

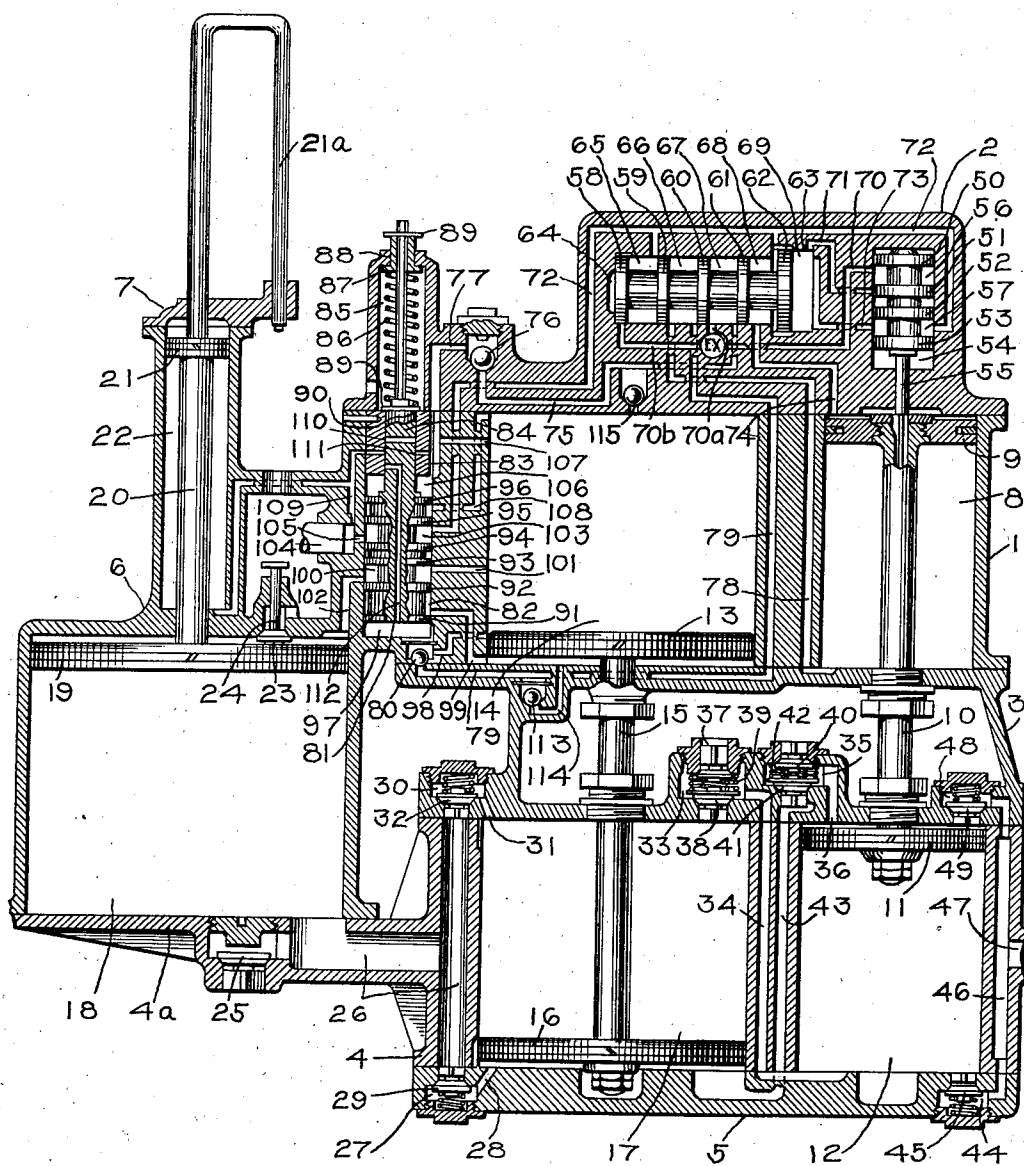
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B. S. AIKMAN

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COMPRESSOR MECHANISM

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INVENTOR
Burton S. Aikman
BY *A L Vernell*
ATTORNEY

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COMPRESSOR MECHANISM

Burton S. Aikman, Wilkinsburg, Pa., assignor to
The Westinghouse Air Brake Company, Wil-
merding, Pa., a corporation of Pennsylvania

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This invention relates to steam driven fluid compressors and more particularly to the type employed on locomotives in steam railway service.

The object of my invention is to provide a steam driven compressor having novel means for effecting an economy in steam consumption by utilizing the exhaust steam to effect a supply of supercharging air to the compressor and thus obtain the delivery of air at higher pressures with the same supply of steam.

Other objects and advantages will be apparent from the following more detailed description of the invention.

In the accompanying drawing the single figure is a diagrammatic vertical sectional view of a cross compound steam driven air compressor having the invention embodied therein.

Referring to this drawing, the compressor comprises a steam actuated driving portion, designated by the numeral 1, which is covered by a valve portion 2, and to the bottom of which is secured by suitable means, not shown, an intermediate connecting portion 3. Mounted on the bottom of the portion 3, is an air compressing portion 4 which is closed at the bottom by a cover portion 5. Disposed at the left-hand side of the several aforementioned portions is a supercharger portion 6 which may be formed integral with the steam portion 1 and which is closed at the top by a cover portion 7.

Contained in the cylinder 8 of the steam portion 1 is a high pressure steam piston 9 which is connected by a rod 10 to a high pressure air piston 11 carried in the cylinder 12 of the air compressing portion 4. Similarly, a low pressure steam piston 13 is contained in the cylinder 14 of the steam portion 1 and is connected by a rod 15 to the low pressure air piston 16 disposed in the cylinder 17 of the portion 4.

The supercharger portion 6 is provided with a cylinder 18 in which there is operatively disposed a supercharger piston 19 connected by a rod 20 to a steam actuated return piston 21 which is contained in a cylinder 22 located in the upper region of the portion 6. Rigidly secured to the upper side of the piston 21 is an inverted U-shaped valve actuating member 21a which is arranged to unseat an exhaust valve 23.

This valve, preferably of the tapered type, may engage a corresponding valve seat formed in the interior surface of the upper end of the cylinder 18 and is provided with a stem 24 which is slidably guided in a bore in the portion 5. This stem is so located that it will be engaged by the actuating member 21a when the connected piston 19 nears the end of its downward stroke as will appear more fully later.

The lower end of the cylinder 18 is closed by a pressure head 4a which is carried by the compressing portion 4. In this head there is operably

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mounted a fluid inlet valve 25 which is arranged to permit inlet fluid to flow through a passage 25 to the cylinder 18 and to the cylinder 17.

The low pressure air cylinder 17 is closed at its lower end by a portion of the upper surface of the cover portion 5. Formed in this portion is an inlet valve chamber 27 connecting with the chamber at the under side of piston 16 in cylinder 17 by way of a passage 28. In the chamber 27 there is operably mounted a valve 29 which may open and close communication between the chamber 27 and the inlet passage 28 and which is spring biased toward closing position.

The upper end of the low pressure air cylinder 17 is closed by the connecting portion 3 in which is formed a similar inlet valve chamber 30 open at all times to the chamber at the upper side of piston 16 in the cylinder 17 by way of passage 31 and open to inlet passage 28 when a similar spring biased valve 32 mounted in chamber 30 is unseated in response to inlet air pressure.

In the central part of the portion 3 there is formed a valve chamber 33, which is open to the chamber at the lower side of high pressure air piston 11 by way of a passage 34. In this part there is also formed a valve chamber 35 which is open to the chamber at the upper side of piston 11 by way of a passage 36. Mounted in the chamber 33 are check valves 37 and 38 which have a spring 39 interposed between and operatively engaging them so as to urge valve 37 upwardly to seat against atmosphere and valve 38 downwardly to seat against the pressure of air above the low pressure air piston 16. Mounted in the chamber 35 are check valves 40 and 41 which have a spring 42 interposed between and operatively engaging them so as to urge valve 40 upwardly to seat against atmosphere and valve 41 downwardly to seat against the pressure of air under piston 16 transmitted therefrom by way of a passage 43.

The high pressure air cylinder 12 is closed at the bottom by another part of cover portion 5. In this part of the portion 5 there is formed a discharge valve chamber 44 in which is operably mounted a spring biased valve 45 which, in response to the force of high pressure air, opens communication from the lower end of cylinder 12 to chamber 44. From this chamber air may flow through a passage 46 to an air discharge port 47.

The cylinder 12 is closed at the top by a part of connecting portion 3 in which is formed a similar discharge valve chamber 48 containing a similar spring biased valve 49 which controls communication between the upper end of cylinder 12 and passage 46 in the same way as does valve 45 at the lower end.

Mounted in the valve portion 2 is a main valve mechanism, for governing the flow of steam to

and from the steam cylinders and the supercharging cylinder, and also mounted in this valve portion is a reversing valve mechanism which controls the movement of the main valve mechanism by controlling the supply of steam thereto.

The supply of steam to these valve mechanisms is in turn controlled by an intercepting valve mechanism which is mounted in the steam portion 1, intermediate the low pressure steam cylinder 14 and the cylinder 22.

The reversing valve mechanism comprises a series of connecting piston heads 50, 51, 52 and 53 which may be reciprocated in a vertical bore 54 by the piston 9 through the medium of a reversing rod 55 in the usual manner.

Thus, there is a chamber 56 defined by the wall of the bore 54 and piston heads 50 and 51, and a chamber 57 defined by the wall of bore 54 and piston heads 52 and 53.

The main valve mechanism comprises a series of connected piston heads 58, 59, 60 and 61 having the same diameter, and a differential piston head 62 having a larger diameter than the other heads, all of which are reciprocable horizontally in a bore 63 as determined by the position of the reversible valve mechanism.

At the left-hand end of the bore 63 there is defined by the walls of the bore and the piston head 58 a chamber 64. A chamber 65 is defined by the wall of bore 63 and piston heads 58 and 59. A chamber 66 is defined by the wall of bore 63 and piston heads 59 and 60. A chamber 67 is located between piston heads 60 and 61 and a chamber 68 is located between chambers 61 and 62 and at the right-hand face of piston 62 there is a chamber 69.

With the reversing valve mechanism in its uppermost position as shown and with the main valve mechanism in its extreme position to the left as shown, chamber 56 is connected to passage 70 which at all times is open to atmosphere. With the reversing valve mechanism in its lowermost position, the piston head 50 closes communication between the chamber 56 and the atmospheric passage 70. Further with the valve mechanism in this latter position, the piston head 51 uncovers passage 71 thereby connecting the chambers 56 and 69.

Chamber 57 is always connected to a steam supply passage 72 leading from the intercepting valve mechanism, and as shown may conduct steam to chamber 69 by way of passage 73. In the lower position of the reversing valve mechanism passages 72 and 73 are closed off by piston head 52.

Chamber 63 in the main valve mechanism is always open to steam supply passage 72 and may, as shown, conduct steam to the chamber at the upper side of piston 9 by way of passage 74, which latter passage will be closed off by piston head 61 when the piston assembly is moved from its left-hand position.

Chamber 67 is always connected to a passage 75 which leads to the under side of a ball check valve 76 the upper side of which valve is connected to the intercepting valve mechanism through a passage 77. With the piston 60 positioned as shown, chamber 67 is connected to atmosphere by way of passage 78a, but in its other position connects passage 75 to passage 74 leading to the chamber at the upper side of piston 9.

With the main valve mechanism positioned as shown, chamber 66 connects a passage 79 leading from the chamber at the under side of piston 9 to a passage 79 leading to the under side of a

ball check valve 80, the upper side of which valve is open to the intercepting valve mechanism. With the main valve mechanism in its other position, chamber 66 connects passage 79 to atmospheric passage 78a.

Chamber 65 is always open to steam supply passage 72 and in its right-hand position conducts steam to the chamber at the under side of piston 9 by way of passage 78.

Chamber 64 is closed by piston 58 when the main valve mechanism is in the position in which it is shown, but in its other position is open to atmosphere by way of passage 78b.

The intercepting valve mechanism comprises a multiple head piston member 81 slidably mounted in a bore 82 in the steam portion 1, into which bore is pressed a bushing 83 for sliding and port controlling engagement with the stem 84 of the piston member. Directly over the bore 82 there is formed in the valve portion 2 a chamber 85 in which is mounted a spring 86 for determining the movement of the piston member 81 in either direction from the position in which it is shown.

Held in abutting engagement with the upper inner surface of the chamber 85 by the spring 86 is an annular vertically movable spring seat member 87 which extends through an opening 88 in the top wall of the chamber 85 and through which the upper end of the stem 84 extends. Above the member 87 there is secured to the stem 84 a cross-member 89 which engages the upper surface of the member 87 so as to transmit the downward movement of the stem to the spring 86.

Held in abutting engagement with the lower inner surface of the chamber 85 is an annular spring seat member 89, the lower surface of which may be engaged by a shoulder 90 formed on the upper end of stem 84 so that the member 89 may be moved upwardly against the pressure of the spring 86.

The piston member 81 comprises integrally connected piston heads 91, 92, 93, 94, 95 and 96. Defined by the lower end surface and wall of the bore 82 and the piston head 91 is a chamber 97 which is open to the upper side of the ball check valve 80 and by way of passage 98 to the chamber at the upper side of piston 13 when it is at the bottom of the low pressure cylinder 14. This chamber will also communicate by way of passage 99 with the under side of piston 13 instead when piston head 91 crosses the mouth of passage 99 in the upward movement of piston member 81 from the position in which it is shown.

Defined by the wall of bore 82 and piston heads 92 and 93 is a chamber 100 which with the piston assembly in the position illustrated, is in communication with low pressure steam cylinder 14 by way of passage 101 and with the chamber at the upper side of piston 19 in the supercharging cylinder 18 by way of passage 102.

Defined by the wall of the bore 82 and the piston heads 94 and 95 is a chamber 103 which with the piston assembly positioned as shown is connected to steam supply pipe 104 through passage 105 and to the main valve mechanism and reversing valve mechanism by way of passage 72.

Defined by the lower surface of the bushing 83, wall of the bore 82 and the piston head 96 is a chamber 106 which is open to the upper side of the ball check valve 76 by way of passage 77 and may connect, by way of passage 107, with the chamber at the under side of piston 13 when it is at the top of its stroke. This chamber may also communicate with the chamber

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at the upper side of piston 13 when piston head 96 crosses the mouth of passage 108 in its downward movement from the position in which it is shown.

Leading from the steam supply pipe 104 is a restricted passage 109 which conducts steam through the wall of the bushing 83 to the surface of that portion of the stem 84 which is in closely fitting sliding engagement with the bushing 83. This passage also conducts steam to the chamber at the under side of piston 21 for the purpose of returning the supercharging piston 19 to the position shown after it has completed its downward stroke.

The piston stem 84 is provided with a transverse port 110 which, when the piston member is in its extreme lower position, connects passage 109 with port 111, in the bushing 83, and passage 77. With the piston member 81 in its extreme upper position port 112 in piston stem 84 registers with passage 109 and extends longitudinally through the stem to conduct steam to chamber 97 at the lower end of the piston member.

A ball check valve 113 is operatively mounted in the center portion 3 with its under side open by way of passage 114 to the chamber at the under side of piston 13 and its upper side open to passage 79 so that any steam or air trapped in cylinder 14 during the downward movement of the piston may flow to atmosphere through passage 79 and chamber 67 which at this time will be open to atmosphere by way of passage 70a.

In a similar manner ball check valve 115 is operatively mounted in portion 2 to permit trapped air or steam on the upper side of piston 13 to pass to atmosphere by way of passage 75, chamber 67 and passage 70a.

Operation

With the several parts of the compressor in the position illustrated, the high pressure steam piston 9 has just completed its upward stroke. Near the end of this stroke, the reversing rod 55 was moved upwardly by the piston 9 in the usual manner, thereby moving the reversing valve mechanism into the position illustrated. The connection of main valve chamber 69 to atmosphere by way of passage 71, chamber 56 and passage 70 was closed off by piston head 51. Steam passed from pipe 104 through port 105 and chamber 103 in the intercepting valve mechanism to passage 72 from whence it passed directly to chamber 69 and, by way of reversing valve chamber 57 and passage 73, to chamber 69. The combined pressure of steam on the right-hand sides of main valve pistons 58 and 62 caused them to move toward the left-hand end of bore 63 into the position illustrated.

In this position of the main valve mechanism, steam flows from the chamber at the under side of piston 9 in the cylinder 8 through passage 73 to main valve chamber 66. From this chamber the steam flows through passage 79 and past ball check valve 80 into chamber 97 on the under side of piston head 91, causing intercepting valve piston member 81 to move against the pressure of spring 86 into its upper position.

With piston member 81 in its upper position, chamber 97 is connected to the chamber at the under side of low pressure steam piston 13 by way of passage 99. Steam will pass from cylinder 8 into cylinder 14 by way of passage 78, main valve chamber 66, passage 79, intercepting valve cham-

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ber 97 and passage 99 to actuate low pressure steam piston 13 upwardly.

Also, in this position of member 81, port 112 registers with passage 109 so that steam may also flow from supply pipe 104 at a restricted rate to chamber 97 and to the chamber at the under side of piston 13 to insure that the piston will complete its upward stroke.

At the same time, the steam supply passage 72 is closed off by piston head 94 and the passage 102 is closed off by piston head 92, so that neither the high pressure steam piston 9 nor the supercharging piston 19 will operate.

Previous to this action, low pressure air cylinder 17 had been supercharged with air under pressure on the upper side of piston 16 by the supercharging piston 19 in a manner to be more fully described later.

As piston 16 moves upwardly with piston 13, air under pressure is delivered past check valve 38 into chamber 33 and thence by way of passage 34 to the chamber at the under side of the piston 11 mounted in the high pressure air cylinder 12. Also air is drawn into the chamber at the under side of piston 16 from atmosphere by way of check valve 25, passage 26, past valve 29, through chamber 27 and passage 28.

When the steam piston 13 reaches the end of its upward stroke, steam in the chamber under the piston will pass into chamber 106 by way of passages 107 and 77 and thus substantially equalize the steam pressures in the chambers above piston head 96 and below piston head 91. With the steam pressures thus equalized, spring 86 will return intercepting piston member 81 to the position in which it is shown.

With the intercepting valve mechanism in the position shown and piston 13 at the top of cylinder 14, steam in the chamber under piston 13 will flow through passage 101, chamber 100 and passage 102 into the chamber at the upper side of the supercharging piston 19. In response to this pressure, piston 19 will move downwardly forcing the air in the chamber at the underside of the piston through passage 26, past valve 29, through chamber 27 and passage 23 into the chamber beneath the piston 16.

When the piston 19 nears the end of its downward stroke, the actuating member 21a moving with the piston, will engage the stem 24 to unseat the valve 23 and vent the steam from the chamber at the upper side of piston 19 to atmosphere. With the steam pressure on piston 19 substantially reduced, piston 21, under the pressure of steam from passage 109, will move upwardly carrying with it the piston rod 19 and thereby piston 19. As piston 19 nears the position in which it is shown it will engage the lower surface of valve 23 and move it to its closed position.

The piston 19 as it was moving upwardly sucked air past check valve 25 and through passage 26 into the chamber beneath the piston in readiness for the next supercharging stroke.

With the valve mechanisms in the positions shown, steam also flows from steam supply pipe 104, through passage 105, chamber 103 and passage 72 to chamber 68 in the main valve mechanism. From this chamber, steam will flow through passage 74 into the chamber above the piston 9 in the high pressure steam cylinder 8 to cause the steam piston 9 and thereby the high pressure air piston 11 to move downwardly.

When piston 11 was being moved upward by piston 9, air was drawn from atmosphere past check valve 37, through chamber 33 and passage

34 into cylinder 12. When piston 16 was being moved upward the supercharged air in the chamber at the upper side of the piston was compressed past check valve 33, through chamber 33 and passage 34 into cylinder 12. As piston 11 moves downwardly, the air so compressed is now transmitted under high pressure past valve 45, through chamber 44 and passage 46 into air discharge port 47 and a suitable reservoir, not shown. At the same time, air is drawn from the atmosphere past check valve 40 through chamber 35 and passage 36 into the chamber at the upper side of piston 11.

It should be noted that the supercharging piston and the high pressures steam piston move substantially concurrently since the control of the ports which supply steam to these pistons is so incorporated in the intercepting valve mechanism that the ports are open only in the position illustrated.

As the piston 9 approaches the end of its downward stroke, the reversing rod 51 is moved downward by piston 9 in the usual manner, thereby moving the reversing valve mechanism into its lower position. Chamber 57 which formerly conducted steam to the main valve chamber 69 by way of passage 73 is now closed off therefrom by piston head 52. Chamber 56 which is constantly open to atmosphere by way of passage 70 is now also open to main valve chamber 69, thereby venting the steam pressure from this chamber 69 to atmosphere.

With chamber 63 vented to atmosphere and chamber 68 open to a steam supply from passage 72, steam pressure in this chamber 65 will cause the main valve mechanism to move to its right-hand position.

Chamber 67 will be connected by way of passage 74 to the steam chamber at the upper side of the piston 9. It will also be connected by way of passages 75 and 77 to chamber 106 in the intercepting valve mechanism. Steam will flow from this steam chamber through passage 74, chamber 67, and passage 75, past ball check 76, through passage 77 and into chamber 106 above piston head 96 and move the piston member 81 to its lower position.

Chamber 66 now connects to the upper side of valve 113 and to passage 70a so that fluid in the chamber at the under side of the piston 13 may pass to atmosphere by way of passages 114 and 70, chamber 66 and passage 70a.

Chamber 65, although connected to steam passage 71 and also to the chamber at the under side of piston 9, cannot transmit steam at this time because the steam supply to passage 71 is interrupted as will appear later. Chamber 64 is open to atmosphere by way of passage 76b to eliminate differential pressure opposing movement to the left for the next stroke.

With piston member 81 in its lower position, steam in chamber 106 will flow by way of passage 108 to the chamber at the upper side of piston 13. Thus steam from the chamber above the high pressure steam piston 9 will be expanded into the chamber above low pressure steam piston 13 when the intercepting valve mechanism is in its lower position.

Steam passage 109 will be connected by passage 110 to passages 111 and 77 to augment the steam supply from the chamber above the piston 9 and insure the completion of the down-stroke of the piston 13.

Delivery of steam from pipe 105 to passage 72 and to the chamber at the under side of the

high pressure steam piston 9 will be intercepted by piston head 95.

The flow of steam from the chamber at the under side of the low pressure steam piston 13 to the chamber above the piston 19 will be interrupted by piston head 93 closing passage 102. Passage 99 will be blocked between piston heads 91 and 92, so steam and air in the chamber underneath piston 13 will be permitted to exhaust to atmosphere through passage 114, past ball check valve 113, and through passage 79 and chamber 66 to passage 70a and atmosphere.

When the piston 13 reaches the end of its down-stroke, the chamber at the upper side of the piston is connected to chamber 57 by way of passage 98. With the pressures above piston head 96 and below piston head 91 equalized, piston member 81 will be returned by spring 86 to the position in which it is shown. Steam will flow from the chamber at the upper side of piston 13 to chamber at the upper side of piston 19 to produce the supercharging action previously described when pistons 13 and 19 were at the end of their upstroke. This time however air will flow past check valve 32, through chamber 30 and passage 31 to the chamber at the upper side of piston 16.

The main valve piston being now in its right-hand position, steam may flow through chamber 106 in the intercepting valve mechanism, passage 72, chamber 65, and passage 74 to the chamber at the under side of piston 9 and cause piston 9 to move upward.

As piston 16 moves downward it will force compressed air in cylinder 17 through passage 43, past valve 41 into chamber 35, and through passage 36 to the chamber at the upper side of piston 11. As piston 11 subsequently moves upward it will deliver this air past check valve 45, through chamber 44 and passage 46 into the discharge pipe 47 and an air reservoir, not shown.

Summary

The intercepting valve mechanism in normal position as shown, passes live steam to the high pressure steam piston 9 for its next stroke and also passes exhaust steam from the low pressure cylinder 14 to the supercharging cylinder 18. In its upper position it intercepts this flow of steam to the piston 9 and from the low pressure cylinder 18 and passes steam from the under side of high pressure steam piston 9 to the under side of the low pressure steam piston 13. In its lower position it intercepts the flow of steam to the piston 9 and from the low pressure cylinder 18 and passes steam from the upper side of piston 9 to the upper side of piston 13.

The reversing valve piston member moves upwardly when piston 9 completes its up-stroke causing the main valve piston member to move to the left. The intercepting valve piston member 81 is then moved upwardly by steam from the under side of piston 9, which steam is then delivered to the under side of piston 13 to move it upwardly. At the top of the stroke of piston 13 the intercepting valve mechanism returns to its normal position.

When the low pressure air piston 16 moves upwardly with piston 13, the air under pressure in the chamber above piston 16 is transferred to the underside of the high pressure air piston 11 which is at the top of cylinder 12 and air is drawn from atmosphere to the under side of piston 16.

While piston 16 remains at the top of cylinder

der 17, the supercharging piston 19 charges the chamber at the under side of piston 16 with air under pressure. At the same time the high pressure air piston 11 moves downwardly transferring the air under pressure in the chamber at the under side of piston 11 to a suitable reservoir. As this piston moves down air is drawn from atmosphere to the chamber at the upper side of it.

The reversing valve piston member moves downwardly when piston 9 completes its down-stroke causing the main valve mechanism to move to the right. Piston member 81 is then moved downwardly by steam from the chamber at the upper side of piston 9, which steam is then delivered to the chamber at the upper side of piston 13 to move it down. At the bottom of the stroke by piston 13, piston member 81 returns to its normal position.

In normal position of piston member 81 the supercharging piston 19 is again actuated and at the same time high pressure steam piston 9 is again actuated upwardly.

When the low pressure air piston 16 moves down with piston 13, the supercharged air in the chamber at the under side of piston 16 is transferred to the chamber at the upper side of piston 11 which is now at the bottom of cylinder 12. Air is drawn from atmosphere to the chamber at the upper side of piston 16.

While piston 16 remains at the bottom of cylinder 17, the supercharging piston 19 charges the chamber at the upper side of piston 16 with air under pressure. At the same time the high pressure piston 11 moves upwardly, transferring the air under pressure from the chamber above piston 11 to a suitable reservoir. As this piston moves upwardly air is drawn from atmosphere to the chamber at the under side of it.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A steam driven air compressor, in combination, a first steam operated piston and cylinder means for compressing air into a reservoir, a second steam operated piston and cylinder means for compressing air into said first means, a third steam operated piston and cylinder means for compressing air into said second means, and valve means conditionable upon the position of the piston of said first means to control the sequence of operation of the three said means, said valve means being effective in one position to admit steam to said first means and to said third means and being effective in another position to interrupt the steam supply to said first means and to said third means and to supply steam to said second means.

2. A compound steam driven air compressor, in combination, a high pressure air compression cylinder and piston, a high pressure steam engine cylinder and piston for operating said air compression piston, a low pressure air compression cylinder and piston, a low pressure steam engine cylinder and piston for operating said low pressure air compression piston, a main valve mechanism operative for supplying steam to said high pressure steam cylinder and exhausting steam therefrom to said low pressure steam cylinder, a reversing valve mechanism actuated by the high pressure steam piston for controlling the operation of said main valve mechanism, an intercepting valve mechanism operative in response to the pressure of exhaust steam from said high pressure steam engine for so controlling

the supply of steam to said high pressure steam cylinder and to said low pressure steam cylinder that one engine is rendered inoperative while the other operates, valve means for admitting air from the atmosphere to said low pressure air cylinder before the beginning of the stroke of the low pressure air piston, and valve means for admitting air from the atmosphere to said high pressure air cylinder before the beginning of the stroke of the high pressure air piston.

3. A compound steam driven air compressor, in combination, a high pressure engine cylinder and piston, a low pressure engine cylinder and piston, a high pressure air compressing cylinder operatively related to said first engine, a low pressure air compressing cylinder operatively related to said second engine, a main valve mechanism governing the supply of steam to said high pressure engine and the transfer of exhaust steam therefrom to said low pressure engine, a reversing valve mechanism actuated by said high pressure engine piston for controlling said main valve mechanism, intercepting valve means controlled by said main valve mechanism for so controlling the supply of steam to said high pressure engine and said low pressure engine that one engine is maintained inoperative while the other engine operates, means responsive to the pressure of exhaust steam from said low pressure engine to supercharge said low pressure air cylinder, and means controlled by said low pressure engine for transferring exhaust steam therefrom to said supercharging means when said low pressure engine is inoperative.

4. A compound steam driven air compressor, in combination, a high pressure air compression cylinder and piston, a high pressure steam engine cylinder and piston for actuating said air piston, a low pressure air compression cylinder and piston, a low pressure steam engine cylinder and piston for actuating said low pressure air piston, steam operated means for supercharging said low pressure air cylinder, valve means conditionable upon the position of the high pressure steam piston to control the sequence of operation of said steam engines and said supercharging means, said valve means being operative in one position to admit live steam to said high pressure steam cylinder and to transfer exhaust steam from said low pressure steam cylinder to said supercharging means and operative in another position to interrupt the flow of steam to said high pressure steam cylinder and to said supercharging means and to transfer exhaust steam from said high pressure steam cylinder to said low pressure steam cylinder.

5. A compound steam driven air compressor, in combination, a high pressure air compression cylinder and piston, a high pressure steam engine for actuating said air piston, a low pressure air compression cylinder and piston, a low pressure steam engine for actuating said low pressure air piston, means responsive to exhaust steam from said low pressure engine for supercharging said low pressure air cylinder, a valve mechanism controlled by the piston of said high pressure steam engine for controlling the supply of live steam thereto and the exhaust of steam therefrom to said low pressure steam engine, intercepting valve means rendered effective when said low pressure steam engine completes its stroke to suspend the operation thereof while said high pressure steam engine and said supercharging means operate and rendered effective when said high pressure steam engine completes its stroke to suspend

the operation thereof and of said supercharging means while said low pressure steam engine operates.

6. A compound steam driven air compressor, in combination, a first steam operated piston and cylinder means for compressing air into a reservoir, a second steam operated piston and cylinder means for compressing air into said second means, a third steam operated piston and cylinder means for compressing air into said second means, valve means controlled in accordance with the operation of the piston of the first said means to control the operation of all of said steam operated piston and cylinder means, said valve means being operative in one position to deliver steam to said first means and to transfer steam from said second means to said third means and operative in another position to interrupt the delivery of steam to said first means and the transfer of steam from said second means to said third means and to transfer steam from said first means to said second means, and means rendered effective by the piston of said second means, to return said valve means to its first mentioned position.

7. A compound steam driven air compressor comprising a high pressure air compression cylinder and piston, a high pressure steam cylinder and piston for actuating said high pressure air piston, a low pressure air compression cylinder and piston, a low pressure steam cylinder and piston for actuating said low pressure air piston, a main valve mechanism operative in accordance with the operation of the high pressure steam piston for controlling the supply of live steam to the high pressure steam cylinder and the exhaust of steam therefrom to the low pressure steam cylinder, a cylinder and piston means responsive to the pressure of exhaust steam from the low pressure steam cylinder to supercharge the low pressure air cylinder, an intercepting valve mechanism having a position to which it is moved in response to the pressure of exhaust steam from the high pressure steam cylinder when the high pressure steam piston is at substantially the end of its stroke in which position said mechanism effects the suspension of the operation of the high pressure steam piston and of said supercharging piston and permits the low pressure steam piston to make its stroke, and means operative when the low pressure steam piston has completed its stroke to move said intercepting valve mechanism to another position in which the mechanism suspends the operation of the low pressure steam piston while permitting the high pressure steam piston and said supercharging pistons to complete their strokes.

8. A multiple stage air compressor comprising a first cylinder and piston means for compressing air into a reservoir while charging its non-pressure side with air from the atmosphere, a second cylinder and piston means for compressing air into the first means while charging its non-pressure side with air from the atmosphere, a first engine responsive to the pressure of live steam to actuate said first means, a second engine responsive to the pressure of exhaust steam from said first engine to actuate said second means, a third cylinder and piston means chargeable with air from the atmosphere upon movement of the piston thereof in one direc-

tion and operative in the opposite direction in response to the pressure of exhaust steam from said second engine to compress air with which it has been charged into said second means, a third engine responsive to the pressure of live steam to cause the piston of said third means to make its charging stroke, a main valve mechanism for controlling the admission of steam to and the exhaust of steam from said first and said second engine, a reversing valve mechanism actuated by said first engine for controlling the operation of said main valve mechanism, an intercepting valve mechanism effective in one position to admit live steam to said main valve mechanism, thereby causing said first engine to operate, and to admit exhaust steam from said second engine to said third means to cause the third means to compress air, said intercepting valve mechanism being responsive to the pressure of exhaust steam from said first engine to move to another position and being effective in said other position to admit the exhaust steam from said first engine to said second engine to render the latter operative, and being further effective to interrupt the flow of live steam to said first engine and the flow of exhaust steam to said third means to thereby render them inoperative, and means for returning said intercepting valve mechanism to the first position when said second engine has substantially completed a stroke.

9. A compound steam driven air compressor, in combination, a first steam operated piston and cylinder means for compressing air into a reservoir, a second steam operated piston and cylinder means for compressing air into said first means, a third steam operated piston and cylinder means for compressing air into said second means, a reversing valve mechanism positioned by the piston of said first means to supply steam to one side or the other of the piston of said first means and to transfer steam from said first means to one side or the other of the piston of said second means, intercepting valve means controlled in accordance with the operation of the piston of said first means to move to one or the other of two positions to interrupt the supply of steam to said first means and the transfer of exhaust steam from said second means to said third means and to transfer the exhaust steam from said first means to said second means, said intercepting valve means being movable to a third position in accordance with the operation of the piston of said second means, to interrupt the transfer of exhaust steam from said first means to said second means and to supply steam to said first means and to transfer exhaust steam from said second means to said third means.

BURTON S. AIKMAN.

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