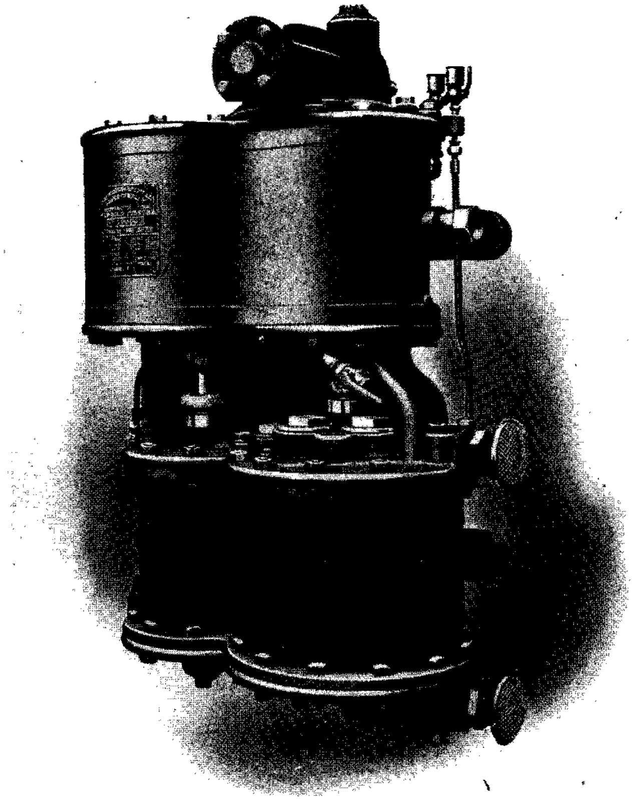

Fig. 1. $8\frac{1}{2}$-INCH CROSS COMPOUND COMPRESSOR. AIR INLET SIDE.

WESTINGHOUSE AIR BRAKE CO.
Instruction Pamphlet No. 5026.
February, 1911.

(SUPERSEDING ISSUE OF JUNE, 1910.)

Westinghouse Cross Compound Air Compressors.

$8\frac{1}{2}$-inch Cross Compound Air Compressor.

NOTE.—The reference numbers shown herein are for convenience only and are not to be used when ordering repair parts. See Part Catalog giving piece numbers, prices, etc.

It is generally recognized that the duty imposed upon the locomotive air compressor has very largely increased from year to year, but the extent of this increase is more fully appreciated when the following factors are considered:—

(*a*) The development of locomotives of great weight and tractive power and in consequence longer trains of heavy, large capacity cars.

(*b*) The large cylinders and reservoirs required for the heavier cars, the longer brake pipe due to the

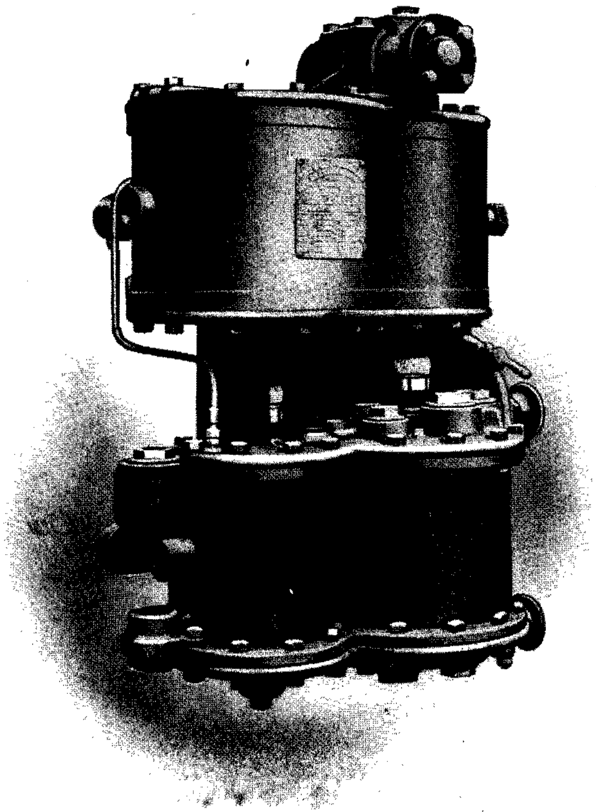

Fig. 2. $8\frac{1}{2}$-INCH CROSS COMPOUND COMPRESSOR. AIR DISCHARGE SIDE.

longer trains hauled, and the greater number of flexible connections and fittings where leakage may occur, combine to demand normally a larger volume of compressed air than ever before.

(*c*) The growing use of many *pneumatically* operated auxiliary appliances, such as water scoops, automatic ash pans, engine reversing appliances, Pullman water raising system, bell ringers, etc., which take their supply from the air compressor.

(*d*) The present practice on the part of most railroads of using practically all-air trains.

(*e*) The necessity of avoiding delays at terminals, where traffic tends to congest, by a prompt charging of long trains. Present day service conditions demand a pump of ample capacity to secure maximum brake efficiency.

The great increase in pump capacity called for in modern service has resulted in a much more careful consideration of the matter of steam consumption than formerly, and as a result the Westinghouse $8\frac{1}{2}$-inch Cross Compound Compressor was developed for the specific purpose of combining maximum capacity and highest efficiency, by compounding both the steam supplied and the air compressed to the extent that, while this compressor has a capacity over three times greater than the well known $9\frac{1}{2}$-inch single stage compressor, the steam consumption per 100 cubic feet of air compressed is but one-third.

The following table gives the principal dimensions, displacement, weight, etc., of the $8\frac{1}{2}$-inch compressor.

GENERAL DIMENSIONS, DISPLACEMENT AND WEIGHT OF THE 8½-INCH CROSS COMPOUND COMPRESSOR.

Diameter of High Pressure Steam Cylinder	8½ in.
Diameter of Low Pressure Steam Cylinder	14½ in.
Diameter of High Pressure Air Cylinder	9 in.
Diameter of Low Pressure Air Cylinder	14½ in.
Length of Stroke	12 in.
Governor	1¼ in.
Diameter of Steam Admission Pipe	1¼ in.
Diameter of Steam Exhaust Pipe	1½ in.
Diameter of Air Admission Pipe	2 in.
Diameter of Air Delivery Pipe	1½ in.
Designed for Steam Pressure of	200 lbs.
Working against an Air Pressure of	140 lbs.
Normal Speed, single strokes per minute, under above conditions	131
Displacement, cubic feet per minute, under above conditions	150
Over-all Dimensions: Height	52 in.
(Approximate) Width	37 in.
Depth	18⅛ in.
Average Net Weight	1500 lbs.
Weight, boxed for shipment	1750 lbs.
Lift of Air Valves	$\frac{3}{32}$ in.

DESCRIPTION.

As in the case of the Standard Westinghouse Single Stage Compressors, the steam cylinders are placed vertically above the air cylinders and joined by a common center piece, see exterior views, Figs. 1 and 2.

The diagrammatic views, Figs. 9 and 10, serve to illustrate the *simplicity* of this design and emphasize the fact that the cross compound compressor is a serial arrangement of two standard single stage pumps, actuated by the same controlling mechanism, and with pistons moving uniformly in opposite directions. These cuts also show the few moving parts employed, which comprise, first, the high pressure steam low pressure air pistons, connected by a Vanadium steel piston rod drilled for the reversing valve rod which operates the reversing valve, and which in turn moves the main piston valve controlling the admission of steam to and the exhaust from both the high and low pressure steam cylinders, and, second, the low pressure steam and high pressure air pistons connected by a solid Vanadium steel piston rod having no mechanical connection with the valve gear.

Figs. 3, 4, 5 and 8, are sectional views showing the ports and passages, also numbered parts which are referred to as follows: 2, top head; 3, steam cylinders; 5, air cylinders; 4, center piece forming the connection between 3 and 5; 6, lower head; 7, high pressure steam piston, 8½ inches in diameter, and its rod; 8, low pressure steam piston, 14½ inches in diameter; 9, low pressure air piston, 14½ inches in diameter; and 10, the high pressure air piston, 9 inches in diameter. The maximum stroke of each pair of pistons is 12 inches; 11, high pressure steam piston ring; 12, low pressure steam piston ring; 13, low pressure air piston ring; 14; high pressure air piston ring; 15, piston rod nut; 16, piston rod jam nut; 17, piston rod cotter; 18, reversing valve plate; 19, reversing valve plate bolt; 21, reversing valve rod; 22, reversing valve; 23, reversing valve chamber bush; 24, reversing valve chamber cap; 25, piston valve, complete; 27, large piston valve ring; 28, exhaust piston

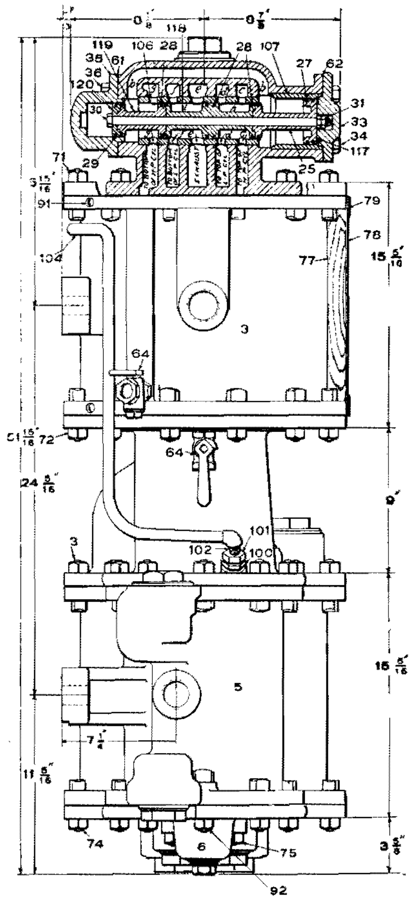

Fig. 3. 8½-INCH CROSS COMPOUND COMPRESSOR. SIDE ELEVATION.

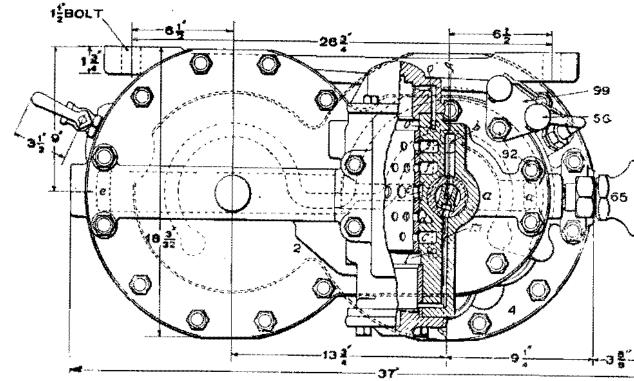

Fig. 4. HORIZONTAL SECTION OF REVERSING VALVE CHAMBER.

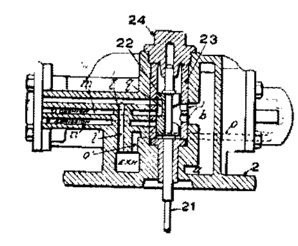

Fig. 5. VERTICAL SECTION OF REVERSING VALVE CHAMBER.

valve ring; 29, small piston valve ring; 30, piston valve bolt, complete; 31, piston valve bolt nut; 33, large piston valve cylinder head; 34, large piston valve cylinder head cap screw; 35, small piston valve cylinder head; 36, small piston valve cylinder head cap screw; 37, upper inlet valve; 38, lower inlet valve; 39, upper intermediate valve; 40, lower intermediate valve; 41, upper discharge valve; 42, lower discharge valve; 43, upper inlet valve seat; 44, upper inlet valve chamber cap; 45, lower inlet valve cage; 46, upper intermediate valve seat; 47, upper intermediate valve cap; 48, lower intermediate valve cage; 49, upper discharge valve cap; 50, lower discharge valve cage; 51, 1-inch steam pipe stud; 52, governor union nut; 53, stuffing box; 54, stuffing box nut; 55, stuffing box gland; 56, air cylinder lubricator; 57, upper steam cylinder gasket; 58, lower steam cylinder gasket; 59, upper air cylinder gasket; 60, lower air cylinder gasket; 61, small piston valve cylinder head gasket; 62, large piston valve cylinder head gasket; 63, $\frac{1}{4}$-inch drain cock; 64, $\frac{1}{2}$-inch drain cock; 65, air strainer; 66, 1-inch steam pipe sleeve; 67, lower head plug; 68, piston rod swab; 69, top head bolt and nut; 71, tee head bolt and nut; 72, tee head bolt and nut; 73, tee head bolt and nut; 74, tee head bolt and nut; 75, tee head bolt and nut; 76, guard plate for upper intermediate valves; 77, lagging; 78, jacket; 79, jacket band; 82, packing nut wrench; 86, piston rod packing; 87, reversing valve rod bush; 89, upper discharge valve seat; 91, jacket band screw; 92, tee head bolt and nut; 93, tee head bolt and nut; 94, tee head bolt and nut; 99, lubricator bracket; 100, union stud; 101, union nut;

102, union swivel; 103, oil pipe to low pressure air cylinder; 104, oil pipe to high pressure air cylinder; 106, piston valve bush; 107, large piston bush.

The drain cock 63 is intended to draw off any condensation in the steam passage *a* and should always be opened when the pump is first started. The drain cock 64 connected to the low pressure steam cylinder is for the same purpose and should also be opened for a short time before the compressor is started so that any condensation of steam in the cylinder may be removed.

The Governor is connected to the steam inlet at S, Fig. 8. Steam entering passes through port *a* to the top head, and thence through ports *a* and *b*, Fig. 5, to the reversing valve chamber *k* and main valve chamber, Fig. 8; *e* is the exhaust passage leading to the steam exhaust pipe. As it is difficult to follow the ports in these cuts, we have prepared two diagrams, as shown in Figs. 9 and 10, in which the steam valve gear is turned 90 degrees horizontally from its actual position in order to make the operation more easily understood, and all ports and passages are connected in the simplest possible manner, without regard to the actual construction of the compressor.

Referring to Fig. 9, passage *a*, communicating with cavity C and the two chambers *b*, conveys the steam from the source of supply to the operating valves, of which there are two, namely: the reversing valve and the piston valve. The piston valve is a multiple piston device, consisting of a large piston at one end, a small piston at the other, with three intermediate pistons of uniform size, which will be referred to hereinafter as numbers 1, 2 and 3, numbering from the small piston end of the piston valve.

It is evident that, with five pistons mounted on a common rod and working in a cylinder, we have, including the ends, six separate chambers. In this particular construction, five of these chambers have permanent connections as follows:

The first chamber, *E*, behind the outer end of the small piston, to the atmosphere.

The second chamber, *b*, between the small and No. 1 intermediate piston, to passage *a*.

The third chamber, *i*, between the No. 1 and No. 2 intermediate pistons, to the lower end of the low pressure steam cylinder.

The fourth chamber, *h*, between the No. 2 and No. 3 intermediate pistons, to the upper end of the low pressure steam cylinder.

The fifth chamber, *b*, between the third intermediate and the inner side of large piston to passage *a*.

The reversing valve 22, moving vertically on its seat in chamber *C*, controls the admission and exhaust of steam from the cavity *D*, behind the outer end of the large piston of the piston valve, causing it to operate horizontally, the intermediate pistons moving as follows:

Intermediate piston No. 3 crosses a port connecting passage *c* controlling the flow of steam to the upper end of the high pressure steam cylinder, and also the exhaust into the upper end of the low pressure steam cylinder.

Intermediate piston No. 2 crosses a port connecting with passage *e*, controlling the exhaust of steam from either end of the low pressure steam cylinder.

Intermediate piston No. 1 crosses a port connecting the passage *g*, causing steam to be admitted to the lower end of the high pressure steam cylinder or exhausting the same from this cylinder into the lower end of the low pressure steam cylinder. A passage, *z*, leading from the upper end of the high pressure steam cylinder is the means of supplying pressure to balance the reversing valve rod.

OPERATION.

When the high pressure steam piston has nearly completed its up stroke the reversing valve plate 18, comes in contact with the shoulder on the reversing rod, forcing said rod 21, to its uppermost position, carrying with it reversing valve 22, the movement of which, in turn, not only blanks port to passage *m*, thereby cutting off means of exhausting steam from cavity behind the large end of piston valve, but also opens port to passage *n*, filling this chamber, D, with live steam from passage *a*. The pressure thus exerted on the outer side of the large piston added to the pressure on the inner side of the small piston is now greater than the pressure exerted against the inner side of the large piston, and the piston valve moves to the left, or in the direction of chamber E, which movement admits steam to the upper end of the high pressure steam cylinder, starting the high pressure steam piston on its downward stroke. All parts have now assumed the position shown in Fig. 9.

A direct communication is now established whereby live steam is supplied through passage *a*, chamber *b*, and passage *c* to the upper end of the high pressure steam cylinder, forcing downward the high pressure steam piston and low pressure air piston to which it is rigidly connected by the piston rod, that is free to move in the necessary stuffing boxes. The downward movement causes steam to be exhausted from the lower end of the high pressure steam cylinder through passage *g*, cavity *i* and passage *f*, into the lower end of the low pressure steam cylinder. The latter being of materially larger volume than the former, it will be seen that the steam is thereby made to do its work expansively in the low pressure steam cylinder. At the same time—

(*a*) the low pressure air piston, 9, is compressing air in the lower end of the low pressure air cylinder and forcing same through the intermediate valves 40, and passage *u'* into the lower end of the high pressure air cylinder, and—

(*b*) air at atmospheric pressure is being drawn into the upper end of the low pressure cylinder, through the upper air strainer and inlet valve 37.

It will be observed that the steam exhausted into the lower end of the low pressure steam cylinder and the low pressure air forced into the lower end of the high pressure air cylinder act simultaneously on the lower sides of their respective pistons. The force thus exerted results in an upward movement of the low pressure steam and high pressure air pistons. The upward movement causes—

(*a*) steam to be exhausted from the upper end of the low pressure steam cylinder through passage *d*, chamber *h* and passage *e* to the atmosphere, and—

(*b*) the high pressure air piston 10, to compress the air in the upper end of the high pressure air cylinder to its final pressure and to discharge it through passage *v*, discharge valve 41, and passage *w* into the main reservoir.

After the low pressure steam (high pressure air) piston has completed its upward stroke, as explained, the lower end of the high pressure air cylinder is, of course, filled with air compressed from the lower end of the low pressure air cylinder, and the lower end of the low pressure steam cylinder is filled with steam exhausted from the lower end of the high pressure steam cylinder. However, just as the low pressure steam (high pressure air) piston has completed its upward stroke, steam is by-passed through three by-pass grooves *x* from the lower to the upper side of the low pressure steam piston, thereby preventing an accumulation of back pressure in the lower end of the high pressure cylinder.

At this stage of the cycle, also, the upper end of the low pressure air cylinder is filled with air at atmospheric pressure and the upper end of the high pressure steam cylinder is filled with live steam; but just before the high pressure steam (low pressure air) piston completes its downward stroke, reversing valve plate 18 engages the button end of the reversing valve rod, moving it downward and carrying the reversing valve to its extreme lower position, thereby closing port leading to passage *n*, cutting off the supply of live steam to chamber *D*, and connecting passage *m*, cavity *q* and passage *l*, thereby exhausting steam from cavity D behind the outer end of the large piston of the piston valve. Since the pressure against the inner side of the large piston is now greater than the pressure exerted against the inner side of the small piston, the piston valve moves to the right or in the direction of chamber D, and all parts are in the position shown in Fig. 10.

Live steam is now supplied from passage *a*, through chamber *b*, and passage *g*, to the lower end of the high pressure steam cylinder, forcing upward the high pressure steam piston which, as already explained, carries with it the low pressure air piston. The upward movement causes steam to be exhausted from the upper end of the high pressure steam cylinder, through passage *c*, chamber *h* and passage *d*, into the upper end of the low pressure steam cylinder. At the same time—

(*a*) the low pressure air piston is compressing the air in the upper end of the low pressure air cylinder and forcing same through the intermediate valves 76, and passage *u*, into the upper end of the high pressure air cylinder, and—

(*b*) air at atmospheric pressure is drawn into the lower end of the low pressure air cylinder, through the lower air strainer, passage *r'* and lower inlet valve 38.

Again it will be observed that the steam in the low pressure steam cylinder and air in the high pressure air cylinder act simultaneously against their respective

pistons, steam being exhausted from the upper end of the high pressure steam cylinder through passage *c*, chamber *h* and passage *d*, to the upper end of the low pressure steam cylinder, in which it acts expansively on the low pressure steam piston. The downward movement of the low pressure steam piston causes steam to be exhausted from the lower end of the low pressure steam cylinder, through passage *f*, chamber *i* and passage *e*, to the atmosphere, and the high pressure air piston to compress the air in the lower end of the high pressure air cylinder to its final pressure, forcing same through passage *v'*, discharge valve 42, and passage *w'*, into the main reservoir. When the pistons have moved as explained, the low pressure steam (high pressure air) piston has completed its downward stroke; the upper end of the high pressure air cylinder is filled with air compressed from the upper end of the low pressure air cylinder; and the upper end of the low pressure steam cylinder is filled with steam exhausted from the upper end of the high pressure steam cylinder. However, just before the low pressure steam (high pressure air) piston has completed its downward stroke, steam is by-passed through the three by-pass grooves from the upper to the lower side of the low pressure steam piston, thereby preventing an accumulation of back pressure in the upper end of the high pressure steam cylinder. At this stage of the cycle also, the high pressure steam (low pressure air) piston has completed its upward stroke; the lower end of the high pressure air cylinder is filled with air at atmospheric pressure; and the lower end of the high pressure steam cylinder is filled with live steam. Here again the pump is reversed, by means of the reversing valve plate attached to the high pressure steam piston coming in contact with the shoulder of the reversing valve rod which, in turn, actuates the reversing valve, and the cycle of operation already described is repeated.

10½-inch Cross Compound Air Compressor.

The use of compressed air in industrial fields has been so widely extended that for this particular purpose we have developed the 10½-inch cross compound air compressor which operates on a relatively low steam pressure (100 lbs.) and requires a lower differential between steam and air pressures than the 8½-inch cross compound. This compressor follows in all essential details the general design of the 8½-inch cross compound compressor. The air cylinders are not water jacketed and no intercooler is required.

The following table gives the principal dimensions, displacement, weight, etc., of the 10½-inch compressor.

General Dimensions, Displacement and Weight of the 10½-inch Cross Compound Compressor.

Diameter of High Pressure Steam Cylinder	10½ in.
Diameter of Low Pressure Steam Cylinder	16¾ in.
Diameter of High Pressure Air Cylinder	9½ in.
Diameter of Low Pressure Air Cylinder	14½ in.
Length of Stroke	12 in.
Governor	1¼ in.
Diameter of Steam Admission Pipe	1½ in.
Diameter of Steam Exhaust Pipe	2½ in.
Diameter of Air Admission Pipe	2½ in.
Diameter of Air Delivery Pipe	1½ in.
Designed for Steam Pressure of	100 lbs.
Working against an Air Pressure of	80 lbs.

Normal Speed, single strokes per minute, under above conditions		131
Displacement, cubic feet per minute, under above conditions		150
Over-all Dimensions:	Height	51⅞ in.
(Approximate)	Width	41⅞ in.
	Depth	21 in.
Average Net Weight		1800 lbs.
Weight, boxed for shipment		2150 lbs.
Lift of Air Valves:	Intermediate	⅛ in.
	Suction	5/32 in.
	Discharge	5/32 in.

INSTRUCTIONS.

Piping. All pipes should be hammered to loosen the scale and dirt, have fins removed, and be thoroughly blown out with steam before erecting; bends should be used wherever possible instead of ells, and all sags avoided. Shellac or Japan varnish should be applied on the *male threaded portion only,* and *never* in the socket. Do not use red or white lead.

Starting and Running. The drain cocks are placed at the lowest points of the steam passages, as shown, for the purpose of draining condensed steam when the compressor is stopped and when starting it. They should always be left open when the compressor is to stand idle for any length of time. These drain cocks are provided with suitable union fittings, so that drain pipes may be connected if desired.

In starting the compressor, always run it slowly until it becomes warm, permitting the condensed steam to escape through the drain cocks and the exhaust, until there is sufficient pressure in the main reservoir (25 to 30 lbs.) to provide an air cushion. Then close drain cocks and open the steam (throttle) valve sufficiently to run the compressor at the proper speed, according to circumstances. Racing or running at excessive speeds should not be allowed. The pump governor automatically controls the operation of the compressor when maintaining the air pressure.

To Stop the Compressor. (1) Close the feed and steam valves on the sight-feed lubricator, if the compressor has a separate one, or the feed, if supplied from the locomotive lubricator; (2) then close the steam (throttle) valve; (3) and open all drain cocks on the compressor. Keep the steam valve closed and the drain cocks open when the compressor is not working. The main reservoir drain cocks should also be left open when the compressor is stopped for any length of time. The compressor should always be stopped while the engine is over the ash pit. If kept open, ashes and dust will be drawn into the air cylinder and injure it, besides clogging up the air strainer.

Lubrication.—Air Cylinders—On account of the high temperatures developed by air compression, the variation between maximum and minimum delivered air pressures, and the necessity of preventing oil from passing into the system, one of the vital problems in efficient compressor operation is to provide a simple means for supplying lubrication to the air cylinders in proper quantity and at regular intervals.

To overcome the difficulties attending the lubrication of the air cylinders of the $8\frac{1}{2}$-inch and $10\frac{1}{2}$-inch cross compound compressors, two non-automatic oil cups are mounted on a bracket, which, in turn, is connected to the

air cylinders by the necessary piping, thereby establishing an independent passage from each cup to the high and low pressure air cylinders respectively.

This cup, Fig. 6, is of extremely simple design. The lower end is threaded for a $\frac{3}{8}$-inch tapped opening, while the upper end is provided with a tight-fitting screw cap. A screen prevents any dirt in the oil being carried into the cylinder. When the handle is turned, a cavity in the key, which normally forms the bottom of the oil cup, deposits a definite amount of oil in the air cylinders, at the same time preventing back pressure from reaching the oil chamber.

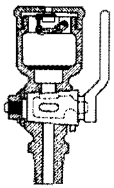

Fig. 6.
OIL CUP.

The bracket may be attached to the top head of the compressor, or placed in the locomotive cab, to suit the convenience or standard practice of any railroad.

To oil the *low pressure air cylinder,* open its oil cup and blow out all dirt, close and fill it with *valve oil,* and on the *down stroke* of the piston open the cup to allow the oil to be drawn into the cylinder, closing the cup before the beginning of the up stroke. This is most easily done when the speed is moderate and the air pressure low. To oil the *high pressure air cylinder,* open its oil cup and blow out all dirt, then close and fill with *valve oil* and screw on the cover. Now open the cup and leave it open for a short time so as to permit the oil to find its way into the cylinder, after which it should be left closed. Valve oil only should be used in the air cylinder. A lighter oil will not last and is dangerous. A heavier oil very soon clogs and restricts the air passages, causing the compressor to heat unduly and compress air slowly; valve oil gives the best performance. Judgment should determine the amount for both the air and steam cylinders, it being remembered that the lack of a little oil when needed may result in much damage to the compressor.

A *swab,* well oiled, is essential on each piston rod.

Many railroads now consider quite essential the use of a Double Sight Feed Lubricator Fitting *located in the cab* and connected in the piping leading from the oil well of the locomotive lubricator to the compressor air cylinders, and from the very satisfactory results obtained,

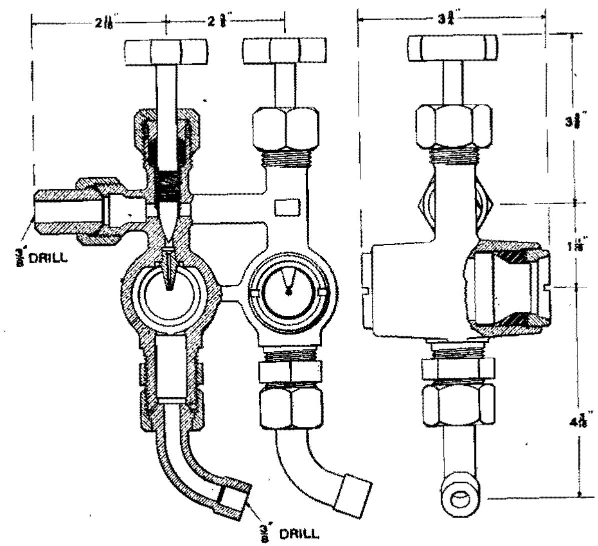

Fig. 7. DOUBLE SIGHT FEED LUBRICATOR.

we are prepared to recommend these fittings strongly as particularly advantageous and effective.

The Double Sight Feed Lubricator, Fig. 7, gives the engineer complete and convenient control of air cylinder lubrication, so that the minimum amount and proper quality of oil required may be supplied at regular intervals. The sight feed lubricator can be attached to any locomotive lubricator. In order to prevent compressed air from entering the oil delivery pipe between the sight feed fitting and the air cylinder, a ball check valve connection is screwed into the air cylinder. No trap should exist in the oil delivery pipe between the sight feed fitting and the air cylinder.

Lubrication.—Steam Cylinders—The *steam cylinder lubricator* should not be started until all condensation has escaped from the compressor and the drain cocks closed. After closing the drain cocks start the lubricator to feed in ten or fifteen drops of oil as rapidly as possible, then regulate the feed to about one or two drops per minute *for each steam cylinder.* No definite amount can be specified, as the amount of lubrication required depends on the work the compressor has to do, the quality of the steam, condition of compressor, and so on. Keep the lubricator feeding while the compressor is running.

DISORDERS.

Causes and Remedies.

Compressor Refuses to Start. Cause:—insufficient oil, from scant or no feed or working water; worn main-piston rings; or rust having accumulated during time compressor has lain idle. Remedy:—shut off steam, take off cap nut, put in about a table-spoonful of valve oil (not too much), let the oil soak down for one or two minutes, and then turn on steam quickly. In many cases when the compressor will not start when steam is first turned on, if steam is then turned off and allowed to remain off for one or two minutes, and then turned on quickly, it will start without the use of any oil, except that from the lubricator.

Compressor Groans. Cause:—(1) air cylinder needs oil. Remedy:—(1) put some valve oil in air cylinder and saturate piston swab with valve oil, then replace it on the rod. Cause:—(2) steam cylinder needs oil. Remedy:—(2) increase lubricator feed.

Leakage past the air piston packing rings or past a discharge valve causes heating, destroys lubrication, and results in groaning. Piston rod packing dry and binding is another cause of groaning.

Uneven Strokes of the Compressor. Cause:—probably (1) leakage past air piston packing rings and sticky air valves; (2) unequal lift of air valves; (3) clogged discharge valve passages; or, (4) leaky air valves. Remedy:—locate cause, if possible, and correct it by cleaning out clogged or dirty passages, adjusting lift of valves or replacing leaky valves or rings.

Slow in Compressing Air. Cause:—(1) leakage past the air piston packing rings, due to poor fit, or wear in cylinder or rings; (2) valves and passages dirty; or, (3) air suction strainer clogged. Remedy:—(1) and

(2). To determine which is causing the trouble, obtain about 90 lbs. air pressure, reduce the speed to from 40 to 60 single strokes per minute, then *listen* at the "Air Inlet" and note if air is drawn in during only a portion of each stroke, and if any blows back. If the latter, an inlet valve is leaking. If the suction does not continue until each stroke is nearly completed, then there is leakage past the air piston packing rings or back from the main reservoir past the air discharge valves. One of the latter leaking will cause an uneven stroke. Remedy:—(3) clean strainer thoroughly.

Compressor Erratic in Action. Cause:—Worn condition of valve motion. Remedy:—Renew it.

Compressor Heats. Cause:—(1) air passages are clogged; (2) leakage past air piston packing rings; or, (3) the discharge valves have insufficient lift. Remedy:—(1) clean air passages; (2) renew air piston rings; (3) regulate lift of discharge valves to $\frac{3}{32}$ of an inch on the $8\frac{1}{2}$-inch and of $\frac{5}{32}$ of an inch on the $10\frac{1}{2}$-inch compressor. A compressor in perfect condition will become excessively hot and is liable to be damaged if run very fast and continuously, for a long time.

Compressor Pounds. Cause:—(1) air piston is loose; (2) compressor not well secured to boiler, or causes some adjacent pipe to vibrate; (3) the reversing valve plate, 18, is loose; or, (4) the reversing rod or plate may be so worn that the motion of compressor is not reversed at the proper time. Remedy:—repair and renew worn parts and tighten loose connections.

MAINTENANCE.

The *air cylinder heating* is a feature of air compression which cannot be prevented. As an example of the normal heating, resulting from extreme duty, a $9\frac{1}{2}$-inch compressor in good order which for one hour maintained an average speed of 174 single strokes or exhausts per minute, working constantly against 100 pounds of air pressure, was discharging the air at a temperature of 408 degrees.

Higher speed or greater air pressure would have increased the heating, while slower speed, shorter time of test or lower air pressure would have decreased it.

Speaking generally, the speed should not exceed 140 exhausts per minute and such a speed should not be continuously maintained for any considerable time, as even this speed will cause excessive heating. This is shown by another test where an average speed of about 60 exhausts per minute, after the main reservoir pressure was pumped up, and a maximum of 77 strokes per minute at the completion of an hour and fifty minutes of the test, gave a discharge temperature of 316 degrees. The foregoing show plainly the great need of good maintenance, of not wasting air either by leakage or poor handling and of giving the compressor as much time to do its work as is practicable.

One of the most serious leaks is through the air cylinder stuffing box as it not only greatly decreases the air delivered and, by the faster speed required, increases the heating, but it also causes pounding through loss of cushion. When tightening the packing, do not bind the

rod, as to do so will damage both the packing and the rod. Be careful not to cross the gland nut threads.

With two compressors per engine, the separate throttles should be kept wide open and the speed regulated by the main compressor throttle. The purpose is to equally divide the work.

If necessary to replace a broken air valve on the road or elsewhere not permitting of proper fitting, at the earliest opportunity have the repairman replace the temporary valve with another so as to insure the correct angle and width of valve and seat contact, the needed ground joint and the requisite lift of $\frac{3}{32}$ of an inch for all valves.

Never remove or replace the upper steam cylinder head with the reversing valve rod in place as to do so will almost invariably result in bending the rod. A bent rod is very liable to cause a "pump failure".

It is evident that a compressor cannot compress more air than it draws in and not that much if there is any leakage to the atmosphere about the air cylinder. Bearing this in mind, practice frequently listening at the "Air Inlet" when the compressor is working slowly while being controlled by the governor, and wherever a poor suction is noted on either or both strokes locate and report the fault.

Any unusual click or pound should be reported as it may indicate either a loose piston or a reversing-valve plate cap screw or other serious fault.

Any steam leakage that can reach the Air Inlet of the compressor should be promptly repaired as such increases the danger of water entering the brake pipe.

Keeping the suction strainer clean is of the utmost importance, as even a slightly clogged strainer will greatly reduce the capacity where the speed is at all fast. A seriously or completely obstructed strainer, as by accumulated frost, aggravated by rising steam, will increase the compressor speed and will also be indicated by inability to raise or maintain the desired pressure.

It is an aid to good operation to thoroughly clean the air cylinder and its passages at least three or four times a year, by circulating through them a hot solution of lye or potash. This should always be followed by sufficient clean, hot water to thoroughly rinse out the cylinder and passages, after which a liberal supply of valve oil should be given the cylinder. Suitable tanks and connections for performing this operation can easily be arranged in portable form. Never put kerosene oil in the air cylinder to clean it.

Westinghouse Air Brake Company.

Pittsburg, Pa., U. S. A.

WORKS AT WILMERDING, PA.

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CHICAGO	Railway Exchange Building
CLEVELAND	Schofield Building
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DENVER	Majestic Building
HOUSTON, TEX.	403 Hawthorne Ave.
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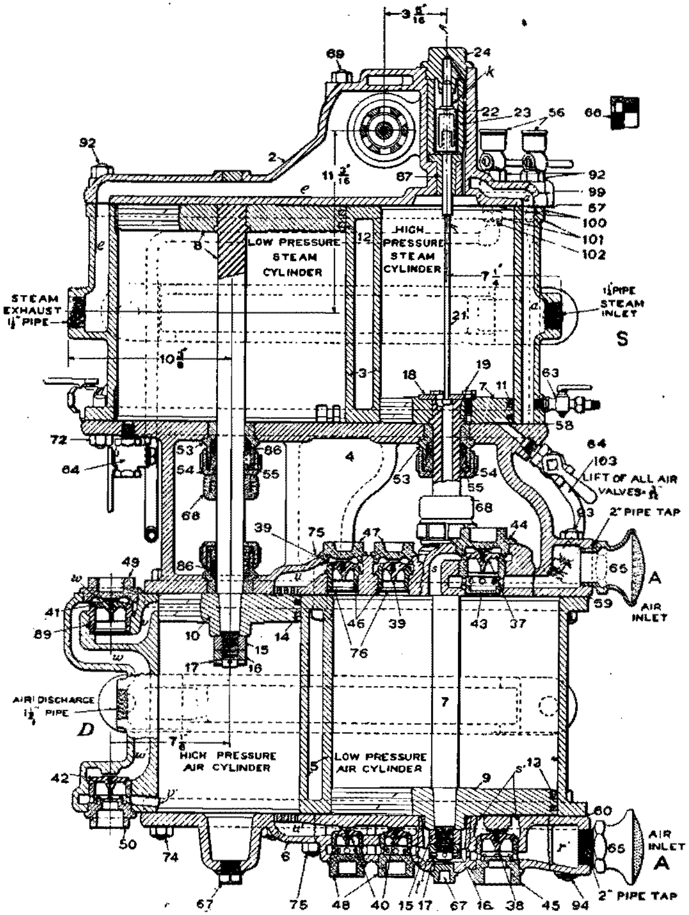


Fig. 8. 8½-INCH CROSS COMPOUND COMPRESSOR. VERTICAL SECTION.

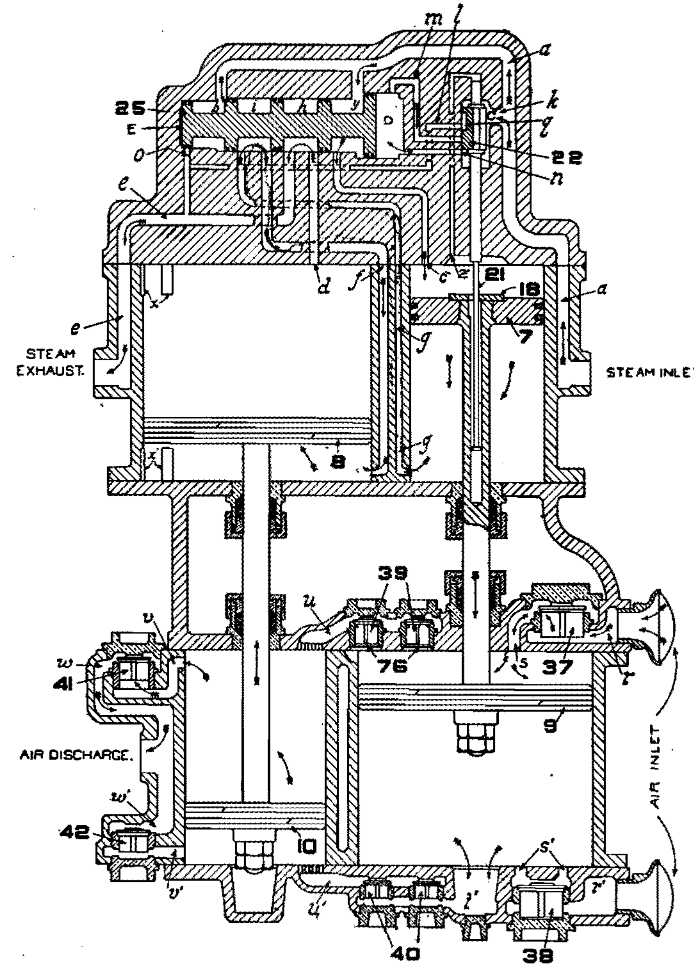
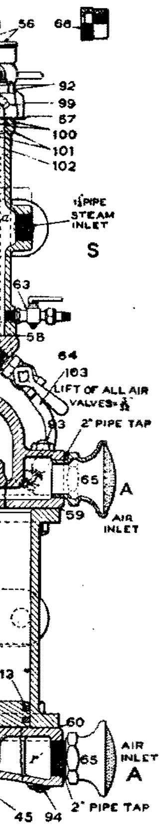


Fig. 9. DIAGRAM OF 8½-INCH CROSS COMPOUND COMPRESSOR. THE HIGH PRESSURE STEAM (LOW PRESSURE AIR) PISTON ON ITS DOWNWARD STROKE.



MPRESSOR.

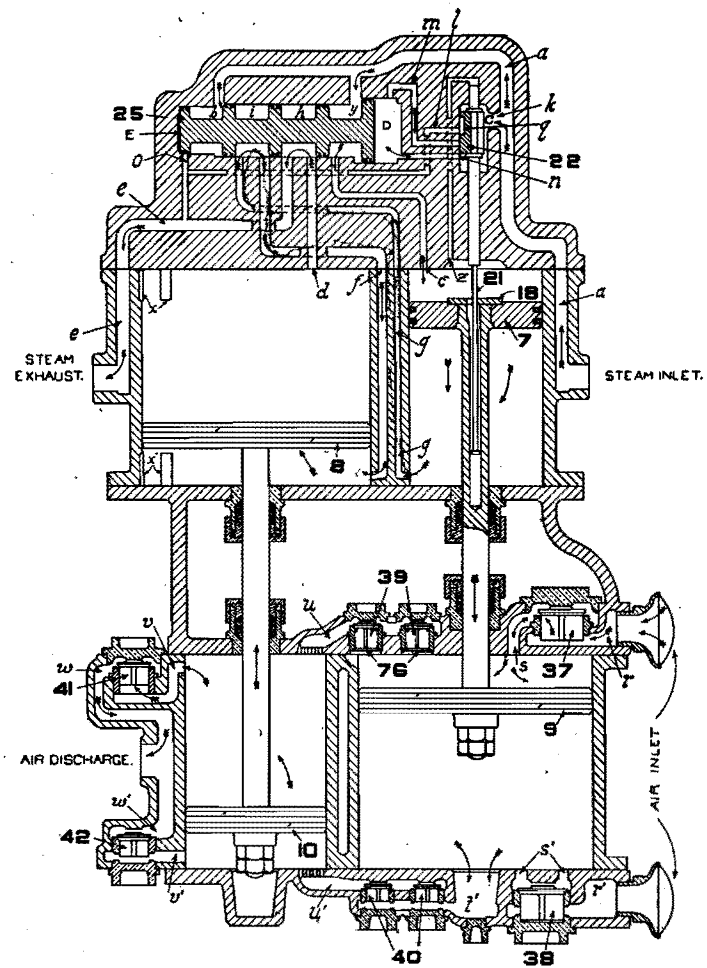


Fig. 9. DIAGRAM OF 8½-INCH CROSS COMPOUND COMPRESSOR. THE HIGH PRESSURE STEAM (LOW PRESSURE AIR) PISTON ON ITS DOWNWARD STROKE.

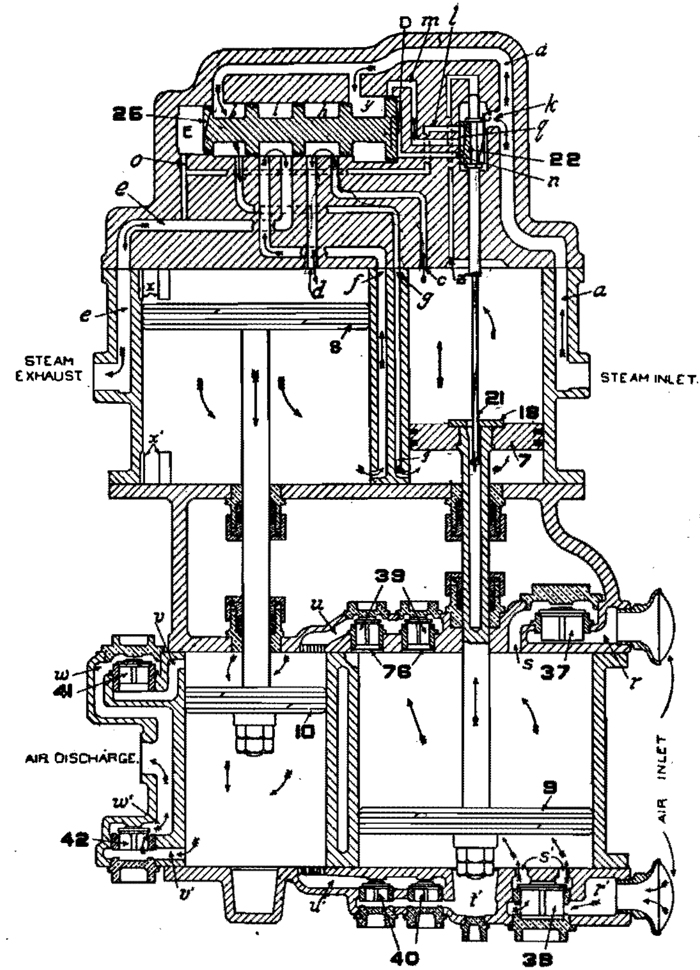


Fig. 10. DIAGRAM OF 8½-INCH CROSS COMPOUND COMPRESSOR. THE HIGH PRESSURE STEAM (LOW PRESSURE AIR) PISTON ON ITS UPWARD STROKE.