Some Inclined Plane Notes, Etc.

In 1831, I was appointed Senior Principal Assistant Engineer under my friend and preceptor, Sylvester Welch, on the Allegheny Portage Rail Road in Pennsylvania. The other two Principal Assistants, were my friends Solomon W. Roberts, and Edward Miller, (the latter deceased).

I surveyed and located eight of the ten inclined planes, and superintended their Construction; namely, Nos. 3, 4 & 5, on the Western Slope, and 6, 7, 8, 9 and 10, on the Eastern slope of the Mountain.

Mr. S. W. Roberts surveyed, located and superintended the Construction of Nos. 1 & 2, on the Western Slope, ~~[illegible]~~ upon the Western half of the road, which was under his immediate Charge.

Mr. Edward Miller's duties, (who began later, and were Chiefly in the main Office, with Mr. Welch, arranging the plans, and making the drawings for the Engines and Machinery for the working of the Inclines.

The inclination of the planes varied from eight per cent., to ten and a quarter per Cent. The longest plane, No 8, being 2100 feet, with a rise of 10 1/4 ft. per 100; being a little less than 6.°*

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* The old Phil.a & Pittsburgh turnpike, which crossed the Mountain close by, had grades of 6.°, and I made it a point in establishing the grade of the steepest planes on the Railroad, that they should be less steep than the grade of the turnpike; and it was so stated in our reports of that day.

In 1832, in Company with Mr. Welch, Chief Engineer, I visited the Inclined Planes on the Morris Canal, in New Jersey, and those on the Carbondale and Honesdale Rail Road, in North Eastern Pennsylvania, ~~both in New Jersey~~, and took notes and made drawings, for the purpose of aiding us in our Studies of the details of the inclined planes we were then building on the State Rail Road over the Allegheny Mountain. Various plans had been suggested for working the planes; but no survey had been made or ordered by the State for a railroad grade without inclined planes. It is however true that a survey was made across the Allegheny Mountain, between Hollidaysburg and Johnstown- in 1826, about 37 miles, having in view a low grade Macadamized road, a kind of road which was then new. George J. Olmsted, C. E., under Canvass White, Chief Engineer, had charge of the field work, and I was a rodman in his party. John J. Young of New York State, was one of the leaders. F. H. Petrie of Portland, Maine, was the Compass.

The Canal system, in preference to a railroad system, had been deliberately adopted in the Session of 1825-26 of the Legislature of Pennsylvania; and Mr. Canvass White then Chief Engineer of the Union Canal - a Canal extending from the Schuylkill to the Susquehanna, was appointed by the Legislature to make the surveys from the Susquehanna to the Ohio, via the Juniata, on the Eastern side of the Mountain, and via the Conemaugh and Kiskiminitas, and the Allegheny rivers on the Western.

In 1829, preliminary surveys across the Allegheny Mountain were made under the direction of Col. S. H. Long, (U. S. A.) for a railroad with inclined planes between Hollidaysburg and Johnstown. This survey was made for the State of Pennsylvania, under the direction of the Canal Commissioners. Col. Long proposed eleven inclined planes, some of them considerably curved.

In 1830, another set of preliminary surveys was made between the same points under the direction of Mr. Moncure Robinson (one of the oldest members of this Society) who also recommended eleven inclined planes, but urged that they should be straight.

In the session of 1830-31, the Legislature of Pennsylvania authorized the Construction of the railroad, with a gauge of 4 ft. 9 inches, with inclined planes, without designating the number. I suggested that it might be practicable to locate a line with five inclines on each side of the mountain, all straight, although it might involve the expense of heavy retaining walls at a few points; and I was directed by Mr. Webb to try to locate the line so as to have but five straight inclines on each side, which I succeeded in doing, by having one plane (No 8, the third one from the summit on the eastern slope,) considerably longer than the others, and with the maximum inclination of 10 ¼ ft. per 100.

My impression is that had the Legislature authorized surveys with a view to determine whether a railroad with or without inclined planes should be adopted, that possibly a location at that day might have been made with a grade of 52 ft. per mile, which

could not have increased the distance more than about ten miles. It was not certain at the time that locomotives would be used on any part of the Mountain railroad. On a portion of the road, at my earnest solicitation, a grade of 52.8 ft. per mile, on a straight track, for about three miles, between the foot of Plane No 10 and Hollidaysburg, was adopted in lieu of a line with numerous Curves on a grade of 42 29/100 ft. per mile; and upon this grade locomotives were afterward used. At that period (1831), there was quite a common impression that locomotives could do any little work on grades above 30 ft. per mile; and this was the maximum fixed by Major Wilson, Chief Engineer, in locating the State railroad, 80 miles long, between Philadelphia and Columbia, a town on the Susquehanna twelve miles West of Lancaster. This decision involved the location of two inclined planes on the Columbia railroad, and which were Constructed; one near Philadelphia, called the "Schuylkill Inclined Plane", and the other at Columbia, called the "Columbia Inclined Plane". These planes had grades of 8 feet per 100, and were about half a mile long, each. The intermediate line - about 76 miles, was located with the maximum grade of 30 feet per mile, and numerous Curves of 13°, or about 439 ft. radius. The "gap, summit" cut, however, proved to be so troublesome and costly, on account of Quicksand encountered in the excavation, that it was finished with a grade of about 45 feet per mile; and it so remains. (On the Continuation of this railroad from Lancaster to Harrisburg - 37 miles,

which I located for a private Company, in 1833, then styled the "Harrisburg, Portsmouth, Mount Joy and Lancaster Rail Road Company," ~~in 1833~~, I adopted a maximum gradient of 0.75 per 100, or 39 6/10 ft. per mile. This was strictly adhered to. Afterward, when the Pennsylvania Rail Road Company became the purchasers of the State works, they leased for 999 years this Harrisburg and Lancaster line; and it now constitutes a part of their main road between Philadelphia and Pittsburgh *

To return from this digression, to the Allegheny Mountain Inclined Planes: In the spring of 1834 the road was regularly opened to the public for traffic. It was literally "opened to the public." Any person could put Cars on the road, and have them, with horses, to the foot of the Planes on either side of the Mountain, and between the Planes. The State transported the same over the Planes, by means of Stationary engines, One at the head of each Plane. This system in a short time, as the number of Cars increased, as well

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* In the session of 1847-
In 1848, the Legislature of Pennsylvania appointed me the Engineer to survey and report upon a route for avoiding the "Schuylkill Inclined Plane" near Philadelphia. At the time of this appointment I was engaged in building a Canal in the State of Ohio. I made the survey and report upon a line avoiding the Inclined Plane, in the summer of 1848; recommending the line substantially upon which it was afterward Constructed, where it stands now, Terminating, as a Steam-road, in West Philad^a, and Continuing into Market Street by a bridge across the Schuylkill — where now passes without change. [overleaf.]

as the number of separate parties doing business on the road, became exceedingly troublesome.

During that year, (1834) I had Charge of the management of the running of the road, and the inspection, weighing and numbering of the Cars etc, as well as the Control and management of the running of the two Inclined Planes.

At the same time, the State having so determined, a second track was being laid Immediately between the Planes, during that year and duplicate Engines were erected at the heads of the Planes. This work was under the Charge of Mr. S. W. Roberts,

A large number of Cast iron Chairs were required for this railroad, there being one way thereof on each line of the rails, the rail used being of the "edge" pattern - so-called, and weighing 39 lbs. per Yard. Added to my other duties, was that of superintending the Manufacture and delivering the Contents of the Manufactury of these Castings - which weighed about 14 lbs. each - In the first track, Stone - blocks 2 ft. square, 1 foot thick, were used as supports for the Chairs, which were fastened thereon by means of Spikes driven through locust plugs set in holes six inches deep previously drilled in the Stone. In the second track stone Cross-ties, 7 ft. long, at intervals of 3 ft. from Centre to Centre were used. This made a very solid and a very rigid road, as may well be imagined. It may as well be here stated that in a few years these stone supports were superceded by the ordinary wooden Cross-tie.

The "Columbia Inclined Plane" was also unided about the same time, upon a route surveyed by W. H. Hoffnagle, C. E. (who had previously been one of my Assistants on the Lehigh Canal - who is now deceased.)

So that about 1850, the State railroad between Philadelphia and the Susquehanna River was freed from Inclined Planes, and having no grade over about 45 ft. per mile.

The delay of much of the material along the line for the second track, and for the duplicate engines at the planes, added to the general transportation of freight and passengers, with only a single track Completed between the planes, demanded daily attention on the line, as there were questions Constantly arising in the use of the road, which I was daily called upon to settle - and the telegraph was not yet born. In fact railroading such as we see in the world to day had no existence.

The machinery which worked the planes was simple. An endless rope of about three inches diameter passed around a horizontal double-grooved spur wheel at the head of the plane, and a smaller horizontal double-grooved movable wheel at the foot - between the two tracks, where the slack, when necessary was taken up. The motion was transferred from the Engine by strong bevelled Cog wheels. The engines, two double Cylinders, of sizes proportioned to the particular plane. There were two System of brakes for restraining and stopping; one the ordinary iron band friction; the other a water Cylinder, with a regulating valve, which by partly Closing Checked the speed, and which when entirely Closed stopped the motion. I often let trains down a plane by the water brake alone, without using any steam; and sometimes I let a loaded train of four Cars, bring up several empty Cars, by means of the Water-brake alone. Engines rated at 30 to 40 horse-power. All high pressure.

The ropes were hempen, at first, though some grass ropes were tried, and answered tolerably

well. The Cars usually weighed about three to three and a half net tons - all four-wheeled. The passenger Cars were also 4-wheeled, and large enough to seat about 25 persons inside, and about ten or sometimes more on top. We sometimes sent the passenger Cars through, from Hollidaysburg to Johnstown, 37 miles, or vice versa, in less than six hours, and accasionally in Considerably less time. It depended very often upon delays arising from the number and position of the freight trains.

Upon one occasion, at Plane No 10. when the Engine was out of order, I carried the business of the road by means of One of Wm Norris' locomotives, which weighed I think about twelve tons, by running it up the plane empty, and then attaching it to the endless rope on the descending track, putting on steam, and thus pulling up a train on the Ascending track; then detatching the Engine at the foot and running up as before. The same or a similar engine was run up all the planes on the East side of the Mountain by its own steam-power during the season of 1834. The grade of No 10, plane was 8 ft per 100, or about 422 ft. per mile and about half a mile long. The steepest plane on the road was 10¼ feet per 100, or 541.20 ft. per mile. * and 3100 ft long. The grades between the planes were very light, generally, not exceeding 0.40 per 100, or 21.12 ft. per mile

* My opinion at the time the engine was run up a grade of 541 ft. per mile, straight track, that it was near the limit of grade at which an engine by its own adhesion could be run up by steam power.

The cars passing up and down the planes were attached by means of stopper ropes, on to each car, and the men at the planes soon acquired wonderful dexterity in hitching and unhitching; so that when a train of four cars came to a plane, either ascending or descending, it was sometimes passed with very little loss of time.

Occasionally a defective hitch would cause a run off of a car or train, doing considerable damage.

W. Welch, the Chief Engineer, suggested the use of a small 4-wheeled car with an iron shoe extending along the rail. Whilst I was drawing a plan from which to have one constructed, as an experiment, it occurred to me to make one with only two wheels, which would be very much lighter, and more easily handled by the men at the head and foot of the plane. This idea being approved, I had one built under my direction in Johnstown. It was tested on Plane No 1, by allowing a Car of iron ore or pig metal to strike it with a run of some feet down the plane. It stopped the Car at once. This Car was then immediately adopted, and followed by others similar cars, and they were thenceforward used at all of the planes on that Railroad; the plan was also copied and introduced on the State Inclined Planes at Philadelphia and Columbia, and used for many years. Accidents from the breaking of the main rope, or of the hitching rope, were thus rendered comparatively harmless.

There was one other incident at Plane No 10, the lowest on the Eastern side of the Mountain, which may

not be uninteresting. The head of this plane was at an elevation of nearly 200 ft above a mountain stream called Blair's-Gap Run, upon the top of a very compact slate rock formation, with no flowing stream nearer than the one first mentioned. The foot of the Inclined Plane was carried ten feet below the old bed of the stream — in order to keep the grade of the railroad down to 52.8 ft. per mile. This was managed by Culverting the stream under the Inclined Plane, some distance above the foot, and excavating a new channel bringing it in and passing it under the grade of the railroad half a mile or so below the Plane.

A well was begun at the head of the Plane, and a five-inch bore hole was started and sunk. It found to be so dry that the water for boring purposes, as well as for the use of the Stationary Engine at the head of the Plane, had to be hauled up the Plane. After it had been sunk some feet below the bed of Blair's-Gap Run, I proposed to get water — at least temporarily by laying wooden pipes from a point in the run about 2½ miles up, which was found to be high enough to allow the water to flow to the head of the Plane by gravity, and this was soon done. Meanwhile the boring went on to the depth of between 700 and 800 feet, without ever finding a drop of water excepting what was found into it at the top. It was then abandoned. The slate rock formation, through which much of the Inclined Plane was excavated dipped into the mountain spur in which it was located at an angle of about 30°. It turned out to be so compact, as far down as the above deep boring, as to be equivalent to solid rock. No water whatever percolated through it, to that depth.

In 1836, Mr. Wm. Norris invited me to meet a number of gentlemen and himself, to witness a promised performance of one of his locomotives. He said he would take a passenger Car with 50 passengers in it up the Schuylkill Inclined Plane, ~~near~~ Philadelphia, at the rate of ten miles an hour. The first time he went with his engine to make this experiment, it was found that some malicious person had greased the track; which prevented the test that morning, but soon after when the grease had been removed he did take up a passenger Car* with 50 passengers, at the rate of ten miles an hour. A careful record of this performance was made and printed in pamphlet, ~~form~~ (quarto form) but I have not seen it for many years. One of the passengers was an English Officer, who, as Mr. Norris afterward told me, when he related the occurrence in England, was not credited; the railroad savants in Europe at that time having decided that the limit of locomotive possibilities on grades, stopped far short of 422 feet per mile; which was the grade of the Schuylkill Plane, with a length of about half a mile. (I write entirely from recollection.)

Mr. Norris was about that ~~at the~~ time building several locomotives for me to be used on the Cumberland Valley Rail Road between Harrisburg and Chambersburg, (51 miles) which was opened in 1836–37. One of those locomotives, the "Nicholas Biddle", continued running on that road til within a very few years. I think it ran about 38 years. It had only two drivers of about five feet diameter.

* Passenger Cars with 8 wheels were then in use; but they had not been very long in use. At some period between 1833 and 1836, Mr. Norris took me from his shop on Bush hill over to Mr. Imlay's shop, where I examined the first 8 wheeled Car I had seen, and pronounced it "not the thing, for the Columbia R. Road ⊕

⊕ which abounded with curves. It was shortly after placed on the Columbia Rail Road. That Rail Road was opened in 1833. [I think it must have been in 1835 that I saw this 8 wheeled car.]

After the Pennsylvania Rail Road Company had built their railroad (with 95 ft. grade on the East side) over the Allegheny Mountains between Altoona and Johnstown, and after the Allegheny Portage Rail Road with its Inclined Planes had been in use for about twenty years, the Legislature of Pennsylvania directed surveys to be made by ~~my friend~~ Robert Fanies C. E. who was then in the State service, and to ascertain the feasibility of a graded road without inclined planes, with a maximum grade of 75 feet per mile. The Legislature appointed Edward F. Gay, C. E. Robert Fanies C. E. and myself a Commission to examine and report upon the advisability of retaining all or some of the Inclined Planes, or of Constructing a graded line without inclined planes. Accordingly the said Commission made the necessary examinations in the Summer of 1853 & 4 We were unanimously of opinion that it was better for the State to abandon all the planes and Construct a new line on the route recommended by Mr. Fanies, and the road was built by the State upon the route recommended by the Commission, having a maximum gradient on the Eastern side of the Mountain of 75 ft. per mile and on the Western side of about 52.8 ft. per mile. The new State Rail Road and the Pennsylvania, Crossed the summit of the Mountain within less than a mile of each other, both through tunnels; the tunnel of the Penn.a R.R. Co. being something over 3700 feet, and that of the State road about 1850 feet or about half the length of the other. The two roads are in sight of each other on the

eastern side of the Mountain for several miles before reaching the summit, and on the Western slope of the Mountain they run almost side by side for some miles, and both pass down the Valley of the Conemaugh to Johnstown.*

Shortly after the Completion of the new State Rail-Road, and the abandonment of the old Allegheny Portage Rail Road, mostly, the State public works were sold, and the Pennsylvania Rail Road Company became the owner of the Columbia Rail Road, the Old Allegheny Portage, the new State Rail Road over the Mountain, and all the State Canals between Columbia and Pittsburgh. That Company soon after took up the rails from the new State Railroad and applied them on the line between Pittsburgh and Fort Wayne and Chicago; and so ended the last vestige of State railroads in Pennsylvania. I therefore literally attended at the birth of Pennsylvania State Railroads, assisted them in their youth and manhood, and witnessed their funeral obsequies; all in a period of about twenty one years.

In December, 1857, I visited Brazil, and in Company with several other gentlemen made a Contract with

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* About the time that the Commission referred to were engaged examining as already stated, I received a letter from my friend Wm. D Edgar Thomson, President of the Pennsylvania Rail Road, to the effect that that Company entertained serious thoughts of building an inclined plane railroad over the Mountain— for their freight business. It was not however built. It is a question for Calculation and discussion

the Dom Pedro Segunda Railway Company to build this difficult and costly ~~rail road~~ railway across the Serra, back of the City of Rio Janeiro. It was regarded at the time as the most difficult and expensive railway that had at that time been undertaken. More difficult and more costly works have since been carried through, in Europe, and on the West Coast of South America.

The limit of grade and curvature adopted was the same as had been used on the Pennsylvania Rail Road Mountain Division above Altoona; namely, 95 ft. per mile ascent, and 8 degrees deflection per 100 feet. This involved a number of tunnels - 13 in the distance of nine miles, one of which at the summit was 7200 feet long (another nearly half a mile long, the others shorter; making together 3½ miles of tunnel in the nine miles of line.

About 1863, the road being well advanced on Eastern slope of the Mountain, and considerably forward west of the summit, it became obvious that time and money might be saved by the construction of a temporary track over the Mountain around the Tunel Grande, or Big Tunnel, and the Company agreed to allow about $125,000 toward building it. It was built with maximum grades of about 238 feet per mile, with curves of only 230 feet radius. The summit of the Serra which had to be surmounted was about 500 ft. above the grade of the railway at the eastern Portal of the Big Tunnel. ~~The road~~

The temporary road was about three miles long on the Eastern side and about two miles on the Western - making a total length of about five miles.
This was and about two years, during which a large amount of material for the Western side was carried over, and much freight, especially of Coffee, and many passengers were daily transported, without any accident. The Locomotives were built by Baldwin & Co. of Philadelphia, moguls, weighing 42 tons each. They turned the curves very well, and usually took over a baggage Car, Passenger Car, American, 8 Wheeled, and four or five freight Cars. They were limited to a slow speed, about four or five miles an hour, though they could have gone faster had it been desirable; but absolute safety was deemed to be an essential element in the management of a great railroad among a People, unaccustomed to such work, many of whom had declared that they "would never ride through the Big Tunnel under the Serra".

The Emperor of Brazil, Dom Pedro Segundo, was not however one of that Class, (as the people of the United States and of many other Countries have since had opportunities of knowing) He visited the railroad several times in person, and inspected every part of the works carefully and intelligently; descending the last shafts of the Big Tunnel - 340 feet deep, without the slightest hesitation; and when the time came for blowing away the last remaining few feet of

granite rock to effect a Centenary passage through this tunnel he was there. The Emperor walked up to the face of the rock, listened to the blow of a hammer on the other side about four feet of this rock intervening, had the drill holes loaded and partly loaded, then stepping back a few hundred feet behind a safety barricade awaited the firing which took place a few minutes later, and was then the first man to pass through the space which the blasting had made; the writer following closely accompanied him through, where he was met and greeted over the debris of the rock by Mr Boyd the foreman on that side.

The temporary track over the Mountain was used for a long time after this occurence; for strange to say, this granite Mountain, where it was the highest on the line of the tunnel - 500 ft. above grade, instead of being very rotten, as was anticipated consisted of not decomposed granite subject to heavy caving and requiring arching in many places. This caving delayed the opening of the tunnel and increased its cost. Its construction occupied about seven years. The Credit of the admirable management of this difficult work belongs largely to Jacob Humbird now of Cumberland Maryland, who had previously had experience upon some of the difficult tunnels on the Baltimore and Ohio Rail Road.

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On the Baltimore and Ohio Rail Road the experience

in the use of heavy grades has been more complete than elsewhere and upon a heavier grade than any known on which freight and passengers have been regularly carried. Until it was mentioned at the last meeting I was not aware that a portion of the grade over the temporary track at Kingwood Tunnel was so great as 10 per cent. I was under the impression that the grade used was about 360 ft. per mile as at first used, and that that was the heaviest at Parr's Ridge, over which a locomotive had steamed on the Baltimore & Ohio road. I have since seen Mr. Latrobe's admirable paper — which he kindly sent me — on the subject, published in the "Rail Road Gazette", of Dec. 5. 1874, which gives all the particulars, with maps, and profiles of main line, at the "Kingwood" and "Board Tree Tunnel." *

In regard to "Parr's Ridge", Mr Latrobe says —

"The occasions referred to were not indeed the first upon
"which locomotives had ascended steep inclines, for one of the
"little 8-ton grasshopper engines of the Baltimore and Ohio
"Railroad had mounted and descended the original
"grades of that road across Parr's Ridge, (one of which was
"360 feet per mile), since superseded by one of 82 feet. An
"engine of some 10 tons, built by the late William Norris,
"had also ascended the old Schuylkill inclined plane near
"Philadelphia, and no doubt these experiments upon a
"small scale encouraged those upon a more extended one
"of which I have given the preceding account."

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* During the fall of 1874, I was in Europe, for some months, and my Rail Road periodicals so accumulated up to the end of that year, that I made them all a present to a young friend, and thus I mislaid Mr. Latrobe's excellent paper.

The Gettw of W. Latrobe, already mentioned, is the most interesting and satisfactory presentation of experience on steep grades I have ever seen. It should be read by every one who feels an interest in that subject

At Kingwood Tunnel, on the B. & O. R.R. the top of the Ridge was 210 ft. abm level grade of road at East end of Tunnel. Temporary track on the East side reached Summit in 3,400 ft. Grade first 2200 ft. not uniform - Steeper at first then was moderate till 90 ft. attained. average 216 ft. per mile. Remaining 1200 ft distance, and 120 ft. height, 528 ft. per mile. Completed in a Curve of 180° with radius of 300 ft. and 400 ft. One in ten, on a Curve of only 300 ft. radius is a Considerably greater rate than 10¼ per 100 ft. on a straight track. The average ascent of the whole 3,400 feet, on the East side, was at the rate of 336 ft. per mile.

An engine of 28 tons (56,000 lbs) tender 34,000 lbs. Car of coal & other materials at 30,000 lbs. = total 120,000 lbs. or 60 tons of 2000 lbs, taken up a grade of 528 ft. per mile through a Curve of 300 feet radius. The grade and curvature on the West slope were much lighter than on the East slope - falling 305 feet in 7000 ft. - averaging 1 in 23, or 230 ft. per mile. The steep grade was used about two months, in 1852. Afterward an improved temporary line reduced the grade from 528 ft. to 230 ft. per mile.

At Board Tree Tunnel, on the B. & O. R.R. there was also a temporary track on the Ridge, with a grade of 1020, or 264 feet per mile, on curves 328 ft. - with two switch backs on the East and five on the West side. Max. grade 6 ft per 100, or 316 8/10 ft. per mile, Other reaches 4 ft. per 100 or 211 ft. per mile. Engine 56,000 lbs., tender 34,000 lbs. two loaded Cars 30,000 lbs. each - total 150,000 lbs. or 75 net tons. When proved another Car could be added, and still another. Mr Latrobe refers to a pamphlet published by the late Charles Ellet, C. E., in 1856 - "Mountain Top Tracks"