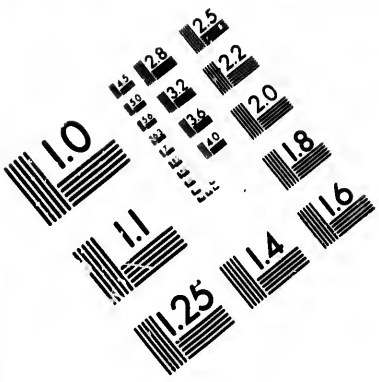

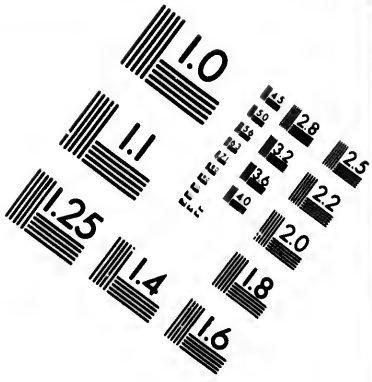

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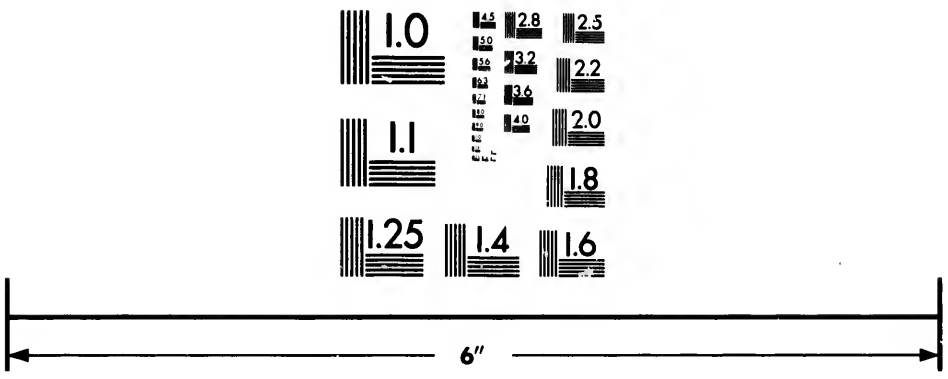

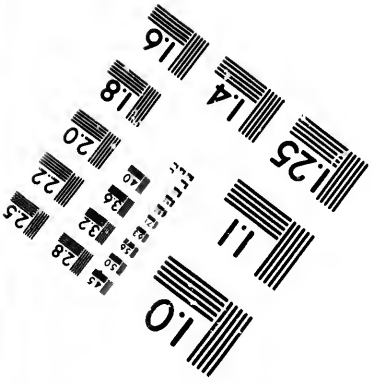

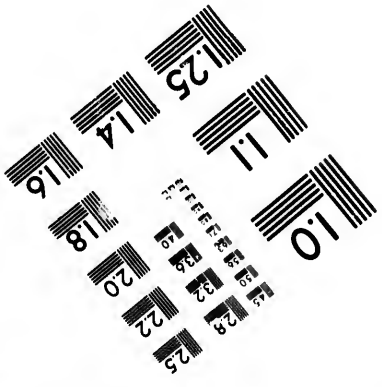

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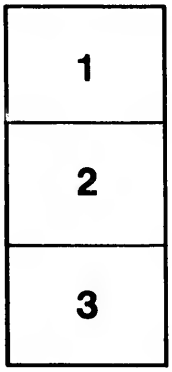

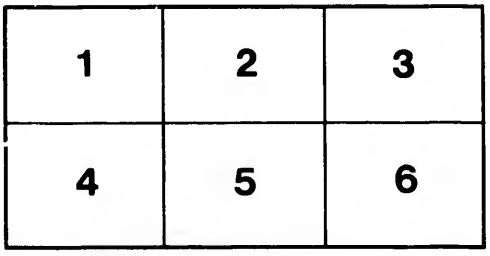

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EXTRACTS

OF A

TREATISE ON ROADS,

BY

THE RIGHT HONBLE.

SIR HENRY PARNELL, BART.

PUBLISHED BY ORDER OF

HIS EXCELLENCY THE LIEUTENANT GOVERNOR,

CHIEFLY FOR THE USE OF ROAD COMMISSIONERS

IN NOVA SCOTIA.

HALIFAX:

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1839.

INTRODUCTION.

WHEN the state of a society has arrived at a high degree of industry and wealth, so many persons and such quantities of goods, are set in motion, for the purpose of administering to its business and its luxuries, that it becomes of the greatest importance to construct the public Roads in such a manner, as to admit of travelling with rapidity and safety, and of reducing the cost of the carriage of Goods to the lowest possible point.

To explain how these objects can be most effectually secured, is the purpose of the following pages.

The measures necessary to be taken for affording the means of travelling with rapidity and safety, and of transporting goods at low rates of carriage, form an essential part of the domestic economy of every people. The making of Roads, in point of fact, is fundamentally essential to bring about the first change that every rude country must undergo in emerging from a condition of poverty and barbarism. It is, therefore, one of the most important duties of every government to take care that such laws be enacted, and such means provided, as are requisite for the making and maintaining of well constructed roads into and throughout every portion of the territory under its authority.

Adam Smith says, " Good roads, canals, and navigable rivers, by diminishing the expense of carriage, put the remote parts of a country, nearly on a level with those in the neighbourhood of a town ; they are upon that account the greatest of all improvements."

The establishing generally, throughout a Country, of perfect roads, is an object of no small importance in regard to public economy. In proportion as roads are level and hard, there will be a saving of horse labour ; fewer horses will be required ; they will last longer and a cheaper description of horse may be employed ; less food will be consumed and fewer servants will be wanted. In consequence of this reduction of expense, the charges for travelling will be lowered, and also the rates for the carriage of goods.

The first attempt to put the roads into order occurred when the turnpike system was introduced. The ancient method employed to mend roads in England, until after the restoration of King Charles 2d, was by a pound rate in the respective Counties on the landholders ; and by the supplying of carts and horses of parishes for a limited number of days. But when, after the last named period, commerce was become so generally increased, and in consequence thereof, wheel carriages and pack horses, were so extremely multiplied, the first turnpike road was established by law (the 16 Charles 2d, cap. 1, anno 1653) for taking toll of all but foot passengers on the northern road, through Hertfordshire, Cambridgeshire, and Huntingdonshire ; which road was then become very bad, by means of the great loads of barley and malt, &c., brought weekly to Ware in waggons and carts, and from thence conveyed by water to London.

It was not, however, till after the peace of 1748, that anything like a great exertion was made to redeem the public highways from the wretched state in which they had always been.

Mr. Chambers says, in his estimate, "Turnpikes which we saw first introduced soon after the restoration, were erected slowly, in opposition to the prejudices of the people. The Act which for a time made it felony at the beginning of the reign of George the Second to pull down a toll gate, was continued as a perpetual law before the conclusion of it. Yet the great roads of England remained almost in their ancient condition, even as late as 1752 or 1754, when the traveller seldom saw a turnpike for 200 miles after leaving the vicinity of London."

After 1760, the general spirit of improvement led to that of the Roads; and in fourteen years from that period to 1774, no less than 452 Turnpike Acts were passed. Since that year a number of Turnpike Acts have continued to be passed, as will appear from the following Table.

In eight years, from

1785 to 1792	302
1792 to 1800	341
1800 to 1809	419

In every year since 1809, the establishing of Turnpike Roads has gone on progressively, till they have extended to nearly 23,000 miles.

But although this Turnpike system has led to the making of many new roads, and to the changing of many old ones, into what may be called good roads, in comparison with what they formerly were, this system has been carried into execu-

tion under such erroneous regulations, and the persons who have been entrusted with the administration of them have uniformly been either so negligent, or so little acquainted with the business of making or repairing roads, that at this moment it may be stated, with the utmost correctness, that there is not a road in England, except those recently made by some eminent civil engineers, which is not extremely defective in the most essential qualities of a perfect Road.

With regard to the lines of direction of the turnpike roads, they evidently have not been laid out according to any fixed principle ; they are in fact precisely the identical lines, almost in every instance, which formed the footpaths of the aboriginal inhabitants of the country.

The following passage is taken from a pamphlet called "The Landed Property of England":—"Most of the old Roads of the Kingdom (the remains of the Roman ways excepted,) owe their present lines to particular circumstances. Many of them were, no doubt, originally footpaths ; some of them, perhaps, the tracks of the aboriginal inhabitants, and these footpaths became, as the condition of society advanced, the most convenient horsepaths. According as the lands of the kingdom were appropriated, the tortuous lines of road became fixed and unalterable, there being no other legal lines left for carriage roads, and hence the origin of the crookedness and steepness of existing roads."

The crookedness and steepness in numerous places, at this moment, of almost every great road, is thus accounted for. These defects are attended with great inconvenience and danger to travellers, and are quite disgraceful to the national character.

As many other great defects exist in all the principal roads, it is to be hoped, that at length the attention of the public and of government will be roused, and seriously and effectually applied to bring about a proper remedy. These defects are, in point of fact, so numerous and so glaring, that it is quite evident that the true principles of the art of Road making have not yet been followed. The breadth of a Road is seldom defined to a regular number of feet by straight and regular boundaries, such as fences, footpaths, mounds of earth, or side channels. The transverse section of the surface, when measured, is rarely to be found of a regular convexity. The surface of all the roads, until within a few years, was every where cut into deep ruts, and even now, since more attention has been paid to road works, though the surface is smoother, the bed of materials which forms it is universally so thin, that it is weak and consequently exceedingly imperfect. Drainage is neglected ; high hedges and trees are allowed to intercept the action of the sun and wind in drying the roads ; and many roads, by constantly carrying off the mud from them for a number of years, have been sunk below the level of the adjoining fields, so that they are always wet and damp, and extremely expensive to keep in order, owing to the rapid decay of the materials which are laid upon them.

The business of road making in this country, has almost entirely been confined to the exclusive management of individuals, wholly ignorant of the scientific principles on which the making of good Roads depends. It has received until very lately, little attention from the scientific world ; so little, indeed, that the primary and indispensable objects of

providing a dry and sound foundation for the surface materials, and of giving the surface a regular convexity, have not, till within a short time ago, been recognised and explained by any scientific rules whatever.

While during a considerable number of years, every improvement which depended on the industrious classes has made immense progress, the improvement of Roads, the management of which the laws have vested in the hands of the land proprietors, made no advancement at all until very recently.

It is only about twelve years ago that the land proprietors, seem to have begun to comprehend the value of good roads, and to be aware that large funds and a considerable share of science and constant attention, are necessary to bring them into a perfect state.

At the present time, although the country gentlemen are somewhat more active and better informed, the degree of improvement which they have introduced is little more than the palliation of a great evil, and goes but a short way towards securing that perfection, which ought to be universally introduced.

One of the greatest efforts which has been made in modern times by the Legislature, to afford, on an extensive scale, to a part of the public, the benefit of improved communication, is the plan that was adopted in 1803 for making roads in the Highlands of Scotland. Commissioners were appointed in that year for making these roads. The expense was defrayed in equal portions by grants of parliament and local contributions. The operations were conducted by Mr. Telford; and the result has been the constructing of 875

miles of road in every respect suitable to the country, and the building of 1117 Bridges. These roads traverse the Highlands of Scotland in all directions; and although the whole region consists of high mountains, the lines of road have been laid out with so much science, that the inclinations are every where moderate.

Next to the tracing of these roads, the principal merit consists in the forming and draining of them in such a manner, as to place them out of the reach of all injury from the torrents of water to which they would otherwise be exposed.

In the Districts between Glasgow, Cumbernauld, and Carlisle, upwards of 150 miles of new lowland roads have been made by Mr. Telford, acting under the same commission. But it was not until Mr. Telford was employed by the Commissioners appointed by Parliament, in 1815, for improving the Holyhead road, that he had an opportunity of carrying into execution a plan of road-making suitable to a great traffic on completely perfect principles. In that year a sum of money having been voted by Parliament for the improvement of the Holyhead road, Mr. Telford was consulted by the Commissioners with respect to the best plan of accomplishing the object Parliament had in view. He strongly recommended that he should be allowed, if employed by them, to execute all the new works upon this line of road in the most substantial and perfect manner, in consequence of its great importance from being the main communication between England and Ireland.

The Commissioners having adopted Mr. Telford's advice, and Parliament having continued to grant further sums of money, an extent of eighty two miles of new road has

been made by him through North Wales, between Chirk and Holyhead : three miles between Chirk and the village of Gobowen, near Oswestry, and seven miles on the Holyhead and Chester road. Thirty-one miles have also been made by Mr. Telford, at various places on the Holyhead road, between London and North Wales, with money advanced to the Parliamentary Commissioners, on loan, by the Commissioners for giving employment to the poor. These roads have been constructed in the most substantial manner. A foundation of rough pavement has been made as a bed to support the surface materials. They are uniform in breadth and superficial convexity. They are completely drained, and when carried along the face of precipices, they are protected by strong walls. They are acknowledged by all persons competent to form a correct judgment on works of this kind, to be a model of the most perfect road-making that has ever been attempted in any country.

A

TREATISE ON ROADS.

CHAPTER I.

RULES FOR TRACING THE LINE OF A NEW ROAD.

THIS business of tracing the line of a road, should never be undertaken without the assistance of instruments; and all local suggestions should be received with extreme caution.

To guard against errors in this important point, it is essentially necessary not to trust to the eye alone, but in every case to have a survey made of the country lying between the extreme points of the intended new road. For this purpose an experienced surveyor should be employed to survey and take the levels of all the various lines that, on a previous perambulation of the country appear favorable. It is only by such means that the best line can be determined. These surveys should be neatly and accurately protracted, and laid down on good paper, on a scale of sixty-six yards to an inch for the ground plan, and of thirty feet to an inch for the vertical section.

The map should be correctly shaded, so as to exhibit a true representation of the country, with all its undulations of high grounds and valleys, streams and brooks, houses, orchards, churches, ponds of water adjacent to the line of road; and all other conspicuous objects should also be laid down in the map. A vertical section should be made, and the

nature of the soil or different strata should be shown over which each apparently favourable line passes, to be ascertained by boring ; for it is by this means alone that the slopes at which the cuttings and embankments will stand can be determined and calculated. If it be necessary to cross rivers, the height of the greatest floods should be marked on the sections ; and the velocity of the water and the sectional area of the river should be stated.

If bogs or morasses are to be passed over, the depth of the peat should be ascertained by boring ; and the general inclination of the country for drainage should be marked.

All the gravel pits, or stone quarries contiguous to the line should be described on the map, with the various roads communicating with them ; and the existing bridges over the streams or rivers which are immediately below the proposed point of crossing them should be carefully measured, and the span or waterway stated on the section.

These preliminary precautions are absolutely necessary, to enable an engineer to fix upon the best line of road, with respect to general direction and longitudinal inclination. Without the unerring guide of actual measurement and calculation, all will be guess and uncertainty.

It may be laid down as a general rule, that the best line of road, between any two points, will be that which is the shortest, the most level, and the cheapest of execution : but this general rule admits of much qualification ; it must, in many cases, be governed by the comparative cost of annual repairs, and the present and future traffic that may be expected to pass over the road. Natural obstructions also, such as hills, valleys, and rivers, will intervene and frequently render it necessary to deviate from the direct course.

HILLS.

In every instance of laying out a road in a hilly country, the spirit-level is essentially necessary to show the pro-

per line of road to be selected. The general rule to be followed in surveys is to preserve the straight line, except when it becomes necessary to leave it to gain the rate of inclination that may be considered proper to be obtained, without expensive excavations and embankments. When a deviation is made for this purpose, it becomes necessary to proceed in a direct line from a new point.

Thus for instance, if it be decided to have no greater rate of inclination than 1 in 35, on a new line of road from A to B, (Plate I. Fig. 1.) and the Surveyor, when he arrives at the point *a*, finds a greater inclination than this, he must incline from the direct line to *b*—having then gained the summit of the hill, he does not endeavour to get back into the original straight line A B, but pursues the direct line *b* B, unless he is again obliged, from a similar cause, to deviate from it. This part of the survey being accomplished, it will then become necessary to examine the practicability of making a direct line of road, between A and *b*, instead of going to the point *a*.

When hills are high and numerous, it sometimes appears, from a perambulation and inspection of the country, to be advisable to leave the straight line altogether from the beginning, in order to cross the ridges, at lower levels by a circuitous course, in the way represented by the dotted lines A *c d*, in the above figure.

It constantly happens that although inclinations, which do not exceed the prescribed rate, can be had without quitting the straight line, the ridges may be crossed, at many feet of less perpendicular height, by winding the road over lower points of them—but the propriety of doing so will depend upon the length that a road will be encreased by going round to avoid passing the ridges in the direct line. The saving of perpendicular height to be passed over by a road, though a matter of so much importance and practical utility, has not hitherto received that attention from engineers which it deserves.

When expeditious travelling is the object, the maximum rate of inclination that never should be exceeded in passing over hills, if it be practicable to avoid exceeding it, is that which will afford every advantage in descending hills, as well as in ascending them. For as carriages are necessarily retarded in ascending hills, however moderate their inclinations may be, if horses cannot be driven at a fast pace in going down them, a great loss of time is the result. This circumstance is particularly deserving of attention, because the present average fast rate of driving over any length of road can be accomplished in no other way than by going very fast down the hills. But when the hills are very steep, and a coachman cannot keep his time except by driving very fast down them, he exposes the lives of his passengers to the greatest danger. How much time is lost in descending steep hills will appear from the following statement :—Suppose a hill to be so steep as not to admit of a stage coach going faster down it than at the rate of six miles an hour, five minutes will be required for every half mile : but if the hill were of an inclination of 1 in 35, it might be driven down with perfect safety at the rate of twelve miles an hour ; at which rate the time for going half a mile would be two minutes and a half, so that there is a loss of half a mile in distance for every half mile down the steep hill.

Besides the loss arising from the additional horse-power required to draw over very steep hills, there are other circumstances, which make it desirable to avoid them.

In descending them, the drag becomes indispensably necessary. In coach travelling, the stopping to put it on and take it off, will be the loss of at least one furlong to a coach travelling at the rate of ten miles an hour ; for in slacking the pace of the horses and before they stop, nearly one minute will be occupied.

When coachmen, to save trouble, omit to put on the drag, or, as it sometimes happens, when it breaks, travellers

are liable to the most dangerous description of accidents, by the overturning of a coach, when going at a great velocity. Even with the drag, heavy loaded carts are always taken by their drivers into the side channels of the road to try to check their speed ; and thus the channels are cut into deep ruts, or rather troughs, and the under-drains broken in, unless strong posts of wood or stone are set up, which are unsightly, and dangerous to other carriages, when descending at a quick rate.

An inclination of 1 in 35 is found by experience to be just such an inclination, as admits of horses being driven in a stage coach with perfect safety when descending in as fast a trot as they can go ; because in such a case, the coachman can preserve his command over them, and guide and stop them as he pleases. A practical illustration that this rate of inclination is not too great, may be seen on a part of the Holyhead Road, lately made by the Parliamentary Commissioners on the North of the city of Coventry, where the inclinations are at this rate, and are found to present no difficulty to fast driving, either in ascending or descending. For this reason it may be taken as a general rule, in laying out a line of new road, never if possible, to have a greater inclination than that of 1 in 35. Particular circumstances may no doubt, occur to require a deviation from this rule—but nothing except a clear case that the circuit to be made to gain the prescribed rate would be so great, as to require more horse labour in drawing over it, than in ascending a greater inclination, should be allowed to have any weight in favor of departing from this general rule. On any rate of inclination greater than 1 in 35, the labour of horses, in ascending hills, is very much increased. The experiments detailed in the Seventh Report of the Parliamentary Commissioners of the Holyhead Road, made by a newly invented machine for measuring the force of traction or power required to draw carriages over different roads, fully establish this fact.

Hilly ground is not always to be avoided, as being unfit for a road ; for if the hills are steep and short, it will often be easier to obtain good inclinations or even a level road, by cutting down the summits and laying the materials taken from them in the hollow parts. But this must be regulated by the expense to be incurred, which is a main consideration, that should always be scrupulously attended to before an engineer decides upon the relative merit of several apparently favorable lines. A perfectly flat road is to be avoided, if it is not to be raised by embanking at least three or four feet above the general level of the land on each side of it, so as to expose the surface of it fully to the sun and wind ; for if there is not a longitudinal inclination of at least 1 in 100 on a road, water will not run off, in consequence of which, the surface, by being for a longer time wet and damp than it otherwise would be, will wear rapidly away, and the expense of maintaining it in order by scraping it and laying on materials, will be very much increased.

The great fault of all roads in hilly countries is, that, after they ascend for a considerable height, they constantly descend again before they gain the summit of the country, which they have to traverse. In this way the number of feet actually ascended is increased many times more than is necessary, if each height, when once gained, were not lost again.

As one instance among others, of the serious injury which the public sustains by this system of road-making, the road between London and Barnet, may be mentioned, on which the total number of perpendicular feet that a horse must now ascend is upwards of 1300, although Barnet is only 500 feet higher than London : and in going from Barnet to London, a horse must ascend nearly 800 feet, although London is 500 feet lower than Barnet.

In tracing a road across a deep valley between two hills, it should be carried in a direction opposite to the fall of the valley, as by so carrying it, that is, by crossing the valley

at the highest practicable point, the descent and ascent are diminished.

RIVERS.

THE peculiar circumstances of a river may render it necessary to deviate from a direct line in laying out a road.

A difficulty may arise from the breadth of the river requiring a bridge of extraordinary dimensions, or from the land for a considerable distance on the sides of the river being subject to be covered with water to the depth of several feet in floods.

In these cases it may appear, upon accurately calculating and balancing the relative inconvenience and expense of endeavouring to keep as traight line and of taking a circuitous route, that upon principles of security, convenience and expense, the circuitous course will be the best.

In general rivers have been allowed to divert the direct line of a road too readily. There has been too much timidity about incurring the expense of new bridges, and about making embankments over flat land to raise the roads above the level of high floods.

These apprehensions would frequently be laid aside, if proper opinions were formed of the advantages that arise from making roads in the first instance, in the shortest directions, and in the most perfect manner. If a mile, half a mile, or even a quarter of a mile of road be saved, by expending even several thousand pounds, the good done extends to posterity, and the saving that will be the result in annual repairs and horse labour, will, before long, pay off the original cost of the improvement.

BOGS AND MARSH GROUND.

THE elastic nature of all bogs and marshes, and of all boggy and bottom land, makes it impossible to form a road

of perfect hardness over a soil of this kind, unless a great deal of labour and expense is applied in draining the soil, and afterwards compressing it, by loading it with large quantities of earth embanked upon it, in order to destroy the elasticity of the subsoil.

Although the surface coating of a road over such a subsoil may be made with a great abundance of the hardest materials, and be perfectly smooth, the porous and moist texture of the subsoil will cause the road to yield to a carriage passing over it, and thus, by destroying the momentum of it, add greatly to the labour of the horses in drawing it.

For this reason it will generally be prudent to deviate from the direct line in laying out a new road, if by doing so this sort of subsoil can be avoided, without adding much to the length of it. But when the additional length of the road would be considerable, it will then be necessary to incur the expense of a proper drainage, and of forming so high an embankment, as to compress and harden by its weight the moist and porous subsoil. Such an embankment of 1740 yards in length, having this object in view, was made over Maldreath Marsh, in the Island of Anglesea, on the new line of the Holyhead Road.

MATERIALS.

It will sometimes happen that road materials can be better obtained by carrying a line of road in one direction than in another. This will be a good reason for making a road deviate from the direct line, because the expense of making and repairing it will much depend on the distance which materials have to be carried.

EXPOSURE.

It is necessary in making a road through a hilly country, to take particular care to give it a proper aspect. It is a great

advantage to have a road on the north side of a valley fully exposed to the sun. For the same reason, all woods, high banks, high walls, and old fences ought to be avoided, in order that the united action of the sun and wind may have full power to produce the most rapid evaporation of all moisture. Too much attention cannot be bestowed on this object, in consequence of the effect of water in contributing to cut and wear down the hardest substances. It is for this reason that road materials, when they are wet or damp, wear rapidly away under the weight and pressure of heavy carriages. The hardest limestones wear away very quickly when wet, and all stones of an aluminous character, and also gravel, that consists of flint, sandstone or other weak pebbles.

The great advantage of having a road perfectly exposed to the action of the sun and wind, will be more accurately conceived, by referring to writers of science on evaporation. Dr. Halley states, that one-tenth of an inch of the surface of the sea is raised per diem in vapour. He also says, that the winds lick up the water somewhat faster than it exhales by the heat of the sun. Other writers say the dissipation of moisture is much accelerated by the agency of sweeping winds, the effects being sometimes augmented five to ten times.

Trees are particularly injurious by not allowing the sun and wind to have free action on the surface of roads in producing evaporation.

It may sometimes be proper to make a road deviate from a straight line, in order to go through a town; but the expediency of such a deviation must wholly depend on the general object of the road. If it be intended to expedite the communication, between two places of great trade, or otherwise of great importance, then nothing can be more erroneous than allowing the general line of road to be taken from the best and shortest direction, in order to pass through a town. It is for this reason that little attention should be paid to the opposition of inhabitants of towns to new roads, when to be

made for the advantage of the general communication of distant and important parts of the kingdom.

Some persons may be disposed to say, that a road should be made to deviate from a direct line in order to avoid crossing parks, or demesnes, and, to a certain extent, no doubt it should; but this motive ought not to be allowed to have much weight, where the consequence is to force the road over an inconvenient ascent, or to add very materially to its length. It should be recollected, that, by judicious management, a road may be made, if not ornamental, at least not injurious or detrimental to the appearance or privacy of a park, by carrying it in hollow ground, or between sunk fences.

The principle of protection of private property is itself founded on the same principle that should govern the line of a road, and that principle is the public advantage; and therefore it should be laid down and acted upon as a general maxim, that private considerations ought in all cases to be made to give way, with respect to roads, to public convenience. "For let it be remembered that society is formed for the mutual and general benefit of the whole; and it would be a very unjust measure to incommode the whole merely for the convenience, or perhaps the gratifying of the whim or caprice of an individual."

After fixing upon a general line of a road with respect to its direction, the precise line of it must be marked out, according to the smaller acclivities and declivities of the natural surface of the country it is to pass over. As moderate curves add but little to the length of a road, they will not be objectionable, if they assist the inclinations and save expense.

CHAPTER II.

PRINCIPLES OF ROAD-MAKING.

IN this chapter, the general principles will be examined, according to which the art of constructing roads should be practised; and the particular methods will be explained, by which various kinds of roads should be constructed. The art of road-making, like every other art, must essentially depend for its being successfully conducted on its being exercised in conformity with certain general principles, and the justness of these principles should be rendered so clear and self-evident as not to admit of any controversy.*

One of the most important and most obviously correct of these principles, is that which requires a road to be made of such a degree of substance, as shall be in a due proportion to the weight and number of the carriages that are to travel over it.

Let the construction of any turnpike road, of one commonly considered as among the best, be properly examined; that is, let measure be taken of the quantity of hard-road materials that compose the crust of the road over the subsoil, and it will almost universally be found that it consists of only from three to five, or six inches in thickness. Whereas, instead of this weak and defective system of road-making, it may be laid down as a general rule, that on every main road

* "A knowledge of true principles is indispensably necessary in every art, and in that of making roads as much as in any other. Some preliminary species of knowledge is very necessary in every superintendant or surveyor. A beaten track of knowledge is but a bad guide in cases which very frequently occur, when, amongst several ways, the best is to be preferred." —*M. S. Haldimand*, Secretary to the Bailiwick of Yverdun, on the Construction of Highways.

where numerous heavy waggons and heavy loaded stage coaches are constantly travelling, the proper degree of strength which such a road ought to have, cannot be obtained except by forming a regular foundation constructed with large stones, set as a rough pavement, with a coating of at least six inches of broken stone of the hardest kind laid upon it ; and further, that in all cases where the subsoil is elastic, it is necessary, before the foundation is laid on, that this elastic subsoil should be rendered non-elastic by every sort of contrivance ; such, amongst others, for instance, as perfect drainage, and laying a high embankment of earth upon the elastic soil, to compress it.

The right understanding of this principle of road-making, which requires roads to be constructed with four or five times a greater body or depth of materials than is commonly given to them, is of such great importance, that it is requisite to illustrate and establish the grounds on which it rests ; first, by reference to the laws of science concerning moving bodies, and secondly, by reference to experiments, which accurately prove the force of traction on different kinds of roads.

As a carriage for conveying goods or passengers, when put in action becomes a moving body, in the language of science, the question to be examined and decided is, how a carriage when once propelled, can be kept moving onwards with the least possible quantity of labour to horses, or of force of traction.

Sir Isaac Newton has laid it down as a general principle of science, that a body, when once set in motion, will continue to move uniformly forward in a straight line by its momentum, until it be stopped by the action of some external force. This proposition is admitted and adopted by all natural philosophers as being perfectly true, and therefore, in order to apply it to roads, it is necessary to enquire what kinds of external force act in a manner to diminish and destroy the momentum of carriages passing over them. With respect to these external

forces, the general doctrine is, that they consist of—1st, Collision; 2d, Friction; 3d, Gravity; and 4th, Air.

1st. The effect of Collision is very great in diminishing the momentum of carriages; it is occasioned by and is in proportion to the hard protuberances and other inequalities on the surface of a road. These occasion, by the resistance which they make to the wheels, jolts and shocks, which waste the power of draught, and considerably check the forward motion of a carriage.

2nd. Friction has a very great influence in checking the motion of a carriage; for when the wheels come into contact with a soft or elastic surface, the friction which takes place operates powerfully in obstructing the tendency of the carriage to proceed; the motion forwards is immediately retarded, and would soon cease if not renewed by the efforts of the horses. The "resistance," Professor Leslie says, "which friction occasions, partakes of the nature of the resistance of fluids; it consists of the consumption of the moving force, or of the horse's labour, occasioned by the soft surface of the road and the *continually depressing of the spongy and elastic substrata of the road.*"

An ivory ball, set in motion with a certain velocity, over a Turkey carpet, will suffer a visible relaxation of its course; but with the same impelling force, it will advance further if rolled over a superfine cloth; still further over smooth oaken planks; and it will scarcely seem to abate its velocity over a sheet of pure ice.

This short explanation of the nature and effects of collision and friction is sufficient to shew, that smoothness and hardness are the chief qualities to be secured in constructing a road. But perfect smoothness cannot be obtained without first securing perfect hardness, and therefore the business of making a good road may be said to resolve itself into that of securing perfect hardness.

With a view of taking the right course for securing this

object, the first thing a road trustee or engineer should do, is to form a correct notion of what hardness is ; because the common habit of overlooking this circumstance has been the source of great error in forming opinions upon the qualities of different kinds of roads.

Gravel roads, for instance, to which an appearance of smoothness is given, by incurring a vast expense in scraping them and patching them with thin layers of very small gravel, are very commonly declared to be perfect, and unequalled by any other kind of road. But if the best gravel road be compared with one properly constructed with stone materials, the hardness of the former will be found to be greatly inferior to that of the latter, and the error of the advocates of smooth looking gravel roads, will be immediately made manifest.

By referring to works of science, it will be seen that hardness is defined to be that property of a body by which it resists the impression of other bodies which impinge upon it ; and the degree of hardness is measured by the quantity of this resistance. If the resistance be so complete as to render it totally incapable of any impression, then a body is said to be perfectly hard.

Now this hardness is the hardness which a road ought to have, as far as it is practicable to produce it, and it is the chief business of a scientific road-maker to do every thing necessary to produce it. For this purpose when making a new road, he should first select, or establish a substratum of soil or earth that is not spongy or elastic, for the bed of the road ; and then he should so dispose the materials of which the crust of the road is to consist, as to form a body sufficiently strong to oppose the greatest possible quantity of resistance to the weight of heavy carriages passing over it.

That an elastic subsoil is unfit for a road, is evident from the nature of the resistance occasioned by friction, as above described by Professor Leslie, and from the terms of the definition of hardness ; for however strong the crust of materials

finition of hardness ; for however strong the crust of materials may be which is formed over such a subsoil, it will not be capable of opposing a perfect resistance to a heavy moving body. The moving body will sink more or less in proportion as the subsoil is elastic, and the hardness of the road will be imperfect in proportion as this sinking takes place ; so that nothing can be more necessary, as a preliminary step in making a new road, than to take every possible precaution to avoid elastic subsoils, or to destroy the elasticity as much as possible, when no other can be found.

After the engineer has prepared a proper substratum of earth for the bed of a road, he next must construct a crust of road materials in such a manner that, when consolidated, it shall possess such a degree of hardness as will not admit the wheels of carriages to sink or cut into it. For this purpose it will not be sufficient to lay upon the prepared bed of earth merely a coating of broken stones, for the carriages passing over them will force those next the earth into it, and, at the same time, press much of the earth upwards between the stones ; this will take place to a great degree in wet weather, when the bed of earth will be converted into soft mud by water passing from the surface of the road, through the broken stones, into the bed of the road. In this way a considerable quantity of earth will be mixed with the stone materials laid on for forming the crust of the road, and this mixture will make it extremely imperfect as to hardness. It might be possible, in some measure, to cure this defect by laying on a succession of coatings of broken stones ; but several of these will be necessary, and, after all, in long continued wet weather, the mud will continue to be pressed upwards from the bottom to the surface of the stones. If even a coating of from sixteen to twenty inches of stone be laid on, it will produce only a palliative of the evil. So that this plan of making a road will be not only very imperfect, but at the same time very expensive.

Mr. Telford's plan, which has completely succeeded on the Holyhead Road, the Glasgow and Carlisle Road, and several other roads in Scotland, of making a regular bottoming of rough, close-set pavement, is a plan that secures the greatest degree of hardness that can be given to a road ; it is also attended with much less expense than when a thick coating of broken stones is used ; for six inches of broken stones is sufficient when laid on a pavement, and the pavement may be made with any kind of common stone.

By laying the stones in making the bottoming with their broadest face downwards, and filling up the interstices closely with stone chips well driven in, the earthy bed of the road cannot be pressed up so as to be mixed with the coating of broken stones. This coating, therefore, when consolidated, will form a solid uniform mass of stone, and be infinitely harder than one of broken stones, when mixed with the earth of the substratum of the road. It is by proceeding in the way here recommended, that the friction of wheels on a road will be reduced as much as possible.

To comprehend thoroughly the great importance of making a regular and strong foundation for a road, it should be borne in mind, that roads are structures that have to sustain great weights, and violent percussion ; the same rules therefore, ought to be followed in regard to them, as are followed in regard to other structures.

In building edifices which are to support great weights, whether a church, a house, or a bridge, the primary and indispensable consideration of the architect is to obtain a permanently firm and stable foundation ; well knowing that unless this be first substantially made, no future dependence can be placed on the stability of the intended superstructure ; but this most requisite precaution has but recently been attended to in the formation of roads, and only on those roads in Scotland, and between London and Holyhead, which have been under the direction of Mr. Telford.

If the foundation of a road be not sufficient and equal to the pressure it has to sustain, the whole fabric, though in other respects ever so well constructed, must fail in permanent stability, and the hardness of it will be imperfect from its elasticity.

Having now stated all that the rules of science relating to moving bodies suggest, in order to defend the principles of road making, which have been laid down as the proper principles to be adopted, we shall now proceed further to illustrate and support these principles, by referring to experiments of the force of traction on different kinds of roads. These experiments have been made with the machine invented by Mr. Macneill, which has been already mentioned, and may be relied upon for their accuracy, in consequence of their having been carefully examined by several very eminent civil engineers.

These experiments uniformly show, that the force of traction is, in every case, nearly in an exact proportion to the strength and hardness of a road. The following are the results: on a well made pavement, the power required to draw a waggon is 33 lbs.; on a road made with six inches of broken stone of great hardness, laid on a foundation of large stones, set in the form of a pavement, the power required is 46lbs.; on a road made with a thick coating of broken stone laid on earth, the power required is 65 lbs.; and on a road made with a thick coating of gravel, laid on earth, the power required is 147 lbs. Thus it appears that the results of actual experiments fully correspond with those deduced from the laws of science.

It has been considered necessary to enter into these details in showing that no road can be correctly called a good road, unless it is so constructed as to be a very strong and so very hard one, because all the main roads of the kingdom are still very defective in respect to strength and hardness. This is a fact which cannot be disputed; first, because there is always mixed up with the body of materials, which forms the crust of

every road, a great quantity of earth ; secondly, because this crust is every where too thin ; and, thirdly, because it very frequently lies upon an elastic substratum. Although there may be exceptions, this may be taken as an accurate description of the general state of the roads.

Notwithstanding all the roads are now much better than at any former period, and may deserve to be called good roads, in comparison with the roads of ten or fifteen years ago ; when it is considered how much better they would be if they were reconstructed with a proper foundation coated with broken stones of great hardness, they should still be set down as being imperfect roads. Let any road trustee or surveyor who doubts this, reconstruct a mile of a road, now considered an excellent one, with a bottoming of pavement, coated with hard stones, and no stage coachman who shall drive over it will hesitate to bear testimony to the increased ease with which his horses do their work upon it.

CHAPTER III.

FORMING A ROAD.

IN marking out the line of a road, a great deal of expense in cutting and embanking for forming the bed on which the road materials are to be placed, may be avoided by a judicious selection of the high and low ground which the surface of the country affords.

The chief care, where a road must be carried over a high elevation, is to lay it out so that it shall not have any fall in it from the point from which it departs till it reaches the summit. The lowering of heights, and the filling of hollows, should be so adjusted as to secure gradual and continued ascending inclinations to the highest point to be passed over.

It is a most important part of the business of a skilful engineer, to lay out the longitudinal inclinations of a road with the least quantity of cutting and embanking.

He must do this by measuring and calculating the quantity of earth to be removed in cuttings, and taking care that it shall exactly make the embankments for raising the hollows to the required heights ; a proper allowance being made for the subsidence of the soil according to its quality, without leaving an overplus to be carried to spoil.

When it is necessary to make a deep cutting through a hill, the slopes of the banks should never be less, except in passing through stone, than two feet horizontal to one foot perpendicular ; for though several kinds of earth will stand at steeper inclinations, a slope of two to one is necessary for admitting the sun and wind to reach the road. The whole of the green sod and fertile soil on the surface of the land cut

through should be carefully collected and reserved, in order to be laid on the slopes immediately after they are formed.

If a sufficient quantity of sods cannot be procured in the space required for the road, the slopes should be covered with three or four inches of the surface mould, and hay seeds should be sown on it ; by this plan the slopes will soon be covered with grass, which will be a great means of preventing them from slipping.

When stones can be got, the slopes should be supported by a wall raised two or three feet high at the bottom of them. These walls prevent the earth from falling from the slopes into the side channels of the road, and add very much to the finished and workmanlike appearance of a road.

In many cases it may be advisable, particularly if an additional quantity of earth be wanted for an embankment, to make the slopes through the cuttings on the south side of a road of an inclination of three horizontal to one perpendicular, in order to secure the great advantage of allowing the sun and wind to reach more freely the surface of the road.

In districts of country where stones abound, expense in moving earth and purchasing land may be avoided, by building retaining walls, and filling between them with earth. In rocky and rugged countries this is generally the best way of obtaining the prescribed inclinations.

In forming a road along the face of a precipice, a wall must be built to support it. The difficulty of forming a road in such a place is not so great as is imagined, for the face of a precipice is seldom perpendicular, and if the inclination should be half a foot perpendicular to one foot horizontal, this will admit of a retaining wall being built.

In forming the bed for the road materials care should be taken, except where cutting into the surface is wholly unavoidable in order to obtain the proper longitudinal inclinations, to elevate the bed with earth, two feet at least, above the natural surface of the adjoining ground : by following this

course the road will not be affected by water running under or soaking into it from the adjoining land. In arranging the inclinations, they should be obtained by embanking, when that is practicable, in preference to cutting.

Almost all old roads across flat and wet land are sunk below the adjacent fields : this has arisen from the continued wearing of them, and carrying away the mud. No improvement is more generally wanting than new forming these roads so as to raise their surfaces above the level of the adjoining land. This would greatly contribute to the hardness of them, to economy in keeping them in repair, and to enabling horses to work with the advantage of having sufficient air for respiration.

EMBANKMENTS.

THERE have been but few attempts to make embankments by turnpike trustees that do not afford illustrations of this defect, and of a want of knowledge of the proper rules by which these works should be managed. No doubt, a chief reason for making cuttings and embankments, as is frequently the case, with slopes of one to one, has been, to save expense in the purchase of land, and moving earth. But the consequence of making such slopes, is that the earth is constantly slipping ; so that, in the end, the expense is always greater in correcting the original error, than it would have been if proper slopes had been made in the first instance.

In forming embankments along the sides of hills, or what is called side-forming, the rule that should be followed, is that the slope to be covered should be cut into level steps to receive the earth, otherwise it will be very liable to slip down the hill : in such cases, the earth should be well compressed, and great care should be taken to intercept all the land springs about it by proper drainage. For this purpose, a drain should be cut on the upper side of the road, and open drains should be made on the side of the hill above the road, to catch the surface water of the hill.

CHAPTER IV.

DRAINAGE.

SO much depends upon the proper draining of a road, that too great attention cannot be given to this part of the business of road-making.

This operation should be carried on at the same time with the forming of the road. When a road is to be made over flat and wet land, open main drains should be cut on the field side of the road fences : these drains should communicate with the natural watercourses of the country ; their size should depend upon the nature of the country and the local circumstances of the road.

In general, these side drains should be cut at least three feet deep below the level of the bed of the road ; they should be one foot wide at bottom, and five feet wide at top.

If main open drains cannot be formed, in consequence of the road running along the side of a hill, or of its passing through a cutting of a hill, or of buildings or other obstructions lying close to the road, it then becomes necessary to make covered drains on each side of the road. These should be formed of stone or brick, and be strongly and substantially built. A flat stone should be laid at the bottom of the drain, the side walls should be not less than twelve inches thick, and built in regular level courses ; they should be eighteen inches high, and twelve inches apart.

Particular care must be taken that the covering stones have a bearing of at least four inches on the side walls. They should have a layer of brushwood put over them ; and the drain should then be filled up with gravel, or small stones. In gravel countries, or where stone is difficult to be procured, it

in thickness in the middle, and six at the sides. The stones should be laid on in successive layers, taking care to let each layer be worked in, and consolidated, before a fresh one be laid on. If the subsoil is clay, a course of earth should be laid upon it, as proposed in the last plan.

Roads of this description are not sufficiently strong for great thoroughfares. This plan, however, having of late been recommended, as greatly superior to all other plans, by persons who profess to be experienced and scientific road-makers, a number of turnpike trustees have adopted it ; but experience has fully established its unfitness for roads of great traffic, in comparison with roads made with a proper foundation. In point of fact, there is nothing new in this plan ; for all the roads of the kingdom have been made in this way, and the universal defect of them, namely, their weakness, is the result. The reason is very obvious ; for if a body of small broken stones be laid on the natural soil, the weight of carriage wheels passing over it forces the lower course of the stones into the soil, while the soil is forced up into the interstices between them ; the clean body of stones, first laid on to make the road, is thus converted into a mixed body of stones and earth, and, consequently, the surface of the road cannot but be very imperfect as to hardness. It is necessarily heavy in wet weather, on account of the mud the earth makes on its surface ; and, in dry weather, on account of a quantity of dry dirt.

A road made on this plan will require, for two or three years after it is said to be finished, the expending of large sums in new materials, to bring it into any thing like even an imperfectly consolidated state ; and, after all that can be done, such a road will always run heavy, and break up after severe frosts ; for, as the natural soil on which such a road is laid is always more or less damp and wet, it will necessarily keep the body of materials, of which the road is made, damp and wet ; in consequence of which, the surface of the

road will wear down quickly. Hard frosts will penetrate through the materials into the under soil, and, when thaws take place, break up the whole surface.

It is in this way that the ruinous state of most roads, after severe frosts, is to be accounted for.

Roads made with Gravel.

In a country where no stone can be got for making a road, and nothing better than gravel can be procured, the following plan of employing it may be adopted:—When the bed of the road has been formed, a coating of small gravel should be laid on, four inches thick, over the whole breadth of the road; carriages should then be let to run upon it, and the ruts should be raked in as soon as they appear. When the first coat of gravel has become tolerably firm, another coating, once screened, should be laid on, three inches thick, over the whole surface, and the ruts raked in as before. When this second coat of gravel is consolidated, a third should be laid on, three inches thick: this coat of gravel should be well riddled, and cleansed from all earth or clay, and all pebbles exceeding one inch and a half in diameter should be broken before they are laid on the road. This process should be repeated until there is a body of gravel laid on the road sixteen inches thick in the middle, and ten at the sides, so as to form a convex surface rising six inches from the sides to the centre. The strongest and best part of the gravel should be put on the middle fifteen feet of the road, and the small part of the gravel on the sides. In all gravel roads of this description the greatest care must be taken to drain the subsoil by a sufficient number of cross and mitre drains, communicating with the main drains. If this is not attended to, it will be impossible to form a good carriage way.

A road made with gravel in the way here recommended will be much stronger than gravel roads usually are; but it

will be much inferior to one made with stone materials. The roundness of the gravel stones prevents them from becoming consolidated by pressure, so as to form a perfectly hard road surface; and when the gravel consists of limestone, flint, freestone, sandstone, or other kinds of weak stone, it is so rapidly pulverised that the friction produced by wheels passing over it, adds greatly to the labour of horses.

CHAPTER VII.

ROAD MASONRY.

IN constructing roads, masonry is used in a great many cases, and too much pains cannot be taken to have it perfect both in plan and execution.

BRIDGES.

IN arranging the plan of a bridge for a road, it should be considered how far it may be made subservient to improve the longitudinal inclination of a road, and save perpendicular height.

When valleys are deep and narrow, they may frequently be passed without great inclinations in the roadway, by selecting a proper position, and building high piers and arches for a bridge, if a stream or river is to be crossed, as is usually the case. On the other hand, when the land on each side of a river is flat, the bridge should be kept low, to avoid an inconvenient ascent to the top of it.

The following are the principal objects, with respect to bridges, which road-makers should have in view, viz. :— 1st, the most eligible situation as regards the direction of the road ; 2dly, the proper width for the roadway ; 3dly, the inclinations of the roadway over the bridge ; and 4thly, the number and span of the arches.

The best situation for a bridge, as it respects a road, will evidently be that which preserves the most direct line : but, for the security of the bridge, it is desirable to have a straight reach above it, and no bend near it.

The width of a bridge between the parapets should be regulated by the nature and quantity of traffic that is to pass over it. On turnpike roads near large towns the width should

be at least near forty feet. On turnpike roads in the country thirty or thirty-six feet will be sufficient, and on parish roads, twenty or twenty-four feet.

The inclinations of a roadway over a bridge should be very moderate. On turnpike roads they should never exceed one in thirty where it is possible to avoid it, without incurring a great expense in filling for the approaches. The number and span of the arches must depend on various circumstances, which can only be taken into consideration by the engineer on the spot; and even then much more must be left to his experience and judgment than can be derived from any precise rules as to the proper number and size of the arches.

It will be sufficient to state that the main point to be attended to in every case is that the water way should be of ample dimensions, to allow the whole body of water to pass freely in the highest floods.

For this purpose the bridges below the site of the proposed bridge should be carefully measured, and the effects of floods upon them observed. This will be a good criterion for assisting in determining what the water way should be of the intended bridge.

In making a plan and estimate of the expense to be incurred in building a bridge, the most essential point to be fully examined and considered, is the securing of such a foundation as will be sufficient to preserve the stability of the edifice. An engineer should make accurate borings, to ascertain the nature of the sub-soil; and when the slightest defect appears, piling should be used.

RETAINING WALLS.

WHERE the natural surface of a country is very rugged and precipitous, it will frequently be necessary to build retaining walls.*

* The wall which supports the road is called a breast wall; that which is on the hill side of a road is called a retaining wall.

"On sloping ground there must be a retaining wall along the upper side of the road eighteen inches wide at top; its foundation to be laid at least four inches below the bottom of the side drains, and is to be carried up, so as to intersect the slope of the bank, when falling at the rate of two horizontal to one perpendicular, and the slope is to be formed in this manner for at least one yard from the back of the wall, by means of swarded turf or stone pavement. The face is to have a curved batter, at the rate of one inch and a half in every foot from the top: the back may be in the shape of a rough dyke wall; but every one of the back stones are to be regularly connected with the body of the wall, and not to depend upon the earth behind them."

If a retaining wall be built of brick, the thickness at top should be one brick, or nine inches, and it should increase in breadth by onsets of half a brick at every eight courses to the level of the road, below which the thickness for the stepping of the foundation should increase half a brick at every four courses to the bottom. All walls of this description should batter in a curve line on the face at the rate of one inch in every foot.

BREAST WALLS.

THESE walls are necessary for supporting earth or other materials when used for forming a road; they should be built in the same way as retaining walls, and should increase, from one foot six inches in breadth at top, at the same rate as has been described for retaining walls.

These walls should have a strong coping of large stones, set on edge in mortar of the best description.

The following is a specification of a breast wall built across a very deep hollow, along an old road in North Wales on the Holyhead road:—

"Across the hollow there is to be a breast wall built, in

good lime and sand mortar, along the foot of the lower slope of the present road, or thirty feet distant from the retaining wall. This breast wall is to be two feet and a half thick at top, and to increase in thickness downwards at the rate of two inches and a half for every foot of depth, by a regular batter on the outside. There is to be a four-feet parapet wall on the top, two feet thick at the bottom, and eighteen inches at the top."

CROSS DRAINS.

Cross Drains should be built of good masonry, eighteen inches in the clear.

They should be continued under the fences into the ditches on each side of the road. When made of stone masonry the side walls should be sixteen inches thick, faced on both sides, eighteen inches high at the upper end, and twenty three inches at the lower end. The top of the walls to be level, and the bottom of the drain to have an inclination of one inch in every ten feet. The stones at top on which the covers are to be laid are to project about two inches and a half into the open space on each side, leaving about thirteen inches clear between them; the covers to be stone not less than four inches thick and twenty-seven inches long; they should be neatly jointed and closely laid together, and properly bonded on the side walls; a concave pavement of stones, not less than five inches deep, should be laid between the side walls. The body of the building should be placed so low, as to admit of six inches of earth to be laid between the cover of the drain and the bottom course of the road materials, without elevating the surface of the road.

The ends of the cross drain must be secured with a strong pavement, four feet three inches, by two feet three inches; the paving stones below the discharging end should be of large stones, sunk so deep as to secure the whole from being injured by the current of water.

When a cross drain is connected with a water course, the upper end should be secured with wing walls, at least five feet in length, and there should be the same walls at the lower end. These wing walls should be covered with two rows of swarded turf, the lower one with the swarded side down, and the upper one with the swarded side up.

The following is a specification of a cross drain, five feet diameter, built on the Holyhead road :—

" The arch to be hammer dressed course work, and the rest of good sound rubble work. It is to be in length the full breadth of the road and dikes. The faces to range with the faces of the breast walls, and the dikes to be continued over them. The breast walls, for ten feet from the face of each abutment, are to be built with mortar, and to finish by a pilaster projecting four inches, to be three feet wide at the level of the road way, and increase in breadth downwards, by a matter of three-fourths of an inch, to a foot on each side. The dikes are also to be built in mortar between these pilasters.

" Water wings are to be built into and extended from each abutment for eight feet in length and to splay back to eight feet apart at their extremities. They are to be founded at the same depth as the abutments, and be carried up to the level of natural ground. A stone pitching to be set between the abutments and water wings ; to be set endwise to the streams, and be firmly secured at each extremity. Except the stone pitching, the whole is to be built in good lime and sand mortar. The thickness of the water wing walls to be the same as specified for the breast walls.

Specification for a Three-feet Stone Drain.

" The arch to be hammer-dressed, and the rest of the masonry good sound rubble-work. The abutments must be continued as water wings above and below the arch, for five feet in length, and be splayed back at their extremities. To

be founded as low as the abutments, and rise to the springing of the arch. A dry stone pitching to extend under the arch and between the water wings.

"Except the pitching, the whole to be set in good lime and sand mortar up to the level of the roadway. To be the full length of the breadth of the road and dikes. The faces to range with the faces of the breast walls, and the stone dikes to be continued across the arch in the usual manner."

CHAPTER VIII.

MANAGEMENT OF ROAD WORKS.

WHEN a new road is to be made, as soon as the precise line of it is finally determined upon, the following circumstances should be particularly attended to.

I. Drawings to show, 1st, the natural surface of the ground; 2nd, the longitudinal inclinations of the proposed road; 3d, the slopes of the cuttings and embankments; 4th, the form of the bed of the road, and footpath; and 5th, the courses of materials to be laid on, and the thickness of each course.

. 'vings should also be made, describing the plans of the b s, culverts, cross drains, inlets, outlets, depôts, and fe.. vhich are required to be made.

II. A specification should be prepared, to explain in detail the precise method of executing every part of the work.

III. After the specification has been settled, an estimate should be made of the expense to be incurred.

IV. The next step to be taken, is to make a contract for executing the work.

Contract work is commonly supposed to be preferable to other work, for no other reason than because it is the cheapest, but experience shows that, when it is properly regulated, it is by far the best mode of securing sound and durable work. This, however, will not be the case if the contracts and specifications are prepared by unskilful and inexperienced persons, if inspection is omitted, and if the contractors are driven by excess of competition to make bad bargains.

But if the plans, specifications, and estimates for making a road are properly prepared, then the most safe and satisfactory way of having the work properly executed will be by letting it to a contractor.

As there is no difficulty in making an accurate estimate of the sum which a new road ought to cost, if a contractor of established reputation for skill and integrity, and possessing sufficient capital, is willing to undertake the work for the estimated sum, it will always be decidedly better to make an agreement with him than to advertise for tenders.

If a contractor cannot be got, possessing the qualifications which he ought to have to justify a private arrangement, then an advertisement must be had recourse to. But when tenders are delivered in, it is very important to take care to act upon right principles in making a selection from them. The preference should invariably be decided on by taking into consideration the skill, integrity, and capital of the persons who make the tenders, as well as the prices which they offer; for if a contractor be selected without skill, or integrity, or capital, merely because his tender is for the smallest sum, the consequence will inevitably be imperfect work, every kind of trouble and disappointment, and frequently expensive litigation.

The true principle to go upon in selecting a contractor is to lean in favour of liberal terms; and rather to overpay than underpay him. He should be made quite confident by his bargain, that he will receive a fair profit for his time and labour; he will then embark in his work with spirit, and be led by a desire to gain reputation to perform his agreement to the satisfaction of all parties; but when, in following an opposite principle, a contractor is led by competition to undertake a work for a price that is too low, he starts, from the commencement, by having recourse to every species of contrivance for avoiding the fair fulfilment of what he is required to perform; every thing is done in an imperfect way;

sub-contracts are made at inadequate prices, a continual contest is carried on between the contractor and the inspector, and most commonly the whole concludes in a law-suit, the ruin of the contractor and his securities, and great loss to tradesmen and others by debts due by the contractor and his workmen.

V. After fixing upon a contractor, a deed of contract is to be prepared. In this the contractor should be bound to execute the work not only according to the general conditions contained in the deed, but also according to drawings and specifications to be annexed to it.

The deed should contain a clause to provide that no deviation should be made from it or the specifications, except by agreement in writing; and also a clause to provide for settling all disputes by arbitration. The other clauses which are fit to be inserted in the deed will hereafter be described, by inserting an exact copy of a deed, according to which a part of the Holyhead Road was made.

VI. Before the work is commenced, an inspector should be appointed to lay out the work, to settle the levels, and to see that every particular thing required to be done, is done precisely according to the specifications.

A person to be qualified to act as an inspector of a contract should have considerable experience as a civil engineer; he should be strictly sober and honest, and of reserved habits; he should avoid familiarity with those he is placed over; his disposition should be somewhat inclined to be severe, but he should be actuated at all times by the highest principles of justice and honesty in his conduct.

A chief engineer who is engaged in conducting public works, will owe his success in great measure to the skill and care with which he selects the inspectors of his contracts. The necessity of making such selections forms an essential part of his occupation, and requires considerable talents to direct it.

Above all things, a chief engineer should possess the quality of securing implicit obedience from those under him, by showing a decided superiority in the knowledge of his profession, and by acting with unsparing severity whenever the occasion may require it.

VII. It is of importance to arrange the mode of paying a contractor with punctuality; by doing so he may be kept under more control, and he will be able to perform his engagements in a more complete manner. For this purpose the deed of contract should provide that the work, as it proceeds, should be measured by the inspector every fourth week, and that a certificate should be given by him to the contractor for the value of the work that he finds executed according to the terms of the contract, deducting, in each certificate, one-tenth part of the sum, to be withheld till the whole work be finished. This plan affords the best description of security for the faithful performance of a contract.

If, in place of acting upon a regular plan of paying a contractor, he is kept out of his money, he will often be placed in difficulties, and rendered incapable, however willing, to perform the conditions of his contracts in a perfect manner.

CHAPTER IX.

IMPROVING OLD ROADS.

Mr. Telford gives the following account of the state of the Turnpike roads in 1819, in his evidence before the Committee of the House of Commons on the highways of the Kingdom :—

" With regard to the roads of England and Wales, they are in general very defective, both as to their directions and inclinations : they are frequently carried over hills, which might be avoided by passing along the adjacent valleys ; the shape, or cross sections and drainage of the roads are quite as defective, as the general directions and inclinations ; there has been no attention paid to constructing good and solid foundations ; the materials, whether consisting of gravel or stones, have seldom been sufficiently selected and arranged ; and they lie so promiscuously upon the roads, as to render it inconvenient to travel upon them. and to promote their speedy destruction. The shape of the road or cross section of the surface is frequently hollow in the middle ; the sides encumbered with great banks of road dirt, which have accumulated in some places to the height of six, seven and eight feet ; these prevent the water from falling into the side drains, and also throw a considerable shade upon the road, and are great and unpardonable nuisances. The materials, instead of being cleaned of the mud and soil with which they are mixed in their native state, are laid promiscuously on the road : this in the first place creates an unnecessary expense of carriage of soil to the road, and afterwards, nearly as much in removing it, besides inconvenience and obstruction to travelling."

The committee of 1819, attributing by their report, the imperfect state of the roads to the negligent and culpable conduct of the Trustees, who had the management of them, roused the attention of the public to the subject, and thus led to the introduction of an improved system of management. But although a considerable change for the better has taken place since 1819, many of the defects described by Mr. Telford still remain; and all that has been done towards removing them, falls far short of what ought to have been done to put the turnpike roads into complete order.

In improving old roads, nearly the same objects should be attended to as are to be secured in making new ones; such for instance, as the direction, the longitudinal inclinations, the breadth, form, and hardness of the surface, the drainage and the fencing.

With respect to the turnpike roads as they now are, it will be found upon an inspection of them, that in regard to their direction they are universally defective. Scarcely any road between two places is in the best line with respect to distance and hills. The reason of this is, that the present lines of roads are the same, except those of roads made of late years, as they were when first established by the aboriginal inhabitants of the country, as footways or horse tracks.

The first step which should be taken towards the improvement of the principal roads of the kingdom, is the making of surveys of the mail-coach roads: this work should be done by Government. The Engineers employed should also be required to make plans and estimates for the improvements which may appear to be necessary: and the Trustees of every principal road should be furnished with copies of the surveys, and of the plan and estimates for improvements relating to the road under their care.

The number of single mail-coach miles daily travelled in Great Britain, including pair-horse coaches, is 15,604. The expense attending the surveying of them should not exceed 3*l*.

a mile ; so that the whole expense to be incurred on this important preliminary step, for the improvement of these roads, would not be of a large amount.

Whenever the improvement to be made on an old road does not require the present line to be departed from, the road should first be put into a proper form, according to the rules already laid down, in respect to the breadth and convexity of a road. A sufficiently strong crust of road materials should then be laid on ; and particular care should be taken to provide a sufficient number of drains.

Where the old road is below the level of the adjoining fields, it should be raised by embanking, so as to be, at least two feet above them.

will be necessary to build the main-side drains of brick; the side walls should be four inches thick, and three bricks high, and five inches apart, and covered with brick on the flat: these covering bricks should not be laid close together; an interval of at least half an inch should be left between each to allow the water to enter the drain from above.

In very wet clay soils, a flat tile should be laid at the bottom of the drain, sufficiently large to extend two inches under each side wall; a layer of brushwood, or straw, should be put over the bricks, and then the drain should be filled up with cleansed gravel or small stones.

If springs rise in the site of the road or in the slopes of deep cuttings, stone or tile drains should be made into them, so as completely to carry away all the water.

In cuttings it is necessary to make drains of small dimensions from the centre of the road to the side drains. These drains should form an angle in the centre of the road, in the shape of a V, technically called mitre drains: the angle or splay of these drains should depend upon the inclination of the road; it should not make the inclination of the drains exceed one inch in 100; for if it be greater, the run of the water will undermine the sides, and injure them. These mitre drains should be nine inches wide at bottom, twelve inches wide at top, and ten inches deep. These drains should be placed at about sixty yards from each other, or about thirty in the mile; but if the soil be wet, this number should be considerably increased. They are to be filled with rubble stone or cleansed gravel. If gravel is used, a draining tile should be laid along the bottom before the gravel is put on.

According to the inclinations of a road, and the form and wetness of the country through which it passes, cross drains of good masonry should be built under the road, having their extremities carried under the road fences.

One of these drains should be made wherever the water

would lie on one side of the road, and can only be got rid of by carrying it to the other side. When the road passes along the slope of a hill or mountain, a great number of these drains are necessary to carry off the water that collects in the channel of the road on the side next the high ground. They should be placed at from 50 to 100 yards distance from each other, according to the declivity of the hill; so that the side channels may not be cut by carrying water too far. In these situations inlets should be built of masonry, to carry the water from the side channel of the road into the cross drains. Numerous outlets should also be made from the side channels of the road, under the footpaths or wastes and fences, into the field ditches.

In mountainous countries, where the road passes along the slopes of the hills, it is necessary to carry open or catch-water drains, branching from the upper ends of the cross drains, in an inclined direction, so as to catch the surface water before it can reach the road.

After all these precautions have been taken, the preservation of the surface of the road from injury by water should be further secured, by giving to the surface of it a proper convexity in its cross section, and by making regular side channels.

These side channels will be formed by the angle where the slope of the side parts of the surface of the road abuts against the edge of the footpath, or other defining bounds of the roadway. They will be capable of carrying off a great quantity of water, without being made into the form of a square-sided drain.

Attention to make the surface of a road of a proper convex form, is particularly necessary on hills, in order that the water may have a tendency to fall from the centre to the sides, in place of running from the sides to the middle part of the road, which it certainly will do, unless the side channels are kept below the centre of the road, in the manner hereafter described.

On all hills, the greatest care should, also, be taken to keep the side channels always open; for, if they are obstructed with dirt, the water will find its way over the middle of the road, and cut channels in it. The side channels of a road should be all thoroughly repaired, as well as all the road drains, before the approach of winter, and again after the winter is over; but besides these repairs at fixed periods, daily attention should be given to take care that no obstruction gets into them.

In addition to all these means, recommended to be adopted for securing the drainage of a road, it is of the utmost importance that evaporation should have full effect in drying up the surface of a road, by allowing the sun and wind to act upon it, in the freest manner.

The necessity of giving a road a good exposure has already been mentioned, under the head of "Laying out a Road;" and the value of a rapid evaporation will be more fully explained when the repairing of roads is brought under consideration.

If roads be kept dry, they will be maintained in a good state with proportionally less expense. It has been well observed, that the statuary cannot saw his marble, nor the lapidary cut his jewels, without the assistance of the powder of the specific materials on which he is acting; this, when combined with water, produces sufficient attrition to accomplish his purpose.

A similar effect is produced on roads, since the reduced particles of the material, when wet, assist the wheels in rapidly grinding down the surface.

CHAPTER V.

DIFFERENT KINDS OF ROADS, AND MODES OF CONSTRUCTING THEM.

A Road with a Foundation of Pavement and a Surface of Broken Stones.

" UPON the level bed prepared for the road materials, a bottom course or layer of stones is to be set by hand in form of a close firm pavement : the stones set in the middle of the road are to be seven inches in depth ; at nine feet from the centre, five inches ; at twelve from the centre, four inches ; and at fifteen feet, three inches. They are to be set on their broadest edges lengthwise across the road, and the breadth of the upper edge is not to exceed four inches in any case. All the irregularities of the upper part of the said pavement are to be broken off by the hammer, and all the interstices to be filled with stone chips firmly wedged or packed by hand with a light hammer ; so that when the whole pavement is finished, there shall be a convexity of four inches in the breadth of fifteen feet from the centre.

" The middle eighteen feet of pavement is to be coated with hard stones to the depth of six inches. Four of these six inches to be first put on, and worked in by carriages and horses ; care being taken to rake in the ruts until the surface becomes firm and consolidated, after which the remaining two inches are to be put on.

" The whole of this stone is to be broken into pieces as nearly cubical as possible, so that the largest piece, in its longest dimensions, may pass through a ring of two inches and a half inside diameter. The paved spaces on each side of the eighteen middle feet are to be coated with broken

stones, or well-cleansed strong gravel, up to the footpath or other boundary of the road, so as to make the whole convexity of the road six inches from the centre to the sides of it ; and the whole of the materials are to be covered with a binding of an inch and a half in depth of good gravel, free from clay or earth."

The work of setting the paving stones must be executed with the greatest care, and strictly according to the foregoing directions, or otherwise the stones will become loose, and in time may work up to the surface of the road : when the work is properly executed, no stone can move.

If the work be executed by contract, the inspector should see all the operations as they are going on. He should walk over the pavement when it is completed, and try whether the stones be firmly fixed : and he should not allow any broken stones to be laid on over the pavement till it has undergone an examination of this kind.

In breaking stones, the workmen should be required to break them as nearly cubical as possible. When this rule is not attended to, a great quantity of materials is wasted by first splitting the stones into thin slices, and then breaking them into pieces that are too small, and too thin. If the stones or top metal are not broken very small, the proper degree of smoothness of surface will not be obtained.

When stones are very hard, they never make a very smooth surface. Limestone will make a much smoother surface than whinstone and other harder stones, but they should not for this reason be preferred to harder stones ; for these will wear longest, carriages will run lighter over them, and the expense for scraping and repairing will be less. All the soft kinds of stones make heavy roads in wet weather ; and in dry weather there will be more friction upon roads made with them, because there will be more dust on their surface.

The breadth of the road which has been described in the foregoing specification of thirty feet, is recommended as

fully sufficient for any road, except a road forming the approach to a very populous city. The confining of a road to this breadth contributes very much to preserve the whole surface of it, from side to side, in a good state, and to diminish expense. For when a road is of greater breadth, the scraping and repairing of the excess beyond thirty feet, costs annually a considerable sum. Mr. Telford says on this point, in his second Annual Report on the Holyhead Road, dated 17th June, 1825 :—" He" (the surveyor of the Stonebridge and Birmingham Road) " seems to be still too much disposed to prefer a road of a greater breadth than that recommended by me, of thirty feet: he should reflect, that every yard in breadth makes 1760 superficial yards to be kept in good order in a mile, and therefore that a road of thirty-nine feet wide has 5280 superficial yards to be coated with materials, and kept clean, more than a road of thirty feet wide. The additional expense of the wider road may be set down at 15*l.* a mile, and this rate for ten miles will make on his road an extra expenditure of 150*l.* a year."

With respect to the convexity of a road, it should be so arranged that it should be slight in the middle. In giving a convexity of six inches to a road of thirty feet in breadth, the convexity at four feet from the centre should be half an inch ; at nine feet, two inches ; and at fifteen feet, six inches. This will give the form of a flat ellipsis.

The binding, which in the foregoing specification is required to be laid on a new made road, is by no means of use to the road, but on the contrary, injurious to it. It is however, unavoidable, when a long piece of new road is to be opened ; for, without it, the wheels, by sinking into the new materials, would make the draught of the carriages much too heavy for the horses. This binding, by sinking between the stones, diminishes the absolute solidity of the surface of the road, lets in water and frost, and contributes to prevent the complete consolidation of the mass of broken stones.

If the plan here laid down for constructing a road be faithfully executed, it will secure all the objects that can be required. From the moment it is first opened, it becomes daily harder and smoother, and very soon consolidates into as hard a mass as can be obtained by the use of broken stones. The subsoil of the road cannot get into a state of puddle, and rise up and mix with the surface materials, and thus produce those quagmires and deep ruts that are met with in wet weather on new roads made in the usual way.

Although the expense of constructing a road on this plan may seem to be greater than that of making a road in the usual manner, taking on an average of five years, the joint expense of constructing and repairing such a road as the former, it will be much less than that of constructing and repairing a road made by putting the surface materials on the natural soil, without a paved foundation ; for, in point of fact, such a road has usually to be nearly new made every year, for some years after it is first opened.

This method of making roads with a foundation of pavement is described in French works on roads ; the following is taken from the *Encyclopédie de l' Ingénieur*, vol. i. page 356. :—

" The first course of stones are to be from ten to twelve inches long, and nine inches deep. These are to be set by the hand on the bed of the road, with their broadest faces down and their pointed ends upwards ; the interstices are to be filled up with stone chips. The upper course of stones is to be of the hardest kind, broken to the size of an inch cube, on a large stone, as an anvil.

" This course is to be nine inches in thickness, so that the whole thickness of the two courses will be eighteen inches."

The bed of pavement, for the whole width of the road, may, in some instances, be too expensive, in consequence of the difficulty of procuring proper stone.

In such instances, it may be expedient to have only the eighteen middle feet of the carriage way with a foundation of pavement.

In a district of country where any coarse sort of stone can be got for making a pavement, it will be cheaper to make a road with a pavement and six inches of broken stones, than with ten inches of broken stones, without a pavement.

Roads made with a Foundation of Rubble Stones, and Surface of Broken Stones.

A USEFUL road may be constructed by making a foundation with rubble stones, and laying broken stones or gravel upon them.

The stones should be reduced so as not to have any of them more than four pounds in weight ; these should be laid in a regular bed, to the depth of seven inches in the middle and four inches at the sides, supposing the road to be thirty feet in breadth ; a coating of small broken stones should then be laid on in the way directed when a pavement is used.

If the subsoil be clay, a course of earth, of any kind, that is not clay, of the thickness of six inches, should be laid on the clay, to prevent it from rising and mixing with the stones.

A road made according to the rules here given, will not be a very expensive one ; it will answer for cross turnpike roads, and other roads that do not communicate between large towns and collieries.

This plan is much superior to and not more expensive than the next plan.

A Road made wholly of Broken Stones.

A ROAD may be constructed, suitable to light carriages and little traffic, by forming a level bed on the natural soil, and putting upon it a body of broken stones, of twelve inches

CHAPTER X.

REPAIRING ROADS.

THE business of repairing a road should always be managed on a regular and fixed plan.

The following matters require particular attention :—

1st. The quality of materials.

2d. The quantity to be put on per mile, per annum.

3d. The preparation of the materials.

4th. The method of putting them on the road.

5th. The number of labourers to be employed.

1st. With respect to the quality of the materials to be used, the hardest should always be preferred ; for it should ever be borne in mind, that hard stones brought from a distance are found by experience to be cheaper in the end than those of a softer kind which may be got near the road at a much lower price.

Another reason for making use of the hardest materials that can be procured, is the greatly increased labour of horses, which is occasioned by working into a smooth surface often renewed coatings of weak materials. With respect to the subject generally of road materials, it may be observed, that the best descriptions consist of basalt, granite, quartz, syenite, and porphyry rocks. The whinstones found in different parts of the United Kingdom, Guernsey granite, Mountsorrel and Hartshill stone of Leicestershire, and the pebbles of Shropshire, Staffordshire, and Warwickshire, are among the best of the stones now commonly in use. The schistus rocks being of a slaty and argillaceous structure, will make smooth roads, but they are rapidly destroyed when wet by the pressure of

wheels, and occasion great expense in scraping, and constantly laying on new coatings.

Limestone is defective in the same respect, it wears rapidly away when wet, and therefore when the traffic on a road is very great, it is an expensive material. Sandstone is generally much too weak for the surface of a road; it will never make a hard one. It is very well adapted to the purpose of a pavement, as a foundation for a road. Flints vary very much in quality as a road material. The hardest of them are nearly as good as the best limestone, but the softer kinds are quickly crushed by the wheels of carriages, and make heavy and dirty roads. Gravel, when it consists of pebbles of the hard sorts of stones will make a good road, particularly when the pebbles are so large as to admit of their being broken; but when it consists of limestone, sandstone, flint, and other weak stones, it will not; for it wears so rapidly, that the crust of a road made with it, always consists of a large portion of the earthy matter to which it is reduced. This prevents the gravel from becoming consolidated, and renders a road made with it extremely defective with respect to that perfect hardness which it ought to have.

2d. With respect to the quantity of materials to be put on a road in the course of a year, this should be regulated by the traffic on the road and the durability of the materials. The object to be secured, is the giving to the road a sufficient degree of strength to have it at all times smooth and hard. The materials to be provided should be quarried, carted and broken by contract. The materials when brought in their rough state to the road should be packed in depôts, or laid up on the wastes, in regular shaped heaps, so as not to interfere with the side channels of the road.

3d. When the materials are stone, they should be broken as before described for making new roads, to a size of a cubical form, not exceeding two inches in their largest dimensions.

When gravel is used, the persons who dig it, should be required to pass it through sieves, before it is carted to the road, so that no gravel pebble, less than one quarter of an inch in diameter, should be carried from the pits to the road.

When the gravel is brought to the road, it should be again sifted by the road labourers, so as to separate the pebbles that are less than three quarters of an inch in diameter from the rest, and all the large pebbles exceeding one inch in diameter should be broken.

4th. The materials after they have been properly prepared, should be laid on in small quantities at a time: care should be taken to fill up ruts or hollows as soon as any appear.

In those places where the surface of the road has become much worn, a coating of one inch and a half of materials should be laid on: that is to say, a coating only a single stone in thickness, when stones are used; and when gravel is used, a coating not exceeding one inch in thickness. If more materials are necessary, they should be laid on after the first coating is worked in.

The work of repairing roads by laying on new coatings of materials, ought to be done between the months of October and April, and when the surface of the road is wet. By laying on the materials at this season of the year in thin coatings, they are soon worked into the surface without being crushed into powder, and without producing any great distress to horses drawing carriages over them.

5th. When the funds will admit of it, a road should be divided into districts of four miles each; and a foreman, with three labourers, should be appointed for each district. The foreman and one or more of the labourers should be daily on the road, taking care that the side channels of the road are kept clean, and making good any injury to the road as soon as it appears.

The foreman should work with the men: he should take care that the orders of the surveyor are attended to, and be able to measure road work.

A regular plan should be arranged, and strictly adhered to, for keeping the water channels and drains of a road always open, and free from dirt.

In the month of October in each year, every water channel and drain should undergo a general repair, and be cleared of all deposited earth and weeds.

At the same time, the surface of the whole road should be scraped, all ruts and hollows should be carefully filled with materials, and all weak parts of the surface coated with materials ; that is to say, the road should be put in every respect into a complete state of repair, so as to preserve it from being broken up during the approaching winter.

A road should be scraped from time to time, so as never to have half an inch of mud upon it ; this is particularly necessary to be attended to, when the materials are weak ; for if the surface is not kept clean, so as to admit of its becoming dry in the intervals between showers of rain, it will be rapidly worn away.

The road men should scrape from the centre to the sides ; the mud should not be scraped into or allowed to remain in the channels, as is too frequently the case ; but put into small heaps, about one foot from the side channels, so as not to stop the running of water in them.

These heaps should always be removed, the moment the mud is sufficiently dry to admit of its being put into carts or barrows.

Constant attention on the part of a road surveyor is necessary to keeping hedges clipped and the branches of trees in the fences lopped. The hedges should be cut so as to be as low as they can be kept, without making the fence unfit for confining cattle within them. The superior condition of roads, at all times, crossing uninclosed land, shows how valuable a full exposure to the sun and wind is, in contributing to the preservation of roads.

CHAPTER XII.

ROAD LEGISLATION.

Turnpike System.

IT is owing to the turnpike system of road management, that England is so superior to other countries with respect to her public roads.

The Legislature, by giving powers to persons willing to come forward as subscribers, commissioners or trustees, and act together for the purpose of making new roads, or improving old ones, adopted the wisest principle for securing an abundance of good roads.

Had the Legislature refused to incorporate those persons who have executed the duties of turnpike trustees, and given the management of the roads to the Government, or left them wholly with the parishes, this country could never have reached the degree of wealth and prosperity to which it has arrived, for want of proper means of inland communication.

It must be quite clear to every one who has carefully examined this subject, that nothing but leaving the management of the roads to those persons who live in their neighbourhood, would ever have induced the people of England to pay as they now do, a road revenue, arising from turnpike tolls, to the amount of £1,200,000 a-year: for although tolls are in every respect fair and proper for maintaining a road; and although Government, by employing scientific engineers, might have expended the produce of them with greater skill than country gentlemen; the hostility to pay them, if they had been wholly at the disposal of Government, would no doubt have prevented the making of useful roads,

so universally over the whole country as they have been made under the established system.

It should be remembered that turnpike roads owe their origin, in many instances, to private subscriptions of considerable amount; and in every such case, the main inducement to subscribe must have been the entrusting of the management of the funds to the subscribers, and giving them corporate powers.

The same principle of association has led to the making of the canals, the docks, the great bridges, and all the most useful public works of the country; and it is not conceivable how such large funds for making new roads, or for converting parish roads into turnpike roads, could have been obtained as have been obtained, if the legislature had not acted on this principle.

But although it is unquestionably true, that it is to the turnpike system that the abundance of useful roads is owing, it must at the same time be observed, that great errors have been committed in carrying the system into operation. For however numerous and however useful the roads may be, they are, as has been already stated more than once, extremely imperfect, in comparison with what they might and ought to be.

In respect to the lines of direction, it has been observed that the roads are every where extremely faulty. They have, commonly, been carried over all the hills, between the points of communication, when they might have been kept on comparatively level ground, along the valleys of the country.

While the most magnificent improvements have been going forward in all other kinds of public works, displaying the greatest efforts of human skill, and a rapid advancement in the science of civil engineering, scarcely any road can be pointed out, except a few, which have been put under the management of civil engineers, that is not defective in the most essential particulars. Who is to blame for this? Not

the Government, because the business is not in its hands. The leading men of the commercial and manufacturing classes, who have been chiefly concerned in forming companies for making canals, docks, bridges, and other splendid improvements, are not to blame, for they have been too generally excluded from the business of road management. Nor are the civil engineers of Great Britain to blame, because they have seldom been consulted ; on the contrary, this profession has been too commonly deemed, by turnpike trustees, as something rather to be avoided, than as useful and necessary to be called to their assistance.

The country gentlemen of England in point of fact, are alone responsible for the defective state of the roads, because the business of managing them has been vested by the Legislature exclusively in their hands.

Dr. Adam Smith bears testimony to the bad management of road trustees in his time. He says :—" The money levied is more than double of what is necessary for executing, in the completest manner, the work, which is often executed in a very slovenly manner, and sometimes not executed at all." This remark, in too many cases, is just as applicable now, as it was when first made, nearly sixty years ago.

In those instances where a turnpike road is used merely for local purposes, however defective it may be, those persons only are put to inconvenience, who live near it ; but where a turnpike road forms the communication between populous cities or towns, at a considerable distance from each other, then the misconduct of trustees, whether arising from negligence, ignorance, or corruption, is of serious importance, and loudly calls for correction and control.

We shall now proceed to state what appear to be the principal errors, which have been committed in our road legislation in giving effect to the turnpike system.

According to the provisions of every turnpike act, a

great number of persons are named as trustees : the practice is to make almost every one a trustee, residing in the vicinity of a road, who is an opulent farmer or tradesman, as well as all the nobility and persons of large landed property ; so that a trust seldom consists of fewer than 100 persons, even if the length of the road to be maintained by them does not exceed a few miles. The result of this practice is, that in every set of Trustees there are to be found persons who do not possess a single qualification for the office ; persons who conceive they are raised by the title of a road trustee to a station of some importance ; and who too often seek to show it, by opposing their superiors in ability and integrity when valuable improvements are under consideration ; taking care too frequently, to turn their authority to account, by so directing the spending of the road money as may best promote the interest of themselves or their connections.

It sometimes happens that if one trustee, more intelligent and more public spirited than the rest, attempts to take a lead, and proposes a measure in every way right and proper to be adopted, his ability to give advice is questioned, his presumption condemned, his motives suspected ; and as every such measure will, almost always, have the effect of defeating some private object, it is commonly met, either by direct rejection or some indirect contrivance for getting rid of it. In this way intelligent and public spirited trustees became disgusted, and ceased to attend meetings ; for besides frequently experiencing opposition and defeat at the hands of the least worthy of their associates, they are annoyed by the noise and language with which the discussions are carried on, and feel themselves placed in a situation in which they are exposed to insult and ill usage.

Numerous cases could be quoted to prove the accuracy of what is here stated ; but it is unnecessary to do so, because every one acquainted with the subject, who reads these remarks, will readily allow their general correctness, and be

prepared to admit, that the sketch might easily have been still more highly coloured.

There is one effect of having these large bodies of managers, which is particularly deserving of notice, and that is the necessary want of uniformity and system in their measures. It often happens that, when some important business is to be performed, one set of ten or twenty trustees, after devoting a great deal of their time in attending meetings, finally decide upon some useful measure, when another set of trustees summon a meeting, and rescind all their fellow trustees have done. This is a course of proceeding which is, of itself, sufficient to establish, beyond all dispute, the absolute necessity of some considerable change in the existing system.

Notwithstanding the state of the Turnpike roads was enquired into by select committees of the House of Commons, in the sessions of 1819, 1820, and 1823, and in consequence of their reports a new general turnpike act was passed in 1823, the evil of the mal-administration of the powers of trustees has not been cured by the 153 clauses contained in this act. The evil in point of fact, having its source in the principle on which the governing body of road business is formed, is not of a nature to be cured by a multitude of regulations; and the framers of the law committed a great error in overlooking this point. It is the principle of having such a number of trustees that throws every thing belonging to road operations into confusion, and produces the waste of the road funds. A law therefore, to do any good, should provide that the number of trustees shall be limited within some rational bounds.

The Committee of the House of Commons appointed in 1823 to enquire into the state of the turnpike roads, say, in their report,—"Your committee would therefore strongly recommend to the House the consideration of the subject of

making and managing the roads of the kingdom in the course of the ensuing sessions of Parliament: feeling convinced, that whatever plausible appearance the plan may assume of appointing a large number of noblemen, gentlemen, farmers, and tradesmen, commissioners of the roads, that the practice has every where been found to be at variance with the supposed efficiency of so large a number of irresponsible managers; and that the inevitable consequences of a continuance of this defective system will be to involve the different trusts deeper in debt, and leave the roads without funds to preserve them in proper order."

But besides diminishing the number of trustees, another step should be taken in order to secure a uniform and efficient system of managing the executive business of maintaining a road.

Each body of trustees should be obliged to elect by ballot a committee of seven trustees, in whose hands every thing relating to the business of managing the road should be vested. What belongs to the management of the revenue and general affairs of the road might be transacted by the body at large.

But all the funds, after paying the officers and interest on loans, should be at the disposal of the committee. The committee should be required to lay half yearly accounts before the body at large, with reports of their proceedings.

To enable such a committee to act with effect, they should have full power to appoint and dismiss surveyors.

Another great evil of the existing system, which a new law should correct, is that of placing a line of road under the management of too many separate boards of trustees. With respect to cross country roads, it may be difficult to apply a remedy to the evil; but as to all the great main roads of the kingdom, a law should be passed to consolidate the existing trusts, so as to have at least fifty miles in each trust. All the

mail-coach roads in each county should be placed under the management of one trust.*

There remains to be noticed another very great defect in our legislation on roads, viz: the want of some power to control the trustees of turnpike roads, to prevent neglect and corrupt practices. No other trustees are free to do whatever they please with perfect impunity; and no reason can be given for not making every one who takes upon himself the office of a road trustee, accountable before a proper tribunal for his conduct in the discharge of the duties of it. Dr. Adam Smith has remarked this great defect in the turnpike laws, of not providing such a control. If a board of trustees suffer the road under their care to get into a bad condition, the only remedy now is to indict the parish through which the road passes; but nothing can be more contrary to every principle of justice than such a state of law. In all cases where trustees have the management of landed property, applicable to the maintaining of buildings, bridges and roads, proceedings may be taken against them in the Court of King's Bench, if they abuse the trust reposed in them. In the case of roads, the circumstance of the funds for maintaining them being derived from tolls, should make no difference, and they should be equally liable with the trustees of estates to be brought before this court. But this remedy would not be sufficiently easy and efficacious. A more direct and easy course of proceeding would be to allow complaints against trustees to be brought by petition before the judges at assizes. The judges

* Extract from Mr. Telford's first annual report on the Holyhead road, dated May 4th, 1824, p. 25 :—"Perfect management must be guided by rules and regulations; and these must be carried into effect by the unceasing attention of a judicious and faithful surveyor, who has by actual experience and attention, acquired a thorough knowledge of all that is required and applicable to the general and local state of particular districts, as regards soil, materials, and climate; likewise the sort of wear to which the surface is liable. A person possessed of all these requisites and otherwise properly qualified to level and set out new lines, &c. where necessary, must receive the remuneration which such a character merits, and may always obtain in this active and industrious country."

should be empowered to try with a jury, the allegations contained in the petitions ; and in case of a verdict in favor of the petitioners, they should be enabled to set aside the trustees, and name commissioners to take charge of the road for as long a period as they might think advisable.

But in addition to the measures now proposed, however well adapted they may be for putting the trustees of turnpike roads under more control than they now are, another should be taken further to secure an upright and efficient discharge of their duties, namely, that of placing them under the immediate superintendance of a public Board of Commissioners.

If this plan were adopted, the commissioners should have power given to them to cause annual inspections to be made by competent civil engineers, of all the principal roads in England, Scotland and Wales, so as to obtain accurate information concerning the proceedings of every turnpike trust. Every trust should be obliged to furnish them with an annual account of its income, expenditure and debt, and they should also have authority to enquire into the details of the income and expenditure of every trust. An annual report should be made by the commissioners to parliament, containing a summary of the information derived by them, from their inspections and enquiries.

This Board in addition to what is here required of it as a board of control, should be enabled to act as a board to assist the trustees in making alterations and improvements. It should be authorised to have surveys made of all the mail coach roads of Great Britain. These surveys should show the ground plan of each road, its vertical longitudinal section, and the alterations and improvements that may be made in it. The board should furnish each trust with a copy of the survey of the road under its management, and be enabled to make an arrangement with it for carrying the necessary alterations and improvements into execution.

The following extract from the report of the committee of the House of Commons in 1819, on the public highways, contains remarks which concur fully in principle with the recommendations now given for the improvement of the turnpike roads.

The importance of land carriage to the prosperity of a country need not be dwelt upon. Next to the general influence of the seasons, upon which the regular supply of our wants and a great proportion of our comforts, so much depend, there is perhaps no circumstance more interesting to men in a civilized state, than the perfection of the means of interior communication. It is a matter, therefore, to be wondered at, that so great a source of national improvement has hitherto been so much neglected. Instead of the roads of the kingdom being made a great national concern, a number of local trusts are created, under the authority of which large sums of money are collected from the public, and expended without adequate responsibility or control. Hence arises a number of abuses for which no remedy is provided ; and the resources of the country, instead of being devoted to useful purposes, are too often improvidently wasted.

The next great error in principle, as to legislation on the common highways, is the means by which the funds for maintaining them are provided, namely, statute labour ; and it may be said with respect to this point, as it has been already said with respect to the former, that so long as this radical error in principle shall be recognized by parliament, it will be labour in vain to pass new acts to remedy existing evils.

And a third great error in the system of parish management, consists in the regulation by which a surveyor is appointed to act only for one year. This practice is founded on the vulgar notion that the management of roads is something that requires no education ; that it is not an art which requires skill and science. This practice may be set down

as one which had its origin in very rude times, and which long usage has made familiar; but it certainly is one which ought to be abolished in the present enlightened state of society.