Letter from Lieut. Colonel S. H. Long, U. States Topographical Engineer, to Philip E. Thomas, Esquire.

Sir,—Agreeably to promise I submit a few statements in relation to the subject of Rail roads, having for their object a developement of some of the leading principles that ought to be kept in view in the location and construction of works of this nature. Having no treatise at hand for ready reference, and no leisure for a careful investigation and application of principles, I shall confine myself to such remarks as a general view of the subject may suggest.

The topic first presented for our consideration, as immediately connected with the means of transportation, is a proper estimate or expression, for the locomotive power employed for that purpose. Inasmuch as all expressions of this import hitherto adopted are of an arbitrary character, (except in as far as relates to a proportional part of the load being regarded as capable of giving motion to the residue) we shall choose that which approximates a mean of the various estimates that have, from time to time, been made. A great variety of experiments have been tried in England and elsewhere, for the purpose of ascertaining the average power of force of a horse, or the greatest *useful effect* resulting from an application of the power of this animal. These have led to various results, each of which has been assumed by different writers, as the measure for estimating not only the effective force of animal labor, but that of mechanical agents of various kinds.—The results we shall choose as approximating the mean of those alluded to, is the same as that adopted by Mr. Wood in his late treatise on Rail-roads.—This result which is usually denominated a "horse power," may be expressed as follows, viz: A horizontal *stress* or *traction* of 112 pounds, moving at the rate of two miles per hour during ten hours of each day. This amount of force being resolved into a continual action, operating day and night, will give for the expression of the power of a horse, 46 3 4 pounds, continually moving at the rate of two miles per hour. But as we shall not have occasion to consider, very particularly, the speed or rate of travelling, at which a horse can labor to the greatest advantage, or ease to himself, we shall assume a ... acting through the space of 20 miles as the daily performance of one horse.

Agreeably to the statements of Mr. Wood and others, based upon experiments, a single horse laboring at the rate above stated, viz: two miles per hour, and ten hours per day, with a stress of 112 lbs can draw on a canal 30 tons, exclusive of the weight of the boat in which it is conveyed. But as the resistance to the progress of a boat through the water, is as the square of the velocity with which it moves, and consequently the load is inversely as the square of the velocity it follows, that when a horse moves with a speed greater than that above mentioned, the load he is able to draw will be far less than if he moved slower.

The resistance to the progress of carriages on a Rail-road of the best construction is governed by laws widely different. According to experiments of Messrs. Coulomb and Vince, this resistance remains very nearly the same, whatever may be the velocity, except in so-far as relates to atmospheric resistance, which, though inconsiderable, at the greatest speed attainable upon a Rail-road, is to be estimated on the same principle as that encountered by bodies in their passage through water. The amount of this resistance, according to Mr. Wood, is equal to 1-200 part of the load, on a horizontal Rail-way, weight of carriages being included. Hence a traction of 112 pounds, or one horse power, will propel on a level Rail-road 22,400 pounds, or 10 tons, through the distance of 20 miles per day.

It is obvious that a horse exerting the force above mentioned cannot attain a speed greater than four or five miles an hour, without serious injury; nevertheless, for the sake of a more extensive application of the principles involved in the discussion before us, we shall suppose him capable of moving with this force at any rate of speed not exceeding 11 m's an h'r.

Mr. Wood, in the treatise before alluded to, estimates the expense of a locomotive engine, including first cost, cost of repairs, fuel and attendance, as equal to the expense of four horses, every thing included. But as horses can be procured and subsisted somewhat cheaper in this country than in England, we shall estimate the expense of an engine as equal to that of five horses, which is probably near the truth, inasmuch as machinery and fuel will cost much less in this country than in England, owing in no small degree to the great difference in the expense of procuring coal and other fuel, in the two countries. As horses, *actually hitched*, or *five and a half horses*, (the expense being the same, or very nearly so, in both cases) as may suit the occasion, the weight of the engine being five tons.

From these premises, the following tables, exhibiting the comparative advantages of canals and Rail-roads, and of animal and mechanical labor, are constructed.

Table I.—*Showing the comparative advantages of Canals and Rail-roads.*

Speed per hour.	Daily duration of labor.	Daily distance travelled by a horse drawing 112 lbs.	Load for one horse, moving with different velocities on a canal.	Load for one horse, travelling at different velocities on a rail-road.	Number of horses required to draw on a canal the load of one horse on a rail-road
miles.	h. m.	miles.	tons.	tons.	horses.
2	10	20	30	10	0.23
3	6 40	20	13.33	9.86	0.74
3½	5 42	20	9.8	9.8	1
4	5	20	7.5	9.75	1.3
5	4	20	4.8	9.64	2.08
6	3 20	20	3.33	9.53	2.86
7	2 51	20	2.43	9.42	3.87
8	2 30	20	1.87	9.31	5.98
9	2 13	20	1.48	9.2	6.22
10	2	20	1.2	9.2	7.68
11	1 48	20	1	9	9.

Table II—*Showing the comparative advantages of Animal and Mechanical labor.*

Speed per hour.	Daily duration of animal labor.	Daily duration of mechanical labor.	Number of tons that can be conveyed by five horses or one locomotive engine.	Daily distance travelled by horses.	Daily distance travelled by a locomotive engine.	Number of horses required to perform the labor of one engine.
mil	h. m.	hours.	tons.	miles.	miles.	horses.
2	10	24	50	20	48	12
3	6 40	24	49.33	20	72	18
3½	5 42	24	49	20	84	21
4	5	24	48.75	20	96	24
5	4	24	48.25	20	120	30
6	3 20	24	47.66	20	144	36
7	2 51	24	47.1	20	168	42
8	2 30	24	46.55	20	192	48
9	2 13	24	46	20	216	54
10	2	24	45.5	20	240	60
11	1 48	24	45	20	264	66

In the construction of the foregoing tables, no allowance has been made for the unavoidable detentions, that must occur, both on Canals and Railroads; of course the daily performance will be somewhat less than that stated in the tables;—moreover, in reference to canals, the weight of boats is not included in the estimate, whereas, in reference to Rail-roads, the carriages are regarded as constituting a part of the load; of course, some allowance ought to be made in favor of canals, on this account. But as the difference thus resulting is small and somewhat difficult to estimate, it has been altogether omitted in the tables.

We shall next consider some of the circumstances attendant on the passage of hills, by means of inclined planes, with the design of exhibiting the comparative expense of transportation, on *horizontal* and *inclined Rail-ways*. Our estimates under this head will be predicated on the supposition, that this expense will always be in *direct* proportion to the *quantity* of power applied.

We would farther premise, that all descents are to be regarded as equivalent to levels of the same extent, inasmuch as the maximum speed admissible in descending a plane, whatever its inclinations, ought not to exceed that determined upon, as most proper for level roads; and, although no locomotive power, except that of gravitation, may be required in the descent, the usual power (or rather the means of generating it) whether animal or mechanical, must descend in company with the load, in order to be in readiness for application at the bottom of the plane.

All ascents, whatever may be the length of the planes, will be attended with an expensive power, in direct proportion to their heights,—double the elevation in all cases requiring double the expense of power. Hence, if we assume for the cost of transportation ... height is readily computed. We shall accordingly exhibit in a tabular form, a variety of statements illustrative of the difficulties of ascending inclined planes, compared with those of passing on a level road, under the following several heads, viz: Height of plane or elevation to be overcome;—amount of power, or force of traction required to ascend thro' any given height;—the distance on a level road thro' which a given load may be conveyed with the same expense of power;—the distance on a level road, through which a given load may be conveyed as equivalent to the ascent of a plane whose height and length are given; the amount of tonnage, or number of tons that can be conveyed upward daily, on inclined planes of a given length, and of different heights, by means of a given power;—the time required to ascend such planes with a given load and power, (viz: 55 tons, and 5 1-2 horses;)—the number of horses required to ascend each plane, with a speed of six miles per hour;—and the cost of ascending, estimating at the rate of one cent per ton, for each horizontal mile. We would further premise, that the daily performance of a horse is to be rated at six miles per hour, for 3 hours and 20 minutes of each day;—that a locomotive engine, weighing five tons, can perform, during every hour of the day, the labor of five horses actually employed, independently of its own locomotion and that of its tenders;—of 5 1-2 horses independently of its own locomotion;—or, of 6 horses inclusive of its own locomotion and that of its entire train of carriages, the whole weight being 60 tons. N. B. It may here be suggested, that in all estimates of mechanical labor in its application to transportation upon Railroads, a locomotive engine, in order to perform the work of five horses actually hitched, in addition to the conveyance of its own weight and that of its tender (the sum of which may be estimated at from 6 to 10 tons) must possess the power of 6 horses. In conformity to this view of the subject, a locomotive engine of the power just intimated, and moving with its train on a horizontal road, will afford a *useful effect* applicable to the purposes of commerce, equal to that of 5 horses, and when serving in the capacity of a stationary engine at the head of an inclined plane, its useful effect will be equal to that of 5 1-2 horses. * * * *

Table III.—*Expense of surmounting Heights, the length of the planes being indefinite.*

Heighth of Plane. Length indefinite.	Amount of power required to elevate 55 tons, being the load for 5½ horses.	Number of miles on a horizontal road equivalent to heighth of plane.	Time required to ascend, the power being equal to that of 5½ horses.	Cost of transportation, estimated at the rate of one cent per ton per horizontal mile.
feet	pounds.	miles.	h. m.	dols. cts.
26.4	1232	1	0 10	1 10
52.8	1848	2	0 20	1 65
79.2	2464	3	0 30	2 20
105.6	3080	4	0 40	2 75
132	3696	5	0 50	2 30
158.4	4312	6	1 00	3 85
184.8	4928	7	1 10	4 40
211.2	5544	8	1 20	4 95
237.6	6160	9	1 30	5 50
264	6776	10	1 40	6 05
290.4	7392	11	1 50	6 60
0	616	1	0 10	55

Table IV.—*Comparative expense of Transportation on Horizontal and Inclined Rail-roads.*

Height of Plane. Length being ½ a mile.	Angle of ascent, or inclination of the plane.	Equated distance on a level road.	Number of horses required to ascend with 55 tons, at the rate of six miles per hour.	Time req'd to ascend with 5½ horses—load 55 tons.	Amount of tonnage that can pass daily, power being 5½ horses—load 55 tons.	Load for 5½ horses, or one locomotive engine.	Expense per mile for each ton ascending the plane.
feet.	deg. m.	mile	horses.	min.	tons.	tons.	cts.
0	0 0	0.5	5.5	5	0	55	1
13.2	0 17	1	11	10	7920	27.5	2
26.4	0 34	1.5	16.5	15	5280	18.33	3
39.6	0 52	2	22	20	3960	13.75	4
52.8	1 9	2.5	27.5	25	3168	11.	5
66	1 26	3	33	30	2640	9.16	6
79.2	1 43	3.5	38.5	35	2262.8	7.85	7
92.4	2	4	44	40	1980	6.87	8
105.6	2 17	4.5	49.5	45	1760	6.05	9
118.8	2 34	5	55	50	1584	5.5	10