

No. 171-A

# THE PENNSYLVANIA RAILROAD

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MACHINERY EXAMINATIONS

FOR

LOCOMOTIVE FIREMEN

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1949



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## MACHINERY EXAMINATIONS FOR LOCOMOTIVE FIREMEN

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Issued Philadelphia, Pa.  
June 1, 1949

### GENERAL NOTICE

The examinations contained herein have been compiled with the view of establishing a uniform method of examination and rating for Locomotive Firemen.

Locomotive Firemen will be required to pass the examination and obtain not less than the minimum rating on the questions herein set forth.

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General Manager, Eastern Region,  
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APPROVED :

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Chief of Motive Power.



## GENERAL DESCRIPTION

1. Firemen, when first employed, and those now in service, will be furnished a copy of the authorized Machinery Examinations. They must visit the Motive Power Instruction Room or Car where such facilities are provided and receive instructions, and where such facilities are not provided, they will receive their instructions from the Assistant Road Foreman of Engines or such other persons that may be assigned to do such duties. Firemen must continue to study the subjects outlined in the Examination Book to become well informed on mechanical appliances.

2. These examinations are on the progressive plan. The entire subject is divided into four parts; the first, the second, the third and the fourth, or promotion examination.

If fireman is to be promoted to engineman at the time he receives the third progressive examination, he will be required to take the fourth, or promotion examination, otherwise, he will not be required to take the promotion examination until notified by the Road Foreman of Engines to prepare for promotion.

3. Fireman will receive the first progressive examination at the end of twelve (12) months extended to cover 365 days period of actual service. The second examination at the end of an additional twelve (12) months, extended to cover 365 days period of actual service, and the third examination after a succeeding period of twelve (12) months, extended to cover 365 days period of actual service. If furloughed, an extension of time will be given, extending to that extent the 365 days period. Ninety (90) days continuous service must be had preceding the several examinations.

4. This method of progressive examinations shall become effective three (3) months after the date this book is issued, and each Fireman then in service will receive the progressive examination corresponding to his years of service. Firemen may, if they so desire, take their proper progressive examination in less than the three (3) months above stipulated.

5. No further machinery examination will be required for promotion to the position of engineer unless promotion is deferred for one (1) calendar year after passing the third progressive examination, in which event, Fireman will be required to pass the fourth machinery examination for promotion.

6. Engineers demoted to the position of Fireman and who have not been used as engineers for a period of two (2) years, will be required to pass the final or fourth machinery examination before permanently resuming duty as engineers.

7. The required rating for the examinations will be as follows :

First progressive examination	-	80	per cent.
Second progressive examination		80	per cent.
Third progressive examination	-	80	per cent.
Fourth examination	- - - -	85	per cent.

8. Firemen failing to obtain the required rating will be promptly notified in writing, and furnished with copy of rating form showing by number the questions in which they failed.

9. Firemen failing to pass the first examination on any of the several progressive examinations will be allowed thirty days in which to prepare for a re-examination, and failing to pass the re-examination will be allowed an additional thirty days further to prepare themselves for a second re-examination. Firemen failing to obtain the required rating after a second re-examination of the several progressive examinations will not be permitted to resume duty until they pass. This opportunity is not to extend beyond nine (9) months and will be cancelled if the employe takes employment elsewhere. Reasonable transportation will be given the employe to visit the instruction room.

Failure to pass the promotion examination will be handled in accordance with promotion rule.

10. Examiner may require answers to other questions than those enumerated on the printed list in order to determine if the man thoroughly understands the entire subject on which he is being examined. The examiner is privileged to take the fireman to a locomotive and have him demonstrate that he fully understands the questions and answers. The Fireman has the same privilege if he desires to avail himself of it.

11. When the introduction of new equipment requires it, Engineers and Firemen will be instructed on same and examined if considered necessary.

12. All examinations will be oral and promotion examination will be individual.

#### METHOD OF RATING

1. In order that an accurate record may be obtained showing the employes' general knowledge of the locomotive, a master form showing the questions and their value is at the rear of book.

2. When the employe is being examined, the examiner will place an (X) mark on the number of all questions on which the employe fails, which will represent a total failure on that particular question, while a partial failure will be represented by one line drawn, crossing the square from diagonally opposite corners in which the number is enclosed.

3. The value of each question is shown in the corner of the square in which the number is enclosed. Each block has a total rating of 100%. In case of failure to answer a sufficient number of questions in any one block to obtain the required rating, a re-examination will be required of the entire block in which these questions appear.

4. After the examination has been completed, the average rating for the examination will be obtained by adding the total rating of each block and dividing by the number of blocks on which the employe is examined. The average rating, however, will not be considered as a passing mark, unless the specified minimum rating has been obtained on each of the several blocks.

5. Employes will not be examined on blocks of questions covering equipment that is not operated on his division.

6. After completion of the examination, the examiner will make up the result of the examination from the master form M.P. 33-F appended at rear of book, and notify the employe of the result and have him sign Form C.T. 1515. After Form C.T. 1515 has been received by the officer designated by the Superintendent, the information contained therein shall be transferred to Form C.T. 170 for each employe as a permanent record. The C.T. 1515 will be returned to the employe as his record after being recorded.



# INSTRUCTIONS FOR LOCOMOTIVE FIREMEN-

## PART I

### GENERAL

In becoming a locomotive fireman you are serving an apprenticeship as a prospective locomotive engineer and should consider the engineer for whom you are firing in the same position as the foreman of the shop in which you might be learning a trade.

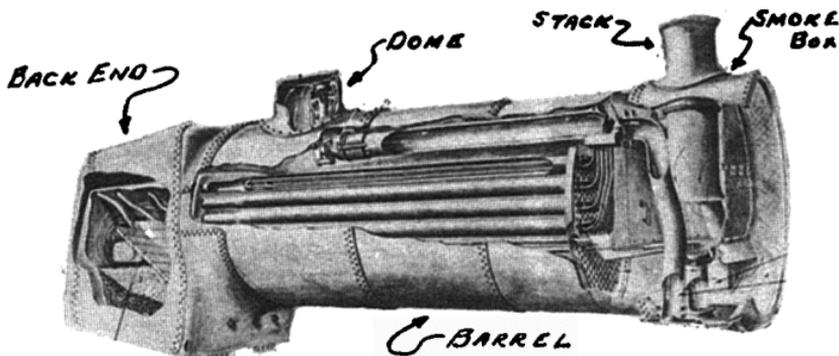
In no other situation is close cooperation more important between two persons than between the engineer and fireman operating a modern locomotive. Upon the decisions and performance of these two men depend the proper operation of the locomotive and the skillful handling of the train.

The engineer is responsible for the locomotive and its performance; the fireman is responsible to the engineer. Lack of crew cooperation is far reaching and may result in disastrous consequences.

There are different kinds of equipment used on locomotives which require care, skill and intelligence to operate properly and secure the best results. The purpose of this book is to give you a general idea of the various kinds of equipment and their operation and to prepare you for promotion to locomotive engineer.

## CHAPTER I

### Description of Boiler—Back End—Arch Tubes—Circulator—Fusible Drop Plugs—Smoke Box—Steam Pressure—Safety Valves



LOCOMOTIVE BOILER  
FIG. 1.

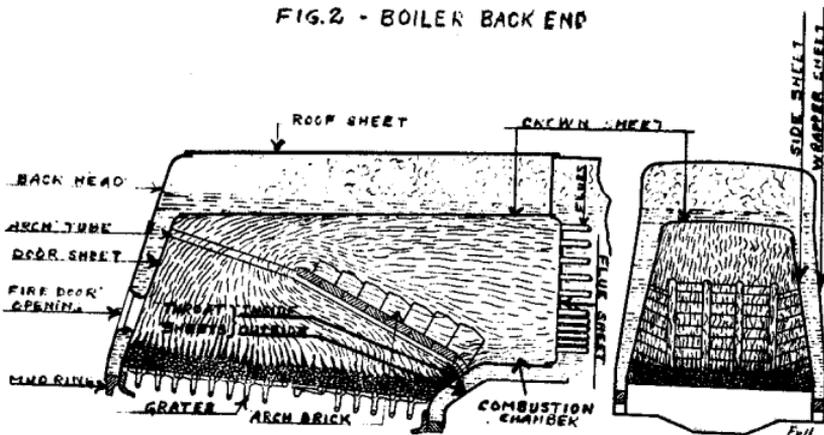
**Boiler**—A locomotive boiler (Fig. 1, page 7) is cylindrical in shape with the exception of the back end which is a rectangular shaped structure. The boiler is provided with a front and a back flue sheet through which tubes or flues pass, a fire box, a steam dome, and a smoke box at the front end.

**Back End**—The boiler back end consists of two shells (Fig. 2, page 8.). The firebox, or inner shell consists of a crown sheet, two side sheets, a flue sheet through which tubes or flues extend to the smoke box, and a door sheet, together with arch tubes and circulator if used. Fire boxes on larger type locomotives have a combustion chamber with an inside throat sheet.

The outer shell consists of a roof sheet, two wrapper sheets, back head, and throat sheet. The inside and outside sheets are secured to a mud ring located between the sheets at bottom of firebox.

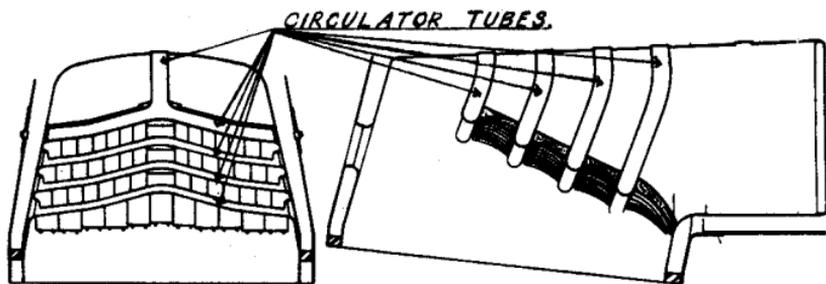
The inside sheets are in contact with the water on one side so that the heat is transferred to the water and prevents damage to the sheets due to overheating. The space below the crown sheet between the inside and outside sheets is known as water legs.

FIG. 2 - BOILER BACK END



The flue sheet and flues are most sensitive to sudden changes of temperature.

**Arch Tubes**—The arch tubes are steel tubes extending from the lower part of the fire box at the front, to the top of the door sheet, and are for the purpose of supporting the brick arch (Fig. 2, page 8).



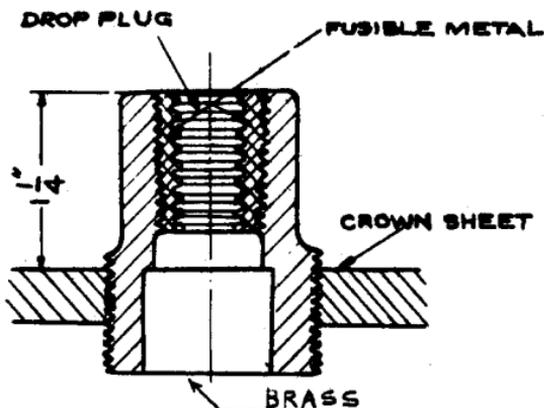
TYPICAL INSTALLATION OF COAL BURNING TYPE CIRCULATORS

FIG-3.

**Circulators**—The circulators are steel tubes connected to each side of the fire box with an extension into the crown sheet. They add to the effective heating area of the boiler, improve the circulation of the water in the side water legs and over the crown sheet, and also, support the brick arch (Fig. 3, page 9).

**Fusible Drop Plugs**—Each locomotive fire box is, equipped with from 2 to 6 fusible drop plugs (Fig. 4, page 10). These plugs have soft metal around the center or core and are screwed into the crown sheet with the top of the plug extending above the level of the sheet. Their purpose is to prevent damage to the fire box from low water. If the water over the crown sheet gets below the top of the plug, the heat from the fire melts the soft metal, causing the center or core to blow out. The escaping steam tends to deaden the fire, reduce the pressure on the crown sheet, and gives warning of what has occurred by a loud hissing sound. Any unusual sound in the fire box should be carefully inves-

tigated to determine the cause, and if it is due to the core of the fusible plug blowing out, the fire must be immediately dumped or extinguished and the matter reported at once.



FUSIBLE PLUG  
FIG. 4

**Smoke Box**—The smoke box is secured to the front end of the boiler. Located inside the smoke box are pipes to carry steam from the boiler to the steam chest or valve chambers, also draft appliances to create draft when locomotive is not working. The smoke stack located on top of the smoke box is the only outside portion of the draft appliances.

**Steam Pressure**—Steam pressure is the pressure per square inch inside the boiler and is shown on the steam gauge located on the back head. The maximum working pressure for each locomotive is shown on a badge plate secured to the back head.

**Safety Valves**—Each locomotive boiler is equipped with at least two safety valves (Fig. 5, page 11). Their purpose is to relieve the boiler of excess pressure. These valves are located on top of the boiler and operate automatically. If one valve fails or does not relieve the pressure fast enough, the other valve will assist.

It is important to know that the safety valves open at the maximum working pressure as shown on the badge plate. This can be determined by comparing the steam gauge with the opening or discharge of steam from the safety valves.

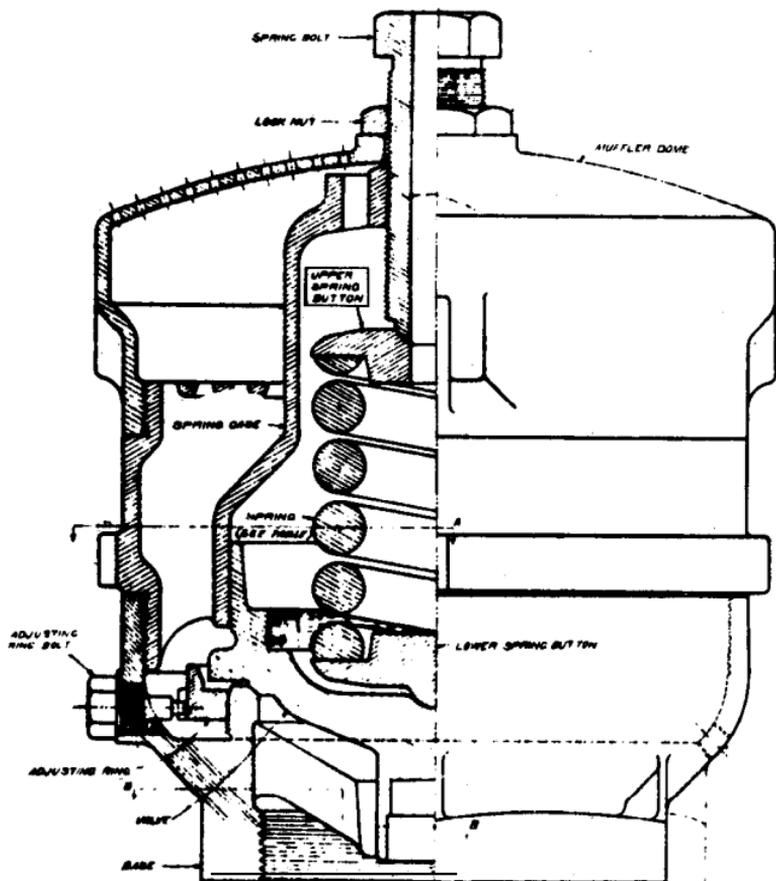


FIG. 5 SAFETY VALVE.

## QUESTIONS ON CHAPTER I

1. Describe the general shape of a locomotive boiler.
2. What does a boiler back end consist of?
3. What is the inner shell of a boiler back end called?
4. Name the sheets that comprise a fire box.
5. Name the outside sheets that surround a fire box.
6. Where is the mud ring located?
7. What sheets are entirely surrounded by water and for what purpose?
8. What are the water legs of a boiler?
9. What parts of a boiler are most sensitive to sudden changes of temperature?

10. What are arch tubes and what is their purpose?
11. What are circulators?
12. What is the purpose of circulators?
13. What is a fusible drop plug?
14. Where are fusible drop plugs located in a fire box?
15. What is the purpose of fusible drop plugs?
16. What occurs to fusible drop plugs when the water over the crown sheet gets below the top of the plug?
17. What should be done if the core of a fusible drop plug has blown out?
18. What should be done if an unusual sound is heard in fire box?
19. Where is the smoke box located?
20. What appliances are located in the smoke box?
21. What is meant by steam pressure and how can you tell what steam pressure you have on the boiler?
22. How do you tell the maximum working pressure of a locomotive boiler?
23. What is the purpose of safety valves on a locomotive boiler?
24. Why is more than one safety valve necessary?
25. When should safety valves open and how can this be determined?

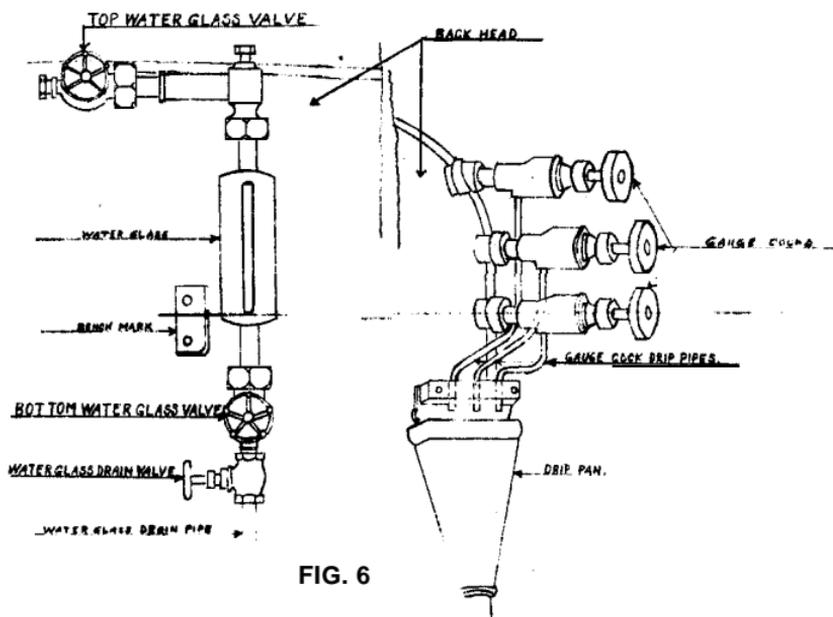
## CHAPTER 2

### Description and Operation of Gauge Cocks—Water Glass—Injectors—Feed Water Pumps

**Gauge Cocks**—The gauge cocks are valves screwed into the back head (Fig. 6, page 13) or water column (Fig. 7, page 14) for the purpose of ascertaining the water level in the boiler. This is determined by the discharge of water or steam from the drip pipes attached to the gauge cocks. The difference between water and steam can only be determined by looking and seeing what comes out of the drip pipes. Never trust to sound.

Gauge cocks must be tested before each trip and used frequently when the engine is working and immediately after closing the throttle if conditions require.

## WATER GLASS and GAGUE COCKS on BACK HEAD



Some classes of locomotives that have an unusually long crown sheet are equipped with an auxiliary set of gauge cocks known as mountain gauge cocks. They are located at top of back head and have a feeder tube inside the boiler extending from the gauge cock to the front end of crown sheet. This type is used when ascending steep grades to insure that there is sufficient water over the front or highest point of crown sheet.

When it is definitely known that there is no indication of water out of the bottom gauge cock, the fire must be dumped or extinguished immediately.

**Water Glass**—The water glass is a glass gauge connected at both ends to either the back head (Fig 6, page 13) or the water column (Fig. 7, page 14). The bottom or lowest reading of the glass is on the same

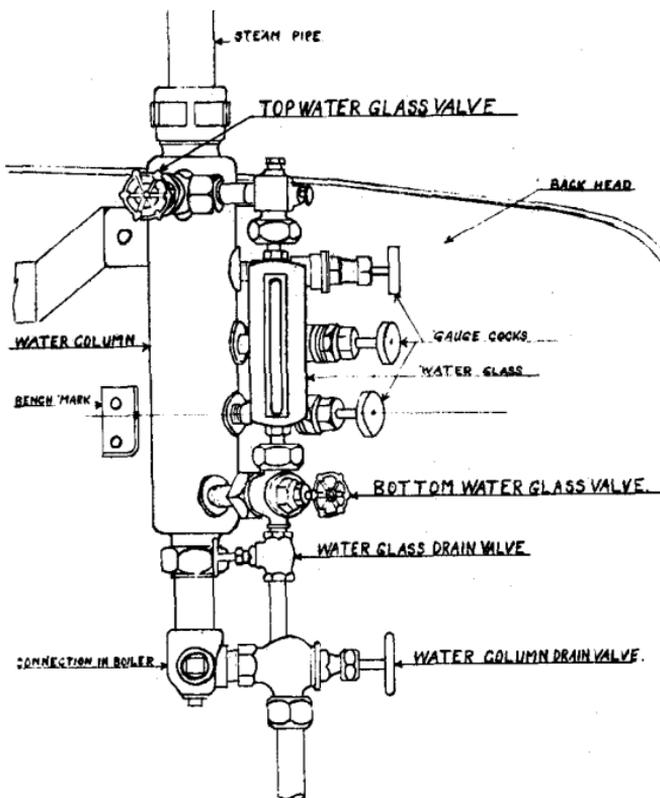


FIG. 7-ARRANGEMENT of WATER COLUMN.

level with the bottom gauge cock. It is an auxiliary to the gauge cocks for the purpose of ascertaining the water level in the boiler, but its use must not be wholly depended upon.

The water glass and water column must be blown out before each trip, and the water glass tested in the following manner to insure that water is circulating in the glass and the water glass valves operate properly:

1. The water column, if used, must be blown out first to keep sediment from entering the water glass.

2. Open the water glass drain valve to blow out water glass, then close the bottom water glass valve and note that there is a good flow of steam from the drain pipe.

3. Then close the top water glass valve and see if both cocks are tight. (There should be no discharge from drain pipe.)

4. Open the bottom water glass valve wide and note that there is a good flow of water from the drain pipe.

5. Slowly open the top water glass valve wide, after which the drain valve should be slowly closed. Note that water glass indicates the same level as the gauge cocks.

During the trip the water column and water glass must be blown out to insure proper water circulation.

The least amount of water carried in the boiler is dependent on the position of the engine, but a sufficient amount must be carried at all times to insure full protection to the crown sheet and flues. When running on level track the greatest amount carried should be one-half to two-thirds of a glass.

When going up a grade with a locomotive, such as the "I" or "K" types that are not equipped with mountain gauge cocks, the water level at the front of the crown sheet will be about 2" lower than that shown in the water glass for each one percent of grade.

**Bench Mark**—The bench mark is a metal plate secured to the back head with a notch on it, indicating the lowest visible reading of the water glass and the center of the bottom gauge cock (Figs. 6 and 7, pages 13 and 14). It should be checked to insure that the water glass and gauge cocks are in line.

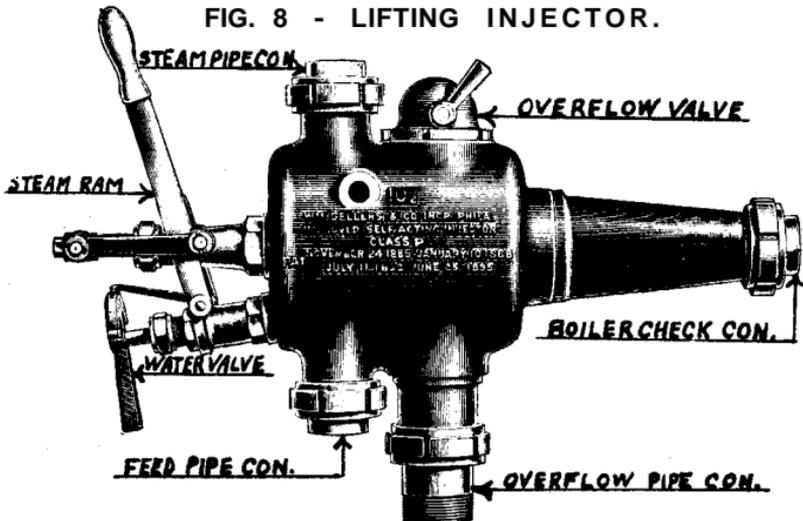
**Injectors**—An injector is a device to force water into the boiler by use of steam pressure. The following general types are used: Lifting Injectors (Fig. 8, page 16). Non-lifting Injectors. (Figs. 9 and 10, pages 17 and 19).

**Lifting Injector**—These injectors are located on the back head above the water level in the tender and must raise the water to force it into the boiler.

They are operated in the following manner:

1. See that tank valve, valve in steam line to injector, water and overflow valves on injector are open wide.

FIG. 8 - LIFTING INJECTOR.



2. Crack steam ram until injector primes. (This can be determined by the sound.)

3. Pull steam ram wide open.

4. Note that there is no discharge from overflow pipe. (If water or steam comes out overflow pipe, it indicates injector is not delivering all the water to the boiler due to some defect.)

5. Regulate water valve for the quantity of water desired.

Lifting injectors and their piping, tank hose and tank valves can be prevented from freezing, when not used frequently in cold weather, in the following manner :

1. Close steam supply valve at turret.

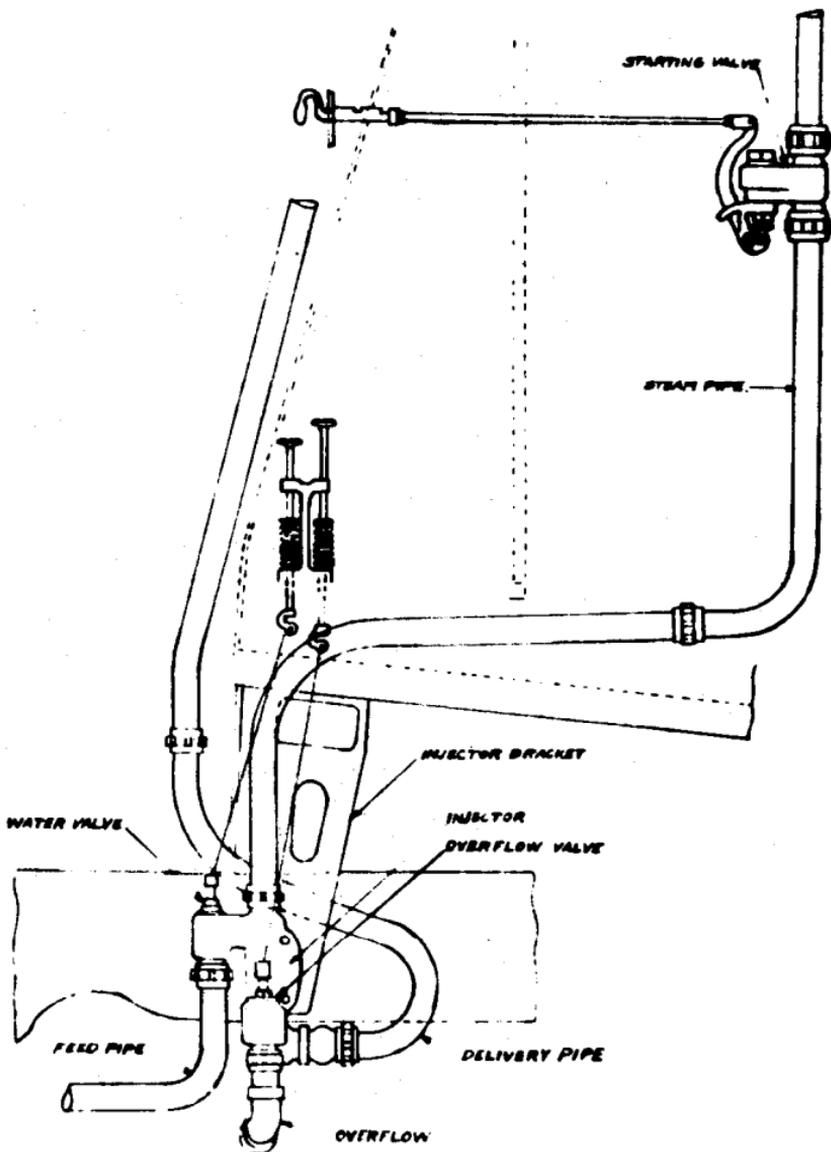
2. Close injector overflow valve.

3. Open injector water valve.

4. Open injector steam ram.

5. Open steam supply valve at turret a sufficient amount to let steam pass through injector, tank hose and tank valve.

Care must be taken to know that tank valve is open or steam pressure will build up in tank hose and cause it to burst. When steam is used to prevent freezing, care must be exercised to prevent overheating the water in tender.



**FIG 9 NON-LIFTING INJECTOR**

Non-lifting injectors cannot raise water and must be located below the lowest water level in the tender as they receive their water supply by gravity. There are two types of non-lifting injectors and they are operated in the following manner:

**Non-lifting injector with water and overflow valve extensions through cab floor and starting valve in front of cab (Fig. 9, page 17) :**

1. Open water and overflow valves.
2. Prime injector by cracking the starting valve.
3. Pull starting valve wide open.
4. Note that there is no discharge from overflow pipe.
5. Regulate water valve for quantity of water desired.

This injector together with its piping, tank hose and tank valves can be prevented from freezing, when not used frequently in cold weather, in the following manner.

1. Close injector overflow valve.
2. Open injector water valve.
3. Pull starting valve open a sufficient amount to let steam pass through injector, tank hose and tank valve. (The extension rod used to operate the starting valve can be secured in the desired position by means of the notches or slots on the rod.)

Care must be taken to know that tank valve is open or steam pressure will build up in tank hose and cause it to burst. When steam is used to prevent freezing, care must be exercised to prevent overheating the water in tender.

**Type SR Non-lifting Injector with single lever operated on quadrant on inner side of cab (Fig 10, page 19).**

On this type of injector, the lever controls both the water and steam. The first movement of the lever primes the injector and as the lever is pulled back into the upright position, the water and steam valves are both opened wide and the injector operates at full capacity. Moving the lever ahead of the wide open position reduces the capacity to the desired amount of water and can be maintained in this position by

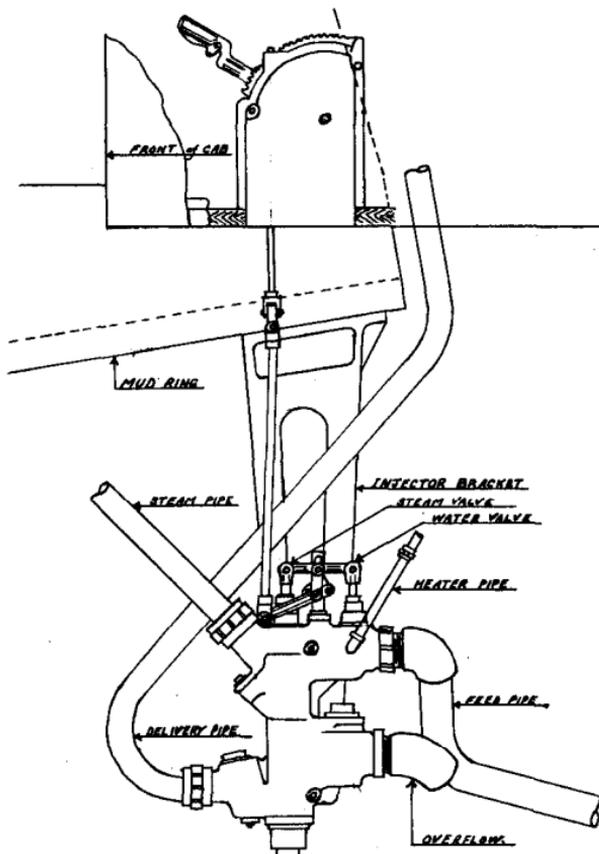


Fig. 10.-Type SR Non-Lifting Injector

latching the lever in the quadrant. The injector is shut off by moving the lever all the way ahead.

This type injector together with its piping, tank hose and tank valves can be prevented from freezing, when not used frequently in cold weather, by cracking the valve in the heater line to the injector. In all cases where steam is used to prevent freezing, care must be taken to prevent over-heating the water in tender cistern.

Care must be taken to know that tank valve is open or steam pressure will build up in tank hose and cause it to burst.

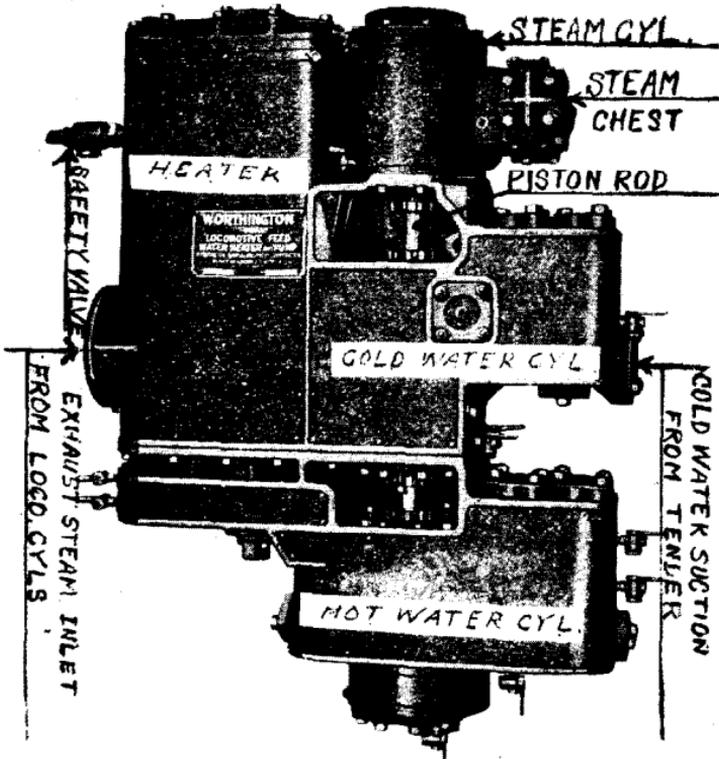
**Feed Water Pumps**—A feed water pump is used for supplying a boiler with water that has been heated before it enters the boiler. The use of heated water effects a fuel saving.

The following types of feed water pumps are in use on our locomotives at the present time:

Worthington Type B (Fig. 11, page 20).

Worthington Types S-SA-SAS  
(Figs. 12-13-14, page 21).

Hancock Turbo Feed Water Heater.



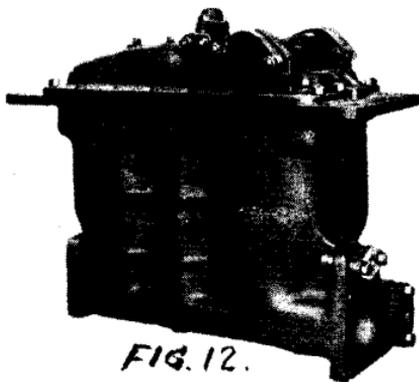
**FIG. 11 - TYPE B FEED WATER PUMP**

### **Worthington Types B-S-SA-SAS Feed Water Pumps.**

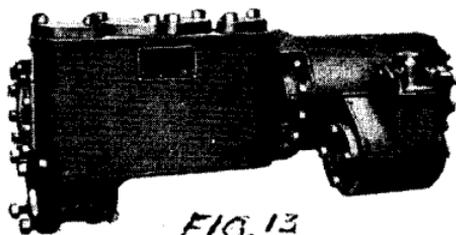
The Type B is a combined vertical unit consisting of steam cylinder, hot and cold water cylinders and heater.

The Types S-SA-SAS consist of three separate units located as follows:

- (a) The cold water pump (Fig. 14, page 21) for the Type S is mounted under the right side of the cab, while the Type SA or SAS is mounted on the left side.
- (b) The heater (Fig. 12, page 21) which is set into the top of smoke box.
- (c) The hot water pump (Fig. 13, page 21) mounted on the side of the boiler.



*FIG. 12.*  
Feedwater heater



*FIG. 13*  
Reciprocating  
hot water pump



*FIG. 14*  
Centrifugal  
cold water pump

The Worthington feed water pumps should be used only when the locomotive throttle is open or when injector is inoperative, as the heater is then receiving exhaust steam from the locomotive from which it can recover heat, and return it to the boiler with the feed water.

In all types of Worthington feed water pumps, the water is heated and delivered to the boiler in the following manner:

Water is taken from the tender by the cold water pump and delivered to the heating chamber where it comes in contact with exhaust steam from the locomotive cylinders. The combined steam and heated water then pass through the hot water pump, and is delivered to the boiler through the discharge pipe and boiler check.

The feed water pump should be started by slowly opening the steam valve to force water out of the steam cylinders. To show whether the Type B pump is operating, a delivery indicator connected to the suction pipe is placed in a convenient location on the back head in the cab. The movement of the plunger indicates that pump is operating. The Type S pump is equipped with a gauge in the cab connected to the discharge chamber of the hot water pump and indicates by a movement of its hand whether the hot water pump is operating. The Types SA and SAS are equipped with a cab gauge connected to the cold water discharge pipe and registers the water pressure developed by the cold water pump in delivering water to the heater.

The suction pipe and tank hose for all types of Worthington feed water pumps can be kept from freezing by cracking the valve in steam line to suction pipe. This valve must not be opened too wide, as too much steam may cause the pump to become steam bound.

### Hancock Turbo Feed Water Heater

This device delivers heated water to the boiler when the locomotive is working, drifting or standing. The principal parts of the heater are:

1. Operating valve.
2. Centrifugal pumping unit.
3. Condenser.
4. Control valve.
5. Automatic heating valve.
6. By-pass valve

The operating valve is used to start and stop the pump and to regulate the amount of water entering the boiler.

**The centrifugal pumping unit** pumps cold water from the tender to the condenser and hot water from the condenser to the boiler.

**The condenser** receives cold water from the pump, passes it through a series of jets, condensing the heating steam, and returns the heated water to the pumping unit for delivery to the boiler.

**The control valve** allows exhaust steam from the locomotive cylinders to enter the condenser. It also prevents water from passing into the locomotive cylinders when the system is not in operation.

**The automatic heating valve** arranges for live steam to enter the condenser when the locomotive is standing or drifting, and for exhaust steam to heat the water when the locomotive is working.

**The by-pass valve** assists in regulating the amount of water being fed to the boiler and also prevents hot water from flashing into steam on its way back to the pumping unit from the condenser.

The water is heated and delivered to the boiler in the following general manner:

Water comes from the tender through the suction pipe to the first stage of the pump and is then delivered to the nozzles of the condenser. It then passes through the tubes of the condenser, forming a jet where exhaust from the locomotive cylinders enters and heats the water. The heated water is then delivered from the condenser back to the first stage of the hot water pump and in three hot water stages has its pressure built high enough to lift the boiler check. Part of the hot water being delivered from the condenser is by-passed back to the hot well in the tender which is built around the tank valve.

When the locomotive is standing or drifting, the feed water is heated by live steam from the operating valve through the automatic heating valve.

This feed water heater is operated in the following manner :

1. Open the regulating wheel wide.
2. Pull handle of operating valve to priming position and let it stay there until some steady pressure is indicated on the delivery pressure gauge.

3. Pull handle of operating valve wide open. The delivery pressure gauge will then indicate a pressure slightly higher than the boiler pressure, showing that water is being fed to the boiler.

If the system does not start after following the above instructions, put the operating handle to priming position, open the sprinkling hose valve and wait until a steady pressure is indicated on the delivery pressure gauge and a steady flow of water is coming through the sprinkling hose. Then pull handle to pumping position. If the locomotive is standing, open drain cock in control valve, condenser and suction pipe before placing handle in priming position.

The two ball bearings of the pumping unit are the only points in the system that require lubrication. The oil cups on these bearings are filled with SAE oil by shop forces. The engine crew should see that these cups are properly filled before leaving enginehouse territory. Engine or valve oil must not be used in these cups.

## QUESTIONS ON CHAPTER 2

26. What are gauge cocks and where are they located?
27. What is the purpose of gauge cocks?
28. How can you tell the difference between water and steam when operating the gauge cocks?
29. What determines the water level in the boiler when using the gauge cocks?
30. When must gauge cocks be tested and how often should they be used?
31. What are mountain gauge cocks?
32. What is the purpose of mountain gauge cocks?
33. What must be done when there is no discharge of water from the bottom gauge cock?
34. What is a water glass and where is it located?
35. What relation is there between the lowest reading of the water glass and the bottom gauge cock?
36. should you depend entirely upon the indication shown by the water glass?
37. When should the water column and water glass be blown out and the water glass tested?

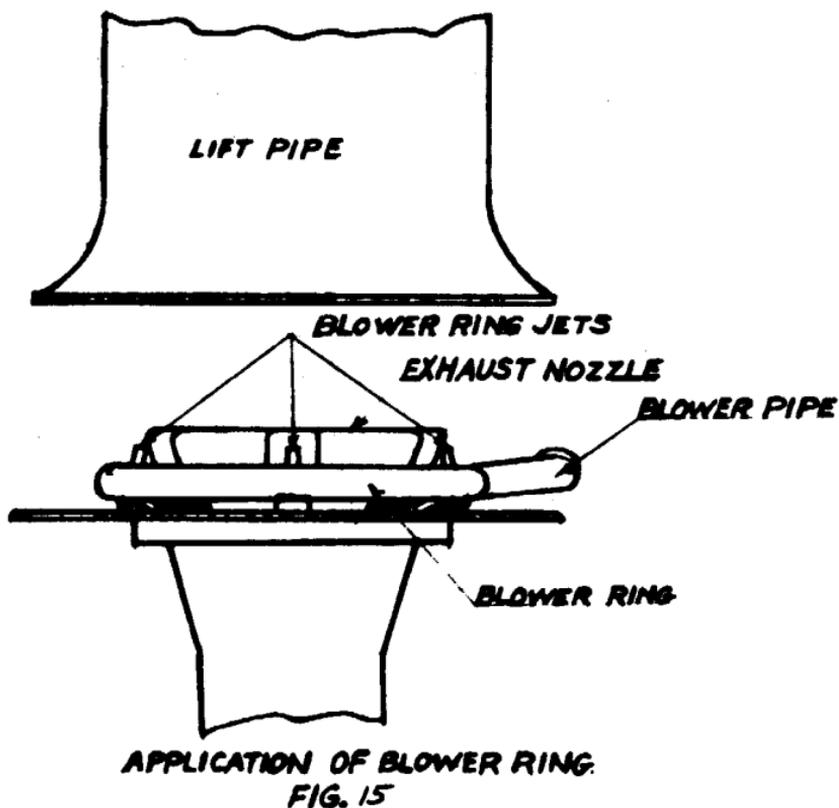
38. What is the reason for testing a water glass?
39. How do you test a water glass?
40. What is the least amount of water that should be carried in the boiler?
41. What is the greatest amount of water that should be carried in the boiler when running on level track?
42. When ascending a grade with a locomotive of the "I" or "K" Type that is not equipped with mountain gauge cocks, what is the variation of the water over the front of the crown sheet with that shown in the water glass for each one percent of grade?
43. What is a bench mark and what is its purpose?
44. What is an injector?
45. What general types of injectors are used?
46. Where is each type of injector located?
47. How do you operate a lifting injector?
48. What should be done to prevent a lifting injector, piping, etc., from freezing?
49. How do you operate a non-lifting injector other than Type SR?
50. What should be done to prevent a non-lifting injector other than Type SR from freezing?
51. How do you operate the Type SR non-lifting injector?
52. What should be done to prevent the Type SR injector from freezing?
53. What is the purpose of a feed water pump?
54. What types of feed water pumps are now in use?
55. Describe briefly the Worthington Type B feed water pump?
56. Describe briefly the Worthington Types S- SA-SAS feed water pumps?
57. When should the Worthington feed water pumps be used?
58. How is the water heated and delivered to the boiler on all types of Worthington feed water pumps?
59. How do you determine that each type of Worthington feed water pump is operating?

60. How do you prevent the Worthington feed water pumps, piping, etc., from freezing?
61. What is the Hancock Turbo Water Heater?
62. What is the function of the Hancock Feed Water Heater operating valve?
63. What is the function of the Hancock Feed Water Heater pumping unit?
64. What is the function of the Hancock Feed Water Heater condenser?
65. What is the function of the Hancock Feed Water Heater control valve?
66. What is the function of the Hancock Feed Water Heater automatic heating valve?
67. What is the function of the Hancock Feed Water Heater by-pass valve?
68. What are the principal parts of the Hancock Feed Water Heater?
69. Describe briefly how the Hancock Feed Water Heater delivers heated water to the boiler when the locomotive is working.
70. How is the feed water heated when the locomotive is drifting or standing?
71. What is the proper method of operating the Hancock Feed Water Heater?
72. If the Hancock Feed Water Heater does not start after the instructions have been followed, what should be done?
73. What points in the Hancock Feed Water Heater system require lubrication?
74. What inspection should the engine crew make of the oil cups on the bearings of the pumping unit?
75. Is it permissible to use engine or valve oil in the oil cups of the pumping unit?
76. What type of oil should be used in the oil cups on the pumping unit?

### CHAPTER 3

#### **Description of Blower-Brick Arch-Grates-Ash Pan**

**Blower**-The Blower (Fig. 15, page 27) consists of a steam valve located in the cab with a steam pipe coupled to it leading to the smoke box where it is attached to the blower ring around the exhaust nozzle.



The jets in the blower ring point upwards toward the stack.

Its use is to form a partial vacuum in the smoke box, which creates a forced draft on the fire when the locomotive is not working. When the locomotive throttle is closed, the blower is turned on to keep smoke out of the cab. It must not be used too strongly when fire is being cleaned or while the fire box door is open, as cold air will be drawn through the flues causing them to contract and leak.

**Brick Arch**—The brick arch supported by arch tubes (Fig. 2, page 8) and circulator tubes (Fig. 3, page 9) induces better combustion by increasing the length of the flamework from the fuel bed to the flues and by baffling and mixing the combustible gases and fine particles of coal, holding them in suspension until they are burned before entering the flues where all combustion ceases. This prevents, to some extent, black smoke by giving the fire time to consume the gases. It also protects the flues by keeping the fire box at a more uniform temperature and preventing cold blasts of air entering through the fire box door or through holes in the fuel bed from striking the flues, causing a certain amount of contraction, tending to make them leak.

Defective condition of arch or missing brick should be reported on M. P. 62 Form for attention.

**Grates**—Grates (Fig. 16, page 28) are metal bars across the bottom of the fire box for the purpose of supporting the fire. Suitable openings are provided in them to permit air to pass through the fuel bed. On most of our locomotives, the grates are coupled together in separate sections and each section can be operated from the cab by means of the grate shaker post located at the bottom of the back head.

The grates are locked in a level position by means of keepers and latches over the shaker posts. Grates can be rocked for the purpose of removing dead ashes

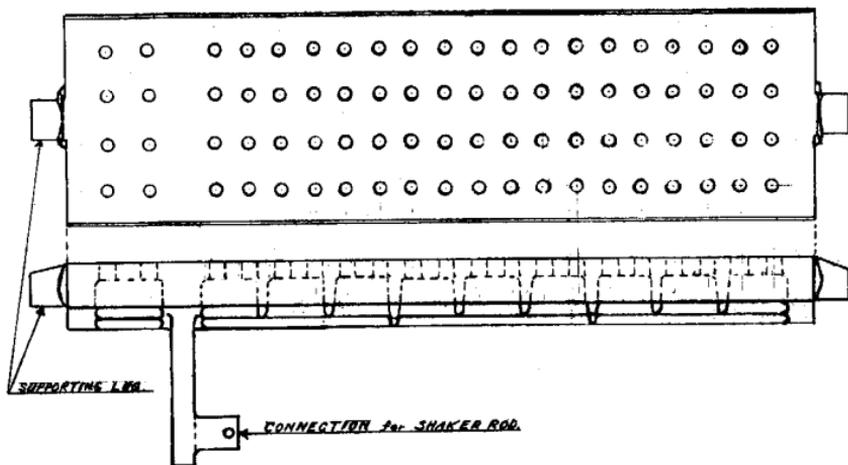


FIG. 16 - Grate Bar

from under the fuel bed by removing the keeper around the shaker post but leaving the dumping latch in place. When cleaning fires, it is necessary to remove both the keeper and the dumping latch. At all other times the grates must be kept level to prevent burning off the edges of the bars.

Emergency repairs to broken or burned grates can be made by placing pieces of iron or other available material over the opening. If pieces of iron are not available, pull down sufficient fire brick from the arch with fire rake to cover the opening.

**Ash Pan**—The ash pan is a metal box or hopper located below the grates and supported from the mud ring for the purpose of collecting ashes and hot coals from the fire box. Ash pan doors must be kept closed at all times while the locomotive is running to prevent hot coals from falling out and setting fires along the right of way. Care must be taken that ash pan does not become too full with ashes as grates are likely to be burned, also, air supply restricted.

Any defect in ash pan, doors, and operating rigging must be reported on M. P. 62 Report for attention.

### QUESTIONS ON CHAPTER 3

77. Describe a blower.
78. What is the use of a blower?
79. How can the use of the blower be abused?
80. What are the advantages of the brick arch in a fire box.
81. What are grates and what is their purpose?
82. Into how many sections are grates divided and how are they operated?
83. How can grates be rocked to remove dead ashes from under the fuel bed?
84. In what position must the grates be kept to prevent burning off the edges?
85. What emergency repairs can be made to broken or burned grates?  
What is an ash pan and where is it located?
86. Why is it important that ash pan doors be kept closed?
88. What may result from ash pan becoming too full of ashes?

## CHAPTER 4

### Description and Use of Firing and Stoker Tools

**General**—Extreme care must be exercised in handling and using firing and stoker tools to prevent injury or accident. When handling these tools they must not be extended beyond the line of the engine, except where length of tool makes it necessary, in which case, it must be known that the tool will not come in contact with other engine, obstruction, or overhead wire. While using tools, have hands in a position on tool where they will not be caught between tool and other object or part of engine and tender. Feet should be firmly placed to avoid slipping or overbalancing.

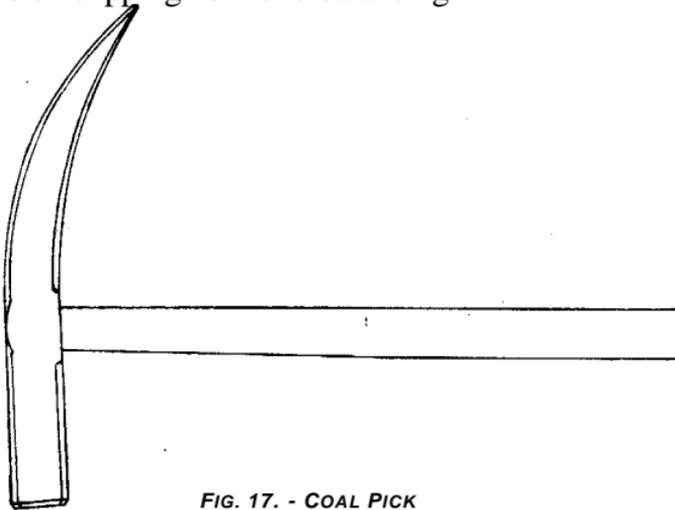


FIG. 17. - COAL PICK

**Coal Pick**—The coal pick (Fig. 17, page 30) is used for loosening coal in the tender and for breaking large lumps of coal.

**Fire Hoe and Hook**—These tools (Figs. 18-19, page 31) are for the purpose of spreading the fire before leaving the enginehouse or starting with the train. They may be used on the road, when necessary, to rake fire lightly to break crust formed by too heavy firing. Raking the fire bed tends to form clinkers, especially when the hook is pushed through the fire. Avoid the use of these tools whenever possible.

**Shaker Lever**—The shaker lever (Fig. 20, page 31) is applied to the grate shaker post for the purpose of shaking the grates. The lever should be applied cor-

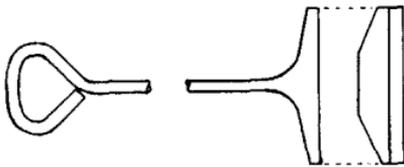


Fig. 18 - Fire Hoe

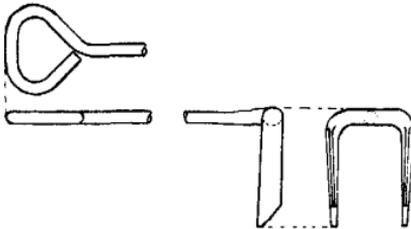


Fig. 19 - Fire Hook

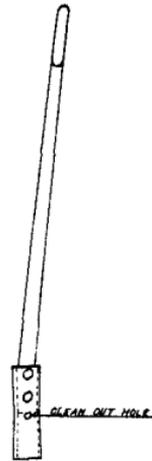


Fig. 20 - LEVER for Shaking Grates

rectly and securely to the shaker post with the feet braced in firm position to maintain balance before attempting to shake the grates.

Near the bottom of the shaker lever is a clean out hole for the purpose of removing foreign substance that may become lodged in the socket of the lever and interfere with the proper application of the lever to the shaker post.

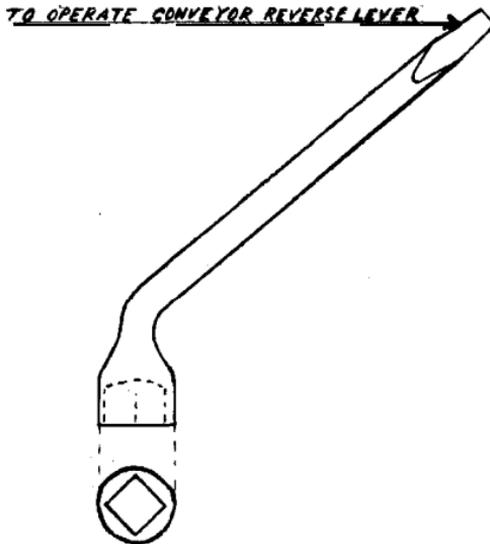
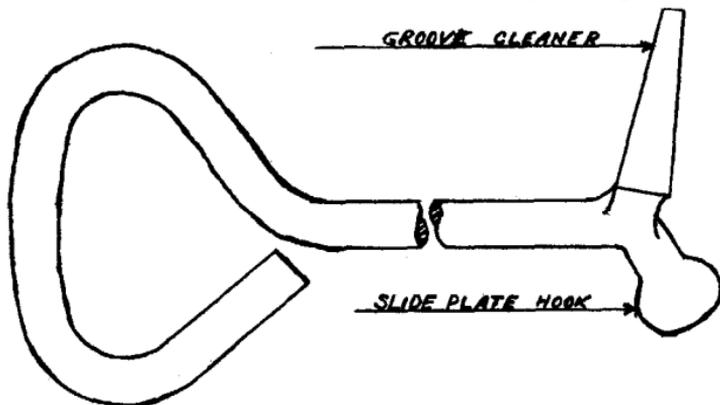


Fig. 21 - Duplex Stoker Dividing Rib Wrench

**Duplex Stoker Dividing Rib Wrench**—This wrench (Fig. 21, page 31) is used on locomotives equipped with Duplex stokers. The socket end of the wrench is for adjusting the dividing rib in the stoker hopper to the desired position. The other end of the wrench is made to fit into the socket of the conveyor reverse lever for use when necessary to change its position.



*FIG. 22- Stoker Slide Plate Hook and Groove Cleaner*

**Stoker Sliding Plate Hook and Groove Cleaner**—This tool (Fig. 22, page 32) is necessary on all stoker equipped locomotives. The ball part of the tool is inserted in the slot in the stoker slide plates for the purpose of moving them to the desired location. The opposite or pointed end of the tool is used for cleaning out the stoker slide plate groove.

## QUESTIONS ON CHAPTER 4

89. What precautions must be observed in handling and using firing and stoker tools?
90. For what purpose is the coal pick used?
91. For what purpose is the fire hoe and hook used?
92. Describe the proper method of applying the shaker lever to the post.
93. For what purpose is the stoker dividing rib wrench used?
94. For what purpose is the stoker slide plate hook and groove cleaner used?

## CHAPTER 5

### Description and Operation of Hydrostatic and Mechanical Lubricators

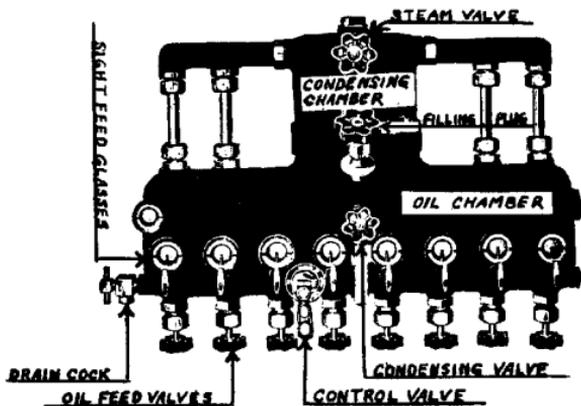


Fig. 23. - HYDROSTATIC LUBRICATOR

**Hydrostatic Lubricator**—The hydrostatic lubricator (Fig. 23, page 33) is located on the back head of the boiler and is used entirely for lubricating the interior of the cylinders and valves of the locomotive, air pumps, feed water pump and stoker.

Nothing but valve oil must be used in a hydrostatic lubricator.

The lubricator is started and operated in the following manner:

1. Be sure steam valve in boiler is wide open.

2. Open wide the steam valve at top of lubricator, allowing sufficient time for the sight feed glasses to fill with water.

3. Open the condensing valve.

4. Open the control valve if so equipped.

5. Adjust the oil feeds as directed by the engineer and check at intervals.

The control valve is for the purpose of starting or shutting off the feeds of the lubricator without disturbing the adjustment of the oil feed valves. This is obtained by moving the handle to the "Closed-All Open-Pump" positions on the dial. With the lever handle in the "Pump" position, only the feed to the air pump is left open.

To shut down the lubricator, close oil control valve first, then the condensing valve and last the steam valve.

The hydrostatic lubricator should be started and adjusted before leaving the storage track or engine-house, to see that all feeds are working properly and should be set to feed uniformly the proper amount 15 minutes before departure with train, to insure the valves and cylinders being lubricated when starting.

The lubricator is under boiler pressure when operating and no attempt must be made to remove any parts or make any repairs until the steam has been shut off and the pressure removed through the drain cock.

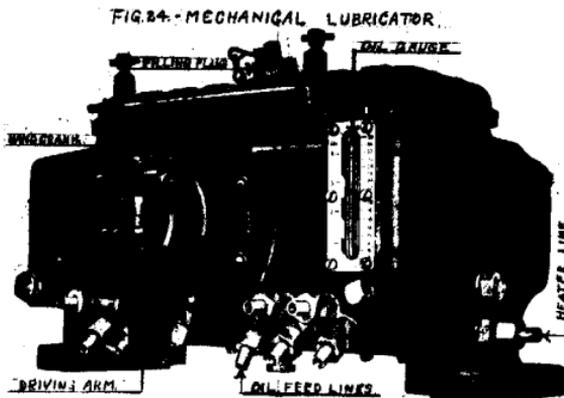
To fill a hydrostatic lubricator with oil, the following procedure should be followed:

1. Close all oil feeds or place control valve on "Closed" position, close condensing valve and steam valve.

2. Open drain cock to allow pressure to escape.

3. Remove filling plug carefully to prevent being splashed by hot oil or water.

4. Apply valve oil. (If there is not sufficient oil to fill the lubricator, water should be used to make up the required quantity. This will expel the air and enable the lubricator to start feeding quicker.)



**Mechanical Lubricator**—The mechanical lubricator (Fig. 24, page 35) is a device in which the oil is regulated and forced to the point of delivery by mechanically operated pressure pumps contained within the lubricator. The lubricator is located on the side of the locomotive near the front and is operated by some moving part of the valve gear on the locomotive. It is used for lubricating the interior of steam cylinders, as well as other bearings on the locomotive.

A hand crank is provided for use in case of an emergency if the operating mechanism becomes broken or disconnected. Prior to departure from the enginehouse tracks, the hand crank should be given at least 25 revolutions to provide initial lubrication to the valves. The engine crew must know that the lubricator is properly secured to the brackets, the operating mechanism is in good condition, that the heater is operating (by placing hand on end of lubricator at bottom) and that hand crank is in the place provided.

This lubricator is not subject to boiler pressure and can be filled at any time by removing the filling plug and applying valve oil. The engine crew cannot regulate the amount of oil fed by the mechanical lubricator.

If the mechanical lubricator runs empty enroute and is refilled at some intermediate point, a report should be made at the end of the run on M. P. 62 work report, because it is quite probable that the lubricator is air-bound and will not feed. Excessively high or noticeably low oil consumption for the mileage for the trip should also be reported.

## QUESTIONS ON CHAPTER 5

95. Where is the hydrostatic lubricator located and what is its purpose?
96. What kind of oil must be used in the hydrostatic lubricator?
97. How is the hydrostatic lubricator started and operated ?
98. What is the purpose of the oil control valve?
99. How do you shut down the hydrostatic lubricator?
100. When should the hydrostatic lubricator be started and the feeds adjusted?
101. When the hydrostatic lubricator is operating should any repairs or parts be removed? Why?
102. Give the procedure for filling a hydrostatic lubricator.
103. What attention should be given the mechanical lubricator before leaving a terminal?
104. Why is a hand crank provided for a mechanical lubricator?
105. What should be done if the mechanical lubricator runs empty enroute and is filled at some intermediate point? If the oil consumption for the mileage of the trip is excessively high or noticeably low?

## CHAPTER 6

### Description and Operation of Stokers

A stoker is a mechanical device for conveying coal from the tender to the fire box. The following types of stokers are in use on our locomotives:

Duplex (Figs. 25 and 28, pages 37 and 39).

Standard (Figs. 26, 29, 30, pages 38, 42, 43).

Hanna (Fig. 31, page 45).

Berkley (Fig. 32, page 47).

On all of these types of stokers the coal is delivered to the fire box in the following general manner:

Coal from the tender drops by gravity into a trough or conveyor and is moved forward by the conveyor screw through the crusher zone at front end of conveyor trough, where oversize lumps of coal are broken

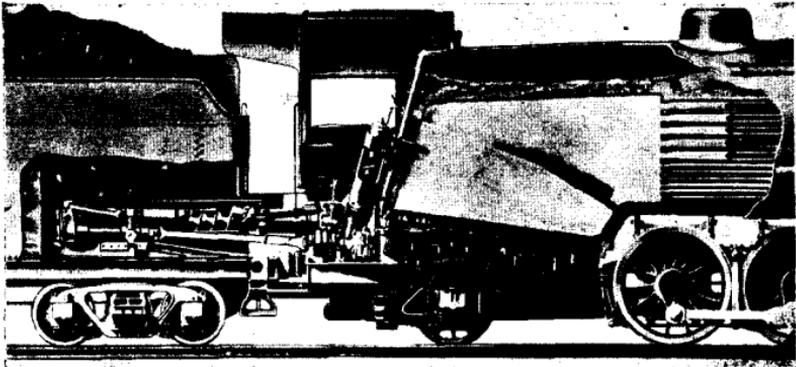


FIG. 25. Sectional View Showing the Duplex Stoker as Applied to a Locomotive and Tender

down to a size suitable for firing. The coal is then moved to the fire box where it is distributed over the fire space by means of steam jets.

The amount of coal delivered to the fire box is governed by the speed of the stoker engine, which is under the direct supervision of the fireman. The supply of coal from the tender to the conveyor is regulated by slides. It is the usual practice to open the front slide when the engine is coaled.

All stokers are equipped with a large or booster valve in the steam line to stoker engine. This booster valve is in addition to the regular or small valve and is for the purpose of crushing hard lumps of coal by rapidly increasing the steam pressure in the stoker cylinders. As soon as the heavy duty is performed, the booster valve should be closed and the stoker operated with the small steam throttle valve.

Trouble is occasionally experienced due to stoker stopping suddenly after it has been working properly for some time. This trouble is usually due to a piece of iron, wood or similar foreign substance being caught in the stoker. The majority of clogs occur at the crusher zone (Fig. 2'7, page 38) in the conveyer. If this occurs, open the booster throttle. If this has no effect, reverse the stoker engine a few times. Continue to alternately operate the stoker forward and in reverse to try to work the obstruction through; if, after repeated efforts the stoker will not work, close the stoker throttle valves, and place the operating

lever in neutral position, then look for the obstruction and remove it. Conveyor screw should not be run in reverse more than three full turns to prevent damage to rear of trough.

If the obstruction or clog is located, great care must be taken to know that the stoker throttle valves are shut off and the operating lever is in neutral position to prevent undesired action of the stoker while removing the clog. Serious injury may result if this precaution is not taken.

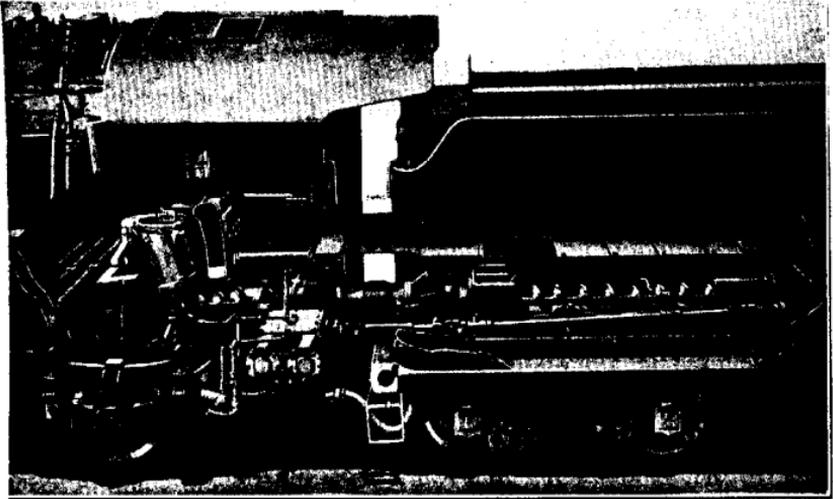
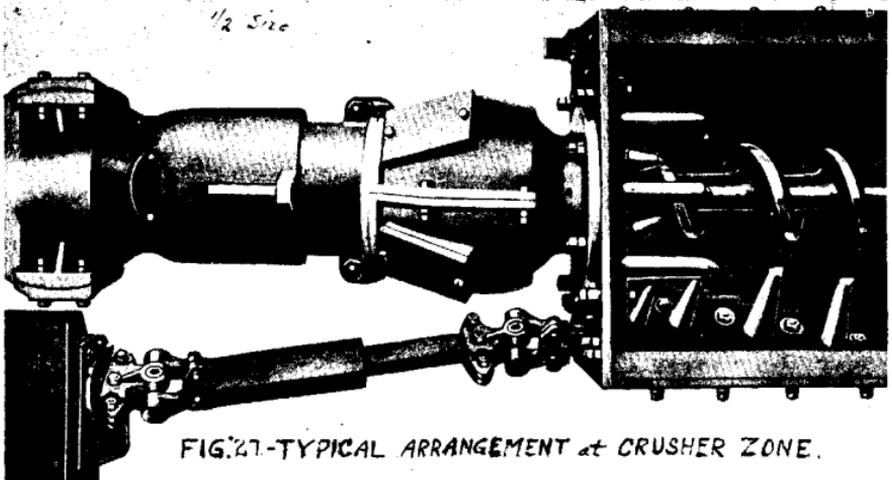


Fig. 26 -Standard Type B Stoker Applied to Locomotive.

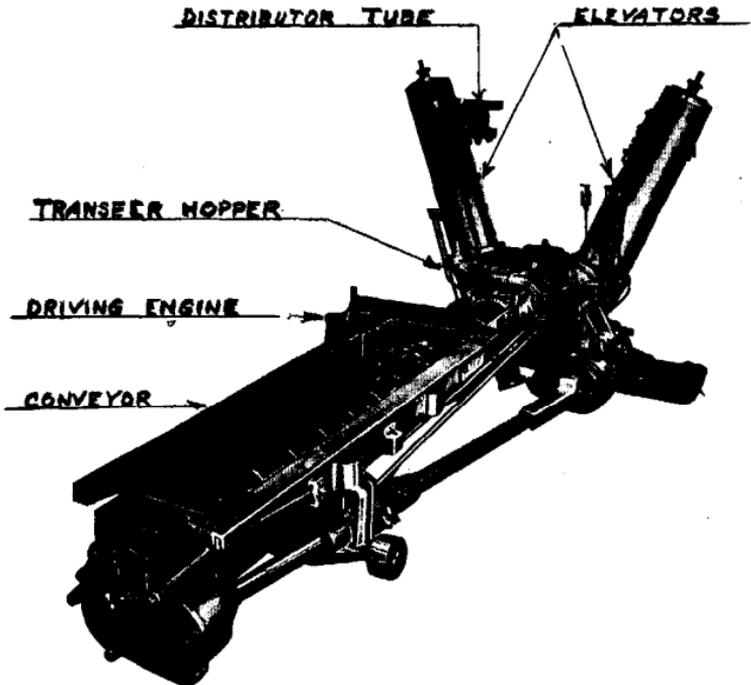


Do not allow rock, iron, wood waste or other foreign material to be fed into the stoker if it can be detected in the coal and removed before it enters the conveyor trough. Do not use hooks or firing tools in such a way as to risk getting them caught in conveyor screw.

Before any stoker is started, an inspection of visible parts should be made to see that it is in good working order. The steam cylinders of all stoker engines receive their lubrication from the lubricator on the locomotive. Oil should be fed at the rate of about three drops per minute when hydrostatic lubricator is used. Mechanical lubricator adjustments are made by the enginehouse forces.

The only rule for stoker steam jet adjustments is careful watching of the fire. Varying conditions may call for change in firing, but the nature of the change cannot be predicted by rule. Maximum boiler pressure as shown on the gauge, with the minimum of smoke at the stack, indicates that conditions are right in the firebox.

FIG. 28 - DUPLEX STOKER



**Duplex Stoker**—This stoker consists of four main units, namely, the driving engine, the transfer hopper, the elevators, and the conveyor (Fig. 28, page 39). The first three of these parts are attached to the locomotive, while the fourth part is on the tender.

The coal after passing through the crusher zone, is delivered to the transfer hopper beneath the cab deck (Figs. 25 and 28, page 37 and 39) where it is divided equally or unequally, according to the position of the dividing rib between the right and left elevators. It is then raised by means of the screws in the elevators to the distributor tubes, which extend through openings in the back head on each side of the fire door. The distributor portion of each tube is located inside the fire box above the grates.

**Lubrication of Stoker Parts**—Put one fourth pint of engine oil in sight feed cup at intervals; put one-eighth pint engine oil in right and left elevator casings—this can be done by lifting the paul shifter on top of elevator head casings and dropping oil into the small holes in elevator pawl cover. Fill oil box on right and left elevator casings with engine oil and refill every two or three hours. Slide support bearings and universal joints are oiled from cups under door in cab deck.

**Starting and Operating the Stoker**—Open branch line jet valve which allows steam to flow to the distributor jet line. Right and left jet valves which regulate the steam pressure on the jets are left set when stoker is stopped; therefore, in starting the stoker, these valves should be open at about the right pressure. Always see that steam is flowing through the jets before starting the stoker engine. Place the operating lever to stoker engine in running position and conveyor reversing lever in forward position. Start stoker engine by slowly opening the small valve so as to permit condensation to escape through the automatic drain. Give the stoker engine sufficient steam to run at the speed desired. When coal appears at the distributor plates, adjust the pressure on the jets to get an even distribution of coal over the entire grate area.

**To reverse conveyor screw in tender**—Stop stoker engine, move screw conveyor reverse lever back to rear or reverse position.

**To stop conveyor screw**—Place reversing lever in center position.

**To reverse right or left elevator screws**—Raise elevator pawl shifter at top of vertical shaft to upper position. (Conveyor screw must be stopped before reversing elevator screw or stoker will be jammed with coal.)

**To stop right or left elevator screws**—Raise elevator pawl shifter at top of elevator to middle position. (Stop conveyor before stopping elevator or stoker will be jammed with coal.)

**To locate obstruction if stoker stalls due to foreign matter:**

1. Shut off stoker throttle and place tender conveyor screw reverse lever in center position.
2. Place right elevator pawl shifter in middle or neutral position.
3. Operate stoker engine sufficiently to run left elevator. If left elevator does not operate, obstruction is in left elevator. If left elevator operates, cut in right elevator by lowering pawl shifter. If stoker stops, obstruction is in right elevator; if it operates, obstruction is in tender conveyor. The obstruction in the tender conveyor will usually be found in the crusher zone.

If the stoker conveyor screw becomes inoperative or broken, the stoker engine and elevators can be used to distribute coal over the fire box in the following manner :

1. Place conveyor reversing lever in center position.
2. Raise trap door in cab deck and fire by hand into stoker hopper.

**Standard Stokers**—There are four general types of Standard Stokers known as Type “B”, Modified “B”, “HT” and “LT”.

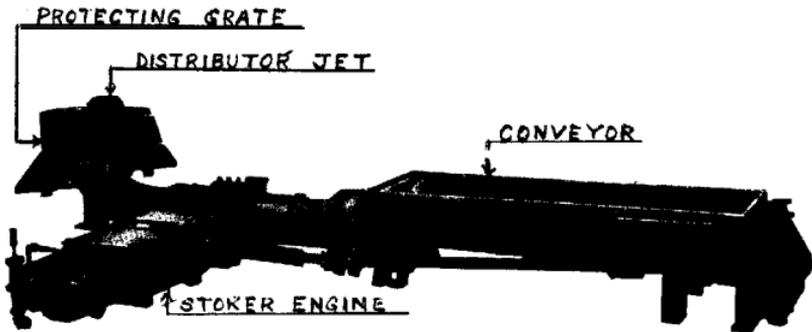


FIG. 29. - Standard Modified Type B Stoker.

The difference between the Type "B" and Modified "B" stoker (Fig. 29, page 42) is in the arrangement of the screws between the conveyor trough and the elbow in the fire box. This difference is not visible unless the stoker is dismantled. The tender unit, driving engine and operation of jet valves are the same. After passing through the crusher zone, the coal is carried forward to the termination of the conveyor screw, then by means of an elbow of gradual curvature to a straight conduit parallel with the door sheet of fire box. The coal is forced through this conduit in sufficient quantities, governed by the speed of the stoker engine, to meet the locomotive requirements. It is then distributed over the fire space by manual operation of distributor jets, which are located in the fire box on top of back portion of vertical conduit. The vertical conduit and distributor pipes in fire box are protected from heat by what is termed the protecting grate, which surrounds the vertical conduit.

**"HT" Stoker**—The operation of the conveyor trough and driving engine of this stoker is similar to the Type "B" and Modified "B" stokers. However, both Type "B" stokers deliver coal inside the fire box, while the "HT" delivers coal at the fire door (Fig. 30, page 43). Adjustable vane in each side of the upper end of the elevator pipe is for controlling the amount of coal delivered to the back corners of the fire box. These vanes are adjusted by means of hand screws, and after obtaining the proper distribution, it should not be necessary to change their setting.

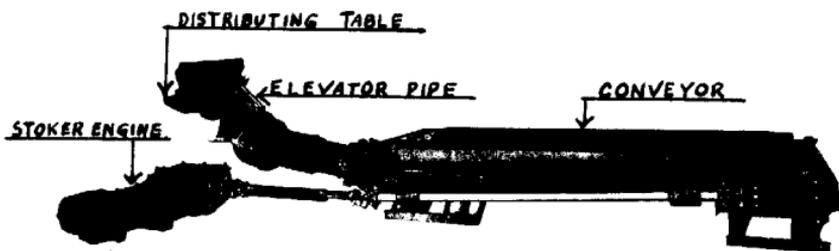


Fig. 30 Standard Type HT Stoker.

**Lubrication of Type "B", Modified "B" and "HI" Stokers**—The eccentrics, crank shaft, wrist pins, guides, and other wearing parts of the stoker engine are lubricated by the splash system from engine oil in the engine bed. Sufficient oil in the engine bed can be determined by the appearance of oil when the pet cock in engine bed is opened. Before starting the stoker, fill the 4-compartment oil box located in bulk-head of tender with engine oil and apply a few drops to the universal joints and slip shafts. These parts, when in service, should be oiled once every eight hours unless the bearings indicated they are running dry.

**Starting and Operating the Stoker**—If closed, open the distributor jet valves, then slowly open the main control valve of distributor to gradually force out any condensation that may be in the distributor pipes. Next, open the main engine steam valve at the turret, then the small throttle valve to the stoker engine gradually to allow all condensation to escape through the automatic drain valve, then place the reversing rod handle into normal operating position by placing the control lever in down position. See if the engine operates in reverse position. After the control lever has again been placed in normal operating position, give the stoker engine sufficient steam to run at the speed desired.

After the stoker has been started and coal begins to appear at the jets, adjust the pressure on the distributor jets so as to get a hot, clear, thin fire. Supply valve to jet manifold should be wide open.

If one or more holes in the steam jet stop up, close all the jet valves but the one controlling the stopped holes. Open this valve wide and try to blow out the obstruction. If the obstructed hole cannot be opened in this manner, leave the jet valve closed as before, close the main valve, remove bonnet and valve stem from the valve controlling the obstructed hole, then open the main valve ; the vacuum created should carry out the obstruction. If this method fails, the holes will have to be cleaned out with a tool.

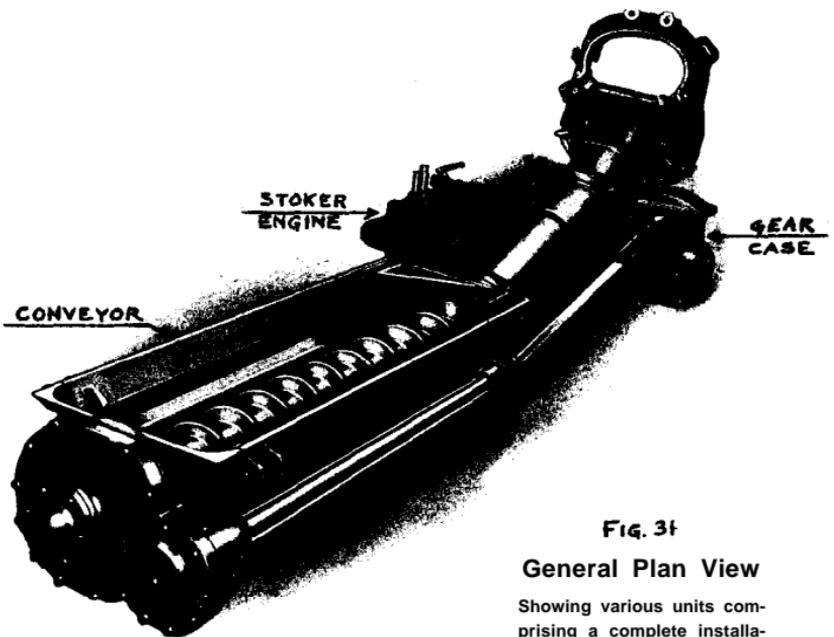
In the event the stoker becomes inoperative for any reason, the fire may be kept up by hand by placing the coal just ahead of the jets, which will distribute it over the fire box.

**“LT” Stokers:**—The “LT” stoker is a conversion of the Duplex Type stoker, displacing the elevator and hopper units, but retaining the driving engine and conveyor reverse mechanism as well as the tender unit. The new parts applied to the locomotive are similar to those of the “HT” type stoker. It is fired the same way as an “HT” stoker and operated as a Duplex.

This stoker is lubricated in the same manner as the Duplex stoker, excepting the elevators.

**Hanna Stokers:**—This stoker (Fig. 31, page 45) consists of a conveyor, crusher and screws that convey coal through a conduit to transfer hopper, and is elevated to point of delivery by a pair of cone shaped screws in the fire door housing. The stoker engine consists of a simple two-cylinder horizontal engine completely enclosed. The eccentrics, crank shaft, wrist pins, guides, and other wearing parts are lubricated by the splash system. Sufficient oil in the engine bed can be determined by the appearance of oil when pet cock on side of engine bed is opened.

Oil jack shaft bearings with engine oil through pipe attached to leg of tender at front. Apply engine oil to knuckle joints of gear housing and tender drives.



**Fig. 3f**

**General Plan View**

Showing various units comprising a complete installation - Type H4- 1A Hanna Stoker.

**Starting and Operating Stoker:-**

1. Be sure main turret valve is open.
2. Open jet valves to see that passages are free from obstructions.
3. Open stoker engine operating valve slowly to exhaust condensation and heat the cylinders.
4. Adjust jet pressures for proper distribution.

**Stalling of Stoker:-**The following causes may stall the stoker:

1. Lack of lubrication in stoker engine cylinders.
2. Foreign matter in the coal.

Determine the cause of stalling by slowly reversing stoker engine, which is accomplished by holding the

reversing handle in upward position. If engine will not reverse, stalling is probably caused by foreign matter becoming lodged in the crushing zone on the tender, or there is a possibility it may be lodged in the conical screws. Slowly reverse the engine several times to dislodge the foreign matter and cause it to pass through without further interference. If this does not dislodge it, its location should be determined and removal effected by hand. If not found at the conical screws, investigate at the crushing zone in conveyor, but if this point is not accessible, and further efforts to dislodge it by reversing the engine are not effective, resort to the following:

Place fuel into the door housing of the stoker, allowing it to fall on the distributing plate. Increase jet pressure as judgment dictates.

**Berkley Stoker:**—This stoker (Fig. 32, page 47) consists of three main units, namely, the driving engine, riser conduit, and the conveyor. The first two of these units are attached to the locomotive, while the third unit is on the tender. The coal is conveyed from the tender to the distributor jet apron by screws, where distribution is accomplished by means of jet blasts and top deflector. This stoker does not take up any grate area.

### **Starting and Operating the Stoker:—**

1. Be sure main turret valve is open.
2. If closed, open the distributor jet valves, then slowly open the main control valve of distributor to gradually force out any condensation that may be in distributor pipes.
3. Open the small throttle valve to the stoker engine gradually to allow all condensation to escape. The stoker engine is always in forward position as the reversing lever is held down by spring tension and requires reversing only when any foreign substance should foul the conveying system.
4. After the stoker has been started and coal begins to appear at the jets, adjust the pressure on the distributor jets so as to get a hot, clear, thin fire.

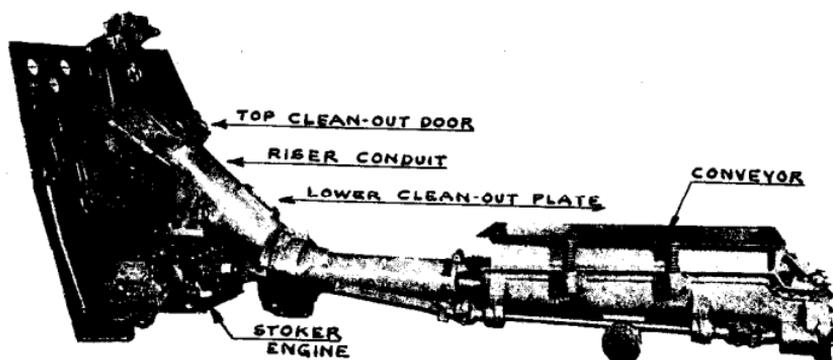


Illustration of the Berkley Stoker

FIG. 32

5. It is very important that the stoker engine crank case be filled with oil before leaving the terminal.

**Removing obstructions:**—If the stoker stalls and the obstruction is not at the crusher zone in the conveyor, investigate the riser conduit by opening the top clean-out door and removing the lower clean-out plate.

## QUESTIONS ON CHAPTER 6

110. What is a stoker?
111. What types of stokers are now in use?
112. Describe the general manner in which coal is delivered to the fire box from the tender.
113. How is the coal distributed over the fire box area?
114. What regulates the supply of coal to the conveyor?
115. What is the stoker booster valve and when should it be used?
116. Where is the coal crusher located?
117. What is usually the cause when stoker stops suddenly after it has been working properly?
118. Where do obstructions or clogs usually occur?
119. Give the procedure for removing clogs in the conveyor.

120. To what extent should the conveyor screw be run in reverse?

121. What precaution should be taken before attempting to remove clogs by hand?

122. Why is this precaution necessary?

123. What care should be exercised in observing the stoker at work?

124. What may result from the careless use of firing tools?

125. What should be done before any stoker is started.

126. How are the steam cylinders of stoker engines lubricated?

127. What determines the proper adjustment of steam jets?

128. What are the main units of a Duplex stoker?

129. What is the purpose of the elevators on a Duplex stoker?

130. How should the Duplex stoker parts be lubricated?

131. How is the Duplex stoker started and operated?

132. How do you reverse the Duplex stoker conveyor screw in tender? How do you stop conveyor screw?

133. How do you reverse the right or left Duplex stoker elevator screws? How do you stop them?

134. How do you locate obstruction if Duplex stoker stalls due to foreign matter?

135. How can the locomotive be fired if the Duplex stoker conveyor screw becomes inoperative or broken?

136. What types of Standard Stokers are in use on our locomotives?

137. What units are the same for the Type "B" and Modified "B" stokers?

138. How do the Type "B" stokers differ from the "HT" type ?

139. What controls the amount of coal delivered to the back corners of fire box by "HT" stokers?

140. Where are the vanes located and how are they adjusted on the "HT" stokers?

141. How are the Type "B", Modified "B" and "HT" stoker engines, other than steam cylinders lubricated?

142. How can sufficient oil in the engine bed be determined on the Type "B", Modified "B", and "HT" stokers?

143. How should the moving parts, other than stoker engine, of the Type "B", Modified "B", and "HT" stokers be lubricated?

144. How do you start and operate the Type "B", Modified "B" and "HT" stokers?

145. What should be done if one or more holes in jet become plugged?

146. What is an "LT" stoker?

147. How is an "LT" stoker fired and operated?

148. Describe a Hanna stoker.

149. How is a Hanna stoker lubricated?

150. How is a Hanna stoker started and operated?

151. What may cause a Hanna stoker to stall?

152. How can the cause of Hanna Stoker stalling be determined?

153. What can be done if standard or Hanna stokers become inoperative?

154. Describe a Berkley stoker.

155. How is the Berkley stoker engine, other than cylinders, lubricated?

156. How is the Berkley stoker started and operated?

157. Give the procedure for removing obstructions in the Berkley stoker.

## CHAPTER 7

### Preparation for Trip—Combustion—Hand and Stoker Firing—Smoke Prevention

The fireman's duties, when reporting for service, are to sign the register and examine the Bulletin Board for any new general orders or instructions.

Upon arrival at the locomotive he should determine the amount of water in the boiler by looking at the water glass and trying the gauge cocks. He should apply the blower, examine the fire box for leaks, and give particular attention to the crown sheets and note the condition of the arch. An examination should be made to see that the locomotive is supplied with a full set of serviceable equipment; examine the lubricator to see that it is working properly, that the in-

jectors and feed water pump work properly; examine the ash pan, see that doors are closed, examine the grates to see that they are level and operate, check water level indicator in tender bulkhead and open the valve to see that tell tales are open, then test the stoker. He should then prepare the fire for the trip by hand firing.

**Combustion:**—Good combustion consists of supplying the proper amount of air to the fire box, so that all the coal put in the fire box will burn without any smoke. One pound of coal requires about 15 pounds or 200 cu. ft. of air to burn it completely. This air is drawn through the ash pan and grates in the following manner:

- (a) When locomotive is working:—The exhaust steam from the cylinder passes up through the stack, carrying air and gases out, and creates a partial vacuum in the air tight smoke box. Atmospheric pressure then forces the air through the ash pan openings, grates, fire and flues, thus creating a draft through the fire.
- (b) When locomotive is not working:—By use of

The easier it is made for air to come up through the fire, the more completely the coal will be burned, which is another way of saying “Keep your fire thin”. Combustion is best when the fire is thin because the hottest fire is found about 4” above the bottom of the fuel bed. A thin fire saves coal and makes a freer steaming engine. One pound of coal should evaporate about one gallon of water if the proper firing practice is used.

Our bituminous coal contains 1½ to 4 parts of gaseous matter, 5 to 7½ parts of carbon, and about one part of ash or earthy matter. When coal is burned, the carbon forms coke, which burns slowly and without smoke ; the gaseous matter burns as flame and the earthy matter forms ash and clinkers. When the coal is first heated by being thrown on the fire, the gaseous matter is expelled in the form of a gas, and if the fuel bed is hot enough, and plenty of air pres-

ent, this gas will be burned before it escapes out of the stack. The air passing through the grates and fire bed burns the coke and fixed carbon. while the air passing over the fire bed consumes the volatile gases. It is therefore, necessary that there be a proper balance between air and fuel to insure proper combustion and prevent the formation of carbon monoxide, which is incompletely burned carbon. If the gas arising from the coal is unburned, it will produce smoke. Smoke, therefore, means waste of coal and must be avoided.

**Nature of Coal:**—Low volatile, or so-called smokeless coal has a high percentage of pure carbon, and less of the smoke producing hydrocarbon than any others. These hydrocarbons make a fire kindle easier, and their scarcity in low volatile coal makes this coal take longer to brighten a fire. Because it is friable or easily broken, there are not many lumps, and it is easy to choke the air spaces throughout. the fire. Hence, be very careful not to put too much coal at any one time in any one location. In general, this coal chokes easily and will not clinker.

True clinking coals found mostly in Indiana, Illinois and Western Kentucky, and to some extent in Ohio and Pennsylvania, have an ash which melts at a relatively low temperature, below 2200°. This ash, when fluid, runs down through the fire and, chilled by the cold air coming up through the grates, solidifies in large sheets or pieces. The process is gradual, however, and there are two important rules for keeping a good fire:

1st—Keep the hook out.

2nd—To keep the fire clean, lift the latch keepers, leaving dumping latch in place and rock the grates gently as conditions require.

Watch the fire frequently, keep it thin, and do not allow uneven piles to grow. Any coal tends to clinker when the fire has holes in it, or uneven draft, or large piles, but the true clinking coals are worse in this respect. Use of the fire hook, opens holes in the fire and allows green coal to get into the hot portion of the fire, which melts the ash into clinker.

Slack coal is that portion below 1¼" in maximum size. High slack coals from any district will burn like lump coal from the same territory, if the coal is properly distributed over the fire box. Although slack coal will, in general, have slightly more ash than lumpy run-of-mine, the common practice of referring to it as "dirt" is not justified. If the fire builds up in thickness faster than normal, rock, not shake, the grates a little more often.

Coal is one of the greatest single items of expense to the railroad, and the engine crew can save coal by the proper handling and firing of the locomotive. Care must be taken to keep the coal in the coal space of the tender and it should not be permitted to collect on the gangway, deck or steps where it may fall from the locomotive and endanger the lives of persons along the tracks or be wasted.

## FIRING

**General:**—The fire box door must be kept closed, except when coal is being put into fire box by hand or firing tools are being used. Doors are provided with indirect openings to provide heated air to assist in the proper combustion of the coal. At no time must a hook or other implement be used to hold mechanically operated fire doors partly or fully open, either when firing or standing. When closed, these doors are locked shut by air pressure as a safety precaution for the engine crew in the event of a failure of some part inside the fire box. Excessive opening of the fire door permits cold air to enter the fire box and be drawn through the flues. The flue sheet and flues are most sensitive to a sudden change in temperature and may result in leaks developing.

Coal will be saved by maintaining a uniform water level and by using the injector or feed water pump to prevent loss of steam due to the safety valves opening. Thirty pounds of coal are required to generate the steam that escapes from a large modern safety valve in one minute. High water in the boiler results in water being carried into the superheater and reducing the degree of superheat, or in water being carried to the valve chambers and cylinders and washing

off the lubricant, all of which increases the coal and water consumption.

Slipping of the drivers must be avoided, as it tears and upsets the fire and causes a waste in rebuilding.

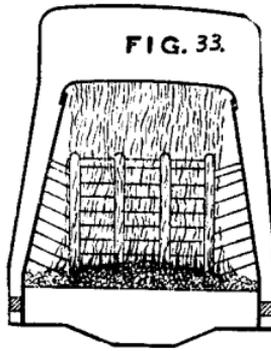
The grate bars must be kept level, so as to prevent the burning off of the fingers or edges of the bar. They should be shaken often enough to keep the dead ashes off the grates to insure the proper amount of air passing through the fire, and, if possible, when not using steam. They must not be shaken while the locomotive is working in or around stations and industrial plants, nor while over bridges, trestles, or track troughs.

The fireman should be familiar with grades and location of stations, and should anticipate the need for more or less steam in order to have his fire in proper condition to meet the work as it develops.

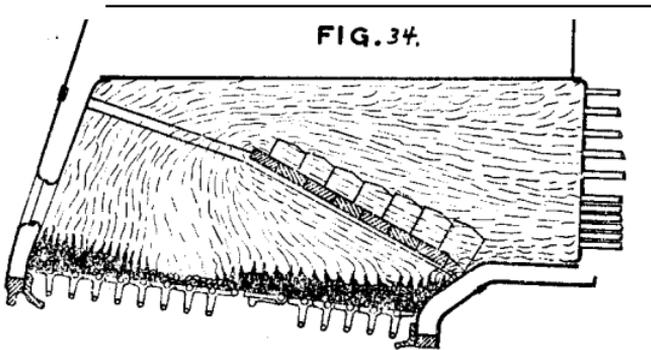
The following are some of the causes that prevent a locomotive from steaming freely:

- (a) Smoke box not air tight. The amount of air that enters the smoke box openings or leaks would correspondingly reduce the amount of air that would pass through the grates. This results in reduced draft through the fire.
- (b) Grates becoming clogged with ashes and clinkers or too heavy fire retards the flow of air through the grates. This produces a red fire.
- (c) Restricted ash pan openings, heavy or dirty fire, flues or front end netting stopped up.
- (d) Flues stopped up. This will not permit the fire to burn brightly or uniformly over the grates.

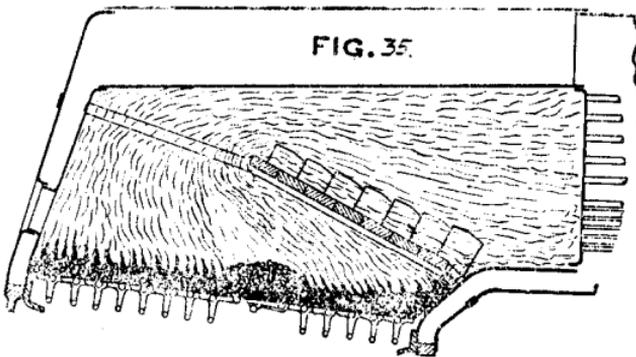
**Hand Firing:**—Small quantities of coal placed in the fire box at regular intervals keep the fire bright, reduce smoke and maintain maximum steam pressure. It is a good practice to maintain a slightly heavier fire along the sides than in the center of the fire box, as it prevents the tendency for an excess of air to pass next to the side sheets, which would cause thin spots to form, allowing cold air to pass into the fire box (Fig. 33, page 54). Thin spots or holes in the fire caused by improper firing also permits cold air to enter the fire box (Fig. 34, page 54).



Thinning action of the drafts along the side sheets.



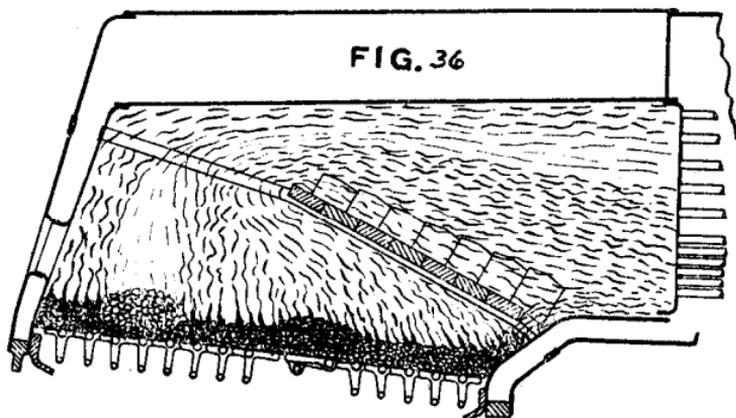
Effect of thin spots or holes in the fire.



Temporary reduction in fire box temperature, due to the introduction of a shovelful of coal.

Each shovelful of coal placed in the fire box causes a temporary reduction in fire box temperature (Fig. 35, page 54), and in order to maintain a light and level fire there should be a restoration of temperature before a succeeding shovel of coal is placed at another part of the fire box (Fig. 36, page 55).

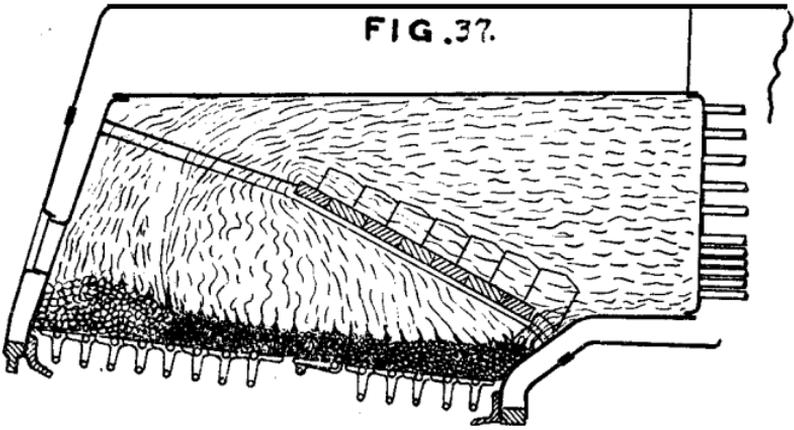
Adding too much coal to a fire at one time reduces the temperature in the fire box below the igniting point, with the result that combustion is stopped until this fresh coal is heated to the burning point. During this time, there has been heat enough in the fire box to drive off the gases, and the draft has forced these gases out through the stack unconsumed. This results in a waste of fuel and unnecessary black smoke.



Restoration of temperature before a succeeding shovelful of coal is placed at another part of the firebox.

Heavy firing at the fire door (Fig. 37, page 56) lowers the temperature at the back end of the fire box, as a sufficient supply of air cannot pass through to support proper combustion and practically eliminates this portion of the fire box for steam generating purposes.

Wherever coal piles up in the fire box, a clinker may form. Where practicable, the clinker should be knocked through the grates or taken out of the fire box through the fire door hole. If this cannot be done, the fire rake should be used to pull the clinker to the back



Effect of heavy firing at fire door. Such firing lowers the temperature at the back end of the fire box.

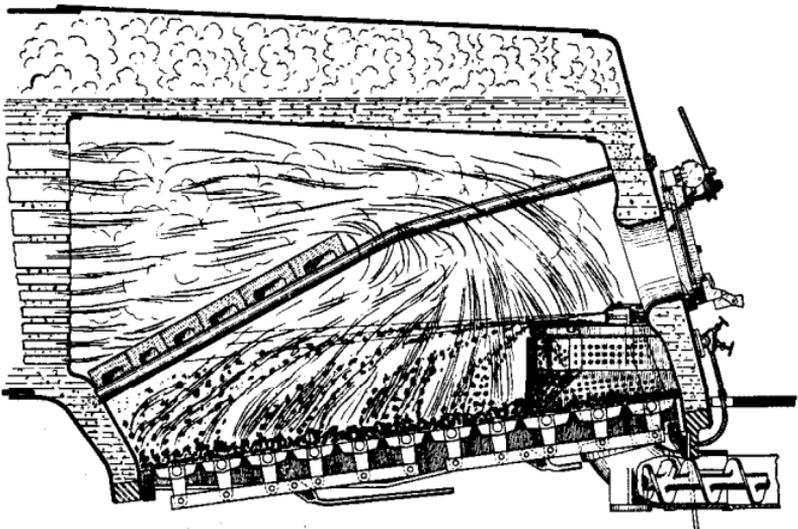


FIG. 38 -Side View of Fire Box Showing Distribution with Standard Stoker.

corners. In opening grates to break up, or remove clinkers, only one section should be opened at a time, and clinkers removed, saving as much fire as possible.

Large lumps of coal do not make a satisfactory fire, and they should be broken into pieces approximately four inches in size.

**Stoker Firing** (Fig. 38, page 56):—In stoker firing the fire should be carried much lighter than with hand firing. Start with a clear bright coke fire, free from clinkers. Avoid overloading the fire box—starve the fire.

A good stoker fire is thin enough to be self cleaning, with the result that the grates do not become filled with ashes. Correct firing is reflected in the steam pressure. If the pressure is sensitive to the rate of firing, the fire is in good condition. If the pressure changes very slowly, the fire is too heavy. A good stoker fire goes out quickly when the stoker is stopped. If a long station stop or road delay is imminent, use the scoop to cover the fire with coal, which will be coking until the engine starts again. Do not let the fire go out in spots.

Fine coal can be blown further, so that the jets must be closed down slightly for slack, and opened up a little if the coal gets more lumpy. If this is not carefully watched, the arch can easily be plugged. Wet coal is much heavier than the same coal dry, and hence the jets must be carefully watched. If wet coal cokes on the firing table, or in a Duplex distributor, use a stoker slide hook or coal pick handle to break it up.

No matter what kind of coal you may have on the tender, it is important to realize that no set jet pressure can be given or used with the various kinds and sizes of coal, and it the duty of the fireman to watch the fire very closely, particularly when starting out, to regulate the jet pressure to get the best distribution (Fig. 38, page 56), to supply only the required amount of coal, and to watch the fire very closely by shutting off the stoker and looking at the entire fire (not just the back portion) and to know at all times the condition of the fire.

Wet coal, high-slack coal, clinkering coal, and high ash coal can be fired successfully if the following practices are observed.

1. Maintain an even stoker speed to keep the fire at the minimum depth that will maintain the desired boiler pressure.
2. Adjust the stoker jet pressure to maintain an even distribution of coal over the whole fire. Change jet pressures as necessary if the size, grade, or condition of the coal delivered to the distributing table changes.
3. Inspect the fire frequently and correct unsatisfactory conditions.
4. Hand fire the light spots when necessary to maintain a level fire.
5. Rock the grates frequently, but lightly.
6. Maintain the correct water level at all times by even pumping.
7. Fire according to the condition under which the engine is working.
8. Avoid excessive use of the fire hook.
9. Call the engineer's attention to bad fire conditions so that the locomotive can be worked accordingly.

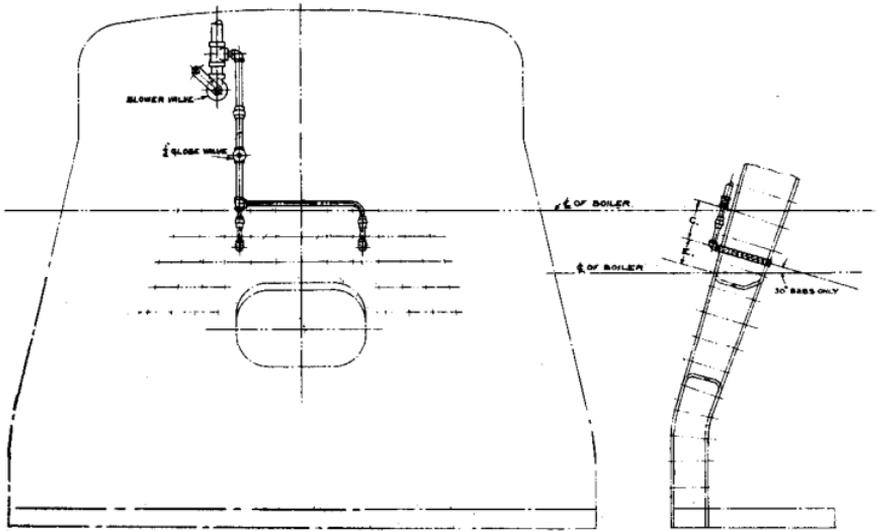
At the end of the trip and before arriving at the terminal, the following should be done:

1. Close the slide plates.
2. Place the operating lever in neutral position.
3. Close the stoker engine throttle valve and main distributor jet valve, the individual jet valves should be left open.

**Smoke Prevention:**—Black smoke consists of small particles of unburned carbon suspended in the gases and contains a large percentage of the heat value of the coal.

Excess smoke can be avoided if the fire is in good condition, if coal is supplied to the fire box in the proper amount, and if the coal is evenly distributed over the fire bed.

Black smoke is an indication of a waste of coal and is the result of over-crowding the fire, or in other words, feeding coal to the fire box in such a quantity that a sufficient supply of air cannot be obtained to burn the fuel.



**SMOKE ABATEMENT DEVICE  
OVER FIRE DOOR** **FIG 38-A**

The proper use of the blower when engine is idle and at other times when the throttle is closed, will assist in eliminating smoke. The smoke abatement device (Fig. 38A, page 59) should, be used when coal is being added, to the fire when the locomotive is idle and at other times when the throttle is closed.

Excess smoke will be produced when the rate of firing exceeds the rate of burning. Don't overload the fire box.

**Completion of Trip:**—On the arrival at the terminal the engine should be brought to the pit as near the maximum steam pressure as possible, and with a light bright fire so that it can be cleaned without waste of fuel. The tools and other equipment should be properly put away. Hood and side curtains, if used, should be folded and secured properly in place. The engineer should be informed of any defects in the equipment you handled or operated, as well as any other defects you noted on the locomotive, so that they can be reported on M.P. 62 work report.

## QUESTIONS ON CHAPTER 7

160. What are the fireman's duties when reporting for service?

161. What is combustion? Is air necessary to combustion?

162. How is draft created through a fire:

(a) When engine is working?

(d) When engine is not working?

163. How do you obtain the best results if using low volatile or so-called smokeless coal?

164. What two important rules should be followed for keeping a good fire if using true clinkcring coals?

165. How do you obtain the best results if using slack coal?

166. What is one of the greatest single items of expense to the railroad?

167. How can the engine crew help to save coal?

168. Why should the gangway, deck and steps be kept clear of coal?

169. How should the fire door be handled?

170. What provision has been made in mechanical fire doors to assist in the proper combustion of coal?

171. What bad effects result from the excessive opening of fire door?

172. What parts of fire box are most sensitive to sudden changes of temperature?

173. What bad effect is produced in carrying water too high in the boiler?

174. What is the estimated waste of coal for each minute a safety valve is open?

175. Why should slipping of the drivers be avoided?

176. How should the grate bars be kept? Why?

177. When should the grates be shaken?

178. When must the grates not be shaken?

179. How can the fireman anticipate the work the engine is about to do?

180. What are some of the causes that prevent a locomotive from steaming freely?

181. What is the best method of obtaining maximum steam pressure when firing by hand?

182. In what part of fire box should fire be the heaviest? Why?

183. What is the best method of maintaining a light and level fire?
184. What is the effect of putting too many shovels full of coal on a bright fire?
185. What is the effect of heavy firing at the fire door?
186. What may cause clinkers to form in the fire box?
187. What should be done when clinkers form in the fire box?
188. What should be done if large lumps of coal are encountered in the coal supply?
189. How should a stoker fire be carried in comparison with hand firing?
190. Describe a good stoker fire.
191. What may happen to a good stoker fire when stoker is stopped?
192. How should the jets be handled for fine coal? For lumpy coal?
193. What should be done if wet coal cokes on the firing table or in a Duplex distributor?
194. What are the duties of the fireman in handling the stoker jets to get the best distribution with the required amount of coal?
195. How should the stoker be handled when arriving at a terminal?
196. What is black smoke?
197. How can excess smoke be avoided?
198. What does black smoke indicate?
199. What will assist in eliminating black smoke?
200. What produces excess smoke?
201. What are the fireman's duties on the completion of the trip?



# INSTRUCTIONS FOR LOCOMOTIVE FIREMEN—

## PART II

### CHAPTER 8

#### Boiler—Fire Box—Smoke Box

**Boiler:**—A locomotive boiler (Fig. 1, page 7) is securely fastened to the frame at the front end by means of the cylinder saddle and is supported by flexible waist or expansion sheets and boiler pads at front portion of mud ring on top of frame. This permits the boiler to move forward or backward on the frame as expansion and contraction takes place. The barrel of the boiler is subject to strain from expansion and contraction, internal pressure and vibration, while the fire box is subject to crushing strains and those of unequal expansion and contraction.

Best results are obtained when the boiler is free from leaks, mud and scale; flues and seams tight and no flues stopped up. Boilers can be abused in the following manner:

- (a) Allowing the steam pressure to drop and then blowing the boiler hot quickly.
- (b) Overpumping the boiler, thereby reducing the steam pressure and then allowing the pressure to rise quickly.
- (c) Improper firing, causing sudden changes in the fire box temperature.

Boilers are provided with steam domes in order that the openings for the main and auxiliary steam pipes may be placed as high as possible and thus supply dry steam for use in cylinders and locomotive appurtenances.

**Fire Box:**—The fire box sheets (Fig. 2, page 8) are held in place in the following manner:

The crown and roof sheets are held together by rigid and expansion crown bolts; the side and door sheets are supported by rigid and flexible staybolts and rivets; the flue sheet is supported by rivets, rigid and flexible staybolts, and the flues.

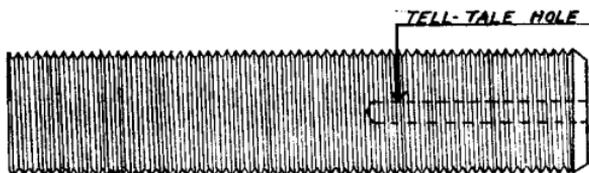


FIG.-39. - RIGID STAYBOLT.

The most common type of staybolt is the rigid staybolt (Fig. 39, page 64). This staybolt has a screw thread on it and is screwed through both the inside and outside sheets and its ends riveted over. All rigid staybolts have a tell-tale hole drilled in them to indicate by the escape of steam or water that the bolt is cracked or broken.

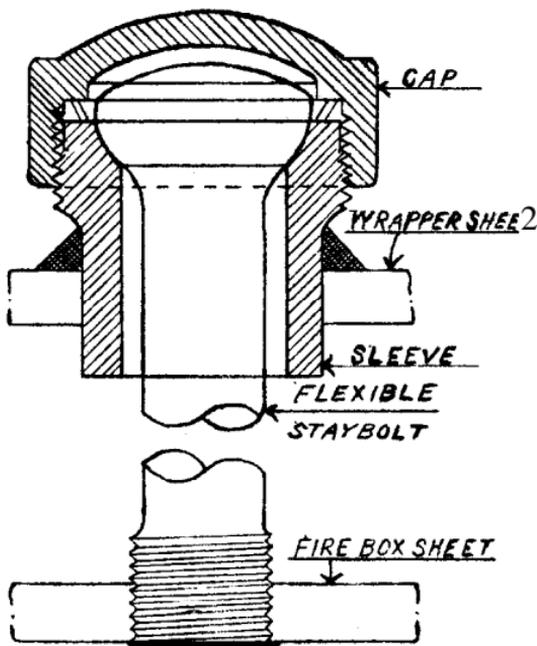


FIG. 40 - FLEXIBLE STAYBOLT ARRANGEMENT

A flexible staybolt (Fig. 40, page 64) has thread on one end and a round head on the other end. The thread end is screwed into the inside sheet and riveted over. The head or outside end fits into a sleeve or socket. This permits the bolt to adjust itself to unequal expansion and contraction. The sleeve is covered by a cap to prevent the escape of steam or water.

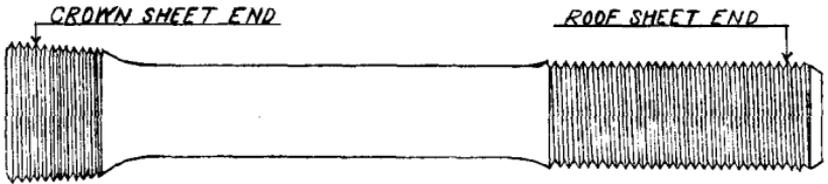


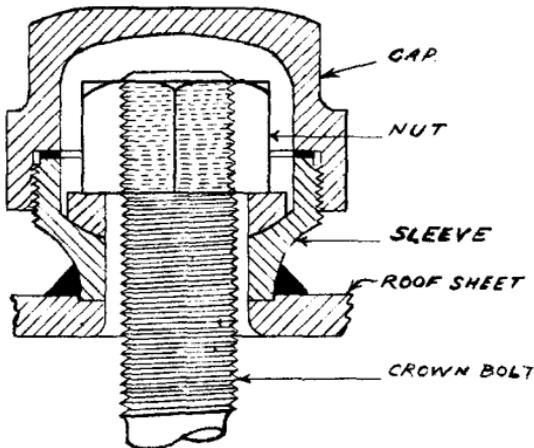
FIG. 41. - RIGID CROWN BOLT.

A rigid crown bolt (Fig. 41, page 65) has threads on each end and is screwed through the crown and roof sheets and its ends riveted over.

An expansion crown bolt has thread on each end. The crown sheet end screws through the crown sheet and is riveted over. The other end passes through the roof sheet and a sleeve and is secured by a nut (Fig. 42, page 65). A cap covers the sleeves to prevent the escape of steam.

Slight overheating of the crown sheet due to low water may result in the crown bolts and seams becoming loosened; if greatly overheated, the crown sheet will force the sheet off the crown bolts and probably rupture the crown sheet, causing injury to life and property.

FIG.- 42.



EXPANSION CROWN BOLT ARRANGEMENT.

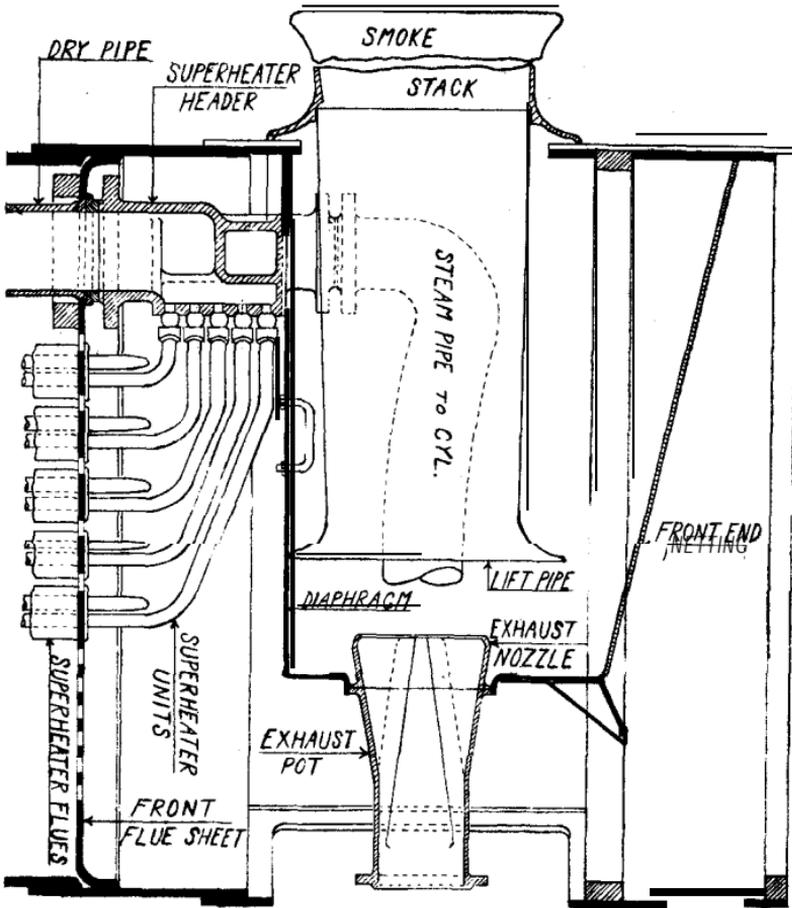


FIG.43- SMOKE BOX ARRANGEMENT - K4S

**Smoke Box:**—The smoke box is located at the front end of the boiler and contains the following appliances (Fig. 43, page 66):

- (a) Pipes to carry steam to the valve chambers,
- (b) Exhaust pot and nozzle. Exhaust steam passing through the exhaust pot and nozzle, towards the stack creates a draft on the fire when the engine is working.

- (c) Blower (Fig. 15, page 27) to create a draft on the fire when engine is not working.
- (d) Lift pipe which is an internal extension of the smoke stack.
- (e) Diaphragm to equalize the draft through the flues.
- (f) Netting to prevent large sparks from passing out through the stack and starting fires along the right of way.
- (g) Superheater header which is connected to the dry pipe and used to convey steam from the dry pipe to the superheater units and thence to the steam pipes.

A defective netting or draft appliances will be indicated by fire being thrown from the stack. This should be reported on M. P. 62 work report.

Exhaust steam or smoke issuing from one side of the stack may be caused by draft appliances loose or out of line.

The smoke box must be kept free of air leaks to prevent air from entering and destroying the vacuum. Air admitted directly to the smoke box may cause collected cinders to burn and overheat the smoke box sheets causing them to warp or crack, also reduce the draft through the flues. Air leaks must be reported on M. P. 62 work reports.

## QUESTIONS ON CHAPTER 8

205. How is a locomotive boiler connected to the frame?

206. To what strain is the barrel of the boiler subjected?

207. To what strain is the fire box subjected?

208. What must be the condition of the boiler to give the best results?

209. How is the boiler sometimes abused?

210. Why do boilers have steam domes?

211. How are the fire box sheets held in place?

212. Describe a rigid staybolt.

213. What is the purpose of the tell-tale hole in a rigid staybolt?

214. Describe a flexible staybolt.

215. Describe a rigid crown bolt.

216. Describe an expansion crown bolt.

217. What is the result if crown sheet is overheated?

218. Name and explain the various appliances in the smoke box.

219. What is the indication of defective netting or draft appliances?

220. What is the indication of draft appliances loose or out of line?

221. Why must the smoke box be kept free of air leaks?

## CHAPTER 9

### Water Glass and Gauge Cocks

The water glass is an auxiliary to the gauge cocks (Figs. 6 and 7, pages 13 and 14) for purpose of ascertaining the water level in the boiler, but its use must not be entirely depended upon as there are a number of conditions that may cause it to give an incorrect indication of the actual water level in the boiler. These conditions are :

- (a) **Leak in top joints or union of water glass.**—This may cause the water glass to register a higher level than the water in the boiler.
- (b) **Leak in bottom joints or union of water glass.**—The water glass may register a lower level than the water in the boiler.
- (c) **Water glass drain valve leaking or not properly closed.**—This will cause the water glass to register a lower level than the water in the boiler.
- (d) **Top water glass valve closed or defective or top passageway into boiler stopped up.**—This will cause the water glass to register a full glass of water when there may be only one gauge or less of water in the boiler and is due to not having the same steam pressure on top of the water in the glass as there is in the boiler. This results in the pressure in the boiler forcing the water to the top of the water glass.

- (e) **Bottom water glass valve closed or defective or bottom nipple into boiler stopped up:**—Steam condensation will gradually fill the water glass with water and will show a stationary reading when the engine is in motion.
- (f) **Cloudy or dirty water glass:**—This may be due to the ridges on the inside surface of the water glass being worn or an accumulation of scale on the inside surface. This condition will not give a distinct reading of the water level in the glass.

All of these conditions may be detected by blowing out the water glass and testing it to insure that water is circulating in the glass when taking charge of a locomotive, and frequently checking the water level in the glass with the gauge cocks while the locomotive is in motion.

When the water glass is in good working order, the water level will move up and down in the water glass with the movement of the locomotive. When the locomotive is started ahead, the water surges to the backhead of boiler and shows a higher water level. Just the opposite occurs when the locomotive is started backwards.

Knowledge of the action of water in the boiler is important and necessary to prevent damage to the boiler as the water glass and gauge cocks only register the water at the point where they are located. Allowance must be made when the locomotive is on other than level track.

## QUESTIONS ON CHAPTER 9

225. Why should you not depend entirely upon the water level as shown by the water glass?

226. How does a leak in the top joints or unions of water glass effect the water level in the glass?

227. How does a leak in the bottom joints or unions of water glass effect the water level in the glass?

228. What effect does a leaking or improperly closed water glass drain valve have on the water level in the glass?

229. What is the cause when you find the water glass full of water and there is only one gauge or less of water in the boiler?

230. What is wrong when the water in the glass shows a stationary reading when the locomotive is in motion?

231. What causes a cloudy or dirty water glass?

232. How can the conditions that cause incorrect water level in the glass be detected?

233. How does water in the glass act when the glass is in good working order?

234. Explain the action of water in the boiler when engine is started ahead? Backwards?

235. Why is the knowledge of the action of the water in a boiler necessary?

## CHAPTER 10

### Circulation—Saturated and Superheated Steam

**Circulation:**—Circulation is the movement of water within the boiler and is caused by heat. The water in contact with the fire box sheets and flues absorbs heat from the fire and rises. As the heated water rises it is replaced by water of a lower temperature. Good circulation is obtained by firing a light, bright, long flame fire over the entire fire box, thus producing the greatest amount of heat. Water, as it enters the boiler, is at a low temperature and feeding the boiler too fast retards circulation, with the result that steam pressure is not increased promptly.

**Saturated Steam:**—Steam is a gas which is converted from water by means of heat. Saturated steam is steam at the same temperature as the water in the boiler. Any reduction in temperature results in condensation.

**Superheated Steam:**—Superheated steam is steam heated to a higher temperature than the water in the boiler by passing through an appliance known as a superheater. After leaving the dry pipe, the steam enters the superheater header on one side of a partition wall in the header, then passes through the superheater units (Fig. 43, page 66), which are a series of pipes located inside the large boiler flues, to the other side of the superheater partition, and

from there through steam pipes to the valve chambers. The hot gases from the fire box, passing through the large flues and coming in contact with the superheater units, heat the steam in the superheater units on its way to the cylinders, with the result that it is of much higher temperature than when it left the boiler. This addition of heat reduces or totally eliminates condensation and increases the volume and expansive power of the steam with the result that water consumption is reduced about twenty percent and the coal consumption is also less.

The success of the superheater depends largely upon the performance of the fireman. A heavy or humped short flame fire may produce maximum boiler pressure, but a high temperature is not developed around the superheater units, with the result that steam enters the valve chambers at a very low degree of superheat. A light, bright, long flame fire not only produces maximum boiler pressure, but maintains a very high temperature around the superheater units with the result that steam enters the valve chambers at a very high degree of superheat. This saves water, fuel, and labor.

Water carried too high in the boiler is carried over through the dry pipe and reduces the effectiveness of the superheater because the heat that should superheat the steam is used to make steam out of the water passing through the superheater. It also washes the lubrication off the valve and cylinder walls causing damage to valve rings and cylinder packing, retards the action of the engine and causes a considerable waste of fuel.

## QUESTIONS ON CHAPTER 10

240. What is meant by circulation in a boiler?
241. How is good circulation obtained by the fireman?
242. What will retard the circulation of water in a boiler?
243. What is steam?
244. What is saturated steam?

245. What is superheated steam?  
246. Describe how steam is superheated.  
247. What are the advantages in the use of superheated steam?  
248. How does superheated steam save water and fuel?  
249. How can the fireman aid or retard the effectiveness of the superheater?  
250. How does water carried too high in the boiler affect the superheater?  
251. What bad effect does high water have on the cylinders?

## CHAPTER 11

### Foaming and Treated Water—Blow Down

Foaming is caused by an excessive amount of impurities present in the water. These impurities remain in the boiler when the water is evaporated into steam and become concentrated if not removed. These impurities are of two kinds:

1. Soluble elements that dissolve in water. This results in the formation of a hard scale on the interior of the boiler which causes a reduction in heat transferred from the fire and gases to the water in the boiler, thus lowering the steaming capacity of the boiler. These elements are found by testing the water, and their harmful effects inside the boiler can be neutralized by chemical treatment of the water.
2. Solids that form mud or sludge and do not dissolve, but settle to the lowest part of the boiler. These solids can be removed with the automatic and manually operated blow down systems.

Foaming water causes the locomotive to work water and has the same effect as carrying too much water in the boiler. This will cause a difference in the water level as shown by the water glass and the gauge cocks as the gauge cocks show the agitated condition of the water at the point where they are located, while the water passing through the boiler connection to the water glass may not show the agitated or foaming condition of the water.

When a locomotive starts to work water, and the gauge cocks show three gauges of water while the water glass registers a much lower reading, it would be an indication that the boiler is foaming and there is danger, when throttle is closed, that the water level may fall below the top of crown sheet and upper flues causing crown sheet to overheat. In this case, the throttle should be closed slowly and the bottom gauge cock tried to show the true water level which must, at all times, be maintained above the top of crown sheet, cylinder cocks opened to prevent damage to cylinders, and the supply of water increased. The true water level is indicated when the throttle is closed.

**Blow Down:**—Blow downs on boilers are for the purpose of removing the mud and sludge that form from impurities in the water and also the concentrations of suspended chemicals that are present in boiler water that has been chemically treated. Failure to properly use blow down as instructed will result in road failures due to “Bad Water” (water raising) and leaking staybolts or burned fire box sheets.

All locomotives are equipped with one or more of the following blow downs:

- (a) Automatic, which operates only when throttle is open.
- (b) Manually operated from cab, with outlet in rear water leg.
- (c) Manually operated from running boards, with outlet in side of water legs.
- (d) Manually operated from ground, with outlet in throat sheet.

**Automatic Blow Down:**—The automatic blow down (Fig. 44, page 75) is a device that allows a small amount of water (approximately 300 gallons per hour) to be discharged from the boiler when the throttle is open. The purpose of this device is to control the boiler water concentration at a reasonable figure by continuously removing dissolved solids and sludge at approximately the same rate they are added with the feed water.

The main parts of the automatic blow down system are the automatic blow down valves located in the rear water leg, and the separator located on top of the boiler. The automatic blow down valve discharges water from the boiler to the separator which permits steam to escape to the atmosphere and discharges the water to the ground through the discharge pipe. This device is working when water comes from the discharge pipe.

If the automatic blow down system continues to discharge water from the boiler after the throttle is closed, open the cylinder cocks and move the reverse lever forward and back several times to relieve the pressure in the valve chambers. If this does not eliminate the trouble, it may be due to excessive leaking throttle or defective blow down valve. This condition should be reported on M. P. 62 form at end of trip.

A discharge of water from the top of the separator is an indication of a clogged or frozen discharge pipe. This condition should be reported on M. P. 62 form at end of trip.

**Manual Blow Down:**—Boilers equipped with manual blow down should be blown down only at points specified by the Road Foreman of Engines. The following road procedure shall be followed:

1.—When train is stopped enroute for coal or water:

- (a) Fill boiler, with water level to within 1" or less of top of water glass.
- (b) Shut off injector and feed water pump.
- (c) Blow down boiler until water is within ½" of the bottom of glass, using throat sheet blow down.
- (d) Refill boiler to within 1" or less below top of water glass.

2.—Locomotives equipped with blow down which can be operated from the cab, same procedure (1) shall be followed while moving, except that injector or feed water pump should not be shut off when blowing down with the engine working steam.

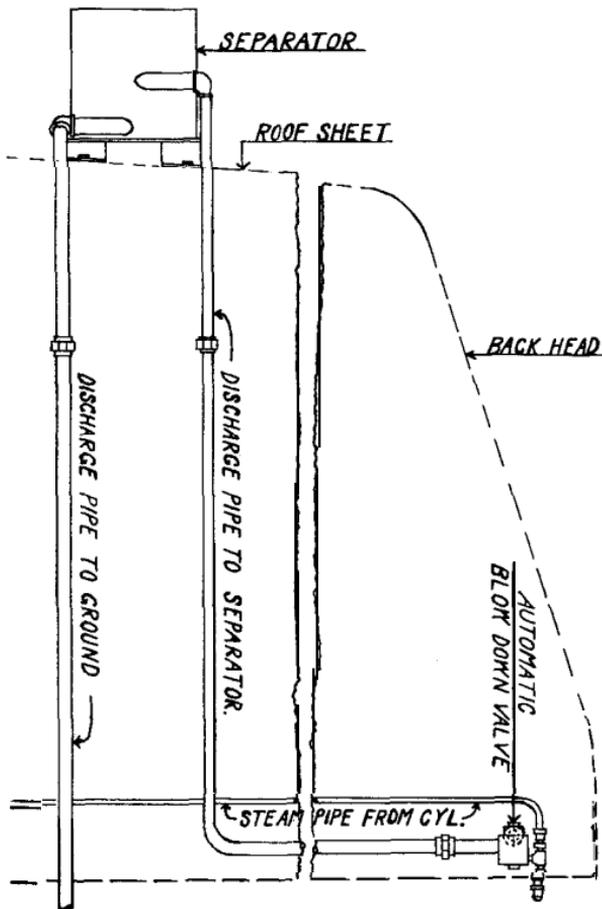


FIG. 44-AUTOMATIC BLOW DOWN ARRANGEMENT.

3.- When train is stopped for reasons other than taking coal or water, or station stop:

- (a) The blow down shall be opened wide just prior to starting for at least twenty
- (b) After again starting, the boiler should not be blown down until a speed of at least eight miles per hour has been attained.
- (c) All blowing down, unless engine is working steam, should be done with the injector and feed water pump shut off.

Proper blowing down should not be neglected because of light train or because boiler has just been washed or has had water changed as this may leave the water in bad condition for the next run, which may be with a heavy train.

Best results are obtained in correcting a foaming condition by blowing down the boiler while working steam.

## QUESTIONS ON CHAPTER 11

255. What causes foaming in a locomotive boiler?
256. What two kinds of impurities are found in boiler water?
257. Why is boiler water chemically treated?
258. How can solids that form as mud and sludge in the boiler be removed?
259. What effect does foaming water have on a locomotive?
260. What effect does foaming water have on the water level in the boiler as indicated by the gauge cocks and water glass?
261. What are the indications that the water is foaming in a boiler when the engine is working?
262. What dangerous condition may result from the water foaming in the boiler?
263. What action must be taken when water in the boiler is foaming?
264. What are the purposes of blow downs on boilers?
265. What bad results may be obtained in the operation of the locomotives and the maintenance of the boiler through failure to use blow down as instructed?
266. What are the various kinds of blow downs now in use and how is each one operated?
267. What is an automatic blow down?
268. What is the purpose of the automatic blow down?
269. What are the main parts of the automatic blow down system and where are they located?
270. How can you tell when the automatic blow down is working?

271. What is the purpose of the automatic blow down valve.
272. What is the purpose of the separator?
273. What should be done if the automatic blow down continues to discharge water from the boiler after the throttle is closed?
274. What may cause water to discharge from the top of separator?
275. At what points should boilers equipped with manual blow down be blown on the road?
276. What procedure should be followed in blowing down boiler when train is stopped for coal and water?
277. How should boiler be blown when train is moving?
278. How should boiler be blown when train is stopped for reason other than taking coal or water, or station stop?
279. Is it necessary to blow down boiler with a light train or when boiler has just been washed or water changed? Why?
280. How are best results obtained in correcting a foaming condition?

## CHAPTER 12

### Injectors and Feed Water Pumps

**Lifting and Non-Lifting Injectors**—The principal valves and tubes of an injector are the steam valve, water valve, overflow valve, steam nozzle, combining and delivery tubes. Water is taken from the tank into the injector in the following manner:

**Lifting Injector** (Figs. 8 and 45, pages 16 and 78)—Priming the injector permits a jet of steam to pass through the steam nozzle and exhausts the air from the body of the injector and feed pipe, creating a partial vacuum therein. Atmospheric pressure on the water in the tank forces the water up into the injector.

**Non-Lifting Injector** (Figs. 9, 10, 46, pages 17, 19, 78)—This type of injector is located below the level of water in the tank and the water flows directly to the injector.

Water is forced into the boiler on the principle of imparting to cold water the velocity of steam. The

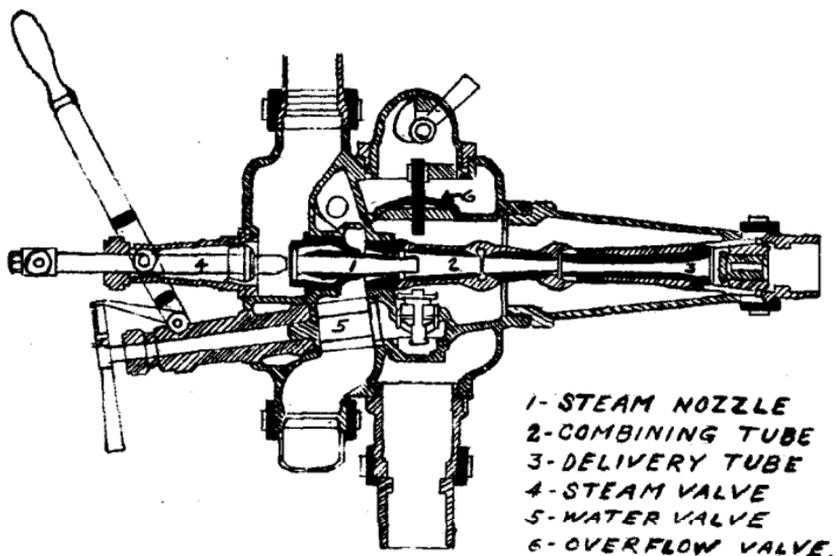


FIG.-45.-LIFTING INJECTOR

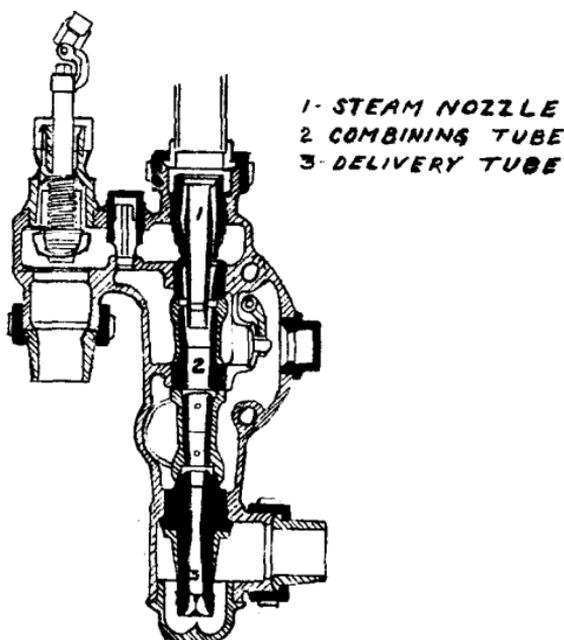


FIG.-46.-NON-LIFTING INJECTOR

flow of water having been started through the injector to prime it, opening the steam valve causes the jet of steam to impinge on and combine with the water, imparting velocity to the water sufficient to force it through the delivery pipe, opening the boiler check and allowing water to enter the boiler.

An injector to work properly must have a free and unobstructed flow of water from the tank; steam to impart sufficient velocity to the water to force it into the boiler; no leaks in suction pipes; feed water must be cool enough to condense steam; no obstructions in the tubes, and boiler check valve must be free and have proper lift.

Some of the causes for an injector failing to prime are:

- (a) No water in tank.
- (b) Tank valve partly or entirely closed.
- (c) Strainers stopped up.
- (d) Hose lining loose or hose kinked.
- (e) Leaks in feed pipe.
- (f) Tubes in injector cut, limed up or out of line.
- (g) Leaking boiler check valve.
- (h) Supply or inlet valve stuck open.
- (i) Overflow pipe obstructed.
- (j) Turret valve not wide open.
- (k) Man hole covers on tank too tight or frozen.

Failure of an injector to work properly after it is primed may be due to any of the following causes:

- (a) Insufficient water or steam supply.
- (b) Tubes badly cut or out of line.
- (c) Boiler check stuck shut.
- (d) Overflow valve not properly open.
- (e) Combining or delivery tubes stopped up.

Escape of steam from the overflow pipe when the injector is not working is an indication of leaking steam ram or steam valve. When steam and water escape, the boiler check is leaking.

When an injector is working and discharges water or steam from the overflow, it may be caused by the following:

- (a) Too much water.

(b) Steam not all condensed due to too much steam or insufficient water.

(c) Tubes cut or worn or partially stopped up.

When the water in the tank becomes too hot, it should be cooled. If this cannot be done, the steam pressure to the injector should be reduced by closing the injector turret valve tight and then opening it very slowly about one-third or until the injector operates. With a non-lifting injector, the steam pressure can be controlled with the injector steam valve.

**Worthington Feed Water Pumps—Types B—A—SA—SAS**—All types of Worthington feed water pumps should be run continuously while the locomotive is in operation at the speed necessary to maintain the proper water level in the boiler. When the engine is standing or drifting, the speed of the pump is slowed down by the drifting control valve which automatically slows down the pump when the throttle is closed and will automatically speed up when the throttle is opened. This device is controlled by live steam pressure from the valve chambers. No attempt should be made to adjust this valve. If it does not function properly, report should be made at the end of the trip.

With feed water heating equipment, it is not necessary to fill the boiler while the locomotive is standing in order to be ready to start a train. The smaller steam requirement of the hot water pump as compared with the injector makes it possible to start the pump when the locomotive is started without losing steam pressure. This method of operation yields the best results both from the heater and the locomotive. Because of the heat recovered from the exhaust steam, and because of the improvement in boiler conditions due to the reduced firing rate, the heater saves from 10 to 20 percent of the coal which otherwise would be required while running. Unless more work is to be done by the locomotive because of the heater, less coal should be fired than when using the injector.

The sound of the exhaust from the locomotive is softer when using the heater. Allowance should be made for this in judging the amount of work the locomotive is doing in determining the position of the reverse lever.

The following is a list of possible trouble that may be encountered with the feed water pump and the procedure to be followed:

- (a) **Locomotive throws water from the stack**—Stop the pump and use the injector for a time to see if the locomotive stops throwing water, if it does, then start the pump and see if the throwing of water starts again. If so, stop the pump and use the injector for the remainder of the trip.
- (b) **Feed water pump does not start promptly**—Open and close the pump throttle several times. If this does not start pump, increase lubricator feed temporarily and repeat the above. If the pump will not then start, proceed, using the injector.
- (c) **Feed water pump does not supply the boiler**—This may be due to a partly closed tank valve, a clogged tank hose or strainer, defective discharge or suction valves, defective hot water cylinder packing, or defective drifting control valve.
- (d) **Excessive discharge at vent pipe while the feed water pump is in operation**—This indicates defective hot water cylinder packing or valves on the Type B pump or a stuck or loose float valve in the heater of the Type S-SA or SAS.
- (e) **Feed water pump becomes steam bound**—This occurs when the cold water pump loses its suction and becomes filled with air and later with steam, and may be due to the water in the tank getting too low. Proceed with train to the nearest water stop, using the injector, and when the tank is again filled with water, the pump should be tried. If the trouble persists, it is an indication that the suction line or strainers are obstructed.

Work reports should state as clearly as possible what troubles are encountered on the road. If cause is known, it should be reported. If not known, the trouble should be carefully described.

## QUESTIONS ON CHAPTER 12

285. Name the principal valves and tubes of an injector.
286. How is water taken from the tank into the lifting and non-lifting injector?
287. How is water from the injector forced into the boiler?
288. What is necessary if an injector is to work properly?
289. Name some of the causes for an injector failing to prime.
290. Name some of the causes why an injector will not work after it is primed.
291. What are the indications of a leaking steam ram or steam valve? Of a leaking boiler check?
292. Name some of the reasons which cause an injector while working to discharge water or steam from the overflow.
293. What should be done if water in tank becomes too hot?
294. Describe how and when the Worthington feed water pump should be operated.
295. What controls the speed of the Worthington feed water pump when standing or drifting?
296. What controls the action of the drifting control valve?
297. Should the drifting control valve be adjusted by the engine crew if it does not function properly? What should be done?
298. What should be done when a locomotive equipped with a Worthington feed water pump throws water from the stack?
299. What is the cause when the Worthington feed water pump does not supply the boiler?
300. What should be done when the Worthington feed water pump does not start promptly?
301. What is indicated by an excessive discharge from the vent pipe of Worthington feed water pump?
302. What is the cause of a Worthington feed water pump becoming steam bound and what is the best method of overcoming this difficulty?

303. When the Worthington feed water equipment fails to function properly enroute, how must it be reported on arrival at the terminal?

## CHAPTER 13

### LUBRICATION

**General**—Lubrication is the placing of a thin layer of lubricant between the moving surfaces of metal so that they do not touch each other. Proper lubrication prevents friction and reduces wear and the consumption of coal and water. When lubrication is applied by hand to the machinery, care should be taken to know that oil holes are open and that the oil gets to the bearings. Only enough oil should be used to properly lubricate the parts. Engine oil should be kept away from the boiler in warm weather to keep it from becoming too hot, as hot oil runs off bearings and is wasted.

**Hydrostatic Lubricator**—The hydrostatic lubricator is located in the cab at as high an elevation as possible in order to induce the oil to flow more readily to the various parts to be lubricated. The principle of the hydrostatic lubricator is that a column of water exerts a pressure upon the oil in the reservoir so as to force the oil past the regulating valves to the point of delivery. This principle operates in the following manner:

Steam being admitted to the condensing chamber, water of condensation flows through water pipe inside the lubricator to the oil reservoir and settling at the bottom it raises the oil and forces it down through oil tube to sight feed regulating valves. When these valves are opened, small drops of oil pass up through the water in sight feed glasses to the oil pipes leading to the valve chamber, cylinders, stoker, air compressors, feed water pump and booster. This flow of oil is regulated by valves and choke plugs.

Choke plugs are for the purpose of balancing the flow of steam from the lubricator to the steam chests and are located as follows:

**For valve chambers and cylinders**—At front end of oil pipe.

**For stoker, air pumps, feed water pumps, booster-**  
At connection of oil pipe with lubricator.

It is an indication that holes in choke plugs are too large when the lubricator feeds faster when the throttle is closed than wide open.

When the lubricator is working properly and feeding the right amount of oil and the valves or cylinders appear dry, the throttle should be eased off to relieve the steam chest pressure. Oil that is being held above the choke plugs should then flow to the steam chest. If this does not correct the trouble, it is possible the oil pipe is stopped up.

The hydrostatic lubricator should be regulated to deliver the following amount of oil:

Cylinder Feeds:

Yard locomotives (depend- ing upon speed and size of cylinders - - - - -	3 to 8 drops per min.
Road locomotives (depend- ing upon speed and size of cylinders - - - - -	6 to 12 " " "
Stoker Feed - - - - -	3 " " "
Air Pump Feed (each pump)	2 to 4 " " "
Feed Water Pump Feed - -	3 " " "
Rooster Feed - - - - -	2 " " "

The feeds of a hydrostatic lubricator must be watched frequently to insure that it is delivering the proper amount of oil. Improper lubrication may result in worn valves and cylinder packing rings and bushings or possibly breakage of valve gear parts.

**Mechanical Lubricator**—A mechanical lubricator delivers oil to the valve chambers, cylinders, and other parts of the locomotive. Some of the later type locomotives are equipped with five lubricators.

The principal parts of the mechanical lubricator are body, cover, pumping unit, heater, filler cap and drain plug, oil gauge, drive mechanism, necessary piping and terminal checks.

A high pressure terminal check (Fig. 47, page 85) is used in the lubricator line near the point at which oil is introduced into the steam, and a low pressure ter-

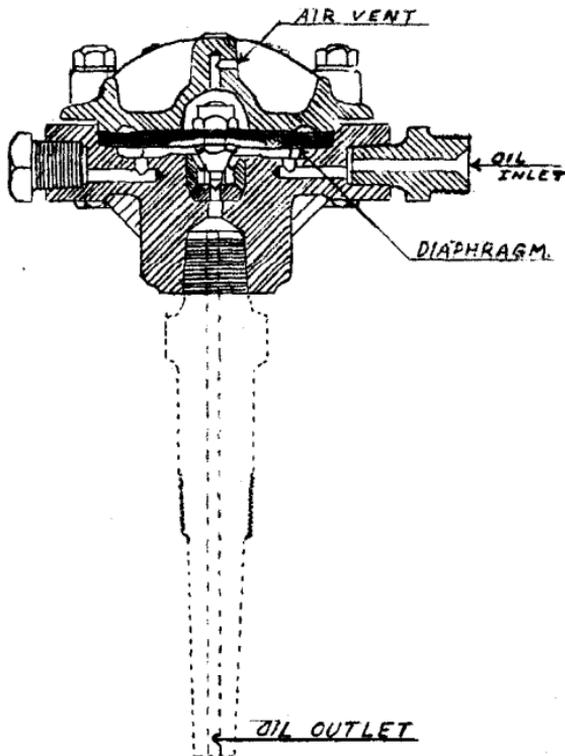


FIG. - 47 - TERMINAL CHECK VALVE-DIAPHRAM TYPE

minal check is used at other points such as guides, etc., that are not subject to steam pressure. Each check is provided with a valve that is held in closed position until the oil pressure is sufficient to raise the diaphragm to which the valve is attached.

The purpose of the terminal check is to eliminate the possibility of water and steam getting into the lubricator, also to prevent draining oil out of the oil pipes when the locomotive is standing.

When it is known that there is oil in the lubricator and there are no visible defects, but the valves and cylinders are not receiving proper lubrication, the trouble may be due to water in the oil reservoir. This can be determined by opening the drain plug and if water is

found, it should be drained out and report made on arrival at terminal.

If heater pipe to the mechanical lubricator should break, the end of pipe should be pounded shut to prevent the escape of steam, or if in cold weather, the pipe should be bent, if possible, so that escaping steam will surround and heat the lubricator.

When the mechanical lubricator runs empty enroute and is refilled at some intermediate terminal, a report should be made at the end of the run, because it is quite probable that the lubricator is air-bound and will not feed. Excessively high or noticeably low oil consumption for the mileage of the trip should also be reported.

### QUESTIONS ON CHAPTER 13

310. What is lubrication?
311. What results are obtained by proper lubrication?
312. What should be observed in oiling the machinery?
313. Why should engine oil be kept away from the boiler in warm weather?
314. Where is the hydrostatic lubricator located and why?
315. What is the principle of the hydrostatic lubricator?
316. How does the hydrostatic lubricator operate?
317. What is the purpose of choke plugs and where are they located?
318. What is usually the cause if the hydrostatic lubricator feeds faster when the throttle is closed than wide open?
319. What should be done if valves and cylinders appear dry while using steam and the hydrostatic lubricator is working properly?
320. Why must the feeds of the hydrostatic lubricator be watched frequently?
321. What may result from improper lubrication?
322. What are the principal parts of a mechanical lubricator?
323. What is a terminal check?

324. What is the purpose of the terminal check?
325. Where might the trouble be if it is known that there is oil in a mechanical lubricator and no visible defects, but valves and cylinders are not receiving proper lubrication?
326. What can be done if heater pipe to mechanical lubricator should break?
327. What action should be taken at end of run if mechanical lubricator runs empty and is filled at some intermediate point or the oil consumption has been excessively high or noticeably low for the mileage of the trip?

## CHAPTER 14

### Electric Headlight Equipment

**Turbo-Generator**—Power for electrical equipment on locomotives is provided by a steam driven turbo-generator composed of a turbine and an electric generator and located on the smoke box.

The turbo-generator is started by opening the steam valve slowly to permit condensation to drain from the turbine and then opening the steam valve wide. It should not be run unnecessarily and when the steam is turned off be sure the valve is tightly closed.

Lubrication of the turbo-generator by the engine crew is not necessary as all bearings are inspected and lubricated at the end of each run by enginehouse em-

**Electric Headlight**—There are two types of headlight lamps, namely:

- (a) Screw base lamps, the bases of which are threaded.
- (b) Prefocused lamps, which have bayonet type bases with a retaining fin mounted on opposite sides near the glass bulb. One of these fins is wider than the other and corresponds with the slots in the socket, one of which is also wider than the other, the wider slot being at the top.

Prefocused lamps are installed by inserting the base of the lamp into the socket with the fins opposite to their corresponding slots, push home and give a quar-

ter turn to the right. They are removed by depressing the lamp straight into the socket, give a quarter turn to the left and pull out.

The base of a broken headlight bulb may be removed from the socket in the following manner:

- (a) By use of a standard wooden spike plug (used to plug spike holes in ties). If screw type bulb, insert square end of plug in the stub and turn counter clockwise; for bayonet type bulb, insert the pointed end in and press hard enough to overcome the springback of the bulb. then turn counter clockwise until the stub is released.
- (b) By use of a flag stick. (A flag stick can only be used if the headlight is equipped with a front door.)

A gloved hand should be used, if possible, in changing headlight lamps to avoid injury.

The following locomotives are equipped with a spare headlight lamp carried in its original carton in the headlight housing:

- (a) All passenger locomotives.
- (b) All freight locomotives equipped with single headlight with glass reflector and prefocused base lamp.

When a headlight lamp fails enroute on freight or switching locomotives equipped with screw base lamps, it shall be replaced by a lamp removed from the center light or the headlight on the rear of the tender.

If a headlight lamp failure occurs on a locomotive equipped with full power headlights at both ends, the headlight lamp shall be removed from the trailing end and installed in the leading end.

When trouble has been experienced with the electrical equipment, report shall be made on M. P. 62 form stating what occurred, what seemed to be the cause of the trouble and what, if anything, was done to remedy the trouble.

## QUESTIONS ON CHAPTER 14

335. How is power provided for electrical equipment on locomotives?
336. How should the turbo-generator be started?
337. Is lubrication of the turbo-generator necessary while enroute?
338. What types of headlight lamps are in use?
339. Describe each type of headlight lamp.
340. How is a prefocused headlight lamp installed?
341. How is a prefocused headlight lamp removed?
342. How may the base of a broken headlight lamp be removed from the socket?
343. What precautions should be used in changing headlight lamps to avoid injury?
344. What locomotives are furnished with a spare headlight lamp?
345. What should be done if headlight lamp fails enroute on freight or switching locomotives equipped with screw base lamps?
346. What should be done if headlight lamp failure occurs on locomotives equipped with full power headlights at both ends?
347. What must be reported at the end of trip when trouble has been experienced with electrical equipment?

## CHAPTER 15

### Conditions Causing Poor Steaming

The principal causes that prevent a locomotive from steaming freely and creating excessive smoke are defects in the locomotive or improper firing. These causes effect the complete combustion of coal by not permitting a sufficient supply of air to mix with gases from the coal and a sufficient high temperature to ignite the mixture. Good combustion consists of supplying the proper amount of air to the fire. This air is drawn in by the draft that is created from exhaust steam passing up through the stack when the locomotive is working and by the use of the blower when the locomotive is not working. Not enough air being admitted to the fire will materially effect the free steaming of the locomotive and may be caused by the following:

## 1. Defects on Locomotive:

- (a) **Smoke box not air tight.**—This permits air to enter the smoke box through openings and destroys the vacuum, as the amount of air that enters would correspondingly reduce the amount of air that would pass through the grates and results in reduced draft through the fire.
- (b) **Steam leaking in smoke box.**—This may be due to leaking steam pipe joint, loose exhaust pot or nozzle, or leaking superheater unit. This condition causes an engine to steam poorly while working, but gains steam rapidly when 'the throttle is closed and blower applied.
- (c) **Smoke box full of cinders or netting plugged.**—This causes the locomotive to steam poorly while working and does not gain steam rapidly when the throttle is closed and the blower applied ; if practicable, the smoke box should be opened and front end or netting cleaned.
- (d) **Smoke box draft appliances loose or out of line.**—This is indicated when exhaust steam and smoke issues from one side of stack.
- (e) **Flues stopped up.**—This has a tendency to produce a red fire as sufficient air cannot pass through the fire.
- (f) **Leaking flues and other fire box leaks.**—Water from leaks in the fire box evaporate into steam and coming in contact with the hot gases, lowers their temperature and also effects the vacuum in the front end, resulting in less draft through the fire.

## 2. Improper Firing:

- (a) **Grates becoming clogged with ashes and clinkers.**—This does not permit sufficient air to pass through the fire. Clinkers are caused by heavy firing in spots which permits slag and ash to run together. They

should be removed if possible. If this cannot be done they should be broken and worked through the grates or pulled to the back corners.

- (b) **Putting too much coal on a bright fire.**— This temporarily deadens and cools the fire, with the result that combustion is stopped until this fresh coal is heated to the burning point. This is a waste of fuel and is conducive to clogging front end netting and flues.

Many bad fire conditions can be prevented before they develop into serious difficulties if the fireman forms the habit of frequently inspecting the fire.

There are so many factors which have a tendency to change fire conditions that frequent inspection of the fire is absolutely necessary. Shortening the cut-off or "easing off" on the throttle, requires a decreased amount of coal in the fire box and decreases the amount of water required to maintain the boiler water at the proper level. Fire box conditions are changed when the coal changes from lump to slack or from slack to lump, or if the condition of the coal changes from dry to wet or from wet to dry. Jet pressures have an effect on the condition of the fire. The stoker speed and the stoker jet pressures must be adjusted if the condition of the coal changes or if the load conditions change.

By frequent inspections the fireman can detect the formation of clinkers, and can prevent plugged arches, banks, and holes. Any condition in the fire box which causes unbalanced draft tends to cause a carryover of cinders and unburned coal which may result in a plugged front end netting. Through frequent inspection most difficulties can be detected and corrected before they become serious.

The engineer and fireman are in the best position to determine the cause of a locomotive not steaming and the M. P. 62 report should furnish detailed information, specifying just where, in their opinion, the trouble is, so that the enginehouse force will not be compelled to make expensive tests unnecessarily, which holds engine out of service.

## QUESTIONS ON CHAPTER 15

355. What are the principal causes that prevent a locomotive steaming freely?
356. What is one of the chief causes of imperfect combustion?
357. What locomotive defects effect the free steaming of the locomotive?
358. What bad effect is produced if the smoke box is not air tight?
359. What condition causes an engine to steam poorly while working, but gains steam rapidly when the throttle is closed and blower applied?
360. What trouble is indicated when a locomotive steams poorly while working and does not gain steam rapidly when the throttle is closed and the blower applied?
361. What action should be taken if smoke box is filled with cinders or the front end netting is plugged?
362. What causes the exhaust to issue from one side of the stack?
363. What condition has a tendency to produce a red fire?
364. How do leaking flues and fire box leaks effect the steaming qualities of a locomotive?
365. How does improper firing effect the free steaming of a locomotive?
366. What causes clinkers?
367. What should be done when clinkers form in a fire?
368. What is the effect of putting too much coal on a bright fire?
369. Who is in the best position to determine the cause of a locomotive not steaming and how should M. P. 62 reports be prepared covering this matter?

# INSTRUCTIONS FOR LOCOMOTIVE FIREMEN—

## PART 3

### CHAPTER 16

#### Qualifications and Duties of an Engineer—General Operation of Locomotive

**Qualifications**—An engineer must be a man of good habits, trustworthy, faithful and intelligent. He must understand the rules and obey them. He is responsible for the engine and its performance, and must not only be skilled in its care and handling, but must know what to do in cases of break-down and emergencies.

**Duties**—The first duty of an engineer when taking charge of an engine is to see that there is sufficient water in the boiler by operating the gauge cocks and seeing what comes out of the drip pipes. He must know that they are open and working freely. An examination and test should then be made of the water glass. The firebox and flues should be examined for leaks, giving special attention; to the crown sheet and bolts. He must know that the injectors and feed water pump are working properly.

While the engine is being prepared, the following inspection should be made:

1. The locomotive and tender should be inspected for defects, seeing that all important bolts, nuts, taper pins and cotter keys are properly applied.
2. See that there are no loose bolts, nuts, tools or other material lying on runningboards, frames, etc.
3. That sand pipes are clamped in proper position and the sanders are operating.
4. Examine the grates and ash pan.
5. See that steam heat connector at rear of tender is properly hung up.
6. Blow out brake pipe and steam heat line at rear of tender.
7. Check all turret valves to know that the proper valves are wide open or closed as conditions require.

8. See that locomotive has a full supply of coal, water, sand, tools, etc.
9. Test brake and air signal whistle.
10. Try water scoop.
11. See that heater lines are open in cold weather.
12. That whistle and bell ringer are in good condition.
13. That power reverse gear is properly lubricated and works freely in all positions.

**General Operation of Locomotive**—Before an engine is started, the cylinder cocks must be opened, brakes applied, throttle opened and steam admitted alternately to both ends of cylinders by slowly moving the reverse lever back and forth until dry steam appears at all cylinder cocks. This warms up the cylinders and removes all accumulated water that may be in the cylinders. During this operation the throttle should be opened up slightly or just cracked. If too much steam is permitted to enter the superheater, accumulated water in the units is driven with great force against the return bends and may cause them to leak.

Water can not be compressed and if trapped in the cylinders when the piston is moving toward the cylinder head it is liable to crack or knock out the cylinder head, crack or break the rods or pins. Damage of this kind may not become apparent at once, but the parts affected and fractures started may fail at some later time.

When starting a train, the reverse lever should be put in full gear to insure the greatest pull, the rapid heating of the cylinders and the proper oil distribution. The engine should be started slowly until all the slack is out of the train. Jerking the train may result in pulling out or breaking drawheads in the cars. When hauling a long train, care should be taken in closing the throttle to ease off slowly to allow the slack in the train to gradually run in.

Slipping of the drivers must be avoided, as it not only tears and upsets the fire and causes a waste in rebuilding, but it wears out tires and rails and may result in serious damage to the running gear. It also results in reducing the pulling power of the engine and rough handling of the train.

A slipping engine must not be caught on sand nor should sand be used on one side only. This may cause rods, pins or axles to break. Sand should only be used in sufficient quantity to prevent slipping.

When making stops or when descending grades, the throttle must not be shut off suddenly, but closed to a point where sufficient steam will be admitted to prevent carbonization of lubrication, also to hold snifting valves to their seats, and the reverse lever should be regulated according to the type of gear and conditions.

If for any reason water in the boiler cannot be maintained at a safe level the fire must be deadened or drawn.

Locomotives can be abused by:

1. Failure to properly lubricate.
2. Failing to use cylinder cocks to know that cylinders are free from water before the locomotive is moved.
3. Carrying too much water in the boiler.
4. Working the locomotive unnecessarily hard.
5. Reversing with steam in the cylinders and especially when driver brakes are set.
6. Slipping of the drivers.
7. Using sand on one side only ; using sand when slipping without closing the throttle, and not using sand when it should be used.

## QUESTIONS ON CHAPTER 16

375. What are the qualifications in general that an engineer should possess?
376. What is the first duty of an engineer when taking charge of an engine?
377. What inspection should be made of an engine?
378. What should be done before an engine is started?
379. How should the throttle be operated when warming up or blowing water out of the cylinders?
380. What is liable to occur if an engine is moved with water in the cylinders?
381. How should an engine be started to avoid jerks to the train?

382. How should the throttle be closed when hauling a long train?
383. Why should slipping of the drivers be avoided?
334. How should sand be used?
385. How should the throttle and reverse lever be handled when making stops or descending grades.
386. What should be done if the water in the boiler cannot be maintained at a safe level?
387. How can a locomotive be abused?

## **CHAPTER 17**

### **Throttle Valves**

The following two general types of throttle valves are used on our locomotives:

1. Dome throttle.
2. Multiple valve-throttle.

#### **Dome Throttle**

This throttle valve is located in the highest part of the dome on the boiler (Fig. 1, page 7) so that it may be supplied with dry steam. Its purpose is to regulate the flow of steam from the boiler to the cylinders.

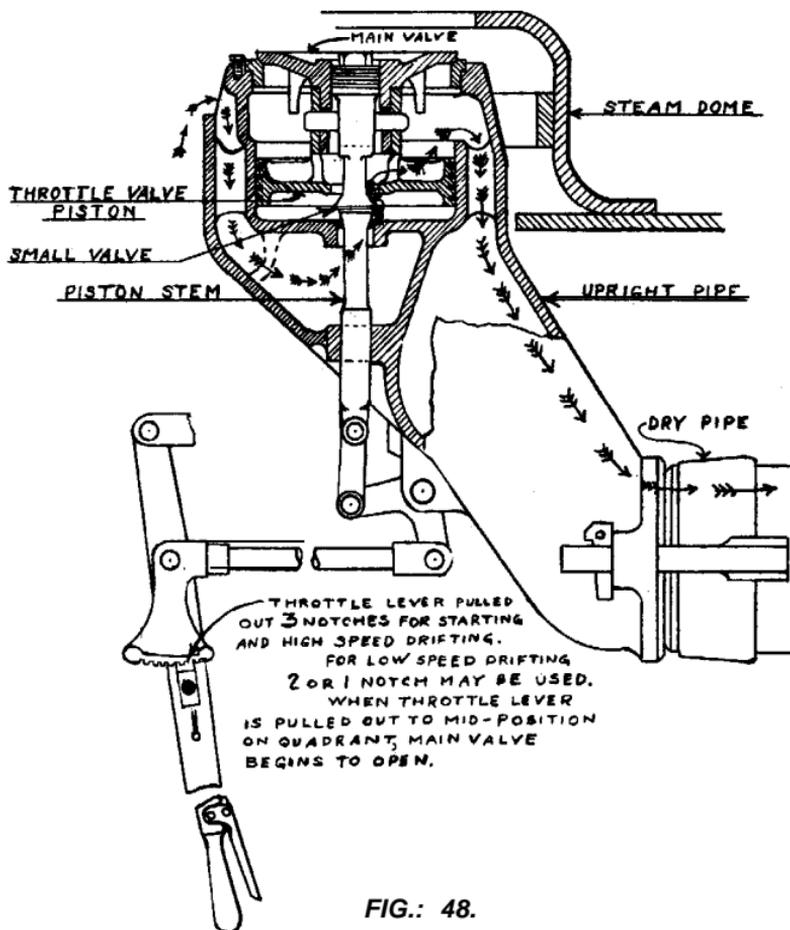
Most of our locomotives are equipped with the piston stem throttle valve (Fig. 48, page 97). This throttle consists of the following main parts:

- (a) Upright pipe.
- (b) Piston stem which contains the small valve.
- (c) Main valve.
- (d) Throttle valve piston.

The small valve is used for starting and drifting and the main valve begins to open when the throttle lever is pulled out to mid-position on the quadrant.

**Operation**—When the throttle lever is pulled out 3 notches for starting and high speed drifting, the small valve opens permitting steam to pass through the throttle valve piston and then to the dry pipe on its way to the cylinders. When the throttle lever is pulled out to mid-position, the collar on the piston stem contain-

## PISTON STEM THROTTLE VALVE



**FIG.: 48.**

ing the small valve moves up into the opening on the bottom of the throttle valve piston and shuts off the flow of steam through this piston. This permits the pressure of the steam to act on the bottom of the throttle valve piston and balances the main valve so that further opening of the throttle lever raises the main valve off its seat for the admission of steam through this valve.

Steam issuing from the cylinder cocks when an engine is standing with the throttle shut off and lubricator closed is an indication of a leaking throttle or

dry pipe. However, it may also be due to steam coming from the water which may have accumulated in the superheater units. In this case it will cease when all the water in the units has evaporated.

In the event the throttle valve becomes disconnected while the valve is closed, the engine is powerless and assistance must be obtained. If the throttle valve fails to seat after the throttle lever is in the closed position, the engine must be controlled by the reverse lever and brakes and the steam pressure reduced.

### **American Multiple-Valve Throttle**

**General**—Since the first steam locomotive was built, a steam dome on the top of the boiler has been used in order to obtain steam as dry as possible. In recent years, however, as locomotive boilers have increased in size, the height of the steam dome has necessarily decreased with the result that the dome is no longer a suitable place for the throttle. Also the introduction of the superheater added considerable steam space between the throttle and the cylinders, resulting in delayed response to the movement of the throttle.

In view of the above, it has been concluded that the smoke box location offers the most advantageous position for the throttle. In addition to eliminating the disadvantages of the dome throttle, the smoke box throttle has the following advantages:

1. Full use of the additional steam space afforded by the superheater header, units, and dry pipe.
2. Instant response of locomotive to movement of the throttle.
3. Availability of superheated steam for the auxiliaries at all times with resultant economy.
4. Protection for the superheater units. (The superheater units are filled with steam the entire time there is pressure on the boiler. This protects them from the heat passing through the flues from the firebox, when the throttle is closed.)

**Operation**—The valves of the American throttle open in sequence. The sequence and the intervals between valve movements are established by the graduated contours of the cams on the camshaft. The main valves, other than the "A" valve, are identical in con-

struction, but are assigned designations "B," "C," "D," etc., which relate to the position of each valve in the throttle and the sequence in which each valve is set in motion in opening the throttle (Figs. 48A and 48B, page 99). The number of main valves varies with the size of the boiler and range from three to seven.

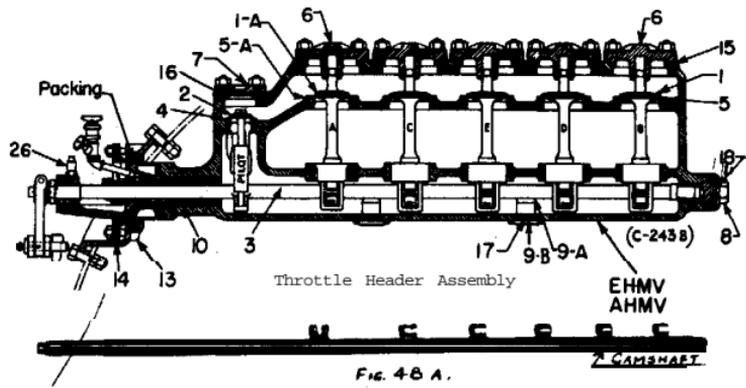
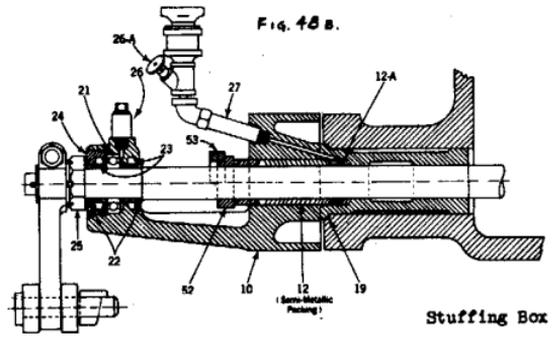


Fig. 48 A.

REF. NO.	NAME OF PARTS	REF. NO.	NAME OF PARTS
EHMV AHMV	American multiple-valve throttle as an integral part of an Elesco type "A" or type "E" superheater header	12-A	Lantern Gland
1	Main Valve	13	Stuffing Box (Gas Joint)
1-A	"A" Valve	14	Stuffing Box Gland (Gas Joint)
2	Pilot Valve	15	Main Valve Cover Gasket
3	Camshaft	16	Pilot Valve Cover Gasket
4	Pilot Valve Seat	17	Camshaft Bearing Plug Gasket
5	Main Valve Seat	18	Camshaft Bushing Gasket
5-A	"A" Valve Seat	19	Camshaft Bearing Gasket
6	Main Valve Cover	21	Camshaft Ball Bearing
7	Pilot Valve Cover	22	Camshaft Sleeves
8	Camshaft Bushing	23	Camshaft Oil Rings
9-A	Camshaft Plug Bearing	24	Camshaft Ball Bearing Retaining Plug
9-B	Camshaft Bearing Plug	25	Camshaft Nut
10	Camshaft Bearing	26	Oil cup
12	Stuffing Box Packing (Steam Joint)	26-A	Lubricator
		27	Lubricator Extension
		52	Stuffing Box Gland (Steam Joint)
		53	Stuffing Box Gland Flange



The first movement of the throttle operating lever, from the closed position to the open position, raises the pilot valve and permits steam to pass from the upper chamber of the throttle to the balancing chamber at the bottom. The main valves are then in balance. Further movement of the throttle lever opens the "A" valve, followed at the established intervals, by valves, "B," "C," "D," etc. The flow of steam from the upper chamber to the middle chamber and thence to the steam pipes and cylinders begins at the moment the "A" valve is opened, and increases in volume as the other valves are subsequently set in motion until full throttle opening is attained.

When the throttle lever is moved from the open position to the closed position, the valves will close in reverse order, the pilot valve closing last. As the throttle lever approaches the closed position, the lower side of each cam exerts force upon the bottom portion of the valves and closes each valve tightly. Leakage past the balancing pistons permits escape of the steam from the balancing chamber.

### **Causes for a Hard Working Throttle:**

1. Binding in throttle rigging, due to a misalignment. Throttle connecting rods tight in guides or moving parts of rigging not free to move readily. These faults are corrected by proper adjustment of rigging.
2. Lack of lubrication in the rigging.
3. Packing gland on camshaft drawn up too tight or packing dried out.
4. Excessive end play of camshaft, causing the cams to bind against the valve spindles or stirrups.
5. Incorrect intervals caused by wear of the cams or valves.
6. Excessive clearance between balancing piston and balancing piston guide in throttle.

## QUESTIONS ON CHAPTER 17

390. Where is the throttle valve located? Why?
391. What is the purpose of the throttle valve?
392. What are the main parts of the piston stem throttle valve?
393. Describe the operation of the small valve of the piston stem throttle valve.
394. Describe the operation of the main valve of the piston steam throttle valve.
395. What is indicated by steam issuing from the cylinder cocks when the throttle is shut off and engine standing?
396. What should be done if throttle valve becomes disconnected while valve is closed?
397. What should be done if throttle valve fails to seat after the throttle lever is in closed position?
398. Where is the multiple valve throttle located?
399. What does a multiple valve throttle consist of?

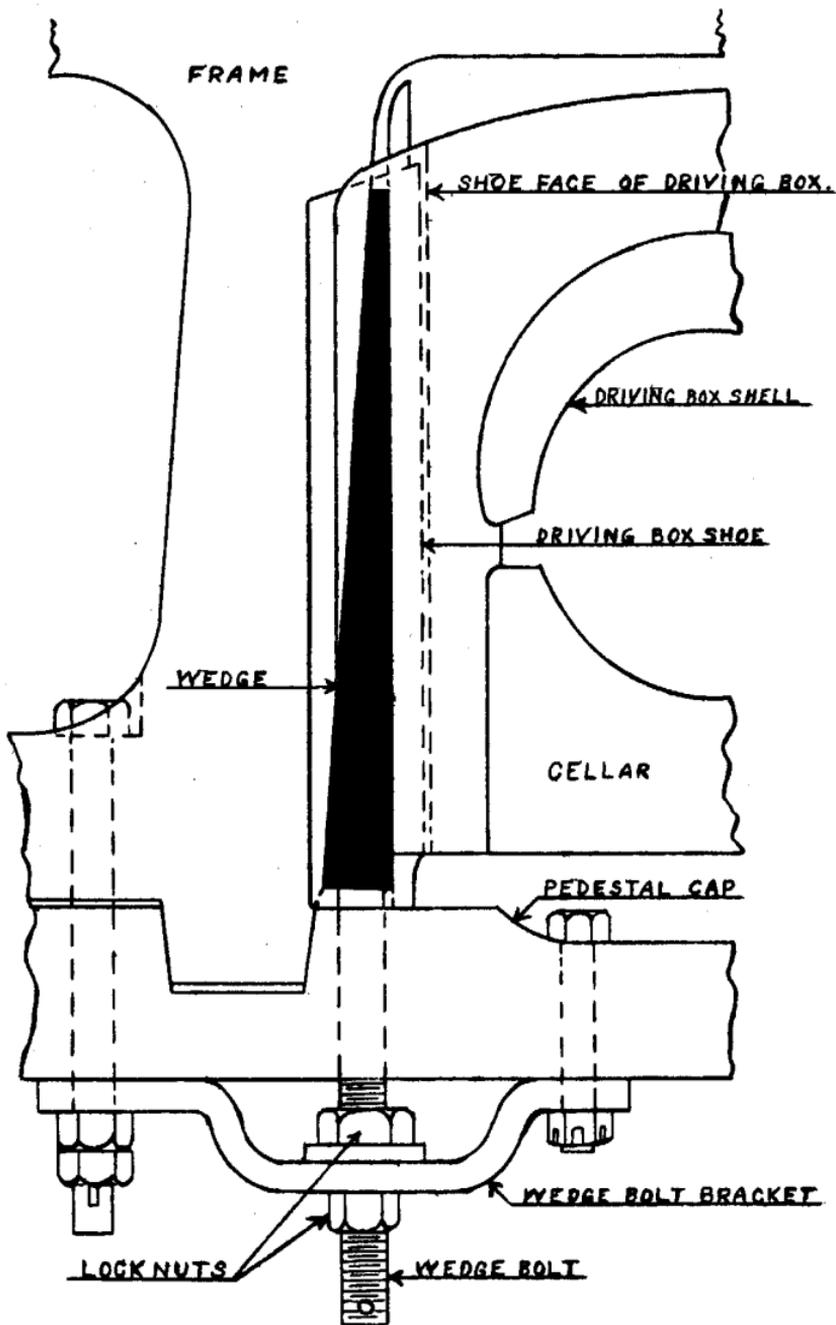


FIG.-49 - DRIVING BOX WEDGE ARRANGEMENT

## CHAPTER 18

### Driving Boxes—Shoes and Wedges

Driving boxes are for the purpose of supporting the weight of the frames and boiler on the axles. They are held from moving forward or backward by shoes and wedges located between the box and the jaws of the frame. The chief purpose of the shoes and wedges is to keep the driving axles in tram, take up the lost motion between the driving box and the pedestal as wear progresses and to prevent the pedestals from wear.

The wedge (Fig. 49, page 102) is located back of the driving box between the shoe and the pedestal jaw of the frame. It is an adjustable steel liner and is used to take up the lost motion between the driving box and jaw of frame.

Wedges are adjusted in the following manner:

1. Place engine over a pit having a straight level track when the driving boxes are cool.
2. Apply the driver brakes to take up the slack between the driving box and the front pedestal leg of frame.
3. Slack off both locking nuts, and with no pressure in the cylinders, adjust the wedge so that the wedge shoe is  $1/32$ " loose between the box and wedge.
4. Tighten locking nuts to hold wedge in this position.

It is necessary for the wedge shoe to be slightly loose to allow for expansion of the driving box when it reaches a running heat. Wedges that are adjusted too tight restrict the vertical movement of the driving box and interfere with the action of the springs. This will cause the engine to ride hard and may result in driving boxes heating excessively.

Driving box wedges should be lined when the wedge has been adjusted to the limit of its travel, as determined by the length of the wedge bolt, and lost motion still appears between the box and the shoe.

A broken wedge bolt may cause the wedge to be forced up so tight that it restricts the vertical movement of the driving box in the jaw of the frame. This causes the engine to ride hard and the box to run hot. A condition of this kind may be remedied by running

the wheel over a block. If a metal block is used, care must be taken to stand in a position where there will be no possibility of injury from being struck by the block if it should fly out.

A driving box that begins to heat excessively may be due to various causes but in most cases is caused by lack of lubrication from the grease pad being stuck away from the journal. This trouble may be overcome by tapping the end of the grease pad indicators, that extend below the bottom of the cellar, with a bar to force the grease pad up against the journal. Oil should also be applied between the driving box and hub of wheel.

Without jacks the weight can be taken off a hot driving box by running the wheel involved up on blocking. Place blocking between the top of frame and saddle; run the wheel off blocking and the weight that the disabled box carried will be placed on the frame and distributed to the other boxes.

## QUESTIONS ON CHAPTER 18

402. What is the purpose of driving boxes?
403. How are driving boxes held so they do not move forward or backward?
404. Where is the wedge located and what is it for?
405. How are wedges adjusted?
406. What effect is produced when wedges are adjusted too tight?
407. When should the driving box wedge be lined ?
408. What trouble may be caused by a broken wedge bolt? What may remedy this trouble and what precaution should be taken?
409. What is the most usual cause of a driving box heating excessively?
410. What should be done when a driving box begins to heat excessively?

## CHAPTER 19

### Spring Rigging—Driving Wheel Tires

**Spring Rigging**—Springs are for the purpose of lessening the amount of shock imparted to the frames and engine and may be classed as shock absorbers.

Spring rigging (Fig. 50, page 105, consists of the following parts:

- a. Saddles
- b. Springs
- c. Hangers
- d. Equalizers and seats
- e. Gibs or pins

The springs are carried by the saddles or equalizers, which rest on the driving boxes, and the frames are suspended from the springs by hangers and equalizers. Gibs or pins are used for securing the hangers and equalizers. The weight between the driving boxes is equalized or distributed by the equalizers by transmitting the shock sustained by one spring to other springs.

The spring rigging is properly equalized when the springs and hangers are level and straight, and there must be clearance between the tops of driving boxes and frame; also, between the bottom of the boxes and pedestal cans. This clearance is necessary to prevent the frame from striking the top of driving box and the pedestal cap from striking the bottom of the

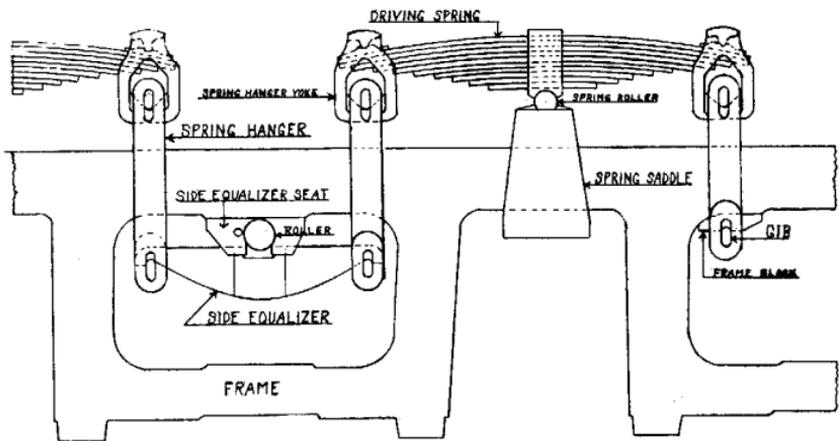


FIG.50-DRIVING SPRING RIGGING ARRANGEMENT.

driving box. The minimum clearance between the pedestal caps and driving box should be not less than 1" to prevent contact which will knock nuts, bolts, and other parts loose, cause the engine to ride hard and may result in derailment.

In the event an engine truck spring or front driving spring or hanger is broken, an examination must be made to see that the pilot clears the rail properly and if not, the front end of the engine should be raised and blocking placed between the top of the driving box and the frame.

If a spring hanger or equalizer is broken and the wheels do not rub the boiler, air pipe, etc. and the pilot clears the rail, the engine can be run carefully.

When necessary the engine frame can be raised off the driving box without jacks in the following manner:

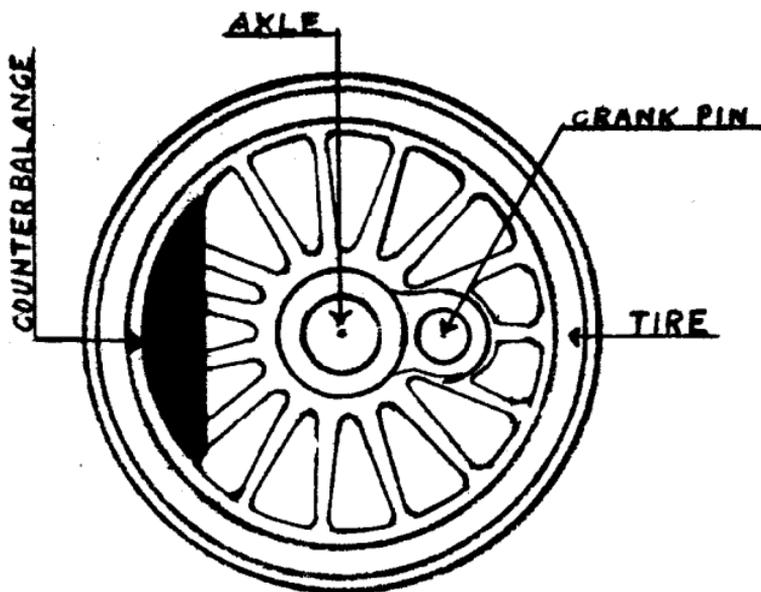
1. Block between frame and top of driving box next to disabled point.
2. Run the blocked wheel up on a wedge or blocking.
3. Block between frame and top of driving box at disabled point.

The above operation should be repeated if the frame is not raised high enough.

A two wheeled trailer truck not equipped with coil springs under the pedestal caps must not be run in backward motion if a trailer spring or hanger should break as there is possibility of the trailer truck being derailed. Those equipped with coil springs under the pedestal caps may be run in backward motion as the coil springs support the trailer truck when a spring or hanger breaks.

**Driving Wheel Tires**—Driving wheel tires (Fig. 51, page 107) are applied to the wheel by shrinkage. This consists in having the inside diameter of the tire the required amount smaller than the wheel. The tire is then heated until it expands larger than the wheel. After it has been applied to the wheel and cools, it becomes a tight fit. Retaining plates, held in place by rivets through the rim of the wheel, are used as an additional retaining feature.

The following procedure is necessary in the event a tire should break on other than the front drivers:



**FIG-51.-DRIVING WHEEL**

1. The disabled wheel must be raised to clear the rail by running it up on wedges or blocking.
2. Block between pedestal cap and driving boxes of disabled wheel.
3. Block between frame and top of adjacent driving boxes.
4. Cut out driver brake.

No attempt should be made to raise the front driving wheel clear of the rail. Assistance should be requested so the engine can be properly prepared for movement.

### **QUESTIONS ON CHAPTER 19**

415. What is the purpose of engine springs?
416. Name the principal parts of the spring rigging.
417. How is the weight of the frames and boiler suspended on the driving springs?
418. What is the purpose of gibs or pins in spring rigging?
419. What is the purpose of the equalizers?

420. How can you tell if an engine is properly equalized.
421. Why is clearance above and below the driving boxes necessary?
422. What should be the minimum clearance between the pedestal caps and the driving boxes?
423. Why is this minimum clearance necessary?
424. What should be done if an engine truck spring or front driving wheel spring or hanger is broken?
425. What should be done if a spring hanger or equalizer is broken?
426. How can the engine frame be raised off the driving box without jacks?
427. If a trailer spring or spring hanger should break on a two-wheeled trailer truck not equipped with coil springs, what precaution should be taken? Why?
428. How are driving wheel tires applied to a wheel?
429. What should be done if a driving wheel tire should break on other than the front drivers?
430. What should be done if a driving wheel tire should break on the front drivers?

## CHAPTER 20

### Crank Pins—Counterbalance—Rods—Break Downs

**Crank Pins**—Crank pins are applied to the driving wheels for the purpose of supporting the rods which transmit power from the piston to the main crank pin and thence to each pair of driving wheels.

An engine is said to be on “Dead Center” when the crosshead is at either the front or back end of the stroke and the crank pins and rods are on line with the center of the wheels. An engine is on “Top Quarter” when the crank pins are directly above the center of the wheels with the center of the crank pins in a vertical line with the center of the axles and on “Bottom Quarter” when the crank pins are directly below the center of the axle.

When driving wheel crank pins are not the same distance apart as the length of the side rods, it causes the side rod bushings to bind on the pins when passing

center and run hot. This may be due to the engine being out of tram which means that the center of the wheels are not the correct distance apart.

The crank pins on one side of an engine are located 90 degrees or a quarter of a turn apart from the crank pins on the other side. This gives the most favorable position for starting because, when one side stops on "Dead Center", the other side is on "Quarter" and is in a position to exert its maximum leverage. With an engine "Out of Quarter", the side rod will bind on the crank pins when they are passing the "Quarters", thereby causing the driving wheels to skid, thus giving the impression that the engine is slipping with the throttle closed.

When trouble is experienced with a hot pin or bearing, all stops should be made, if practicable, clear of main track, or at a point where trains will not be delayed before attempting to correct the defect.

**Counterbalance**—The effect of using an arrangement of pistons, crossheads, main rods, and side rods to turn the driving wheels is to set up forces when running, that, unless corrected, interfere with the smooth running of the locomotive. These forces are:

1. The force resulting from the action of various revolving parts at the driving wheels. The weight of these revolving parts, such as the crank pins and the rear ends of the main and side rods, places excess weight on one side of the wheels, and throws them out of balance.

2. The force resulting from the action of the parts that have a reciprocating, or a to-and-fro, movement such as the piston, the piston rod, the crosshead, and the front end of the main rod. The movement of these parts is reversed at the end of each stroke.

The action of the above forces is neutralized to some extent by a weight called a counterbalance (Fig. 51, page 107). The counterbalance is cast to the wheel center on the side opposite the crank pin.

The thrust from an unbalanced wheel occurs so rapidly at high speed that it becomes a heavy blow which is destructive to the track and is detrimental to the engine frames, frame bracing and springs.

Removing the main rods and side rods on a locomotive destroys the counterbalance and it should be handled at slow speed to avoid damage to track.

**Main Rods**—There are three general types of main rods that are classified according to the construction at the rear end. They are:

(a) **Strap-end rods**—This rod has a separate strap secured to the main rod by bolts. The brasses made in halves, which form a bearing for the main rod at the crank pin, are prevented from moving lengthwise in the rod by a wedge or key which is adjusted by means of a bolt.

(b) **Forked-end rod**—This arrangement consists of brasses made in halves, a block, and a wedge or key, and a keybolt. The block is located between the flanges of the back brass and contains set screws for securing the key. The key with a groove for the set screw, and the keybolt pass through a slot in the forked end of the rod. The brasses will be held firmly when the key is driven between the tapered surface of the keybolt and the block.

(c) **Solid-end rod**—This contains a round floating bushing which is in contact with the main pin and is free to turn in the rod.

The strap and forked-end rods should be kept tightly keyed to prevent pounding. If necessary to key the back end brasses, the side of the engine on which the work is to be done should be placed so the crank pins are in the upper forward eighth position, as this presents the greatest diameter of the pin to the rod brasses. Rod brasses should be reported closed or reduced when they are keyed brass to brass and still pound.

**Side Rods**—Side rods connect the crank pins of the driving wheels and transmit to the other driving wheels some of the force imparted to the main driving wheel by the main rod.

The sections of the side rods are connected by knuckle pins which provide vertical flexibility thereby relieving the up-and-down bending strain on the side rods.

The number of side rods used on a side is always one less than the number of crank pins, and the various sections are named according to their position as shown below :

(a) A locomotive with 3 pair driving wheels has 2 sections of side rods on each side. The one nearest the cylinders is called the front section; and the other the back section.

(b) A locomotive with 4 pair driving wheels has 3 sections of side rods. The one next to the first section is called the intermediate section, and the last one the back section.

(c) A locomotive with 5 pair driving wheels has 4 sections of side rods. The one next to the first section is called the front intermediate section, and between this section and the back section is the back intermediate rod.

**Break Downs**—In the event of a breakdown of a locomotive the most important factor is to clear the track in the shortest possible time. Minor damage that may occur in moving the locomotive is not considered as the clearing of the track is of first importance. Good judgment must be used and, if there is a strong possibility that further damage might occur and cause a total failure, the engine should not be moved. However, even with quite a serious breakdown, the locomotive, if moved slowly, can often be run to a siding with comparative safety.

Breakdowns can be largely prevented by an inspection at intermediate stops. Particular attention should be paid to the rods and brasses and all moving parts as far as time will permit.

It is difficult to lay down the exact procedure to follow in many cases of locomotive breakdowns, because the extent of the damage that actually occurs varies and depends on the speed and other factors.

The side rods, in addition to distributing the thrust of the pistons equally to all crank pins, also perform the important function of keeping the crank pins in line. When a side rod breaks there is a possibility that the rods on the opposite side will buckle, resulting in bent or broken side rods or broken crank pins. While

the usual procedure is to remove the corresponding section of rod on the opposite side of the broken rod, there are times when this would cause considerable delay to traffic. For this reason, the following general principles should be followed when a breakdown occurs that requires the disconnecting or removal of the rods:

### **Main Pin Broken off Close to Hub**

Remove main and side rods on disabled side.

Cut out driver brakes.

Tow engine carefully to siding or terminal with main and side rods on one side only.

### **Back Section of Side Rod Broken or Knuckle Pin Lost out**

Remove the broken rod and the corresponding rod on opposite side.

Proceed under own steam.

### **Front Section of Side Rod Broken on Engine With 3 Pair Driving Wheels**

Remove main rod and all side rods on disabled side.

Cut out driver brakes.

Tow engine carefully to siding or terminal with main rod and side rods on one side only.

### **Front Section of Side Rod Broken on Engine With 4 Pair Driving Wheels**

Remove the broken rod and the corresponding rod on opposite side.

Proceed under own steam.

### **Exception—Ls Locomotives**

Remove broken rod.

Cut out driver brakes.

Tow engine carefully to siding or terminal.

If corresponding rod on opposite side is damaged and must be removed, the crank pins on the front driving wheel will get out of line with the other crank pins and strike the crosshead. This will require the following to be done:

Remove both main rods.

Block both crossheads by securing between the locking bolts.

Engines will have to be towed to terminal.

## **Front Section of Side Rod Broken on Engine With 5 Pair Driving Wheels**

Take down the broken rod.

Cut out driver brakes.

Tow engine carefully to siding or terminal.

If corresponding rod on opposite side is damaged and must be removed, the crank pins on the front driving wheel will get out of line with the other crank pins and strike the crosshead. This will require the following to be done:

### **I1 Locomotives**

Remove both main rods.

Block both crossheads by securing between the locking bolts.

Engine will have to be towed to terminal.

### **N1 Locomotives**

Remove both main rods.

Block both crossheads by securing in the full forward position.

## **Back Intermediate Section of Side Rod Broken on Engines With 5 Pair Driving Wheels**

Remove broken parts and corresponding rod on opposite side, also both back sections of side rods.

Proceed under own steam.

If not possible to remove the corresponding rods on the opposite side, the following should be done :

Remove broken rod and back side rod on disabled side.

Cut out driver brakes.

Tow engine carefully to siding or terminal.

## **Intermediate Section of Side Rod Broken on Engine With 4 Pair Driving Wheels**

Remove main rod on disabled side.

Remove all side rods on disabled side. (If rod is broken between the crank pins, the knuckle pins may hold the broken rod sufficiently in place to tow the engine to a siding or terminal without removing any rods.)

Cut out driver brakes.

Tow engine carefully to siding or terminal.

## **Front Intermediate Section of Side Rod Broken on Engine With 5 Pair Driving Wheels**

Remove main rod on disabled side.

Remove all side rods on disabled side. (If rod is broken between the crank pins, the knuckle pins may hold the broken rod sufficiently in place to tow the engine to a siding or terminal without removing any rods.)

Cut out driver brakes.

Tow engine carefully to siding or terminal.

### **QUESTIONS ON CHAPTER 20**

435. What is the purpose of crank pins?
436. What is meant by "Dead Center"?
437. When is an engine on "Top Quarter"?
438. What is the effect if the crank pins are not the same distance apart as the length of the side rods?
439. What is meant by an engine out of tram?
440. How are the crank pins on one side of an engine located in relation to those on the opposite side?
441. What is the effect of an engine being out of quarter?
442. If a hot pin or bearing develops what should be done?
443. Why is a counterbalance necessary on driving wheels?
444. Where is the counterbalance located?
445. What are the bad effects of an unbalanced wheel?
446. What is the effect of removing the main and side rods from a locomotive?
447. What are the general types of main rods in service?
448. Describe a strap-end main rod.
449. Describe a fork-end main rod.
450. Describe a solid-end main rod.
451. Why is it necessary to keep rod brasses keyed and how should it be done?
452. When should main rod brasses be reported closed or reduced?
453. What is the purpose of the side rods?

454. Why are knuckle joints provided in side rods?
455. What are the names of the side rod sections on:  
A locomotive with 3 pair driving wheels?
456. A locomotive with 4 pair driving wheels?
457. A locomotive with 5 pair driving wheels?
458. In the event of a breakdown of a locomotive, what is the most important factor to be observed?
459. How may breakdowns be largely prevented?  
What should be done if:
460. Main pin is broken off close to hub?
461. Back section of side rod broken or knuckle pin lost out?
462. Front section of side rod broken on engine with 3 pair driving wheels?
463. Front section of side rod broken on engine with 4 pair driving wheels?
464. Front section of side rod broken on Lls locomotive ?
465. Front section of side rod broken on engine with 5 pair driving wheels?
466. Both front sections of side rods broken or damaged on 11 locomotive?
467. Both front sections of side rods broken or damaged on N1 locomotive?
468. Back intermediate section of side rod broken on engine with 5 pair driving wheels?
469. Intermediate section of side rod broken on engine with 4 pair driving wheels?
470. Front intermediate section of side rod broken on engine with 5 pair driving wheels?

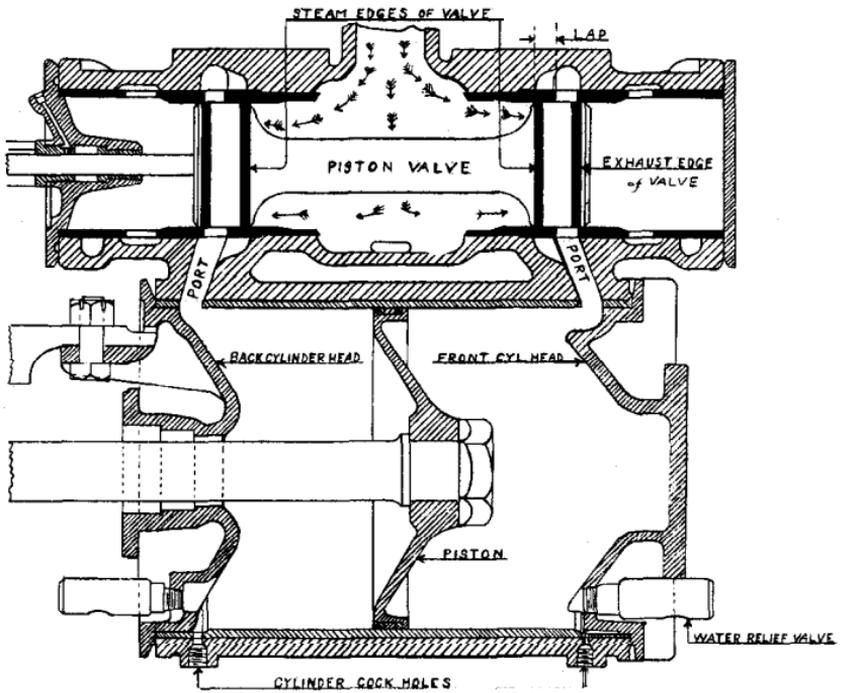


FIG. 52 - POSITION OF VALVE - ENGINE ON BOTTOM QUARTER - REVERSE LEVER IN CENTER

## CHAPTER 21

### VALVE GEARS

#### Walschaert and Baker Valve Gears

**General**—Valve gear is the mechanism used for the purpose of regulating the distribution of steam to the cylinders by moving the piston valve so the steam ports are opened and closed in proper sequence:

The following are definitions of various valve terms :

1. **Piston Valve** is a cylindrical spool fitted with packing rings at each end (Fig. 52, page 116). It operates in a cylindrical valve chamber which has an opening from the steam pipe at the center, and to the cylinders at each end. It permits alternate inlet and outlet of steam and distributes piston pressures. The inner packing ring at each end is known as the steam ring and the outer ring as the exhaust ring.
2. **Valve Chamber** is an enclosed steam reservoir in which a valve operates.
3. **Port** is the opening or passageway between the valve chamber and cylinder for the admission of live steam and the exhaust of steam that has been used (Fig. 52, page 116).
4. **Full Gear** is the position at which a valve gear causes maximum valve movement, and consequently maximum cylinder power. This position insures the greatest reliability for starting. The direction of starting movement is positively predetermined by placing the reverse lever in either full gear forward or full gear backward.
5. **Cut-Off** is the closing of the steam port by the valve before the piston has reached the end of its stroke. A 25 per cent cut off means that the steam to the cylinders has been shut off when the piston has traveled one quarter of the length of the stroke.
6. **Steam Lap** is the distance between the admission edge of the valve and the nearest edge of the steam port when the valve is in mid-position (Fig. 52, page 116). This permits the steam in the cylinders to be worked expansively.
7. **Lead** is the width of steam port opening at the beginning of the piston stroke.

8. **Admission** is the applying of live steam pressure to the piston through the steam port opening between the valve chamber and the cylinder. Its duration is from the beginning of the stroke to the point of cut off and is manually controlled by the position of the reverse lever.
9. **Expansion** is the steam pressure on the piston beyond the admission period. This is accomplished by valve lap, which permits a cut-off mass of steam to increase in bulk and relatively decrease in pressure.
10. **Exhaust** is the discharge of expanded steam from the cylinder to the atmosphere through the exhaust port opening. Its duration is from the time the exhaust ring opens the port until the piston completes its stroke.
11. **Compression** is the pressure built up in the cylinder by the piston after the exhaust port is closed. The remaining steam is compressed by the piston for the purpose of producing initial pressure for the return piston stroke and acts as a cushion to absorb the momentum of moving parts.
12. **Valves Out of Square** means that the engine has a greater port opening at one end of the cylinder or that one side is working stronger than the opposite side. Distribution of steam is uneven and the efficiency of the engine is reduced. This can be determined by the sound of the exhaust from the stack which is uneven and the time elapsing between the exhausts is not the same.

Figure 52, page 116, shows the piston valve in mid-position with the engine on bottom quarter and the reverse lever in the center. This position has both ports closed for the admission of steam to the cylinders. Moving the reverse lever to the full forward position will move the valve ahead so that the front port will be wide open for admission of steam to the cylinder and the back port will be wide open to the exhaust.

**Walschaert Valve Gear**—This valve gear (Fig. 53, page 119) consists of the following principal parts:

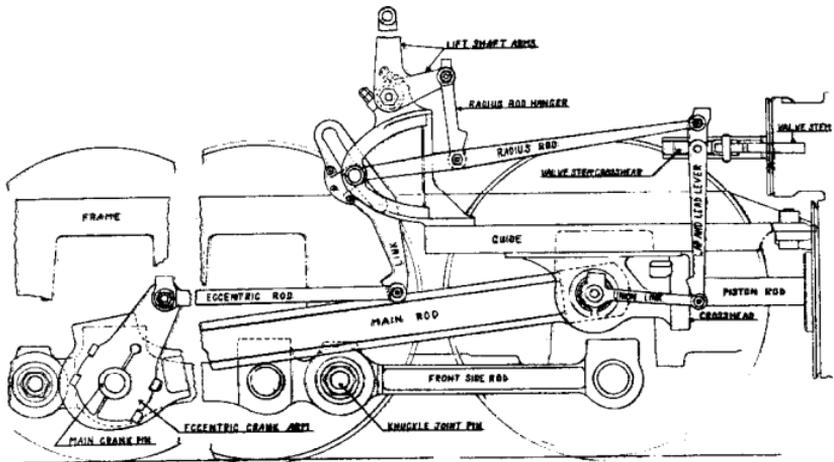


FIG.53- WALSCHAERT VALVE GEAR ARRANGEMENT.

1. **Eccentric Crank Arm** on each side attached to main crank pins to give proper travel to the valve.
2. **Eccentric Rods** transmit motion to the links.
3. **Links** which oscillate on trunions at their centers and carry link blocks which are moveable up and down in the link, and, according to position, impart proper movement to valves through radius rods and valve stems.
4. **Radius Rods** attached to link blocks, also to reversing mechanism attached to lifting arms on reversing shaft, which is connected through reach rod arm to reverse lever.
5. **Lap and Lead Levers** have the upper end coupled to the radius rods and just below this point they are coupled to the valve stem crosshead to which is attached the valve stem and valve.
6. **Union Links** connected to the lower end of the lap and lead lever and the crosshead.

**Operation**—The rotation of the axle imparts to the eccentric crank arm a circular motion that moves the eccentric rod and the valve. When the main pin arrives at the bottom quarter position, the piston is practically at half stroke and the valve has moved the limit of its travel and will have the front port open for the admission of steam and the back port open to the exhaust. Further movement of the main pin causes the eccentric crank to move the valve and open the back steam port for steam and the front port to exhaust. This action will keep the piston in motion and the driving wheels turning so long as the steam supply is maintained.

Any movement of the reverse lever changes the position of the link block in the link and care should be taken to obtain the most economical cut-off required to handle the train at the speed required. When cut-off is less than 25 per cent, poor steam distribution results.

When drifting, starting or moving at slow speed the valve gear should be in full travel. This will insure proper lubrication and uniform wear of valve and bushings.

Most of our locomotives are equipped with a snifting valve located in the side of the valve chamber. This valve opens when the engine is drifting with the throttle closed and prevents air, hot gases, etc. from being drawn from the smoke box into the cylinders.

Every effort should be made to prevent water from getting into the cylinders as it cannot get out past the valve packing rings and may result in damage to the locomotive.

Leaking piston valve or cylinder packing rings retard the operation of the engine by causing back pressure in the opposite end of the cylinder and destroys lubrication.

**Break Downs**—A number of break downs require disconnecting of the valve gear and the following general principles should be observed:

### **Blocking of Valve to Cover Ports**

1. Remove eccentric rod.
2. Disconnect union link at front end and secure bottom of lap and lead lever to back cylinder cock to clear crosshead.
3. Place valve to cover ports and fasten securely by means of blocking bolts in valve stem cross-head guide.
4. Open cylinder cocks and crack throttle; if steam does not appear at either cylinder cock, the valve is central on its seat.

### **Front Cylinder Head Broken or Knocked Out or Piston Broken**

1. Block valve to cover ports on side involved and proceed on one side.

### **Guide Is Broken or Lost, or Piston Rod Bent**

1. Take down main rod.
2. Remove broken parts.
3. Block crosshead in such a manner as to clear crank pins and rods.
4. Block valve to cover ports on side involved and proceed on one side.

### **Eccentric Crank Arm Broken**

1. Remove broken or damaged parts.
2. Block valve to cover ports on side involved and proceed on one side.

### **Main Rod Is Broken**

1. Remove broken parts.
2. Block crosshead in forward position on guide.
3. Block valve to cover ports on side involved and proceed on one side.

### **Failure or Breakage of Power Reverse Gear-Reach Rod-Lift Shaft or Arms**

1. Remove or secure broken parts.
2. Block link block in desired position and proceed.

### **Valve Stem Broken Outside the Cylinder**

1. Place valve to cover ports.
2. Loosen valve stem gland and secure in a cocked position on the valve stem to hold valve and proceed.

## **Valve Broken Inside the Cylinder**

1. Engine will be disabled and assistance should be requested.

## **Failure of Other Valve Gear Parts**

1. Remove or secure broken parts.
2. Disconnect any parts that will impart any motion to the valve on the side involved and remove or secure them in a safe position.
3. Block valve to cover ports on side involved and proceed on one side.

## **Breakdown Not Due to Defective Valve Gear Parts That Totally Destroys Movement of Valve**

1. Remove or secure broken parts.
2. Block valve to cover ports on side involved.

## **Engine Running on One Side Stops on Dead Center on Side Not Disconnected**

1. If main rod is not disconnected, unclamp the valve on disabled side and move it off center.
2. Give engine enough steam to move good side off center.
3. Re-block valve to cover ports on disabled side.

A light train may be handled by an engine with a broken eccentric crank arm or eccentric rod without blocking the valve on the disabled side in the following manner :

To start the engine it will be necessary to place the reverse lever in about 25 per cent cut-off. After making part of a revolution, the reverse lever must be placed in position so the link block will be at the center of the link. In this position the back end of the radius rod will be held firmly and the valve will receive its movement from the crosshead, which is sufficient to admit steam to the cylinder. Starting assistance may be necessary. After the engine is in motion, the reverse lever must not be moved off center or steam will be trapped in the cylinders and considerable damage may result.

When necessary to run on one side, with both main rods up, the dead cylinder may be lubricated by removing the test or indicator plugs on the side of the cylinder and pouring oil through these holes. To prevent churning air and heating the cylinder, leave these plugs out or remove the cylinder cocks.

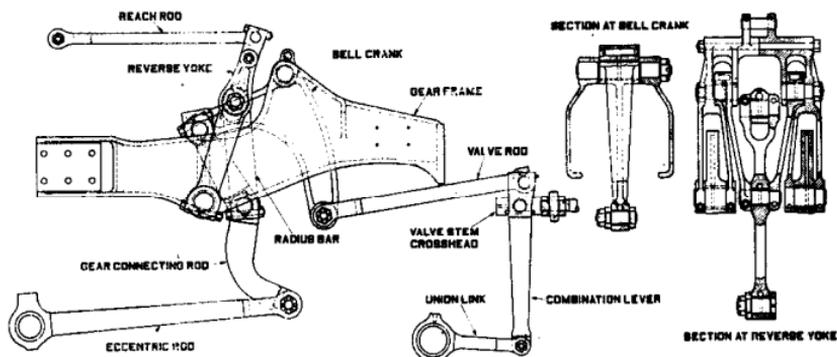


FIG. 54 - Section Through The Baker Valve Gear (inside admission).

**Baker Valve Gear**—This is an outside gear taking its motion from an eccentric crank attached to the main crank pin and from the main crosshead. This valve gear (Fig. 54, page 123) consists of the following parts :

1. Eccentric crank arm.
2. Eccentric rod.
3. Gear connecting rod.
4. Gear frame.
5. Reverse yoke.
6. Radius bar.
7. Bell crank.
8. Valve rod.
9. Valve stem and valve stem crosshead.
10. Combination lever.
11. Union link.

The reverse yoke is pivoted to the gear frame having the upper yoke end attached to the gear reach rod. In the reverse yoke are pivoted the radius bars, to the lower ends of which the gear connecting rod is attached. This gear connecting rod extends downward, connecting with the eccentric rod, and upward, connecting

with bell crank which is pivoted in the gear frame. The motion derived from the eccentric crank is carried through the valve gear to the valve rod. It is here combined with the motion of the combination lever and transmitted to the valve by means of the valve stem.

**Breakdowns**—The handling of the Baker Valve Gear in case of accident may be divided into the following three general classes:

### 1. Main Rod Up—Valve Not Blocked

- (a) Broken eccentric crank arm, eccentric rod, connecting rod, radius bar, horizontal arm of bell crank or reverse yoke below reach rod:

Remove eccentric rod and block bell crank. The valve on the disabled side then receives a motion from the combination lever and admits enough steam to the cylinder to do a certain amount of work and the engine can be reversed. Care must be taken not to come to a stop with the good side on center as it would be impossible to start the engine.

- (b) Broken valve, gear reach rod, reverse arms or reverse yoke at reach rod connections.

Remove broken parts, block disabled side in desired position and proceed. Engine should not be reversed without changing the blocking on the disabled side.

- (c) Failure of main reach rod, lift shaft bearing or lift shaft arm:

Block both reverse yokes at desired cut-off and control speed with throttle.

### 2. Main Rod Down—Valve Blocked

- (a) Damaged main rod, main crosshead, guides or piston:

Remove main rod and valve rod, leaving rest of gear intact. (If main rod is of the solid rear end type, making it necessary to remove eccentric rod and crank arm, the valve rod may be left up.) Block valve to cover ports. Clamp or block main crosshead in such a manner as to clear crank pins and rods. The reverse lever is free to operate the other side and engine can be run on one cylinder by working engine at long cut-off.

- (b) Broken crosshead pin when union link pin is coupled to it:

Proceed the same as damaged main rod, main crosshead, etc., except remove union link and wire bottom end of combination lever to some convenient place to keep it from swinging.

### 3. Main Rod Up-Valve Blocked

- (a) Broken vertical arm of bell crank or cylinder head broken or blown out:

Remove valve rod.

- (b) Broken union link, crosshead arm or combination lever:

Remove valve rod and such broken parts as would interfere with the running of the engine.

When drifting down long grades the reverse lever should never be dropped below 40 per cent cut-off. If the lever is lowered further than this it will cause excessive stresses to be set up in the valve gear parts while traveling at high speed. On locomotives not equipped with drifting valves, the main throttle should be left open slightly to admit a little steam so the valve lubrication will not be destroyed.

Every effort should be made to prevent water from getting into the cylinders as it cannot get by the valve packing rings and may result in serious damage to valve, valve gear, or crosshead and piston.

## Franklin System of Steam Distribution—Type A— Class T1 Locomotives

This system of steam distribution involves the use of the poppet type of valves for controlling the admission and exhaust steam in the locomotive cylinders and consists of the following principal parts:

1. Drive (Plates I and II, rear of book).
2. Cylinders and Associated Parts (Plates I, II and IV, rear of book).
3. Cam Boxes
4. Gear Boxes
5. Power Reverse Gear

1. **The Drive** (Plates I and II, rear of book)—The actuating motion for this equipment is taken from the two crosshead pins of each unit. (By unit is meant either the front or back engine.) A union rod is mounted on the end of each crosshead pin, and connects with the crosshead drive arm. Crosshead drive arm is fitted to intermediate drive shaft, the short arm of which connects with drive rod. The other end of drive rod is attached to gear box drive arm. Advantage is taken of the fact that one main driver follows the other by ninety degrees to cause the device to function without eccentrics or eccentric cranks.

The remainder of the outside drive consists of the connecting rods joining the gear box take-off arms with the cam shaft arms.

2. **The Cylinders and Associated Parts** (Plates I, II, and IV, rear of book)—Steam chests, one on each end of the cylinder, contain the poppet valves, and are cast integral with the cylinder.

The cylinder barrel, the saddle, and the frame mounting are similar to conventional types. However, the steam and exhaust passages are arranged differently to suit the requirements of the poppet valve.

For each of the two steam chests, there is a separate steam pipe flange, these being connected over the top of the cam box by a branch pipe joined to the steam pipe from the header. The intake valves open into the steam chambers, and admit steam to the cylinder port. The exhaust valves open into the cylinder port,

and release steam to the exhaust passages. For each exhaust valve at each end of the cylinder, there is a separate exhaust passage, all of these passages being brought together below the exhaust stand seat.

The poppet valves are of the horizontal double-seated type. For each end of each cylinder there are two intake and two exhaust valves ; the exhaust valves being located close to the cylinder barrel and below the intake valves.

**3. The Cam Boxes**—Plates I, II and IV, (rear book)—On each cylinder is mounted one cam box in the space between the two steam chests.

Each box contains two cam shafts, the lower for the exhaust, and the upper for the intake. The cams are pressed on the cam shafts and receive an oscillating motion from the gear box through the gear box take-off arms and connecting rods.

As the cams, oscillate, the contact rollers carried in intermediate levers are fulcrumed at the upper end. At the lower end of the intermediate levers are hardened buttons bearing against tappets which pass through the walls of the cam box and contact the valve stems to push the valves open. Springs are provided to close the valves.

The maximum opening of the exhaust valves is attained in all but the shortest cut-offs. The opening of the intake valves decreases at the shorter cut-offs.

An air cylinder on the top of each cam box, through a system of splined shafts and levers, holds all the intake valves open when air is admitted to it while drifting.

**4. The Gear Boxes**—(Plates I and II, rear of book)—One gear box is located slightly ahead of and above the front cylinders. The other is located vertically behind the rear cylinders.

The gear boxes contain the valve motions and reverse mechanism. On each side of the gear boxes there is one connection to the engine mechanism. This connection is made from the crossheads by drive rods, and crosshead drive arm and shaft which transmit the crosshead movement to the gear boxes,

The mechanism in the gear box consists of four independent valve motions: one intake and one exhaust valve motion for each side of the engine. The principal of the valve motion is similar to that of a Walschaert gear, with the exception that the links are not driven from an eccentric crank but from the crosshead of the opposite side. Drive shaft on the right hand side of the engine is connected to a yoke which drives the link saddle of the left hand side of the engine through yoke connecting rod, link drive rocker, and link connecting rod. The link saddle on the right hand side of the engine is driven by drive shaft on the left hand side of the engine through yoke, yoke connecting rod, link drive rocker, and link connecting rod.

An intake link and exhaust link on each side are mounted in the same link saddle and receive the same movement.

**5. Power Reverse Gear**—(Plate XIV, page 130)—A small power reverse gear controls this system of steam distribution. This power reverse gear is located entirely within the cab and is connected to the gear box by rotating shafts equipped with universal joints. Splined joints allow the shafts to adjust themselves to the expansion and contraction of the boiler.

The power reverse gear is actuated by a small air motor controlled by a control valve and by hand lever. There are two mid-gear positions: mid-gear forward and mid-gear backward. Between these two positions is a neutral position called “drifting position” into which the reverse gear should be moved during long drifting periods. At such times the three-way cock should also be opened to admit air to the drifting cylinders on the cam boxes.

The desired cut-off is obtained by positioning the reverse lever which is held in place by a latch engaging a notched quadrant. The cut-offs are indicated by a pointer attached to the hand lever and traveling over a calibrated cut-off indicating plate on the quadrant.

To change from full gear forward to full gear backward, pull handle back; to change from full gear backward to full gear forward, push handle ahead.

In case of an air failure, the gear can be worked by hand. Remove cap at the rear of the gear. A wrench can then be used on the exposed hex end of the operating screw. The hand lever must be unlatched while doing this.

### **Instructions for Operation**

There is very little difference in the handling of a locomotive equipped with the Franklin System of Steam Distribution as compared with a conventional piston valve locomotive.

This system allows the use of very short cut-offs (approximately 10 per cent). For most economical operation at speed, the throttle should be kept wide open, and the locomotive should be operated with as short a cut-off as possible. The shortest running cut-off is mid-gear (marked on reverse gear plate Mid-gear Forward and Mid-gear Backward).

Due to short cut-offs, the exhaust of a poppet valve locomotive is likely to be soft. Therefore, the depth of the fire must be regulated accordingly and should be as thin as possible.

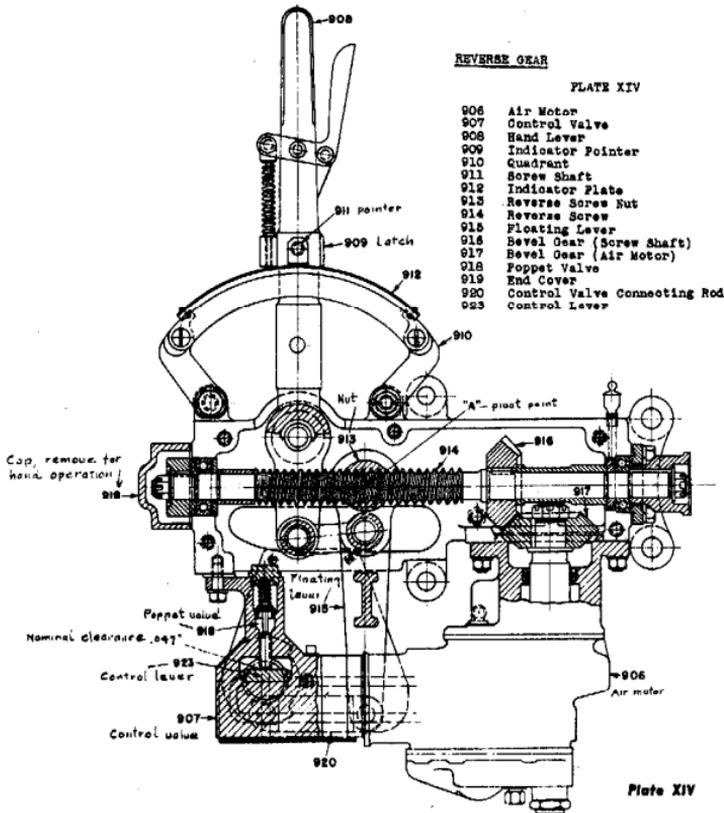
When starting the train, it is necessary to have the reverse gear in the maximum cut-off position (full gear). As soon as the train is under way, the cut-off should be shortened gradually.

Upon shutting off throttle, move handle of three-way drifting control cock into drifting position.

During long drifting periods, move the reverse gear into the position indicated on the reverse gear dial by "Drifting". When running in one direction, never pass drifting position (located centrally between mid-gear forward and mid-gear backward on reverse gear indicator) toward the other direction.

When the engine is left by the crew, the reverse gear and the drifting control valve should be placed in drifting position.

Before dispatching the locomotive, it must be known that gear boxes, cam boxes and mechanical lubricator contain a sufficient quantity of oil and that the mechanical lubricator is working properly.



**Operating with One Unit**—In case of damage to either unit, that unit can be cut out and the engine moved with the operative unit by proceeding as follows :

Remove the crosshead drive arms and union rods on both sides of the damaged unit. This allows all the intake valves to remain closed, held by spring and steam pressure.

Block the outside exhaust valves open. This is done by loosening the exhaust valve chamber head covers to relieve spring pressure and introducing one inch blocks of wood between the exhaust valve stems and tappets. Replace the cover plates.

In case the distance to be travelled is not too great, it is permissible to block open the cylinder cocks instead of the exhaust valves, and proceed with the good unit.

Never, under any circumstances, attempt to move the engine with one side of a valve motion disconnected. Very serious damage to the gear box is likely to result.

**Lubrication**—The valve stems are lubricated with valve oil from the mechanical lubricator.

The various pins and bearings in the drive are lubricated through regular Alemite fittings. Bearings in back of the cam boxes are oiled from inside the cam boxes or from independent force feed connections.

Parts inside the gear boxes are splash lubricated by medium gas engine oil (S.A.E.-30).

The cam boxes are flooded with valve oil pumped through the distributor pipes in the cover plate. The pump is located at the bottom of the cam box and is driven by an arm and link connected to the outer face of the exhaust cam shaft. If necessary, this pump can be cranked by hand. An oil level indicator is provided in the outside face of the cam box.

The reverse gear mechanism in the cab has one point to Alemite and three points to lubricate with motor oil. The air motor is oiled through a drop feed oil cup set into the air supply line, using motor or compressor oil.

## QUESTIONS ON CHAPTER 21

475. What is the purpose of valve gear?
476. Describe a piston valve?
477. What is a valve chamber?
478. Define the valve term Port.
479. " " " " Full Gear.
480. " " " " Cut-off.
481. " " " " Steam Lap.
482. " " " " Lead.
483. " " " " Admission.
484. " " " " Expansion.
485. " " " " Exhaust.
486. " " " " Compression.

487. What is meant by “Valves Out of Square”?
488. What is the effect of “Valves Out of Square”?
489. How can you determine that valves are “Out of Square”?
490. What are the principal parts of the Walschaert valve gear?
491. Describe briefly the operation of the Walschaert valve gear.
492. At what cut-off should the engine be worked in order to obtain the most economical results?
493. At what cut-off should the valve be placed when drifting, starting, or moving at slow speed with the Walschaert valve gear?
494. What is a snifting valve and what is its purpose?
495. What damage may result from water getting in the cylinders?
496. What effect does leaking piston valve or cylinder packing rings have on the operation of the engine?
497. How do you block a piston valve to cover the ports?
498. On a Walschaert valve gear engine what should be done if: Front cylinder head is broken or knocked out or piston broken?
499. Guide is broken or lost or piston rod bent?
500. Eccentric crank arm broken?
501. Main rod is broken?
502. Failure or breakage of power reverse gear, reach rod, lift shaft, or arms?
503. Valve steam broken outside the cylinder?
504. Valve broken inside the cylinder?
505. Failure of other valve gear parts?
506. Breakdown not due to defective valve gear parts that totally destroys the movement of valve?
507. Engine running on one side stops on dead center on side not disconnected?
508. How can a light train be handled by using both sides, if a Walschaert valve gear eccentric crank arm or eccentric rod is broken?

509. With the eccentric rod disconnected and using both sides, should reverse level be placed in other than center position? Why?
510. When running on one side, with both main rods up, how may the dead cylinder be lubricated?
511. Where does the Baker valve gear receive its motion for the movement of the valve?
512. Name the parts of the Baker valve gear.
513. Describe the operation of the Baker valve gear. On a Baker valve gear engine with main rod up and valve not blocked, what should be done if:
514. Eccentric crank arm, eccentric rod, connecting rod, radius bar, horizontal arm of bell crank, or reverse yoke below reach rod is broken? Is steam admitted to both cylinders? Can engine be reversed? What precaution should be taken when coming to a stop?
515. Valve gear reach rod, reverse arms, or reverse yoke at reach rod connection is broken? How can engine be reversed?
516. Main reach rod, lift shaft bearing, or lift shaft arm is broken?
517. Main rod, main crosshead, guides, or piston is damaged?
518. Broken crosshead pin when union link is coupled to it?  
On a Baker valve gear engine with main rod up and valve blocked, what should be done if:
519. Vertical arm of bell crank is broken or cylinder head is broken or blown out?
520. Union link, crosshead arm or combination lever is broken?
521. At what cut-off should the Baker valve gear engine be placed when drifting down long grades? Why?
522. How should the throttle be used when drifting with a Baker valve gear engine not equipped with drifting valves? Why?
523. What damage may result from water getting in the cylinders of a Baker valve gear engine?
524. Name the principal parts of the Franklin System of Steam Distribution.

525. From what part of the locomotive is the actuating motion taken for this equipment?
526. How many intake and exhaust valves are at each end of each cylinder? Where is their location?
527. How many cam boxes are on each cylinder and where are they located?
528. Where are the gear boxes located?
529. What actuates the power reverse gear?
530. In case of air failure to the power reverse gear, what should be done?
531. How is a locomotive equipped with poppet valves operated?
532. How is the most economical operation at speed obtained?
533. What is necessary in starting a train with poppet valve locomotive?
534. What should be done upon shutting off the throttle?
535. What should be done during long drifting periods.
536. What should be the position of the reverse gear and drifting control valve when the engine is left by the crew?
537. In case of damage to either unit, how can that unit be cut out and the engine moved with the operative unit ?
538. Is it permissible under any circumstances to operate a unit with one side of the valve motion disconnected? What is likely to result?

## **CHAPTER 22**

### **Pounds—Blows in Cylinders and Valves**

**Pounds**—The principal causes of pounds are:

1. Loose wedges.
2. Driving box shells worn or loose.
3. Loose pedestal caps.
4. Broken frame.
5. Loose or worn side or main rod brasses.
6. Worn guides or crossheads.
7. Piston rod loose in crosshead.
8. Piston striking front or back cylinder head.
9. Piston head loose on rod.

10. Cylinders loose on frame.
11. Crosshead pin loose.
12. Flat spots on tires.
13. Loose crank pin.
14. Water in cylinders.

Pounds may be located by placing the main pin on top quarter on the side to be examined, giving the cylinders a little steam while moving the reverse lever back and forth, and observing the different parts.

An engine that develops a cylinder pound when drifting is an indication of a loose piston head or the piston is striking a cylinder head due to the main rod being too long or too short. The throttle should be kept slightly open to form a cushion in the cylinders.

When running with the reverse lever in full gear and the valve gear knocks and rattles but ceases when the reverse lever is moved a notch or two is an indication that the link block is striking the end on the link. This is generally caused by the reach rod being too long or too short.

If repairs cannot be made to stop pounds, a prompt report should be made giving the location of the pounds.

**Blows in Cylinders and Valves**—The cylinder packing rings located in the grooves in the piston head, and the piston valve packing rings should always be in good condition. Leaking cylinder packing or valve rings causes steam to blow by them and is wasted. This causes a loss of power and destroys lubrication.

A broken valve, main piston, or cylinder packing will cause the engine to blow so badly that it will be disabled. A broken valve will not permit the engine to proceed on one side. However, if the trouble is in the cylinder, the engine may be prepared for operating on one side.

The following tests may be made for locating a blow in valve chamber or cylinder:

1. Place the main pin on top quarter on side to tested.

2. Apply independent brake and open the cylinder

**Valve Test**—Place the reverse lever in the center so the valve covers the ports. Open the throttle, and if no steam appears at either cylinder cock, the valve is tight.

**Cylinder Packing Test**—Let the engine stand in same position as when testing the valve. Move reverse lever to full forward or backward position. Open the throttle and if steam does not appear at both cylinder cocks at the same time, the packing is tight.

The above procedure should be duplicated to test the opposite side.

## QUESTIONS ON CHAPTER 22

550. What are the principal causes of pounds?
551. How can pounds be located?
552. What may be the cause if an engine develops a cylinder pound when drifting. What should be done?
553. What may be the cause of knocks and rattles in valve gear when the reverse lever is in full forward gear but ceases when engine is hooked up a notch or so?
554. What should be done when pounds develop?
555. Why should cylinder and piston packing rings be in good condition?
556. What may cause an engine to blow so badly it will be disabled?
557. If valve is damaged can you proceed on one side?
558. If piston is damaged can you proceed on one side?
559. How do you test a piston valve for blow?
560. How do you test a cylinder for defective cylinder packing rings?

## CHAPTER 23

### Locomotive Boosters

The purpose of the booster is to give additional tractive power in the starting of a train or when the loco-

motive is about to stall. It consists of a two cylinder steam engine mounted on the trailer truck frame.

When taking charge of a booster equipped locomotive, the following instructions should be observed:

1. Idle booster to insure it is in readiness for operation and free from condensation.
2. After idling booster, allow booster engine to come to a stop before raising booster latch, to prevent clashing of gears.
3. Booster must not be cut in at speeds above 15 miles per hour, and must not be operated at speeds above 30 miles per hour.

The booster is designed for forward operation only, and booster gears should be disengaged before coming to a stop to prevent damage.

If the train stalls with booster engaged, the following procedure should be followed to disengage the booster :

- (a) Close locomotive throttle.
- (b) Disengage the booster latch.
- (c) After the booster cylinder cocks open, allow the locomotive to move several feet backwards.
- (d) Move the locomotive ahead and the booster gears will disengage.
- (e) It is permissible to slowly move the locomotive backward for short distances with the gears engaged if it is impossible to move the locomotive ahead to disengage the gears.

**Lubrication**—All moving parts within the booster engine bed are lubricated by the splash method. Maintenance of the proper supply of oil in the bed is attended to by enginehouse forces.

The booster cylinders and valves are lubricated from the locomotive lubricator. If hydrostatic lubricator is used, it should be adjusted to feed at the rate of 2 drops per minue. Mechanical lubricator adjustments are made by the enginehouse forces.

If the ash pan is dumped for any reason, the locomotive should be moved so the booster will not be near hot ashes.

Any improper operation and defects in booster must be reported on form M. P. 62.

## QUESTIONS ON CHAPTER 23

565. What is the purpose of the locomotive booster?
566. What does the booster consist of and where is it located?
567. What should be done when taking charge of a booster equipped locomotive?
568. What is the maximum speed that booster may be cut in?
569. What is the maximum speed that booster may be operated?
570. Can booster be operated in backward motion?
571. What should be done before coming to a stop when booster engine is in operation?
572. If the train stalls with booster engaged, what should be done to disengage booster?
573. How are the moving parts in booster engine bed lubricated? How are cylinders and valves lubricated?
574. If necessary to dump ashes from the ash pan, what should be done to protect the booster?
575. What should be done if booster does not operate properly or defects are noted?

## CHAPTER 24

### Slip Control—Q2 Locomotives

The slip control on Q2 locomotives is automatic in operation and the throttle need not be closed when slipping occurs except when the automatic control is not functioning properly. In that case the throttle may be closed to prevent slipping to excessive speed.

If air leaks develop in slip control piping, close shut-off cock in air line above operating cylinder on left side of locomotive. In this case the slip control for the particular engine from which the air supply has been shut off will not operate but the cab light will still indicate when a slip occurs. Under this condition the slip must be stopped by the locomotive throttle.

If the slip control light comes on and stays on continuously when engine is not slipping a drive cable may be broken. In this case turn off switch on left side of relay box by pulling switch down to off position. All slipping must then be controlled by closing the locomotive throttle.

If a slip control light comes on when locomotive brakes are applied, the drivers on one engine are sliding.

## QUESTIONS ON CHAPTER 24

580. Should throttle be closed when slipping occurs on locomotive equipped with slip control?
581. Under what conditions should throttle be closed?
582. What should be done if air leaks develop in slip control piping?
583. What result is obtained when the shut-off cock in air line is closed?
584. How can the slip be stopped when the air supply has been shut off to the slip control?
585. What may cause the slip control light to come on and stay on continuously when engine is not slipping?
586. What should be done when the slip control light comes on and stays on continuously when engine is not slipping?
587. How can slipping then be controlled?
588. What is taking place if slip control light comes on when locomotive brakes are applied?

## CHAPTER 25

### Duties of Engineer at Completion of Trip

At the completion of the trip, the engine should be inspected for hot parts and other defects. The engineer should also know that:

- (a) The fire is in proper condition.
- (b) There is not less than two gauges of water in the boiler.
- (c) There is sufficient water in the tender to handle the engine over the ash pit.
- (d) Throttle is securely closed.
- (e) Reverse lever is in center.
- (f) Cylinder cocks are open.
- (g) Hydrostatic lubricator valves are closed.
- (h) Independent brake valve is applied.
- (i) Necessary action has been taken to prevent the various appliances from freezing in cold weather.

An intelligent report of the condition of the engine must be made on the M. P. 62 form provided for that purpose. Special attention should be given to defects that would not otherwise be detected, such as pounds, blow in valves or cylinder packing, valves out of square, defects in feed water pump, low steam and steam leaks.

Any unusual condition that occurred on the trip should be taken up personally with the foreman in charge.

## **QUESTIONS ON CHAPTER 25**

- 590. What are the duties of an engineer at completion of trip?
- 591. In what condition should the engine be left at the terminal?
- 592. What attention should be given to the preparation of M. P. 62 Work Reports.
- 593. What should be done to cover any unusual condition that occurred on the trip?



