PRECISION POWER REVERSE GEAR

TYPE F

INSTRUCTION BOOK No. 4

FRANKLIN RAILWAY SUPPLY COMPANY, Inc.
17 East Forty Second Street,
New York

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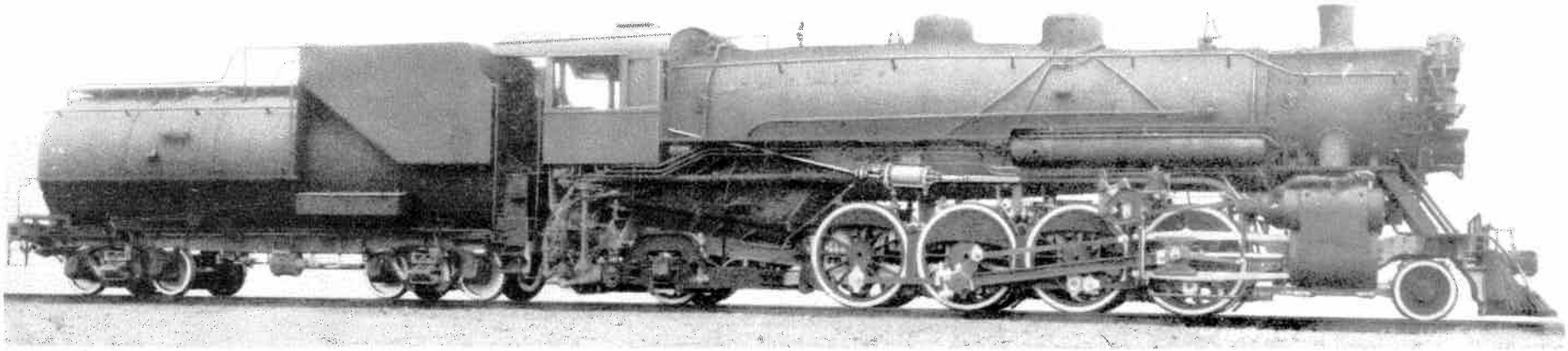

Fig. 1. Typical Gear-Equipped Locomotive: Precision Power Reverse Gear, Type F

LOCOMOTIVE POWER REVERSE GEARS

With the continual increase in the size and power of locomotives, especially during the last twenty-five years, much attention has been given to the subject of lightening the work of the engineman by providing a power-operated means of positioning the valve gear.

Previous to the advent of the Mallet type, locomotives were of such size that the valve gear could be effectively handled directly by the reverse lever. Power reverse gears, therefore, received little attention. With the Mallet, however, this was not possible and interest in power reverse gears became active.

The original Ragonnet Power Reverse Gear was designed for Mallet locomotives and with its successful development it soon found a broader field due to the increasing sizes of simple locomotives. Today the power reverse gear is recognized as a necessity, not alone on heavy locomotives but on lighter ones as well, in both switching and road service.

Economy in the use of fuel in properly designed road locomotives depends very largely upon proper regulation of the cut-off. The power reverse gear makes it safe and easy for the engineman to adjust the cut-off at all times and it is indisputable that this has a material effect on the locomotive economy.

The salient features of the Precision Power Reverse Gear, Type F, are as follows:

1. Steam connections are unnecessary. The engineman can operate the gear without fluid pressure within the gear cylinder.
2. Micrometer adjustment for any desired cut-off.
3. Permits an accurate synchronism of gear piston with indicator, due largely to the one to one ratio of valve to piston movement, and lack of pins or levers.
4. Lower maintenance cost due to absence of pins.
5. Expansion and contraction of boiler does not affect the relative position of indicator and gear piston, so that an accurate indication of the position of cut-off always results.
6. The gear is very sensitive and quickly readjusts itself with a minimum of movement to variation in load placed upon it, because of the one to one ratio mentioned above.

GENERAL DESCRIPTION

THE PRECISION POWER REVERSE GEAR, Type F, is an air-operated device for positioning the locomotive valve gear. Its operation is controlled by a small hand wheel in the cab through the gear reach rod and a screw threaded into the gear piston, which screw makes direct connection with the valve gear through the piston trunk and the locomotive reach rod.

The gear provides for micrometer adjustment of the locomotive cut-off by means of the hand wheel, which causes the small gear valve to move so as to admit air at reservoir pressure to one side of the piston and release exhaust air from the other side, causing the piston and valve gear to move, adjusting the valve gear to the cut-off shown by the indicator in the cab.

Regardless of the throttle opening or locomotive speed, little or no effort is required to turn the hand wheel, since it is used only to move the small gear valve by screwing the adjusting screw into or out of the piston head.

A typical gear-equipped locomotive, using the Type F gear, is shown in Fig. 1.

THE CYLINDER is 10″ in diameter by 24″ long and flanged at the ends for bolting the cylinder heads in place. Four lugs are cast integral with the cylinder for securing it to the supports on the boiler. The air passage to the front end of the cylinder is cored through a boss extending along the cylinder wall, making outside piping unnecessary.

A drain cock is tapped into the flange at each end of the cylinder for draining it.

THE PISTON. This assembly consists of a cast iron piston head riveted to the flanged end of the piston trunk; a cast iron bull ring; two boiler plate followers; and two packing cups with expander rings. Six studs are used, with stud caps drawn up against copper washers to prevent air leakage. The stud caps, by striking against the front cylinder head, serve as stops for the piston at its extreme forward travel point.

THE PISTON PACKING consists of two cup packing rings held in position by the two followers and the bull ring and pressed against the cylinder wall by the two expander rings.

When air is on the gear, reservoir pressure is exerted against the flanged sides of the cups, while there is but atmospheric pressure on their opposite sides, or between them. This condition increases the sealing effect of the cups.

Kerosene or signal oil should not be used to loosen up or clean the cup packing rings, as they are injurious to them, except when the parts are removed from the gear so that the oil may be thoroughly wiped off before returning the parts.

THE PISTON TRUNK is of drop forged steel, its flanged end being riveted to the piston head. Within the core of the trunk and extending almost its entire length is the trunk tube, the back end of which is screwed into the piston head. This prevents escape of the air which may leak along the adjusting screw. The tube is packed with grease for lubricating the screw.

There is a small tapped hole at the front end of the trunk through which air will pass in case of leakage at either of the packing cups. After passing a cup the air flows into the groove around the bull ring and the six holes through the ring and the piston, into the core of the piston trunk and through the small tapped hole at its front end, which hole in this way, acts as a tell-tale for leakage of the packing cups.

THE TRUNK PACKING consists of one set of Sea Ring packing, $3\frac{1}{4}$″ inside diameter by $4\frac{1}{4}$″ outside, $2\frac{3}{4}$″ long.

A set of this packing contains one Header Ring, three Sea Rings, and one Follower Ring. The Header Ring rests against the shoulder at the rear of the bore in the head; the three Sea Rings must be put in with their open sides toward the rear; and then the Follower Ring, against which the trunk packing gland bears.

As this packing is self-retaining, the trunk packing gland is drawn up tightly against the front cylinder head.

THE FRONT CYLINDER HEAD is extended to include the trunk packing and a long packing gland, which arrangement provides the necessary bearing for the piston trunk, so that a crosshead and guides are unnecessary.

The wide asbestos gasket used for making the joint between the head and the cylinder flange also provides for closing the front end of the air passage in the boss along the cylinder wall to prevent escape of air from the cylinder.

THE BACK CYLINDER HEAD is extended to include the valve chest, valve and valve seat; also the stuffing box gland for the sleeve packing.

The boss on the inside end of the head casting provides a stop for the piston at its extreme backward travel point. There is also a boss on the extension of the back head to provide for a lubricator for the thrust bearing when required.

The bore in the back head is made sufficiently large to permit removal of the adjusting screw from the forward end of the gear without removing the sleeve and its packing.

The air supply piping is applied to a boss on the inner side of the head, through which boss the inlet passage is drilled leading through the head and the valve seat to the front end of the valve chest.

There is a partly drilled and partly cored passage through the head casting, leading from the port at the back end of the valve seat to meet the passage in the boss along the cylinder wall.

The cylinder head has a wide jointing surface against the full width of the cylinder flange and a wide asbestos gasket is used for making the joint.

THE ADJUSTING SCREW in the cylinder has $1\frac{1}{2}''$ triple Acme thread, left-hand or right-hand, three threads per inch, 1″ lead and requires 19 full turns of the hand wheel to move the piston its entire stroke.

The back end of the adjusting screw is square in section to provide a sliding connection with the screw shaft sleeve to permit the necessary longitudinal movement of the adjusting screw to obtain valve movement. Through this square, the adjusting screw transmits rotary movement to the screw shaft sleeve, which is rigidly connected to the gear universal joint.

This sliding connection also prevents any vibrations and shocks being transmitted to the hand wheel.

The left-hand lead adjusting screw is the one most generally used, where the horizontal reversing arm of the tumbling shaft extends forward, as shown in Fig. 7. Where the horizontal arm extends backward, a right-hand lead adjusting screw must be used, so that the gear piston will move backward to set the valve gear for a forward cut-off.

THE ADJUSTING SCREW SHAFT SLEEVE, made of steel, provides for turning the adjusting screw to move the gear valve, and a sliding connection for the longitudinal movement of the adjusting screw when the piston moves to the desired cut-off and returns the gear valve toward its central position. See Fig. 4.

SCREW SHAFT THRUST BEARING. Since the sleeve packing remains stationary while the adjusting screw shaft sleeve turns with the adjusting screw, it is necessary to have the screw-shaft thrust bearing between the packing and the collar on the screw shaft sleeve.

There is a slight difference between the inside diameters of the two ball races. The one with the smaller diameter must be placed over the shoulder just back of the collar on the sleeve, with which it is a sucking fit so that it will turn with the sleeve. The other race, with the larger diameter, is loose on the sleeve so that it will remain stationary with the packing. This thrust bearing, therefore, provides for easy turning of the sleeve notwithstanding the pressure against it when the gear is in operation.

THE SLEEVE PACKING is of a design especially developed for this service. The gland is drawn up tightly against the head, no adjustment being necessary, since when the gear is in operation the air pressure acting against the adjusting screw shaft sleeve keeps the packing tight due to movement of the sleeve in the sliding connection.

THE VALVE, Fig. 2, of the slide type, is made symmetrical of cast iron. It has a maximum travel of $\frac{1}{2}''$, or $\frac{1}{4}''$ on each side of the center. When placed in the central position on the seat, there is 1/64″ port opening (negative lap) at each end of the valve. In other words, the valve is 1/32″ shorter than the dimension between the outside edges of the inlet ports in the valve seat, as shown in the illustration.

The inlet and exhaust ports in both valve and valve seat proper are carefully machined, being slots rather than holes. Kerosene or signal oil should not be used to clean the valve or valve seat—as they are injurious to the cup packing rings in the cylinder—except when the parts are removed from the gear so that the oil may be thoroughly wiped off before returning the parts.

THE VALVE SEAT, Fig. 3, which is removable is made in the form of a flat cast iron plate and is secured to the back head casting on the same studs which hold the valve chest. The re-

movable feature provides for easy replacement of the valve and seat by other parts which may be carried in stock properly spotted for emergency use.

The valve seat proper is raised above the surrounding surface, with a minimum wearing

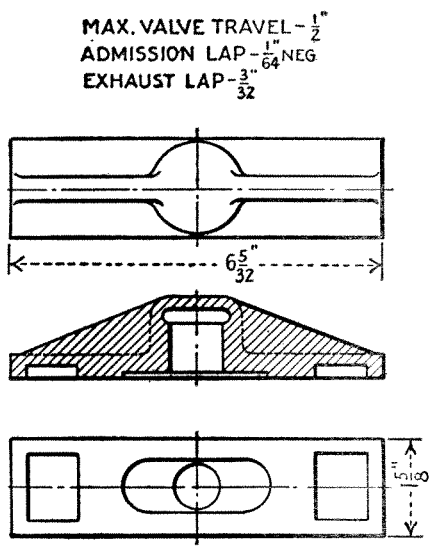

Fig. 2. Valve

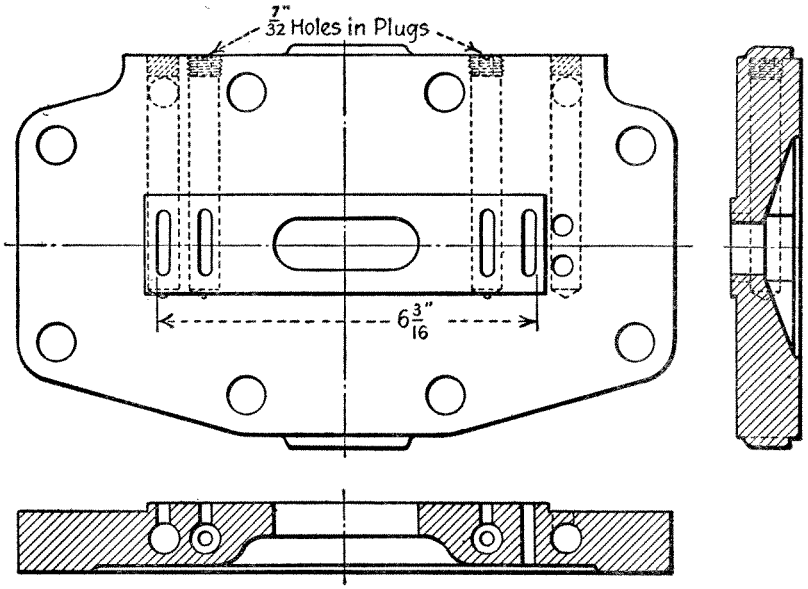

Fig. 3. Valve Seat

surface. This casting includes the inlet ports to the valve chest, which consist of two 3/8" holes drilled into the inlet passage; the two ports leading to the cylinder; and the two exhaust ports to the atmosphere. The drilled passages are 1/2" in diameter, the atmosphere openings of the exhaust passages being choked with brass plugs having 7/32" openings.

Asbestos gaskets are used between the valve chest and valve seat; between the valve seat and the back head casting; and between the cover plate and the back head casting. To facilitate the removal of the parts and prevent damaging the edges and the gaskets, bosses are cast on the sides of the parts to provide lifting shoulders.

THE VALVE OPERATING ARM AND CAP, shown in Fig. 4, which is made of bronze, provides the connection between the adjusting screw and the valve. It is secured to the shaft of the screw by four through bolts, while the finger extends into the opening in the center of the valve. Through this finger is an oil hole, which is filled with oil when assembling the gear, to provide lubrication of the four bearing rings.

The bronze bearing rings on each side of the integral collar on the adjusting screw mate against steel bearing rings, which latter bear against the shoulders of the valve operating arm and cap.

The valve operating arm is symmetrical, so that it is not possible to place it in position incorrectly. The ends of the arm and cap make contact with surfaces on the cylinder head casting, which surfaces provide stops to limit the extreme forward and backward travel of the gear valve.

When spreading the cotter pins on the through bolts, the ends of the cotters should be bent around the nuts so that they will not rub against the cover plate.

THE HAND WHEEL AND INDICATOR, Fig. 5, is fastened to the boiler head through four bolting lugs. The screw shaft has 1½" triple thread, left hand, six threads per inch, 1/2" lead. The indicator block moves along the screw to show the point of locomotive cut-off.

When used on Booster-equipped locomotives, the steel forged indicator block has an extension arm which carries the Booster latch. The reverse lever pilot valve is fastened to the forward end of the indicator bracket on a steel plate. This arrangement requires that the indicator block be in or near the corner in the forward position in order to engage the Booster latch or latch lever; as well as to permit it to automatically disengage when the indicator block is moved back to a point where the latch or latch lever will not engage with the end of the spring

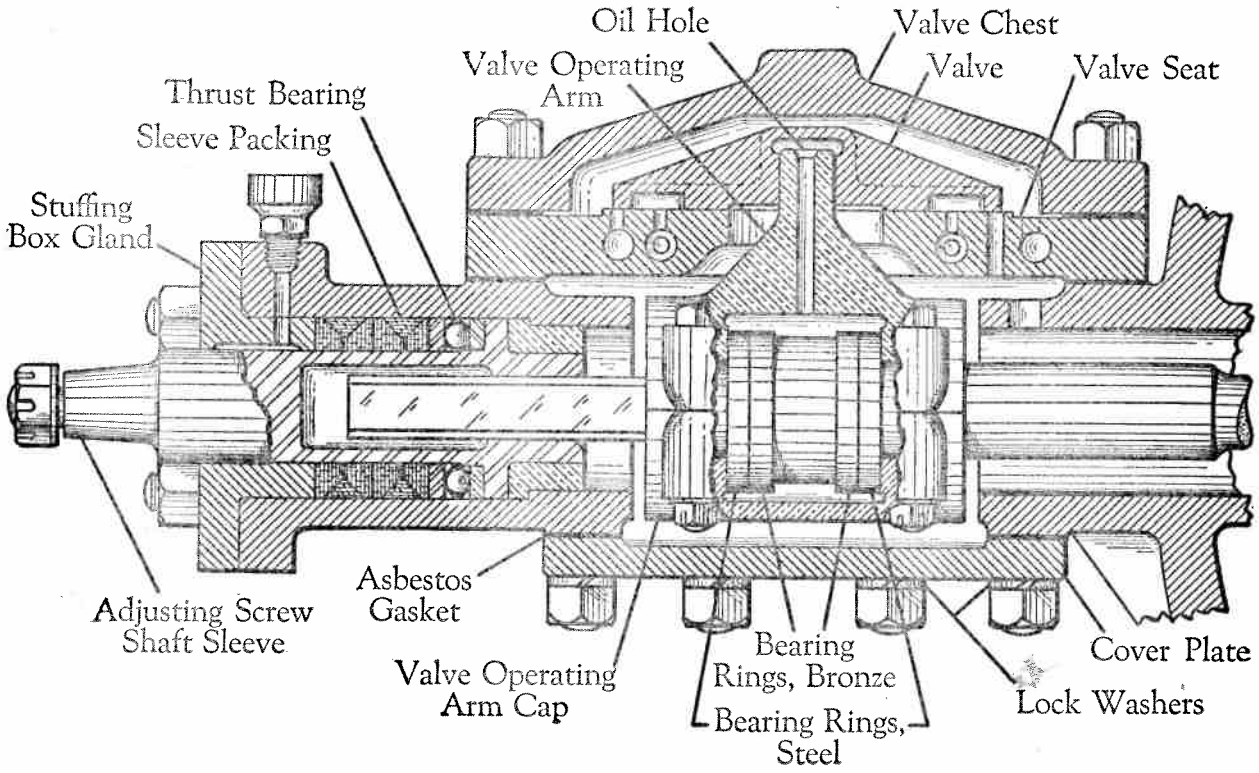

Fig. 4. Cross-Section Through Back Head Unit.

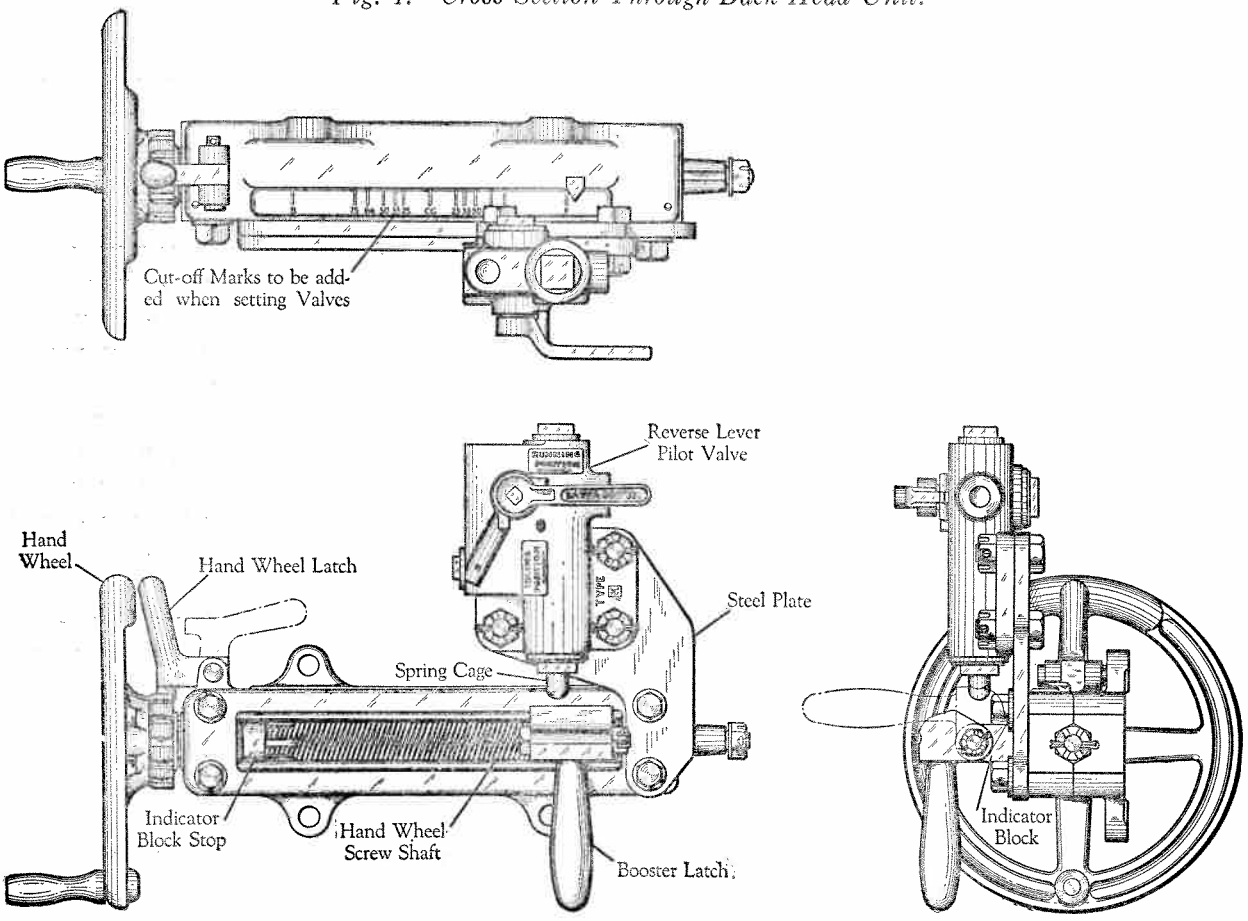

Fig. 5. Precision Reverse Gear Hand Wheel and Indicator with Reverse Lever Pilot Valve.

cage of the reverse lever pilot valve. The above mentioned point of disengagement for the long cut-off locomotive is about 66% locomotive cut-off; and for the limited cut-off locomotive it is proportionately shorter.

The two splined indicator block stops are permanently secured to the hand wheel screw shaft to limit the full forward and backward travel of the indicator block as outlined under APPLICATION.

THE UNIVERSAL JOINTS, Fig. 6, provide the

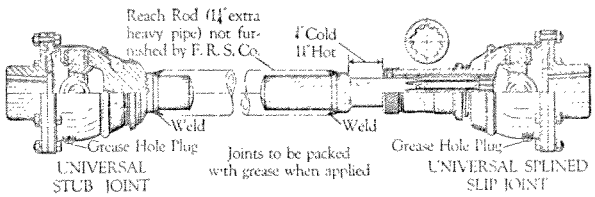

Fig. 6. Universal Joints: Precision Power Reverse Gears

necessary flexible connection between the hand wheel screw shaft and the adjusting screw shaft sleeve with which they have keyed and taper fit connections.

The gear universal joint has a splined slip joint to provide for the longitudinal movement of the shaft sleeve, which is due to the difference in expansion or contraction of the boiler and the reach rod. The total permissible movement of the slip joint is 2". This joint is used at the gear end of the rod in the two-joint installation, also at the gear end and at the indicator end in the three-joint application so that the joint does not have to carry the weight of the rod.

The ends of the stub ball yoke and of the slip stud shaft of the universal joints are machined slightly under the inside diameter of the 1¼" extra heavy pipe reach rod, to which they are secured by welding.

THE GEAR REACH ROD, which connects the indicator and the gear through the universal joints, is made of 1¼" extra heavy pipe. Its ends are welded to the stub ends of the joints. The length of this reach rod is determined as outlined under APPLICATION.

To provide for the proper operation of the universal joints, the angles between the center line of the indicator and the gear reach rod; and between the center line of the gear and of the gear reach rod, must not exceed 15°.

When a third universal joint is used, there being slip joints at both the indicator and at the gear, a combination plain reach rod bearing and thrust bearing or a combination roller and ball thrust bearing, must be applied near the fire box throat sheet, between the indicator and the joint, to carry the weight of the reach rod and its integral parts, as well as to distribute the movement so that each slip joint will take care of its proportion of the movement.

After the bearing has been secured in position, a steel collar should be spot-welded to the reach rod on the cab side of this bearing to relieve the intermediate and gear universals of the thrust due to the weight of the rod.

LUBRICATION. Light engine oil is supplied to the valve and cylinder from the lubricator on the air line in the cab. The lubricator should be filled at least once each trip.

The screw shaft sleeve and packing are lubricated from a compression grease cup, on the extension of the back head, which should be turned down daily and filled as required.

The boss on the extension of the back head provides for a lubricator for the screw shaft thrust bearing, when required.

The trunk tube is packed with grease for lubricating the adjusting screw. The supply put in by the builder should be sufficient to run between shoppings.

The piston trunk and packing are lubricated from wicking in the swab ring.

The universal joints should be packed with soft grease when applied.

When the gear is overhauled, the top of the cylinder should be well lubricated by swabbing with oil and the trunk tube should be repacked.

The tapped hole at the end of the piston trunk may be used to introduce lubricant to all surfaces of the cylinder by the use of a pressure gun when desired.

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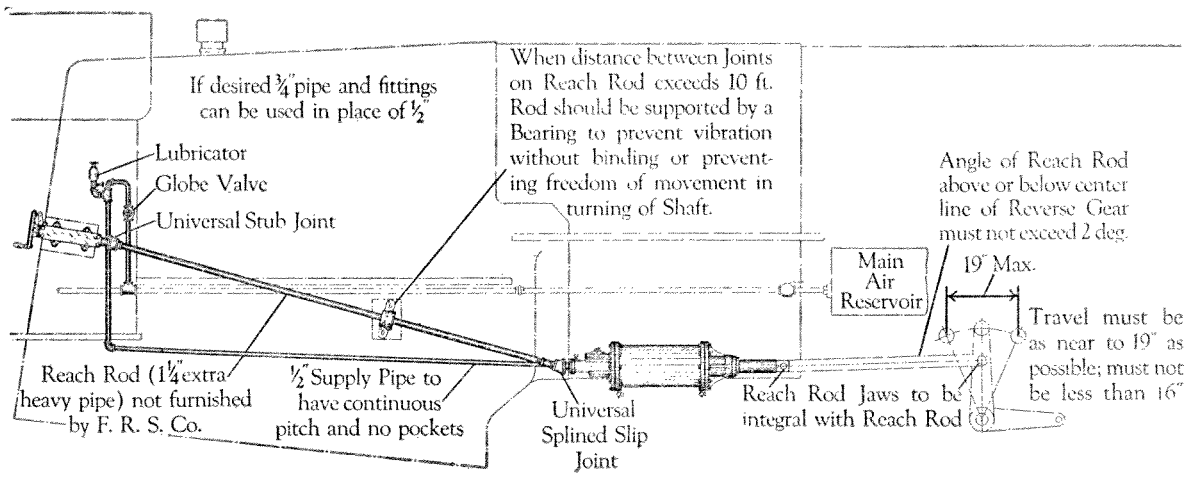
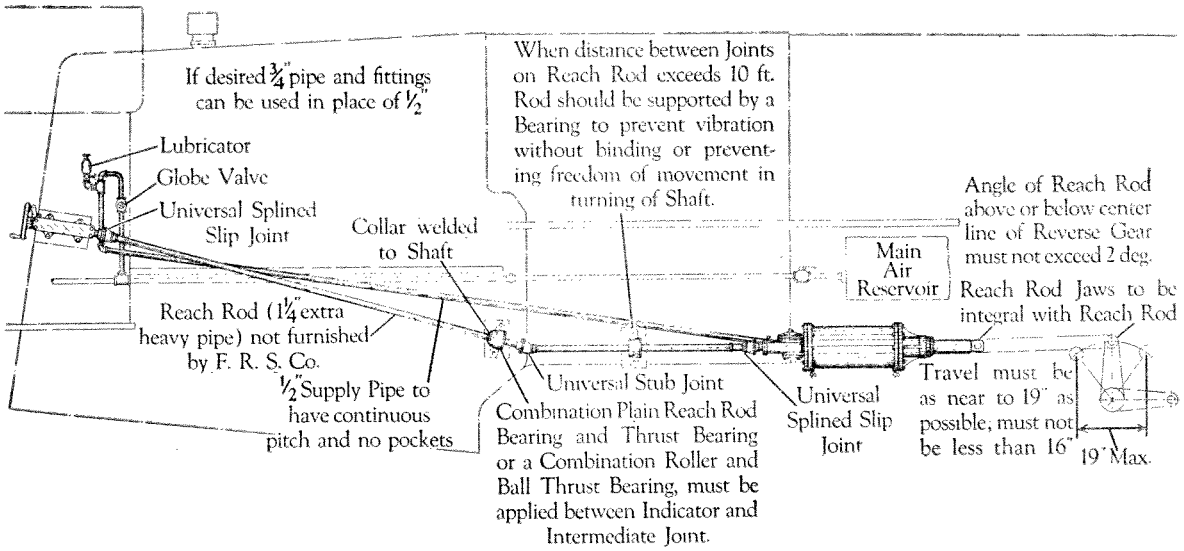


TYPICAL APPLICATION USING TWO UNIVERSAL JOINTS



TYPICAL APPLICATION USING THREE UNIVERSAL JOINTS

Fig. 7. Typical Applications and Piping Arrangements, Precision Power Reverse Gear, Type F

APPLICATION

Typical applications and piping arrangements of the Precision Power Reverse Gear, Type F, are shown in Fig. 7. The air piping layouts are shown as made for air operation only, as the use of steam for emergency steam operation is not desirable. This gear is designed so that it can be manually operated in case of air failure. The introduction of steam into the cylinder has a detrimental effect upon the cup packing rings.

The cylinder supports should be located so as to provide for the locomotive reach rod being not less than 36″ long. These supports, as well as the one for the indicator, should be of sufficient size and construction to hold the parts rigidly.

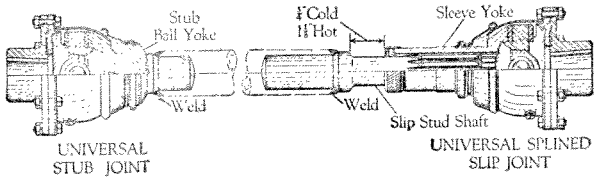


Fig. 8. Universal Joints: Precision Reverse Gears

The following outlines an effective method for the application of this gear.

1. Bolt the reverse gear and the indicator in their respective positions, making certain that their positions will provide for the proper operation of the universal joints; that is, so that the angles between the center lines of the indicator and the gear reach rod; and between the center lines of the gear and the gear reach rod, will not exceed 15°.

2. *To Determine Locomotive Reach Rod Length.* The locomotive valve gear must be placed on dead center position.

3. Make a temporary air supply connection to the gear. Admit air to the gear and, by turning the companion flange of the gear universal joint, place the piston at its central position. While turning the flange and screw, the piston trunk should be held to prevent it from turning. When the piston is in this position, the center of the piston trunk pin hole will be 13⅛″ from the front face of the trunk packing gland (not swab ring).

4. The length of the locomotive reach rod can then be measured, making necessary allowance for expansion or contraction of the boiler.

5. *To Determine Gear Reach Rod Length.* Lay off the center line on the cover plate of the indicator. This may be done by backing off the indicator block stops so that the indicator block may be run to its maximum travel points in both directions. Midway between these maximum travel points will be the position of the center line.

6. Push the slip stud shafts of the splined universal joints, Fig. 8, into the sleeve yokes as far as possible.

7. *Two-Joint Application:* Measure the distance between the shoulder of the slip stud shaft of the gear universal joint and the shoulder of the stub ball yoke of the cab universal joint. The proper length of the gear reach rod will be 3/4″ less than this measurement when making the application to a cold boiler, and 1⅛″ less than this measurement when making the application to a hot boiler.

8. *Three-Joint Application:* Locate the intermediate joint, Fig. 7, near the fire box throat sheet. For the front section of the rod; measure the distance between the shoulder of the slip stud shaft of the gear joint and the shoulder of the ball yoke of the intermediate joint. For the back section of the rod; measure the distance between the end of the companion flange of the intermediate joint and the shoulder of the slip stud shaft of the indicator joint. The lengths of each section of the gear reach rod will be 3/4″ less than the respective measurements when making the application to a cold boiler, and 1⅛″ less when making the application to a hot boiler.

9. The above mentioned 3/4″ and 1⅛″ allowances are made to provide for the expansion or contraction of the boiler, which allowances also provide a minimum 3/4″ clearance when disconnecting the gear universal joint at the companion flange. The total allowable movement of the slip joint is 1″ in either direction from the center position.

10. The stub ends of the universal joints should be fastened to the 1¼″ extra heavy pipe gear reach rod by welding.

11. In the case of a three-joint application, a round piece of steel should be fitted and keyed to the intermediate joint, after which it should be welded to the back section of the rod. When welding the bearing collar to the back section

of the reach rod, locate it so that it will distribute the longitudinal movement of both sections of the rod between the slip joints at the indicator and at the gear, retaining the 3/4" and 1⅛" clearances mentioned above.

12. Place the indicator block on the center line as noted in paragraph 5. Place the gear piston at its central position as noted in paragraph 3. The gear reach rod should then be put into position.

13. Connect the locomotive reach rod to the trunk piston and to the reversing arm of the tumbling shaft.

14. The lines of full gear forward, and full gear reverse, can then be located on the cover plate of the indicator, as follows:

15. With the air on the gear, by means of the hand wheel and as directed by the valve setter determine the proper locations of these lines to give full valve travel of the engine. This may most conveniently be done at a time when the valve setter is setting the valves, as it is necessary to rotate the driving wheels to operate the valve motion to obtain the correct travel of the engine valves.

16. The indicator block stops may then be permanently located so as to limit the travel of the indicator block to these lines. Spot the holes at least 3/16" deep in the screw shaft and use 3/8" headless set screws reaching into the holes in the shaft to prevent the stops from moving along the splines. The screw heads must be flush with the stops, so that they may be locked in position by forcing some of the metal of the stops into the screw driver slots of the set screws. Any intermediate lines, as specified by the railroad, to indicate different cut-off positions may then be added.

17. With those valve motions where tumbling shaft stops are used, the clearance betweeen the top of the stops and of the stop lugs on the tumbling shaft arm should not be less than 3/16". front and back, when the indicator block is against the stop in either direction.

One of the illustrated applications shows the use of two universal joints and one bearing, while the other shows the use of three universal joints and two bearings.

In cases where it is impossible to run the gear reach rod directly from the indicator to the gear, it is necessary to use a third universal joint placed at any convenient point where the rod changes direction. In this case, universal splined slip joints are used at both the indicator and at the gear, while a stub universal joint is used at the junction of the two parts of the reach rod.

The bearing, as used for the two-joint application, must be used on the front section of the rod; and a combination plain reach rod bearing and thrust bearing or a combination roller and ball thrust bearing on the back section of the rod, as noted under THE GEAR REACH ROD, page 8.

PIPING. In the piping arrangements shown in Fig. 7, it is important that the lubricator be located in the cab so that the oil will flow freely to the gear. The air supply pipe should have a continuous pitch to its connection at the gear and so arranged as to avoid pockets in which moisture may collect. If this matter does not receive proper attention, trouble may be experienced in cold weather from the freezing of water in the pipes.

All pipes should be thoroughly hammered and blown out, in order to loosen and remove all scale and foreign matter before being connected. This is especially important in new installations. After the piping is complete, all joints must be thoroughly tested under pressure and made air tight.

TESTING

If the gear has been disassembled, be sure that the indicator block is in the central position and that the center of the piston trunk pin hole is 13⅛" from the trunk packing gland (not swab ring) before connecting the gear reach rod.

At the front end of the piston trunk there is a small tapped hole communicating with the space between the walls of the trunk and the trunk tube. The holes through the bull ring and the piston also communicate with this space.

To test the piston packing cup on the back of the piston, turn the hand wheel to the right, if the adjusting screw is left-hand. This will move the small gear valve backward and open the ports for admission of air to the back end of the cylinder and for exhaust from the front end. If the air blows through the small tapped hole at

the end of the piston trunk before movement of the piston has ceased, it indicates that the back packing cup is leaking.

The packing cup on the front end of the piston may be similarly tested by reversing the operations of the above test.

The trunk packing may be tested while pressure is in the front end of the cylinder, as leakage would show at the trunk packing gland.

The sleeve packing may be tested while pressure is in the back end of the cylinder, as leakage would show at the stuffing box gland.

As wear or leakage is automatically compensated for in both the trunk and sleeve packings leakage through either indicates worn out packing and it should be renewed.

If necessary to replace packings, the work should be done as described under TERMINAL MAINTENANCE.

A leak at the gear valve, when the gear is at rest, is shown by a blow at the exhaust port. If reseating is necessary, the valve and the valve seat should be separately spotted to a surface plate and then spotted to each other. The removable feature provides for easy replacement of the valve and seat by other parts which maybe carried in stock properly spotted for emergency use.

It is to be noted that a leak at the valve does not always mean that reseating is necessary. The cause may be merely a deposit of pipe scale or dirt which can usually be removed by a bath of light oil applied through the lubricator in the cab.

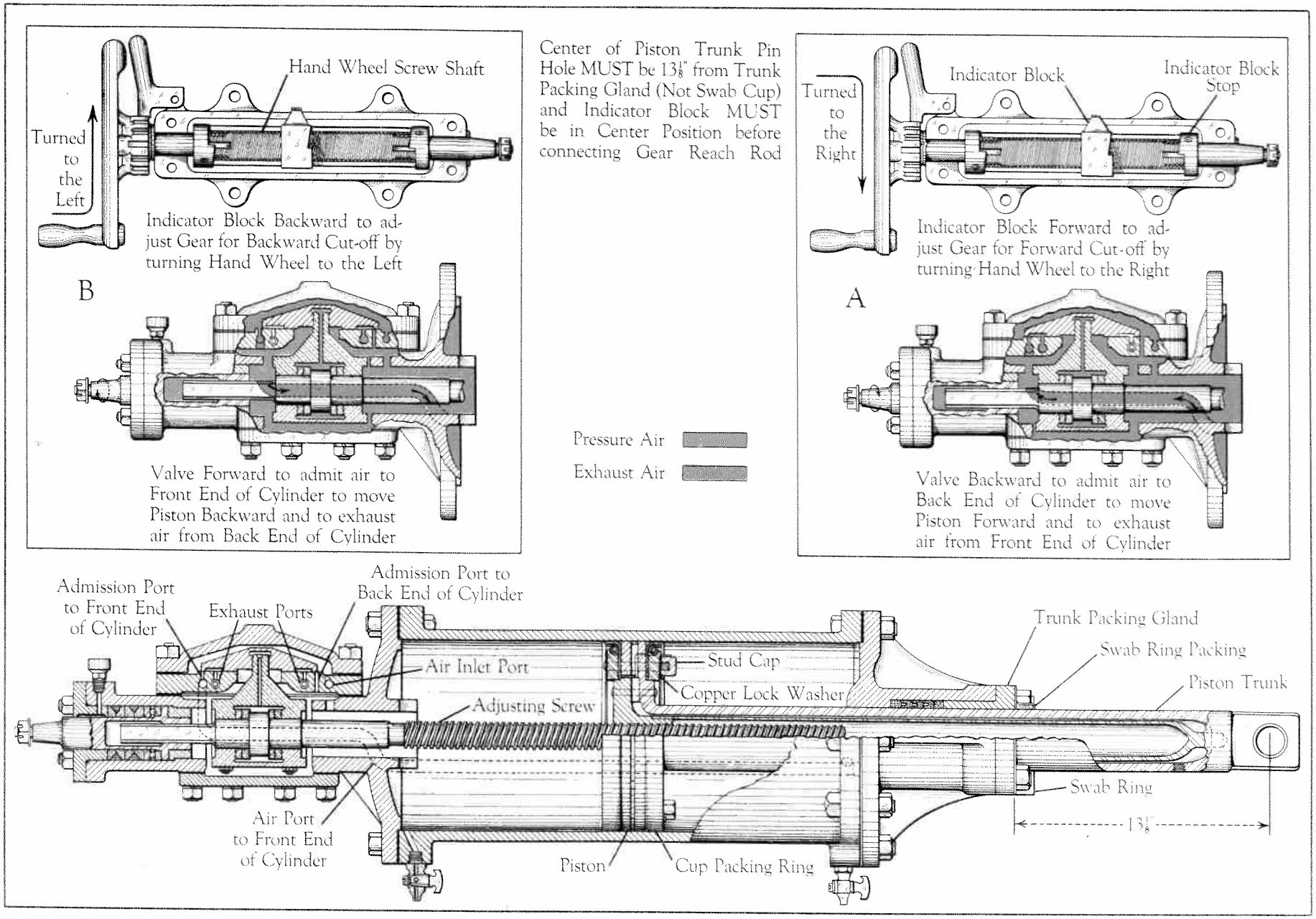


Fig. 9. Sequence of Operations

CONTROL

SEQUENCE OF OPERATIONS

Fig. 9 shows a cross-section of the Type F gear. The two separate back head units are broken away sufficiently to expose the parts in order to illustrate the manner in which the valve directs the air to and from both sides of the piston; the two assembled indicators show the indicator block in positions to correspond with the positions of the parts in the back head units. when the hand wheel is being turned in the directions indicated.

In order to clearly illustrate the movement of the air to and from the cylinder, the PRESSURE AIR is shown in RED, while the EXHAUST AIR is shown in GREEN.

It must be remembered that the air flows to and from the front end of the cylinder through the port at the back end of the valve seat and the passages in the back head casting and in the boss extending along the cylinder wall.These passages are shown dotted in the cross-section view of the gear and are indicated by RED or GREEN, on the back head units, depending upon whether the air at the time is PRESSURE or EXHAUST.

It must also be remembered that the air flows directly to and from the back end of the cylinder through the port at the front end of the valve seat.

Air is supplied to the reverse gear from the main reservoir through the brake pipe or a main reservoir pipe and the globe valve near the indicator in the cab. When this valve is open, the air passes through the line to the inlet port at the side of the back head casting, through the valve seat and into the valve chest.

Consider that the locomotive valve gear is on dead center and it is desired to adjust it to a forward cut-off, the gear having a left-hand adjusting screw.

The hand wheel must be turned to the right, and since the screw shaft is left-hand, the indicator block will move to a forward position as shown at A, Fig. 9. This movement is transmitted to the adjusting screw which moves the gear valve backward, since the gear piston, at this moment, is stationary and since the adjusting screw is also left-hand. This movement of the valve allows PRESSURE AIR to pass to the back end of the cylinder and EXHAUST AIR to pass from the front end of the cylinder.

This condition, as regards both the indicator block and the gear valve, is shown at A. PRESSURE AIR is shown as passing through the admission port at the front end of the valve seat to the back end of the cylinder, while EXHAUST AIR is shown as passing through the cored passage in the back head casting and the exhaust port at the back end of the valve seat from the front end of the cylinder.

Due to the release of the EXHAUST AIR from the front end of the cylinder and the continued supply of PRESSURE AIR to the back end of the cylinder, the gear piston is moved forward to adjust the locomotive valve gear to the desired forward cut-off, as shown by the indicator block. This forward movement of the gear piston, together with turning of the hand wheel, moves the gear valve to a position where it will admit PRESSURE AIR and release EXHAUST AIR from the proper sides of the piston in sufficient quantities to obtain the desired locomotive cut-off. The piston tends to move the valve the same distance and direction it is traveling, but turning of the hand wheel varies the distance between the piston and the valve, so that air is continuously admitted to one side of the piston and released from the other side as long as the turning is continued.

The gear valve can never stand in the exact central position on the valve seat, as shown in Fig. 4, when air is on the gear, due, first; to the difference in effective areas of the two sides of the piston, and second; to the pull and weight of the locomotive valve motion.

Consider that the locomotive valve gear is on dead center and it is desired to adjust it to a backward cut-off and that the left-hand adjusting screw is used.

The hand wheel must be turned to the left. The indicator block will move to a backward position as shown at B, Fig. 9, while the gear valve will move forward. This movement of the valve

allows PRESSURE AIR to pass to the front end of the cylinder and EXHAUST AIR to pass from the back end of the cylinder.

This condition, as regards both the indicator block and the gear valve, is shown at B. PRESSURE AIR is shown as passing through the admission port at the back end of the valve seat and through the cored passage in the back head casting to the front end of the cylinder, while EXHAUST AIR is shown as passing through the exhaust port at the front end of the valve seat from the back end of the cylinder.

Due to the release of EXHAUST AIR from the back end of the cylinder and the continued supply of PRESSURE AIR to the front end of the cylinder the gear piston is moved backward to adjust the locomotive valve gear to the desired backward cut-off, as shown by the indicator block. This backward movement of the gear piston, together with turning of the hand wheel, moves the gear valve to a position where it will admit PRESSURE AIR and release EXHAUST AIR from the proper sides of the piston in sufficient quantities to obtain the desired locomotive cut-off.

In order to move the locomotive valve gear for a considerable distance in either direction, the hand wheel must be continually turned until the indicator block registers the desired position of the locomotive valve gear. This is necessary in order to maintain the gear valve in a position so that it will continue to admit PRESSURE AIR to one side of the gear piston and release EXHAUST AIR from the other side of the piston, since the continued movement of the piston, after turning of the hand wheel has ceased, moves the gear valve toward its central position on the seat. The only effort required of the engineman is that of turning the hand wheel and attached rotating parts and moving the valve, as the air pressure acting upon the gear piston does the actual work of moving the locomotive valve gear.

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OPERATING INSTRUCTIONS

1. *How Should the Gear be Lubricated?*

Engine oil should be used in the lubricator in the cab, filling it at least once each trip. The grease cup on the end of the back cylinder head should be turned down daily and filled as required. The piston trunk and packing are lubricated from lamp wicking in the swab ring.

2. *What Precaution Should Be Taken Before Moving a Gear-Equipped Locomotive?*

Be sure that sufficient air pressure is available for operating the gear.

3. *What Is the Position of the Globe Valve When Operating the Gear By Air?*

The valve should be wide open.

4. *What Provision Is Made for Operating the Gear When Air Is Not Available?*

The gear may be manually operated.

5. *Should the Hand Wheel Fail To Turn Easily and There Be No. Exhaust from the Reverse Gear, What Is the Cause?*

There is either no air on the gear or the supply is not sufficient to properly operate it. The design of the Precision Gear provides for its being operated manually without the assistance of air pressure, although the hand wheel will not turn as easily as under normal conditions when air is on the gear.

6. *Under What Circumstances Is It Sometimes Possible to Overcome a Blow from the Exhaust?*

If it is caused by pipe scale or other foreign matter holding the valve off of its seat, one or two cups of light oil, applied through the lubricator in the cab, and a rapid working of the gear forward and backward may overcome the difficulty.

TERMINAL MAINTENANCE

1. *If There Is a Blow from An Exhaust Port, What Is the Probable Cause? How Remedied?*

This may be due to either pipe scale or foreign matter holding the valve off of its seat or to a leaky valve. If scale, one or two cups of light oil, applied through the lubricator in the cab and a rapid working of the gear, forward and backward, may overcome the difficulty. If a leaky valve, the valve and seat should be spotted or preferably replaced by similar parts carried in stock and properly spotted for emergency use.

2. *How Should the Valve Be Spotted?*

When a complete job of valve seating is necessary the valve and seat should be separately spotted to a small surface plate after which the parts should be spotted together.

3. *What Would Allow the Gear to Move After Being Adjusted?*

A leaky sleeve, trunk or piston packing; or gear valve, would allow air to escape from the cylinder thus unbalancing the pressures in the cylinder and allow the gear to move.

4. *Should the Hand Wheel Fail To Turn Easily and There Be No Exhaust from the Reverse Gear, What Is the Cause?*

There is either no air on the gear or the supply is not sufficient to properly operate it. The design of the Precision Gear provides for its being operated manually without the assistance of air pressure, although the hand wheel will not turn as easily as under normal conditions when air is on the gear.

5. *If There Is a Blow from the Hole at the End of the Piston Trunk, What Should Be Done?*

This would indicate a leaking piston cup packing. To determine which cup is leaking, turn the hand wheel to the right, if the left-hand adjusting screw is used, so as to move the gear valve backward to admit air into the back end of the cylinder and to exhaust it from the front end. If the blow at the hole continues before movement of the piston has ceased, it indicates that the packing cup on the rear side of the piston is leaking. Reversing the operation admits air into the front end of the cylinder and exhausts it from the back end. If the blow continues before movement of the piston has

ceased, it indicates that the cup on the front side of the piston is leaking.

6. *How Should New Cup Piston Packing Be Applied?*

(a) Place the gear piston on center by means of the hand wheel.

(b) Turn off the air.

(c) Disconnect locomotive reach rod from the trunk piston.

(d) Disconnect universal joint at gear by removing bolts through the companion flanges.

(e) Remove front cylinder head complete, including the trunk packing, gland, and swab ring.

(f) Run the piston out of the cylinder by turning the companion flange of the universal joint.

(g) Replace the piston packing cups, being sure to place the piston follower having the tapped holes at the rear of the piston, so that the stud caps will be on the front side of the piston.

(h) It is important that the copper lock washers be in good condition so as to prevent leakage through the piston. If they are worn, new ones should be applied.

(i) It is necessary to exercise special care when returning the piston to the cylinder to be sure that the cups enter the cylinder bore correctly.

(j) It is now necessary for one man to hold the piston trunk in position in the front end of the cylinder, while a second man turns the adjusting screw to enter the threads into the piston. The cover plate should be removed so that the adjusting screw may be held up to assist in entering the threads, which is made easy by the chamfer on the end of the screw. Run the piston into its approximate center position in the cylinder.

(k) Replace the front cylinder head complete (as removed) unless it is necessary to renew the trunk packing.

(l) The head should be drawn evenly into position, using four opposite T-bolts, in pairs at 90° to each other. If not drawn up evenly, free movement of the piston will be prevented. This can be tested by running the piston back and forth the full length of the cylinder by turning the screw by hand.

(m) Replace cover plate. Turn on the air. Place the piston on center by turning the adjusting screw by hand. Piston is on center when center of the piston trunk pin hole is $13\frac{1}{8}$" from end of trunk packing gland (not swab ring). Place indicator block on center. Bolt together the companion flanges of the universal joint. Connect locomotive reach rod to the piston trunk.

7. *When Should New Sleeve Packing Be Applied?*

When the end of the universal joint has worked about 1" away from the gland. This amount of movement indicates a worn out condition and new packing should be applied.

8. *How Should New Sleeve Packing Be Applied?*

(a) Set the indicator block and the gear piston on their central positions, so that the gear setting will not be changed by disconnecting the universal joint. It is desirable to set the gear piston on its central position, as the $13\frac{1}{8}$" dimension can then be used as a check against possible movement of the piston.

(b) Turn off the air.

(c) Remove bolts through the flanges of the universal joint, and remove the gland and screw shaft sleeve.

(d) The new packing can then be applied without disturbing the indicator block or any other part of the gear.

(e) The gland should be drawn up tightly against the head.

(f) Replace bolts in flanges of universal joint.

9. *What Should Be Done If the Trunk Packing Leaks?*

The trunk packing is self-retaining and compensates for wear as it develops. If the packing leaks, it indicates a worn out condition and new packing should be applied.

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