# TEST

# OF

# MALLET ARTICULATED

# COMPOUND LOCOMOTIVE

# ON

# ERIE RAILROAD

BY

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&

SIDNEY DIAS GRIDLEY

1908.

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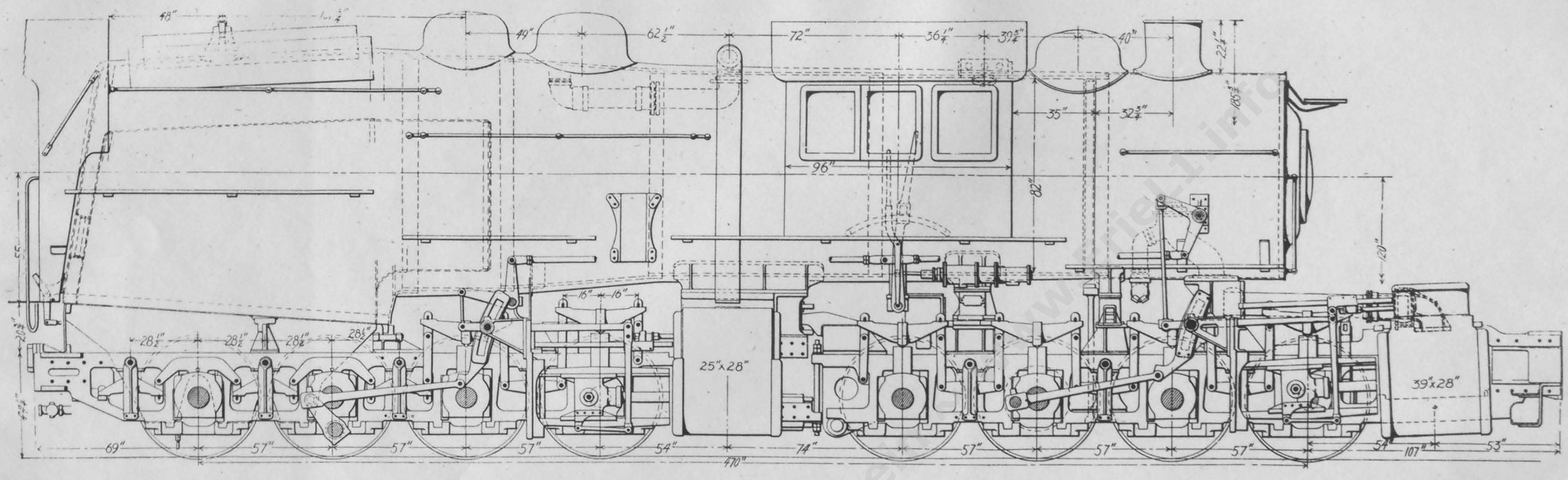
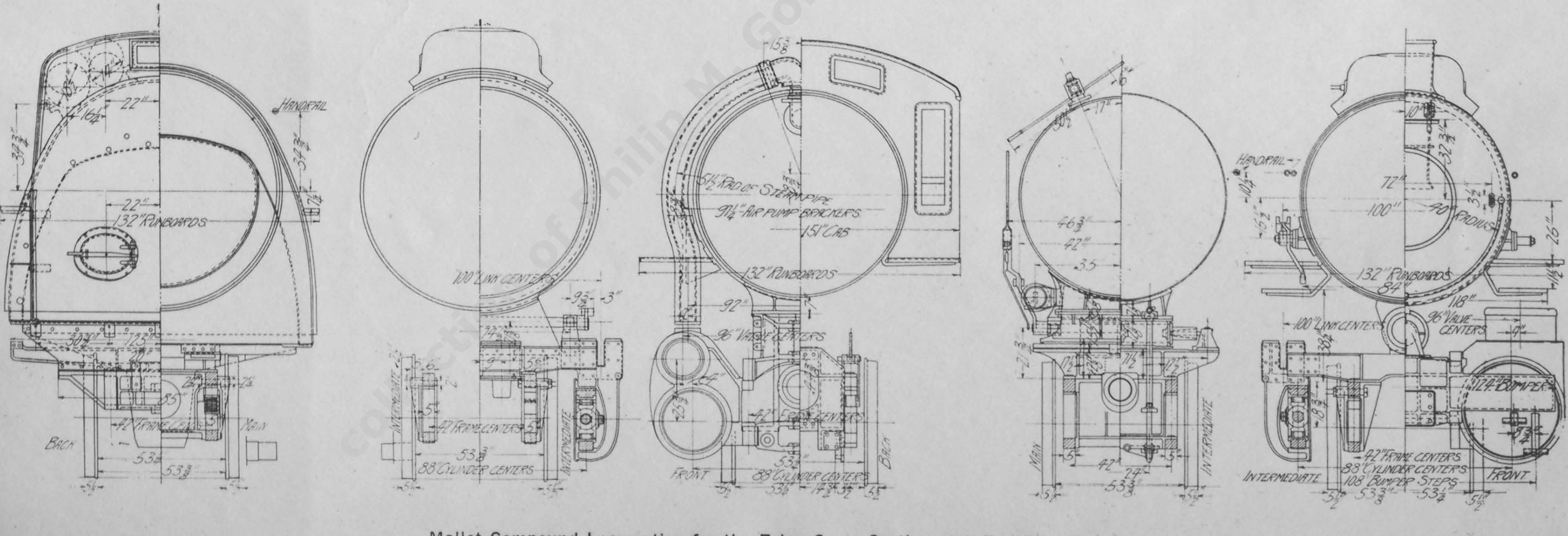
Erie Mallett Articulated Compound Locomotive.



Mallet Compound Locomotive for the Erie—Side Elevation.



Mallet Compound Locomotive for the Erie—Cross Section and End Elevation.

## Preface.

The authors wish to extend their thanks to the Erie Railroad for its kind loan of locomotive 2602 for the test, and for materials and aid in fitting up the locomotive. We are especially indebted to the following officials of the Erie;-
Mr. A.G.Trumbull, Mechanical Superintendent;
Mr. H.H.Harrington, Master Mechanic at Susquehanna;
Mr. W.H.Hunt, General Foreman at Susquehanna;
Mr. R.B.Watson, Chief Engineer of Tests. We also wish to thank Mr. Mellin, Chief Engineer of the American Locomotive Co. for his oversight and advice to us during the test.

We owe much to the advice and aid in looking up references to Prof. H Wade Hibbard of the Department of Railway Mechanical Engineering. Mr. E.A.Averill, editor of "The American Engineer and Railroad Journal" was of immeasurable value to us, both in making the test, by his knowledge and executive ability, and in working up the data, by his experience and technical skill. We also wish to thank Mr. M.F.Thomas and Mr. G.B.Upton, of the Sibley faculty, for their aid in preparing and calibrating instruments, for analysis of the coal used, and for their general advice and aid. For aid in fitting up the locomotive and conducting the test we are indebted to the following Sibley students:-

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We have made use of all available material in our descriptions,etc.. The history of the compound locomotive is taken from Gairus' "Locomotive Compounding and Superheating" and from a thesis published in 1891 by E.C.Lombard and H.G.Van Everen. The figures concerning the B.&O. locomotive are taken from a paper used by Mr. J.E.Muhlfeld of that road before the New York Railway Club; while the description of the Erie locomotive is taken from "The Railway Age", "The American Engineer and Railroad Journal", and from prints and information furnished by the American Locomotive Co. The results of the tests of the Pennsylvania Railroad at the St. Louis Exposition were also consulted frequently.

# Introduction.

The introduction of the Mallet articulated compound locomotive in America has been viewed with intense interest by all railway men. These locomotives with their immense power, coupled with ability to get around sharp curves, and their very favorable distribution of weight, allowing great increase in the weight of the locomotive without undue strain on the track and road bed, have given us a new and remarkably efficient factor in freight transportation. Their ability to haul the same trains with the same total motor weight without increasing the strain on the rails and under more favorable conditions of adhesion, since the total weight of the locomotive is on the drivers; their offering of less resistance on sharp curves than the large consolidation freight locomotives, in use to day, due to their shorter rigid wheel-base; and their saving in fuel and water by the use of compounding have made them a factor to be reckoned with by every railroad official.

These locomotives are at present mostly used as pushers up heavy grades where the freight traffic is very heavy. The Erie Railroad having put three of these locomotives in service and used them for six months, it was desired to give them a general test as to power developed, efficiency, and fuel

and water consumption. The Erie, having granted their consent to this test, the results obtained are here inclosed.

HISTORY.

The first attempt at compounding locomotives was made by Roentgen in France in 1834. This however was not developed practically . In 1850 Nicholson and Samuels patented a continuous expansion engine , which was used on the Eastern Counties Railway , now the Great Eastern Railway of England . Steam was admitted to the one cylinder for half the stroke ; the communication with the other cylinder , which was on dead-center , was established , and the steam expanded in both cylinders , thus allowing expansion in the first cylinder for half stroke and in the second cylinder for full stroke. These engines were not strictly compound , and the saving in cylinder condensation sought by compounding was not attained.

In 1853 Sutcliff invented a three-cylinder arrangement , with two high pressure cylinders outside operating the driving axle, and a low pressure cylinder inside, on an axle geared to the driving axle by a two to one gear. This cylinder ran at double the speed of the two high pressure cylinders, and was supplied alternately by their exhaust. In 1859 Salmon proposed a four cylinder engine , with two high pressure cylinders at the fire-box end,

driving the front axles, and two low pressure cylinders at the smoke-box end, driving the rear axles ; the connecting rods crossed, being in different planes.

In 1860 a tandem compound was invented by Kemp , and in 1866 Joy patented a compound in which the high pressure cylinders drove small drivers the low pressure cylinders larger ones , the different speeds compensating for the difference in pressure. Several modifications of the preceding systems were suggested during the next few years , but none proved practical.

In 1874 Monsieur Anatole Mallet patented a compound system in France ; this is one of the two systems of compounding in use today , the other being the Wordell - von Borries . In the Mallet system the engineer is given control of the use of boiler steam in the low pressure cylinders, while in the Wordell - von Borries system the engine is automatically converted into a compound after starting simple . This control is established by means of a distributing valve admitting live steam to both cylinders independently, while allowing the exhaust from the high pressure cylinder to pass into the stack. At first no reducing valve was used for the low pressure cylinders , and when working simple these cylinders did about

two or three times as much work as the high pressure cylinders . Later Mallet designed a reducing valve to obviate this , by means of which the live steam is admitted to a chamber through a small orifice allowing expansion and consequent reduction of pressure .

The term articulated, as applied to locomotives , means, that the locomotive is so constructed that some of the driving wheels may move in planes at an angle to the planes of the other driving wheels. This is done by having two sets of driving wheels operated from seperate cylinders thus allowing movement around sharp curves, although the wheel base is long. The usual type of articulated locomotive has part of the drivers on a bogie truck, operated by one set of cylinders , the other set of cylinders operating a set of drivers on the frame fastened rigidly to the boiler. Compounding is almost a necessity , as with engines of any power four cylinders are necessary and the boiler could not supply these while acting simple. This most common type of articulated locomotive was introduced by Meyer in 1867 , and adapted for compounding by Mallet in 1884 .

In the Mallet articulated compound locomotive the high pressure cylinders drive the rear or fixed set of drivers , while the low pressure cylinders drive the front drivers on the bogie truck. This

is done for the reason that the necessary ball-and-socket and telescopic steam joints can be made steam tight more easily for low pressure steam , and also because the exhaust is required to pass up the stack at the front end.

The Mallet articulated compound locomotive was first used in 1887 on the Decauville road and later on the St. Gothard Railway , and was quite extensively used in Europe before being introduced into America. The first large locomotive of this type in America was built by the American Locomotive works for the Baltimore and Ohio Rail Road in 1904 ; this locomotive was exhibited at the St. Louis Exposition , and was at that time the largest locomotive in the world. At the close of the exposition , the locomotive was put in service between Connellsville and Rockwood, a mountain division 43.4 miles long , in places the ruling grade being 1% . The locomotive often, singly , moved loads of 2300 tons over this division in four hours . At the end of one year some figures of its performance were made public : Among these:-

Total locomotive milage(computed) 44,976 mi.

Miles run per 2000#, 20 to 40%

volatile coal 9.[illegible] mi.

Gallons of water per 100 miles 15,[illegible] gls.

Pounds of water per lb.coal 5.87#

Miles run per pint engine oil 145 mi.
" " " " valve " 200 mi.
" " " pound crankpin grease 294 mi.
" " " ton of sand 485 mi.

Cost of labor and material for repairs , per 100 miles $3.16

Total operating and maintenance expenses, including all wages of engineers and round house men per 100 miles $24.50

The engine lost about 6% of its time in repairs.

It was estimated that the cost of a general pverhauling , at the end of the year, to put the locomotive in condition for another years service would be about $1000.

The following features of the locomotive seemed to give general satisfaction :-

(1). Flexible joints to high and low pressure cylinder , receiver and exhaust pipes.

(2). Articulated frame.

(3) . Intercepting , reducing and emergency valve and intermediate chamber system of compounding and simpling.

(4). Combination hand and power reversing gear.

(5). Walschaert motion valve gear.

(6). High pressure piston and low pressure double ported slide valves.

(7) . Single disc main throttle valve.

(8) . Tracking and riding qualities.

Most. of these features have been incorporated in the later designs.

This type of locomotive gave the following results :-

(1) Large tractive power for starting trains on heavy grades.

(2) Hauling of trains with the same total motor weight without increasing the strain on the rails, and under more favorable conditions of adhesion, since total weight is on the drivers.

(3) Offering of less resistance on sharp curves.

(4) Saving of fuel by compounding.

(5) Elimination of retarded movement and stalling of trains because of slipping of drivers since, if one set starts to slip, the other takes up more work, and the locomotive grips the track without throttling the steam supply.

(6) A minimum capital investement , repairs, fuel, crew, and supply bill per ton mile.

(7) A sub-division of power and balancing, resulting in minimum strains on locomotive and track.

(8) Ability to move itself and one half its rating in case one set of machinery or engine becomes disabled.

Because of the success of this locomotive, in 1906 the Great Northern Rail Road ordered five of them for use as pushers on mountain grades, and later ordered twenty-five more for heavy road service.

In 1907, the Erie Rail Road ordered three locomotives of this type for use as pushers on the road between Susquehanna, Pa., and Gulf Summit N.Y., a distance of eight miles, on a ruling grade of 1.3% . At this point the heavy freight traffic of the Erie line between New York and Chicago is carried over the divide between Susquehanna and Delaware Valleys. These engines took the place of three pushers, whereas the B & O locomotive had taken the place of two pushers. These engines were numbered 2601, and 2600, and 2602. This test was run on Number 2602.

A comparrison of these Erie locomotives with the B. & O. and the two orders of Great Northern locomotives of this class is given on the next page.

| Owner | Erie. | G.N. | G.N. | B.&O. |
| --- | --- | --- | --- | --- |
| Number of Locomotives. | 3 | 25 | 5 | 1 |
| Type. | 0-8-8-0 | 2-6-6-2- | 2-6-6-2 | 0-6-6-0 |
| Builder. | American Loco. Co. | Baldwin Loco..Co. | Baldwin Loco. Co. | American Loco. Co. |
| Total Weight in pounds. | 409,000 | 288,000 | 355,000 | 334,500 |
| Weight on drivers #. | 409,000 | 250,000 | 316,000 | 334,500 |
| Tractive effort, #. | 94,8000 | 57,760 | 71,600 | 70,000 |
| Size of cylinders. | 25"&39"x28" | 20"&31"x30" | 21½"&33"x32" | 20"&32"x32" |
| Diameter of boiler. | 84" | 72" | 84" | 84" |
| Steam pressure in pounds. | 215" | 210" | 215" | 235" |
| Diameter of drivers. | 51" | 55" | 55" | 56" |
| Total heating surface. sq.ft. | 5313.7 | 3906 | 5703 | 5600 |
| Total weight divided by heat.surf. | 76.9 | 73.8 | 62 | 59.5 |
| Total heating surface divided by cylinder vol. | 222 | 229 | 275 | 295 |
| Total heating surface divided by grate area. | 53 | 73 | 73 | 77.3 |
| B.D.Factor. | 910 | 813 | 690 | 700 |

By this it will be seen that in 1908, when these tests are made, these locomotives are the largest and most powerful in existance.

## Method.

The test consisted of a series of five runs. The first four runs were a general test, while the fifth run was made merely for coal and water consumption.

Readings were taken every three minutes for steam pressure, injector, reverse lever and throttle positions, pressure of calorimeter in inches of mercury and water, and temperature in branch pipe from steam dome to high pressure cylinder, revolutions per minute on front engine, revolutions per minute on rear engine, cards from each end of each cylinder, temperature and pressure in receiver, temperature of exhaust steam, pyrometer, and vacuum manometer in inches of water. Water was measured at beginning and end of run, coal was weighed as required, and flue gas analysis were made as frequently as possible. In the dynamometer car, besides the record, the mile posts were marked as were the places on the runs where readings were taken. A clock arrangement marked off fifteen second periods on the record.

Signals were given by a short blast on the locomotive whistle. This worked very well as is shown by the fact that every observer's book checked up in number of readings at end of each run. Effort was made to start the test just as the

engine was nearing the iron bridge at Lanesboro.

A preparatory signal for starting test was two short whistles followed in about a minute time by the first short blast. This indicated the first reading of the run.

The Coal.

The coal was weighed up as needed for the fire. This was arranged by having a wooden partition placed in the tender, behind which was the coal. In front was a scales mounted on a platform, and on the scales was a can into which the coal was shoveled; it was then weighed and dumped out for the use of the fireman.

The Water.

The tender was unhitched while the engine was fitting up, and was emptied of all coal and filled to the top of tank with water. This height was measured.

Tender was then placed on scales, previously calibrated, and water was let out an inch at a time, the tender being weighed each time. When all the water was out, the tender was weighed empty, and the other readings minus the weight of the tender gave the weight of water for each inch. Thus when the test was started, a reading was made and when the test was finished a reading was also made, and the weight at the first reading minus weight at the second gave the weight of water used.

The injector was in service nearly all the time, and while running, a leak occured. This leak was weighed up for the time the injector was on during the run, and a correction subtracted from the total water used to cover the leakage.

The steam pressure was read in the cab from a guage calibrated with a standard guage and found to be accurate. The positions of the reverse lever and throttle were also observed in the cab, this being done by observing the notches from full gear.

The revolutions per minute were recorded for both front and rear engines by means of revolution counters. These counters recorded for each revolution and were so placed that the lever of the counter was connected to the rocker of the Waelschaert valve motion. Readings were taken on these every minute, and time recorded so as to check up at end of run with other observer's time.

For the quality of the high pressure steam a throttling calorimeter was used. This was inserted into the branch pipe about midway between the entrance to the cylinder and the return pipe in the boiler. The manometer read in inches of mercury. Temperature of the steam was also read, as was the steam pressure in the branch pipe. From this data the quality was obtained.

On the receiver a similar arrangement was

placed, just at the point where receiver separated into the two pipes leading to the two low pressure cylinders. The exhaust steam temperature was read on the thermometer placed just at the elbow of the exhaust pipe.

The vacuum guage was arranged so that a pipe perforated on the inner end was inserted on the left side of the smoke box. The perforated end of the pipe was in front of the diaphragm, and on the other end outside of the smoke box, a manometer was adjusted to read in inches of water.

The pryrometer was inserted on the right side of the smoke box, and behind the diaphragm in such a position with respect to the tubes that an average temperature could be obtained; but owing to poor adjustement of the pryrometer itself, the readings can not be relied on to any extent. A calibration of this pryrometer was made and the curve is shown in this report.

For the flue gas samples, a pipe was inserted thru the front plate of the locomotive, reaching to the tubes. By this means a good sample of the flue gas was obtained and the steam jet was avoided. The flue gas was analyzed immediately after each sample was taken. The apparatus used was the Orsat flue gas case, which consisted of three tubes, one with sodium hydroxide, one with phosphorus pentoxide, and the third with cuprous chloride. The hydroxide mixture was used to extract the $CO_2$ in the gas,

the phosphorus to extract the oxygen, and the cuprous chloride to remove the CO. The remainder of the gas was assumed to be Nitrogen.

The indieators were four in number, and were of the Thompson make. The holes in the cylinders were tapped for $\frac{3}{4}$ inch pipe, and were in a plane parallel to the ground. The pipes were given radii of about four inches and were made with easy curves. The piping from each hole to the three way cocks was in two pieces. One piece had a radius of about four inches and was screwed into the tap. The other piece had a long gradual curve, being connected at one end to the first pipe by a coupling and at the other end to the three way cock, so a reducing coupling was necessary. This was fitted for $\frac{1}{2}$" pipe. The piping was so arranged that the indicator drum would unroll in a straight line parallel to the motion of the cross head. All the piping was heavily covered with asbestos and canvass, and offered very little opportunity for radiation. The reducing motion was accomplished by means of reducing wheels. These wheels allowed an adjustment of stroke that would give a good lanfth of card. Owing to the difficulty of fastening and unfastening the string to the reducing wheel and on the cross head upright, an iron plate was so fastened to each indicator that the reducing wheel was about eight inches from the indicator;

between the indicator and reducing wheel the string could be hooked and unhooked. This did away with the necessity of attaching the card to the upright each time, allowing the string from the upright on the cross head reducing wheel to keep in motion, while the indicator could be stopped for adjusting cards by unfastening hooks on strings between the reducing wheel and the indicator. The diagram for the head and crank end of each cylinder for the same reading was taken on the same card.

Upright.

To get the same motion to the reducing wheel as the crosshead, an iron plate was bolted to the crosshead to which was fastened an upright, $\frac{1}{2}$"x$\frac{1}{2}$" stock, securely braced. The upright moved in a straight line; as far as the indicator motion was concerned, this did not introduce the error of a varying angle as the crosshead changed its position. Cards were taken on the low pressure cylinder by having the indicator men sit on the cylinders; but on the high pressure cylinders, owing to the lack of room, a platform had to be built in front of the cylinders. This platform was held in place by two iron supports, fastened at the top to the cab floor, and held rigidly at the bottom by a clamp attached to the relief cock of the high pressure cylinder. A flooring pn this brace completed the platform. The men could get on and off

at will, owing to the slow speed of the locomotive and were in no danger. A railing protected the men at the front end. This was erected on the front of the engine. This consisted of an iron brace, shaped like an inverted U and fastened to the by-pass valve studs on the front and back of the low pressure cylinders, these bracings being connected by a crossbar at the front.

The Dynamometer Car.

This car was the Erie dynamometer car which has a capacity of 70,000 pounds either in tension or compression. It was in charge of the Superintendent of Tests of the Erie R.R. The dynamometer was of the spring type; by means of a system of levers it moved a beam across the paper. The paper was attached to a set of rollers; these were fixed to a mechanism or train of gears, intermeshing with the car axle, causing the paper to move one foot to the mile. To the beam indicating tension or compression a pencil was attached giving a graphical record. To a stationery beam was fixed a pencil, giving the zero or datum line. Lines were drawn on either edge of the paper one recording a mark every fifteen seconds, the other by means of an electrical circuit recording at will, marks for mile posts and readings. The dynamometer car also contained two speed recorders but because of the very slow speed of the engine , these could not be used owing to their inaccuracy.

For the running of the test the following men were necessary:

3 men to shovel coal.

1 " " weigh coal and take water measurements.

1 " in engineer's cab.

1 " for high pressure calorimeter.

1 " " speed of front engine.

1 " " " " rear " .

1 " " pyrometer.

1 " " vacuum manometer.

1 " " low pressure calorimeter and exhaust temperature.

1 " " flue gas.

1 " " high pressure right indicator.

1 " " low pressure right indicator.

1 " " high pressure left indicator.

1 " " low pressure left indicator.

2 " " dynamometer car records.

The run consisted of a trip from Susquehanna Pa. to Gulf Summit N.Y. This piece of track is about eight miles long and has a heavy grade varying from % to % , with several very heavy curves . The engines are used for pushing East bound freight up this grade, and are at present doing the work formerly performed by 3 and 4 decapod type engines. The run lasts between an hour and an hour and a half depending on condition of track, load, etc..

Description of the Locomotive.

The boiler of this locomotive is designed for 215# per sq. in.. It is of the radial stay type, with a length overall of 43 ft. It is equipped with a combustion chamber of 4 ft. in depth, radially stayed to the shell of the boiler. The widest part of the boiler is at the back end base, measuring 126 inches.

The back head has a slope from base to top of 16" in a distance of 99¾", the height of the boiler at this end. The distance betweenthe back head and the fire-box sheet is 6". The fire-doors are two in number, and are 20"x16".

The fire box is of the Wooten type and is 126" long x 114" wide, with a depth at the back end of 72", being provided with a rocking grate. The water space at the mud-ring is 5" on all sided.

The thickness of the boiler plate varies from 1&1/8" at the gusset to 1" at the sheet next the smoke-box. The thickness of the smoke-box sheet is 1/2". The back head has a thickness of 5/8", while the fire-box sheet is 3/8".

There are 404 tubes of charcoal iron, weighing 23,700#, each having a length of 21 ft. and an outside diameter of 2¼". The tube sheet at the combustion chamber end is 9/16" thick, while at the smoke-box end, the sheet is 3/4". The smoke-box is

about 84" long, and has an outside diameter of 87". The weight of the boiler complete is 97,200#, and it holds 42,700# of water.

The receiver pipe is 9" in diameter, and extends forward from the cylinder saddle, being connected to the latter by a ball-joint. It is made up of three sections to facilitate removal for repairs. At the front end it is connected to a curving Y pipe by means of a slip-joint, allowing variations in length due to curving. Thru this Y pipe steam passes to the low pressure cylinders. The receiver pipe allows a 16 degree curve to be passed over. Steam for the low pressure cylinders exhausts thru a flexible pipe connection to the exhaust pipe in the smole-box.

The part of the weight of the boiler resting on the forward engine is supported by a self-adjusting sliding bearing located between the third and fourth driving wheels. This bearing consists of a built up saddle casting, which extends down, bearing on a cast steel cross-tie directly below it thru a wrought iron, case hardened sliding plate. Brasses are introduced between the boiler bearing casting and the wrought iron plate. The sliding plate is planed radially on the bottom, adjusting itself to the alignment of the engine; the load on the sliding plate is at all times perfectly distributed, there being no cutting of the wearing surfaces. Movement in a vertical direction is

prevented by a safety connection between the boiler bearing casting and the cross tie, which prevents the frames from hopping away from the boiler in case of derailment. There is also a similar connection provided at the front end of the boiler between the guide yoke casting and the exhaust pipe below.

Another sliding support is located between the second and third pair of driving wheels. This support is so adjusted that it does not take any of the load except under unusual conditions when inequalities in the road bed make it necessary. It is provided with a floating balanced device, which serves to take some of the load off the main boiler bearing. This device consists of a pair of columns, one on either side of the center of the engine, free to sway as the engine turns thru curves; these columns have a ball-joint connection at the upper ends, with a saddle castings bolted to the boiler and a ball-joint connection at the lower ends with flap castings hinged to the bottom of a cross-tie across the lower rails of the frame. Around the outer ends of these hinged castings are U bolts the horns of which extend up thru the bottom of the cross-tie, and thru coiled springs seated on the cross-tie. These springs thus exert an upward sorce on the columns equal to the total compression of the springs. The initial total compression is 30,000#, which can be increased by

screwing down the spring caps by means of nuts on the ends of the bolts. This boiler support is also provided with a spring centering device. Another sliding support is formed between the exhaust pipe elbow and the guide yoke casting, also forming a connection between the frames and the boiler.

A novel design of throttle valve has been fitted to these locomotives, which in addition to taking steam at the top only, also acts as a steam separator. The arrangement is such that the entering steam strikes against a curved surface on which the entrained water will be deposited, and following this surface will pass down thru the center of the valve to an outlet belw. The top of the casting does not take a bearing and hence does not in any way act as a valve. The steam is led from the throttle pipe thru a short dry-pipe to a joint directly above the high pressure cylinders, where it passes thru the shell to a T-head on top of the boiler, and thence thru wrought iron steam pipes on either side to the top of the high pressure steam chest.

The intercepting valve is simplelin operation. In starting live steam enters thru the head and causes the valve to move due to differential areas being exposed to the pressure, causing unbalancing. This movement closes the high pressure exhaust and allows the steam to enter the receiver thru a reducing valve. After a few revolutions acting

sufficient pressure is accumulated by the exhaust of the high pressure cylinder to force it open against the pressure of the live steam on the differential area of the reducing valve, This opens the intercepting valve and at the same time closes the reducing valve. The engine is then working compound. The reducing valve being loose on the stem of the amin valve is capable of sufficient movement to close the live steam inlet independently of the movement of the main valve, thus working as an ordinary differential reducing valve to restrict the pressure in the low pressure cylinder to the amount determined upon in equilizing the work of the two cylinders.

In case it is desired to work the engine simple for a longer period in starting the emergency exhaust valve is opened admitting steam behind the piston by means of a three way cock inn the engineer's cab, which allows the exhaust from the high pressure cylinder to escape to the atmosphere and prevents the accumulation of pressure behind the main valve. In changing from compound to simple the balancing piston and chamber, features peculiar to the Mellin compound, came into play. The balancing chamber is of small volume, opening into the receiver thru six ¾" holes in the balancing piston, which ordinarily suffice to equalize the pressure between them. But upon opening the emergency exhaust valve, this chamber is emptied more rapidly than

the area of these holes can supply it, with the result that the intercepting valve is closed instantly by the pressure on the balancing piston. This prevents the loss of pressure in the receiver which would be necessary to shut the valve in the ordinary manner, and avoids a drop in the power of the engine right at the sticking point.

A by-pass valve is used on the low pressure cylinders whose office is to prevent an air pump action of the pistons while drifting; this action would create a draught thru the exhaust pipe as good as that when working under steam. When working under steam, the pressure from the steam chest keeps these valves closed. But on shutting the throttle a partial vacuum is soon formed in the steam-chest, which acting on the ends of the valves causes them to open and establish direct comminidation between the opposite inds of the cylinders. Owing to the extreme width of the fire-box it was necessary to place the cab over the boiler shell near the front, and hence all the controlling apparatus, injectors, etc., are located on the right hand side.

Inspite of the fact that the locomotive weighs 409,900#, it has a weight per driving axle that is less than many large consilidation freight locomotives, thus allowing an enormous amount of power to be centered in one machine, which is still capable of operating over the same track that other

heavy freight locomotives use. The frames are of cast steel; special attention being paid to obtain a thorough system of cross-bracing. The front and rear frames are joined by a 5" pin connection thru castings secured ahead of the high pressure cylinder. The 2" vertical bolts connecting the upper rail of the front frame with the lower rail of the rear frame are fitted with ball-joints to permit free movement of the two frames relative to each other, and are provided to hold the frames in line and prevent binding on the hinged connection.

Of the 16 journal boxes, the four under the main drivers, the third in each group, are 10"x13", while those under the other drivers are 9"x13". The drivers are 51" in diameter.

The high pressure cylinders are cast in pairs with saddles, the separation between the two cylinders being 8½" to the right of the center. This permits the intercepting valved to be placed in the left cylinder casting, and also gives room for the connection to the receiver pipe. The low pressure cylinders are cast in pairs, the connection to the receiver pipe being made thru a Y shaped casting connected at the back to the cored passages in the cylinders. The exhaust is carried thru an elbow located at the top, and in the center , to a short pipe with universal joints leading to the exhaust pipe in the front

end. The high pressure cylinders are fitted with piston valves having internal admission, and the low pressure cylinders have balanced Richardson slide valves with external admission. The diameter of the high pressure cylinders is 25", of the low pressure is 39". This is in accordance with the general principal in the Mallet compounds of having the ratio about 1½ to 1, thus equilizing the work done by the high and low pressure cylinders. The stroke is 28".

The valve gear, which is of the Walschaert type, is so arranged that the return crank leads the pin in both sets, and hence the block is at the bottom of the link for forward motion for the low pressure cylinders and at the top of the link for the high pressure cylinders. In this way the weight of the two valves counterbalancing.

The operation of reversing is further assisted by a pneumatic reversing device, which is connected to the reverse lever and consists of two cylinders, one of which contains oil under pressure for locking the device in any desired position, the other cylinder being the air cylinder. The operation of this device is controlled from an auxiliary reversing lever in the cab.

## General Data.

| | |
|---|---|
| Guage | 4 ft. 8½ in. |
| Sefvice | Pushing |
| Fuel | 2 Bituminous Coal |
| Tractive effort, compound | 94,800# |
| Weight in working order | 409,000# |
| Weight on drivers | 409,000# |
| Wt. engine and tender, working order | 572,000# |
| Wheel base, driving | 39ft. 2 in. |
| Wheel base, total | 39ft. 2 in. |
| Wheel base, rigid | 14ft. 3 in. |
| Wheel base, total, engine and tender | 70ft. 5½in. |
| Brake | New York Air |

### Ratios.

| | |
|---|---|
| Weight on drivers÷ tractive effort | 4.32 |
| Total weight ÷ tractive effotrt | 4.32 |
| Tract.ef. x diam.drivers ÷heat,sf. | 910.00 |
| Total heat.surf. ÷ grate area | 53.14 |
| Fire box sf. ÷ total heat. sf. % | 6.46 |
| Weight on drivers ÷ total heat. sf. | 76.90 |
| Volume both cylinders, cu.ft. | 24.00 |
| Total heat sf. ÷ volume cylinders | 222.00 |
| Grate area ÷ volume cylinders | 4.17 |

### Cylinders.

| | |
|---|---|
| Kind | Mellin compound |
| Number | 4 |
| Diameter | 25" and 39" |
| Stroke | 28" |
| Piston rod, diameter | 4½" |

## Cylinder Clearances.

| | |
|---|---|
| Vol of clearance, H.E. & C.E. H.P. cyl, | 10.2% |
| " " " " " " " " " " " " " " | 1400 cu.in |
| " " " " " " " " " " L.P. " " | 8.3% |
| " " " " " " " " " " " " " " | 2500cu.in |
| " " receiver cylinder, pump & pipe | 37 cu.ft. |

## Wheels .

| | |
|---|---|
| Driving, diameter over tires | 51" |
| Driving, thickness of tires | 3½" |
| Driving journals, main, diameter and length | 10"x13" |
| Driving journals, others, " " " " " " | 9"x13" |

## Boiler

| | |
|---|---|
| Type | Radial stay |
| Style | Straight with Conical Connection |
| Working pressure | 215# |
| Outside diameter of first ring | 84" |
| Firebox type | Wooten |
| Firebox, length and width | 126 1/8"x114¼" |
| Firebox plates, thickness | 3/8" and½" |
| Firebox water space | 5" |
| Tubes, material | Charcoal iron |
| Tubes, number | 404 |
| Tubes, guage | 0.125mm. |
| Tubes, outside diameter | 2¼" |
| Tubes, length | 21' |
| Heating surface, tubes | 4,971.5 sq.ft. |
| Heating surface, firebox | 342.2 sq.ft. |
| Heating surface, total | 5313.7 sq. ft. |
| Stack diameter | 18" |

| | |
|---|---|
| Stack, height above rail | 15ft.5¾". |
| Center of boiler above rail | 120". |

Tender.

| | |
|---|---|
| Tank | Water bottom |
| Frame | 12"-40#Channels |
| Water Capacity | 8500 gals. |
| Coal Capacity | 16 tons |
| Wheels diameter | 33" |
| Journals, diameter and lenght | 5½"x10" |

## Conclusions

Below is given a table of results as obtained on the Pennsylvania R.R. tests, at the St. Louis Exposition on freight locomotives running at about the same speeds as the locomotive under test:-

| | P.R.R. | Erie. |
|---|---|---|
| Speed, mi. per hr | 6.7-7.5 | 5.0-6.5 |
| I.H.P. | 454-633 | 800-1141 |
| D.H.P. | 373-557 | 584-999 |
| Dynamometer push, lbs. | 20800-31100 | 41000-66000 |
| Mech. Eff. | 82.2-94 | 73.0-87.1 |
| Dry coal per sq' grate area per hour | 21.7-60.3 | 34.2-49.1 |
| Dry steam per sq' heating surface per hour | 3.5-6.1 | 3.3-7.9 |
| Dry steam per lb. dry coal | 7.6-10.1 | 5.1-10.0 |
| Lbs. steam per I.H.P. | 20.3-27.3 | 22.0-37.5 |
| " " " " " D.H.P. | 21.6-33.2 | 30.0-46.3 |
| Draft in inches of water | 0.9-3.1 | 3.0-5.0 |
| Efficiency of boiler | 58.6-78.4 | 48.0-80.5 |
| Heat efficiency of locomotive | 4.2-8.0 | 2.0-5.1 |

These comparrisons tend to show that the locomotive compares favorably with modern standard freigh practice in locomotives at about the same speed.

The test of this locomotive was made in actual service, no special repairs having been made on the locomotive previous to the test. Difficulty was experienced in the third and fourth runs with the blower, causing the engine to steam poorely.

The fact that these engines have taken the place of three pushers, allows savings to be made in fuel, supplies, crew, repairs, and round-house labor.

During the six months in their service, the tires by actual measurment had worn from 51 inches to $50^{5}/8$ inches, the wear being uniform on all the driv(ers)

Considering the conditions under which this locomotive has been during the time it has been in service, i.e., severe grade, wintry weather, and severe and sudden variations in load, it is in very good condition, not having been laid up for serious repairs as yet.

Of these three locomotives, one is kept in reserve, the other two pushing an average of seven or eight trains each day of 24 hours up the grade from Susquehanna to Gulf Summit. These trains average about 60 tp 70 loaded cars, or about 3000 to 3500 tons.

As to the dynamometer records, these show the steady pushing obtainable from this type of engine. In various parts of the records, severe vibration appeared, indicating slip as was marked on one of the plates shown. Quite frequently, however, straight lines were recorded for some distance. An example of this also appearing on the print. This line indicates the steady even push that was given when the engine was working compound, steam being admitted, and cut off occurring at the same time in

the cylinders on the same side of the engine. There were some places in the record where the push was greater than 70,000#, the capacity of the car. In such a case, the recording lever was unfastened, these cases, however were few and ~~for~~ in all lasted for a very short period.

The coal used on the test was Bituminous and was from the Dagus Mine of the Erie R.R. A sample of coal was taken from each run, pulverized, and placed in a glass jar, analyses were taken of these separate samples, but did not prove satisfactory, so they were mixed and an average analysis taken, which was used in working up the data.

Moisture in the coal was about 3.1%, the ash about 15.7%, ~~the~~ volatile matter 28.4% leaving fixes carbon of 52.8 %. The calorific value of the coal was 12,000 B.T.U. per pound.

Analysis of the flue gas pointed out the good service rendered by the combustion chamber, the percentage of CO being very small.

# CALIBRATION.

## Thermometers

| Standard | #6 | #4 | #1 | #3 |
|---|---|---|---|---|
| 201 | 205 | 238 | 204 | 228 |
| 219 | 222 | 256 | 222 | 244 |
| 239 | 242 | 275 | 242 | 264 |
| 262 | 263 | 296 | 262 | 286 |
| 268 | 262 | 297 | 262 | 288 |
| 281 | 282 | 316 | 280 | 305 |
| 298 | 298 | 332 | 297 | 322 |
| 319 | 318 | 352 | 317 | 341 |
| 338 | 337 | 370 | 335 | 360 |
| 360 | 356 | 390 | 356 | 380 |
| 385 | 380 | 414 | 380 | 404 |
| 402 | 396 | 431 | 396 | 421 |

| Standard | #5 |
|---|---|
| 35 | 38 |
| 48 | 60 |
| 55 | 63 |
| 65 | 69 |
| 75 | 75 |
| 85 | 83 |
| 95 | 92 |
| 105 | 106 |

| Standard | #2 |
|---|---|
| 40 | 38 |
| 50 | 48 |
| 62 | 61 |
| 70 | 70 |
| 80 | 80 |
| 90 | 91 |
| 100 | 102 |
| 110 | 106 |

# CALIBRATION.

## Indicator Springs.

| Actual Pressure #/sq. in. | R.L.P. Spring #/sq.in. | L.L.P. Spring #/sq. in. | R.H.P. Spring #/sq. in. | L.H.P. Spring #/sq.in. |
|---|---|---|---|---|
| 10 | 11.0 | 11.0 | 10.3 | 10.5 |
| 20 | 21.0 | 21.5 | 19.5 | 19.5 |
| 30 | 31.5 | 31.5 | 29.5 | 29.0 |
| 40 | 41.0 | 41.5 | 37.5 | 37.5 |
| 50 | 50.5 | 51.5 | 47.5 | 47.0 |
| 60 | 60.5 | 62.5 | 56.5 | 57.5 |
| 70 | 70.5 | 71.5 | 66.0 | 67.0 |
| 80 | 80.5 | 82.0 | 75.0 | 76.0 |
| 90 | 90.5 | 92.0 | 85.0 | 85.0 |

# CALIBRATION.

## Tank (1)

| Height of water | Gross weight in pounds | Net Weight in pounds. |
|---|---|---|
| 5-11½ | 138,000 | 70,000 |
| 5-9½ | 136,740 | 68,740 |
| 5-8½ | 135,900 | 67,900 |
| 5-7 | 134,810 | 66,810 |
| 5-6 | 134,000 | 66,000 |
| 5-5 | 133,200 | 65,200 |
| 5-4 | 132,580 | 64,580 |
| 5-3 | 131,620 | 63,620 |
| 5-2 | 131,000 | 63,000 |
| 5-1 | 130,200 | 62,200 |
| 5-0 | 129,240 | 61,240 |
| 4-11 | 128,500 | 60,500 |
| 4-10 | 127,680 | 59,680 |
| 4-9 | 126,900 | 58,900 |
| 4-8 | 126,070 | 58,070 |
| 4-7 | 125,330 | 57,330 |
| 4-6 | 124,400 | 56,400 |
| 4-5 | 123,540 | 55,540 |
| 4-4 | 122,720 | 54.720 |
| 4-3 | 121,980 | 53,980 |
| 4-2 | 120,800 | 52,800 |
| 4-0½ | 119,700 | 51,700 |
| 3-11 | 118,200 | 50,200 |
| 3-10 | 117,360 | 49,360 |
| 3-9 | 116,500 | 48,500 |
| 3-7½ | 115,240 | 47,240 |

# CALIBRATION

## Tank (2).

| Height of water | Gross weight in pounds | Net weight in pounds |
|---|---|---|
| 3-6 | 113,980 | 45,980 |
| 3-5 | 113,000 | 45,000 |
| 3-4 | 112,040 | 44,040 |
| 3-3 | 111,080 | 43,080 |
| 3-2 | 110,100 | 42,100 |
| 3-1 | 109,050 | 41,150 |
| 3-0 | 108,200 | 40,200 |
| 2-11 | 107,270 | 39,270 |
| 2-10 | 106,340 | 38,340 |
| 2-9 | 105,380 | 37,380 |
| 2-8 | 104,400 | 36,400 |
| 2-7 | 103,480 | 35,480 |
| 2-6 | 102,550 | 34,550 |
| 2-5 | 101,550 | 33,550 |
| 2-4 | 100,560 | 32,560 |
| 2-3 | 99,580 | 31,580 |
| 2-2 | 98,600 | 30,600 |
| 2-1 | 97,590 | 29,590 |
| 2-0 | 96,580 | 28,580 |
| 1-11 | 95,540 | 27,540 |
| 1-10 | 94,500 | 26,500 |
| 1-9 | 93,600 | 25,600 |
| 1-8 | 92,700 | 24,700 |
| 1-7 | 91,620 | 23,620 |
| 1-6 | 90,540 | 22,540 |
| 1-5 | 89,240 | 21,240 |

# CALIBRATION.

## Tank (3).

| Height of water | Gross weight in pounds | Net weight in pounds |
|---|---|---|
| 1-4 | 87,940 | 19,940 |
| 1-3 | 86,670 | 18,670 |
| 1-2 | 85,400 | 17,400 |
| 1-1 | 83,050 | 15,050 |
| 1-0 | 82,700 | 14,700 |
| 0-11 | 81,400 | 13,400 |
| 0-10 | 80,100 | 12,100 |
| 0-9 | 78,660 | 10,660 |
| 0-8 | 77,160 | 9,160 |
| 0-7 | 75,960 | 7,960 |
| 0-6 | 74,700 | 6,700 |
| 0-5 | 73,300 | 5,300 |
| 0-4 | 71,800 | 3,800 |
| 0-3 | 70,620 | 2,620 |
| 0-2 | 69,860 | 1,860 |
| 0-1 | 69,000 | 1,000 |
| 0-0 | 68,000 | ----- |

# COAL ANALYSIS.

| | % |
|---|---|
| Moisture | 3.1 |
| Volatile Matter | 28.4 |
| Fixed Carbon | 52.8 |
| Ash | 15.7 |
| B.T.U. per pound | 12,100 |

COAL

Tare equals 25#.

Run (1)

| No. of reading | Gross weight, # | Net weight, #. |
| --- | --- | --- |
| 1 | 303 | 278 |
| 2 | 317 | 292 |
| 3 | 335 | 310 |
| 4 | 318 | 293 |
| 5 | 315 | 290 |
| 6 | 300 | 275 |
| 7 | 315 | 290 |
| 8 | 322 | 297 |
| 9 | 315 | 290 |
| 10 | 310 | 285 |
| 11 | 293 | 268 |
| 12 | 300 | 275 |
| 13 | 330 | 305 |
| 14 | 322 | 297 |
| 15 | 332 | 307 |
| 16 | 325 | 300 |
| 17 | 299 | 274 |
| 18 | 291 | 266 |
| | | 5192.0 |
| | Subtract 152 | 127.0 |
| | Weight burned | 5065.0 pounds. |

# COAL

Tare equals 25#.

Run (2)

| No. of reading | Gross weight, # | Net weight, # |
|---|---|---|
| 1 | 308 | 283 |
| 2 | 332 | 307 |
| 3 | 322 | 297 |
| 4 | 323 | 298 |
| 5 | 319 | 294 |
| 6 | 323 | 298 |
| 7 | 311 | 286 |
| 8 | 321 | 296 |
| 9 | 332 | 307 |
| 10 | 331 | 306 |
| 11 | 319 | 294 |
| 12 | 344 | 319 |
| 13 | 327 | 302 |
| | | 3887 |
| | Subtract 201 | 176 |
| | Weight burned | 3711 pounds. |

# COAL

Tare equals 25#.

Run (3)

| No. of reading | Gross weight, # | Net weight, # |
|---|---|---|
| 1 | 322 | 297 |
| 2 | 325 | 300 |
| 3 | 320 | 295 |
| 4 | 325 | 300 |
| 5 | 334 | 309 |
| 6 | 335 | 310 |
| 7 | 334 | 309 |
| 8 | 325 | 300 |
| 9 | 336 | 311 |
| 10 | 332 | 307 |
| 11 | 334 | 309 |
| 12 | 338 | 313 |
| 13 | 333 | 308 |
| 14 | 322 | 297 |
| 15 | 323 | 298 |
| 16 | 340 | 315 |
| 17 | 331 | 306 |
| 18 | 318 | 293 |
| 19 | 317 | 292 |
| 20 | 311 | 286 |
| 21 | 303 | 278 |
| 22 | 315 | 290 |
| 23 | 317 | 292 |
| 24 | 328 | 303 |

Weight burned 7218. pounds.

# COAL

Tare equals 25#.

Run (4)

| No. of reading | Gross weight, # | Net weight, #. |
|---|---|---|
| 1 | 327 | 302 |
| 2 | 335 | 310 |
| 3 | 328 | 303 |
| 4 | 325 | 300 |
| 5 | 309 | 284 |
| 6 | 307 | 282 |
| 7 | 308 | 283 |
| 8 | 300 | 275 |
| 9 | 304 | 279 |
| 10 | 263 | 238 |
| 11 | 280 | 255 |
| 12 | 325 | 300 |
| 13 | 310 | 285 |
| 14 | 315 | 290 |
| | Weight burned | 3986. pounds. |

# WATER

## Run (1)

| | | |
|---|---|---|
| Beginning of run | 5'-0 7/8" | 130,080 # |
| End of run | 1'-3" | 86,670 # |
| Total weight of water | | 43,410 # |

## Run (1)

| | | |
|---|---|---|
| Beginning of run | 5'-3$\frac{3}{4}$" | 132,340 # |
| End of run | 3'-3$\frac{3}{4}$" | 111,800 # |
| Total weight of water | | 20,540 # |

## Run (2)

| | | |
|---|---|---|
| Beginning of run | 5'-3" | 131,620 # |
| End of run | 1'-6$\frac{3}{4}$" | 91,350 # |
| Total weight of water | | 40,270 # |

## Run (3)

| | | |
|---|---|---|
| Beginning of run | 5'-3" | 131,620 # |
| End of run | 1'-0" | 82,700 # |
| Total weight of water | | 48,920 # |

# PYROMETER, DRAFT, EXHAUST TEMPERATURE.

Run ([illegible]) 1

| No. of reading | Pyrometer degrees F. | Draft inches of water | Exhaust temperature degrees F. |
|---|---|---|---|
| 1 | 510 | 4.4 | 207 |
| 2 | 510 | 4.6 | 202 |
| 3 | 510 | 5.0 | 207 |
| 4 | 510 | 5.0 | 202 |
| 5 | 510 | 4.0 | 202 |
| 6 | 510 | 4.0 | 202 |
| 7 | 510 | 5.0 | 202 |
| 8 | 510 | 4.5 | 202 |
| 9 | 510 | 5.5 | 202 |
| 10 | 510 | 5.5 | 202 |
| 11 | 510 | 5.5 | 202 |
| 12 | 510 | 4.0 | 202 |
| 13 | 510 | 5.0 | 202 |
| 14 | 510 | 5.5 | 202 |
| 15 | 510 | 5.5 | 202 |
| 16 | 510 | 5.5 | 202 |
| 17 | 510 | 5.0 | 202 |
| 18 | 510 | 5.5 | 202 |
| 19 | 510 | 5.5 | 202 |
| 20 | 510 | 3.5 | 202 |
| 21 | 510 | 4.0 | 202 |
| 22 | 510 | 4.0 | 202 |

# PYROMETER, DRAFT, EXHAUST TEMPERATURE.

Run (2)

| No. of reading | Pyrometer degrees F. | Draft inches water | Exhaust temperature degrees F. |
|---|---|---|---|
| 1 | 510 | 4.5 | 194 |
| 2 | 510 | 4.0 | 194 |
| 3 | 510 | 4.0 | 194 |
| 4 | 510 | 4.0 | 194 |
| 5 | 510 | 4.0 | 196 |
| 6 | 510 | 5.0 | 196 |
| 7 | 510 | 5.5 | 198 |
| 8 | 510 | 6.0 | 202 |
| 9 | 510 | 5.5 | 200 |
| 10 | 510 | 5.5 | 200 |
| 11 | 510 | 4.5 | 201 |
| 12 | 510 | 4.5 | 200 |
| 13 | 510 | 5.5 | 202 |
| 14 | 510 | 5.5 | 196 |
| 15 | 510 | 5.5 | 198 |
| 16 | 510 | 5.0 | 198 |
| 17 | 510 | 4.5 | 198 |
| 18 | 510 | 4.0 | 198 |
| 19 | 510 | 3.0 | 200 |
| 20 | 510 | 5.0 | 192 |
| 21 | 510 | 5.0 | 191 |
| 22 | 510 | 4.0 | 191 |
| 23 | 510 | 4.0 | 191 |

PYROMETER, DRAFT, EXHAUST TEMPERATURE.
Run (3)



| No. of reading | Pyrometer degrees F | Draft, inches of water | Exhaust temp. degrees F. |
|---|---|---|---|
| 1 | 510 | 4.0 | 222 |
| 2 | 510 | 5.0 | 222 |
| 3 | 510 | 4.0 | 224 |
| 4 | 510 | 4.0 | 230 |
| 5 | 510 | 2.0 | 235 |
| 6 | 510 | 0.0 | 240 |
| 7 | 510 | 4.0 | 230 |
| 8 | 510 | 4.0 | 240 |
| 9 | 510 | 4.5 | 235 |
| 10 | 510 | 5.0 | 238 |
| 11 | 510 | 4.5 | 238 |
| 12 | 510 | 4.5 | 240 |
| 13 | 510 | 4.0 | 238 |
| 14 | 510 | 3.0 | 240 |
| 15 | 510 | 6.0 | 240 |
| 16 | 510 | 4.0 | 244 |
| 17 | 510 | 4.0 | 250 |
| 18 | 510 | 3.0 | 254 |
| 19 | 510 | 4.0 | 244 |
| 20 | 510 | 4.5 | 252 |
| 21 | 510 | 4.5 | 240 |
| 22 | 510 | 4.0 | 230 |
| 23 | 510 | 5.0 | 238 |
| 24 | 510 | 5.5 | 240 |
| 25 | 510 | 5.0 | 236 |
| 26 | 510 | 3.0 | 242 |
| 27 | 510 | 6.0 | 254 |
| 28 | 510 | 4.5 | 256 |

# PYROMETER, DRAFT, EXHAUST TEMPERATURE.

Run (4)

| No. of reading | Pyrometer degrees F | Draft, inches of water | Exhaust temp degrees F. |
|---|---|---|---|
| 1 | 500 | 4.0 | 215 |
| 2 | 470 | 4.0 | 224 |
| 3 | 450 | 3.5 | 222 |
| 4 | 440 | 2.5 | 230 |
| 5 | 430 | 1.0 | 230 |
| 6 | 430 | 2.0 | 222 |
| 7 | 490 | 3.0 | 218 |
| 8 | 510 | 4.5 | 218 |
| 9 | 490 | 4.5 | 222 |
| 10 | 470 | 4.0 | 220 |
| 11 | 450 | 2.5 | 220 |
| 12 | 410 | 2.5 | 222 |
| 13 | 400 | 1.5 | 222 |

# High Pressure Calorimeter

## Run (1)

| No. of reading | Pressure in pounds | Temperature in degrees F | Manometer in. of Hg | Quality % |
|---|---|---|---|---|
| 1 | --- | --- | --- | --- |
| 2 | --- | --- | --- | --- |
| 3 | --- | --- | --- | --- |
| 4 | 175 | 270 ~~14.25~~ | 14.25 ~~270~~ | 99.2 |
| 5 | 190 | 273 | 12 | 98.4 |
| 6 | 180 | 270 | 15 | 99.0 |
| 7 | 180 | 268 | 11.25 | 99.1 |
| 8 | 185 | 268 | 10.5 | 99.0 |
| 9 | 190 | 270 | 12 | 99.3 |
| 10 | 180 | 271 | 15.25 | 99.2 |
| 11 | 180 | 270 | 14 | 99.2 |
| 12 | 190 | 265 | 14 | 98.5 |
| 13 | 194 | 264 | 14.25 | 98.0 |
| 14 | 195 | 272 | 15 | 98.9 |
| 15 | 195 | 276 | 15.25 | 99.4 |
| 16 | 185 | 276 | 15. | 99.5 |
| 17 | 180 | 272 | 15 | 99.1 |
| 18 | 190 | 273 | 14.75 | 99.3 |
| 19 | 185 | 273 | 15 | 99.3 |
| 20 | 182 | 272 | 15 | 99.3 |
| 21 | 180 | 272 | 14.75 | 99.3 |
| 22 | 180 | 272 | 14.5 | 99.3 |
| 23 | 180 | 272 | 14.75 | 99.3 |

Average quality 99.08 %

# High Pressure Calorimeter.

## Run (2)

| No. of reading | Pressure in pounds | Temperature in degrees F | Manometer in. of Hg | Quality % |
|---|---|---|---|---|
| 1 | 175 | 282 | 15 | 97.7 |
| 2 | 175 | 273 | 15.5 | 97.6 |
| 3 | 180 | 278 | 15 | 97.7 |
| 4 | 175 | 280 | 15.5 | 97.6 |
| 5 | 180 | 278 | 17 | 97.4 |
| 6 | 185 | 278 | 17 | 97.1 |
| 7 | 180 | 285 | 16.5 | 97.9 |
| 8 | 180 | 282 | 15 | 97.5 |
| 9 | 170 | 284 | 15 | 98.0 |
| 10 | 170 | 284 | 14 | 97.9 |
| 11 | 165 | 280 | 16.5 | 97.8 |
| 12 | 175 | 278 | 17 | 97.4 |
| 13 | 185 | 282 | 15 | 97.7 |
| 14 | 175 | 285 | 16 | 97.6 |
| 15 | 165 | 283 | 14 | 97.7 |
| 16 | 175 | 278 | 16 | 97.2 |
| 17 | 160 | 278 | 14 | 97.8 |
| 18 | 155 | 276 | 15 | 97.7 |
| 19 | 160 | 276 | 14 | 97.8 |
| 20 | 160 | 274 | 14 | 97.6 |
| 21 | 160 | 276 | 14. | 97.7 |
| 22 | 160 | 288 | 14 | 97.4 |

Average quality 97.65 %

# High Pressure Calorimeter
## Run (3).

| No. of reading | Pressure in pounds | Temperature in degrees F. | Manometer in. of Hg | Quality % |
|---|---|---|---|---|
| 1 | 175 | 298 | 13.5 | 98.7 |
| 2 | 175 | 298 | 13.5 | 98.5 |
| 3 | 170 | 296 | 13.5 | 97.3 |
| 4 | 168 | 296 | 13. | 97.5 |
| 5 | 163 | 296 | 13. | 98.7 |
| 6 | 160 | 295 | 12.5 | 98.5 |
| 7 | 190 | 286 | 16.5 | 97.5 |
| 8 | 190 | 296 | 17. | 98.1 |
| 9 | 180 | 298 | 16.5 | 98.5 |
| 10 | 175 | 298 | 16 | 98.5 |
| 11 | 170 | 298 | 15 | 98.7 |
| 12 | 173 | 298 | 15 | 98.5 |
| 13 | 160 | 298 | 14.25 | 97.8 |
| 14 | 180 | 298 | 16.5 | 98.1 |
| 15 | 186 | 296 | 16.5 | 98.8 |
| 16 | 185 | 298 | 18 | 98.9 |
| 17 | 180 | 298 | 16.5 | 98.3 |
| 18 | 177 | 296 | 19.5 | 98.4 |
| 19 | 175 | 296 | 16 | 98.5 |
| 20 | 165 | 296 | 14.5 | 98.4 |
| 21 | 172 | 298 | 15.25 | 98.6 |
| 22 | 185 | 298 | 17.5 | 98.6 |
| 23 | 190 | 298 | 19 | 98.6 |
| 24 | 173 | 298 | 16 | 98.6 |
| 25 | 185 | 300 | 18.25 | 98.6 |
| 26 | 195 | 300 | 19 | 98.6 |
| 27 | 184 | 300 | 18.5 | 98.6 |
| 28 | 160 | 298 | 15.5 | 98.6 |
| | | Average quality | | 98.39 % |

High Pressure Calorimeter.

Run (4).

| No. of reading | Pressure in pounds | Temperature in degrees F. | Manometer in. of Hg | Quality % |
|---|---|---|---|---|
| 1 | 145 | 294 | 10 | 99.0 |
| 2 | 135 | 293 | 10 | 99.0 |
| 3 | 125 | 288 | 7.5 | 99.0 |
| 4 | 120 | 280 | 7.5 | 98.7 |
| 5 | 112 | 276 | 6.5 | 98.8 |
| 6 | 163 | 278 | 13 | 97.8 |
| 7 | 157 | 284 | 12.25 | 98.2 |
| 8 | 155 | 288 | 12.3 | 98.4 |
| 9 | 135 | 292 | 9.5 | 99.0 |
| 10 | 125 | 288 | 9. | 99.0 |
| 11 | 120 | 286 | 9 | 98.9 |
| 12 | 112 | 280 | 7.5 | 98.8 |
| 13 | 107 | 280 | 6.5 | 98.9 |

Average quality 98.73 %

# Low Pressure Calorimeter.

## Run (2).

| No. of reading | Pressure in pounds | Temperature degrees F | Quality % |
|---|---|---|---|
| 1 | 50 | 228 | 97.9 |
| 2 | 50 | 228 | 97.9 |
| 3 | 50 | 228 | 97.9 |
| 4 | 50 | 228 | 97.9 |
| 5 | 50 | 228 | 97.9 |
| 6 | 50 | 228 | 97.9 |
| 7 | 53 | 230 | 98.0 |
| 8 | 53 | 228 | 98.4 |
| 9 | 50 | 236 | 98.4 |
| 10 | 50 | 236 | 98.4 |
| 11 | 50 | 230 | 98.1 |
| 12 | 50 | 230 | 98.1 |
| 13 | 50 | 232 | 98.2 |
| 14 | 50 | 232 | 98.2 |
| 15 | 50 | 232 | 98.2 |
| 16 | 50 | 230 | 98.1 |
| 17 | 50 | 230 | 98.1 |
| 18 | 48 | 230 | 98.1 |
| 19 | 47 | 230 | 98.2 |
| 20 | 48 - | 224 | 97.8 |
| 21 | 48 | 222 | 97.7 |
| 22 | 43 | 222 | 97.9 |
| 23 | 43 | 222 | 97.9 |

**Average quality** 98.05 %

## Low Pressure Calorimeter
### Run (3)

| No. of reading | Pressure in pounds | Temperature in degrees F. | Manometer inches of Hg | Quality % |
|---|---|---|---|---|
| 1 | 50 | 238 | 0.75 | 98.5 |
| 2 | 50 | 238 | 0.75 | 98.5 |
| 3 | 50 | 236 | 0.75 | 98.4 |
| 4 | 50 | 235 | 0.75 | 98.3 |
| 5 | 50 | 230 | 0.75 | 98.1 |
| 6 | 50 | 230 | 0.75 | 98.1 |
| 7 | 60 | 234 | 1.00 | 97.9 |
| 8 | 60 | 236 | 1.00 | 98.1 |
| 9 | 60 | 238 | 1.00 | 98.2 |
| 10 | 60 | 238 | 1.00 | 98.2 |
| 11 | 55 | 238 | 0.80 | 98.3 |
| 12 | 55 | 238 | 0.80 | 98.3 |
| 13 | 55 | 238 | 1.00 | 98.2 |
| 14 | 55 | 232 | 0.80 | 98.0 |
| 15 | 60 | 232 | 1.05 | 97.8 |
| 16 | 60 | 233 | 1.25 | 97.8 |
| 17 | 60 | 230 | 1.00 | 97.7 |
| 18 | 50 | 232 | 1.25 | 97.8 |
| 19 | 55 | 230 | 1.00 | 97.8 |
| 20 | 55 | 236 | 0.80 | 98.2 |
| 21 | 60 | 238 | 1.25 | 98.2 |
| 22 | 60 | 238 | 1.00 | 98.2 |
| 23 | 60 | 240 | 1.25 | 98.3 |
| 24 | 55 | 240 | 1.00 | 98.4 |
| 25 | 60 | 240 | 1.25 | 98.3 |
| 26 | 60 | 236 | 1.25 | 98.1 |
| 27 | 60 | 230 | 1.25 | 97.7 |
| 28 | 50 | 236 | 1.25 | 98.2 |
| | | | Average quality | 98.14% |

# LOw Pressure Calorimeter.

Run (4).

| No. of reading | Pressure in pounds. | Temperature in degrees F | Manometer inches of Hg. | Quality % |
|---|---|---|---|---|
| 1 | 50 | 260 | 2.00 | 99.6 |
| 2 | 48 | 262 | 2.00 | 99.7 |
| 3 | 45 | 258 | 2.25 | 99.6 |
| 4 | 40 | 254 | 2.50 | 99.6 |
| 5 | 40 | 254 | 2.50 | 99.6 |
| 6 | 50 | 252 | 2.50 | 99.4 |
| 7 | 55 | 256 | 2.25 | 99.2 |
| 8 | 55 | 262 | 2.50 | 99.5 |
| 9 | 50 | 266 | 2.50 | 99.6 |
| 10 | 45 | 258 | 2.25 | 99.6 |
| 11 | 40 | 256 | 2.50 | 99.7 |
| 12 | 40 | 254 | 1.00 | 99.6 |
| 13 | 38 | 252 | 1.00 | 99.7 |
| | | | Average quality | 99.56% |

## Card Data.

### Run 1. Right Low Pressure.Cylinder.

### Head End.

| No. of card. | Area, in sq. in. | Length, in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 1.66 | 3.00 | 33.8 | 123 | 75.0 |
| 2 | --- | --- | --- | --- | --- |
| 3 | --- | --- | --- | --- | --- |
| 4 | --- | --- | --- | --- | --- |
| 5 | 2.37 | 3.65 | 38.7 | 127 | 73.2 |
| 6 | 1.76 | 3.27 | 32.0 | 100 | 72.5 |
| 7 | 1.56 | 2.78 | 33.3 | 115 | 60.2 |
| 8 | 2.19 | 3.25 | 40.0 | 139 | 70.6 |
| 9 | 1.75 | 3.27 | 31.8 | 116 | 67.0 |
| 10 | 1.85 | 3.33 | 33.0 | 125 | 78.8 |
| 11 | 2.48 | 3.30 | 44.7 | 144 | 73.9 |
| 12 | 2.09 | 3.27 | 38.0 | 122 | 71.1 |
| 13 | 1.73 | 3.25 | 31.7 | 110 | 71.2 |
| 14 | 2.03 | 3.29 | 36.6 | 133 | 73.0 |
| 15 | 2.01 | 3.32 | 36.0 | 140 | 69.5 |
| 16 | 1.72 | 3.23 | 31.7 | 115 | 70.4 |
| 17 | 1.61 | 2.69 | 35.4 | 129 | 72.5 |
| 18 | 2.17 | 3.27 | 38.8 | 125 | 71.4 |
| 19 | 2.20 | 3.32 | 39.4 | 100 | 71.5 |
| 20 | 2.23 | 3.46 | 38.4 | 117 | 73.4 |
| 21 | 2.51 | 3.48 | 43.0 | 189 | 77.3 |
| 22 | 2.13 | 3.50 | 36.0 | --- | 70.9 |

Card Data.

Run 1. Right Low Pressure Cylinder.

Crank End.

| No. of card. | Area in sq. in. | Lenght in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 1.76 | 3.00 | 34.8 | 125 | 67.6 |
| 2 | --- | --- | --- | --- | ---- |
| 3 | --- | --- | --- | --- | --- |
| 4 | --- | --- | --- | --- | --- |
| 5 | 2.33 | 3.65 | 38.0 | 124 | 72.7 |
| 6 | 2.06 | 3.27 | 37.4 | 118 | 73.5 |
| 7 | 1.61 | 2.71 | 34.3 | 117 | 72.0 |
| 8 | 2.07 | 3.25 | 37.8 | 138 | 70.6 |
| 9 | 1.49 | 3.27 | 28.8 | 103 | 72.8 |
| 10 | 1.82 | 3.33 | 32.4 | 122 | 75.4 |
| 11 | 2.20 | 3.30 | 39.1 | 125 | 77.5 |
| 12 | 2.24 | 3.27 | 40.9 | 139 | 65.0 |
| 13 | 1.85 | 3.25 | 33.8 | 116 | 72.7 |
| 14 | 1.84 | 3.29 | 33.2 | 122 | 72.0 |
| 15 | 1.87 | 3.32 | 33.4 | 128 | 60.3 |
| 16 | 1.80 | 3.23 | 33.2 | 119 | 68.5 |
| 17 | 1.56 | 2.69 | 34.5 | 124 | 71.7 |
| 18 | 1.84 | 3.27 | 34.8 | 110 | 67.3 |
| 19 | 2.02 | 3.32 | 36.2 | 91 | 75.0 |
| 20 | 2.05 | 3.46 | 35.3 | 97 | 70.8 |
| 21 | 2.23 | 3.48 | 38.2 | 170 | 66.4 |
| 22 | 2.26 | 3.50 | 38.4 | ---- | 68.4 |

# Card Data.

## Run 1.

## Left Low Pressure Cylinder.

### Head End.

| No. of card. | Area, in sq. inches. | Length in, in. | M.E.P. in #/″ | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.35 | 3.83 | 36.0 | 131 | 73.1 |
| 2 | 2.41 | 3.79 | 37.4 | 129 | 65.0 |
| 3 | 2.40 | 3.74 | 37.8 | 131 | 65.0 |
| 4 | 2.61 | 3.78 | 40.5 | 140 | 68.0 |
| 5 | 2.53 | 3.76 | 39.7 | 131 | 68.4 |
| 6 | 2.74 | 3.81 | 42.0 | 131 | 61.0 |
| 7 | 2.44 | 3.77 | 37.8 | 131 | 69.5 |
| 8 | 2.51 | 3.80 | 38.5 | 143 | 79.5 |
| 9 | 2.44 | 3.79 | 37.8 | 137 | 72.8 |
| 10 | 2.69 | 3.80 | 41.4 | 157 | 72.5 |
| 11 | 2.42 | 3.77 | 37.5 | 117 | 68.3 |
| 12 | 2.45 | 3.79 | 37.6 | 118 | 73.9 |
| 13 | 2.68 | 3.78 | 41.4 | 143 | 75.8 |
| 14 | 2.56 | 3.82 | 39.6 | 144 | 76.5 |
| 15 | 2.43 | 3.77 | 37.8 | 147 | 68.2 |
| 16 | 2.32 | 3.73 | 36.3 | 132 | 67.6 |
| 17 | 2.36 | 3.75 | 36.2 | 131 | 74.2 |
| 18 | 2.55 | 3.80 | 39.7 | 127 | 74.3 |
| 19 | 2.29 | 3.78 | 35.6 | 91 | 73.8 |
| 20 | 2.69 | 3.75 | 42.0 | 117 | 73.5 |
| 21 | 2.44 | 3.78 | 37.8 | 167 | 76.7 |

## Card Data.

### Run 1. Left Low Pressure Cylinder.

### Crank End.

| No. of card. | Area , in sq. in. | Length, in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.43- | 3.83 | 3.73 | 133 | 70.0 |
| 2 | 2.54 | 3.79 | 39.4 | 134 | 67.3 |
| 3 | 2.52 | 3.74 | 39.6 | 136 | 66.8 |
| 4 | 2.48 | 3.78 | 38.6 | 132 | 72.7 |
| 5 | 2.72 | 3.76 | 42.5 | 138 | 77.4 |
| 6 | 2.64 | 3.81 | 40.8 | 126 | 72.5 |
| 7 | 2.45 | 3.77 | 38.2 | 131 | 75.6 |
| 8 | 2.55 | 3.80 | 39.4 | 144 | 77.5 |
| 9 | 2.65 | 3.79 | 41.2 | 148 | 73.1 |
| 10 | 2.69 | 3.80 | 41.8 | 157 | 69.3 |
| 11 | 2.45 | 3.77 | 38.2 | 121 | 72.1 |
| 12 | 2.59 | 3.79 | 40.2 | 127 | 72.5 |
| 13 | 2.73 | 3.78 | 42.7 | 146 | 78.0 |
| 14 | 2.59 | 3.82 | 39.9 | 146 | 71.3 |
| 15 | 2.50 | 3.77 | 39.0 | 149 | 73.2 |
| 16 | 2.28 | 3.73 | 35.9 | 129 | 66.7 |
| 17 | 2.34 | 3.75 | 36.7 | 132 | 72.0 |
| 18 | 2.42 | 3.80 | 37.6 | 119 | 72.6 |
| 19 | 2.50 | 3.78 | 39.0 | 97 | 72.8 |
| 20 | 2.61 | 3.75 | 40.0 | 110 | 68.3 |
| 21 | 2.35 | 3.78 | 36.5 | 158 | 75.5 |

Card Data.

Run 1. Left High Pressure Cylinder.

Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.47 | 3.77 | 105.5 | 165 | 65.1 |
| 2 | 2.37 | 3.63 | 103.9 | 156 | 59.0 |
| 3 | 2.32 | 3.39 | 107.4 | 145 | 78.2 |
| 4 | 2.54 | 3.62 | 109.6 | 153 | 69.9 |
| 5 | 2.69 | 3.65 | 105.7 | 135 | 72.1 |
| 6 | 2.77 | 3.60 | 120.6 | 146 | 72.5 |
| 7 | 2.62 | 3.67 | 111.6 | 143 | 72.2 |
| 8 | 2.65 | 3.65 | 113.9 | 154 | 74.3 |
| 9 | 2.65 | 3.61 | 114.9 | 163 | 74.8 |
| 10 | --- | --- | --- | --- | --- |
| 11 | --- | --- | --- | --- | --- |
| 12 | --- | --- | --- | --- | --- |
| 13 | --- | --- | --- | --- | --- |
| 14 | --- | --- | --- | --- | --- |
| 151 | --- | --- | --- | --- | --- |
| 16 | --- | --- | --- | --- | --- |
| 17 | --- | --- | --- | --- | --- |
| 18 | --- | --- | --- | --- | --- |
| 19 | --- | --- | --- | --- | --- |
| 20 | --- | --- | --- | --- | --- |
| 21 | --- | --- | --- | --- | --- |
| 22 | --- | --- | --- | --- | --- |

Card Data.

Run 1. Left High Pressure Cylinder.

Crank End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in# | I.H.P. | % cut off- |
|---|---|---|---|---|---|
| 1 | 2.68 | 3.77 | 105.0 | 159 | 74.0 |
| 2 | 2.49 | 3.63 | 107.9 | 166 | 70.4 |
| 3 | 2.21 | 3.39 | 87.8 | 115 | 76.7 |
| 4 | 2.63 | 3.62 | 114.3 | 153 | 73.2 |
| 5 | 2.55 | 3.65 | 110.0 | 137 | 73.0 |
| 6 | 2.82 | 3.60 | 123.4 | 145 | 72.2 |
| 7 | 2.77 | 3.67 | 119.9 | 148 | 72.7 |
| 8 | 2.61 | 3.65 | 112.3 | 147 | 76.2 |
| 9 | 2.51 | 3.61 | 109.3 | 151 | 75.3 |
| 10 | --- | --- | --- | --- | --- |
| 11 | --- | --- | --- | --- | --- |
| 12 | --- | --- | --- | --- | --- |
| 13 | --- | --- | --- | --- | --- |
| 14 | --- | --- | --- | --- | --- |
| 15 | --- | --- | --- | --- | --- |
| 16 | --- | --- | --- | --- | --- |
| 17 | --- | --- | --- | --- | --- |
| 18 | --- | --- | --- | --- | --- |
| 19 | --- | --- | --- | --- | --- |
| 20 | --- | --- | --- | --- | --- |
| 21 | --- | --- | --- | --- | --- |
| 22 | --- | --- | --- | --- | --- |

-

# Card Data.

## Run 1, Right High Pressure Cylinder.

### Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.85 | 3.42 | 130.5 | 204 | 72.8 |
| 2 | 2.52 | 3.40 | 116.5 | 170 | 70.9 |
| 3 | 2.36 | 3.41 | 107.3 | 145 | 72.5 |
| 4 | 2.67 | 3.40 | 123.0 | 171 | 75.0 |
| 5 | 2.58 | 3.45 | 117.0 | 150 | 67.6 |
| 6 | 2.63 | 3.41 | 120.7 | 146 | 76.3 |
| 7 | 2.74 | 3.43 | 125.0 | 160 | 70.9 |
| 8 | 2.54 | 3.39 | 117.8 | 158 | 75.0 |
| 9 | 2.60 | 3.40 | 120.0 | 170 | 77.6 |
| 10 | 2.42 | 3.42 | 110.4 | 154 | 73.6 |
| 11 | 2.55 | 3.45 | 119.4 | 168 | 78.8 |
| 12 | 2.51 | 3.37 | 117.3 | 172 | 75.7 |
| 13 | 2.63 | 3.37 | 122.3 | 179 | 75.4 |
| 14 | 2.66 | 3.43 | 121.4 | 186 | 74.0 |
| 15 | 2.65 | 3.37 | 123.3 | 201 | 72.7 |
| 16 | 2.50 | 3.44 | 113.9 | 166 | 75.0 |
| 17 | 2.75 | 3.45 | 125.7 | 184 | 74.4 |
| 18 | 2.79 | 3.47 | 126.2 | 161 | 74.3 |
| 19 | 2.54 | 3.47 | 114.7 | 119 | 74.8 |
| 20 | 2.75 | 3.35 | 127.4 | 138 | 76.6 |
| 21 | 2.58 | 3.45 | 118.6 | 193 | 76.8 |

Card Data.

Run 1. Right High Pressure Cylinder.

Crank End.

| No. of card | Area in sq.in. | Length in in. | M.E.PE in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.61 | 3.42 | 115.0 | 174 | 67.5 |
| 2 | 2.78 | 3.40 | 127.9 | 180 | 64.2 |
| 3 | 2.14 | 3.41 | 100.0 | 131 | 63.8 |
| 4 | 2.36 | 3.40 | 108.3 | 145 | 69.1 |
| 5 | 2.41 | 3.45 | 109.2 | 136 | 69.3 |
| 6 | 2.55 | 3.41 | 117.2 | 137 | 69.5 |
| 7 | 2.49 | 3.43 | 113.9 | 141 | 68.0 |
| 8 | 2.32 | 3.39 | 107.0 | 148 | 69.0 |
| 9 | 2.29 | 3.40 | 105.5 | 138 | 69.4 |
| 10 | 2.21 | 3.42 | 102.0 | 144 | 70.4 |
| 11 | 2.37 | 3.45 | 112.3 | 138 | 63.4 |
| 12 | 2.32 | 3.37 | 107.8 | 149 | 67.1 |
| 13 | 2.72 | 3.37 | 126.9 | 179 | 66.8 |
| 14 | 2.38 | 3.43 | 108.6 | 161 | 59.0 |
| 15 | 2.46 | 3.37 | 114.6 | 181 | 65.4 |
| 16 | 2.64 | 3.44 | 120.1 | 174 | 59.6 |
| 17 | 2.48 | 3.44 | 112.8 | 163 | 59.0 |
| 18 | 2.26 | 3.47 | 103.0 | 128 | 63.4 |
| 19 | 2.33 | 3.47 | 101.2 | 103 | 63.5 |
| 20 | 2.41 | 3.35 | 112.3 | 117 | 67.2 |
| 21 | 2.35 | 3.45 | 106.2 | 168 | 64.0 |

## Card Data.

### Run 2, Low Pressure Left Cylinder.

### Head End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.47 | 3.77 | 36.9 | 133 | 68.1 |
| 2 | 2.38 | 3.77 | 37.4 | 133 | 74.2 |
| 3 | 2.26 | 3.76 | 35.5 | 123 | 83.7 |
| 4 | 2.31 | 3.72 | 38.1 | 127 | 72.5 |
| 5 | 2.69 | 3.71 | 43.1 | 123 | 72.2 |
| 6 | 2.57 | 3.77 | 40.4 | 118 | 74.3 |
| 7 | 2.49 | 3.73 | 39.7 | 132 | 78.4 |
| 8 | 2.24 | 3.74 | 35.5 | 144 | 78.3 |
| 9 | 2.41 | 3.69 | 38.7 | 160 | 77.7 |
| 10 | 2.41 | 3.76 | 38.0 | 158 | 76.4 |
| 11 | 2.78 | 3.75 | 44.0 | 167 | 75.8 |
| 12 | 2.65 | 3.77 | 41.8 | 142 | 77.2 |
| 13 | 2.67 | 3.80 | 41.7 | 126 | 75.0 |
| 14 | 2.43 | 3.78 | 36.0 | 154 | 78.0 |
| 15 | 2.34 | 3.74 | 37.2 | 160 | 78.1 |
| 16 | 2.48 | 3.76 | 39.2 | 153 | 75.8 |
| 17 | 2.29 | 3.73 | 36.5 | 120 | 77.0 |
| 18 | 2.27 | 3.71 | 36.2 | 125 | 77.0 |
| 19 | 2.24 | 3.71 | 35.8 | 118 | 73.5 |
| 20 | 2.46 | 3.73 | 39.2 | 89 | 77.0 |
| 21 | 2.54 | 3.79 | 40.7 | 57 | 83.7 |
| 22 | 1.96 | 3.74 | 31.0 | 46 | 82.5 |

# Card Data.

## Run 2. Left Low Pressure Cylinder.

### Crank End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P | % cut off |
|---|---|---|---|---|---|
| 1 | 2.31 | 3.77 | 35.5 | 128 | 63.1 |
| 2 | 2.32 | 3.77 | 36.4 | 127 | 73.0 |
| 3 | 2.47 | 3.76 | 38.9 | 133 | 87.6 |
| 4 | 2.61 | 3.72 | 41.6 | 135 | 66.6 |
| 5 | 2.44 | 3.71 | 39.0 | 110 | 74.4 |
| 6 | 2.73 | 3.77 | 43.0 | 124 | 75.0 |
| 7 | 2.52 | 3.73 | 40.0 | 132 | 76.2 |
| 8 | 2.40 | 3.75 | 38.0 | 152 | 75.5 |
| 9 | 2.38 | 3.69 | 38.2 | 160 | 76.8 |
| 10 | 2.40 | 3.76 | 37.8 | 154 | 77.3 |
| 11 | 2.24 | 3.75 | 35.4 | 132 | 72.8 |
| 12 | 2.61 | 3.77 | 41.0 | 133 | 77.7 |
| 13 | 2.63 | 3.80 | 41.0 | 123 | 74.3 |
| 14 | 2.41 | 3.78 | 37.7 | 151 | 77.2 |
| 15 | 2.12 | 3.74 | 33.5 | 142 | 76.8 |
| 16 | 2.45 | 3.76 | 38.6 | 148 | 75.5 |
| 17 | 2.59 | 3.73 | 41.2 | 134 | 78.0 |
| 18 | 2.33 | 3.71 | 37.2 | 127 | 78.8 |
| 19 | 2.33 | 3.71 | 37.3 | 121 | 77.5 |
| 20 | 2.59 | 3.73 | 41.2 | 92 | 80.3 |
| 21 | 2.52 | 3.71 | 40.3 | 56 | 82.7 |
| 22 | 2.14 | 3.74 | 34.0 | 50 | 80.7 |

# Card Data.

## Run 2. Right Low Pressure Cylinder.

### Head End .

| No. of card | Area in sq. in. | Lengthh in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.29 | 3.60 | 37.7 | 136 | 71.2 |
| 2 | 2.21 | 3.60 | 36.3 | 129 | 72.0 |
| 3 | 2.40 | 3.58 | 39.8 | 142 | 75.2 |
| 4 | 2.44 | 3.57 | 40.5 | 134 | 74,3 |
| 5 | 2.27 | 3.52 | 38.2 | 111 | 78.7 |
| 6 | 2.64 | 3.57 | 44.0 | 130 | 81.2 |
| 7 | 2.46 | 3.57 | 40.8 | 133 | 79.3 |
| 8 | 2.30 | 3.59 | 38.0 | 154 | 77.2 |
| 9 | 2.28 | 3.59 | 37.7 | 159 | 78.0 |
| 10 | 2.30 | 3.59 | 38.0 | 158 | 78.0 |
| 11 | 2.26 | 3.59 | 37.2 | 141 | 79.5 |
| 12 | 2.24 | 3.58 | 37.2 | 126 | 78.5 |
| 13 | 2.50 | 3.57 | 41.6 | 126 | 79.4 |
| 14 | 2.44 | 3.59 | 40.3 | 154 | 72.1 |
| 15 | 2.14 | 3.57 | 35.5 | 153 | 78.5 |
| 16 | 2.28 | 3.57 | 37.8 | 147 | 77.5 |
| 17 | 2.26 | 3.57 | 37.5 | 123 | 78.7 |
| 18 | 2.16 | 3.57 | 35.8 | 124 | 79.0 |
| 19 | 2.23 | 3.55 | 37.3 | 122 | 72.5 |
| 20 | 2.34 | 3.56 | 39.0 | 88. | 71.9 |
| 21 | 2.49 | 2.57 | 41.3 | 58 | 81.0 |
| 22 | 2.08 | 3.58 | 34.5 | 51 | 78.4 |

# Card Data.

## Run 2. Right Low Pressure Cylinder.

### Crank End.

| No. of card. | Area in sq." | Length,". | M.E.P. # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.33 | 3.60 | 38.3 | 137 | 67.8 |
| 2 | 2.26 | 3.60 | 37.2 | 130 | 70.4 |
| 3 | 2.24 | 3.58 | 37.2 | 127 | 68.7 |
| 4 | 2.73 | 3/57 | 45.2 | 146 | 67.2 |
| 5 | 2.39 | 3.52 | 41.2 | 116 | 68.3 |
| 6 | 2.52 | 3.57 | 42.0 | 121 | 76.5 |
| 7 | 2.54 | 3.57 | 42.2 | 133 | 76.5 |
| 88 | 2.23 | 3.59 | [illegible].8 | 147 | 76.0 |
| 9 | 2.12 | 3.59 | 35.0 | 146 | 73.4 |
| 10 | 2.18 | 3.59 | 36.0 | 147 | 75.5 |
| 11 | 2.14 | 3.59 | 35.3 | 132 | 76.6 |
| 12 | 2.29 | 3.58 | 38.0 | 126 | 73.5 |
| 13 | 2.49 | 3.57 | 41.5 | 124 | 77.6 |
| 14 | 2.35 | 3.59 | 38.7 | 158 | 73.0 |
| 15 | 1.99 | 3.57 | 33.0 | 141 | 71.7 |
| 16 | 2.31 | 3.57 | 38.3 | 146 | 74.2 |
| 17 | 2.11 | 3.57 | 38.3 | 114 | 73.7 |
| 18 | 2.12 | 3.57 | 35.2 | 120 | 74.7 |
| 19 | 2.18 | 3.55 | 36.5 | 118 | 73.6 |
| 20 | 2.28 | 3.56 | 38.3 | 85 | 72.2 |
| 21 | 2.15 | 3.57 | 35.8 | 49 | 78.1 |
| 22 | 1.95 | 3.58 | 32.2 | 37 | 32.2 |

# Card Data.

## Run 2, Left High Pressure Cylinder.

### Head End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.01 | 3.40 | 83.0 | 118 | 63.5 |
| 2 | 2.25 | 3.46 | 103.2 | 140 | 66.5 ~~104.2~~ |
| 3 | 2.25 | 3.57 | 102.0 | 130 | 64.5 |
| 4 | 2.30 | 3.55 | 102.9 | 129 | 65.2 |
| 5 | 2.45 | 3.57 | 106.9 | 119 | 64.7 |
| 6 | 2.54 | 3.57 | 110.5 | 132 | 69.9 |
| 7 | 2.48 | 3.62 | 108.0 | 129 | 73.8 |
| 8 | 2.33 | 3.67 | 101.0 | 169 | 70.8 |
| 9 | 2.36 | 3.67 | 102.2 | 164 | 70.0 |
| 10 | 2.28 | 3.63 | 99.8 | 160 | 71.7 |
| 11 | 2.30 | 3.63 | 100.8 | 147 | 72.5 |
| 12 | 2.41 | 3.59 | 106.0 | 141 | 72.7 |
| 13 | 2.67 | 3.61 | 116.0 | 141 | 70.2 |
| 14 | 2.31 | 3.64 | 101.0 | 137 | 69.6 |
| 15 | 2.28 | 3.65 | 99.3 | 154 | 71.8 |
| 16 | 2.48 | 3.62 | 108.0 | 163 | 73.2 |
| 17 | 2.30 | 3.60 | 101.4 | 127 | 72.6 |
| 18 | 2.15 | 3.63 | 94.1 | 127 | 72.6 |
| 19 | 2.22 | 3.60 | 98.0 | 122 | 70.5 |
| 20 | 2.38 | 3.53 | 106.5 | 88 | 75.2 |
| 21 | 2.34 | 3.55 | 104.0 | 51 | 74.0 |
| 22 | 1.96 | 3.62 | 86.0 | 48 | 68.3 |

## Card Data.

Run 2. Left High Pressure Cylinder.

Crank End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.31 | 3.40 | 107.2 | 147 | 67.5 |
| 2 | 2.22 | 3.41 | 102.0 | 135 | 66.5 |
| 3 | 2.43 | 3.57 | 109.5 | 137 | 67.8 |
| 4 | 2.43 | 3.55 | 107.8 | 131 | 67.0 |
| 5 | 2.40 | 3.57 | 106.2 | 115 | 66.2 |
| 6 | 2.59 | 3.61 | 113.0 | 132 | 73.4 |
| 7 | 2.68 | 3.62 | 115.3 | 132 | 73.0 |
| 8 | 2.44 | 3.67 | 105.0 | 150 | 71.6 |
| 9 | 2.47 | 3.67 | 106.3 | 164 | 72.3 |
| 10 | 2.30 | 3.63 | 100.3 | 150 | 73.6 |
| 11 | 2.35 | 3.63 | 102.6 | 150 | 72.5 |
| 12 | 2.51 | 3.59 | 110.3 | 141 | 74.4 |
| 13 | 2.45 | 3.61 | 107.0 | 126 | 68.5 |
| 14 | 2.33 | 3.64 | 101.4 | 134 | 72.8 |
| 15 | 2.34 | 3.65 | 101.8 | 154 | 73.4 |
| 16 | 2.50 | 3.62 | 109.0 | 158 | 73.7 |
| 17 | 2.44 | 3.60 | 107.0 | 130 | 74.4 |
| 18 | 2.15 | 3.63 | 94.3 | 124 | 73.2 |
| 19 | 2.31 | 3.60 | 101.8 | 124 | 73.7 |
| 20 | 2.39 | 3.53 | 101.6 | 87 | 77.0 |
| 21 | 2.34 | 3.55 | 103.2 | 48 | 76.1 |
| 22 | 2.19 | 3.62 | 96.1 | 52 | 75.8 |

# Card Data.

## RRun 2 . Right High Pressure Cylinder.

### Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.31 | 3.41 | 106.0 | 151 | 66.5 |
| 2 | 2.37 | 3.50 | 106.3 | 144 | 67.5 |
| 3 | 2.39 | 3.48 | 107.5 | 138 | 68.1 |
| 4 | 2.35 | 3.44 | 107.0 | 135 | 71.6 |
| 5 | 2.55 | 3.44 | 116.3 | 130 | 69.8 |
| 6 | 2.70 | 3.45 | 122.7 | 146 | 74.0 |
| 7 | 2.66 | 3.51 | 119.0 | 140 | 75.5 |
| 8 | 2.51 | 3.52 | 112.0 | 166 | 73.4 |
| 9 | 2.45 | 3.48 | 110.8 | 175 | 78.1 |
| 10 | 2.44 | 3.46 | 111.0 | 175 | 76.5 |
| 11 | 2.35 | 3.50 | 106.0 | 166 | 75.7 |
| 12 | 2.45 | 3.46 | 111.7 | 147 | 77.4 |
| 13 | 2.70 | 3.48 | 121.7 | 149 | 76.7 |
| 14 | 2.53 | 3.46 | 115.0 | 155 | 78.0 |
| 15 | 2.42 | 3.47 | 110.0 | 172 | 75.9 |
| 16 | 2.62 | 3.46 | 118.8 | 178 | 77.5 |
| 17 | 2.39 | 3.50 | 107.8 | 135 | 76.7 |
| 18 | 2.22 | 3.47 | 101.5 | 137. | 76.3 |
| 19 | 2.37 | 3.48 | 107.5 | 134 | 73.8 |
| 20 | 2.40 | 3.46 | 109.5 | 96 | 79.2 |
| 21 | 2.33 | 3.45 | 106.5 | 52 | 77.3 |
| 22 | 2.13 | 3.49 | 97.0 | 54 | 78.5 |

# Card Data.

## Run 2. Right High Pressure Cylinder.

### Crank End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 1.90 | 3.41 | 89.0 | 123 | 66.2 |
| 2 | 2.13 | 3.50 | 96.8 | 128 | 61.5 |
| 3 | 2.12 | 3.48 | 97.0 | 121 | 61.8 |
| 4 | 2.24 | 3.44 | 103.2 | 125 | 65.2 |
| 5 | 2.30 | 3.44 | 105.8 | 114 | 65.9 |
| 6 | 2.39 | 3.45 | 109.3 | 127 | 69.6 |
| 7 | 2.39 | 3.51 | 107.5 | 123 | 69.8 |
| 8 | 2.17 | 3.52 | 98.0 | 138 | 70.1 |
| 9 | 2.17 | 3.48 | 99.0 | 153 | 73.5 |
| 10 | 2.09 | 3.46 | 97.0 | 150 | 65.7 |
| 11 | 2.08 | 3.50 | 94.7 | 134 | 62.4 |
| 12 | 2.28 | 3.46 | 104.3 | 133 | 69.5 |
| 13 | 2.48 | 3.48 | 112.3 | 132 | 69.0 |
| 14 | 2.17 | 3.46 | 99.5 | 131 | 64.5 |
| 15 | 2.08 | 3.47 | 95.3 | 144 | 65.0 |
| 16 | 2.25 | 3.46 | 103.0 | 149 | 76.5 |
| 17 | 2.09 | 3.50 | 95.0 | 115 | 66.4 |
| 18 | 2.07 | 3.47 | 95.0 | 125 | 68.4 |
| 19 | 2.09 | 3.48 | 95.4 | 106 | 61.8 |
| 20 | 2.26 | 3.46 | 103.4 | 84 | 73.5 |
| 21 | 2.22 | 3.45 | 102.0 | 48 | 72.1 |
| 22 | 2.06 | 3.49 | 94.0 | 51 | 71.8 |

## Card Data.

Run 3. Left Low Pressure Cylinder. Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.42 | 3.77 | 39.2 | 139 | 62.9 |
| 2 | 2.21 | 3.68 | 35.7 | 133 | 74.3 |
| 3 | --- | --- | --- | --- | --- |
| 4 | --- | --- | --- | --- | --- |
| 5 | --- | --- | --- | --- | --- |
| 6 | --- | --- | --- | --- | --- |
| 7 | --- | --- | --- | --- | --- |
| 8 | --- | --- | --- | --- | --- |
| 9 | 2.81 | 3.73 | 44.7 | 121 | 72.7 |
| 10 | 2.71 | 3.73 | 43.2 | 161 | 70.3 |
| 11 | 2.38 | 3.72 | 38.0 | 128 | 76.4 |
| 12 | 2.61 | 3.71 | 41.8 | 151 | 76.6 |
| 13 | 2.64 | 3.72 | 42.2 | 139 | 66.5 |
| 14 | 2.80 | 3.71 | 45.0 | 99 | 74.4 |
| 15 | --- | --- | --- | --- | --- |
| 16 | 3.15 | 3.67 | 51.0 | 78 | 75.0 |
| 17 | 2.85 | 3.66 | 47.0 | 72 | 77.0 |
| 18 | 3.00 | 3.67 | 48.5 | 58 | 69.7 |
| 19 | 2.93 | 3.68 | 47.3 | 72 | 76.7 |
| 20 | 2.52 | 3.73 | 40.2 | 122 | 72.4 |
| 21 | --- | --- | --- | --- | --- |
| 22 | 2.87 | 3.70 | 41.2 | 144 | 46.2 |
| 23 | --- | --- | --- | --- | --- |
| 24 | --- | --- | --- | --- | --- |
| 25 | 3.08 | 3.67 | 50.0 | 178 | 74.8 |
| 26 | 3.45 | 3.67 | 40.8 | 97 | 80.0 |
| 27 | 2.80 | 3.63 | 45.8 | 70 | 76.5 |
| 28 | --- | --- | --- | --- | --- |

Card Data.

Run 3. Left Low Pressure Cylinder. Crank End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.54 | 3.77 | 40.0 | 140 | 70.4 |
| 2 | 2.38 | 3.68 | 38.3 | 141 | 72.7 |
| 3 | --- | --- | --- | --- | --- |
| 4 | --- | --- | --- | --- | --- |
| 5 | --- | --- | --- | --- | --- |
| 6 | --- | --- | --- | --- | --- |
| 7 | --- | --- | --- | --- | --- |
| 8 | --- | --- | --- | --- | --- |
| 9 | 2.95 | 3.73 | 47.0 | 125 | 70.4 ~~47.0~~ |
| 10 | 2.68 | 3.73 | 42.7 | 157 | 75.4 ~~42.7~~ |
| 11 | 2.49 | 3.72 | 39.7 | 133 | 71.6 |
| 12 | 2.67 | 3.71 | 43.0 | 154 | 75.4 |
| 13 | 2.68 | 3.72 | 42.8 | 139 | 73.0 |
| 14 | 2.61 | 3.71 | 42.8 | 93 | 74.4 |
| 15 | --- | --- | --- | --- | --- |
| 16 | 3.25 | 3.67 | 52.8 | 80 | 75.0 |
| 17 | 2.69 | 3.66 | 43.7 | 66 | 74.7 |
| 18 | 2.99- | 3.67 | 48.5 | 57 | 73.5 |
| 19 | 3.21 | 3.68 | 52.0 | 78 | 78.0 |
| 20 | 2.52 | 3.73 | 40.3 | 121 | 74.8 |
| 21 | --- | --- | --- | --- | --- |
| 22 | 2.90 | 3.70 | 46.5 | 143 | 73.5 ~~46.5~~ |
| 23 | --- | --- | --- | --- | --- |
| 24 | --- | --- | --- | --- | --- |
| 25 | 3.15 | 3.67 | 51.0 | 178 | 85.0 |
| 26 | 3.46 | 3.65 | 40.0 | 94 | 87.2 |
| 27 | 3.13 | 3.63 | 51.3 | 77 | 71.9 |
| 28 | --- | --- | --- | --- | --- |

Card Data.

Run 3. Right Low Pressure Cylinder. Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.30 | 3.56 | 38.3 | 136 | 75.0 |
| 2 | 2.16 | 3.54 | 36.2 | 135 | 74.4 |
| 3 | 2.30 | 3.57 | 38.2 | 136 | 74.9 |
| 4 | 2.44 | 3.54 | 41.0 | 125 | 69.3 |
| 5 | 2.47 | 3.55 | 41.3 | 94 | 75.7 |
| 6 | 2.44 | 3.33 | 43.8 | 52 | 78.7 |
| 7 | 2.71 | 3.53 | 45.5 | 93 | 78.3 |
| 8 | 2.46 | 3.57 | 41.0 | 104 | 76.7 |
| 9 | 2.62 | 3.56 | 43.7 | 118 | 75.3 |
| 10 | 2.52 | 3.59 | 41.7 | 155 | 78.0 |
| 11 | 2.46 | 3.57 | 41.0 | 139 | 80.2 |
| 12 | 2.61 | 3.55 | 43.7 | 158 | 68.4 |
| 13 | 2.49 | 3.56 | 41.5 | 137 | 75.0 |
| 14 | 2.28 | 3.55 | 38.0 | 83 | 77.1 |
| 15 | 2.33 | 3.52 | 39.3 | 80 | 75.9 |
| 16 | 2.84 | 3.49 | 48.3 | 74 | 74.8 |
| 17 | 2.89 | 3.50 | 49.2 | 75 | 78.5 |
| 18 | 2.72 | 3.52 | 46.0 | 55 | 68.7 |
| 19 | 2.69 | 3.49 | 45.8 | 70 | 77.3 |
| 20 | 2.52 | 3.55 | 42.2 | 128 | 78.9 |
| 21 | 2.48 | 3.56 | 41.3 | 146 | 77.5 |
| 22 | 2.61 | 3.53 | 44.0 | 137 | 71.7 |
| 23 | 2.72 | 3.55 | 45.5 | 142 | 77.8 |
| 24 | 2.33 | 3.55 | 39.0 | 154 | 77.5 |
| 25 | 2.68 | 3.56 | 44.7 | 159 | 74.7 |
| 26 | 3.04 | 3.50 | 51.7 | 122 | 74.6 |
| 27 | 2.82 | 3.54 | 47.3 | 72 | 73.5 |
| 28 | 2.40 | 3.73 | 38.2 | 119 | 68.1 |

Card Data.

Run 3. Right Low Pressure Cylinder. Crank End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.43 | 3.56 | 40.5 | 142 | 71.4 |
| 2 | 2.22 | 3.54 | 37.2 | 137 | 71.5 |
| 3 | 2.22 | 3.57 | 36.9 | 129 | 70.9 |
| 4 | 2.61 | 3.54 | 44.0 | 132 | 71.5 |
| 5 | 2.43 | 3.55 | 40.7 | 92 | 63.3 |
| 6 | 1.87 | 3.33 | 33.2 | 39 | 66.2 |
| 7 | 2.53 | 3.53 | 42.5 | 85 | 76.7 |
| 8 | 2.25 | 3.57 | 37.4 | 94 | 70.2 |
| 9 | 2.62 | 3.56 | 41.8 | 112 | 74.5 |
| 10 | 2.43 | 3.59 | 40.3 | 148 | 73.0 |
| 11 | 2.38 | 3.57 | 39.7 | 133 | 73.7 |
| 12 | 2.47 | 3.55 | 41.3 | 148 | 74.1 |
| 13 | 2.29 | 3.56 | 38.2 | 125 | 77.0 |
| 14 | 2.49 | 3.55 | 42.7 | 93 | 74.8 |
| 15 | 2.20 | 3.52 | 37.0 | 74 | 73.0 |
| 16 | 2.95 | 3.49 | 51.5 | 78 | 77.4 |
| 17 | 2.76 | 3.50 | 47.0 | 71 | 74.8 |
| 18 | 2.78½ | 3.52 | 47.0 | 55 | 66.0 |
| 19 | 2.73 | 3.49 | 46.6 | 70 | 76.1 |
| 20 | 2.23 | 3.55 | 47.3 | 112 | 76.3 |
| 21 | 2.32 | 3.56 | 38.7 | 136 | 75.0 |
| 22 | 2.70 | 3.53 | 45.5 | 140 | 75.4 |
| 23 | 2.69 | 3.55 | 45.2 | 139 | 75.4 |
| 24 | 2.30 | 3.55 | 38.5 | 151 | 76.1 |
| 25 | 2.58 | 3.56 | 43.0 | 151 | 73.3 |
| 26 | 3.07 | 3.50 | 52.2 | 122 | 73.5 |
| 27 | 2.87 | 3.54 | 48.3 | 78 | 74.6 |
| 28 | 2.30 | 3.73 | 36.5 | 113 | 65.8 |

Card Data.

Run 3. Left High Pressure Cylinder. Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.30 | 3.57 | 101.3 | 141 | 65.1 |
| 2 | 2.17 | 3.53 | 97.7 | 146 | 67.2 |
| 3 | 2.13 | 3.53 | 96.4 | 125 | 67.4 |
| 4 | 2.20 | 3.55 | 98.4 | 122 | 66.2 |
| 5 | 2.21 | 3.57 | 98.1 | 89 | 70.0 |
| 6 | 2.17 | 3.53 | 97.8 | 58 | 72.4 |
| 7 | 2.68 | 3.55 | 118.5 | 99 | [illegible] |
| 8 | 2.49 | 3.56 | 110.5 | 113 | [illegible] |
| 9 | 2.67 | 3.61 | 116.4 | 126 | 69.5 |
| 10 | 2.35 | 3.56 | 104.7 | 152 | 70.2 |
| 11 | 2.32 | 3.60 | 102.4 | 128 | 70.8 |
| 12 | 2.16 | 3.60 | 95.4 | 135 | 67.5 |
| 13 | 2.22 | 3.54 | 99.4 | 100 | 68.7 |
| 14 | 2.57 | 3.56 | 113.6 | 91 | 68.6 |
| 15 | 2.46 | 3.51 | 111.0 | 85 | 69.5 |
| 16 | 2.58 | 3.60 | 113.1 | 84 | 69.5 |
| 17 | 2.60 | 3.55 | 115.4 | 68 | 70.5 |
| 18 | 2.29 | 3.53 | 102.4 | 50 | 68.0 |
| 19 | 2.22 | 3.57 | 98.6 | 48 | 72.9 |
| 20 | 2.28 | 3.50 | 101.0 | 119 | 69.0 |
| 21 | 2.58 | 3.60 | 113.0 | 157 | 70.0 |
| 22 | 2.45 | 3.62 | 106.8 | 129 | 70.0 |
| 23 | 2.16 | 3.61 | 95.0 | 119 | 69.0 |
| 24 | 2.47 | 3.62 | 108.2 | 181 | 69.3 |
| 25 | 2.67 | 3.54 | 118.8 | 165 | 69.2 |
| 26 | 2.53 | 3.48 | 114.4 | 114 | 71.1 |
| 27 | --- | --- | --- | --- | --- |
| 28 | --- | --- | --- | --- | --- |

# Card Data.

Run 3. Left High Pressure. Crank End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 2.31 | 3.57 | 102.4 | 137 | 70.7 |
| 2 | 2.27 | 3.53 | 102.0 | 148 | 70.3 |
| 3 | 2.25 | 3.52 | 101.5 | 136 | 70.0 |
| 4 | 2.16 | 3.55 | 96.7 | 117 | 71.5 |
| 5 | 2.38 | 3.57 | 105.5 | 93 | 74.0 |
| 6 | 2.35 | 3.53 | 108.4 | 61 | 76.5 |
| 7 | 2.69 | 3.55 | 113.2 | 92 | 73.8 |
| 8 | 2.60 | 3.56 | 115.4 | 113 | 71.4 |
| 9 | 2.54 | 3.61 | 111.4 | 116 | 74.8 |
| 10 | 2.45 | 3.65 | 109.0 | 154 | 73.0 |
| 11 | 2.35 | 3.60 | 103.4 | 126 | 73.3 |
| 12 | 2.31 | 3.60 | 102.0 | 141 | 74.5 |
| 13 | 2.30 | 3.54 | 103.0 | 135 | 71.2 |
| 14 | 2.54 | 3.56 | 113.0 | 88 | 75.0 |
| 15 | 2.48 | 3.51 | 111.4 | 83 | 72.4 |
| 16 | 2.64 | 3.60 | 116.0 | 82 | 72.6 |
| 17 | 2.42 | 3.55 | 108.4 | 62 | 74.4 |
| 18 | 2.43 | 3.53 | 110.5 | 57 | 66.5 |
| 19 | 2.16 | 3.57 | 96.5 | 46 | 76.8 |
| 20 | 2.35 | 3.57 | 97.5 | 111 | 71.7 |
| 21 | 2.57 | 3.60 | 113.0 | 152 | 72.3 |
| 22 | 2.55 | 3.62 | 111.5 | 130 | 74.5 |
| 23 | 2.44 | 3.61 | 106.5 | 129 | 74.5 |
| 24 | 2.57 | 3.62 | 112.5 | 189 | 74.6 |
| 25 | 2.24 | 3.54 | 101.0 | 135 | 74.9 |
| 26 | 2.52 | 3.48 | 114.5 | 100 | 74.7 |
| 27 | --- | --- | --- | --- | --- |
| 28 | --- | --- | --- | --- | --- |

## Card Data.

### Run 3. Right High Pressure Cylinder. Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 2.25 | 3.42 | 103.7 | 139 | 70.3 |
| 2 | 2.00 | 3.50 | 91.2 | 132 | 69.3 |
| 3 | 2.20 | 3.45 | 101.0 | 135 | 70.5 |
| 4 | 2.12 | 3.42 | 98.5 | 119 | 67.0 |
| 5 | 2.17 | 3.42 | 102.0 | 89 | 73.0 |
| 6 | 2.10 | 3.38 | 98.7 | 57 | 78.4 |
| 7 | 2.60 | 3.43 | 118.5 | 96 | 74.4 |
| 8 | 2.49 | 3.42 | 114.5 | 112 | 74.5 |
| 9 | 2.43 | 3.44 | 111.5 | 116 | 71.5 |
| 10 | 2.34 | 3.43 | 107.5 | 152 | 73.9 |
| 11 | 2.26 | 3.46 | 103.4 | 126 | 74.4 |
| 12 | 2.30 | 3.50 | 104.0 | 144 | 74.5 |
| 13 | 2.17 | 3.46 | 98.7 | 129 | 73.7 |
| 14 | 2.44 | 3.43 | 112.5 | 88 | 74.1 |
| 15 | 2.45 | 3.43 | 113.5 | 84 | 73.7 |
| 16 | 2.38 | 3.39 | 110.5 | 79 | 71.4 |
| 17 | 2.43 | 3.43 | 111.5 | 64 | 76.4 |
| 18 | 2.43 | 3.42 | 112.0 | 53 | 75.8 |
| 19 | 2.36 | 3.43 | 108.5 | 51 | 74.6 |
| 20 | 2.15 | 3.46 | 98.7 | 113 | 73.4 |
| 21 | 2.19 | 3.46 | 101.2 | 136 | 74.0 |
| 22 | 2.43 | 3.43 | 111.7 | 131 | 71.8 |
| 23 | 2.34 | 3.50 | 105.7 | 144 | 71.7 |
| 24 | 2.56 | 3.41 | 121.5 | 178 | 71.5 |
| 25 | 2.61 | 3.44 | 118.8 | 158 | 75.1 |
| 26 | 2.66 | 3.41 | 121.5 | 112 | 72.9 |
| 27 | 2.69 | 3.43 | 122.5 | 66 | 71.2 |
| 28 | 2.18 | 3.46 | 100.0 | 124 | 75.2 |

Card Data.

Run 3. Right High Pressure Cylinder. Crank End

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cu off |
|---|---|---|---|---|---|
| 1 | 2.08 | 3.42 | 96.5 | 134 | 65.7 |
| 2 | 2.01 | 3.50 | 91.5 | 136 | 65.7 |
| 3 | 1.99 | 3.45 | 92 | 128 | 65 |
| 4 | 2.01 | 3.42 | 93.7 | 117 | 64.4 |
| 5 | 2.04 | 3.40 | 96.5 | 87 | 68 |
| 6 | 2.07 | 3.38 | 98.0 | 58 | 70.7 |
| 7 | 2.38 | 3.43 | 109.5 | 92 | 66.2 |
| 8 | 2.34 | 3.42 | 108.5 | 110 | 66.4 |
| 9 | 2.22 | 3.44 | 102.5 | 111 | 65.5 |
| 10 | 2.19 | 3.43 | 99.8 | 145 | 66.2 |
| 11 | 2.19 | 3.46 | 95.5 | 119 | 68 |
| 12 | 2.02 | 3.50 | 92.0 | 131 | 60.5 |
| 13 | 2.13 | 3.46 | 97.8 | 99 | 65 |
| 14 | 2.35 | 3.43 | 108.5 | 87 | 67.5 |
| 15 | 2.31 | 3.43 | 107.2 | 82 | 68 |
| 16 | 2.32 | 3.39 | 108.5 | 79 | 67.3 |
| 17 | 2.25 | 3.43 | 103.8 | 61 | 66.8 |
| 18 | 2.31 | 3.42 | 105.5 | 51 | 70.3 |
| 19 | 2.25 | 3.43 | 104 | 51 | 70.3 |
| 20 | 1.97 | 3.46 | 91.2 | 108n | 67.3 |
| 21 | 2.14 | 3.46 | 98.5 | 137 | 67.3 |
| 22 | 2.15 | 3.43 | 99.5 | 120 | 66.2 |
| 23 | 2.33 | 3.44 | 107.5 | 135 | 65.5 |
| 24 | 2.03 | 3.50 | 92.5 | 161 | 64.4 |
| 25 | 2.18 | 3.41 | 101.5 | 141 | 67.5 |
| 26 | 2.47 | 3.41 | 113.5 | 103 | 69.4 |
| 27 | 2.50 | 3.43 | 114.5 | 64 | 67.1 |
| 28 | 2.01 | 3.46 | 92.7 | 119 | 65 |

# Card Data.

## Run 4, Left Low Pressure Cylinder.

### Head End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 1.75 | 3.70 | 28.0 | 142 | 66.7 |
| 2 | 1.69 | 2.65 | 23.3 | 145 | 64.2 |
| 3 | 1.58 | 3.30 | 28.2 | 119 | 70.4 |
| 4 | 1.76 | 3.74 | 27.8 | 92 | 70.9 |
| 5 | 1.51 | 3.74 | 27.8 | 49 | 70.9 |
| 6 | 2.26 | 3.71 | 36.7 | 81 | 70.6 |
| 7 | 2.15 | 3.71 | 34.3 | 104 | 65.2 |
| 8 | 1.92 | 3.73 | 30.5 | 139 | 66.2 |
| 9 | 1.70 | 3.77 | 26.7 | 129 | 67.0 |
| 10 | 1.68 | 3.73 | 26.7 | 113 | 68.1 |
| 11 | 1.64 | 3.72 | 26.0 | 86 | 68.6 |
| 12 | 1.68 | 3.73 | 26.7 | 61 | 72.4 |
| 13 | 1.62 | 3.71 | 25.8 | 33 | 79.8 |

Card Data.

Run 4. Left Low Pressure Cylinder.

Crank End.

| No. of card | Area in sq in. | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 1.79 | 3.70 | 28.0 | 140 | 66.7 |
| 2 | 1.69 | 3.65 | 27.3 | 148 | 64.2 |
| 3 | 1.58 | 3.30 | 28.2 | 113 | 70.4 |
| 4 | 1.76 | 3.74 | 27.8 | 79 | 70.9 |
| 5 | 1.51 | 3.74 | 27.8 | 46 | 70.9 |
| 6 | 2.17 | 3.71 | 34.7 | 67 | 72.0 |
| 7 | 2.02 | 3.71 | 32.2 | 91 | 65.5 |
| 8 | 1.92 | 3.73 | 30.5 | 130 | 66.2 |
| 9 | 1.72 | 3.72 | 27.0 | 119 | 68.2 |
| 10 | 1.71 | 3.73 | 27.0 | 103 | 71.1 |
| 11 | 1.72 | 3.72 | 27.3 | 87 | 70.5 |
| 12 | 1.79 | 3.73 | 28.3 | 59 | 77.3 |
| 13 | 1.52 | 3.71 | 21.8 | 22 | 21.8 |

Card Data.

Run 4. Right Low Pressure Cylinder.

Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % Cut off. |
|---|---|---|---|---|---|
| 1 | 1.71 | 3.56 | 28.3 | 143 | 71.1 |
| 2 | 1.59 | 3.60 | 26.0 | 138 | 69.5 |
| 3 | 1.53 | 3.57 | 25.2 | 106 | 71.9 |
| 4 | 1.52 | 3.55 | 25.2 | 83 | 66.2 |
| 5 | 1.64 | 3.53 | 27.3 | 56 | 72.5 |
| 6 | 1.51 | 3.55 | 25.2 | 56 | 69.6 |
| 7 | 1.98 | 3.55 | 33.2 | 102 | 67.1 |
| 8 | 1.91 | 3.56 | 31.8 | 145 | 67.5 |
| 9 | 1.69 | 3.57 | 28.0 | 135 | 67.9 |
| 10 | 1.66 | 3.56 | 27.5 | 116 | 69.7 |
| 11 | 1.57 | 3.54 | 26.2 | 87 | 74.0 |
| 12 | 1.54 | 3.57 | 35.5 | 58 | 77.2 |
| 13 | 1.51 | 3.55 | 25.0 | 32 | 25.0 |

Card Data.

Run 4. Right Low Pressure Cylinder.

Crank End.

| No. of card | Area in sq. in. | Length in in. | ½ M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 1.60 | 3.56 | 26.5 | 133 | 68.0 |
| 2 | 1.39 | 3.60 | 22.7 | 123 | 64.1 |
| 3 | 1.51 | 3.57 | 25.0 | 100 | 67.2 |
| 4 | 1.39 | 3.55 | 23.0 | 65 | 66.7 |
| 5 | 1.51 | 3.53 | 25.2 | 49 | 72.2 |
| 6 | 1.41 | 3.55 | 23.3 | 45 | 68.0 |
| 7 | 1.80 | 3.55 | 30.0 | 85 | 67.1 |
| 8 | 1.82 | 3.56 | 30.2 | 128 | 66.9 |
| 9 | 1.53 | 3.57 | 25.2 | 111 | 66.5 |
| 10 | 1.59 | 3.56 | 26.3 | 101 | 68.2 |
| 11 | 1.60 | 3.54 | 26.7 | 85 | 71.2 |
| 12 | 1.51 | 3.57 | 25.0 | 52 | 75.1 |
| 13 | 1.48 | 3.55 | 24.5 | 25 | 74.6 |

## Card Data.

Run 4. Left High Pressure Cylinder.

Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 1.73 | 3.61 | 77.5 | 161 | 61.5 |
| 2 | 1.51 | 3.58 | 69.0 | 156 | 60.6 |
| 3 | 1.50 | 3.57 | 68.7 | 115 | 61.6 |
| 4 | 1.48 | 3.60 | 67.2 | 80 | 60.3 |
| 5 | 1.47 | 3.58 | 67.2 | 54 | 64.2 |
| 6 | --- | --- | --- | --- | --- |
| 7 | 1.97 | 3.50 | 90.0 | 106 | 60.6 |
| 8 | 1.74 | 3.55 | 79.0 | 140 | 60.0 |
| 9 | 1.62 | 3.58 | 73.5 | 135 | 62.4 |
| 10 | 1.55 | 3.57 | 70.7 | 113 | 63.5 |
| 11 | 1.50 | 3.59 | 68.0 | 90 | 64.1 |
| 12 | 1.62 | 3.54 | 74.3 | 65 | 67.9 |
| 13 | 1.54 | 3.57 | 70.5 | 29 | 69.0 |

# Card Data.

Run $. Left High Pressure Cylinder.

Crank End.

| No. of card. | Area in sq. in. | Length in in. | M.E.P. in # | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 1.89 | 3.61 | 84.2 | 170 | 66.5 |
| 2 | 1.67 | 3.58 | 75.5 | 165 | 61.7 |
| 3 | 1.61 | 3.57 | 73.3 | 118 | 63.8 |
| 4 | 1.61 | 3.60 | 72.7 | 83 | 67.2 |
| 5 | 1.57 | 3.58 | 71.3 | 56 | 63.5 |
| 6 | --- | --- | --- | --- | --- |
| 7 | 2.20 | 3.50 | 99.7 | 114 | 64.7 |
| 8 | 1.96 | 3.55 | 94.2 | 162 | 62.1 |
| 9 | 1.67 | 3.58 | 75.5 | 134 | 64.4 |
| 10 | 1.65 | 3.57 | 75.0 | 116 | 67.2 |
| 11 | 1.60 | 3.54 | 73.5 | 94 | 66.9 |
| 12 | 1.54 | 3.57 | 75.5 | 62 | 72.5 |
| 13 | 1.55 | 3.57 | 75.6 | 31 | 75.3 |
| 14 | | | | | |

# Card Data.

## Run 4. Right High Pressure Cylinder.

### Head End.

| No. of card | Area in sq. in. | Length in in. | M.E.P. in# | I.H.P. | % cut off. |
|---|---|---|---|---|---|
| 1 | 1.90 | 3.44 | 89.5 | 184 | 64.8 |
| 2 | 1.75 | 3.44 | 82.0 | 185 | 65.5 |
| 3 | 1.59 | 3.45 | 82.0 | 125 | 62.9 |
| 4 | 1.48 | 3.47 | 69.5 | 82 | 63.7 |
| 5 | 1.51 | 3.41 | 72.0 | 58 | 70.7 |
| 6 | 2.23 | 3.43 | 103.0 | 83 | 70.8 |
| 7 | 2.16 | 3.46 | 99.5 | 117 | 64.2 |
| 8 | 2.00 | 3.46 | 92.5 | 164 | 62.7 |
| 9 | 1.78 | 3.48 | 82.3 | 152 | 82.3 |
| 10 | 1.69 | 3.46 | 76.5 | 127 | 68.2 |
| 11 | 1.63 | 3.45 | 76.5 | 101 | 76.5 |
| 12 | 1.58 | 3.41 | 75.0 | 65 | 75.0 |
| 13 | --- | --- | --- | --- | --- |

# Card Data.

Run 4. Right High Pressure Cylinder.

Crank End.

| No. of card. | Area in sq. in | Length in in. | M.E.P. in # | I.H.P. | % cut off |
|---|---|---|---|---|---|
| 1 | 1.68 | 3.44 | 79.0 | 160 | 57.3 |
| 2 | 1.49 | 3.44 | 70.4 | 155 | 57.0 |
| 3 | 1.23 | 3.45 | 59.0 | 95 | 55.9 |
| 4 | 1.12 | 3.47 | 54.0 | 62 | 58.5 |
| 5 | 1.41 | 3.41 | 67.7 | 53 | 65.1 |
| 6 | 2.13 | 3.43 | 91.5 | 71 | 57.2 |
| 7 | 1.96 | 3.46 | 90.5 | 103 | 57.9 |
| 8 | 1.65 | 3.45 | 77.0 | 132 | 55.0 |
| 9 | 1.60 | 3.48 | 84.5 | 133 | 74.5 |
| 10 | 1.65 | 3.46 | 77.0 | 119 | 62.1 |
| 11 | 1.53 | 3.45 | 72.0 | 92 | 65.8 |
| 12 | 1.60 | 3.41 | 76.0 | 64 | 68.0 |
| 13 | --- | --- | --- | --- | --- |

# I.H.P. Summary.
## Run 1.

| of Card. | L.P.L. | | L.P.R. | | Total | H.P.L. | | H.P.R. | | Total | Total I.H.P. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | H.E. | C.E. | H.E. | C.E. | Low Press. | H.E. | C.E. | H.E. | C.E. | High Press. | |
| 1 | 131 | 133 | 123 | 125 | 512 | 165 | 174 | 204 | 159 | 702 | 1214 |
| 2 | 129 | 134 | 129 | 134 | 517 | 156 | 180 | 170 | 166 | 672 | 1189 |
| 3 | 131 | 136 | 131 | 136 | 524 | 145 | 131 | 145 | 115 | 536 | 1060 |
| 4 | 140 | 132 | 140 | 132 | 535 | 153 | 145 | 171 | 153 | 622 | 1157 |
| 5 | 131 | 138 | 127 | 124 | 520 | 135 | 137 | 150 | 136 | 558 | 1078 |
| 6 | 131 | 126 | 100 | 118 | 475 | 146 | 145 | 146 | 137 | 574 | 1049 |
| 7 | 131 | 131 | 115 | 117 | 494 | 143 | 148 | 160 | 141 | 592 | 1086 |
| 8 | 143 | 144 | 139 | 138 | 564 | 154 | 147 | 158 | 148 | 607 | 1171 |
| 9 | 137 | 148 | 116 | 103 | 505 | 163 | 151 | 170 | 138 | 622 | 1127 |
| 10 | 157 | 157 | 125 | 122 | 561 | 154 | 144 | 154 | 144 | 588 | 1149 |
| 11 | 117 | 121 | 144 | 125 | 507 | 168 | 138 | 168 | 138 | 606 | 1113 |
| 12 | 118 | 127 | 122 | 139 | 506 | 172 | 149 | 172 | 149 | 639 | 1145 |
| 13 | 143 | 146 | 110 | 116 | 525 | 179 | 179 | 179 | 179 | 712 | 1227 |
| 14 | 144 | 146 | 133 | 122 | 595 | 186 | 161 | 186 | 161 | 699 | 1294 |
| 15 | 147 | 149 | 140 | 128 | 564 | 201 | 181 | 201 | 181 | 757 | 1321 |
| 16 | 132 | 129 | 115 | 119 | 495 | 166 | 174 | 166 | 174 | 684 | 1179 |
| 17 | 131 | 132 | 129 | 124 | 516 | 184 | 163 | 184 | 163 | 697 | 1213 |
| 18 | 127 | 119 | 125 | 110 | 491 | 161 | 128 | 161 | 128 | 582 | 1073 |
| 19 | 91 | 97 | 100 | 91 | 379 | 119 | 103 | 119 | 103 | 452 | 831 |
| 20 | 117 | 110 | 117 | 97 | 441 | 138 | 117 | 138 | 117 | 503 | 944 |
| 21 | 167 | 158 | 189 | 170 | 684 | 193 | 168 | 193 | 168 | 718 | 1402 |
| age. | 267. | | 248. | | 515. | 309. | | 317. | | 626. | 1141. |

# I.H.P. Summary.
## Run 2.

| ofCard | L.P.L. H.E. | L.P.L. C.E. | L.P.R. H.E. | L.P.R. C.E. | Total Low Press. | H.P.L. H.E. | H.P.L. C.E. | H.P.R. H.E. | H.P.R. C.E. | Total High Press. | Total I.H.P. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 133 | 128 | 136 | 137 | 534 | 118 | 147 | 151 | 123 | 539 | 1073 |
| 2 | 133 | 127 | 129 | 130 | 519 | 140 | 135 | 144 | 128 | 547 | 1066 |
| 3 | 123 | 133 | 142 | 127 | 525 | 130 | 137 | 138 | 121 | 526 | 1051 |
| 4 | 127 | 135 | 134 | 146 | 542 | 129 | 131 | 135 | 125 | 520 | 1062 |
| 5 | 123 | 110 | 111 | 116 | 460 | 119 | 115 | 130 | 114 | 478 | 938 |
| 6 | 118 | 124 | 130 | 121 | 493 | 132 | 132 | 146 | 127 | 537 | 1030 |
| 7 | 132 | 132 | 133 | 133 | 530 | 129 | 132 | 140 | 123 | 524 | 1054 |
| 8 | 144 | 152 | 154 | 147 | 597 | 162 | 150 | 166 | 138 | 616 | 1213 |
| 9 | 160 | 160 | 159 | 146 | 625 | 164 | 164 | 175 | 153 | 656 | 1281 |
| 10 | 158 | 154 | 158 | 147 | 617 | 160 | 150 | 175 | 150 | 635 | 1252 |
| 11 | 167 | 132 | 141 | 132 | 572 | 147 | 150 | 166 | 134 | 597 | 1169 |
| 12 | 142 | 133 | 126 | 126 | 527 | 141 | 141 | 147 | 133 | 562 | 1089 |
| 13 | 126 | 123 | 126 | 124 | 499 | 137 | 126 | 149 | 132 | 548 | 1047 |
| 14 | 154 | 151 | 154 | 158 | 617 | 154 | 134 | 155 | 131 | 557 | 1174 |
| 15 | 160 | 142 | 153 | 141 | 598 | 163 | 154 | 172 | 144 | 624 | 1220 |
| 16 | 153 | 148 | 147 | 146 | 594 | 127 | 158 | 178 | 149 | 648 | 1242 |
| 17 | 120 | 134 | 123 | 114 | 491 | 127 | 130 | 135 | 115 | 507 | 998 |
| 18 | 125 | 127 | 124 | 120 | 496 | 122 | 124 | 137 | 125 | 513 | 1009 |
| 19 | 118 | 121 | 122 | 118 | 479 | 141 | 124 | 134 | 106 | 486 | 965 |
| 20 | 89 | 92 | 88 | 85 | 354 | 88 | 87 | 96 | 84 | 355 | 709 |
| 21 | 57 | 56 | 58 | 49 | 220 | 51 | 48 | 52 | 48 | 199 | 419 |
| 22 | 46 | 50 | 51 | 37 | 184 | 48 | 52 | 54 | 51 | 205 | 389 |
| rage | 253. | | 251. | | 504. | 257. | | 260. | | 517. | 1021 |

# I. H. P. Summary.
## Run 3.

| No. of Card | L. P. L. | | L. P. R. | | Total | H. P. L. | | H. P. R. | | Total | Total I. H. P. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | H. E. | C. E. | H. E. | C. E. | Low Press. | H. E. | C. E. | H. E. | C. E. | High Press. | |
| 1 | 139 | 140 | 136 | 142 | 557 | 141 | 137 | 139 | 134 | 551 | 1108 |
| 2 | 133 | 141 | 135 | 137 | 543 | 146 | 148 | 132 | 136 | 562 | 1105 |
| 3 | 136 | 129 | 136 | 129 | 530 | 135 | 136 | 135 | 128 | 538 | 1068 |
| 4 | 125 | 132 | 125 | 132 | 514 | 122 | 117 | 119 | 117 | 475 | 989 |
| 5 | 94 | 92 | 94 | 92 | 372 | 89 | 93 | 89 | 87 | 358 | 730 |
| 6 | 52 | 39 | 52 | 39 | 182 | 58 | 61 | 57 | 58 | 234 | 416 |
| 7 | 93 | 85 | 93 | 85 | 356 | 99 | 92 | 96 | 92 | 379 | 735 |
| 8 | 104 | 94 | 104 | 94 | 396 | 113 | 113 | 112 | 110 | 448 | 844 |
| 9 | 121 | 125 | 118 | 112 | 476 | 126 | 116 | 116 | 111 | 469 | 945 |
| 10 | 161 | 157 | 155 | 148 | 521 | 152 | 154 | 152 | 145 | 603 | 1124 |
| 11 | 128 | 133 | 139 | 133 | 533 | 128 | 126 | 126 | 119 | 499 | 1032 |
| 12 | 151 | 154 | 158 | 148 | 611 | 135 | 141 | 144 | 131 | 551 | 1162 |
| 13 | 139 | 139 | 137 | 125 | 540 | 100 | 135 | 129 | 99 | 463 | 1003 |
| 14 | 99 | 93 | 83 | 93 | 368 | 91 | 88 | 88 | 87 | 354 | 722 |
| 15 | 80 | 74 | 80 | 74 | 308 | 85 | 83 | 84 | 82 | 334 | 642 |
| 16 | 78 | 80 | 74 | 78 | 310 | 84 | 82 | 79 | 79 | 324 | 634 |
| 17 | 72 | 66 | 75 | 71 | 284 | 68 | 62 | 64 | 61 | 255 | 539 |
| 18 | 58 | 57 | 55 | 55 | 225 | 50 | 57 | 53 | 51 | 211 | 436 |
| 19 | 72 | 78 | 70 | 70 | 290 | 48 | 46 | 51 | 51 | 196 | 486 |
| 20 | 122 | 121 | 128 | 112 | 483 | 119 | 111 | 113 | 108 | 451 | 934 |
| 21 | 146 | 136 | 146 | 136 | 564 | 157 | 152 | 136 | 137 | 582 | 1146 |
| 22 | 144 | 143 | 137 | 140 | 564 | 129 | 130 | 131 | 120 | 510 | 1074 |
| 23 | 142 | 139 | 142 | 139 | 562 | 119 | 129 | 144 | 135 | 527 | 1089 |
| 24 | 154 | 151 | 154 | 151 | 610 | 181 | 189 | 178 | 161 | 629 | 1239 |
| 25 | 178 | 178 | 159 | 151 | 666 | 165 | 135 | 158 | 141 | 599 | 1265 |
| 26 | 97 | 94 | 122 | 122 | 437 | 114 | 100 | 112 | 103 | 429 | 866 |
| 27 | 70 | 77 | 72 | 73 | 292 | 66 | 64 | 66 | 64 | 260 | 552 |
| 28 | 119 | 113 | 119 | 113 | 464 | 124 | 119 | 124 | 119 | 486 | 950 |
| …erage. | 228. | | 224. | | 452 | 216. | | 218. | | 434. | 887. |

# I. H. P. Summary.
## Run 4.

| of Card | L.P.L. |  | L.P.R. |  | Total | H.P.L. |  | H.P.R. |  | Total | Total I.H.P. |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  | H.E. | C.E. | H.E. | C.E. | Low Press. | H.E. | C.E. | H.E. | C.E. | High Press. |  |
| 1 | 142 | 140 | 143 | 133 | 568 | 161 | 170 | 184 | 160 | 675 | 1243 |
| 2 | 145 | 148 | 138 | 123 | 554 | 156 | 165 | 185 | 155 | 661 | 1215 |
| 3 | 119 | 113 | 106 | 100 | 438 | 115 | 118 | 125 | 95 | 453 | 891 |
| 4 | 92 | 79 | 83 | 65 | 311 | 80 | 83 | 82 | 62 | 307 | 618 |
| 5 | 49 | 46 | 56 | 49 | 200 | 54 | 56 | 58 | 53 | 221 | 421 |
| 6 | 81 | 67 | 102 | 45 | 249 | 83 | 71 | 83 | 71 | 308 | 556 |
| 7 | 104 | 91 | 145 | 85 | 386 | 106 | 114 | 117 | 103 | 440 | 826 |
| 8 | 139 | 130 | 135 | 128 | 532 | 140 | 162 | 164 | 132 | 598 | 1130 |
| 9 | 129 | 119 | 116 | 111 | 494 | 135 | 134 | 152 | 133 | 554 | 1048 |
| 10 | 113 | 103 | 87 | 101 | 433 | 113 | 116 | 127 | 119 | 476 | 909 |
| 11 | 86 | 87 | 58 | 85 | 345 | 90 | 94 | 101 | 92 | 377 | 722 |
| 12 | 61 | 59 | 56 | 52 | 230 | 65 | 62 | 65 | 64 | 256 | 486 |
| 13 | 33 | 22 | 32 | 25 | 112 | 29 | 31 | 29 | 31 | 121 | 233 |
| rage | 194. |  | 183. |  | 377. | 209. |  | 214. |  | 423. | 800. |

# Run 1.

| Reading | Time. | Boiler Pressure. | Pressure in Branch Pipe. | Revolutions. Front Eng. | Back Eng. | Miles per hr. Locomotive | High Press. I. H. P. | Low Press. I. H. P. | Total I. H. P. | Proportion of work. H. P. Cylinders | Dynamometer Car Push in # | Miles per hr. Dyn. Car. | Dyn. H. P. | Mechanical Efficiency %. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9:25 | 205 | — | 43 | 45 | 6.60 | 702 | 512 | 1214 | .580 | 60,500 | 5.90 | 950 | 78 |
| 2 | :28 | 205 | — | 41 | 42 | 6.25 | 672 | 517 | 1189 | .565 | 59,000 | 5.90 | 930 | 78 |
| 3 | :31 | 206 | 190 | 41 | 39 | 6.05 | 536 | 524 | 1060 | .505 | 64,000 | 5.75 | 983 | 85 |
| 4 | :34 | 204 | 180 | 41 | 40 | 6.10 | 622 | 535 | 1157 | .537 | 63,200 | 5.75 | 970 | 84 |
| 5 | :37 | 201 | 180 | 39 | 37 | 5.72 | 558 | 520 | 1078 | .515 | 65,000 | 5.40 | 935 | 87 |
| 6 | :40 | 202 | 185 | 37 | 35 | 5.40 | 574 | 475 | 1049 | .545 | 68,500 | 5.00 | 912 | 87 |
| 7 | :43 | 207 | 190 | 41 | 37 | 5.86 | 592 | 494 | 1086 | .550 | 67,500 | 5.00 | 900 | 83 |
| 8 | :46 | 200 | 180 | 44 | 39 | 6.25 | 607 | 564 | 1171 | .515 | 66,500 | 5.69 | 1010 | 86 |
| 9 | :49 | 207 | 180 | 43 | 41 | 6.32 | 622 | 505 | 1127 | .550 | 64,000 | 6.10 | 1040 | 92 |
| 10 | :52 | 202 | 190 | 45 | 40 | 6.40 | 588 | 561 | 1149 | .517 | 64,000 | 6.10 | 1040 | 91 |
| 11 | :55 | 200 | 194 | 38 | 41 | 5.95 | 606 | 507 | 1113 | .545 | 62,000 | 5.90 | 975 | 88 |
| 12 | :58 | 198 | 195 | 38 | 42 | 6.00 | 639 | 506 | 1145 | .554 | 64,300 | 5.90 | 1018 | 89 |
| 13 | 10:01 | 210 | 195 | 41 | 42 | 6.25 | 712 | 525 | 1227 | .580 | 67,500 | 6.00 | 1080 | 88 |
| 14 | :04 | 210 | 185 | 44 | 44 | 6.60 | 699 | 595 | 1294 | .540 | 68,000 | 6.10 | 1100 | 85 |
| 15 | :07 | 205 | 180 | 46 | 47 | 7.00 | 757 | 564 | 1321 | .570 | 63,000 | 6.28 | 1058 | 80 |
| 16 | :10 | 205 | 190 | 43 | 43 | 6.50 | 684 | 495 | 1179 | .580 | 63,500 | 6.50 | 1100 | 93 |
| 17 | :13 | 207 | 185 | 43 | 43 | 6.50 | 697 | 516 | 1213 | .575 | 65,500 | 5.90 | 1030 | 85 |
| 18 | :16 | 205 | 182 | 38 | 37 | 5.65 | 582 | 491 | 1073 | .545 | 65,000 | 5.65 | 980 | 91 |
| 19 | :19 | 205 | 180 | 30 | 30 | 4.50 | 452 | 379 | 831 | .550 | 63,700 | 3.80 | 645 | 78 |
| 20 | :22 | 202 | 180 | 33 | 31 | 4.82 | 503 | 441 | 944 | .510 | 64,600 | 4.00 | 690 | 73 |
| 21 | :25 | 198. | 180 | 52 | 47 | 7.45 | 718 | 684 | 1402 | .510 | 69,500 | 6.00 | 1100 | 79 |

# Run 2.



| No. | Time | Boiler Pressure | Pressure in Branch Pipe | Revolutions Front Eng. | Revolutions Back Eng. | Miles per hr. Locomotive. | High Press. I.H.P. | Low Press. I.H.P. | Total I.H.P. | Proportion of Work High Press. Cyl. | Dyn. Car Pull in # | Miles per hr. Dyn. Car | Dyn. H.P. | Mech. Eff. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3:47 | 198 | 175 | 43 | 41 | 6.50 | 539 | 534 | 1073 | .505 | 58,000 | 6.10 | 940 | 87 |
| 2 | :50 | 195 | 175 | 42 | 39 | 6.30 | 547 | 519 | 1066 | .512 | 62,000 | 5.80 | 970 | 91 |
| 3 | :53 | 200 | 180 | 41 | 37 | 6.00 | 526 | 525 | 1051 | .505 | 62,000 | 5.75 | 970 | 92 |
| 4 | :56 | 198 | 175 | 39 | 36 | 6.00 | 520 | 542 | 1062 | .485 | 65,000 | 4.90 | 850 | 80 |
| 5 | :59 | 201 | 180 | 34 | 32 | 5.40 | 478 | 460 | 938 | .510 | 67,000 | 4.75 | 850 | 91 |
| 6 | 4:02 | 205 | 185 | 35 | 40 | 4.75 | 537 | 493 | 1030 | .525 | 70,000 | 4.75 | 900 | 87 |
| 7 | :05 | 209 | 180 | 38 | 34 | 5.50 | 524 | 530 | 1054 | .505 | 69,000 | 5.50 | 1007 | 95 |
| 8 | :08 | 207 | 180 | 48 | 42 | 6.75 | 616 | 597 | 1213 | .510 | 64,000 | 6.25 | 1160 | 96 |
| 9 | :11 | 202 | 170 | 50 | 46 | 7.60 | 656 | 625 | 1281 | .510 | 64,000 | 7.25 | 1200 | 94 |
| 10 | :14 | 200 | 170 | 49 | 46 | 7.50 | 635 | 617 | 1252 | .510 | 62,000 | 6.75 | 1100 | 88 |
| 11 | :17 | 198 | 165 | 45 | 42 | 6.60 | 597 | 572 | 1169 | .510 | 62,000 | 5.75 | 970 | 83 |
| 12 | :20 | 202 | 175 | 40 | 38 | 5.90 | 562 | 527 | 1089 | .515 | 66,000 | 5.25 | 915 | 84 |
| 13 | :23 | 210 | 185 | 36 | 35 | 5.50 | 548 | 499 | 1047 | .520 | 70,000 | 5.00 | 950 | 91 |
| 14 | :26 | 205 | 175 | 42 | 36 | 6.00 | 557 | 617 | 1174 | .470 | 65,000 | 6.00 | 1075 | 92 |
| 15 | :29 | 205 | 185 | 49 | 45 | 7.50 | 624 | 598 | 1220 | .510 | 59,000 | 7.20 | 1171 | 96 |
| 16 | :32 | 195 | 175 | 46 | 43 | 6.85 | 648 | 594 | 1242 | .520 | 64,000 | 5.80 | 1000 | 81 |
| 17 | :35 | 195 | 160 | 39 | 36 | 6.00 | 507 | 491 | 998 | .507 | 59,000 | 5.65 | 885 | 89 |
| 18 | :38 | 177 | 155 | 41 | 39 | 6.10 | 513 | 496 | 1009 | .510 | 60,000 | 5.65 | 850 | 84 |
| 19 | :41 | 175 | 160 | 39 | 36 | 5.80 | 486 | 479 | 965 | .504 | 59,000 | 4.35 | 690 | 72 |
| 20 | :44 | 175 | 160 | 27 | 24 | 4.25 | 355 | 354 | 709 | .500 | 64,000 | 2.40 | 410 | 58 |
| 21 | :47 | 170 | 160 | 17 | 14 | 2.20 | 199 | 220 | 419 | .475 | 65,000 | 1.90 | 333 | 79 |
| 22 | :50 | 155 | 160 | 18 | 16 | 2.75 | 205 | 184 | 389 | .525 | 55,000 | 2.50 | 368 | 95 |

# Run 3.

| Reading | Time | Boiler Pressure | Pressure in Branch Pipe | Revolutions Front Eng. | Revolutions Back Eng. | Miles per hr. Locomotive | High Press. I. H. P. | Low Press. I. H. P. | Total I. H. P. | Proportion of Work High Press. Cyl. | Dyn. Car Push in # | Miles per hr. Dyn. Car. | Dyn. H. P. | Mech. Eff. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11:18 | 185 | 175 | 42 | 40 | 6.12 | 561 | 557 | 1108 | .497 | 60,000 | 5.85 | 935 | 84 |
| 2 | :21 | 187 | 175 | 44 | 43 | 6.50 | 562 | 543 | 1105 | .508 | 59,000 | 6.05 | 952 | 86 |
| 3 | :24 | 183 | 170 | 42 | 40 | 6.12 | 538 | 530 | 1068 | .505 | 58,000 | 6.05 | 932 | 87 |
| 4 | :27 | 177 | 168 | 36 | 36 | 5.38 | 475 | 514 | 989 | .480 | 60,000 | 5.25 | 840 | 85 |
| 5 | :30 | 170 | 163 | 27 | 26 | 3.96 | 358 | 372 | 730 | .490 | 61,500 | 3.51 | 565 | 77 |
| 6 | :33 | 165 | 160 | 14 | 17 | 2.17 | 234 | 182 | 416 | .562 | 62,500 | 2.00 | 332 | 80 |
| 7 | :47 | 200 | 190 | 24 | 24 | 3.60 | 379 | 356 | 735 | .515 | 67,000 | 3.30 | 590 | 80 |
| 8 | :50 | 197 | 190 | 30 | 29 | 4.50 | 448 | 396 | 844 | .531 | 65,000 | 4.47 | 775 | 92 |
| 9 | :53 | 195 | 180 | 32 | 31 | 5.50 | 469 | 476 | 945 | .496 | 63,000 | 5.30 | 890 | 94 |
| 10 | :56 | 195 | 175 | 44 | 42 | 6.45 | 603 | 521 | 1124 | .463 | 61,500 | 5.85 | 960 | 85 |
| 11 | :59 | 190 | 170 | 40 | 36 | 5.65 | 499 | 533 | 1032 | .515 | 61,500 | 4.95 | 810 | 78 |
| 12 | 12:02 | 187 | 173 | 43 | 41 | 6.30 | 551 | 611 | 1162 | .525 | 59,000 | 5.45 | 860 | 77 |
| 13 | :05 | 180 | 160 | 39 | 39 | 5.72 | 403 | 540 | 1003 | .538 | 63,500 | 3.48 | 587 | 58 |
| 14 | :29 | 188 | 180 | 26 | 23 | 3.65 | 354 | 368 | 722 | .490 | 67,000 | 2.90 | 537 | 74 |
| 15 | :32 | 188 | 186 | 24 | 22 | 3.42 | 334 | 308 | 642 | .520 | 63,000 | 2.33 | 390 | 61 |
| 16 | :35 | 195 | 185 | 18 | 21 | 2.91 | 324 | 310 | 634 | .511 | 66,000 | 2.33 | 416 | 66 |
| 17 | :38 | 190 | 180 | 18 | 17 | 2.77 | 255 | 284 | 539 | .474 | 66,000 | 1.85 | 325 | 60 |
| 18 | :41 | 185 | 177 | 14 | 14 | 2.10 | 211 | 225 | 436 | .484 | 64,000 | 1.85 | 310 | 71 |
| 19 | :44 | 182 | 175 | 18 | 14 | 2.40 | 196 | 290 | 486 | .403 | 64,000 | 1.85 | 310 | 64 |
| 20 | :47 | 182 | 165 | 36 | 34 | 5.31 | 451 | 483 | 934 | .484 | 60,000 | 5.30 | 850 | 91 |
| 21 | :50 | 192 | 172 | 42 | 40 | 6.15 | 582 | 564 | 1146 | .491 | 61,000 | 5.30 | 862 | 75 |
| 22 | :53 | 200 | 185 | 37 | 35 | 5.40 | 510 | 564 | 1074 | .524 | 65,000 | 5.04 | 860 | 80 |
| 23 | :56 | 207 | 190 | 37 | 36 | 5.45 | 527 | 562 | 1089 | .515 | 63,000 | 5.42 | 920 | 85 |
| 24 | :59 | 210 | 173 | 47 | 50 | 7.25 | 629 | 610 | 1239 | .507 | 60,000 | 6.40 | 1020 | 83 |
| 25 | 1:02 | 207 | 185 | 42 | 40 | 6.30 | 599 | 666 | 1265 | .472 | 64,000 | 5.67 | 1024 | 81 |
| 26 | :05 | 205 | 195 | 28 | 26 | 4.26 | 429 | 437 | 866 | .495 | 70,000 | 3.50 | 1009 | 79 |
| 27 | :08 | 198 | 184 | 18 | 16 | 2.55 | 260 | 292 | 552 | .471 | 70,000 | 2.25 | 420 | 76 |
| 28 | :11 | 193 | 160 | 37 | 37 | 5.80 | 485 | 464 | 950 | .511 | 60,000 | 5.67 | 905 | 95 |

# Run 4.

| Reading | Time | Boiler Pressure. | Pressure in Branch Pipe. | Revolutions. Front Eng. | Back Eng. | Miles per hr. Locomotive. | High Press. I.H.P. | Low Press. I.H.P. | Total I.H.P. | Proportion of Work High Press. Cyl. | Dyn. Car Push in # | Miles per hr. Dyn. Car. | Dyn. H.P. | Mech. Eff. %. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5:00 | 170 | 145 | 60 | 60 | 9.00 | 675 | 568 | 1243 | .542 | 44,000 | 6.85 | 805 | 65 |
| 2 | :03 | 160 | 135 | 63 | 65 | 9.60 | 661 | 554 | 1215 | .544 | 38,000 | 8.25 | 830 | 68 |
| 3 | :06 | 150 | 125 | 50 | 48 | 7.35 | 453 | 438 | 891 | .507 | 36,500 | 6.85 | 670 | 75 |
| 4 | :09 | 135 | 120 | 39 | 34 | 5.50 | 307 | 311 | 618 | .496 | 37,500 | 4.00 | 400 | 65 |
| 5 | :12 | 128 | 112 | 24 | 23 | 3.62 | 221 | 200 | 421 | .525 | 37,500 | 3.50 | 350 | 83 |
| 6 | :47 | 180 | 163 | 26 | 23 | 3.70 | 308 | 249 | 556 | .554 | 47,000 | 3.50 | 500 | 90 |
| 7 | :50 | 175 | 157 | 36 | 34 | 5.25 | 440 | 386 | 826 | .532 | 48,000 | 4.60 | 590 | 72 |
| 8 | :53 | 180 | 155 | 54 | 51 | 7.90 | 598 | 532 | 1130 | .530 | 45,000 | 7.80 | 910 | 81 |
| 9 | :56 | 155 | 135 | 57 | 53 | 8.30 | 554 | 494 | 1048 | .482 | 39,500 | 7.80 | 820 | 78 |
| 10 | :59 | 145 | 125 | 50 | 46 | 7.20 | 476 | 433 | 909 | .524 | 39,000 | 6.65 | 690 | 76 |
| 11 | 6:02 | 135 | 120 | 37 | 38 | 5.30 | 377 | 345 | 722 | .522 | 38,000 | 4.90 | 500 | 69 |
| 12 | :05 | 135 | 112 | 27 | 25 | 3.90 | 256 | 230 | 486 | .526 | 36,000 | 3.90 | 375 | 77 |
| 13 | :08 | 120 | 107 | 15 | 12 | 2.02 | 121 | 112 | 233 | .520 | 37,000 | 1.50 | 148 | 64 |

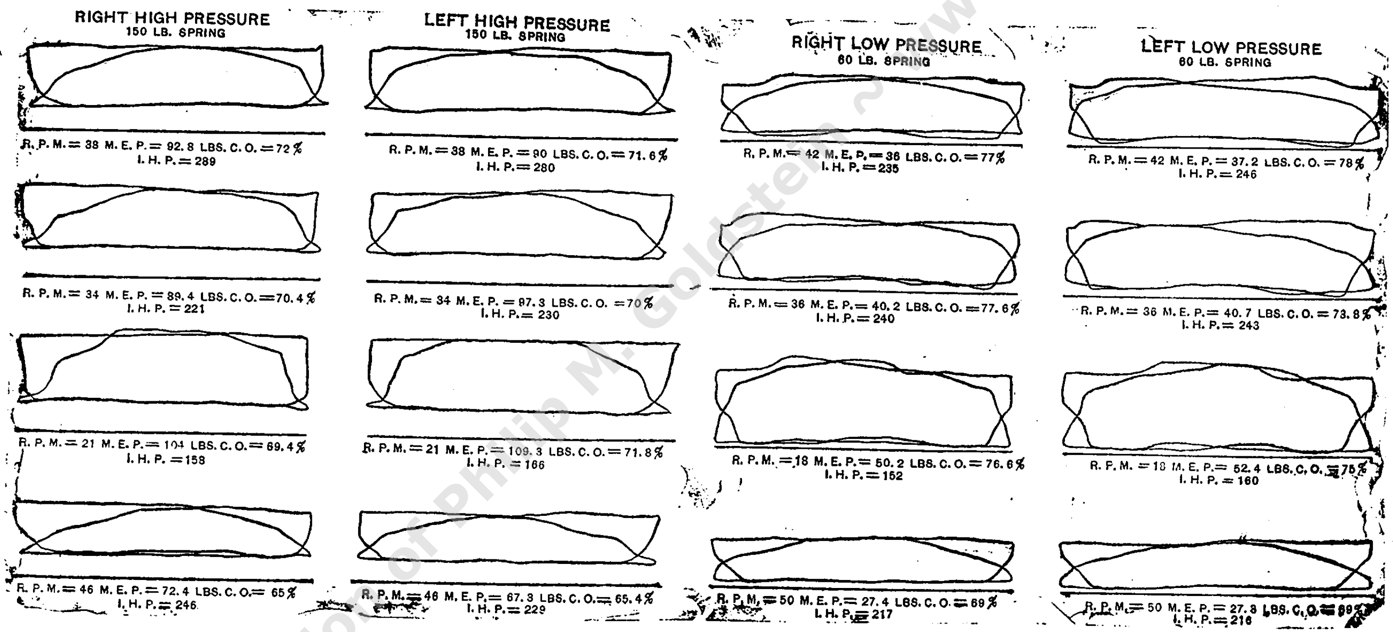
# Summary.

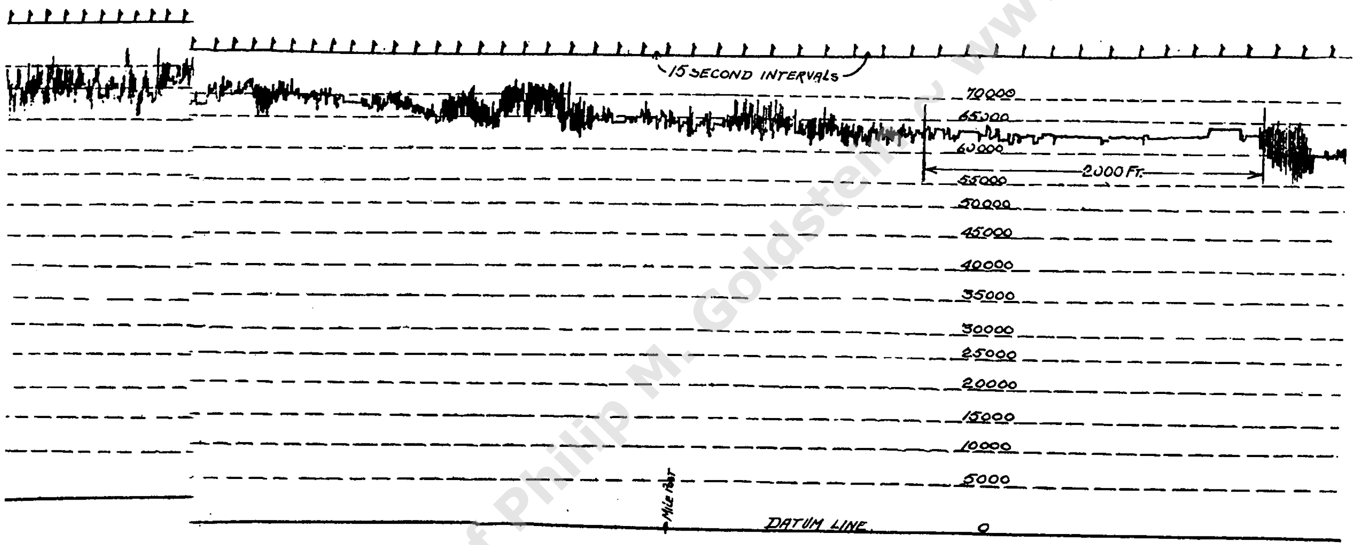


| Run No. | Time in Min. | Front Engine R.P.M. Max. | Front Engine R.P.M. Min. | Front Engine R.P.M. Aver. | Front Engine Aver. Speed miles per hr. | Front Engine Piston Speed, ft/min Max. | Front Engine Piston Speed, ft/min Min. | Front Engine Piston Speed, ft/min Aver. | Rear Engine R.P.M. Max. | Rear Engine R.P.M. Min. | Rear Engine R.P.M. Aver. | Rear Engine Aver. Speed miles per hr. | Rear Engine Piston speed ft/min Max | Rear Engine Piston speed ft/min Min. | Rear Engine Piston speed ft/min Aver. | Pressure in #/□" In boiler Aver. | In boiler Max. | In boiler Min. | In branch pipe | In receiver | Barometer in Hg. | Draft in in. of water in smoke box front of diaphragm | Injector min. in action | Temp. of Feed Water | Lbs. Water Delivered to Injector | Lbs. Water Leak. and Loss. | Lbs. Water Deliv. and Evap. | Dynamomer Push in lbs. Aver. | Dynamomer Push Max. | Dynamomer Push Min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 60 | 52 | 30 | 40 | 6.0 | 244.0 | 141.0 | 187.0 | 47 | 30 | 40 | 6.0 | 220.0 | 141.0 | 187.0 | 200 | 210 | 198 | 185 | — | 28.93 | 4.7 | 53 | 37.7 | 43,410 | 505 | 42,905 | 64,000 | 69,500 | 59,000 |
| 2 | 63 | 50 | 17 | 40 | 6.0 | 233.5 | 79.0 | 187.0 | 51 | 14 | 40 | 6.0 | 240.0 | 66.0 | 187.0 | 200 | 210 | 155 | 171 | 49.3 | 28.77 | 5.0 | 58 | 37.8 | 40,270 | 552 | 39,718 | 66,000 | | 59,000 |
| 3 | 113 | 47 | 14 | 33 | 5.0 | 220.0 | 66.0 | 154.0 | 50 | 14 | 33 | 5.0 | 233.5 | 66.0 | 154.0 | 195 | 210 | 165 | 176 | 59.5 | 29.06 | 4.5 | 99 | 37.5 | 48,920 | 942 | 47,978 | 64,000 | 70,000 | 58,000 |
| 4 | 68 | 63 | 15 | 43 | 6.5 | 292.0 | 77.0 | 200.0 | 65 | 12 | 43 | 6.5 | 302.0 | 56.0 | 200.0 | 160 | 180 | 120 | 132 | 46.6 | 28.74 | 3.0 | 56 | 38.6 | 20,540 | 532 | 20,008 | 41,000 | 48,000 | 36,000 |

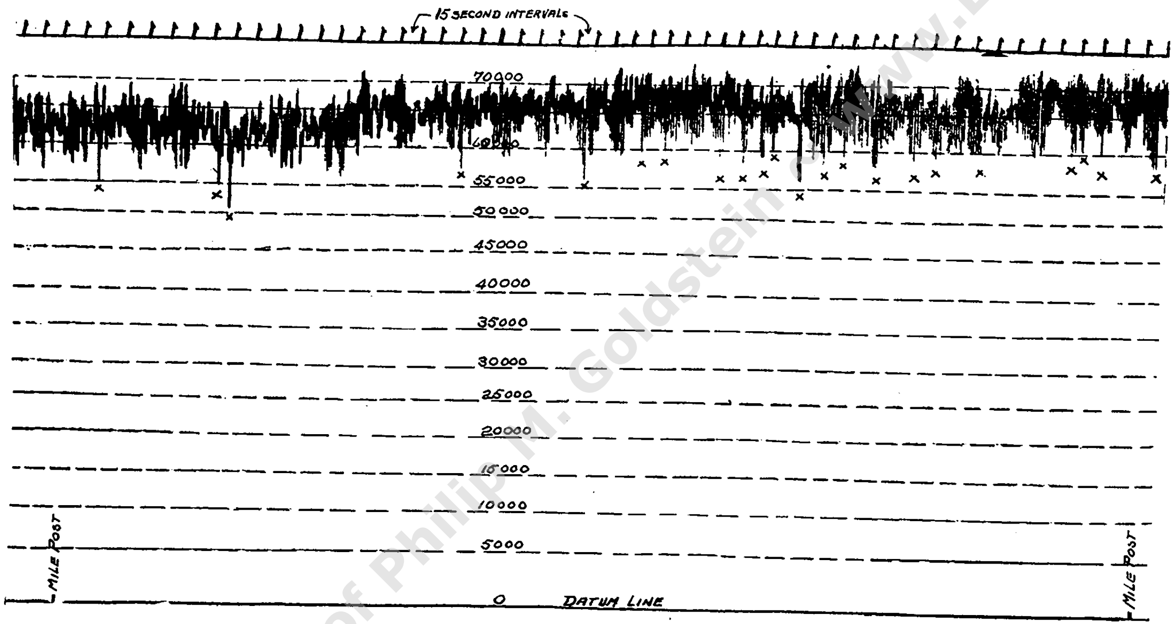
| Run No. | Coal Fired Kind. | Coal Fired Lbs. Total | Coal Fired % Moist | Total Dry Coal Fired | Total Combust. by analysis | Total Ash by analysis | Analysis of coal, by % Fixed C | Volatile matter | Moist % | Ash % | Coal Value B.T.U. Of Moist Coal | Coal Value B.T.U. Of Combust. | Dry Coal, lbs. per hr. | Dry Coal, lbs. Per # G.S. | Flue Gas % O | Flue Gas % CO | Flue Gas % $CO_2$ | Flue Gas % N | Evaporation in lbs. Steam per hr. Moist | Steam per hr. Dry | Steam per hr. Dry per # H.S. | Dry steam per lb. of dry coal. | Equivalent Evaporation from and at 212° Per hr. | Per # H.S. per hr. | Per lb. of coal As Fired | Per lb. of coal Dry | Per lb. of coal Combustible | Boiler B.H.P. | Boiler Eff. | Temp. of Atmosphere |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Bit. | 5065 | 3.1 | 4910 | 4125 | 785 | 52.8 | 28.4 | 3.1 | 15.7 | 12100 | 14910 | 4910 | 49.10 | — | — | — | — | 42,905 | 42,500 | 7.96 | 8.66 | 52,300 | 9.85 | 10.46 | 10.70 | 12.70 | 152.0 | 80.5 | 40 |
| 2 | " | 3711 | 3.1 | 3595 | 3050 | 545 | 52.8 | 28.4 | 3.1 | 15.7 | 12100 | 14910 | 3520 | 35.20 | 4.08 | 0.36 | 12.68 | 82.67 | 37,900 | 37,065 | 6.95 | 10.02 | 45,800 | 8.15 | 11.50 | 13.00 | 15.50 | 1330 | — | 42 |
| 3 | " | 7218 | 3.1 | 7000 | 5900 | 1100 | 52.8 | 28.4 | 3.1 | 15.7 | 12100 | 14910 | 3980 | 39.80 | 8.86 | 1.12 | 9.68 | 80.34 | 25,460 | 25,060 | 4.70 | 6.32 | 31,000 | 5.84 | 7.80 | 8.08 | 9.60 | 900 | 61.0 | 31 |
| 4 | " | 3986 | 3.1 | 3867 | 3867 | 607 | 52.8 | 28.4 | 3.1 | 15.7 | 12100 | 14910 | 3415 | 34.15 | 6.37 | 0.40 | 10.50 | 82.73 | 17,700 | 17,440 | 3.28 | 5.12 | 21,400 | 4.04 | 6.10 | 6.22 | 7.40 | 625 | 48.0 | 46 |

| Run No. | I.H.P. R.H.P. H.E. | R.H.P. C.E. | L.H.P. H.E. | L.H.P. C.E. | R.L.P. H.E. | R.L.P. C.E. | L.L.P. H.E. | L.L.P. C.E. | Division of Power H.P. Right Side | H.P. Left Side | L.P. Right Side | L.P. Left Side | Right Side | Left Side | Total I.H.P. | Consumed per I.H.P. hr. Lbs. of Dry Coal | Consumed per I.H.P. hr. Lbs. of Dry Steam | Consumed per I.H.P. hr. B.T.U. | Locomotive Dyn. H.P. | Lbs per D.H.P. hr. Dry Coal | Lbs per D.H.P. hr. Dry Steam | B.T.U. per D.H.P. hr. | I.H.P. per # H.S. | I.H.P. per # G.S. | D.H.P. per # H.S. | D.H.P. per # G.S. | | Machine Friction in H.P. | Machine Friction in Draw-bar Push. | Mech. Eff. | Eff. of Loco. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 166 | 151 | 153 | 156 | 127 | 121 | 129 | 138 | 317 | 309 | 248 | 267 | 564 | 577 | 1141 | 4.30 | 37.5 | 53,700 | 972 | 5.17 | 43.9 | 66,800 | .215 | 114.1 | .183 | [illegible] | 972 | 169 | 14,400 | 75.8 | 3.8 |
| 2 | 129 | 128 | 129 | 122 | 127 | 124 | 127 | 126 | 260 | 257 | 251 | 253 | 511 | 510 | 1021 | 3.45 | 36.5 | 43,200 | 898.6 | 3.92 | 41.4 | 49,000 | .192 | 102.1 | .169 | 89.9 | | 122 | 7,600 | 87.1 | 5.1 |
| 3 | 108 | 110 | 109 | 107 | 113 | 111 | 111 | 117 | 218 | 216 | 224 | 228 | 442 | 444 | 887 | 4.50 | 29.0 | 56,400 | 694.4 | 5.25 | 36.0 | 65,500 | .167 | 88.7 | .131 | 69.4 | | 195 | 14,600 | 78.5 | 2.0 |
| 4 | 113 | 110 | 102 | 106 | 96 | 88 | 99 | 95 | 214 | 208 | 183 | 194 | 397 | 403 | 800 | 4.30 | 22.0 | 53,700 | 584.0 | 5.85 | 30.0 | 73,000 | .151 | 80.0 | .110 | 58.4 | | 216 | 12,600 | 73.0 | 3.1 |


RIGHT HIGH PRESSURE
150 LB. SPRING
R. P. M. = 38 M. E. P. = 92.8 LBS. C. O. = 72 %
I. H. P. = 289
R. P. M. = 34 M. E. P. = 89.4 LBS. C. O. = 70.4 %
I. H. P. = 221
R. P. M. = 21 M. E. P. = 104 LBS. C. O. = 69.4 %
I. H. P. = 158
R. P. M. = 46 M. E. P. = 72.4 LBS. C. O. = 65 %
I. H. P. = 246
LEFT HIGH PRESSURE
150 LB. SPRING
R. P. M. = 38 M. E. P. = 90 LBS. C. O. = 71.6 %
I. H. P. = 280
R. P. M. = 34 M. E. P. = 97.3 LBS. C. O. = 70 %
I. H. P. = 230
R. P. M. = 21 M. E. P. = 109.3 LBS. C. O. = 71.8 %
I. H. P. = 166
R. P. M. = 46 M. E. P. = 67.3 LBS. C. O. = 65.4 %
I. H. P. = 229
RIGHT LOW PRESSURE
60 LB. SPRING
R. P. M. = 42 M. E. P. = 36 LBS. C. O. = 77 %
I. H. P. = 235
R. P. M. = 36 M. E. P. = 40.2 LBS. C. O. = 77.6 %
I. H. P. = 240
R. P. M. = 18 M. E. P. = 50.2 LBS. C. O. = 76.6 %
I. H. P. = 152
R. P. M. = 50 M. E. P. = 27.4 LBS. C. O. = 69 %
I. H. P. = 217
LEFT LOW PRESSURE
60 LB. SPRING
R. P. M. = 42 M. E. P. = 37.2 LBS. C. O. = 78 %
I. H. P. = 246
R. P. M. = 36 M. E. P. = 40.7 LBS. C. O. = 73.8 %
I. H. P. = 243
R. P. M. = 18 M. E. P. = 52.4 LBS. C. O. = 75 %
I. H. P. = 160
R. P. M. = 50 M. E. P. = 27.8 LBS. C. O. = 69 %
I. H. P. = 216



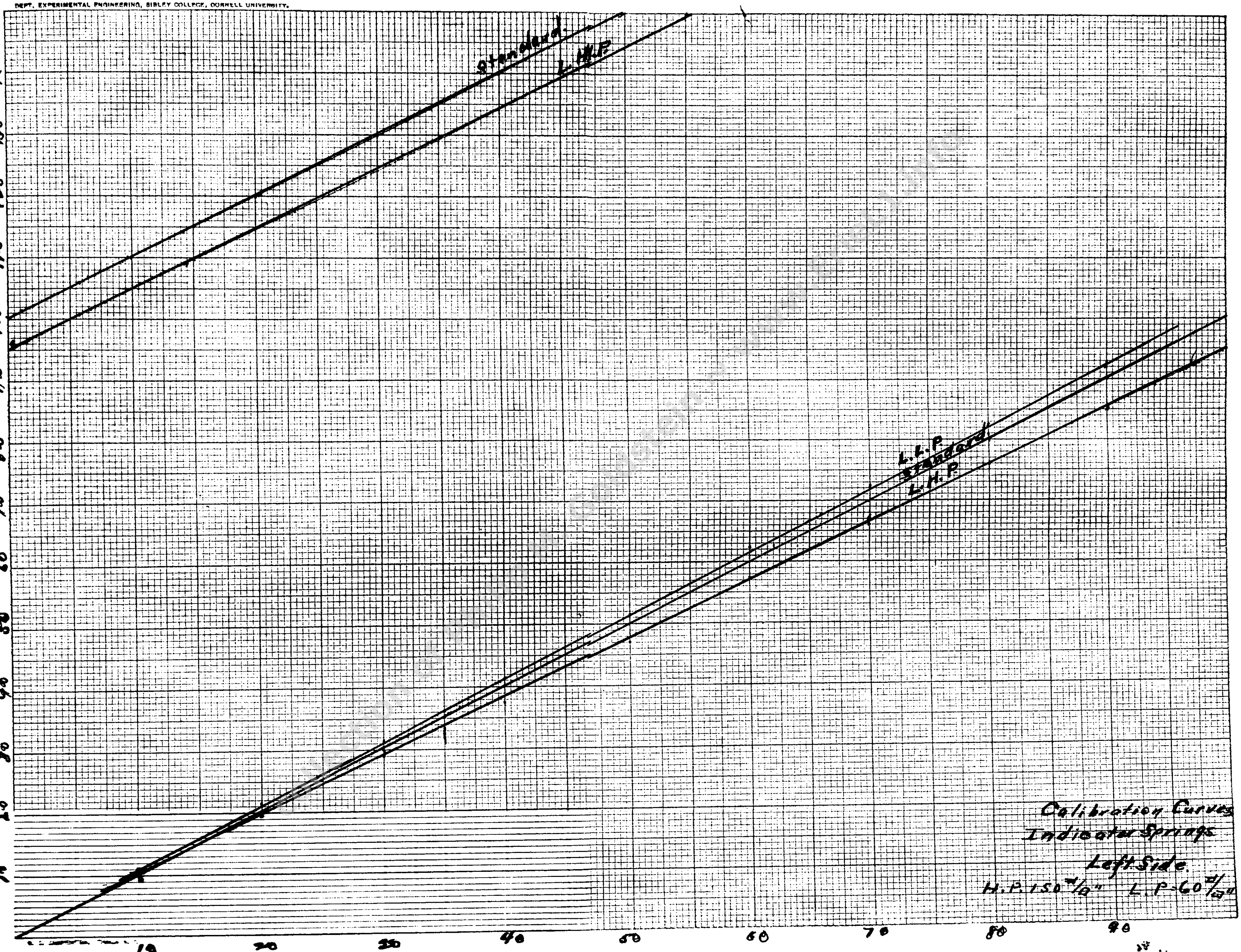

# Sample Dynamometer Record, #1.



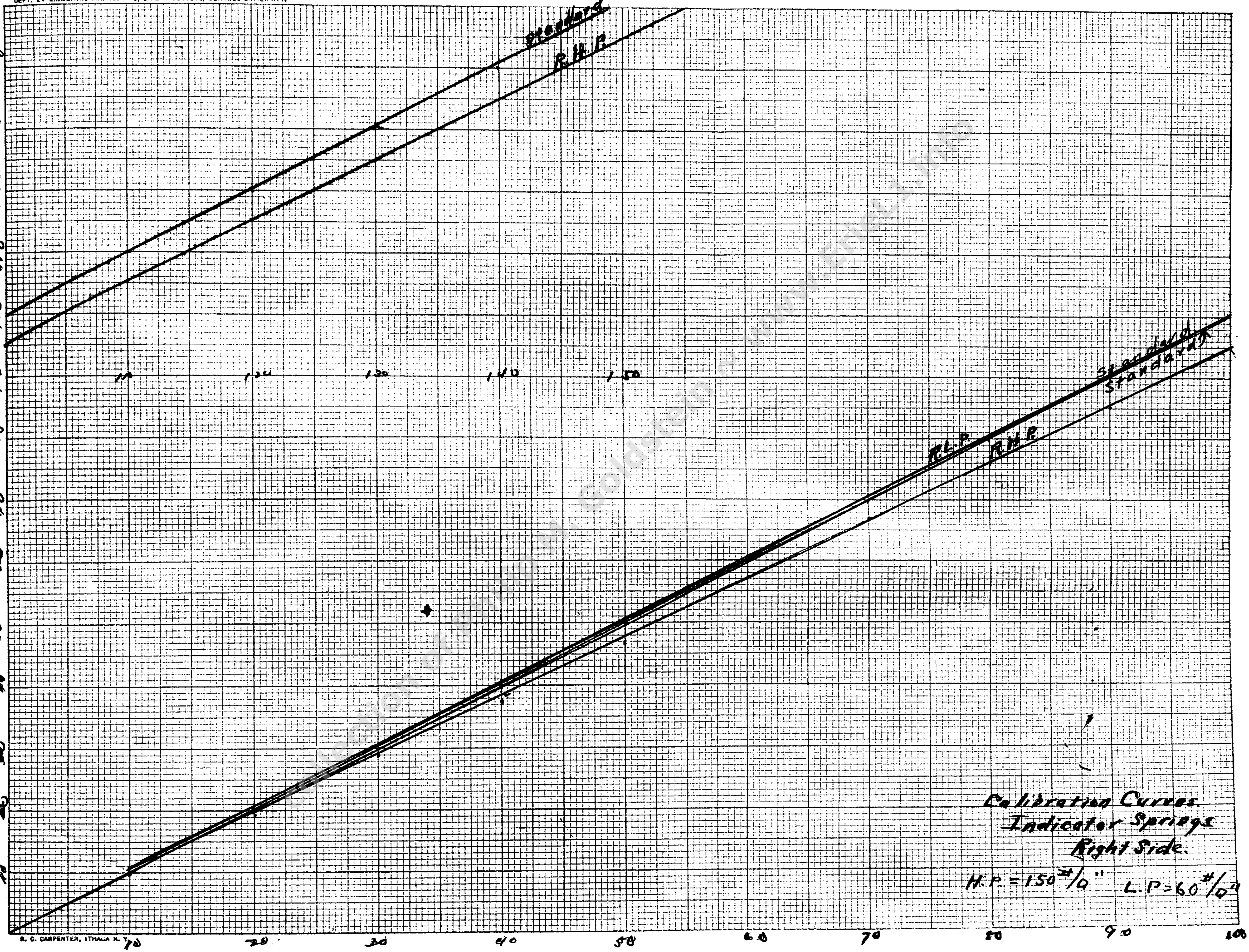

# Sample Dynamometer Record, #2.

"x" indicates points of slipping.

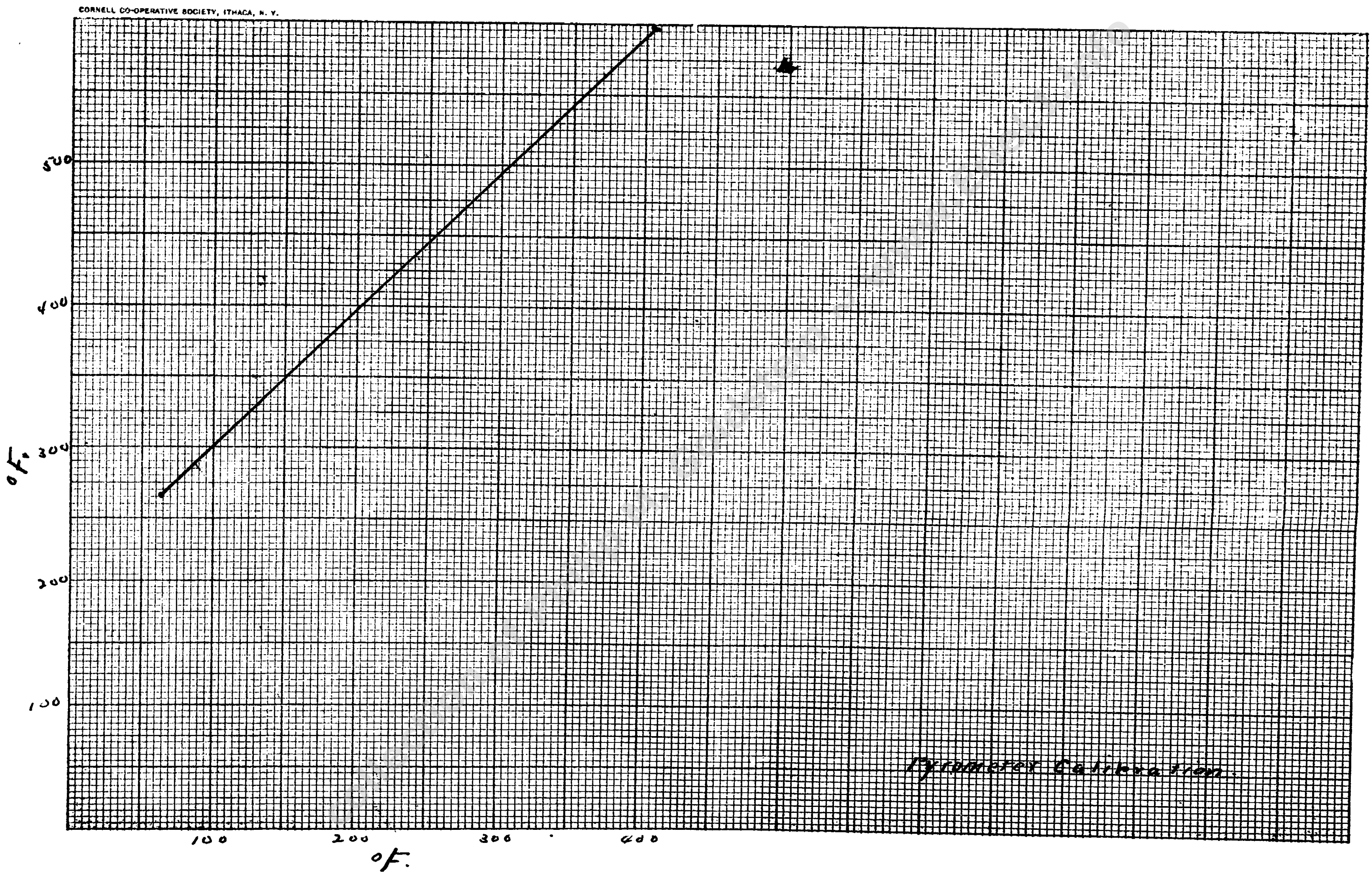
DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY.

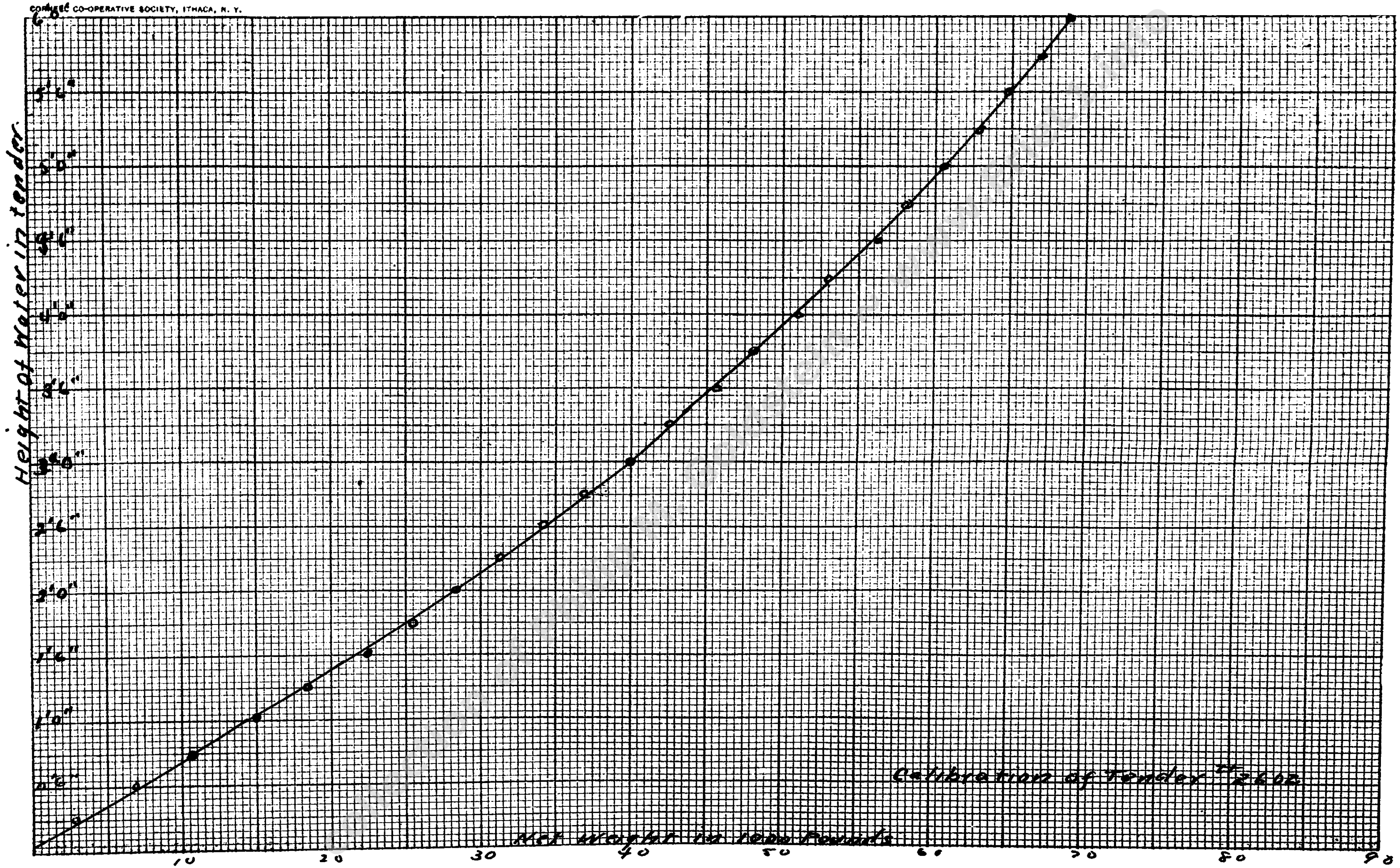


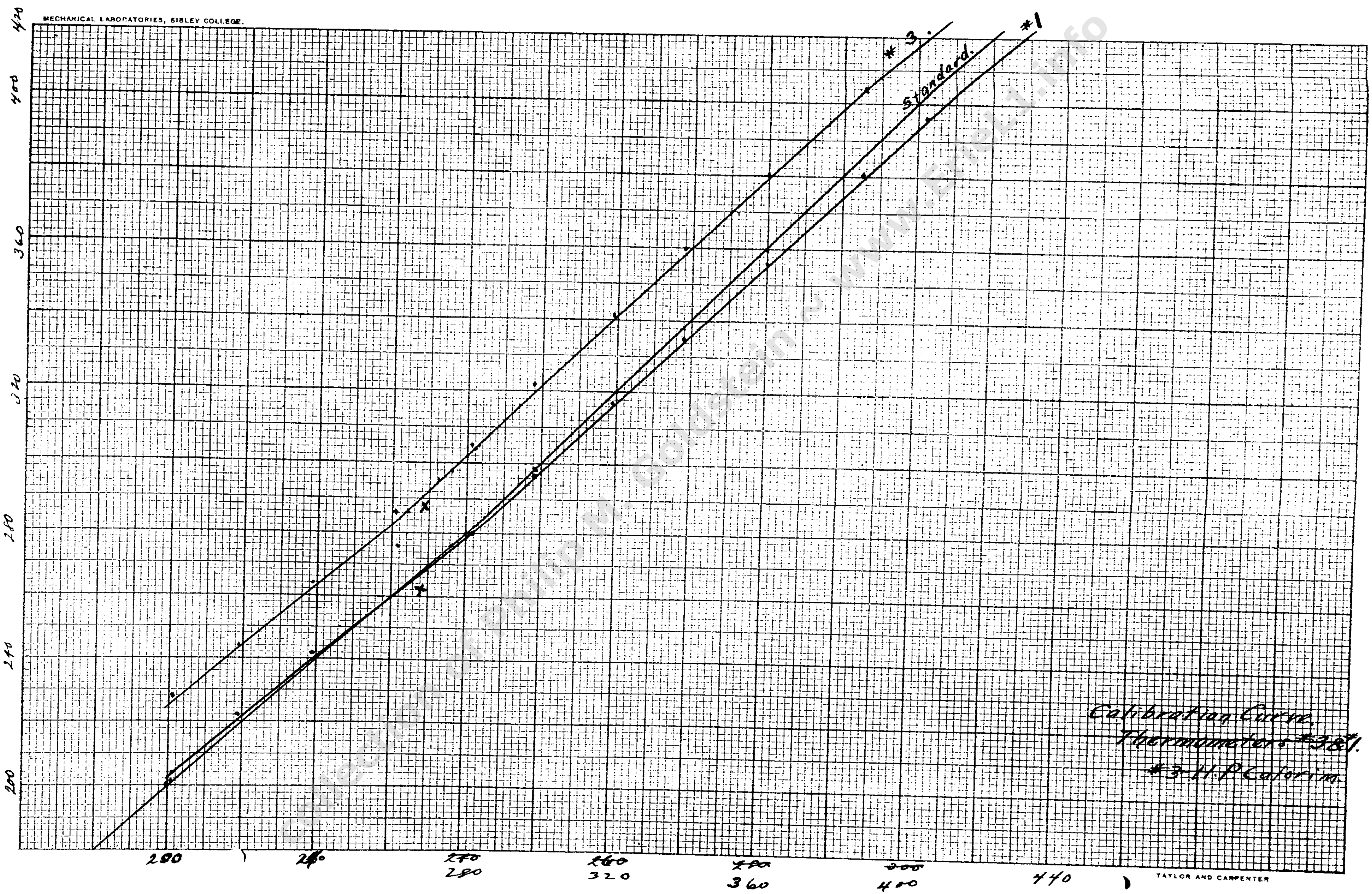
DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY.

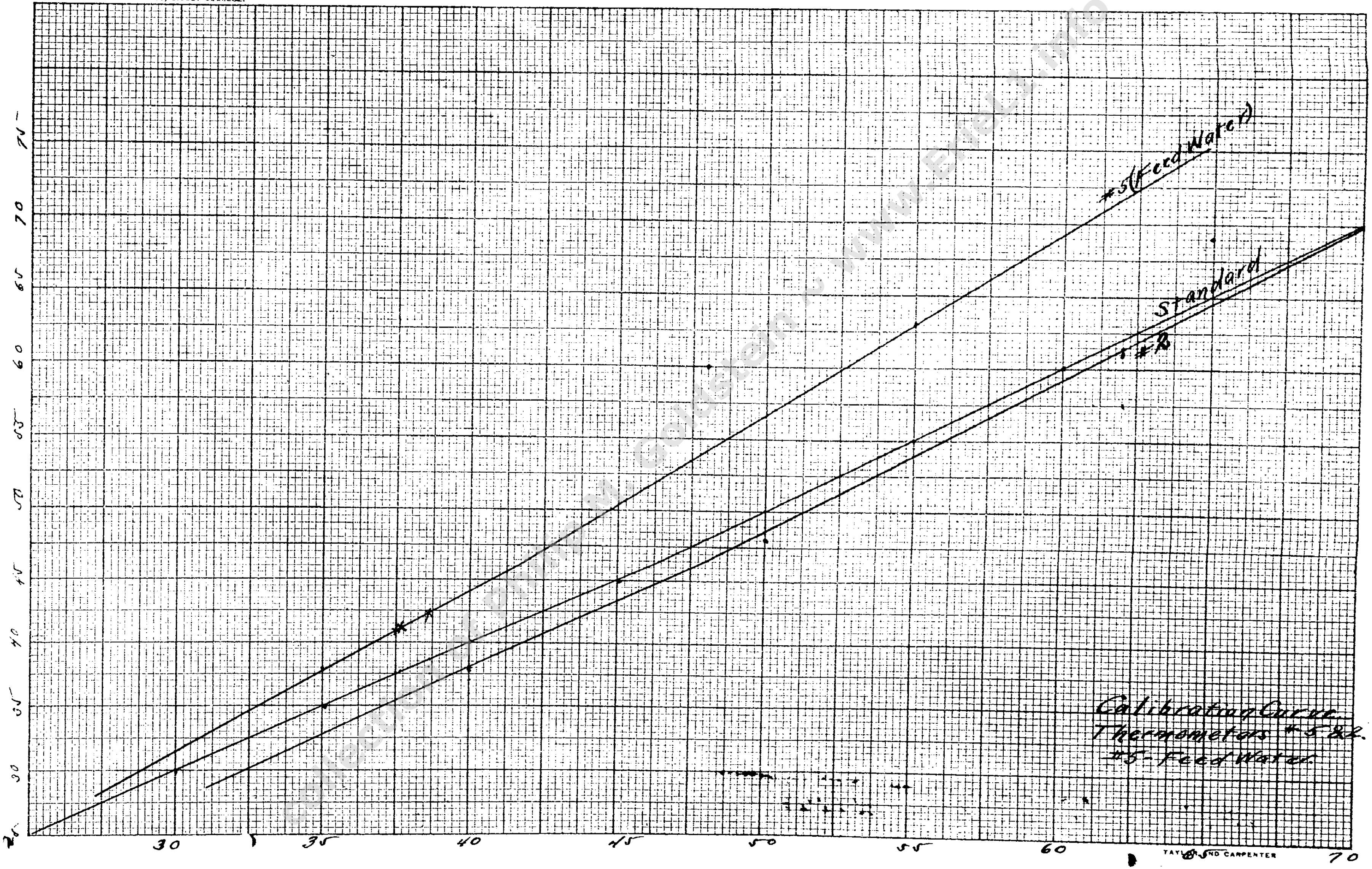


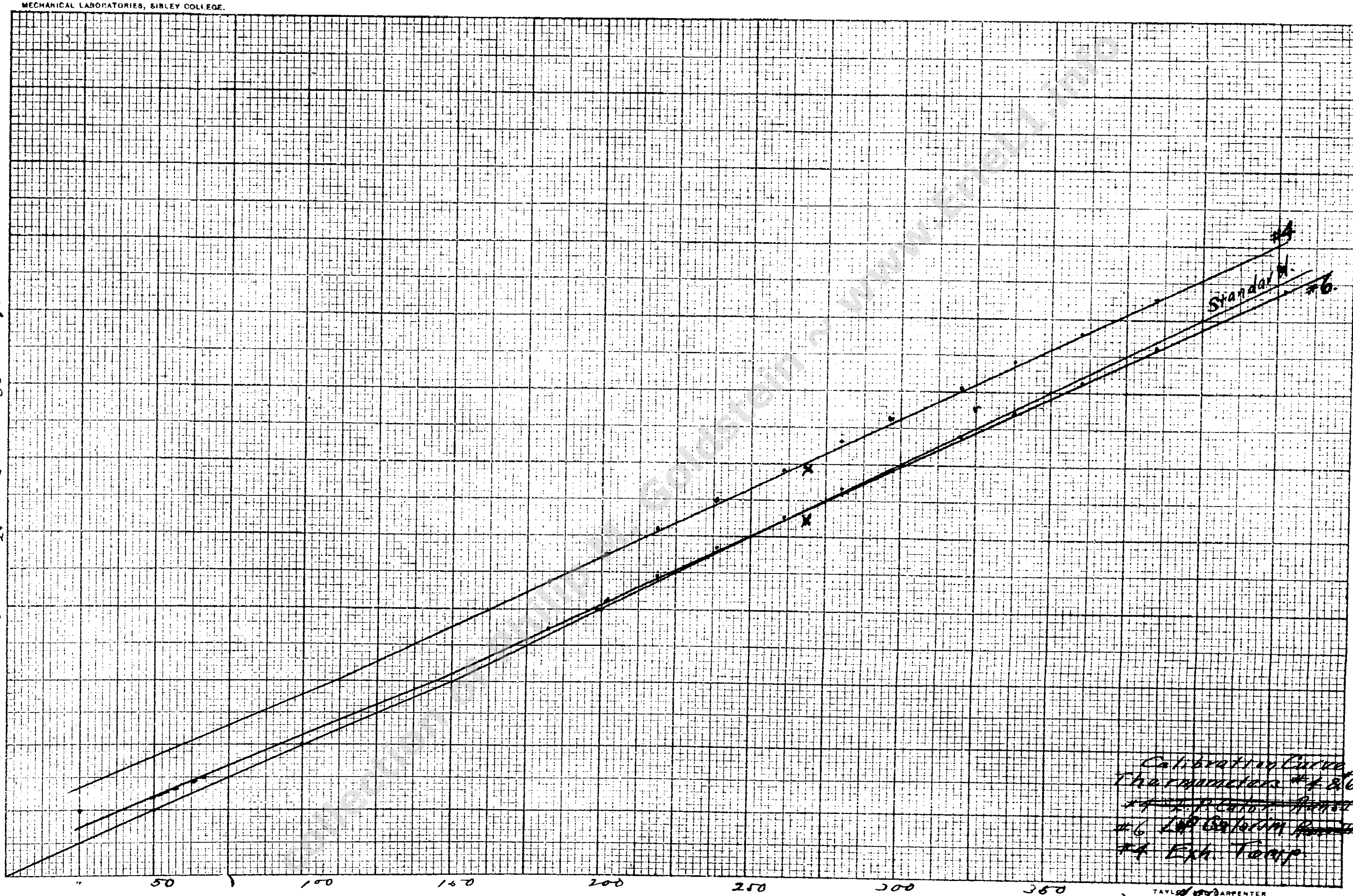

R. C. CARPENTER, ITHACA N. Y.


CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.
500
400
°F. 300
200
100
100
200
300
400
°F.
Pyrometer Calibration.


Height of Water in Tender
6'0"
5'6"
5'0"
4'6"
4'0"
3'6"
3'0"
2'6"
2'0"
1'6"
1'0"
0'6"
Calibration of Tender #2602
Net Weight in 1000 Pounds
10
20
30
40
50
60
70
80
90

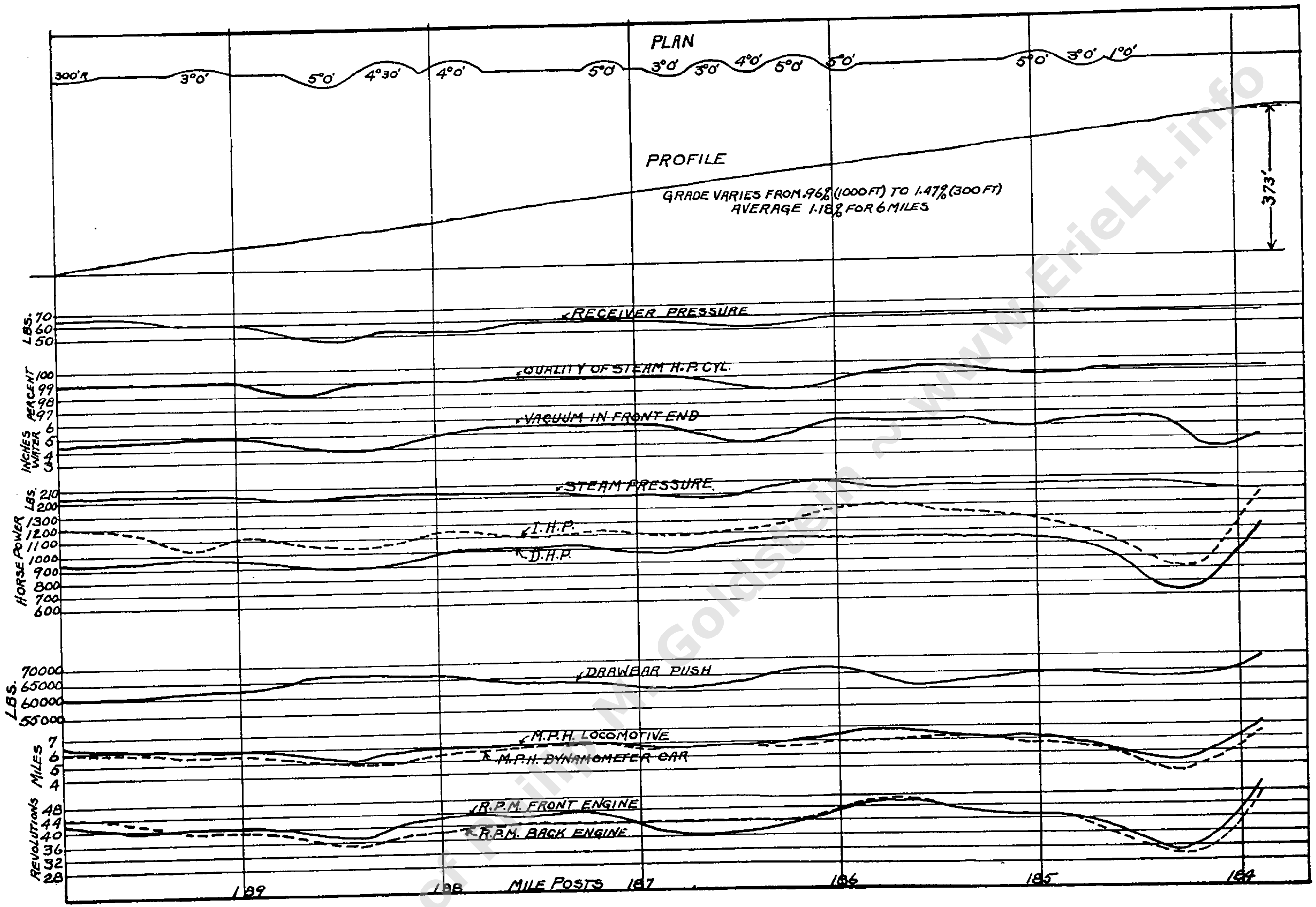

MECHANICAL LABORATORIES, SIBLEY COLLEGE.
TAYLOR AND CARPENTER
# 3.
Standard.
# 1
Calibration Curve.
Thermometers #3 & 1.
#3 H.P. Calorim.
200
240
280
320
360
400
420
440


#5 (Feed Water)
Standard
#2
Calibration Curve.
Thermometers #5 & 2.
#5 - Feed Water.
30
35
40
45
50
55
60
70
65
75

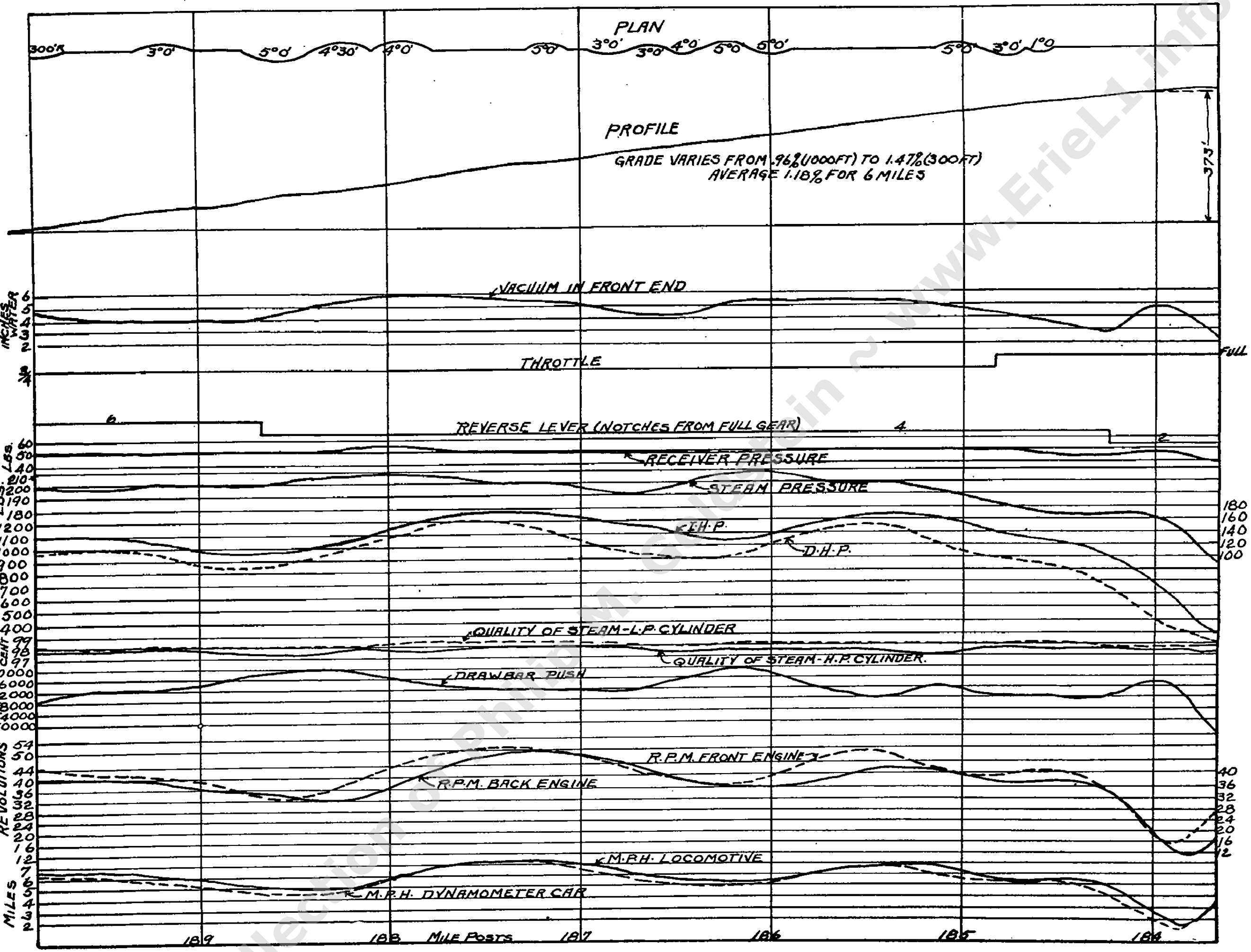

#4
Standard
#6.
Calibration Curve
Thermometers #4 & 6.
#4 Exh. Temp
50
100
150
200
250
300
350
400
400
300
200
150
TAYLOR & CARPENTER



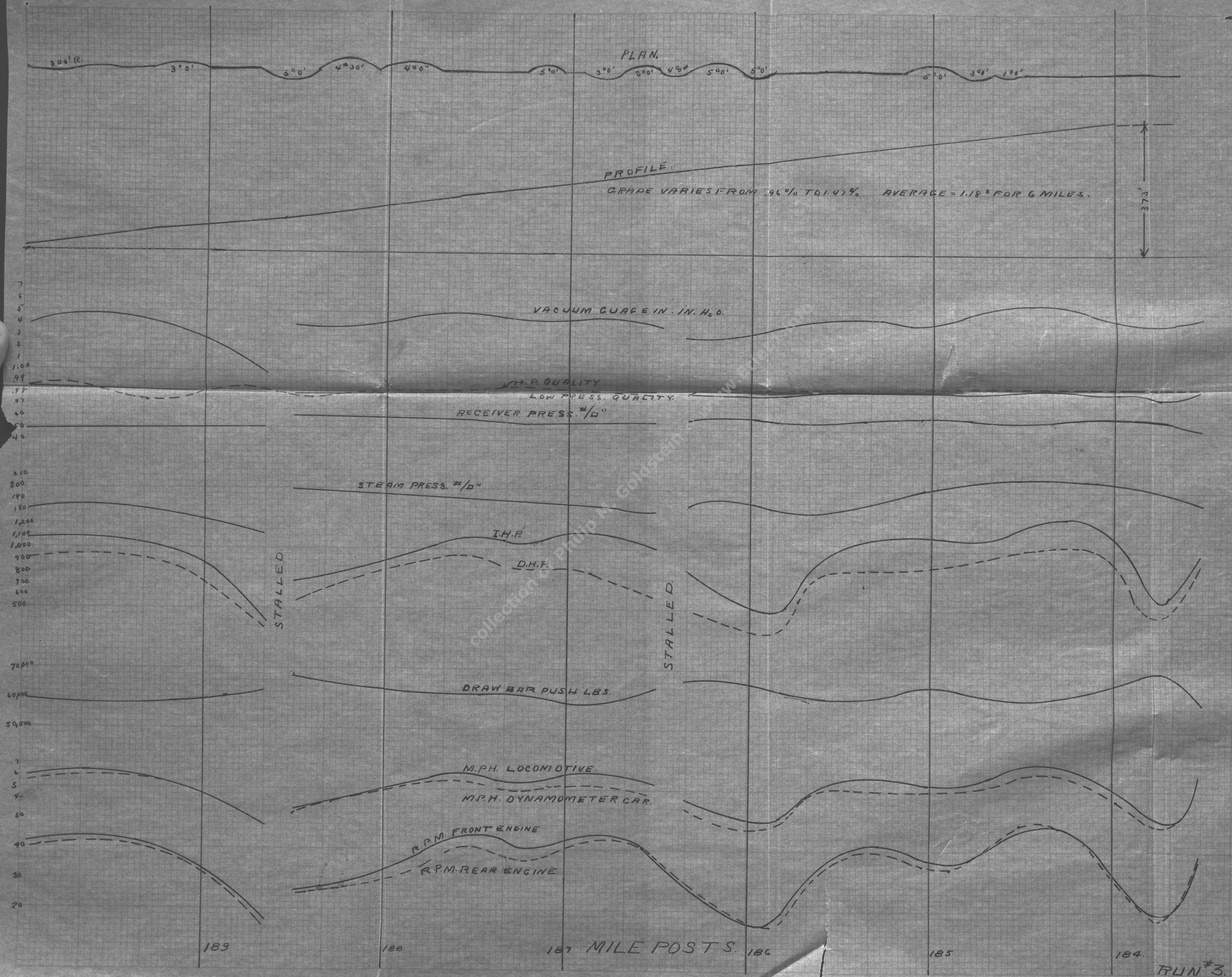
111

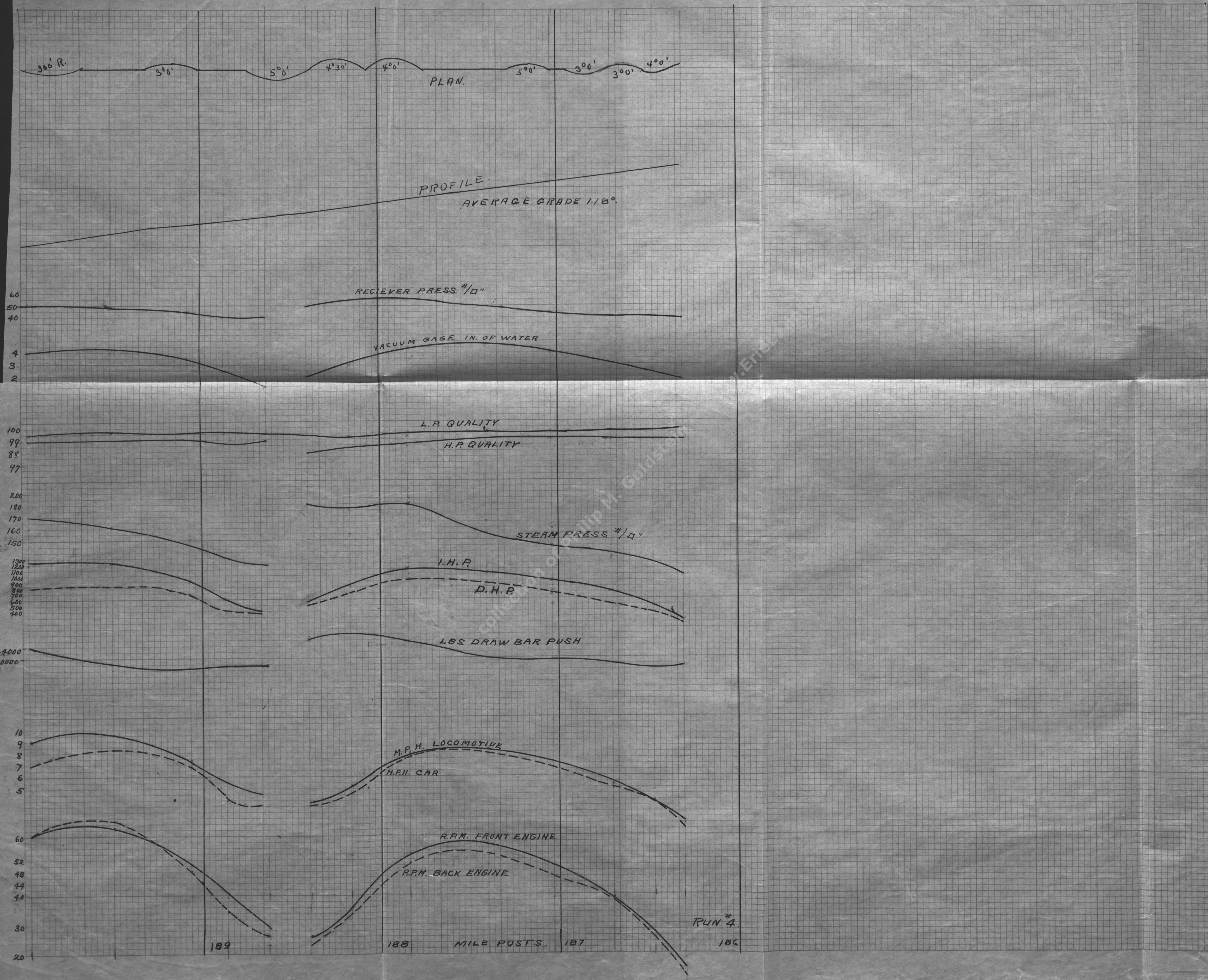

PLAN
300'R
3°0'
5°0'
4°30'
4°0'
5°0'
3°0'
3°0'
4°0'
5°0'
5°0'
5°0'
3°0'
1°0'
PROFILE
GRADE VARIES FROM .96% (1000 FT) TO 1.47% (300 FT)
AVERAGE 1.18% FOR 6 MILES
373'
RECEIVER PRESSURE
LBS. 70 60 50
QUALITY OF STEAM H.P. CYL.
PERCENT 100 99 98 97
VACUUM IN FRONT END
INCHES WATER 6 5 4 3
STEAM PRESSURE
LBS. 210 200
I.H.P.
D.H.P.
HORSE POWER 1300 1200 1100 1000 900 800 700 600
DRAWBAR PUSH
LBS. 70000 65000 60000 55000
M.P.H. LOCOMOTIVE
M.P.H. DYNAMOMETER CAR
MILES 7 6 5 4
R.P.M. FRONT ENGINE
R.P.M. BACK ENGINE
REVOLUTIONS 48 44 40 36 32 28
189
188
MILE POSTS
187
186
185
184

# Log of Run 1.


PLAN
300'R
3°0'
5°0'
4°30'
4°0'
5°0'
3°0'
3°0'
4°0'
5°0'
5°0'
5°0'
3°0'
1°0
PROFILE
GRADE VARIES FROM .96% (1000 FT) TO 1.47% (300 FT)
AVERAGE 1.18% FOR 6 MILES
37.3'
VACUUM IN FRONT END
INCHES WATER
THROTTLE
FULL
REVERSE LEVER (NOTCHES FROM FULL GEAR)
RECEIVER PRESSURE
STEAM PRESSURE
LBS.
I.H.P.
D.H.P.
HORSE POWER
QUALITY OF STEAM - L.P. CYLINDER
QUALITY OF STEAM - H.P. CYLINDER.
PER CENT
DRAWBAR PUSH
POUNDS
R.P.M. FRONT ENGINE
R.P.M. BACK ENGINE
REVOLUTIONS
M.P.H. LOCOMOTIVE
M.P.H. DYNAMOMETER CAR
MILES
189
188
MILE POSTS
187
186
185
184

Log of Run 2.


PLAN.
PROFILE.
GRADE VARIES FROM .96% TO 1.47%   AVERAGE = 1.18% FOR 6 MILES.
37.3'
VACUUM GUAGE IN. IN. $H_2O$.
H.P. QUALITY
LOW PRESS. QUALITY.
RECEIVER PRESS. #/□"
STEAM PRESS. #/□"
I.H.P.
D.H.P.
STALLED
STALLED
DRAW BAR PUSH LBS.
M.P.H. LOCOMOTIVE.
M.P.H. DYNAMOMETER CAR.
R.P.M. FRONT ENGINE
R.P.M. REAR ENGINE
189
188
187
MILE POSTS.
186
185
184.
RUN #3.


300' R.
3°0'
5°0'
4°30'
4°0'
5°0'
3°0'
3°0'
4°0'
PLAN.
PROFILE.
AVERAGE GRADE 1.18°.
RECIEVER PRESS. #/□"
60
50
40
VACUUM GAGE IN. OF WATER
4
3
2
L.P. QUALITY
H.P. QUALITY
100
99
88
97
200
180
170
160
150
STEAM PRESS #/□"
I.H.P.
D.H.P.
1300
1200
1100
1000
900
800
700
600
500
400
LBS. DRAW BAR PUSH
4000
0000
10
9
8
7
6
5
M.P.H. LOCOMOTIVE
M.P.H. CAR
60
52
48
44
40
30
20
R.P.M. FRONT ENGINE
R.P.M. BACK ENGINE
RUN #4.
189
188
MILE POSTS.
187
186