

NEW YORK TO CHICAGO IN SEVENTEEN HOURS.

By W. BARNET LEVAN, Engineer.

[Read at the Stated Meeting, May 21, 1884.]

In this paper I propose to show how the distance between New York and Chicago can be covered in seventeen hours, *via* the Pennsylvania and the Pittsburgh, Fort Wayne and Chicago Railroads. The distance by this route is nine hundred and eight miles as follows :

	Miles.	Minutes.
New York City to Philadelphia, Mantua Station.....	88'26	in 100
Philadelphia to Harrisburg.....	103'07	in 114
Harrisburg to Altoona.....	131'6	in 144
Altoona to Pittsburg.....	116'7	in 128
Pittsburg to Alliance.....	83	in 91
Alliance to Crestline.....	106	in 117
Crestline to Fort Wayne.....	131'39	in 144
Fort Wayne to Chicago.....	148	in 162
Total miles.....	907'91	—
Total time in minutes.....		1,000
Crossings at grade in Ohio.....	16	
“ “ Indiana.....	10	
“ “ Illinois.....	8	
Total crossings at grade.....	34	
Time lost in minutes by slowing down according to law.....		20
Total number of minutes consumed.....		1,020
Total time of run to Chicago in hours.....		17

I have selected the Pennsylvania Railroad, as that company controls the shortest and most direct route between the two cities mentioned, and possesses the further advantage of having its tenders fitted with a “pick-up” apparatus for supplying them, while running, with water from troughs placed between the rails.

To accomplish the distance in the time named is with this company only a question of additional safety gates, so as to keep the track clear through the large towns and cities scattered along the route.

I have divided the route up into eight sections, necessitating the use of eight locomotives. This, however, is because of the way the road is divided into Superintendents’ Divisions, not from the necessity of changing on account of the locomotives, except on the Western Divi-

sion of the Pennsylvania Railroad, where two locomotives will be required in crossing the Alleghany Mountains.

At Philadelphia, in place of running into Broad Street Station, the locomotive and passenger car, with passengers, will be in waiting at Mantua, and take the place of the locomotive and car of passengers for Philadelphia only. At the other stations on the route the passengers can be changed in the time occupied in changing locomotives.

The ability of the locomotives of the Pennsylvania Railroad Company to perform this journey will be seen by the following indicator diagrams:

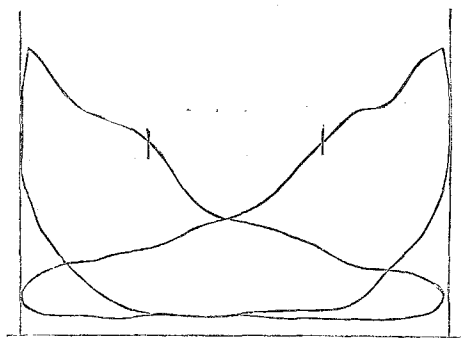


FIG. 1.

Diagram Figure 1 was taken when running at the rate of *fifty-five miles an hour*, cutting off after the piston had traveled seven inches,

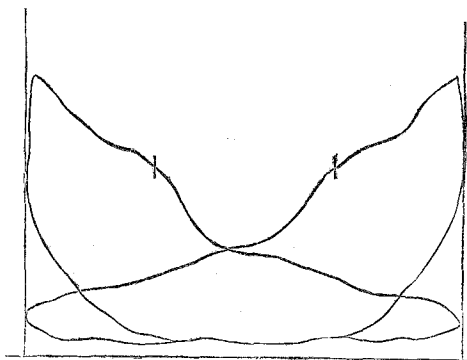


FIG. 2.

with a boiler pressure of one hundred and thirty-five pounds per square inch, an average initial pressure of one hundred and twenty-one, and

one-half pounds at commencement of the stroke and eighty-four and one-half pounds at point of cut-off, and eight pounds average back-pressure.

Diagram Figure 2 was taken when running *sixty miles an hour*, cutting off at seven inches, initial pressure one hundred and nineteen and one-half, and eighty-one pounds pressure at point of cut-off, averaging eight and one-half pounds back-pressure.

Diagram Figure 3 was taken when running *sixty-four miles an hour*, boiler pressure as above one hundred and thirty-five pounds per square

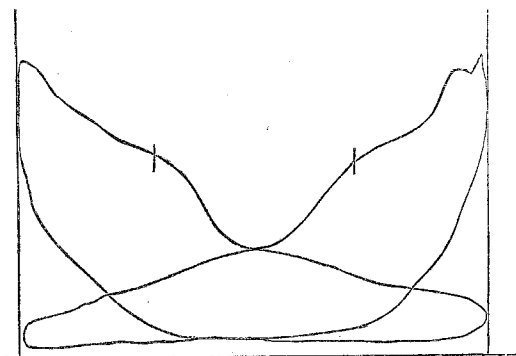


FIG. 3.

inch, initial pressure one hundred and twenty-seven and one-half, and eighty-four pounds at point of cut-off, averaging six and one-quarter pounds back-pressure.

The dimensions of these locomotives are as follows :

Diameter of cylinder in inches.....	18
Diameter of piston rod in inches	3
Area of piston less one-half area of piston rod in square inches.....	251
Length of stroke in inches.....	24
Diameter of drivers in inches.....	78
Capacity of tank in gallons.....	1,920
Capacity of coal box in pounds.....	12,000
Weight of tender loaded in pounds.....	56,300

Weight of locomotive in working order :

On truck in pounds.....	27,400
On first pair of drivers in pounds.....	33,600
On second pair of drivers in pounds	31,700
Total weight in pounds.....	92,700

The tractive force exerted for each pound of effective pressure per square inch on the piston is as follows:

$$\frac{18^2 \times 24}{78} = \frac{324 \times 24}{78} = 99.7 \text{ pounds.}$$

The water tank, as before stated, is fitted with Ramsbottom's water-lifting apparatus for taking in a supply of water while running.

To accomplish 908 miles in seventeen hours the average miles run per hour must be *fifty-five miles*. Therefore, as the locomotive must be able to exceed the average number of miles per hour required for this purpose we will take diagram Figure 3, whose average mean pressure is 40.3 pounds per square inch and 276 revolutions per minute, averaging 677 horse-power.

$$HP = \frac{18^2 \times 0.7854 \times 1104 \times 403}{33000} \times 2 = 677 \text{ horse-power.}$$

It is an every-day occurrence at intervals on the Pennsylvania and Bound Brook route to average for short distances *seventy miles* an hour, in fact, often a mile in *forty-five seconds*, or at the rate of *eighty miles an hour*

$$\frac{60 \times 60}{45} = 80.$$

Therefore, it is not a question of capacity of either the boiler or engines, it is simply a clear track and a disposition of the company to order it done.

It is evident from the indicator diagrams shown that the boilers are superior to the engines. The diagrams show only an average of *sixty-five per cent.* of the theoretical diagrams, while diagrams from stationary engines of similar capacity with automatic cut-off show an average of *ninety per cent.*, this difference is due to the use of the link motion in locomotive engines. The scant opening which it gives when cutting off at *six* to *eight* inches is one of its most prominent defects, as a great part of the actual boiler power is expended in forcing the steam through the narrow openings but partially uncovered by the valve, whereby a loss of over *thirty per cent.* of effective motive power is the result.

By the substitution of a separate cut-off valve similar to that adopted by Mr. A. J. Stevens, of the Central Pacific Railroad, this great loss could be overcome and there would be a great saving of fuel. This substitution would cost about \$300 for each engine, and about *thirty-three per cent.* additional working power would be gained by it.

DISCUSSION.

MR. HUGO BILGRAM:—Referring to Mr. Le Van's statement that an independent cut-off will vastly increase the power, I am of opinion that if there were no wire drawing of the steam at all, only a small corner would be added to the diagram, and the power increased by probably less than 10 per cent., instead of 30 per cent. as stated in the paper. The compression would tend to fill up the clearance and prevent the loss of the steam that would otherwise be required to fill the clearance at every stroke.

MR. CYRUS CHAMBERS, JR.:—I am of the opinion that it is advantageous to have the excessive back pressure at the termination of the stroke, as shown by the indicator cards, and that it is not detrimental to the power of the engine, provided the compression of the exhaust does not exceed the boiler pressure, because it is utilized in the return stroke giving back to the piston all the power consumed in its compression, less friction and leakage. I agree with Mr. Bilgram on this point.

By closing the exhaust valve just in time to compress the exhaust steam at the end of the stroke up to boiler pressure, the momentum of the moving parts is overcome, all lost motion in the connections are quietly taken up at the point of stroke where the pressures from the induced and exhaust steam are equal on either side of the piston.

This makes a smooth running engine even with considerable lost motion in the connections, and as no steam is taken from the boiler for clearances, but that now in the clearances giving off its power by expansion, I see no loss except from friction and leakage.

My firm has built quite a number of engines compressing the exhaust at the end of stroke to boiler pressure with very satisfactory results.

I do not wish to be understood that we "throttle the exhaust," on the contrary we give a free exhaust until there is just enough exhaust steam left to fill the ports and clearances when compressed to boiler pressure.

We are now constructing an engine in which the terminal pressure of the exhaust (if exhaust it be) is greater than the boiler pressure, and economical results are expected.

MR. HECTOR ORR made an inquiry concerning the safety of such fast running trains as the paper of Mr. Le Van described.

MR. J. W. NYSTROM:—The clearance in locomotive engines is about

that in well constructed stationary engines of the same size, but that is no good reason why the exhaust should be compressed as much as shown on these diagrams. The fact is that when the steam is cut off at an early part of the stroke by link motion, the excessive compression cannot be avoided.

The Porter-Allen engines make very good indicator cards, when running as fast as those on locomotives, showing a proper regulation of steam to and from the cylinder, and the same could be done on locomotives.

I believe Mr. Le Van is right in advocating separate cut-off on locomotives, the accomplishment of which would save at least 20 per cent. in the economy of steam. It has been stated that the economy in excessive compression is due to the saving of clearance steam. The locomotive engines have about 8 per cent. clearance, and when the steam is cut off say at $\frac{1}{4}$ of the stroke, then $\frac{3}{4}$ of the clearance steam is expanded into the cylinder, and the loss is thus two per cent. while the loss of power by compression amounts to 10 or 20 per cent.

In answer to Mr. Orr's question of safety on fast-running trains, I may say that the greatest danger is to run fast on sharp curves, which danger is said to be diminished by a peculiar railroad curve introduced in France by M. Froudé, consisting of a parabola of the third order, and called the *elastic curve*. Engineer C. A. Sundstrom, a member of the Institute, has made the elastic curve a special study, and, I believe, has laid out several of them on the Pennsylvania Railroad. I suggested to Mr. Sundstrom to read a paper on the subject at the Institute on the elastic curve. Mr. Sundstrom says that all the curves on the government railroads in Sweden are elastic curves.

MR. BILGRAM:—In reply to Mr. Nystrom's statement that compression absorbs power, let me say that in expanding engines the greater part of that power would be restored by the consequent re-expansion of the compressed steam. The short and steep compress curve of the diagrams of some engines are due to the very small clearance of such engines, a result which is not attainable on locomotives.

MR. LE VAN:—Messrs. Bilgram and Chambers forget that with link motion, when cutting off at less than half stroke, the initial cylinder pressure does not reach that of the boiler pressure by twenty-five per cent., and only momentarily at that (see Fig. 3), whereas, with an independent cut-off valve, the loss in a well-constructed engine will not be over three per cent. up to point of cut-off.

Take the left hand indicator diagram, Fig. 3, on which I have erected a theoretical diagram (see Fig. 4) from the point of exhaust opening, and represented by the dark shaded portion of the card ; this is what would be produced by a perfect engine. Now, in the best practice, with stationary engines of a similar size with our fast locomotives in general use, and running at the same number of revolutions, there are stationary engines that develop *ninety-five per cent.* of the theoretical diagram, whereas diagram, Fig. 3, realizes only *sixty-five per cent.*, a loss of *thirty per cent.*

Now, I maintain that locomotive engine builders can produce just

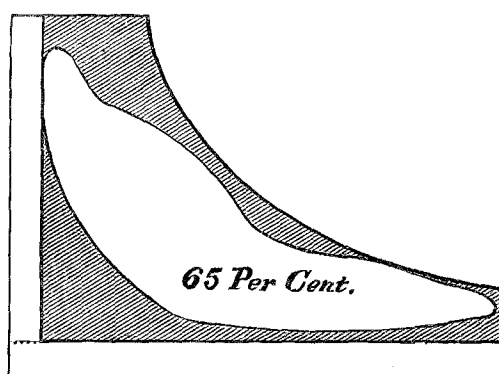


FIG. 4.

as good engines and results as stationary engine builders, and it is incumbent on them to do so.

We all know the difficulties that Mr. Corliss had to contend with when he first introduced his independent cut-off valve ; it seemed incredible to those to whom he offered to sell his engine, from the fact they could not understand it, although he explained to them that the efficiency of his engine was due to a higher initial steam pressure in the cylinder, the steam line maintained without expansion, the rapid closing of the steam-valves so that all wire-drawing was prevented and the whole expansion of the steam secured ; a low terminal and a free exhaust.

I do not propose to dispense with the link motion, but to add a variable cut-off valve in addition. To many this would seem an unnecessary complication, inasmuch as a separate cut-off valve would be supposed to accomplish quite as much without a link as with it.

It is well known that an engine may be run with an admission of steam to a shorter length of the stroke—in other words, with an earlier cut-off—when an independent variable expansion valve is used, than with the link alone. This being admitted, the question again comes up, “What is the advantage of the link used in addition to the cut off?”

Its advantage is simply as follows:

First.—The link is the simplest and readiest means of reversing.

Second.—While the cut-off is being run at, say, one-fourth or three-eighth stroke, the link may be worked to *vary the exhaust*. It is found to be less advantageous to hold on to the steam as long, when cutting off short, as when following for a greater length of stroke. Let an engine constructed with both a link motion and a separate cut-off valve, have the latter set at one-quarter stroke, the engine meanwhile running along at a corresponding speed; the link, which is supposed to be working the main valve at full throw, may now be pulled up, notch by notch, and it will be found that with each rise of the link and consequent shortening of the throw of the main valve, whereby the exhaust is released earlier and earlier, the engine will quicken its speed.

In the early history of the locomotive the independent cut-off valve as built from designs of Mr. Ethan Rogers, of the Cuyahoga Works, Cleveland, Ohio, and were found to be very efficient. Unfortunately at that time, these improvements were in advance of their time, on account of their additional expense, and the small amount of capital then at command of the railroad companies.

The advantages of independent variable cut-off valves over the ordinary valve controlled by the shifting link motion is well known by the locomotive builders of to-day, but they build a standard locomotive, and can ordinarily sell all they can produce at a fair price, and as long as they have customers for their make they will not change their plan of engines.

Mr. Chambers' statement as to the advantage of compression for overcoming the “jars” or “thumps” due to lost motion of the connected parts is correct, but the amount of compression for this purpose is very much exceeded in indicator diagrams Figs. 1, 2 and 3, thereby causing too great a loss of power.

To Mr. Orr's question of safety, I would say, that in England, where there are one hundred trains running daily, averaging over *fifty miles an hour*, the number of killed is only *one* in 62,000,000 of pas-

sengers carried, and with the improvements now adopted by our railway companies in constructing elastic curves, as stated by Mr. Nystrom, in the place of rigid ones, steel bridges and well-ballasted road-beds, all risks are reduced to a minimum.

ELECTRO-DYNAMICS.

By JOHN W. NYSTROM.

[Read before the Electrical Section of the Franklin Institute, June 13th, 1884.]

The object of this paper is to criticise the electro-dynamics advanced by Count Du Moncel in his work on "Electricity as a Motive Power," page 297, English edition, and to show the confusion in which that subject is yet involved.

The Count Du Moncel gives three formulas on page 299, intended to express the quantity of work accomplished by an electric current, namely as follows:

$$K = RI^2 \quad 1.$$

$$K = \frac{E^2}{R}. \quad 2.$$

$$K = EI. \quad 3.$$

K = work expressed in kilogrammeters.

R = resistance in the conductor expressed in ohms.

I = intensity of current expressed in ampères.

E = electro motive force expressed in volts.

No formulas can express quantity of work without representing the three simple elements—*force, velocity* and *time*, and as the time is wanting in Count Du Moncel's formulas, they cannot express work.

In the simplest formula for work, namely, $K = FS$, or the product of force and space, the time is included in the space S , which is the product of velocity and time. No work can be accomplished without time.

Work is transformed into power by eliminating the time, and the power is thus expressed "work per unit of time," and therefore no work can be transformed into power without dividing it with the time in which it is accomplished, but the Count divides work by the acceleratrix of gravity, and calls the quotient *power*, namely, as follows:

$$P = \frac{RI^2}{g}. \quad 4.$$