always, until the flourishing period shall arrive when American money matters will be on a par with English, stand at a lower figure in the market. French and Belgian railway stocks rank nearly equal with English from having London agencies, the absence of which depresses American.

Two great and highly successful American railway corporations, the Michigan Central and New York Central (the latter being the London and North Western railway of America), have recently supplied the deficiency, and established agencies in London for the regular transfer of shares and payment of dividends.

In the transfer department a plan has been adopted for the purpose of security, which, in these Robson and Redpath days, deserves attention.

“Messrs. George Peabody & Co., of 22 Old Broad-street, have been appointed the transfer agents of the Company, and the Union Bank of London the registrar of transfers, to countersign the stock certificates, an arrangement intended to guard the stock issues of the Company in a manner believed to be the most satisfactory of any yet practised.”

Such is the new plan adopted by one of these large American Companies, which is also a counterpart of that by the other.

It certainly seems calculated to prevent fraud of the character which has so disgracefully blackened the face of 1856 in railway proceedings. With such checks against fraud and forgery, the Robson and Sadleir race must be deprived of their occupation.

For the Journal of the Franklin Institute.

Experiments made at the Steam Flour Mills of Messrs. Hecker & Brother, N. Y. By Chief Engineer, B. F. ISHERWOOD, U. S. Navy.

By the kindness and liberality of Messrs. Hecker & Brother, I have been enabled to make a number of experiments at their Steam Flour Mills, situated at the foot of Bridge Street, in the City of Brooklyn, New York. In the prosecution of these experiments every facility was afforded me, and I received in addition the valuable assistance of late Chief Engineer William Sewell, U. S. Navy. The experiments extended from February 21st, to March 4th, 1855.

The mill contains four run of four feet diameter stones, together with the requisite smut machines, elevators for hoisting and lowering grain, &c., to supply the stones. The stones are used for grinding wheat, and for their normal speed are worked at about 228 revolutions per minute, making six revolutions to each double stroke of the engines pistons. The machinery operating the stones, &c., consists of two high pressure steam engines, fitted with a surface tubular condenser for condensing the exhaust steam and returning it to the boilers in the state of hot distilled water. No air pump is used, but both the steam and cold water sides of the tubes are open to the atmosphere, and consequently no vacuum is formed; the sole purpose of the condenser being to supply the boilers with fresh water, as owing to the locality sea water only could otherwise

be obtained ; the loss from leakage and non-condensation is replenished with rain water. A separate Worthington steam pump is used to supply the condenser with cold condensing sea water, which is pumped up from the bay. The boilers are of the ordinary high pressure kind, cylindrical with return cylindrical flues, and having as an appendage a cross boiler or heater. The dimensions of the entire machinery will be hereinafter given in detail.

The objects of the experiments were principally as follows, viz :—

1. To determine the friction resistance of the engines and main shafting, and to ascertain the law regulating that resistance in function of the speed of the pistons : that is to say, to determine the pressure required to work the engines and shafting alone at any given speed, and to ascertain if any increase of pressure on the pistons is required to work the engines and shafting, *per se*, at different speeds, and if any, what increase.

2. To determine the ratio of the increase of power required to grind wheat at increased speeds, and *vice versa* : that is to say, for example, what increase of power is necessary in order to grind at twice the speed.

3. To determine the potential and economical evaporation by the boilers : that is to say, to determine how much steam the boilers will supply in a given time, and how many units of weight of water are converted into steam per unit of weight of fuel.

4. To determine the efficiency of the condenser : that is to say, to determine what proportion of the steam supplied to it is condensed, and incidentally, the amount of condensing water required, its temperature, and the temperature of the water formed by the condensation of the steam.

5. To determine the general condition and efficiency of the engines with regard to the proportions of their steam passages, their cut-offs, &c., &c., and the most economical manner of using the steam.

The following are the descriptions and dimensions in detail of the different machinery, viz :

Engines.—Two horizontal direct acting engines, working upon the same shaft and at right angles to each other, their motion rendered uniform by a fly-wheel and governor. At each end of the cylinder there is a short D steam slide valve, the two are joined by a rod and worked by an eccentric. The cut-off valve first used was a balanced four-way cock, connected with, and variable by, the governor ; it was also variable momentarily by hand ; it was situated in the steam pipe at some distance from the steam slide valve, and worked with no other friction than what was due to its weight and snug fit. With this cut-off no throttle valve was used. The last cut-off is simply a sliding plate worked by the steam slide valve which draws the plate after it, thereby cutting off the admission of the steam into the cylinder at the very cylinder nozzles. This cut-off is fixed, and closes the steam port when the piston is 0.183 of its stroke from the commencement ; a throttle valve controlled by the governor is used with it. The steam pipes leading from the boilers to the cylinders are well covered with felt and canvass, but the cylinders, their valve chests, and connecting pipe, are uncovered.

loss by leakage and non-condensation is replenished with rain water. There is no air-pump, and owing to the fact that both the cold condensing water and the hot water of condensation are open to the atmosphere, the pressure on both sides the tubes will be equal, although *all* the exhausted steam were condensed. For the same reasons, the pressure within the tubes, even with a perfect condensation of the exhaust steam, could never be less than that of the atmosphere.

The diameter of the Worthington steam pump is 7 inches, stroke of piston 7 inches. Diameter of the steam cylinder working the pump 12 inches, stroke of piston 7 inches. The following are the dimensions of the condenser, viz :

Length inside of case,	.	.	.	7 feet.
Breadth	"	.	.	7 "
Height	"	.	.	4 " 8 inches.
Cubic contents of inside of case,	.	.	.	228.67 cubic ft.
Number of copper pipes $1\frac{1}{2}$ -inch outside diameter, and				
58 inches length,	.	.	.	100.
Number of copper pipes $7\frac{3}{8}$ -inch outside diameter, and				
72 inches length,	.	.	.	10.
Number of copper pipes $7\frac{3}{8}$ -inch outside diameter, and				
2 inches length,	.	.	.	4.
Area of condensing surface in all the above pipes,	.	.	.	303.7 sq. ft.

Boilers.—There are three cylindrical boilers, 44 inches outside diameter, and 30 feet length, placed side by side, set and embedded in brick work in the usual manner. Each boiler contains two return cylindrical flues of 12 inches internal diameter, and 30 feet length. On the top of each boiler is a cylindrical steam drum of 30 inches internal diameter, and 63 inches height; the steam drums are connected at the top by a cross pipe which continues to the engines, and supplies them with steam. The drums and steam pipe are well covered with felt and canvass. The boilers are completely surrounded and covered with brick masonry, so as effectually to prevent the radiation of heat. There is but one furnace, and it is situated below and at one end of the boilers, the fire grates extending clear across without interruption. The grate bars are $\frac{3}{4}$ -inch wide on top, with air spaces of $\frac{1}{4}$ -inch wide between them; in cross-section, the bars bevel towards the bottom, where they are only $\frac{1}{8}$ -inch wide, with air space $\frac{7}{8}$ -inch wide between them. Beneath the three boilers, and lying in a direction at right angles to them, is a cylindrical cross boiler or heater of 36 inches external diameter, and 12 feet 2 inches length; this cross boiler having its top connected with the bottom of each of three boilers by a short pipe, is placed in the current of heated gases flowing from the furnace to the chimney, so as to cause the gases to impinge against and be deflected around it. The feed water is pumped into the cross boiler—which is always full of water—and finds its way into the three upper boilers through the connecting pipes. There are four brick bridge walls, similar to each other, in the length of the boilers; they are curved on the top concentrically with the bottoms of each boiler, having a space of $4\frac{1}{2}$ inches left for the passage of the heated gases between the tops of the walls and the bottoms of the boilers.

The following are the principal data of the boilers, viz :

Area of the shells of the three boilers exposed to the heated gases,	510·11 sq. ft.
“ cylindrical return flues of the three boilers,	565·49 “
“ shell of the cross boiler exposed to the heated gases,	93·06 “
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Total area of heating surface,	1168·66 sq. ft.
“ “ grate “	57·50 “
Cross area between top of bridges, walls, and bottoms of boilers,	6·415 “
“ of the cylindrical flues of the three boilers,	4·712 “
Distance traversed by the heated gases from the centre of the furnace to their exit from the flues,	68 feet.
Height of the smoke chimney above the boiler grates,	90 “
Steam space in the shells of the three boilers,	365 cubic “
“ “ drums “ “	77 “ “
<hr/>	
Total steam space,	442 cubic feet.
Ratio of grate to heating surface,	1·000 to 20·325.
“ cross area between bridges, walls, and boilers to grate surface,	1·000 to 8·963.
“ cross area of the cylindrical return flues,	1·000 to 12·203.
Aggregate area of air spaces between the grate bars,	13·52 sq. ft.

Determination of the Friction Resistance of the Engines and of the Main Shafting, per se, and of the Law regulating that resistance in function of the speed of the engines' pistons.—Before commencing the experiments hereinafter described, the power required to overcome the friction of the engines and of the main shafting, *per se*, was determined by a great number of trials at different speeds of the engines' pistons. For this purpose indicator diagrams were taken from each engine; each diagram was traced thrice by the pencil, and where there was any deviation that diagram was rejected. The results thus obtained were found to very closely correspond, the *pressure* being sensibly the same at *all* velocities of piston, showing that the *power* required to overcome the friction resistance of the engines and shafting, was in the direct ratio of the speed of the piston; for the *power* is the product of the *pressure* and the *speed*. During these trials the speed of piston was varied by the throttle-valve from 17 to 44 double strokes per minute, or from 136 to 352 feet per minute. Although the *pressure* on the piston continued always the same to overcome the friction resistance, be the speed of piston what it might, yet for increased speeds it was necessary to open the throttle-valve wider in order to supply the greater quantity of steam required in the same time; so that in order to obtain greater and greater speeds of piston, the throttle-valve needed to be more and more opened, but the pressure remained sensibly the same in all cases, only the opening for the admission of the steam was increased with the increased speed of piston, in order to supply the increased quantity of steam required for maintaining the *same* pressure at the increased velocity of piston. These experiments were varied by entirely shutting off the steam from one engine, and overcoming the friction resistances of both engines and the shafting with the other; in this case, the pressure just doubled what it was with both engines functioning.

The above results are confirmative of the well established law of friction, viz: that it is independent of speed, and that the quantity is measured solely by the space through which it moves; the same friction

moving through a double space requiring a double power, be the velocity of its motion what it may. The resistance of the atmosphere to the moving parts of a steam engine, doubtless makes the power required to work it, *per se*, to increase in a ratio slightly greater than direct; but the atmospheric resistance is so slight, and the opposed surface of the moving parts of the engine so small, that the effect is practically inappreciable. The following table contains a selection of the results from a considerable number of diagrams; they will enable the reader to perceive the limits of variation, the widest of which are therein included. Indicator diagram No. 1, is a representative diagram taken with both engines, functioning and overcoming only their friction and the friction of the main shafting. No. 2 is a representative diagram, taken with one engine only functioning, the steam from the other being entirely shut off, overcoming the same friction resistance as in No. 1.

Table containing the results of trials made to determine the Friction Resistance of the two Engines and Main Shafting.

Number of double strokes of engines' pistons made per minute.	Mean effective pressure throughout stroke, in lbs. per sq. in. of pistons.	Mean back pressure above the atmosphere, throughout the stroke, in pounds per square inch of pistons.
17	3.94	1.00
17	3.70	1.00
18	3.75	1.00
19	3.75	1.00
19	3.70	1.00
22	3.80	1.12
22	3.94	1.13
38	3.90	1.50
38	3.75	1.50
38	3.95	1.50
38	3.90	1.50
44	3.75	1.75
44	3.70	1.75
44	3.95	1.75
Means,	3.82	1.32

From the above table it will be perceived, that the variations due to imperfections of instrument and observation, were comprised within very narrow limits, the minimum being 3.70, and the maximum 3.94, a difference of 3.14 per centum from the mean 3.82. It will also be observed, that the "back pressure" increased with the increased speeds of piston, which is what should have been the case, there being more steam to be exhausted through the same opening in equal times in the direct ratio of the speed of piston.

Determination of the power required to grind Wheat in Function of Speed.
—Experiments were made to determine the relative economy of power in grinding wheat at a lesser or greater speed; that is to say, to determine the ratio of the power employed when the mill stones were rotated at different speeds, the same feed being kept on. For this purpose the machinery was worked at full speeds, at two-thirds speed, and at

half speed, and indicator diagrams were taken at 30 minutes interval; the diagrams were in all cases traced thrice by the pencil, and those showing any disagreement were rejected. The following table contains the data and results, viz:

Table containing the Results of Trials made to determine the Relative Economy of Power in Grinding Wheat at Different Speeds.

Series.	Pressure in pounds per square Inch above the atmosphere.						Actual coefficient of expansion of the steam.	Number of double strokes of en- gines' pistons made per minute.	Available horse power developed by the engines after deducting 382 pounds per sq. inch of pis- tons for friction of engines and shafting.	Cubic feet of steam of atmospheric pressure used per minute calcu- lated from the pressure at the end of the stroke.	Ratio of pres. on op- pos'g sides of piston.																												
	Mean effective pressure on pistons throughout the stroke.	Mean back pressure on the pistons throughout the stroke	Steam pressure in boilers.	Initial steam pressure in cylinders before cutting off.	Steam pressure in cylinders at the end of the stroke above the atmosphere.	Steam cut-off at in cylinder from commencement of stroke of pis- tons.					Total avg pres. throughout the stroke includ'g atmos- phere in lbs. p.sq.in. pist'n.	Total av. back pres. through- out the stroke inc'g atmos- phere in lbs. p.sq.in. pist'n.	Ratio of total back pressure to total average pressure.	Number of bus. of wheat cleaned and ground into flour per hour.																									
A	22-00 18-00 17-63 16-88 17-48 20-63 18-98 19-43	2-63 2-80 2-30 2-20 2-70 2-77 2-70 2-80	95 from 95 to 100 98 98	38-25 36-00 38-63 38-63 36-00 34-50 33-40 33-75	11-25 9-75 7-50 8-00 7-00 10-50 9-75 9-70	0-26 0-23 0-20 0-16 0-22 0-28 0-26 0-30	0-712	36	47-23	1116-2	36-19	17-31	0-478	27																									
Means	18-88	2-61	97	36-14	8-93	0-239																																	
B	11-78 11-04 11-10 11-37 11-25	1-75 1-50 1-50 2-00 1-50	Steam throated off.	27-00 24-21 24-00 23-40 23-63	3-00 3-00 4-50 4-50 3-00	0-25 0-25 0-25 0-25 0-25									0-707	18	11-75	441-3	27-66	16-35	0-591	13½																	
Means	11-31	1-65		24-46	3-60	0-25																																	
C	51-00 48-83 51-97 50-03 49-16 50-25 51-94 52-27	4-58 4-84 5-31 5-14 5-25 4-75 5-13 5-03	83	75-00 75-00 75-00 75-00 72-75 75-75 75-00 75-00	30-00 27-00 33-00 30-00 29-30 30-00 31-50 32-25	0-37 0-33 0-36 0-34 0-35 0-34 0-34 0-35																	0-786	39	159-21	2190-9	70-38	19-70	0-280	78									
Means	50-68	5-00		83	74-81	30-68																									0-348								
D	33-07 37-42 36-90 34-86 35-85 36-75 34-88 34-73	2-16 2-63 2-51 2-45 2-37 2-82 2-95 3-10		96 97 96 96 94 89 84 84	73-50 75-75 75-00 75-00 75-75 74-00 68-00 69-00	16-50 19-50 18-00 18-00 17-60 18-75 16-50 17-25																									0-13 0-15 0-15 0-15 0-16 0-18 0-18 0-18	0-601	26½	73-27	1098-9	52-88	17-32	0-328	53
Means	35-56	2-62		92	73-25	17-76																									0-16								

In the above table, comparing series A and B, which were taken with the same mill stones and feed on, the speed being in series B one-half

of what it was in series A, and the quantity of wheat cleaned and ground one-half; we perceive that after deducting 3.82 pounds per square inch of pistons for the friction resistance of engines and shafting, the average pressures on the pistons per square inch were $(18.88 - 3.82 =) 15.06$, and $(11.31 - 3.82 =) 7.49$ pounds, or sensibly in the ratio of 2 to 1; that is to say, to make twice the number of double strokes of pistons in equal times, twice the pressure was required on the pistons. But the speed at which these pressures moved compared as 2 to 1, and with the double speed, twice the quantity of wheat was cleaned and ground; consequently, the powers 47.23 and 11.75 horses, which are the products of the pressures and speeds, compare as 4 to 1; that is to say, to grind in equal times twice the quantity of wheat by grinding it at double velocity, requires four times the power.

Again, in comparing series c and d, during which exactly the same condition of things existed, with the exception of the speed, which compared as $(\frac{3}{2} \cdot \frac{2}{5} =) 1.4717$ to 1.0000; we perceive that after deducting 3.82 pounds per square inch of pistons for the friction resistance of engines and shafting, the average pressures on the pistons per square inch were $(50.68 - 3.82 =) 46.86$, and $(35.56 - 3.82 =) 31.74$ pounds, or in the ratio of 1.4764 to 1.0000, or sensibly in the same ratio as the number of double strokes of pistons in equal times. The quantity of wheat cleaned and ground with series c, was 78 bushels per hour; with series d, 53 bushels per hour, or in the ratio of 1.4717 to 1.0000, being exactly in same ratio as the number of double strokes of pistons made per minute. The power with series c was 159.21 horses, with series d, 73.27 horses, or in the ratio of 2.173 to 1.000. But the quantities of wheat cleaned and ground compared as 1.4717 to 1.0000, and the squares of 1.4717 and 1.0000 are 2.166 and 1.000, or sensibly in the ratio of the powers 2.173 and 1.000. Hence, we perceive, that the amount of wheat ground, is in the direct ratio of the number of double strokes of pistons, but that the power required to grind is in the ratio of the squares of the number of double strokes of pistons in equal times, and that the pressure required to develop this power, is in the direct ratio of the number of double strokes of pistons in equal times.

The indicator diagrams in series A, B, c, and d, were taken at half-hour intervals. The quantity of wheat cleaned and ground was accurately measured. From 36 to 39 double strokes of engines' pistons was the usual speed of grinding.

With series A, and a speed of 36 double strokes of pistons per minute, there was required for cleaning and grinding 27 bushels of wheat per hour, 47.23 horses power, or $(\frac{4}{3} \cdot \frac{2}{3} =) 1.749$ horse power per bushel. With series c, and a speed of 39 double strokes of pistons per minute, there was required for cleaning and grinding 78 bushels of wheat per hour, 159.21 horses power, or $(\frac{1}{5} \cdot \frac{9}{8} \cdot \frac{2}{1} =) 2.041$ horses power per bushel. The squares of the speeds 36 and 39, compare as 1.000 and 1.173; the powers 1.749 and 2.041 compare as 1.000 and 1.167, or sensibly the same. It is obvious from the foregoing, that a judicious economy requires a low speed of grinding, and that it is far more economical to employ a greater number of stones to do the required amount of grind-

ing at low speed, than a lesser number at high speed. When grinding at from 36 to 39 double strokes of engines' pistons per minute, corresponding to 216 and 234 revolutions per minute of the four feet diameter mill stones, the flour comes from the stones so hot as to require cooling before it can be packed into barrels. This is opposed to the usual practice of English millers, who obtain the flour from the stones so cold that it can at once be run into the barrels; of course, they grind at a much lower speed. Mr. Ellwood Morris (vide *Journal of the Franklin Institute*, vol. iv. 3d Series, p. 22), ascertained by direct experiment on three excellent overshot flouring mill wheels, having all the modern improvements, that calculating from their whole head and fall while they turned at their usual velocity, everything being in perfect order, they required 788 cubic feet of water, falling one foot per minute, to grind and dress one bushel of wheat per hour. This is an expenditure of power equal to $(788 \times 62\frac{1}{2}) = 49250$ pounds, moving at the rate of one foot per minute, or to $(\frac{49250}{33000}) = 1.493$ horse power per bushel of wheat per hour.

Determination of the general condition and efficiency of the Engines with regard to the proportions of their Steam Passages, their Cuts-off, &c., and of the most economical manner of using the Steam.—The experiments made for the purposes of determining the ratio of the power required to grind wheat at different speeds—the evaporation by the boilers; the consumption of steam with the two cuts-off, &c., &c., furnish the means of determining the various points of back pressure, average pressure throughout the stroke, ratio of boiler to cylinder pressure before cutting off, actual co-efficient of expansion of the steam, economy of fuel, &c., corresponding to different steam pressures, points of cutting off, and speeds of pistons. The data and results of these experiments will be found grouped into series in the following table. The means of series A, B, C, and D, are from the immediately preceding table. Series E, F, and G, are the mean of fifteen indicator diagrams taken at ten minutes intervals; series H, is the mean of 31 diagrams taken at 20 minutes intervals; series I and J, are each the mean of twenty-eight indicator diagrams taken at 15 minutes intervals.

All the series of the table, with the exception of series J, were taken with the first or variable cut-off, cutting off in the steam pipe. Series J was taken with the last or fixed cut-off, cutting off at the cylinder nozzles.

With series A, B, and F, the steam was found to be greatly throttled in the steam pipe at the old throttle-valve, which was unused, but allowed to remain. This throttle was a cock, and when examined was found to give, when wide open, an area for the passage of the steam of but 5 square inches; after passing this contraction, the steam had still to pass the cut-off, and the steam slide valve, before it could enter the cylinder.

Relative economy of fuel.	Total horses power.	Cubic feet of steam of atmospheric pressure per total horse power proportionably.	1923	2596	3061	3365	3267	3639	3901	3368	3358	1000
		Cubic feet of steam of atmospheric pressure per total horse power.	1886	2488	1276	1301	1301	1301	1301	1301	1301	1000
		Cubic feet of steam of atmospheric pressure per available horse power proportionably.	2114	3359	1276	1233	1233	1233	1233	1233	1233	1000
		Cubic feet of steam of atmospheric pressure per available horse power.	2363	3750	1233	1233	1233	1233	1233	1233	1233	1000
Ratio of the pressures on opposing sides of pistons.	Ratio of total back pres. to total av'ge press.	Ratio of total back pres. to total av'ge press.	0478	0501	0280	0380	0380	0380	0380	0380	0380	1000
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1070	1000
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1070	1000
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000
Total horses power developed by the engines including the 382 pounds per square inch of pistons for friction of engines and shafting.	Available horses power developed by the engines after deducting the 382 pounds per square inch of pistons for friction of engines and shafting.	Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	5920	1774	4433	2766	1635	1070	1070	1070	1000	
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1000	
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1000	
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000
Number of double strokes of engines' pistons made per minute.	Actual coefficient of the expansion of the steam.	Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	5920	1774	4433	2766	1635	1070	1070	1070	1000	
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1000	
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1000	
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000
Steam cut-off at in cylinder from commencement of stroke of pistons.	Steam pressure in cylinders at the end of the stroke above the atmosphere.	Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	5920	1774	4433	2766	1635	1070	1070	1070	1000	
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1000	
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1000	
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000
Pressure in pounds per sq. in. above the atmosphere.	Initial steam pres. in cylin's before cut'g-off.	Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	5920	1774	4433	2766	1635	1070	1070	1070	1000	
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1000	
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1000	
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000
Mean back pressure on the pistons throughout the stroke.	Mean effective pressure on pistons throughout the stroke including the 382 lbs. per sq. in. for friction of engines and shafting.	Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	5920	1774	4433	2766	1635	1070	1070	1070	1000	
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1000	
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1000	
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000
Series.	A	Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	5920	1774	4433	2766	1635	1070	1070	1070	1000	
		Total average back pressure throughout the stroke, including atmosphere, in pounds per square inch of pistons.	1731	2766	1635	1070	1070	1070	1070	1070	1000	
		Total average press. throughout the stroke including atmosphere, in pounds per sq. inch of pistons.	2619	4433	2766	1635	1070	1070	1070	1070	1000	
		Cubic feet of steam of atmospheric pressure used per minute, calculated from the pressure at the end of the stroke.	11102	1774	4433	2766	1635	1070	1070	1070	1070	1000

In series A, the cock-throttle being wide open, the steam pressure in the cylinder before cutting off was only 37-26 per centum of the boiler pressure, comparing the pressures above the atmosphere, the cut-off closing at 0-239 of the stroke of pistons from the commencement. The cut-off was then changed to close at 0-412 of the stroke from the commencement, when the cylinder pressure became 46-50 per centum of the boiler pressure, and could not be made higher even when cutting off longer. As soon as this effect of the throttle was discovered, it was removed entirely, leaving the area of the steam pipe at that point 8-95 square inches. Series E was then taken, the cut-off closing at 0-298 of the stroke from the commencement; the cylinder pressure now rose to 87 per centum of the boiler pressure.

It is necessary to here explain that the first cut-off valve could be adjusted at will, making it close sooner or later by giving its axis less or more vibration; but just in proportion as the vibration was lessened, was the opening for the passage of the steam decreased, so that the cut-off valve had the double functions of an expansion valve and a throttle valve—the shorter it cut off the more it also throttled. It was a necessity of its construction also, that the tapering cylindrical plug should be an easy fit in its chamber, and it was adjusted by screws that had to be regulated continually for the unequal expansions of the plug and its chamber; there resulted from this, that the valve leaked unequally in a small degree, sometimes leaking more steam than at others, which is perceptible on comparing the actual co-efficients of the expansion of the steam as given in the above table, with the points of cutting off. The comparative ratio of throttling by the cut-off valve when adjusted at different points of cutting off, appears in the following table, viz:—

Series.	Point of cutting off from the commencement of the stroke.	Ratio of the cylinder to the boiler pressure.	Series.	Point of cutting off from the commencement of the stroke.	Ratio of the cylinder to the boiler pressure.
I	0.152	0.79	G	0.237	0.84
D	0.160	0.80	E	0.298	0.87
H	0.203	0.82	C	0.348	0.90

Finally, it was determined to remove the variable cut-off valve, and replace it with a fixed cut-off valve, cutting off the steam at the cylinder nozzles. For this purpose a movable frame was placed in the valve chest around the steam slide valve, but with a certain amount of play between the ends of the steam valve and the frame. By this arrangement the steam valve was free to move alone a short distance, when it struck the frame and drew it after it, the frame closing over the steam port and cutting off the steam. The same eccentric worked both steam and cut-off valve; in fact, the arrangement amounted to working the cut-off by a tappet on the stem of the steam valve with the advantage that the steam was cut off exactly at the cylinder nozzles. The width of the frame pieces at the ends of the frame amounted to so much lap placed on the steam valve, which acted to cut off the steam very short without the disadvantage of disarranging the exhaust. The addition of this frame did not require the eccentric of the steam valve to be changed. The side pieces of the frame were, of course, only useful to connect the end pieces of the frame. With this cut-off, the first one having been entirely removed, series J was taken, when the cylinder pressure rose to 95 per centum of the boiler pressure, showing that a proportion of 1 square inch of opening to every 1249 cubic inches of space displacement of piston per stroke, was sufficient for the admission of steam, having 95 per centum of the boiler pressure with a velocity of piston of 308.8 feet per minute. The steam pipe was 30 feet long, with three right-angled bends.

The reason for changing the cut-off valve, was to avoid the loss of the expansion of the steam between the first cut-off valve and the steam

slide valve. This loss, from the great capacity of that space which was equal to the area of the cylinder by a length of 0.783 foot, was very considerable. The result of the change was extremely satisfactory, as will appear from a comparison of series 1 and J, taken to practically determine the point. In both series, the mean effective pressure throughout the stroke of piston, number of strokes of piston made per minute, and horses power developed by the engines, were made precisely the same; the ratio of the back pressure to the average pressure for the stroke was also nearly the same, but with series 1 (first cut-off), the steam was cut off at 0.152 of the stroke of piston from the commencement, while with series J (last cut-off), the point of cutting off was fixed at 0.183 of the stroke; but notwithstanding this disadvantage, the gain in steam, and consequently in fuel, amounted to 35.8 per centum—that is to say, if the fuel required with the last cut-off be taken at 1000 for a given power, then to obtain the same power with the first cut-off, would require of fuel 1358. After these experiments the last cut-off was permanently retained, giving steadily the above gain of fuel. With the last cut-off a gain was also effected in the back pressure, the final pressure in the cylinder at the end of the stroke being considerably reduced (in series 1 and J, from 13.50 to 5.36 pounds per square inch above atmosphere), and as a consequence, there was a less quantity of steam to exhaust through the openings, making the back pressure on the pistons above the atmosphere respectively 3.22 and 2.08 pounds per square inch, while the average pressure throughout the stroke remained the same.

(To be Continued.)

Extracts from the Engineer's Report to the Trustees of the Philadelphia Gas Works, for the year 1856.

The several factories belonging to the Trust, have produced in the year 1856, four hundred and thirty-four million seven hundred and forty-two thousand cubic feet of gas; of which 163,930,000 cubic feet were made at the works in First Ward; 184,357,000 in Ninth Ward, and 86,455,000 in Fifteenth Ward.

The largest quantity used in twenty-four hours, was 2,166,000 cubic feet, on the last night of the year, and the largest daily product of the several works has been 799,000 in First Ward; 1,084,000 in Ninth Ward, and 440,000 in Fifteenth Ward.

These maximum daily productions did not occur simultaneously, and therefore their aggregate amount was not produced on any one day, it having been found most convenient to manage the different factories in such way, that one might be in full working, when the yield of another had fallen off by reason of the wear of its retorts.

The largest daily average yield of each retort in the year was

7194	feet at the works in	First Ward.
5382	“	“ Ninth Ward.
5150	“	“ Fifteenth Ward.