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PROCEEDINGS OF THE CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA MEETING.

Prince George Hotel, TORONTO, April 18th, 1911.

The President, Mr. G. Baldwin, occupied the chair.

Chairman,—

As every member has received a copy of the minutes of the previous meeting, it will be in order for someone to move their adoption as read.

Moved by Mr. Wickens, seconded by Mr. Latour that the minutes of the previous meeting be adopted as read. Carried.

Chairman,—

The next order of business is the remarks of the President.

Mr. Black has asked me to cut my remarks short as he has not only got a very lengthy paper to get through, but there are a number of his particular friends who have come down from Stratford to hear him to-night, who want to get away on No. 17, so that it wiil be necessary to get through the business a little quicker than would otherwise have been the case.

I would have liked to have seen a larger gathering here to-night to hear this very interesting paper on "Improvements to Locomotives" which is of interest to us all.

I will call on the Secretary to read the list of new members.

NEW MEMBERS.

Mr. J. C. Grant, Foreman, Erection Department, Canada Foundry Co., Limited, Toronto.

Mr. C. Thurston, Foreman Machinist, Polson Iron Works Limited, Toronto.

Mr. J. B. Watson, Machinist, Consumers' Gas Co., Toronto.

Mr. J. G. Corlett, Assistant Foreman Erector, Canada Foundry Co, Limited, Toronto.

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T. Graham.
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A. Woodly.
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J. W. McLintock.
E. G. Southam.

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I. Jefferis.
J. Barker.
C. A. Jefferis.
W. A. Grocock.
J. Herriot.
H. M. Patton.
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D. Peddie.
G. Black.
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W. McRobert.
W. Dermett.
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F. H. Squibb.
W. E. Patton.
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C. D. Scott.
J. F. Campbell.
L. S. Hyde.
E. Blackstone.
E. Logan.
J. Kelley.
G. A. Young.
C. F. Neild.
J. M. Clements.
H. G. Fletcher.
A. M. Wickens.
H. Ellis.
J. Tocher.
T. J. Ward.
W. C. Sealy.
J. Bannon.
A. Stewart.
C. L. Worth.

Secretary,—

It is the smallest number of new members we have had this year. I think every member should bring two or three new members into the Club, and it should not be necessary for me to have to remind you of this month after month.

Chairman,—

I would like to say that these applicants have been duly passed on by the Executive, and have been elected members of the Club.

We will pass on to the order of business of discussions of papers read at previous meetings.

As Mr. Grocock is present, if anybody desires to ask him any questions I have no doubt he will be only too pleased to answer them.

The next order of business is the reading of papers or reports and the discussion thereof.

As our old friend Mr. Black, one of the standbys of the Club, and one of its oldest members, and I think one of the busiest men we have in the Club, has undertaken to give us a very lengthy paper on "Improvements in Modern Locomotives," and I have not the slightest doubt before I listen to it that it will be a very excellent paper. Knowing Mr. Black as I do, to be such a capable man, it is not necessary for me to say any more, and I now introduce Mr. Black to you.

Mr. Black,—

When this Club was formed four years ago, I was one of its Charter Members, and at that time promised to add my mite towards the good work of the Club by getting up a paper, and the following is the one I have prepared.

IMPROVEMENTS IN MODERN LOCOMOTIVES.

BY G. BLACK, ROAD FOREMAN, G.T.RY., STRATFORD.

In preparing a paper of this kind I have endeavored to give a review of the most important improvements in the modern locomotive brought about by the varying conditions and requirements from the time of its first appearance to the present time. In doing this I have been unable, in the limited time at my disposal, to give the exact dates of the introduction of the various improvements but have as far as possible done so.

The first idea of steam navigation was set forth in a patent obtained in 1736 by Jonathan Hulls, for a machine for carrying vessels against wind and tide. In 1778 Thomas Paine proposed in America this application of steam.

In 1781 the Marquis de Jouffray constructed one on the Seine, and in 1785 two Americans published on it.

In 1789 W. Symington made a voyage in one on the Forth of Clyde canal, and soon after one Fulton visited Mr. Symington took notes and then went to America and in 1807 started a steamboat on the Hudson River and made a success of it. In June 1819 the Savannah of 350 tons went from New York to Liverpool by steam. Steam power to convey coal on a railway was first used by Blenkinsop at Hunslet near Leeds, and afterwards for passengers and goods on the Stockton and Darlington Railway, the speed was from five to eight miles per hour.

In the trial of locomotive steam carriages at Liverpool in October, 1829, Braithwaites' carriage including water and fuel weighed 3 tons, 14 cwt., or 8,220 lbs.; Stephenson's 4 tons, 3 cwt., or 9,216 lbs., and ran from fourteen to eighteen miles per hour. Braithwaites' ran twenty-two miles per hour, the size of the cylinder was six inches, and the stroke twelve inches, and the load hauled was ten tons. These figures are in striking contrast to the modern mastadon, weighing 225 tons, and having cylinders of thirty-six inches diameter, and thirty-four inches stroke, and capable of hauling 4,000 tons or more but it is a great tribute to Stephenson that we find on the great majority of the locomotives in service to-day the link motion for steam distribution invented by him and the strange part of it is that we have not as yet found anything to beat it.

Stephenson also saw the advantage of added weight to increase the traction power of an engine, and engines were made heavier and wheels were coupled in series to bring about this result.

Then we find another important matter to be considered, viz., the power to control and stop the engines and trains at the required time and place, this brought about the introduction of brakes, the first of these were of the crudest type and consisted of a block of wood attached to a long lever which, when not in use, was hung on a hook, and when required was let down off the hook and exerted a retarding force on the wheel. The next thing was a brake operated by a crank, and a series of levers and which did service for a great many years until the introduction of power brakes, the first of which I believe was the vacuum brake which consisted of a series of suitable levers and a cylinder on each car and engine, and a pipe connecting all to an ejector on the engine. This ejector was capable of creating a partial vaccuum in the cylinders, and the pressure of the atmosphere acting on the opposite side of the piston caused it to move and exert a force through the levers, etc., to the wheels, and thus bring about the desired result, but this had its great disadvantages that when the pipe connections got broken or leaked or the train broke in two the brakes could not be operated, this condition brought about the introduction of the automatic vacuum which would overcome this difficulty, for when the train broke in two or the pipes of the brake were disconnected, the brakes would automatically apply and stop the train, the name of the inventor of this brake was Smith. About this time there were other brakes operated about in the same manner, some by steam and some by compressed air, but it remained for the great Geo. Westinghouse to give to the world the brake that has made possible the controlling of heavy trains at high speeds, and added the element of safety in handling the commerce of the country and the enormous amount of passengers that travel over the great railroads of to-day. The first of these brakes, as I said before, was rather crude, but as time went on the requirements were noted and met on all sides, so that from the beginning, with the brake only on the engine, and then applied to a few passenger cars, we now have brakes on every wheel of the train whether passenger or freight.

When the Westinghouse Automatic Brake was first introduced we had the old style plain triple valves operated by a three way cock on the engine, and it was found that the operation on long trains was slow on the rear cars and quicker on the cars next to the engine, than when the flow of air from the train pipe was suddenly cut off by the abrupt closing of the three way cock by the engineer, the air would surge from the rear of the train and release the brakes on the front of the train and engine, and sometimes cause damage to draft gear, this brought about the introduction of the equalizing discharge valve, which by its gradual opening and closing made the brakes operate uniformly, then again on longer trains with the plain triples, the brakes in an emergency were too slow to apply on the rear of trains and this brought about the introduction of the quick action triples which operate so quickly that the brakes on the last cars are set before the slack has time to run in. Pump governors have also been put on to govern the pressure of air in main reservoirs and feed valves to regulate the pressure in train pipes and auxiliaries, and reducing valves to regulate the brake cylinder pressures in the operation of high speed brakes, so that trains running at high speeds can be brought to a stand in the shortest possible distance without shock or the skidding of wheels.

The improvements which have been made to the modern locomotive, are of two classes. Those which have been adopted on account of their mechanical advantages, and those which have been adopted to effect economy in steam consumption.

The piston valve, the Walschaert valve gear, and the mechanical stoker belong to the first class, and will be considered in the above order. To the second class belong the compound engine and the superheater.

These are, without doubt, the most important improvements made in the locomotive and have, with one exception, the Walschaert valve gear, been successfully developed within the last fifteen years.

THE WALSCHAERT VALVE GEAR.

The real test which should be applied to every detail which is assumed to increase the cylinder power of a locomotive, concerns its effect on the steam consumption of the engine. Will its use produce a horse power upon less steam than the device which it supersedes. If it will, then, when the boiler is supplying all the steam it can make, it will permit the cylinders to deliver more power than they were able to do without it. If it does not increase the efficiency of the cylinder action it cannot really increase the power.

This suggests the inquiry as to whether the distribution of steam in the cylinders of simple engines is satisfactory, whether, for example, we ought to persist in efforts to secure square cornered cards. The reply is, that in most cases where the gear is sufficiently heavy and stiff, to do the work for which it is designed, the distribution as obtained from present gears is satisfactory. The typical locomotive card, displaying the wire-drawing action throughout the cycle, which, especially at high speed, is strongly marked, is, after all, a card of high efficiency. The steam consumption of the locomotive is less than that of most other forms of high speed steam engines employing atmosphere exhaust. Even when the speed is increased to limits which far outstrip those common to stationary engines, its work is to be regarded as highly efficient.

So well do the better class of valve gears which are now in common use perform their work that anyone who attempts to increase the power of a modern locomotive by improving its steam distribution will find but a narrow margin on which to work.

The Stephenson Link motion has been used on locomotives for very many years, almost since its first development. However on large power the Walschaert gear on account of its important mechanical advantages is displacing it to quite an extent.

The most suitable form of radial gear for locomotives is unquestionably the one invented by the Belgian engineer, Egide Walschaert, in 1844, and applied to locomotives a few years later, but it was not properly understood or appreciated during the first twenty years following its invention, and has ever since then made slow headway until a few years ago, when it took quite a sudden move forward and is at present the dominating valve gear throughout the continent of Europe and is fast gaining ground in this country. This gear may be said to be based on a fundamental principle of its own, but has been subject to a few modifications without any improvements over its original form.

The motion of the valve is derived from two sources—namely, the main crank by connection to the crosshead, and from an eccentric placed approximately at right angles to the main crank. The crosshead connection imparts the motion of lap and lead at the extremities of the stroke of the piston at which moment the link is in its central position. Therefore, in mid gear with the reverse lever in its centre notch, this will be all the motion imparted to a radius equal to the length of the radius bar. By moving the reverse lever forward the eccentric motion is brought into combination with the motion from the crosshead, producing a valve opening for the forward motion of the engine, and by moving the reverse lever backward the link block is brought to the opposite side of link fulcrum, resulting in a valve opening governing the backward motion of the engine, in effect similar to that of the Stephenson motion. The action of this one eccentric is therefore the same as if there were two eccentrics, one for forward and one for backward motion placed diametrically opposite each other, and the angle of advance in the Stephenson motion is taken care of by the main crank in the crosshead connection. The latter motion being constant, it follows that the lead remains constant at all points of cut-off.

The proportions of the various parts of the Walschaert gear cannot be determined experimentally, nor should any change in setting the valves be made unless the effect of the change is known in advance. It is, therefore, important that the different parts of the motion should be made and set correctly from the beginning, and there will be no need for changes when the original dimensions are maintained. The difference in this gear for outside and inside admission valves must be considered in setting the eccentric crank, and as the forward motion of the engine should preferably be taken from the lower end of the link, when the eccentric crank will follow the main crank for *inside* admission valve and *lead* the main crank for *outside* admission valve. For outside admission valve the radius bar is connected to the combination lever below the valve stem and for inside admission above the valve stem.

The motion is reversed by an arm connected to the radius bar. The silding lifter is the best method of suspension of the radius bar but due to wheel arrangements of various designs of engines, this is not always applicable, but must be substituted by swinging lifters, which when properly placed give for all practical purposes equally good results.

It will be noticed that the elipses are slightly flattened on one side, which is caused by the slower lineal motion imparted to the valve relative to the angular motion when the eccentric passes its back centre, compared with that of the front centre, due to angularity of the eccentric rod, and is more marked the shorter the rod. Fully symmetrical curves are not obtainable as this would require the eccentric and main rods to be of infinite length. This angularity, however, is of but little detriment to the distribution of the steam, as long as the relations between the lengths of the eccentric rod and the throw of the eccentric is not less than four, and is present in all kinds of continuous valve motions, derived from uniformly rotary cranks or eccentrics.

GENERAL NOTES FOR ADJUSTING WALSCHAERT GEAR.

1. Ascertain by the following method the position of the eccentric crank. Mark the position of the link relative to its middle position on both of the dead centres of the main crank. If the position of the link is the same in both cases the eccentric crank position is correct, if not, the eccentric crank should be shifted until this occurs, or as near so as possible.

2. After the eccentric crank has been correctly set, the eccentric rod should be lengthened or shortened as may be required to bring the link in its middle position, so that the link block can be moved from its extreme forward to its extreme back position without imparting any motion to the valve.

3. The difference between the two positions of the valve on the forward and back centres of the engine is the lap and lead doubled, it is the same in any position of the link block and cannot be changed by changing the position of the reverse lever.

4. The tram marks of the opening moments at both ends of the valve should be marked upon the valve stem and the latter lengthened or shortened until equal leads at both ends are obtained.

5. Within certain limits this lengthening or shortening may be made on the radius bar, if it should prove more convenient but it is desirable that its length should be so nearly equal to the radius of the link that no apparent change in the lead should occur in moving the link block as stated in No. 2.

6. The lead may be increased by reducing the lap, and the cut-off points will then be slightly advanced. Increasing the lap produces the opposite effect on the cut-off and reduces the lead by the same amount. With good judgment these quantities may be varied to efface the irregularities inherent in transforming rotary into linear motions.

7. The valve events are to a great extent dependent on the location of the suspension point of the lifter of the rear end of the radius bar, when swinging lifter is used, which requires that this point should be properly laid out by careful plotting.

The chief point of difference between the Walschaert and Stephenson gear, when both are in proper condition is, as previously stated, that the former gives to the valve a constant lead at all cut-offs whereas the latter produces an increase of lead by linking up the engine and becomes excessive at short cut-offs. This very point has been the subject for much controversy, and has probably done more than anything else to retard the progress of the use of the Walschaert gear, as it has been argued that in full gear, when the speed of the engine, generally is low, only small lead is needed, but at high speed more lead is required, which is accomplished by the Stephenson motion, though this admittedly becomes excessive at early cut-offs, causing considerable compression and preadmission detrimental both to maintenance and smooth running, and in fact, to some degree counteracts the work done by the steam on the driving side of the piston, which thereby also affects the speed of the engine.

It was generally discovered that the required lead for short cut-off and high speed was of no practical detriment to the working of the engine in full gear, as the preadmission at that point is disappearingly small. The proper amount of lead, however, is dependent somewhat on the service, and the port opening becomes larger with a larger lead, or in other words, when all other conditions are equal in a Stephenson or Walschaert gear, the openings differ by the same amount as the lead, so that one-sixteenth more lead gives one-sixteenth wider port opening, but it is hardly advisable to make this over one-quarter or five-sixteenth inch as a maximum, as the advantage of any additional port opening by means of a larger lead is more than offset by the increase in compression and preadmission, the larger lead would bring about at early cut-offs, and would do no good in the later cut-offs even if it does no harm.

There is no fundamental reason why the Walschaert gear should produce any economy in steam consumption over the Stephenson motion when both are in the best condition, but an advantage in this respect comes to the former by the fact that it remains in its good condition if once made so, from one shopping to another and is, therefore, on an average more economical both in steam consumption and maintenance of the gear than the latter.

On one engine, No. 912, on the Lake Shore and Michigan Southern after making 39,000 miles, the total lost motion in the valves was one-sixteenth inch. Whereas another engine, No. 5912, equipped with Stephenson link motion had five-sixteenths inch lost motion in the valve stem after making 32,000 miles.

Large eccentrics, besides occupying too large space, wear unevenly, and lubrication is difficult with the high surface velocities of the large sizes. With hardened pins and bushings the Walschaert gear has not this disadvantage.

Also Stephenson links, under the influence of two eccentrics, move through wide angles resulting in a wedging action of the link block, which strains the gear when working hard, and produces lost motion. Whereas the Walschaert links oscillate through smaller angles, producing practically no wedging effect and less lost motion.

In many cases the gear can be designed so that the motion is transferred from the eccentric crank to the valve stem in one vertical plane so that practically all of the pins can be put in double shear and all tendency to twist the valve motion is avoided, a thing that is almost impossible in the Stephenson motion.

While it may not be possible to adjust the valve as readily with the Walschaert gear as with the Stephenson motion, for the reason that the parts and connections are not as susceptible to change, it is not as liable to become disarranged and if correctly designed and fitted up will give accurate results.

Equal cut-offs in both ends of the cylinder are more easily secured than with the Stephenson motion, which require an exact location of the saddle pin with regard to the centre line of the link, and the play of the engine on its springs has no more effect on the valve than has the Stephenson motion.

The constant lead of the Walschaert motion prevents the sealing of the cylinders by the piston valve when the piston is at the end of its travel or approaching it. Whereas with the link motion either by derangement or excessive wear, the valve laps the ports at the end of the stroke, causing excessive compression and many other consequent troubles.

The accessibility for attention and examination of the Walschaert gear is a great point of undisputed advantage over the Stephenson motion. There is not room enough for the Stephenson gear under a very large locomotive. The eccentrics are crowded, and proper inspection, not to speak of proper care, is extremely difficult.

It will be borne out in the course of time that the lateral bracing between the frames permitted by the Walschaert gear will bring about a considerable reduction in the maintenance expenses by the less wear and tear this additional rigidity will impart to the entire engine.

Another very important advantage of the Walschaert gear over the Stephenson gear is the great saving of weight possible. A saving of 1,700 pounds was possible by using the Walschaert gear in the case of a very heavy passenger locomotive built for the Lake Shore and Michigan Southern. Stephenson gear, weighing as much as two tons is far too heavy to be satisfactorily reversed twice in every revolution on fast running locomotives.

And finally a feature which appeals particularly to the engineer is the ease of handling the reverse lever when the locomotive is running at a high rate of speed.

THE PISTON VALVE.

With the large increases of the power developed in one cylinder of the modern locomotive and the high steam pressures used, the ordinary balanced valves increase in size proportionately and while they are balanced in the same ratio as the valves on smaller engines the difference in the unbalanced surface increases with the size of the engine, and this combined with the additional weight of the valve and yoke, increases the wear on the valve, the motion and the eccentric straps and also the work necessary on the part of the engineer to handle the engine.

For these reasons the piston valve, which is perfectly balanced, has been very extensively adopted. Another reason for its adoption is its adaptability for compound cylinders since one valve can be arranged to effect the steam distribution of two cylinders, one high and one low.

With the slide valve on a large engine it will hardly exceed 25,000 miles before the valves need facings, which means the loss of the engine for a day, while if the piston valve were used and the rings were broken or needed attention the valve can be removed, new rings applied in from thirty to forty minutes and the engine is ready for service. Of course the bushings wear but they very rarely need renewing for less than 200,000 miles.

Another advantage of the piston valve over the slide valve is accessibility to its parts. When an engine needs its valves reset after running for some time, the port marks on the valve stems become obscured, and possibly the man, who is about to do the work, has a different tram or wants to get new marks on the stem. With the slide valve the machinist has to take off the steam chest cover before he can take his new port marks, while with the piston valves he simply has to remove one plug on each end of the chest leading directly to the edge of the steam port.

With the piston valve there is a much larger port opening than with the slide valve, and this large opening gives a much better admission and release of the steam to and from the cylinder than can be obtained with the slide valve.

Since the piston valve is so perfectly balanced it is not necessary to have a small surface bearing valve, as it is with the slide valve. For this reason the ports can be brought up straight to the valve chamber, instead of curving up as they do for the D valve, resulting in a reduction in clearance loss for the piston valve due to the shorter ports.

There are two types of the piston valve, inside and outside admission. These are modified, some being solid and some hollow.

With the use of the inside admission piston valve, the metallic valve stem packing may be done away with, as there is only the exhaust pressure on the packing side, which results in an appreciable saving in maintenance cost, as the fibrous packing answers the purpose and lasts satisfactorily a long time.

Another feature of the inside admission valve is the protection to the live steam by being jacketed by the exhaust cavities, thus delivering the steam to the cylinder at a higher temperature than would be the case with the outside admission valves. For these reasons the inside admission valve is used much more than the outside admission.

Since the difference of pressure on the two ends of the inside admission solid valve often amounts to over a ton, for each exhaust, the valve acts as a piston and takes up the slack in the valve motion and increases the lead, which is very hard on the valve gear.

For the outside admission solid valve, the moment after exhaust takes place the valve becomes unbalanced on the admission side as the steam enters the cylinder and the higher pressure on the opposite end takes up the slack and decreases the lead as the valve gear wears.

In the outside admission hollow valve the area of the valve stem unbalances this type to the extent of about 600 pounds at 200 pounds boiler pressure, and always in the same direction, which causes the engine to go lame as the gear wears.

With the inside admission hollow valve these defects are absent and the valve is so well balanced that it works very much more easily and does not get out of square so soon as the other types. For these reasons it is the type of piston valve most extensively used.

With the ordinary slide valve, when there is an accumulation of water in the cylinder, the piston in its movement forces the water through the ports to the valve seats, the valve lifts and lets the water pass into the steam chest and out the stack. This will also be true for any excess pressure, on the piston and head, that may take place at the end of a stroke. With the piston valve, the valve sits solid in the bushings and will not admit any water or steam to pass over from steam port into steam chest when that port is closed by the valve. The pressure of this water would cause damage to the engine by breaking the cylinder head or the piston or bending the main rod if means were not taken to provide for it. This is done by a combined pop and by pass valve, the valve chamber being cast in one with the cylinder. This effectually eliminates the danger of any excess compression.

MECHANICAL STOKERS.

By the process which goes on within the firebox of the modern locomotive each pound of coal will, under favorable conditions, sustain one I.H.P. for a period of from twelve to fifteen minutes at the speed of ten miles per hour, it will serve to carry six tons of freight per mile. Within certain limits the power developed is nearly proportional to the coal burned.

In the development of the modern locomotive, grates have been enlarged and heating surface extended that larger amounts of fuel may be burned. In one direction only has the designer found his way blocked against his ingenuity. He has not been able materially to augment the strength of the fireman and consequently when running under constant conditions the power of the locomotive has not increased in proportion to its dimensions.

A laborer is working at a fair rate when, in unloading coal from a gondola car, merely dropping it over the side, he handles 6,000 lbs per hour. At the limit a locomotive fireman will handle an equal amount standing on an unsteady platform placing it upon some particular part of the grate and usually closing the door after each shovelful. This rate will serve to develop, approximately, 1200 I.H.P. This rate cannot be exceeded under sustained conditions of running, though for short intervals the rate of power may outrun the rate of firing. Because of the limitations upon the strength of the fireman is is probable that further growth in locomotives will await the coming of an automatic stoker, which will remove its operation from dependence upon the physical condition and endurance of a single man.

In order to provide for this the following different makes of stokers have been developed, the Victor, Kincade, Lucky, Straus, Crosby, Monarch, and Haydon. All of the stokers are very similar in operation, either by a series of pistons or plungers which produce longer or shorter exhausts or strokes, or steam jets, and tend to throw the coal closer to the flue sheets or the back end of the firebox and spread the coal very uniformly over the grate surface. Some of these use deflection plates to spread the coal.

The Hayden stoker is a representative type of the steam jet design. The method of operation is as follows: The coal is taken from the tank through a grating with three inch openings, by an elevator operated by a quadruplex engine, then it passes into a conveyer and is elevated to the conveyor located over the fireman's head and is dropped into a hopper over the firebox door by a worm screw and falls by gravity through a slide gate opening in the firebox door, on to a table located just inside the firebox door, twenty-four inches long and seven inches wide and is blown by a blast of steam varying in length as desired by five separate nozzles or jets in the firebox door, which have a tendency to cool the table and prevent its burning out. The centre jet blows the coal towards the flue sheet. The two jets on either side are located to place the coal in the front corners of the firebox. The two outside jets are located so that the coal will be distributed along the sides and back corners of the firebox. They are governed by separate valves to regulate the blast of steam through each valve by common steam valves and can be adjusted at will at any time.

The steam that furnishes the blast to place the coal is controlled by a quadruplex engine, located on the back end of the boiler butt, which has a crank movement actuated by a screw wheel, operating a control valve, which admits steam through a one inch pipe passing to the nozzles which are regulated by means of a globe valve.

The control valve, as a general proposition, is run only one turn open and varies with the weight and amount of coal to be handled. The length of blast is governed largely by the raising or lowering of the latch on the trip valve and the speed at which the engine is run. The greater the speed the less coal is thrown at one blast. If desired the valve can be tipped by hand and all of the coal in the hopper, can be blown into the firebox. In fact the fire can be covered black inside of half a minute.

The steam connection to the engine operating the stoker conveyor is by one inch pipes, that to the stoker connection is three-eights inch pipe which is open probably only a quarter of a turn.

This stoker has on various occasions fired a locomotive thirty and forty miles and even farther without there having been any necessity to open the fire door and on opening the door the fire was found to be absolutely level.

Occasionally coal will pile up in some place in the firebox, making it a necessity that it be levelled down, and may be caused by a clinker forming or a little deviation in front of engine and holes in grate.

All that is necessary is to close the hopper, blow the coal off the table, when the door can be easily opened and the fire levelled with a rake if desired. There is nothing to be removed and it is a very easy operation, nearly as much so as though the engine were being fired by hand.

The Victor Locomotive Stoker is of the plunger design, and consists of the following essential parts:

First.—A main cylinder and a trough in which reciprocates a piston and plunger which, with a variable stroke, throws the coal to the different parts of the firebox. This variable stroke is given to the plunger by means of a rotary valve, three separate steam ports leading from the said valve to the rear end of the cylinder, and three choke plugs—one for each of the said steam parts.

Second.—A small controlling engine. It has been found desirable to place the controlling engine on the boiler-head on the fireman's side. This removes the liability of condensation and consequent dryness of engine parts when placed on and below the stoker itself. The steam for the operation of this engine is taken directly from the dome.

Third.—A hopper with two spiral conveyors journaled in the bottom of the hopper-pan. The conveyors carry the coal to the front of the hopper on to the apron of the plunger, which, upon the return of the plunger, falls by gravity in front of it, giving a regular and uniform feed. The speed of the conveyors can be increased or diminished by giving more or less steam as may be required, to the controlling engine. This also increases the number of strokes made by the plunger but does not affect its velocity, or in any manner affect the distribution of coal in the firebox, the latter being governed by the three choke plugs.

Fourth.—A smaller steam chest containing a rotary valve which regulates the number of strokes made by the plunger. The portion of the stoker forming this valve chest is cast o one piece with the main cylinder and has three separate steam ports leading to the rear end of the cylinder for the admission of steam behind the plunger or piston. These steam ports terminate in one common port before entering the rear end of the cylinder, the steam, after reaching this common port, communicates with the rear end of the cylinder, first through a small preliminary port at the end of the cylinder (which also acts in the form of compression by retarding the exhaust on the last portion of the return stroke), and after the piston has advanced a short distance it uncovers the main port, which also leads from the common port, giving free passage to the steam.

A choke plug is placed in each of the steam ports between the valve sleeve and the common port.

The function of the three choke plugs is to vary the amount of steam reaching the rear end of the cylinder through the various ports and thereby giving a variable stroke to the plunger. The valve operates in a rotary manner, each of the ports stopping full open in front of its corresponding steam passages in regular succession. Beginning with number three (the port nearest the rear end of the stroke) the steam, after leaving this valve passes through port number three into the common port and the rear end of the cylinder. By choking down this steam port until it is almost closed we get a very light stroke of the plunger, distributing the coal over the grate near the fire door. The other two operate in the same manner, each taking its respective turn.

They are adjusted so that more steam is admitted on the second stroke than on the third, thus distributing coal over the middle portion of the grate, and more on the first than on the second, thereby scattering coal over the front end of the grate. By this adjustment of the choke plugs any range of distribution can be obtained that may be desired.

The rotary valve and cylinder are provided with suitable live steam exhaust ports for the return of the plunger and the exhaust steam from each end of the cylinder. In the front end of the main cylinder is a very small live steam port, connected directly with the live steam supply and its function is to return the plunger after its forward stroke, and also to add volume to the steam retained after the piston has passed over the forward exhaust port, this giving the desired compression to prevent the piston striking the front cylinder head.

By means of a valve this port can be enlarged to give increased compression, necessary when expelling water from condensed steam in starting the stoker when it is cold.

Fifth.—The furnace door. Each machine is supplied with a furnace door made to fit the standard door frame of the locomotive to which the stoker is to be attached. This door has an opening to receive the stoker through and is provided with suitable brackets for holding the machine in position.

Cast upon its inner side are curved lugs, which serve the purpose of hinges for a deflector for spreading each charge of coal over the width of the firebox. The end of this deflector can be raised, if necessary, to aid in the distribution of coal by means of a set screw directly under its centre.

It also has a small vertical sliding door for use when inspecting the fire, and the deflector can be turned vertically and held in place by a latch to close the opening when the stoker is removed.

When using the stoker the smoke is very much lighter, indicating more thorough combustion of the gases. The darkest color when the stoker is used is not more than brown while most of the times the emission from the stack is pure steam. This is a most important feature when it is taken into consideration that the smoke problem of railroads is becoming serious now that the large cities are objecting so much to the smoke nuisance.

There is no doubt but that with the stoker in use very much less trouble with leaky flues will be found on account of its maintaining a more even heat in the firebox. The sheets of the firebox will last longer for the same reason. It has been proved that corrugation in fireboxes is largely due to the changes in temperature.

When the stoker is used the steam pressure may be kept absolutely constant. This is due to the regularity with which the coal is placed on the grates, the evenness of the distribution and also the fact that the furnace door being closed the furnace is not cooled by the inrush of air. This should effect a great saving in coal since it is estimated that 15 lbs. of coal are lost when a boiler pops.

With a stoker properly installed and set up in a tank, using coal that it will handle properly, the fireman can operate the engine with a saving of 33 to 50% labor, at the same time maintaining a uniform pressure of steam with a large reduction of leaking of flues and furnishing steam under all conditions better than can be done by hand firing and with a noticeable saving in fuel.

Compound Locomotives.

In endeavoring to secure efficiency in the utilization of the steam, thermodynamic reasons make it imperative to use high pressure steam and a long expansion. The high ratio of expansion required cannot—from the point of view of steam economy—be so efficiently carried out in a single cylinder as in two or more cylinders. If expanded in one stage only, the condensation and piston leakage losses are too great for efficiency. In marine service, where efficiency is of first importance single expansion engines have been altogether superceded by multiple expansion engines in the large sizes. In locomotive practice steam economy is of great importance, but the difficulties of maintenance make unnecessary complications undesirable, and thus practically limit the number of successive expansions to two.

In order to take advantage of this economy in steam consumption, and consequently coal consumption, the following types of compound have been developed. The two cylinder cross over compound, the four cylinder tandem compound, the four cylinder balanced compound, and the Mallet articulated compound.

The two cylinder compound can show practically the same efficiency of steam consumption as the four cylinder and has fewer working parts. On the other hand, the power developed is not always equally divided between the two sides of the engine, for instance when the high pressure cylinder is being worked at a long cut-off the steam exhausting from it and supplying the low pressure cylinder is at a much higher pressure than that exhausting from the high pressure at a short cut-off, causing more work to be done on one side of the engine than on the other. Also the excessive diameter of the low pressure cylinder required for high power increases their liability to break and requires an excessive width of the locomotive, and this puts a limit on this class of engine.

The tandem compound gives equal power on both sides of the engine and economical steam consumption. The heavy reciprocating parts, due to both pistons being on the same rod, make the engine difficult to balance, making it very undesirable for high speed work, although at low speeds this is not a great disadvantage. The only factor limiting the growth of this locomotive is the rigid wheel base, the best that can be done being to get six axles in twenty-four feet, seven inches, or five axles in nineteen feet, nine inches. Apart from the great internal resistance of a twelve coupled engine of this description the excessively long wheel base would render it extremely awkward on curves.

If more tractive force is required the Mallet type compound seems to offer the greatest facilities for development. The wheels are in two groups and as these groups have a flexible connection between them, the locomotive can curve easily. The rear group of wheels is driven by two high pressure cylinders, and the front group by the two low pressure cylinders, so that the same power is developed on both sides of the engine. The double expansion of the steam gives economy in fuel and the whole construction of the locomotive is comparatively simple. These engines have been used almost altogether for taking heavy trains over very heavy grades, very little in road service, and altogether for low speed service.

The four cylinder balanced compound is, considering everything, the best of these types. By using four cylinders, two high and two low pressure, and placing them so that each high pressure moves in the opposite direction to the corresponding low pressure piston, both the internal and external forces can be largely balanced. Where only two cylinders are used, the moving parts of the engine must perforce be largely left unbalanced and at high speeds the engine racks itself to pieces and exerts a destructive influence on the track. With the perfect balance obtainable with four cylinders these difficulties may be largely avoided. The mechanical advantages of proper balancing are obtainable with four high pressure cylinders but the four cylinder compound adds to the balancing, the economies resulting from the double expansion of the steam. To this combination of advantages is due the high place taken in modern locomotive practice by engines of the four cylinder balanced compound class.

There are also mechanical advantages which favor the adoption of the four cylinder balanced compound. For one thing the weight on the driving wheels may be increased on account of the complete elimination of the hammer blow on the track. In the case of one engine built it was decided in view of this fact to increase the weight per driving axle from 47,000 lbs to 55,000 which would result in a greater tractive effort for this type of engine for the same number of wheels.

On account of the large amounts of steam which can be worked through the cylinders at long cut-off there is an increase in sustained horsepower at high speeds; without modification of the boiler. The original simple engine developed 1,400 to 1,500 indicated horsepower; the four cylinder balanced compound has developed from 1,900 to 2,000 I.H.P., actually realizing 1,688 at sixty-seven miles per hour, and 1,980, at seventy-five miles per hour in service. (From results of a test of a four cylinder balanced compound on the Pennsylvania Railroad testing plant at the Louisiana Purchase exposition at St. Louis in November, 1904).

Also the power is divided between four cylinders and may be divided between two axles resulting in a reduction of bending stress on the crank axle, and the use of light moving parts which renders them easily handled and which minimizes the wear and repairs of parts.

The De Glehn four cylinder balanced compound which is used extensively in Europe is characterized by an arrangement of cylinders, which divides the application of the power between two driving axles and provides a separate valve gear for each cylinder, so that the high and low pressure cut-offs can be independently varied. The high pressure cylinders are placed outside, while the low pressure are inside between the frames. The Walschaert valve motion is used throughout. The gears for the low pressure cylinders are driven from ecentrics placed on the forward driving axle, while those for the outside cylinders are driven from the second pair of driving wheels by return cranks placed on the crank pins.

The outside or high pressure cylinders are connected to the second pair of driving wheels, while the inside, or low pressure are connected to the first pair, which has a cranked axle. In order to keep the mains rods of as nearly the same length and weight as possible, the high pressure cylinders are set some distance in the rear of the low pressure.

In the Von Boiries type, also used in Europe, the cylinders are all in the same transverse plane, the high pressure cylinders being on the outside. There is only one valve motion for each side, but there are four valves, one for each cylinder. The main rods of both high and low pressure cylinders are connected to the front driving axle resulting in a somewhat short main rod.

In America there are also two principal types in use, the Cole and the Vauclain.

In the Cole type, the low pressure cylinders are located outside of the frame and are connected to the second driving axle while the high pressure cylinders are inside the frames, and are set in advance of the outside cylinders so that the back head of the high pressure is even with the front head of the low pressure. The high pressure cylinders are connected to the leading pair of driving wheels, which has a crank axle. There are two piston valves, one for each cylinder, on the same valve stem but there is only one valve chamber. The high pressure valve is arranged for central admission and the low pressure for central exhaust, both valves being hollow.

The Vauclain type differs from the Cole in placing the cylinders in the same transverse plane, the high pressure being inside and the low pressure outside, of the frames. Also there is only one piston valve used for both cylinders.

In both the Vauclain and the Cole types the connections of the main rods may be varied. By setting the high pressure or inside cylinder high and giving it an inclination all the main rods may be connected to the second driving axle and thus may be the same length. Where the first driving axle is far enough away from the cylinders all the main rods may be connected to the front driving axle.

Superheated Steam and Superheaters.

The necessity of greater economy in steam work is daily becoming a matter of increasing interest. The simple locomotive using saturated steam has been excelled by the compound four cylinder balanced locomotive, yet the fact remains that there is still room for improvement and that other and far more effectual means of obtaining an increase of power and economy lies in the use of superheated steam. It unquestionably constitutes the most important feature of steam locomotive development of modern times.

In the matter of the evident advantages resulting from the use of superheated steam, care must be taken to separate the increased efficiency of the boiler from the corresponding increase in cylinder efficiency, which does not depend, as in the case of saturated steam upon an increase of pressure. On the contrary, superheated steam at a pressure of ninety lbs. per sq. in. can work as efficiently as the other at 180 lbs. The running has, up to the present, been done with a short cut-off ranging from ¼ to 1-10 of the stroke, while the throttle is kept wide open or partially closed dependent on the speed.

The reason for this is, that with a partially closed throttle, the absolute superheating rises. For example, if steam at a pressure of 180 lbs. per sq. in. is superheated to 575° F. the actual superheating is 575°—377 which is temperature due to pressure, = 198°. At 75 lbs. per sq. in. with the same superheating we have an effective superheat of 575°—287 = 288°, so that the excess is such that cylinder condensation does not take place even with an early and economical point of cut-off. In this is to be found a great advantage of superheated steam.

This advantage is only slightly augmented with an increase of pressure and any closing of the throttle is rather apt to be wasteful because the rise of temperature, above that due to pressure by an excessive closing of the throttle, can scarcely be detected in the working of the cylinder.

It has been said that the safe production of superheated steam at a temperature of 570° F., in a locomotive boiler, and its successful use in the cylinders was an impossibility.

Whenever superheated steam has been used to give a notable gain in economy the superheating has been accomplished in a separate apparatus which has taken the form of a coil of pipe exposed to the products of combustion beyond the boiler.

Plates and tubes, thin enough, endure long service in a boiler when exposed to the fire because they are kept at a moderate temperature by the water in the boiler. If steam is to be superheated strongly in a coil of pipe or other device, which is exposed to hot gases, the metal of the superheater must be strongly heated, and is sure to waste away rapidly. There is no material that can stand long service when exposed at once to high pressure and a high temperature. There is little risk therefore in predicting that all superheating devices now used will eventually be discarded for this reason.

The best design by Schmidt was a superheater in the smoke box, directly connected to the boiler. Examination of one of these superheaters in an engine after it had been in service for two years showed it to be free from any defects although with suitable coal it raised the steam to a temperature of 645° F. The valves, packing boxes and pistons were also in excellent condition. So that Peabody's prediction is not borne out in actual practice.

The development of the Schmidt idea and others has, however, demonstrated the great advantages of superheated steam for locomotive work, and tests show that the efficiency of the boiler will be increased about 25% by superheating the steam 180° F. Initial condensation in the cylinders is also be reduced by the use of superheated steam. There appears then to be a prospect of bringing the locomotive back to the construction of the simple engine, and at the same time increasing its efficiency.

Schmidt defines superheated steam as steam having a temperature of at least 575° F. or in general a steam which at a pressure of 150—180 lbs. has been raised about 180° above the temperature corresponding to its pressure at saturation. Such a high degree of superheat absorbs about 10% of all the heat generated. Experiments made with stationary steam engines show that the efficiency of the boiler was increased about 25% when steam superheated about 180° F. was used. The saving in feed water averaged about 33% and in coal 25%. This saving was in part due to the short cut-off which is possible when superheated steam is used.

The great value and advantage of using superheated steam lies not alone in the increase of power but also in the substantial reduction of steam consumption.

In American practice the steam is generally superheated about 150° F., above its temperature due to pressure, while in European practice the superheat is raised 250° to 300° F., without impairing lubrication, when a high flashing lubricating oil is used.

The steam should be delivered to the cylinder at a temperature of about 600° F., in which case it may be defined as highly superheated steam. Its chief superiority over saturated steam lies in the fact that owing to the excess of heat over the point of saturation, it entirely prevents cylinder condensation, which is the most serious of all sources of waste. Apart from this advantage, superheated steam has a greater density and increases in volume corresponding to the superheat applied from twenty-five to forty per cent as compared with equal weights of saturated steam of equal pressures. But superheated steam will not only effect a direct saving in fuel and water, but a direct or indirect saving in other ways. Due to the prevention of condensation and the augmentation in the volume of steam the boiler capacity is increased. Very high steam pressures are not absolutely necessary without sensibly affecting the economy, as this depends on the degree of superheat.

A reversion to relatively normal pressures will ensure a longer life of the boiler and firebox and will render easier the work of keeping the various joints and fittings tight, besides mitigating the staybolt difficulties. The importance of this point is too obvious to need insisting upon.

The principal reason for the economy of the compound locomotive lies in the fact that the losses due to condensation, which in ordinary simple engines amounted to as much as thirty-five per cent., are reduced to about twenty per cent. By the use of highly superheated steam these losses are entirely obviated. This phase of the question may be summed up as follows: By the consumption of one ton of coal it is possible to produce in a certain time 650 h.p. in a saturated steam simple engine, 750 h.p. in a saturated steam compound, 850 h.p. in a superheated steam simple engine, and 875 h.p. in a superheated steam compound.

It does not seem likely that the superheater will be extensively used upon the compound, as the composite saving of the two is not enough in excess of the superheater alone to make the combination of the two worth while. It seems very likely, therefore, that we will see a reversion to the simple engine even to the exclusion and discarding of the compound.

In Schmidt's superheater the high degree of superheating averaging about 575° F. is obtained by bringing a portion of the hot firebox gases into direct contact with superheater. In order to do this a fire tube from 11 to 12 inches in diameter is placed between the regular tubes and the bottom of the shell of the boiler.

The superheater consists of sixty-two tubes from 1 3-16 to 1 5-16 inches inside and from 1½ to 1⅝ inches outside diameter. These tubes are placed about the smokebox in three concentric rings. They are arranged in groups set one behind the other. At their upper extremities these tubes are expanded into a long steam header which branches out to the right and left. The twenty-one tubes of the inner group are arched up at the bottom away from those of the other two groups so that an open space, called the superheating firebox, is found into which the hot gases enter from the large fire tube. The inner jacketing of the body to the right and left of the smokebox extends up to the top of the exhaust nozzle so that nearly the whole of the superheater is enclosed in an iron casing, which can be opened or closed on each side of the smokebox by small dampers operated by the engineer.

The distributing steam header is at the right hand side of the smoke box and has a partition in the middle. When the throttle is opened the damp steam enters the back end of this steam chamber and flows through the rear to ten of the three-fold groups of tubes and passes over to the left side being dried and superheated to some extent. In this steam box there is no partition so that the partially superheated steam enters the forward tubes of the three groups and flows back to the right hand steam box and thence to the cylinders.

The hot gases from the firebox pass through the large fire into the arched chamber formed by the upward bending of the inner group of tubes thence upwards over the whole length of the tubes and escape at the stack. The action of this flow of the hot gases over and about the superheating tubes is in an almost exact ratio to the working of the locomotive and ceases almost entirely when the throttle is closed. This flow of gases can furthermore be regulated by the damper. This simple arrangement also makes it possible to easily avoid all over-heating of the covering of the superheater. The connections to the blower and the superheater damper can be so arranged that the damper will be closed when the blower is at work.

Measurements which have been taken indicate that at the middle point of the superheating chamber the average prevailing temperature is about 1,290 F. and that the escaping gases are about 660° F.

The lower rows of the superheater are placed so far apart that all of the sparks carried through by the draft can be collected at the spark trap. Furthermore a proper adjustment of the tubes of the superheater makes it possible to do away with the jacketing of the side sheets. The soot is removed by a jet of steam. The entire superheating arrangement occupies only a comparatively small part of diameter of smokebox.

Tests on the Berlin division show that in nine days' trial over a run of 102.5 miles with a train weighing on an average 280 tons to which 80 tons should be added for the engine, the following comparative results were obtained. For each train mile engine No. 74 using superheated steam burned 12.94 lbs. of coal and evaporated 78.1 lbs. of water, while the compound locomotives burned on an average 14.47 lbs. of coal, and evaporated 105.35 lbs. of water. The compounds consumed about 11.8% more coal and nearly 30% more water than the one with the superheater.

Following the Schmidt smokebox superheater came the Schmidt smoke tube superheater. In this design a double chambered niggerhead extends horizontally across the front flue sheet and at right angles to the dry pipe to which one chamber is connected midway, while the other chamber is in connection at either end with a steam pipe leading to a cylinder. The under surface of this niggerhead is faced and in it are eight series of ports or openings, the alternate ports in each series leading to one of the two chambers. To this under surface are suspended by means of straps bolted to the niggerhead, square blocks into each of which are secured two sets or pairs of the circulating or superheating tubes. These circulating tubes extend downward at an angle to a point in line with their respective smoke tube where they turn and enter the smoke tube and extend to within thirty inches of the back flue sheet. At the firebox end a return bend is applied to make a connection between two circulating tubes, one leading from each of the chambers and secured to the same block. Thus the steam leaving the dry pipe, passes through one chamber of the niggerhead, out through one circulating tube and back through its complementary tube, thence, through the other chamber of the niggerhead to the steam pipes and on to the steam chests.

The front end opening to the smoke tubes can be entirely closed by a damper so that there will be no flow of the hot gases from the firebox through the smoke tubes when the engine is not working, thus eliminating the danger of burning out the circulating tubes.

Another design of the smoke tube superheater is the Cole-Field tube arrangement. In this design eight double chambered headers are used, which, being secured to the niggerhead extend vertically downward in front of the tube sheet, and the circulating tubes are entered from the back on al ine with the smoke tubes through holes in the back wall of the header chamber and are therein made steam tight. A plugged hole in the front face of the header permits of getting at the end of the tubes to expand and fasten them in the header as well as to plug or work on them in case of their becoming ruputured or leaking. The Field tube not proving as successful as was desirable, was later superseded by the return bend circulating tube. The two chambers of each header have independent walls and are joined together by a web.

A design which has been very extensively adopted on the Canadian Pacific Railway is the Vaughan-Horsey, which in principle the same, differs materially in detail from the other two. There are two elongated chamber castings each entirely independent of the other, and each cast with a series of fingers which act in the capacity of headers. One chamber casting, acting as a niggerhead, is bolted centrally to the dry pipe in such a manner as to have the fingers extend vertically downward, while the other chamber casting, fastened at either end to a short steam pipe has its fingers extending up ward. These fingers when in position interlace, but with sufficient space between to permit the introduction of the circulating tubes. One end of the circulating tube is jumped and a collar upset on it. The end of the tube is then so bent that the milled face of the collar will be parallel to the length of the tube. With a steel union nut the bent end of the circulating tube is secured to a drop-forged two or four way passage, which is screwed into the outer face of one of the fingers of one chamber, while the corresponding end of the companion tube is similarly secured to an adjacent finger of the other chamber. These passageways are in line with the smoke tubes and the circulating tubes enter the smoke tubes the same as in the Schmidt and Coe designs.

The Baldwin is another design of the smokebox type of superheater. It is much simpler than the Schmidt design and consists only of two headers on either side of the smokebox, the two on either side being connected by a series of circulating pipes which are bent to conform to the shape of the smokebox. Two methods for connecting the headers to the niggerheads and steam pipes are provided for, one with the steam entering the superheater at the top back end and emerging at the lower front end, and the other with the steam entering at the top front end and emerging at the bottom back end. The second arrangement would probably give the better results for the reason that the steam leaves the superheater at the point where the gases are the hottest. In this as well as in the Schmidt type diaphragms are employed to cause the gases, on their travel from the smoke tubes to the stack to circulate about the superheater pipes.

With the smoke tube type of superheater the number of circulating pipes employed in the several designs would depend largely upon the size of the boiler, but the common practice is to use twenty-two smoke tubes, placed in the upper part of the boiler with two sets of circulating tubes in each. The smoke tubes are five inches outside diameter at the front sheet, into which they are expanded and beaded over. This diameter is maintained to within seven inches of the firebox end, where it is swedged down to four inches and enters the sheet at that diameter. The hole in the firebox sheet is threaded, care being taken to make it perfectly true and parallel and in line with the corresponding hole in the front sheet and the tube is screwed into the sheet and then beaded over. The circulating tubes are of cold drawn steel, 1¼ inches outside diameter, and extend into the smoke tube to within thirty inches of the firebox, where the return bend joins the two tubes together, and all four circulating tubes are separated as well as being supported in and held away from the walls of the smoke tube, to permit of the free flow and circulation of the gases, by means of lugs or feet cast on the return bends. These tubes, reaching as they do so near the firebox and being subjected to very high temperatures would be liable to burn off at the end when no steam was passing through them were they not to receive attention.

This is afforded them by means of a damper placed in the front end immediately below the large smoke tubes and between the headers and flue sheet. The damper opens and closes automatically with the opening and closing of the main throttle by means of a cylinder piped to the steamway in the cylinder saddle, and piston and weight attached on the outside of the smokebox to an extension of the damper rod.

One of the things that has given a great deal of trouble in the operation of superheater engines has been the difficulty experienced in getting oil to the valves and pistons, especially to the pistons, because of the erroneous idea, imported with the superheater, that a pump lubricator was necessary. A number of these pump lubricators have been tried, but with very indifferent results. Experience has demonstrated that the modern hydrostatic lubricator will deliver the oil in sufficient quantities at all times, and that the usual amount of the better grades of valve oil is sufficient for lubricating valves and pistons. It is noticeable with engines using superheated steam that the walls of the steam chests and cylinders take on a bright polish, but never get rough and cut as is so often the case with the cylinders of compound engines. While there has been some cases of excessive wear of piston packing rings when the rings have failed to make a mileage of 10,000 miles, due partly to insufficient lubrication and partly to soft material, the life of the rings ordinarily is very satisfactory.

While the Schmidt smoke box superheater produces a very high degree of superheat, its expensive and complicated construction and inaccessibility for repairs render it rather undesirable for general adoption.

The Schmidt smoke tube design has in the past required the least attention of any; and when once the equipment is made steam tight but very little trouble is experienced thereafter. However, the blocks into which the circulating tubes are assembled, being secured to the headers by straps, each strap holding a corner of two blocks, when repairs are required such as inserting a new circulating pipe tube, and one of the blocks must be taken down, two other blocks are thereby loosened and this means the taking down of all the blocks and a remaking of all the joints. A steam leak between the header and a block soon cuts grooves, entailing the refacing of the ports which means a great deal of labor.

The Vaughan-Horsey design probably embodies the most successful arrangement of any. Owing to its peculiar construction not only is a higher degree of superheat obtainable, but defective parts are more easily repaired or renewed. Should a circulating tube break and another one not on hand, all that is necessary to do is to remove the front plates, uncouple the defective tube and screw a cap on the passage way.

Also it is very little more work to insert a new tube. It is not advisable to plug too many of these tubes for it reduces the total area, thereby restricting the flow of steam and weakening the engine.

In conclusion let it be understood that the addition of a superheater entails no extra expense or attention to be bestowed on an engine aside from that arising from the repairs of mechanical defects, the keeping of the large smoke tubes free from cinders and the keeping of the damper working. It is not unreasonable to expect that the defects should in time be practically eliminated and an engine go from one shopping to another without having the front plates removed, as some of them are now doing, Unless the cleaning of the tubes is thoroughly and regularly done, a material deterioration in the efficiency of not only the superheater but of the engine itself will follow. With any kind of soft coal, cinders are bound to collect in the large smoke tubes and fill in around the circulating tubes, and it is found that the air blast usually applied is not always sufficient to remove them. A strong pressure of water is necessary to thoroughly cleanse the tubes and this should be resorted to at least every washing out of the boiler. The results from this washing, in the better steaming of the engine and the higher superheat obtained, will more than repay for the work performed.

Mr. Black,—

This has been a pretty lengthy paper, Gentlemen, and I must thank you for your very careful attention.

Chairman,—

I am sure you have all listened with a great deal of pleasure to this very interesting paper of Mr. Black's, and I know you will agree with me when I say that, after waiting three or four years for this paper it has paid us to do so, I intend to call on one or two of the older heads of the Club to either ask a few questions, or make a few comments or notes on the paper.

Mr. Wickens,—

I am not much of a locomotive man, neverthleless, there are so many points brought forward in Mr. Black's paper that apply to stationary work as well, that I feel satisfied that the members present to-night have heard something that is remarkably good.

It is the points that apply more particularly to stationary work that I am interested in.

In reference to the superheater. We are all going into the matter of superheated steam, and the points Mr. Black has brought out in regard to locomotives applies to stationary boilers just as well.

There is one question, however, and that is, that I believe the superheater to be more successful when applied to stationary boilers, as it is a more difficult matter when dealing with this on a locomotive than when used in connection with the ordinary return tubular boiler, or ordinary stationary boiler. The fact that there is much to be gained by using superheated steam is undoubted. Now that it is possible to use superheated steam on locomotives, I think that compound locomotive engines will be perhaps discarded, in a measure, and superheated steam with single or non-compounded cylinders, will take their place, that is how it looks to me, especially after Mr. Black's paper. As far as stationary work is concerned it is possible to use superheated steam with cylinders that have been properly prepared for this work, and get results practically equal to the work of the compound engines.

There are many other points in Mr. Black's paper, that, if I was a locomotive man I would like to take up, and I am sure we have all enjoyed Mr. Black's paper, at least those of us who know anything about steam.

Chairman,—

I would like to hear from Mr. Roberts.

Mr. Roberts,—

I do not think that I can add to the paper which Mr. Black has prepared to-night, I think he has gone very deeply into this matter, and I do not feel that I can say any more about it.

Mr. Jefferis,—

I feel very much like Rip Van Winkle, after being out of railroad service ten or eleven years to hear of all these wonders, it makes one stop and think what new improvements can be made.

There are a one or two questions I would like to ask. Has there ever been a mechanical stoker that has been a practical success? I mean by that, taking into consideration cost of maintenance, saving of fuel, etc. Has one ever been adopted by any road in America and used exclusively?

Mr. Black,—

I understand that many roads in the United States have adopted mechanical stokers and obtained good results from them. We do not have mechanical stokers on the Grand Trunk, but from what I have learned at Travelling Engineers' Conventions they have been used with great success.

Mr. Jefferis,—

The average engineer, like the average other man, wants to get over the road with as little trouble as possible, and when he has been used to the simple engine, and getting good results and good runs from the same, it takes something more than talk to convince him whether there has been any decided financial advantage to be gained by using a compound locomotive. I do not mean simply a saving of fuel, etc., I mean taking two years' service of a compound locomotive with its increased cost of maintenance, delays, damage to track and so-forth, as compared with a simple engine. It used to be a very difficult matter to get a compound engine properly balanced. Hence it was flat spots on the tires, loose bolts and broken frames, but I suppose that has all been overcome.

Speaking of the cross-over compounds I built the first compound designed by the Richmond people for the South. If I remember correctly it was 19 x 33, that is 19 on the high pressure side and 33 on the low. When this engine first went into service it gave us considerable trouble which resulted in us having to apply new frames, and new running gear, rods, etc., and incidentally a new boiler to maintain steam pressure. I do not think the compound designed by the Richmond people at that time could be compared with the Vauclain compound, having a high and low pressure cylinder on each side of the engine, thus equalizing the revolving and the reciprocating parts.

The whole thing to my mind depends on the cost per mile run, taking into consideration the continuous service, and the cost of maintenance every month. It is not what an engine can show for thirty days, or for some record run, that makes money for the shareholders. The earning power of an engine is its capability to run every day, and make a first-class showing both in maintenance and continuous service as well as fuel economy. It seems to me from remarks made by Mr. Black that the simple engine is still very much alive.

I do not know whether you have any figures, statistics or comparisons of total cost per mile running over a period of several months or not, but as I have been out of railroad service for several years, I have of course lost track of these things. No doubt, however, all the troubles of the mechanical department have been removed by this time.

Mr. Black,—

Some time ago the Grand Trunk made a very exhaustive test on the Eastern Division, between Richmond cross-over compound, and simple Mogul engines, and the result of the test was highly satisfactory to the compound engines, and for that reason I believe the compound engine for freight service to be far superior to the simple engine.

As regards the question of maintenance. When the compounds were first introduced we had considerable trouble with the reducing sleeves, and one thing and another getting out of order which certainly did run thc cost of repairs up a little, but as time went on, these little defects were found, and improved upon, until to-day, coumpound engines will come out of the shop, and give very little trouble until the time it goes into the shop again. Of course, compound engines, to give satisfactory results, must be properly maintained, as there are more chances for the steam to leak than in simple engines, and more parts to get out of order, but if these matters are carefully watched, I think the results of compounds in freight service show up very satisfactorily.

Chairman,—

I would like to hear from Mr. McKenzie.

Mr. McKenzie,—

I am out of it too. Speaking about compounds, I may say that I never ran a compound on a freight train, there were cross-overs on the Grand Trunk in my time, but not in passenger service, as twenty-five miles an hour was about the speed limit at that time.

Mr. McRobert,—

I was wondering if a chain grate would be of any service on a locomotive worked on the same principle as the "Green" stoker.

Mr. Black,—

I am afraid there is not enough room to operate them.

Mr. McRoberts,—

It does not take much room to operate these grates.

Mr. Bly,—

It seems to me that there is one point in the paper that we have lost sight of, that is the point in regard to the smoke, particularly the smoke in the City of Toronto.

It seems to me that it is up to this Club to get busy, and either adopt some system for smoke prevention, or have the smoke by-law made less stringent. The smoke by-law is too rigid, and if we cannot keep inside of it then we ought to have it changed. This is a subject that we all ought to be interested in.

From observation I find that it is impossible for the city to keep within the by-law itself, and I have seen the city stacks making offensive smoke from eight to twenty-six minutes per hour, and I think if a railroad were to make laws that it could not keep itself it would be a pretty bad thing to ask the men to keep them, as this is the case in the City of Toronto, it is up to this Club to find out why it is so, and if the by-law is not too stringent I think we ought to devise some means by which this smoke can be eliminated. I know from my own observation of the smoke in the city that there is hardly a manufacturer who is not breaking this by-law, there are also the locomotives along the waterfront which are continually making offensive smoke.

Mr. Black,—

Do you refer particularly to locomotives, or to plants around the city?

Mr. Bly,—

Both.

Mr. Black,—

I might say for the information of those present that at the Stratford shops, before the new shops were built, they had a battery of locomotive boilers coupled together and there was a large volume of black smoke from the stack, but since new power plant has been installed there is scarcely any smoke from the stack.

Mr. McRobert,—

When you have plenty of boilers there is no necessity to force the fires thereby eliminating smoke.

Mr. Bly,—

Of course the smoke can be eliminated by an excessive boiler capacity, there is no question of that, but with a plant such as

I am running it is a question whether you can get boiler power enough to make it pay, at the same time eliminating the smoke and run in competition with the Hydro-Electric system.

Mr. Bannon,—

After listening to what Mr. Bly has said it is up to me to say something.

As far as the smoke by-law is concerned I am not going to defend it. Any plant that is burning bituminous coal will certainly smoke no matter what devise is put in.

I understand that Mr. Bly is using a salt solution of some kind to eliminate the smoke nuisance, and probably he will tell us something about it.

Mr. Bly,—

I would like to know where you got your information from?

Mr. Bannon,—

My source of information is the people who make the solution.

I understand that he is burning 50% of anthracite coal and 50% of bituminous coal without any smoke, which is caused solely by this solution, and the statement I read was made over Mr. Bly's signature.

Mr. Bly,—

If you have read any such statement, I do not know anything about it, as no solution I have had ever eliminated any smoke. As far as the solution is concerned it is the "Fisher Fuel Economizer." These people came to my place and made a test themselves. I am going to make a proper test of this solution in a few days with different kinds of fuel, and I shall be in a position to give you correct information inside of a week.

Mr. McRobert,—

When this was tested at our plant, my firemen said that it was the hardest day's work that they had ever had.

Mr. Bly,—

In watching the smoke stacks in the city I find that the weather conditions have much to do with the smoke. Not very long ago I was watching one of the city stacks, and after it had been smoking for about eight minutes the wind shifted. The wind was south-west and shifted to the north, and in less than two minutes after the wind shifted there was practically no smoke in the city. I have noticed this happen several times, particularly along the lake front. I have seen locomotives come along without emitting any smoke, and suddenly they seem to strike a different atmosphere, and there was a lot of smoke, and the same applies to many of the stationary plants.

I think this Club should appoint a committee to investigate the smoke situation, and see what can be done, because, as soon as the city gets its Hydro-electric power it is going to put some of the plants out of business by a too rigid inspection of the smoke.

I am using the fuel recommended by the Street Commissioner and I find it impossible at all times to keep down the smoke.

Chairman,—

I think that instead of appointing a committee it would be better to get Mr. Harris down here to give us a lecture on "Smoke Prevention." However, I think that is a matter that could be well taken up, as Mr. Bly says.

Mr. McRobert,—

I was sent to see the smoke consumer as approved of by the city. This device may work all right in a small factory where it is only necessary to put coal on the fires occasionally but in a large manufacturing plant where the boilers have to be forced continuously this approved smoke consumer is not a success.

Mr. Neild,—

At Stratford shop you can hardly ever see any smoke coming out of the stack.

Mr. McRobert,—

They must have plenty of grate area there.

Mr. Herring,—

I move that a very hearty vote of thanks be tendered to Mr. Black for his very interesting paper.

Mr. Nield,—

I second that. Carried.

Chairman,—

Mr. Black, it affords me the greatest of pleasure on behalf of the members present to extend to you their hearty vote of thanks.

Mr. Black,—

I am sure I appreciate it very much. I was afraid the paper would not be of much interest except to those interested in locomotives.

Chairman.—

As we have all been so interested in Mr. Black's paper, I am sure you will not let him go so long again before he gives us another one.

Chairman,—

At the last meeting I mentioned that we wanted papers for October, November and December, and asked the members to advise the Secretary that they would be prepared to give a paper on these dates, but up to the present we have not heard from any of the members, and I would very much like to have some of the members get busy, and not leave it to the Secretary and Executive Committee to get papers for these dates.

I may say that the Executive Committee saw fit to strike off the list of members, the delinquent members of 1908, of which there were quite a number, we have been sending them journals and notifications of the meetings but have not got any response from them in regard to their dues and some of them have been attending the meetings right along but never thought about paying their way, so that we had to drop them. At the end of this year we will have to drop the delinquent members for 1909.

The next paper will be on "Modern Ventilation," by Mr. J. C. Grant, of the B. F. Sturtevant Co.

Between now and the next meeting the Executive and Reception Committees will be called toegther for the purpose of making arrangements for the picnic. As you are aware we have only one more meeting before the summer holidays, and the Committees will endeavor to have something definite to report to you at the May meeting.

There is no further business, so it will be in order for someone to move that we adjourn.

Moved by Mr. Campbell, seconded by Mr. Bannon that the meeting be adjourned. Carried.

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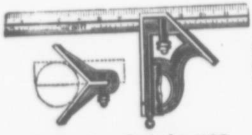

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