Please read and send in as full discussion as possible at earliest date

The Canadian Society of Civil Engineers

INCORPORATED 1887

ADVANCE PROOF—*(Subject to revision)*

POWER PLANT PRACTICE.

By JOHN A. SHAW, B. Sc., A. M. Can. Soc. C. E.

(To be read before the Mechanical Section, November 10th, 1910.)

One of the many problems with which a large corporation, such as a railway system, has to cope, is how to efficiently install, maintain, and operate its many plants. As they are not direct revenue producers like the locomotives or other rolling stock, but more of a means of maintaining the latter, it has been a study how to economically achieve the desired ends without exacting more attention from a motive power department than their proportionate value allows.

A description of the organization and methods found necessary to obtain efficient plants on the Canadian Pacific Railway system will be given in this paper. To show the importance of this branch of the service, it should be stated that on the Eastern Lines of the Company, *i.e.*, from the Atlantic to Fort William, there are over 50 plants, consuming 126,000 tons of coal per annum. Any saving, therefore, in this one item alone is important, without regard to those possible in the other items which enter into the operating costs of all power plants.

The maintenance and operation of stationary plants in shops, roundhouses, elevators, and hotels come under the supervision of the electrical and power plant engineer, who is responsible for recommending the lines of correct design and operation, but is not actually in charge; the plants coming under the direct control of divisional officers or hotel managers.

In common with most railway companies, for operating purposes the system is divided into divisions. On the staff of each division is included a master mechanic, who is in direct charge of all mechanical matters, including power plants. As the latter official is responsible for the care of approximately $2,000,000 worth of locomotives and shop equipment, it is difficult for him, or even his subordinates, the locomotive foremen in direct charge of each divisional plant, to give personal supervision to the various details which must receive close attention in order to give efficient service. It is therefore left to the Power Plant Engineer to determine and recommend the best practice that should be followed and material employed for this service to induce the local staffs to co-operate and work along proper lines. This is determined by the carrying out of frequent tests and inspections at the various plants, the testing of materials in conjunction with the Engineer of Tests, and the use of a test boiler plant at the Angus Shops. Other duties involve the preparation of specifications and plans for new power plant work, *i.e.*, including the installation of steam and electrical equipment, compressed air apparatus, elevators, refrigerating machinery, heating arrangements, vacuum cleaning systems, or other similar matters.

Special effort is made to standardize in all installations, so as to make plants as much alike as possible, thus facilitating their operation and inspection, and reduce the quantity of the various emergency or repair parts necessary to carry in stock. For instance, in small plants boiler equipment consists of standard size boilers of the locomotive type, the principal reason for the adoption of this particular type being that the roundhouse staffs are thoroughly familiar with its maintenance and have all tools available or necessary for making quick and thorough repairs at the lowest possible cost. Mountings for these boilers are also standard with those used on locomotives, and therefore have the advantage pertaining to standard equipment. One size and type of boiler feed pump is adhered to as far as possible, thus permitting one spare pump to be used as reserve for several plants. The same practice is followed with electric generating units, one size and type of set, *i.e.*, a 50 K.W., 3 wire, 220 and 110-volt direct current generating unit being installed where limit of power distribution is restricted, or an alternating current set, generating at 550 volts, where the premises to be served are more scattered.

A closer study of the subject of power plant design is now necessary on account of the increased stringency of the laws being drafted by various municipalities for the repression of smoke, prevention of boiler explosions, muffling of noisy exhausts, etc., as well as on account of the increasing cost of coal and labour. Just as the railway manager now watches the coal consumed by locomotives per

thousand ton mile moved, or the auditor requires an accounting for every cent expended, so will every manager shortly demand the cost of evaporating each 1,000 pounds of boiler feed water in all stationary plants. An effort is therefore being made to obtain this comparative figure for the Company's various plants, in order to determine reasons for the variation of cost in different plants. This study generally brings to light strange errors in initial layout of earlier plants, and also reveals where steam product is being wasted. As the above mentioned unit may now be accurately and economically determined, it is possible to detect errors in former practice with their consequent wastes, and make provision for their elimination. Some of the points brought to light in this way or by periodical inspection are of material use in the laying out of new and the improving of older plants, and as the experience gained may be of interest in connection with power work, they may be referred to in a general way.

In the first place, a study must be made of the probable maximum and average load to be placed on the boilers, and in most cases experience with similar installations is the best guide. Once the boiler capacity has been fixed, the question of the number of units and size to employ must be determined. In almost all cases it is preferable to install at least two units, each with capacity for 60 per cent. of maximum load, to be carried so as to permit shutting down, except for short periods when the maximum load is being carried, one of the units being necessary for washing out, repairs, or inspection. There is no piece of apparatus in a power plant which gives better return for proper treatment than a boiler, and although initial expense may appear to be higher to obtain it, results will show that a convenient arrangement is the most economical in the end.

As the boiler load, especially in this climate, will vary greatly throughout the year, the engineer with most flexible plant, *i.e.*, that which can conveniently be operated at its greatest efficient rating, will obtain the cheapest power. One of the means of obtaining this desired result would be by having a ready way to vary the grate area of boilers, so that it will be properly proportioned to the load carried. It will be quite likely that in the near future specifications for boiler grates will demand this feature, just as they require means for varying the air opening through grates to allow of the proper proportion of air entrance for different coals.

The next important point is to instal a feed water heater of proper dimensions and in such a manner that the boiler will always receive a supply of properly heated water, for which the exhaust steam should be first available. Certain of the boiler laws in some of the States now require every plant to supply only hot water to

boiler feed. The type of heater, whether open or closed, is most important, and as a general rule, it will be found best to make use of the former on account of its greater and continuous efficiency. The study of oil removal, made necessary by the use of the open heater, is not now a serious problem on account of greater knowledge on the subject and the higher efficiency of the apparatus procurable. A very necessary precaution, seldom provided for, is treatment of boiler feed water. This provision is invariably omitted until the condition of the boilers makes it necessary. The proper procedure is to have samples of water analyzed by a competent chemist and treatment arranged for before the starting up of the plant.

In this connection, reference should be made to a means which is apparently effective in overcoming all pitting or corrosion of boilers, condensers, piping, etc. The method is one devised by an Australian inventor, and consists in making use of the well-known principle upon which the primary electric battery depends, *i.e.*, of the greatest chemical action taking place at the positive pole and the liberation of hydrogen at the negative electrode. By connecting the negative pole of a direct current source of power to the metal of the boiler and the positive to an insulated electrode of any suitable substance, an electro-chemical means of effectively protecting against all corrosion is now available. It is stated that results obtained with bad boiler waters, and especially with salt water condensers, have been exceptionally good. A further claim is also made that a material softening of all hard scale or deposits is made in this way.

The boiler feed pump is an item deserving attentive consideration. In small plants, in order to reduce initial outlay, an injector is too often used. This should only be for emergency use. When a pump is installed it is generally too small, owing to its having been purchased on a catalogue rating. As makers give the highest possible rating, *i.e.*, one which can only be obtained with the pump in the best of order pumping cold water, it is wise to specify a size having the required capacity, at a maximum speed of 25 strokes per minute. Where the supply of exhaust steam is plentiful for heating feed water, it is a good plan to instal a triplex plunger pump, or equivalent, driven by a small steam engine, so as to obtain a greater economy by the expansive working of steam than is possible in the usual feed pump. A very necessary precaution also is to specify that the pump be properly fitted, packed, and adjusted for hot water.

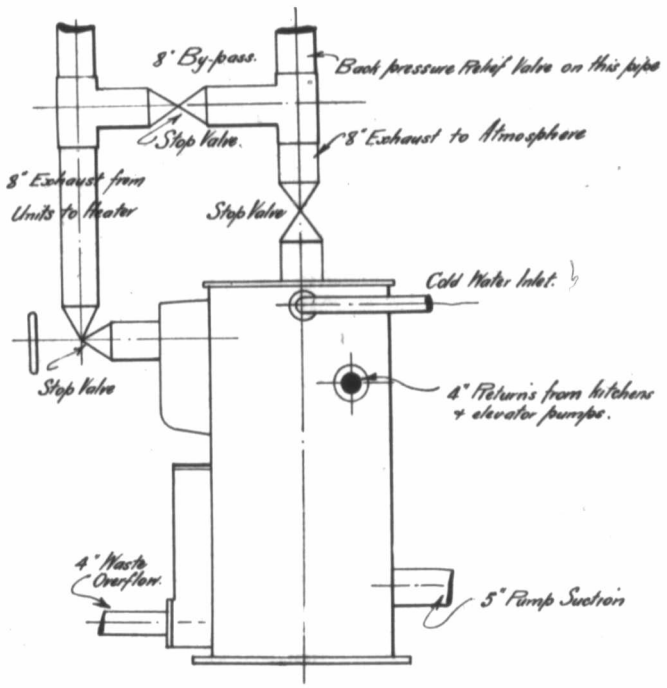
The steam trap is another piece of power plant apparatus which has received too little study. In a number of instances, in older plants, traps have been discarded, it having been reported that they

would not allow of the proper flow of steam. Inspection showed that the trouble was due either to the manner of installation in the piping layout or the traps not being of the proper capacity for the conditions under which they were operated. These latter cases arose from the traps having been purchased on a catalogue rating, *i.e.*, their drainage capacity in feet of one-inch pipe at a fixed pressure of, say, 50 lbs. No allowance was made for varying conditions. A trap that will handle a given quantity of water at 50 lbs. will do nothing like that amount at 5 or 10 lbs. pressure. It is most important that care be taken to determine the actual quantity of water to be handled at the available steam pressure before deciding on the trap to be used.

Too much attention cannot be given to the insulation and arrangement of piping especially when there are lengthy runs between buildings. The most economical installation is to place all piping overhead on supports sufficiently strong to withstand all vibration or movement, the piping being properly insulated with the best and most suitable grade of covering and securely protected by boxing. This form of construction is, however, unsightly, and cannot usually be provided for. In underground construction the work is often carelessly done, resulting in rapid depreciation; continuous waste being only too evident, especially in winter, owing to the lack of snow above all pipe lines about a manufacturing establishment. As it is now possible to instal a steam line at a reasonable first cost in such a manner as to reduce loss by radiation to an infinitesimal amount and at the same time provide for an indefinitely long life, (*i.e.*, with an extremely low depreciation rate, if any), it would seem as if it were only the lack of familiarity with such construction that would account for bare steam pipes being placed in the ground or covered in a box without proper drainage. Such a box acts as a drain and condenser for the greater part of the year, doubling or trebling the necessary fuel consumption. The construction above referred to is that which now makes possible the distribution of low-pressure steam by district heating companies at extremely reasonable rates. The pipes are placed in tile sewer pipe specially designed for this purpose, and proper provision is made for expansion and anchoring of lines and their protection by suitable insulating material. The only requirement to obtain perfect satisfaction is that the installation be carried out with care.

The determination of the actual evaporation of boilers reduced to dollars and cents is one that should be given consideration. Too little attention has been given in the past to the recording of actual work performed by boilers. This has been due until recently to the costly apparatus necessary for the accurate measuring of boiler feed water and coal, and also to the unreliableness of procurable ap-

paratus. There have been water meters without number, but they have never been considered reliable, and whenever an accurate test was desired, recourse had to be made to the cumbersome method of employing barrels or tanks and scales. There are now two simple and accurate devices available, and the cost of such work is already



OUTLINE OF OPEN TYPE HEATER & PIPING.

Fig. 1

being reduced materially and more of it is being done. One of these devices, made by the Wilcox Engineering Co., of Saginaw, Michigan, consists of a metal tank divided into two compartments. A connection from the feed water heater is made from the upper compartment, so that water may flow to it by gravity. When this compartment is

filled, connection to the heater is automatically cut off and a quantity of water discharged to the lower tank and thence to the feed pump. A counter gives the record of the flow of water. The other equipment consists of an automatic record of the flow of water over a calibrated notch or weir placed in a measuring tank connected between the heater and the pump. Cheap forms of both of the recorders suitable to the smallest of plants are now available. It should also be noted, especially where a boiler plant is used in developing electric power, that, by the addition of a water chart to this instrument, as shown in Fig. 7, over that of the electric integrating watt meter recorder, an extremely close check may be had on boiler conditions, and any dropping off in boiler efficiency immediately noted.

The daily record of coal used can always be closely determined, either by a tally being kept on a conveniently located blackboard of the barrows of coal fired, or weighing on a platform scale located on the boiler-room floor, or by means of a calibrated chute with a counter where the coal supply is from overhead. As all coal is usually paid for by weight, any discrepancy in the boiler-room records may be easily checked.

As instances of some of the oversights or errors met with in power plant design, a reference to some troubles encountered and their causes may be of interest.

Explosion of Open Type Feed Water Heater.—In a moderate sized plant the piping contractor had removed an open type heater, with all connections as originally installed some years previously (Fig. 2), from the old plant to the new boiler-room. During the first run of the new plant an accident occurred through the bursting of the heater. Upon investigation it was found this was brought about by an operator closing a stop valve on the vent of the exhaust of the heater after the stop valve on the main steam inlet to the heater had been closed. The pressure in the heater became excessive, owing to live steam escaping into it by way of the return piping for condensation, a bye-pass on a defective trap having been opened in a distant part of the plant. This trouble was directly due to the installation of a stop valve on a heater outlet, which was a common practice some years ago in order to allow the heater to be readily shut off for cleaning purposes.

Broken Engine Cylinders through Failure of Closed Type Heater.—In this instance a closed type heater had been installed in the customary manner in a power plant containing several electric engine sets running in parallel. At the noon hour, when the sets had again started up in preparation for carrying the load and were running with alternating current generators in synchronism, the cylinders on four engines were simultaneously broken. This

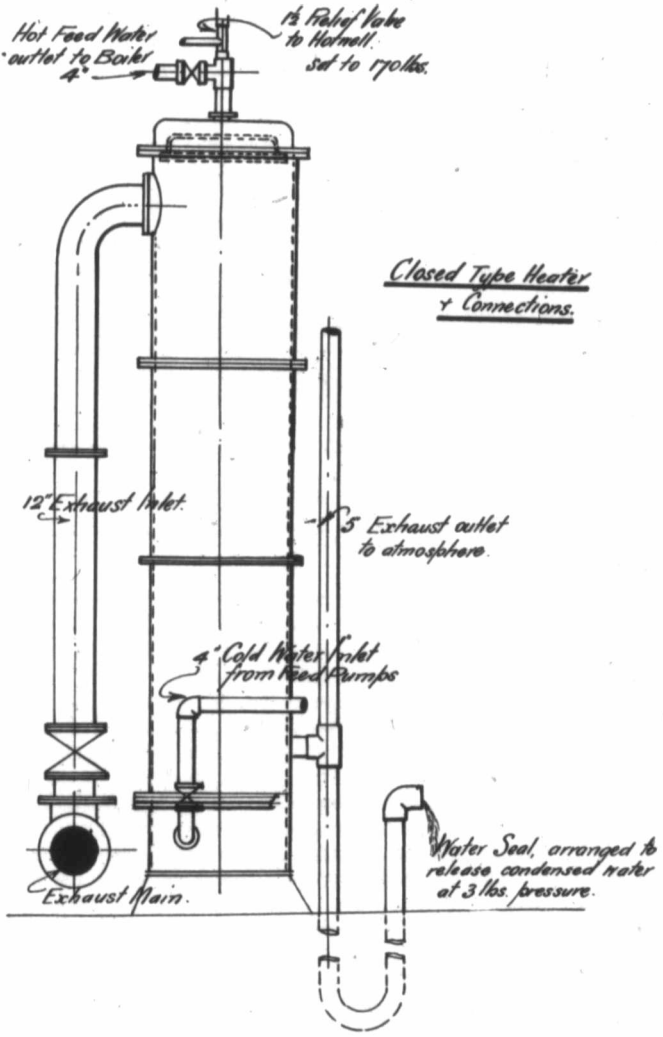

Hot Feed Water outlet to Boiler 4"
1½ Relief Valve to Hotwell. set to 17 lbs.
Closed Type Heater & Connections.
12" Exhaust Inlet.
5" Exhaust outlet to atmosphere.
4" Cold Water Inlet from Feed Pumps
Water Seal, arranged to release condensed water at 3 lbs. pressure.
Exhaust Main.

Fig. 2

occurred through failure of a tube in the heater, thus admitting the water into the exhaust header, whence it was drawn into the low-pressure cylinders, as all the engines but one were practically running as vacuum pumps driven by the synchronous motors. This accident showed the necessity for improving upon standard practice

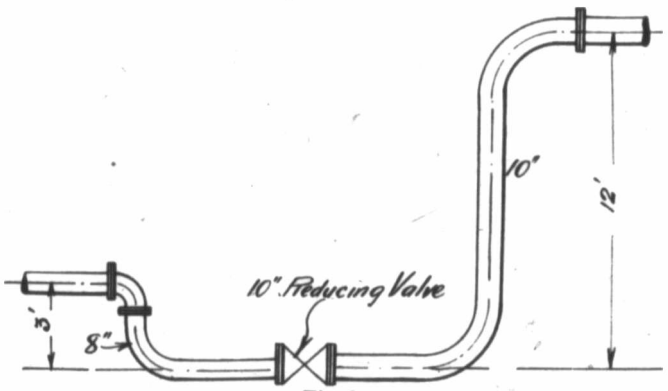


Fig. 3

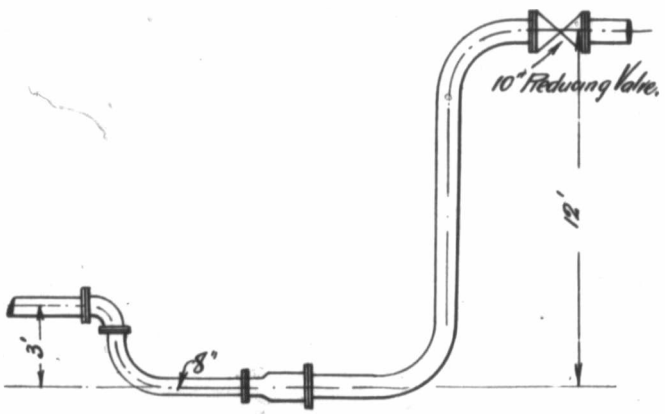


Fig. 4

by the installation of a suitable water seal, as illustrated in Fig. 2, the overflow of water to the sewer giving immediate notice of the collapse or leaking of a tube.

Unsatisfactory Service of a Reducing Valve.—This valve was installed as shown in Fig. 3, and continual trouble was experienced owing to the valve being flooded by water of condensation and the

collection in it of grit, oil, etc. The position of the valve was changed, as shown in Fig. 4, where it worked satisfactorily.

Drainage of an Underground Boiler Flue.—In an installation where an underground flue connected the boilers to the stack below

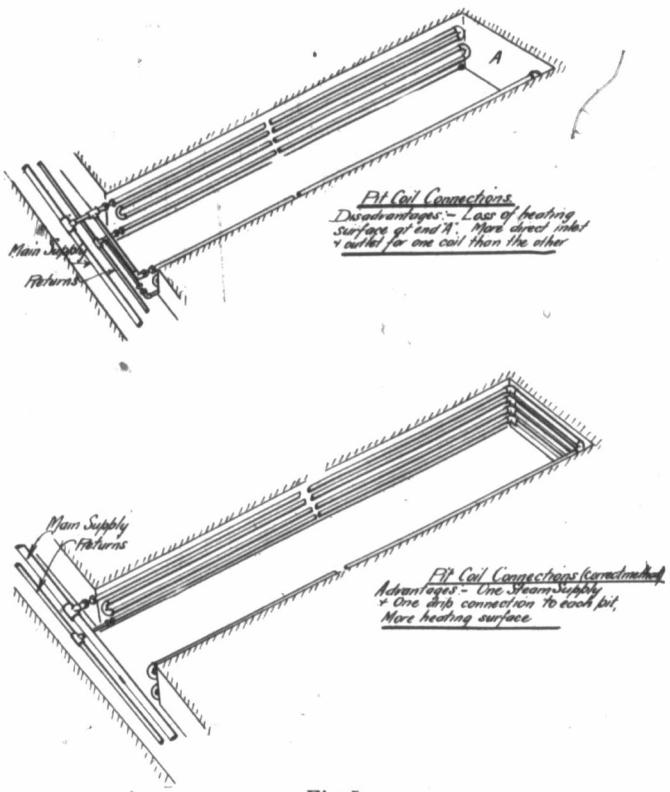


Fig. 5

the level of the sewers, an ordinary reciprocating pump had been installed to remove surface water which leaked into the flue. This pump quickly gave out through the scoring of the cylinders by the fine particles of ash drawn in through the suction in spite of all efforts to strain it. This trouble was overcome by the installation of a centrifugal pump.

Oil in Heating System.—Although an oil separator of proper proportions was installed on an exhaust line, the presence of oil in the heating coils was noticed. It was found that the piping contractor had installed a valve, requiring periodical opening by the engineer, on the drip of the separator. This had not been regularly done. The valve was replaced by a water seal of sufficient height to withstand the heaviest back pressure, as shown in Fig. 6, and all trouble eliminated.

Although some time may be sacrificed by so doing, no engineer should instal new devices in a power plant without first submitting a plan of the installation to the maker. This is often overlooked, and if the results obtained from the installation—which was perhaps made in an unfair manner—prove unsatisfactory, serious injustice will be done to the maker.

A further important point in connection with small plants is that, although the greatest care and experience may be brought to bear in making the most efficient installation, all further care and supervision of plant is left in the hands of unskilled or irresponsible men. To obviate the harm resulting which will be thus caused, it is well for the manager of an enterprise which includes a power plant to have a set of regulations drawn up and conspicuously placed, and have intermittent inspections made by competent men in order to ascertain that the rules are lived up to. Such maintenance regulations might follow the lines of those given below, which have been compiled for the guidance of the locomotive foremen or engineers in charge of the C.P.R. power plants. These are issued under the title of "Maintenance Regulation Cards." They obviate the use of circular letters or framed notices, and serve as a means of disseminating knowledge in a standard form, always accessible for reference. Any alterations in rules are readily made by periodical revision of the cards at small expense. Some of the rules in use on the C.P.R. system to-day are as follows:

"*General.*

"All equipment must be kept clean and dry and repairs made promptly.

"*Engines.*

"1. With all machines (engines, compressors, etc.) care must be taken that knocks be located as soon as developed and looseness at that point taken up gradually, so that no overheating will occur.

"2. Frequent inspection of engines must be made to obtain proper and economical regulation of engine valves, also to obtain a governor regulation such that speed of machine is that rated by manufacturer, and that same does not vary to any extent under different loads.

"3. Drip piping from steam and oil separators, cylinders, etc., must be kept perfectly steam tight and free from grit, etc. Shifting glass connection on steam separators must be in order, to avoid possibility of water of condensation reaching cylinder.

"4. It must be seen that steam valves on engine piping (outside of throttle) are perfectly steam tight, so that pipe above throttle will not fill with water of condensation when engine is out of service, which might cause breaking of cylinder should throttle be opened carelessly on starting up.

"*Oiling.*

"1. When renewing oil in engines, care must be taken that oil-ways and pockets are free from grit, etc. Only special power house engine and valve oil must be used.

"2. When forced lubrication is used, care must be taken that all sighting glasses are kept clean so that it can readily be seen that oil is flowing freely and that oil pump is in proper working order.

"*Electric Machinery.*

"1. Commutators and brushes must be kept clean, sand paper, not emery, being used for this work. Sparking must never be allowed to continue.

"2. When compressed air is available, the generator, motors, and switchboard must be blown out at least once per week. Care must be taken to see that air is dry before it is used, and of not too high pressure.

"3. Only dynamo oil must be used in bearings, and these should be regularly inspected for wear.

"4. All connections on switchboard and machine to be gone over once a week and made tight.

"5. When plant is not running, all switches must be left open.

"6. When lightning arresters are installed, they must be inspected regularly, particular attention being given to ground connection.

"7. Two spare fuses of each size that are used on switchboard must be kept handy so that they can be put in immediately when necessary.

"8. In requisitioning spare parts for the plant, as much detail of the apparatus as possible must be given.

"*Wiring.*

"1. All wiring must be safe and in good order, grounds and short circuits being removed as soon as possible.

"2. All additions must be done according to the rules of the National Board of Fire Underwriters, and must not be made by any other than a qualified electrician.

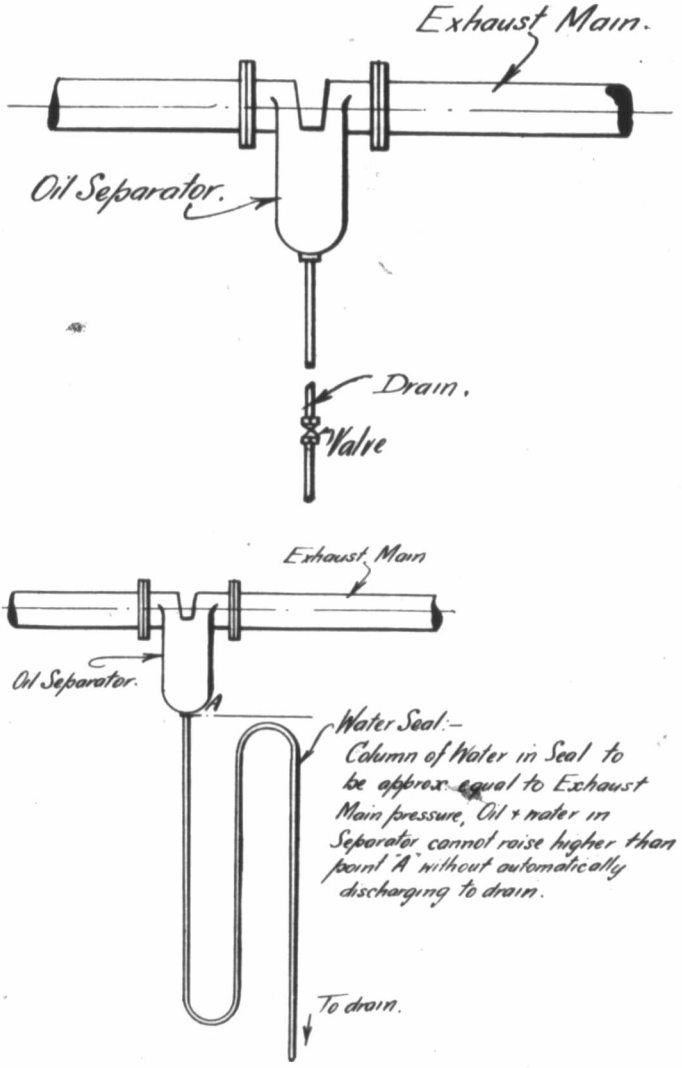

Exhaust Main.
Oil Separator.
Drain.
Valve
Exhaust Main
Oil Separator.
A
Water Seal:-
Column of Water in Seal to be approx. equal to Exhaust Main pressure, Oil + water in Separator cannot raise higher than point "A" without automatically discharging to drain.
To drain.

Fig. 6

"3. Notification to be given to Electrical Engineer at once of damage by fire to wiring or electrical apparatus.

"*Open Type Feed Water Heaters.*

"*General.*—Heater and connections must be thoroughly overhauled at least twice a year and given a proper cleaning.

"Inside copper water trays and coke trays must be removed when worn. Coke in heaters should be removed and new put in at least four times per year; if water contains excessive amount of oil, coke should be changed more often. To do this, only necessary to take off lowest handhole cover.

"Mud deposit in bottom of heater must be blown off at least once in 24 hours.

"The light impurities in water which float on top can be removed by holding cold water regulating valve wide open, raising water line until overflowing occurs. This flushing should be done once every day. Overflow and drip connections must be kept free from grit, etc., also gate and check valves on same made perfectly water and steam tight when closed.

"Float valve on cold water make up to heater must be kept in proper working order, same to be cleaned out at frequent intervals, taking care that proper packing is used for spindle, enabling same to operate freely. Also valve must be kept regulated so that level of water in heater held at from 1 in. to 3 in. below overflow pipe.

"When float does not operate properly, handhole cover should be taken off and float examined and repaired if necessary.

"A calibrated thermometer must be kept in use on suction pipe to feed pump to heater and temperature of feed water maintained as high as steam supply to heater will permit.

"Waste pipe must be kept clear, so that the oil and surplus water may pass away freely and not be dammed back into the heater.

"*Special Points in Care of W. Heaters.*

"The inlet air valve on heater must be examined frequently and kept in proper working order.

"In the newer type of W. heater provision has been made for a reverse circulation of cold water through the filter chamber for thoroughly cleaning the filter bed. A connection to the filtering compartment is made from the water supply pipe to the heater (a valve being placed in the pipe), so that the water can be forced through the filtering material in an opposite direction to the ordinary flow. This reverse circulation loosens and washes back any sediment or impurities that may have collected in the filtering material directly to the settling chamber,

from which, by opening the drain or blow-off valve, they are then forced into the waste pipe or drain. In the case of excessive oil or other impurities in the water, this should be done once every week.

"A pressure relief valve is supplied with the newer type of W. heater. This valve must be kept in proper working order.

"*Special Points in Care of C. Heaters.*

"Ball float (which controls level of water in heater) leaks should be given immediate attention if a leak develops, as same will be detected by water dripping from hollow spindle that passes through handhole cover.

"A gate valve must never be installed on outlet from heater, nor back pressure valve weighted down to create a back pressure greater than 6 lbs.

"*Closed Type Feed Water Heater.*

"*General.*—Heater and connections must be thoroughly overhauled at least twice a year, and tubes, heater shell, heater covers, and drip connections given proper cleaning. Water seal to hold pressure of 4 lbs. in heater must be installed on exhaust outlet from all these heaters, so that when exhaust steam pressure is held at 3 lbs. only water of condensation can escape; also in order that, should any tubes break, same can be readily detected before damage is done to machinery.

"All flanged joints on heater to be made with sheet 'Rainbow' rubber. Water outlet glans to be packed with H. J. M. Co.'s style, No. 182, or A. P. Co.'s style, No. V-340, packing, or its equivalent, if heater is of expansion tube type.

"*Pumps.*

"*Feed Pumps.*—Feed pumps must be kept in good repair. All joints, both steam and water, must be kept tight. Sheet packing to be used on joints of steam chests, and steam cylinder covers must be H. J. M. Co.'s 'Permanite' or A. P. Co.'s H.P., style No. 425, or equivalent. Sheet packing to be used on water valve cover joints and water cylinder covers must be sheet 'Rainbow' rubber. Water valves must be made of vulcanized, not of common hard rubber. Plunger packing used must be A. P. Co.'s style V-340 or H. J. M. Co.'s style 182, or equivalent, of desired thickness, which engineer must make mention of on requisition for same.

"At points where locomotive washout tanks are in use, and a connection taken from same for boiler feed water, either direct to boiler or through feed pump, this connection must only be used when heater or feed pumps are out of order, and care must

be taken that all valves are closed on pipes to and from feed water heater.

"When operating feed pumps where gravity heating systems are installed and receiver tank for returns automatically control steam valve on pump, from float in tank, care must be taken that float is kept in shape, and that automatic control valve is working properly. Receiver tank and all connections must be frequently examined and cleaned thoroughly.

"*Vacuum Pumps.*—These pumps must be kept in good repair, so that a constant vacuum of 15 inches water will be maintained on heating system with pumps operating at from 30 to 50 per cent. of their rated number of strokes. All connections to receiver on suction of vacuum pump must be valved at point near receiver, and these valves kept water and steam tight (when closed), by renewal of disc of valve seats and by packing spindle with H. J. M. Co.'s Vulcabeston, style No. 192, or Palmetto rope packing.

"At least a ¾-in. water connection must be made to end of vacuum pump receiver to temper water to enable pump to handle same and aid in maintaining vacuum, as well as to prolong life of pump valves.

"*Water Service Pumps.*—These pumps must be kept in good repair. Where automatic control or pressure regulating valve are in use on steam supply of these pumps, same must be kept in working order and be frequently dismantled and cleaned.

"Plunger packing used on cold water pumps must be H. J. M. Co.'s hydraulic coil packing, style No. 181, or some other good flax packing. Plunger packing used on hot water pumps must be A. P. Co.'s, style V-340, or H. J. M. Co.'s, style No. 182, or equivalent.

"Water valves on hot water pumps must be of vulcanized and not common, hard rubber. Water valves on cold water pumps may be of vulcanized or hard rubber.

"*Care of Heating System and General Piping.*

"*Pressure Regulating Valves* at junction of heating and steam mains must not be tampered with, but must be regulated and put in use or cut out of service from instructions of foreman or by engineer of plant, who understand care of same. For gravity heating system, valve to be set at a pressure not exceeding 10 lbs. or pressure necessary to heat coil at greatest distance from source of supply. For vacuum heating systems, valves set at pressure not exceeding 5 lbs. For passenger coach heating, valves set at pressure not exceeding 70 lbs.

"These valves must be examined at beginning of winter season, and cleaned and repaired if necessary.

"*Back Pressure Valves* on heating systems to be set to keep closed when low pressure gauge shows greatest pressure allowed on system, and to open at 1 lb. higher pressure. These valves to be examined at frequent intervals and see that same operate easily.

"*Oil Separators and Steam Separators* must be cleaned out at frequent intervals and drip piping from same kept free from grit or dirt of any kind. A water seal must be installed on drip from oil separators of sufficient height to overcome back pressure carried on exhaust line (*i.e.*, to allow water and oil only to escape).

"Gauge glasses and connections on steam separators must be kept clean and free from dirt of any kind. All valves on drip connections from steam separators must be kept in good repair.

"*Steam Traps* must be examined at frequent intervals and cleaned out and repaired if necessary.

"Where by-pass connections are made around steam traps care must be taken that all cutout valves are perfectly clean and water tight, so that same may not affect proper working of traps.

"*Thermostatic Valves.*—Where these valves are in use on heating system or hot water supply tanks, care must be taken that they are kept free from dirt, grit, etc., extreme care being taken in the adjustment of all these valves, it being the particular work of the engineer of plant, who thoroughly understands the operation of same.

"*Automatic Air Valves* on any radiators or coils must be examined and cleaned out at beginning of winter season, and put in proper shape for use. If same are piped up to a vacuum board, as in case of Paul system, piping must be blown out with compressed air at least once per year.

"*Valves.*—All valves must be kept in repair and given thorough internal examination at least once per year.

"Any new valves to be ordered of sizes above 2½ in. for high and low pressure steam, water, or main air service pipes must be Chapman, or equivalent, gate valves, bonneted, with rising spindle where spacing will allow. Valves of sizes under 2 in. must be of the solid disc or 'Victor' globe type. All valves must be installed with spindle in vertical position. All new valves required for water hose connection must be of P. & C., or equivalent, best manufacture.

"*General.*—All joints and unions must be steam tight. All sags in alignment of piping must be removed, and if hangers are broken, pipes must be held in line until new hangers can be applied.

"Vacuum systems of heating can be tested for leaks in piping by application of soap-suds.

"No alteration in run of pipes, additions, or changes in size to be made without consent of Master Mechanic.

"All flanged joints on steam and air piping to be made up with sheet packing equal to H. J. M. Co.'s 'Permanite' or A. P. Co.'s H.P., style No. 425 make. All flanged joints on exhaust steam and water piping must be made up with sheet 'Rainbow' rubber.

"Any trouble with apparatus that cannot be handled by local men must be reported to General Master Mechanic.

"Locomotive Foreman is held responsible for the economical working of the plant and any abuse that it may receive."

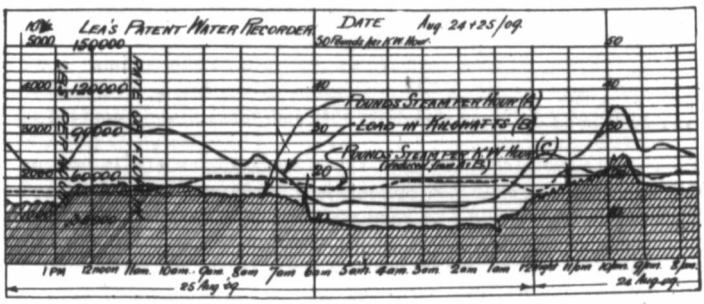


Fig. 7

The closed exhaust or blow-off system is now being tested in four of the Railway's roundhouses as an adjunct to improve power plant economy as well as reduce the time taken in locomotive roundhouse maintenance. It consists in having the roundhouse piped to admit of the heat in the steam and water from locomotive which is to be washed out being made use of for heating the fresh water supply used for washing out and filling. This blow-off piping is connected to a large closed tank placed at a convenient point in the house. Steam and water from the locomotive being blown off is passed through a set of tubes giving off their heat to the fresh water supply circulating in the body of the tank about the tubes. By this means it is possible to blow-off, wash out, fill up, and have a working head of steam on in about two hours without subjecting boiler plates, etc., to any detrimental changes of temperature. The heat saved in this way makes a considerable difference in the coal supplied to round-house boilers, as, without the system, a considerably larger quantity of live steam is required. The saving made for each locomotive

handled averages about one-tenth of a ton of coal, so that, where a number of locomotives are being washed out daily, the saving made is material. By turning all the exhaust steam from the stationary plant into this form of heater and drawing the boiler feed from it, the equipment may be considerably reduced and a supply of hot water always ensured, with still greater economy.

With the more general distribution of electric power, and especially from water power plants, the Company has found opportunity to reduce the operating costs of certain divisional points by purchasing electric power. This practice is especially applicable to the summer months, when all of exhaust steam from air compressors, shop engine, or other prime movers cannot be made use of. It is seldom that it is found economical to consider the purchase of power throughout the entire year, as the power companies cannot then afford to offer as low a rate, and railway terminals do not usually have a continuous surplus of exhaust steam. There are ample opportunities for savings in the smallest of plants, and by the organization here briefly outlined it has been possible in a railway company to introduce economies which have repaid several times over any expenses incurred.