balanced between air in the train pipe, and in the small reservoir above, that in case of any sudden and extreme reduction in the train pipe pressure the diaphragm will be moved down by the air in the reservoir above, unseating the emergency valve, and creating a local discharge from the train pipe to the atmosphere. During service applications of the brake, the device described remains inoperative (the graduating and release of the brakes being accomplished by any other mechanism which may be provided for that purpose).
because of the heavy pressure and spring $d$ holding the emergency valve to its seat.

About four months after the issue of the Sanders patent, Mr. Geo. Westinghouse took out a patent (No. 217,888) on the automatic relief valve shown in Fig. 76.

This was adapted to be put in the main pipe at intervals throughout the train, a sufficient number being used to serve the desired purpose. The one shown in Fig. 76 is encased in one of the halves of a
hose coupling. C is the exhaust port, F the emergency valve, and D the piston used to open the valve. On the unseating of the valve E, air passes freely to the rear portions of the train, through passages B' and B. When a reduction is made at the head end of the pipe, the air at the rear attempts to flow back and equalize, but, as it is stopped by the seating of the valve E, pressure is exerted downward on the piston D to open the valve F, and thus discharge the train pipe pressure locally to the atmosphere.

In 1881 a modification of this valve was patented by Mr. Geo. and H. H. Westinghouse jointly. This we illustrate in Fig. 77.

In charging the train, air from the engine enters at the end towards the left and moving the diaphragm away from the valve v, passes through to the rear of the train. A slight reduction forward of
Fig. 76—Westinghouse Relief Valve of 1879 (Patent 217,838).

Fig. 77—Westinghouse Relief Valve of 1881 (Patent 245,110).
the device produces no effect on cars back of it, but a sudden and extreme reduction on the head end, produces, by reaction of the air behind the diaphragm, the unseating of the valve $e$, and consequent opening of valve $b$ to the atmosphere. This is called a "cut-off and relief valve" for the reason that, when placed in the main line of the train pipe, it prevents any service application of the brakes back of it, but opens to "relieve" the pressure and hasten the application of all the brakes in cases of emergency.
In 1883, Mr. Geo. A. Boyden secured a patent (No. 280,285), from which we reproduce the section shown in Fig. 78.

This valve was designed for the purpose of providing means whereby pressure in the cylinders could be restored or replenished, without releasing the brakes, if, on descending a long grade, the braking power became reduced from leakage. Some time subsequent to the issue of this patent, Mr. Boyden discovered in this mechanism the possibility of quick action, for in 1889 he had the patent reissued, inserting in the reissue claims so worded as to cover such an invention.

Referring now to the drawing, it will be seen that the piston is made with two heads, the space between them constituting the slide valve chamber. Into this chamber there are two openings, one from the reservoir, and one from the train pipe, the latter being controlled by a check valve \( d \). Above the upper piston is a reservoir or chamber in which is stored the air which moves the valve.

On a reduction of pressure in the train pipe, the slide valve \( H \) moves down, uncovers the port \( C' \) vents the pressure from the slide valve chamber, and thus permits air from both the reservoir and train-pipe to flow into the brake cylinder.
In the last preceding chapter we took up the subject of the "quick action brake," and considered it as far as the beginning of the development arising from the Burlington tests of 1887. Before proceeding to follow that line further, let us stop for a time and turn our attention to something of interest that was being done abroad.

As we have seen, the first Burlington tests demonstrated very clearly the fact that the plain automatic brake was not suitable for very long trains, primarily because in cases of emergency action, the shock occasioned to the cars on the rear end of the train was disastrous. In one of the designs which we illustrated in our last issue, combined with certain improvements, covered by subsequent patents of which we shall treat later, Mr. Westinghouse eliminated this shock by the use of means which quickened the action of the brakes on the rear end of the train.

The tests of the Carpenter electric brake had shown clearly that brakes which set simultaneously operated without shock. Other tests had shown that brakes which did not apply on the rear cars until after the slack had run in produced violent shocks. It was found that the time required for all the slack to run in was for a 50-car train, on an average, somewhere in the neighborhood of 4 or 5 seconds. As soon as the time of the application of the brake was shortened so as to be materially less than the length of time required for the slack to run in, the amount of shock decreased, the improvement becoming more and more noticeable the more nearly the time of application approached to the simultaneous action of the electrical devices.

As a result of the widespread interest in the subject, incited by the Burlington tests, the government of France, by a Ministerial resolution passed Dec. 14th, 1888, appointed a commission to investigate the air brake problem in that country. Various tests were made under the commission, concluding with some made in May, 1890, the results of which are given in an annexed table.
Two points in the action of the Wenger brake which attracted particular attention, because of the excellence of the results shown, are: First, the ease with which the engineer handling it was enabled to make accurate stops for water or coal, the position when the train came to rest varying in some instances but a few inches, and this it is to be remembered, with trains of 10 cars, and second, the quickness and certainty of release after emergency applications, the brakes in some cases being all off before the speed of the train had been reduced below 10 miles an hour, thus saving considerable time by permitting the train to proceed without coming to a stop, something practically impossible with the devices we are using. The utility of this can be better appreciated when viewed in connection with the fact that it is common practice to run trains in several sections, and if one sec-

Fig. 79—Fives Lille Brake—(General Arrangement).
<table>
<thead>
<tr>
<th>YEAR</th>
<th>TYPE OF BRAKE</th>
<th>PROGRAM OF TESTS</th>
<th>OTHER CONSIDERATIONS</th>
<th>REPORTS OF THE TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>Disc</td>
<td>Full</td>
<td>40%</td>
<td>No</td>
</tr>
<tr>
<td>1951</td>
<td>Drum</td>
<td>Basic</td>
<td>30%</td>
<td>Yes</td>
</tr>
<tr>
<td>1952</td>
<td>Hybrid</td>
<td>Enhanced</td>
<td>45%</td>
<td>Yes</td>
</tr>
<tr>
<td>1953</td>
<td>Electric</td>
<td>Optimized</td>
<td>50%</td>
<td>Yes</td>
</tr>
<tr>
<td>1954</td>
<td>Pneumatic</td>
<td>Complete</td>
<td>55%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Evolution of the Air Brake**

**Comparison between Various Types of Brakes and Weighing Systems**

**Safety Analysis of Brakes in New York State**
tion is followed very closely by another, and after making an emergency application, is delayed in releasing the brakes and getting out of the way, the danger of collision is more imminent. The writer recollects an actual experience which came under his notice some years ago, where the engineer of an air brake train of some length sighted a freight coming against it on the same track, and failing after making an emergency stop, to get his brakes released, was unable to back up and let the opposing train (which had no air) have more room to stop, although the time was sufficient to permit him
E V O L U T I O N  O F  T H E  A I R  B R A K E.  95

easily to get all his things out of his seat box before leaving his engin e.

We are not in possession of positive information as to just what form of apparatus was used by the Wenger Co. in the above tests.

The commission after the conclusion of the experiments, reported in favor of the Wenger brake and against the quick action brake of the Westinghouse Co., although the latter made, in cases of emergency application, much quicker stops.

Some years after the completion of the 1887 tests another Frenchman named M. L. E. Duval, hit upon the idea of overcoming the shock (which Mr. Westinghouse eliminated by quickening the operation of the brakes on the rear cars) by automatically retarding the operation of the brakes on the head cars. To accomplish this purpose he designed a valve, which we here show in section in Fig. 80, the cut being taken from a U. S. patent issued in December, 1893. This device was designed to be placed between the main train pipe and the triple valve, as shown in Fig. 79 which we have taken from a patent issued in 1892. Fig. 81 shows it combined, with a plain triple valve in one casing, and as the principle on which it operates is the same in either case we shall for convenience of reference use Fig. 81 to illustrate our more detailed description. The diaphragm and slide valve, shown in the upper half of the casing, is substantially identical with the plain triple valves in common use, and any preferred form could be substituted in place of the one shown. The reservoir is charged through the small tube and check valve passage on the right of the drawing. The diaphragm and slide valve shown in the lower half of the casing, called by the inventor a "regulator," are means by which the opening which connects the train pipe with the air chamber on the lower side of the main diaphragm may be increased or decreased in size.

Briefly stated, these parts perform the function of preventing the sudden or extreme variations in the train pipe pressure (such as must of necessity be made to secure emergency action) from producing violent action of the head triple valves, or in fact any of the triple valves, while still permitting the rapid venting of the train pipe at the point of discharge and thus a quick as well as practically simultaneous application of all the brakes in the train. Operating on such a principle it is of course not possible to make as quick or short an emergency stop as with the quick action brake with which this
Evolution of the Air Brake.

Fig. 81 Combined Triple and Regulator.
country is familiar, but that this design would successfully eliminate shock on long trains would seem a reasonable conclusion.

It may be of interest to investigate, now more in detail, the mechanism used by Mr. Duval, or more properly speaking, invented by Mr. Duval, and assigned to and controlled by the well known Fives Lille Co., of Paris.

Referring particularly to Fig. 81, it is to be noted that the parts as shown are in the normal or release position. Air enters from the train pipe at the point marked "train pipe," and flows through the passage in the center of the stem $D$, and past the slide valve $E$, which covers the opening out of the stem into the cavity below the main diaphragm. If, in charging the train, a heavy pressure is let into the train pipe from the main drum suddenly, the diaphragm $B$ will be moved upward partially closing the opening $D$, and preventing any sudden increase of the pressure below the main diaphragm, thus retarding the release of the brakes on the first cars, until the pressure at the car is about equal to that in the head end when all the valves release together.

In making emergency applications a sudden and extreme reduction is made in the train pipe pressure. This causes the "regulator" diaphragm $B$ to move downward again partially or wholly closing the opening which connects the train pipe with the cavity below the main diaphragm, and thus retarding the application of the head brakes until the pressure in the rear end of the train pipe has had an opportunity to become reduced to about the same extent, when all the brakes will set at the same time.

To one familiar with our method of operating things, this scheme appears at first glance to be objectionable, the disadvantages appearing before the advantages. A little careful thought will, however, soon serve to convince the mind that the advantages this system possesses are by no means so inconsiderable as we had been inclined to think them at first, but are on the contrary of considerable importance. Prominent among the desirable results which it aims to obtain may be mentioned the entire elimination of shock, not only in emergency applications, but also to a large extent in service applications.
QUICK ACTION BRAKES (CONTINUED).

We shall now return to a subject introduced in a previous chapter, *i. e.*, "Quick Action Brakes" Our previous investigation of this extended up to the tests made at Burlington, in 1887, with the form of valve shown in Fig 73, and which we designated the Westinghouse '87 Valve.

WESTINGHOUSE BRAKE.

To secure greater reliability in release, this construction was altered in the latter part of 1887 and a separate piston introduced to operate the quick action valve, the resultant design forming at the present day the standard construction of the Westinghouse Company. We illustrate it in Fig. 82.

---

**Fig. 82—Westinghouse Triple Valve.**
In service applications the operation of this valve is the same as that of Fig. 73. In emergency applications the main piston travels back until it compresses the spring to the left of stem C, when air is admitted by the slide valve from the auxiliary reservoir to the top of the piston D, as shown by the arrows, and the piston D is forced down until the valve E is opened. Air from the train pipe then flows to the brake cylinder past the check valve F.

**Fig. 83—Westinghouse Independent Quick Action Valve**
*(Patent No. 448,827).*

Fig. 83 is taken from a patent issued to Westinghouse in 1891, but which was declared by the New York court to be really included in the 1888 patent. The figure shows an emergency valve alone, it being designed particularly for use in conjunction with apparatus already in service, and operating independently of the triple valve itself.

The Burlington tests and the rapid introduction of the device above described soon resulted in the development of competing forms
of apparatus by rival companies and the exercise of great activity on the part of a large number of inventors.

The designs produced were so numerous that we have not the space to illustrate them all, but will confine ourselves to those which are best known or which serve best to exemplify the class to which they belong.

NEW YORK BRAKE.

The New York Air Brake Company first entered the field with the valve shown in Fig. 84.

![Diagram of New York Triple Valve No. 1]

This employed a similar form of graduating valve and emergency valve proper to that shown in Fig. 82, but the emergency piston \( J \) was arranged to secure its actuating force from the train pipe air, through the operation of a valve \( H \) which in turn was operated by air in the reservoir. Soon after the first introduction of this device it was discovered that its operation in emergency was not active enough to
travel through a long train, but gradually weakened as it receded from the engine. As soon as this became manifest the manufacturer substituted a new device in which only one emergency piston was used, and this in a somewhat modified form (as tested by a committee of the M. C. B. Association at Altoona), we here illustrate in Fig. 85.

**Fig. 85—New York Triple Valve No. 2.**

With this valve, when there is a rapid reduction of pressure in the train pipe, the auxiliary reservoir pressure, acting upon the top of the piston C, as shown by the arrow, forces the valve D from its seat, by means of the stem F, and permits air to enter under the check valve E and pass to the brake cylinder, as shown by the arrows.

Receiving an adverse decision from the court on these two forms of apparatus the New York Co. next introduced the device shown in Fig. 86.

In this construction the emergency piston is actuated by a reduction of the pressure on its upper side through a port in the main slide valve which on an extreme movement of the main piston opened communication from the upper side of the emergency piston to the atmosphere. This valve was decided by the court on injunctional proceedings to be an infringement of Westinghouse claims, so another inven-
FIG. 86—NEW YORK TRIPLE VALVE NO. 3.

FIG. 87—NEW YORK TRIPLE VALVE NO. 4.
Evolution of the Air Brake.

In this valve the emergency piston moves within the main piston, and, because of the restricted size of the opening A, operates to open the emergency valve C whenever the reduction in the train pipe pressure is made with great rapidity, remaining inactive however as long as nothing but gradual or service reductions are made. When the valve C unseats, the air vented from the train pipe strikes another piston which in turn opens a large passage from the reservoir to the cylinder, the train pipe air escaping to the atmosphere through the port D.

Boyden Brake.

Fig. 88 illustrates the first or earlier form of valve made by the Boyden Brake Co., and patented by Mr. Geo. A. Boyden something
over a couple of years ago. In this device, which was one of those tested at Altoona by the M. C. B. Committee before mentioned, the emergency passage is made directly through the center of the main valve chamber. Graduation with this device is accomplished through the hollow stem $A$, the emergency valve $C$ remaining seated except in emergency applications.

When a rapid reduction is made in the train pipe pressure the piston $F$ moves forcibly outward until the collar $D$ comes against the valve $C$ and unseating it admits train pipe pressure directly to the brake cylinder.

A later form of valve designed by Mr. Boyden is shown in Fig. 89. In this construction the main slide valve itself performs both graduation and emergency functions, the extreme traverse of the main piston in cases of emergency uncovering the large port leading to the brake cylinder and allowing the train pipe pressure to flow past the check valve $C$ around the port above the main piston chamber and down through the main valve chamber into the brake cylinder. The operation of the parts in service applications is the same as those previously described.

**CRANE BRAKE.**

Another valve which was tested at Altoona in November, 1893, was the one made by the Crane Company. It is shown in Fig. 90.

With this valve any sudden and extreme reduction in train pipe pressure moves the piston $E$ downward, unseating the small valve $D$, and, by venting the pressure below the piston to the brake cylinder, allows the train pipe air to flow in above the piston and by a continuation of the downward movement of the same, unseating the valve $F$, permits the train pipe pressure to discharge into the cylinder. $G$ is a check valve of usual construction provided for the purpose of preventing any return of cylinder pressure to the train pipe.

**LANSBERG BRAKE.**

A number of different forms of valve have been made by the Lansberg Co., of St. Louis, one of the first being shown in Fig. 91.

In this construction the emergency valve was in the shape of a slide valve, moving on the surface of the main piston chamber as a seat and controlling an opening (29) leading to the brake cylinder. This (Fig. 91), as nearly as we can determine, is about the form of valve
which was found to be so unsatisfactory in service that some of the roads refused to accept cars equipped with it. The makers soon began to make improvements in their equipment, however, and now offer the form of construction which we illustrate in Fig. 92, this being substantially the same as the device submitted by them at Altoona, but embodying a number of later improvements.

As will be seen by reference to the cut, cup leather valves are used both for exhaust, graduation and emergency, the arrangement being such that the air pressures upon them are balanced, thus reducing the force necessary to move them to a minimum. A careful study of the drawing will suffice to make the operation clear; provided it be understood that the emergency passage from the valve leads directly to the

---

**Fig. 91—Lansberg Triple Valve No. 1.**
Another brake which has attracted considerable attention in the air brake world is that invented by Mr. T. H. Haberkorn, of Fort Wayne, Ind. From this patent, issued in November, 1893, we take the cut Fig. 93.

In this device the graduation is controlled by a piston $C$ having a stem of graduated size $C\#4$ which, on being drawn out of the seat $a\#4$, allowed reservoir pressure to flow to the cylinder, connected at $N$. $P$ is the emergency valve and $o\#r$ the piston which, on a sudden re-
duction in train pipe pressure, caused the valve $P$ to open and discharge the train pipe pressure to the atmosphere through the port $b-4$.

**DIXON BRAKE.**

A number of patents have been issued to Mr. T. S. E. Dixon, of Chicago, for triple valves which vent train pipe pressure to the atmosphere. One of these we illustrate in Fig. 94.

A careful study of the drawing will serve to make the operation of this device clear.

**PARK BRAKE.**

In Fig. 95 we illustrate the triple valve, the patent for which, issued to H. S. Park, formed one of those used by the Westinghouse Co. against the New York Company in the litigation noted. This was one of the devices which used train pipe pressure to actuate the emer-
EVOLUTION OF THE AIR BRAKE.

Fig. 94—Dixon Triple Valve.
110  EVOLUTION OF THE AIR BRAKE.

Fig. 95—PARK TRIPLE VALVE.
Evolution of the Air Brake.

In the latter part of 1893 a number of patents were issued to H. L. Howe for a form of triple valve in which the main slide valve performed the emergency functions. We have selected the one illus-
trated (Fig. 96) merely as an illustration of the general idea. The principle of its operation will be easily understood without explanation.

Within the last couple of years the number of patents on quick action brakes, issued during each month, seems to be steadily increasing. A complete collection would more than fill a volume. Many disclose original, not to say startling ideas, but as we have already illustrated and described a sufficient number of them to give the reader a fairly good general idea of the state of the art, we shall leave the subject here.

What the brake of the future will be, no man knows, for none can know. Many indications point to a complete revolution in the not very distant future of the whole transportation system, and this, of course, would necessitate a corresponding revolution in the means employed as a braking force.
Both the First and Second Editions exhausted inside casing.

What

DISEASES OF THE
Air-Brake System
CAUSES—SYMPTOMS—CURE

BY
PAUL SYNNESTVEDT

COVERS A FIELD ENTIRELY DISTINCT FROM THAT COVERED BY ANY OTHER PUBLICATION.

SEE WHAT THE CRITICS SAY.

From Mr. S. D. Hutchins, President Association of Railroad Air Brake Men.

"'Presents the disease and remedy in such a plain, practical manner that there is no excuse for not understanding it.'"

From Mr. C. B. Conger, President Traveling Engineers' Association.

"'No one who is learning how to operate, or maintain the air brake in good order, can afford to be without a copy. The information is given in plain language so it can be clearly understood even by beginners.'"

From a letter written by Mr. G. W. Rhodes, Superintendent of motive Power C., B. & O. Ry.; Chairman of the Committee on Air Brakes of the M. C. B. Association.

Mr. Paul Synnestvedt:

"'I think the information you have given will be invaluable to those who must necessarily give the points you mention attention in the future if the railroad companies in this country expect to have safe and effective brakes.

'Your instructions to use reason first and hands afterward is the keynote of the situation.'"

Price, ONE DOLLAR

PUBLISHED BY
THE W. F. HALL PRINTING COMPANY
21 to 25 Plymouth Place, CHICAGO