A TREATISE

ON

CANALS, COTTON SPINNING, CORN MILLS, GRINDING, PRESERVING GRAIN, AND PUBLIC DRAINS.

Hartley, Printer,
Market-place, Rochdale.

J. Wh.

A

TREATISE

on

CANALS AND RESERVOIRS,

and

THE BEST MODE OF DESIGNING AND EXECUTING THEM;

with

OBSERVATIONS

on the

ROCHDALE, LEEDS AND LIVERPOOL, AND HUDDERSFIELD

CANALS,

AND A COMPARATIVE VIEW OF THEM;

and also on the

BRIDGEWATER, THE LANCASTER, AND THE KENNETT AND AVON CANALS.

LIKEWISE

Observations on the best Mode of Carding, Roving, Drawing, and Spinning all Kinds of

COTTON TWIST.

ALSO

INSTRUCTIONS FOR DESIGNING AND BUILDING

A CORN MILL,

and

HOW TO GRIND UPON THE BEST PRINCIPLE;

With a new and simple Mode of preserving Grain from the Consequences of a wet or soft Harvest, and rendering useful Grain that has become foul and fusty;

TOGETHER WITH

IMPORTANT DIRECTIONS ON PUBLIC DRAINS.

BY JOHN SUTCLIFFE,

CIVIL ENGINEER.

ROCHDALE:

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1816.

TO

SIR ROBERT PEEL, BARONET.

Sir,

THE approbation which you have been pleased to express of this work is very flattering to the author. And to whom can a book, the object of which is intended to promote trade, internal navigation, and agriculture, be inscribed with greater propriety than to Sir Robert Peel?

I have the honor to be, with sentiments of the greatest respect,

Sir,

Your much obliged,

And most humble servant,

JOHN SUTCLIFFE.

PREFACE.

THAT canals and river navigations are of great importance to trade and commerce, will not be denied by those who have seriously considered the subject; and I think it is equally true, that there is no subject upon which the ability and eloquence of the senate, and the labour of the press, have been so much displayed; and yet the real state of any subject, perhaps, was never more mistaken, nor the public mind more misled, than by the supposed profits that arise from the making of them.

In the house of commons, I heard it boldly asserted by a member, who had more zeal than understanding, that canals would be the salvation of the state, if made similar to those in Holland. Another member, less noisy, but more wise, ironically observed, was that the case, the succeeding generation should have webbed feet like ducks, that they might the more easily pass upon them.

But from a careful examination of the grounds upon which these supposed profits rest, they will appear to be no better founded than the immense wealth which the silly girl in the fable proposed to raise from her eggs and chickens. And does not this plainly shew how sensible men may, and frequently do, speculate much upon the shell without ever once approaching the kernel of the subject.

Not more than twenty years ago, a man that dared to deliver the opinion, that few of the modern canals would be of public utility, were the dues to be so fixed as to pay the subscriber 5 per cent. became as obnoxious, as if he had engaged in the defence of the abominable doctrines of Tom Paine; and I am inclined to think, there is not a man in the kingdom that has suffered so much obloquy as myself, from the supposed friends to canals and their pretended engineers, for declaring my sentiments upon many of them; but time, the best expositor of future events, has fully confirmed my opinion.

The generally prevailing idea, that canals were extremely beneficial to the subscribers, has had a most injurious effect in misleading the public. And this fatal error has arisen, in consequence of the advocates for canals having only examined one part of the subject; for the great advantage which the public were supposed to derive from the making of them, has been painted in the most glowing colours, while the real state of the subscribers has been passed by in silence, as unworthy of notice.

It is the subscriber I would principally wish to look to, and if possible, procure him 5 per cent; for as the dues are generally fixed, if they have common interest, the public will be well served; and so they are by many of those canals that will never pay one farthing of interest for the original subscription, nor interest even upon the advanced loans. Suppose the subscribers to these canals had a power to raise the tolls until they would pay 5 per cent, what would be the consequence? would the public comply with such a demand? certainly not; for although the company could raise the tolls, they could not compel the public to pay them by carrying goods on the line.

Many have written upon the great gain that would attend the making of canals, but none upon the heavy loss that would be the consequence of it; and this supposed gain has had great influence upon the minds of the subscribers. Mr. Philips, in his treatise upon canals, tells the farmer that he would carry his grain to market 30 per cent cheaper by them than upon the public roads; and such a statement, if credited, would naturally induce the opulent farmer to become a large subscriber, as he would have two motives for so doing: 1st. The great saving by carriage: 2nd. The great interest expected to arise from sinking a certain capital. I can readily admit this statement, and yet it may be easily shewn that if the tolls by which the farmer gains 30 per cent in the carriage of his grain were raised, until the subscriber had 5 per cent, such farmer would not carry a quarter of grain upon them once in seven years, because it might be carried much cheaper on the public roads.

All these writers upon canals have treated the subject as if there was no risk in the subscriber receiving 5 per cent; no wonder, then, that speculating in canals should have been so extremely captivating; for trade without risk is a thing unknown to the mercantile world. And to add weight to the arguments of these Gentlemen for multiplying canals, they have collected the names of a few canals and river navigations that pay well, (and few they are indeed, when compared with those that pay ill, and many nothing at all), without ever examining and comparing the countries through which each of the lines pass, and how one may exceed the other with respect to population, trade, commerce, mines, and minerals; for, it is probable, the lines that pay well are ten times more favourable for a canal than those that pay ill, and a comparative view of them might have prevented the execution of many of the bad lines; but from reading their works, a stranger would conclude that all were alike beneficial.

Moreover, these Gentlemen, in treating upon canals, have paid little attention to the great difference there is in the price of land, labour, and materials, from what they bore at the time when those canals were executed that pay well; for if many of them were to be cut now, though they have long paid well, they would not now pay $2\frac{1}{2}$ per cent interest. Neither have these great advocates for canals once hinted that the subscribers to them might be injured by competition in multiplying them, or by the making of new public roads to communicate with them; though nothing could be more plain than that such an injury would, in a great many instances, take place. For wherever a canal is made, new public roads are sure to be made also to convey the goods to and from the line; and although the general opinion has been, that making canals would render more new roads unnecessary, facts have proved the fallacy of such an opinion.

But eventually, multiplying new roads will militate against canal interests, inasmuch as they will make the trade of the country less dependent upon canals, and will also operate against an advance of the tolls.

I am sorry to say, that long experience has shewn me, that canal subscribers have generally been the dupes of all parties; for the land owner, who may have got a large stone quarry, a lime rock, or a coal mine to dispose of, acts his part with the utmost caution upon the public stage, but frequently behind the curtain, in persuading the unsuspecting subscriber, by a number of fallacious statements, that he will be greatly benefited by permitting him to vary the line here, and make a turn there, until he has at last made it every thing but what it ought to be. The great coal owner always makes sure to be upon the canal committee, recommends subscribing liberally, and with great ingenuity acts the part of a decoy duck for the scheme.

It is not possible to state how many canal schemes have been sacrificed to the interest of these men; but the greatest prostitution of canal interest that I think was ever witnessed was effected by two opulent coal owners, near Manchester, and were I to give the history of it I think few would give me credit. I believe there are not many canals in the kingdom, the interests of which have not been sacrificed to either land or mine owner, or both conjointly: No matter of surprize then, that the subscribers should be in so deplorable a situation. I am sorry to say, that a great part of the capital sunk in making modern canals in this kingdom, has been found upon enquiry to belong to those who can ill spare it; and I find it to be the case with the subscribers to the canals in Ireland, which makes the loss much more distressing.

It is a serious consideration, to take from the pockets of this class of people perhaps more than £5,000,000 sterling, that will never pay a penny of interest; but I by no means wish it to be understood, that this is the whole of the non-productive capital sunk in canals; for I think it is far from being one half of it. I shall for the present conclude this subject by saying, that no man can be more desirous than I am of promoting canals, where there is a fair prospect of the subscriber having 5 per cent interest; but should the country be so unfriendly to a canal, as not to justify the expense of making one, a railway may be made instead of it; and the public I think have as yet but contracted ideas of what may be carried upon a railway made upon the best principle, or of the easy expense of carrying a ton of goods per mile upon them; I shall give my opinion upon railways with my observations on the Irish canals

Perhaps the canal subscriber will ask, by what rule he shall know to what expense per mile he may go in executing a canal before he incurs risk, in not having 5 per cent interest for the capital he may sink. This is a question much easier to propose than to answer.

If the country, through which the line is proposed to pass, be populous, abounding with mines, minerals, trade, and extensive commerce, the subscriber may be justified in expending from £7,000 to £7,500 per mile upon a broad canal. The interest of this sum is £375 per annum, but one-fourth of this must be deducted for wear and tear, which will require a gross revenue to be raised equal to £468,15 per mile, including every expense. There are but few either canals or navigations that raise such a revenue per mile; yet there are a few that raise much more. If this statement is worthy of confidence, it shews the distressed situation the greatest part of our modern canals are in.

The tolls for many of these canals are easy, and were they otherwise, little or no tonnage would ever come upon them; for were they to be advanced 1*d* per ton per mile, three-fourths of the dues would immediately disappear.

Did I wish seriously to injure that respectable body of men, the proprietors of the Leeds and Liverpool canal, I should wish them success in their application to parliament, (for their opposers are their best friends in disguise) and should they be so unfortunate as to acquire a power, and so imprudent as to use it, and advance their dues 1*d* per ton per mile, I think they will quickly dismiss one-third of the transit trade. But with an advance of tolls I think they should not be indulged, until they have corrected the imperfections of their works, and made the public such a canal as they engaged to do when they obtained their act; and from the great power they had given them to supply it with the mill-owners' water, the public have a right to expect a canal made upon the best principle, which is not the case at present. This canal and that of the Rochdale were not originally intended to be rival canals, but from unforeseen circumstances, they are become such, and neither money nor ingenuity can prevent it.

The competition between public roads and canals is great, and the difference in expense, in carrying upon them is, in many instances, very trifling, and differs very much from Mr. Phillips's statement.

The difference in distance between two given points, say thirty miles, where the conveyance is made both by land and water, will generally be nearly one-third more by the former than by the latter, to which add the distance in carrying to and from the canal. The distance between Sowerby Bridge wharf, where the Rochdale canal commences, to Manchester, by the public road, is twenty-two miles, but by that canal thirty-two miles, and the distance from Leeds to Liverpool, by that canal, is one hundred and thirty-one miles, but by a good public road only seventy five miles, which makes a saving, in distance, of fifty-six miles.

I hope, nothing that I have said will tend to discourage the making of canals, but the contrary, where the natural population and trade of the country will justify the expense; for they have already been so much disgraced by the improper designing and conducting of them, that I shall not be surprised to see the making of canals as much exploded, as they once were recommended; for public confidence is much sooner lost than regained.

CONTENTS.

D.

E.

F.

G.

H.

I.

K.

L.

R.

S.

T.

OBSERVATIONS.

OBSERVATIONS

ON THE

CARDING, ROVING, DRAWING, STRETCHING, AND SPINNING OF COTTON.

THE foundation for making good yarn must be laid in the card room; for if the cotton is injured there, no subsequent operation can correct it. The feeding rollers for the cards, should run as near the swift cylinder as possible, so as not to touch it, and the swift cylinder should make sixty-four revolutions for the feeding rollers one, and twenty-six for the doffing cylinder one, and the doffing cylinder should make two and three-quarters revolutions for the feeding roller one. The diameter of the feeding rollers, for the finishers, should be one inch and one-eighth of an inch, but those for the breakers should be one inch and a quarter diameter, and the cotton, when passing through them, should be in a line with the centre of the cylinder. The speed of the swift cylinder may be taken at from 100 to 110, 120, 130, 140, for middle numbers, of from 40 to 50, or 60 hanks in the pound; but should the numbers run from 80 to 120, it would be better if the swift cylinder did not make more than from one hundred to one hundred and twenty revolutions per minute; yet I have seen them make one hundred and forty revolutions, when spinning very good twist 130 hanks in the pound. The flats should be set as near as they can be, without touching the swift cylinder, and the ear is the best guide to know whether they run close or not.

It is but too often the case, that, from the inattention of the carder, the cotton is spoiled by being made knappy, as it is called, that is, full of small round knaps; and, whenever this is the case, the cotton is greatly injured, for if these are made with the breakers, the finishers can never remove them. These knaps may be made by bad cards, but they generally are made by the cards being improperly set, or for want of grinding, or for not stripping the cylinder and flats in proper time. The swift cylinder of the breakers should be stripped once every hour, and a flat every ten minutes, and not more than two flats should be stripped at once, but on no account be more than one half of them at the same time, for if they are all stripped together, it will make a thin place in the lap, and be much too light. But as the laps of the breakers are all weighed, their being too light, is not of so much consequence as, not stripping the flats and the cylinders of the finishers in time, in which case the carding will not be of an even thickness, which will most certainly injure the yarn, for weighing the rovings will not entirely remove this imperfection; but I shall speak more fully of these things hereafter.

The swift cylinder of the finishers will not require stripping more than once in every two hours, and the flats will not need stripping quite so often as those of the breakers, and only one half of them should be stripped at once.

It is of the utmost importance, that the drums of the breakers should be all of an equal diameter, for if there be any variation in them, it will make a difference in the weight of the carding. There is another circumstance that should be carefully attended to, though by most of the carders it is seldom thought of, for the greatest part of them do not know, how necessary it is that all the cardings of the finishers should be of equal weight for an equal length, yet this is sometimes very difficult to obtain. It will frequently happen, that when the laps are of equal weight, and the carding engines have an equal number of wheels with an equal number of teeth, yet, notwithstanding this, there will be a variation in the weight of the carding of four hanks in the pound. To correct this, it will be necessary to change some of the card wheels, to bring them to an equal weight Suppose the cards of one finisher to be much farther worn down than those of another, though the laps may be of an equal weight, and the motion of both engines the same, yet the cardings will frequently vary much in their weight. To adjust the weight of the cardings accurately, the cards should be, as near as possible, equally worn down, and if the cardings of two, or any given number of engines, are tried one against the other, the cylinders should be exactly stripped together; and the state of the flats should be equally alike, with respect to the time of stripping.

Perhaps it will be said, that if the rovings are weighed, it is of small moment whether the cardings are of equal weight, for a given length, say six feet; but this is a great mistake, for if there is a great difference in the weight of an equal length of the carding, it will make two or three more sorts of rovings, which is attended with considerable loss in waste, as well as inconvenient for the spinner to have to change his rovings so frequently. Besides, the yarn is thereby made much worse.

If the carding engines and drawing frames are rightly managed, there will seldom be more than two sorts of rovings; whereas there are frequently not less than five or six sorts. All this exactness in the weight of the laps and the cardings is not necessary for weft spinning; but for making a first rate article of twist, it is requisite. Should the flats run five or six minutes longer than their usual time, before they are stripped, it will produce knaps, which will very much weaken the yarn and create waste, as they will fly off when the brush is dressing the warp. Carding lightly is much in favour of not making knaps; and with a box engine, 18 inches broad, for 80 to 90 hanks in the pound, five ounces is full enough for a lap to weigh; but for 40 twist, many will have their laps nearly six ounces.

When two sorts of cotton are mixed and carded together, I think the best method of mixing them, is to weigh the sorts separately, and let them go upon the feeding cloth in that state; and as one will lap over the other on the drum, they cannot fail being well mixed when they come to the finisher; but there is another way that some make use of, which is carding the cottons on separate engines, and running a carding of each through the drawing frames together; and either way will answer, if properly attended to.

The next thing that calls for the attention of the master spinner, is the grinding of his cards. I am inclined to think, that there is more cotton spoiled by the cards not being ground in due time, and improperly ground, than by any thing else; and from a careful examination of a great many factories, as well as from consulting with the most experienced carders, I am of opinion, that one-fourth of the cotton that is worked in this kingdom, is much injured in the carding and drawing, and consequently, that one-fourth of the yarn spun from it is injured also.

To enable the carder to dispatch his grinding quickly, he will frequently use the fast emery, which should never be applied but when the cards require grinding to an even face; and this fatal instrument is frequently put into the hands of an inexperienced boy, who, not knowing how to use it, will often grind one end of the card much lower than the other, and thereby ruin them. The cards should be well brushed out, or cleaned with an open hand card, made for that purpose, before they are ground, which will fetch the dust and dirt from the bottom of them much better than a brush can. The cylinders should be ground with a light hand emery, about three inches broad and one thick; and afterwards with a piece of curved leather, fitted to the diameter of the cylinder, and covered with emery, which being very light, the cards can hardly be injured by it. In general, cards are not ground more than one half as often as they should be, for the breakers should be ground gently every day, and the finishers every other day; but not more than one half of either should be ground at once, for the cards should never be all sharp or dull at the same time.

As the cylinders of carding engines are apt to fly by change of weather, and from not being dry at first, they should be frequently examined, to see that they are in the round; and the screws, which fasten the cover to the rims, should be inspected twice a year, and every shut cord should be examined, to see that they are not become slack. Should any cylinder be out of the round, it will spoil the cards, the cotton, and the yarn, as one side of it will give the cotton too much work, and the other side too little, which will make the carding uneven, in proportion to the cylinder being out of truth.

New cards require a great deal of time to grind them properly; for if the fast emery be laid on too hard, it will soften the wire and ruin the cards. A set of new cards will require three days, at least, to grind them properly, for they should be ground until there is not a bright tooth to be seen in them, for these do no good in that state; and the cylinder, when ground properly, will appear nearly black.

The working of the crank should be carefully attended to; for generally it is worked much too fast, as the speed should not be more than sufficient to take off the cotton; a quick motion will produce a great deal of waste, and subject the machine to many misfortunes. The feeding rollers of the cards should be frequently examined, to see that they stand square with the cylinder, and that their centres are of a proper height; for if they are not, good work cannot be produced by them. Some carding engines have a small roller, from about $2\frac{1}{2}$ to 3 inches diameter, covered with a kind of fillet, which works against the swift cylinder, a little above the feeding roller, to keep the cotton light upon it; and it answers very well.

When the cards are nailed on, they should be well stretched, and a sufficient quantity of stout tacks put in them, to keep them firm and tight.

The next thing to be considered is, what breadth of carding engine will do its work the best. Box or narrow engines for 18 inch cards, were used for middle and fine numbers, more than twenty years; but for the last three or four years many have made their engines from 2 feet 6, to 3 feet 6 inches, and some 4 feet broad. The only advantage these engines have over narrow ones is, that they take up less room for the same breadth of card; but they are far more inconvenient to work, and much more subject to warp;

besides, it is difficult to get good even leather of the size wanted. For these and many more reasons that might be given, I think narrow engines much better; and many spinners are now rejecting the broad and adopting the narrow ones.

Where the worst of cotton and waste are worked for twist, of from 10 to 12 hanks in the pound, or for low numbers in weft, broad engines made double, and which finish with one operation, may answer; but where good cotton is worked, there never will be any machine invented, in my opinion, that will answer like the narrow ones. Delivering rollers at the tail of the finisher, made of iron turned exactly true, and of the proper size, as they will not draw the carding in the least, are much better than those made of wood, which soon wear too little, and occasion great trouble.

The spinner of Bowdens and Orleans, should have the wire for their cards fine, hard and elastic; for hard stiff wire will very much injure those cottons; a great deal depending on the state of the cards and the quality of the wire. It is therefore necessary for the master spinner to understand the quality of his cards, to prevent him from being imposed upon by either the card-maker, or his carder; between whom there is, sometimes, too great an intimacy. Nor will the master be able to keep his carder in proper subordination, until he has attained a moderate knowledge of his card-room; for such is the base principle of the generality of them, that if they find their employer to be ignorant of what is passing in the card-room, they will do all in their power to keep him so; and in proportion to the want of knowledge in the master, will be the idleness, the insolence, and drunkenness of the carder.

The spinner ought to be cautious in the choice of his carder, and avoid having one that has an asthmatic complaint; as such an one cannot stand the grinding of the cards, but as often as possible, will set boys to do it in the master's absence, by which means the cards will be spoiled; and if he is hard of hearing, he cannot set the flats and doffing cylinder properly. In a large factory, a grinder to assist the carder is necessary; but small factories cannot support the expense. The master, or the overlooker, should, once in the week, have all the cylinders stript, to see how the cards are ground; and whether the flats are set properly.

If the observations I have made are carefully attended to, and the cards are in good condition, the spinner may reasonably expect to have good work, provided the carder knows his business. In order, however, that the carder may produce the best work, he should have good cotton, well prepared by batting and picking; but such has been, and is now the deplorable state of the cotton spinner, as not to admit of this expense, owing to the high price of labour, especially for low and middle numbers; the very fine numbers perhaps may.

Many substitutes for hand batting have been adopted, but none have answered so well as the blowing machine and the single beater, as it is called. The blowing machine however is now almost given up, owing to the great power that is required to work it, and the excess of waste in fly, which is little worth. The beater having no fan, does not make one half the waste that the blowing machine does, and the waste it does make, is much more valuable than that of the blower. But this machine is capable of doing great injury to the cotton, if not properly looked after; for should the beater stand too near the feeding rollers, it will very much chop and cut the cotton; and when thus injured, there is little strength in the yarn spun from it; and it is next to impossible to card it without knapping. Brazil cotton will not bear going through this machine more than twice; and to allow of this, the beater should not make more than from five hundred to five hundred and fifty revolutions per minute, yet many of them make twelve hundred.

It must be allowed, that the quicker the machine runs, and the better it will open the cotton; but it frequently opens it too much; and the slower it runs the better it will take out the dust and motes. For middle numbers this machine will answer well, if properly managed with a feeding cloth to take off the cotton; and a picker should clean it as it passes along.

The drawing machines, or frames, require particular attention to manage them well. It is now admitted by all judicious cotton spinners and well informed carders, that three rollers for one head are much better than two; as there are two drafts with three rollers, but only one with two rollers. By having two drafts, the cotton is drawn less at once, and the yarn much stronger than it can be made by one draft; and four ends may be put up much better at the first head than with two rollers; and may be continued through all the heads of the drawing frames. Many drawing frames have only four heads, but six make much better twist, as it is doubled sixteen times for the other one. Suppose four ends run up for four heads, the doubling, including that of the skellets, will only be five hundred and twelve times in passing through them all; but six heads, including doubling with the skellets, will double it eight thousand one hundred and ninety-two times.

It is of importance to have a right understanding, what the distance should be between the front and middle roller, for an error in this respect will be fatal to the yarn. The distance between them should not be more than a quarter and one-sixteenth of an inch; and the front roller should make two revolutions while the middle roller makes one; and the middle roller nearly two for the back roller one. These calculations are made for working Brazil and Demarara cottons; but I shall give more particular instructions for these movements hereafter.

The first head should draw one foot into full three, and keep advancing one tooth at every head, except the last; for it may be, that if it advances a tooth at the last head, the coil will be weakened too much; and if, upon examination, this is found to be the case, the sixth head should have the same pinion as the fifth; and if the coil should be rather too heavy, it may be regulated at the skellet; for it is much safer to have the cotton under than over drawn at the frames. It is of importance to have the bosses of the drawing frame rollers 4 inches broad at the least, that the cotton may pass thin upon them;

for a piecing may be drawn much better with a broad boss than a narrow one; but broad bosses are of little consequence if the passage to them is contracted. Such, however, is the ignorance of many carders, that when they have a broad boss, they will contract the entrance to it one half at the least, by driving old spindles on each side of it; and this makes the rollers unable to draw a piecing in a proper manner. This contraction is made to save the trouble of placing the cans in a proper position, to admit of the carding passing through the brass conductor without any other assistance. To correct this folly and make the rollers draw, the carder increases the weight upon them to, perhaps, double what would be necessary, if the passage to them was not contracted; and the consequence of this is trebling the roller laps, and increasing the waste in the same proportion; add to this, that the rollers will require covering twice as often, besides wasting the power of the steam engine.

The less weight any roller can be worked with and the better, for no more is necessary than is sufficient to make it draw clear; and the breaking of the coil, and letting the end run loose down without passing the delivering rollers, will shew whether the cotton draws clear; and if it does not, the weight must be increased until it will. Once in the week, the drawing frame rollers, as well as the feeding rollers of the carding engines, should be well scoured; and the distance between the drawing frame rollers should be carefully examined, to see that the stands, or rather the slides, are not shifted; for, by having so much oil about them, the screws work loose, and the slides frequently move, to the great injury of both cotton and twist.

The cloth for covering the drawing frame rollers, should be good, stout and well milled, but double milled would be better, which should be raised with dead teazles, and aftewards have a gentle cut. I should prefer such a cloth to the having two folds, as some spinners have upon their rollers; and the bosses should be made rough with a file, that the paste or paint may stick fast upon them.

The stretching frame is an useful machine, but requires good management. The distance between the front and middle roller, for Brazil and Demerara cotton, should be one-eighth of an inch and full one-sixteenth; but for Georgia cotton it should be a little more, and draw one foot into nearly five feet, but not more. The length of the stretch should be five feet, and the front roller make nearly four revolutions for the middle roller one, and the middle roller should gain upon the back roller nearly one in seven.

The fineness of the roving for 40 twist should be full four hanks in the pound; and this preparation will answer for all numbers, except where they spin from a double roving. The roving for all numbers should have as little twist as it can be spun with, without being strained, for if the roving is hard twisted, no level yarn can be spun from it; and the rollers should have no more weight upon them than will make them draw the cotton clear. The breaking of the coil, as before directed, and letting the card run loose, will shew whether it will draw clear or not. Great care must be taken that the point of the spindle does not go too near the roller beam, as it will cause the roving to fly off at the spindle point when the cop is nearly full; and that part which flies off will have much more twist than the rest of the roving, while the part which is over twisted will never draw freely between the spining rollers; and the yarn spun from it will not be level. It is not possible to estimate the loss which spinners have sustained, by spinning from rovings that have been hard twisted.

That a stretching frame may do its work well, the rollers and wharfs should be well picked and cleaned twice a day; and the carriage board and roller beam wiped down every set; and the roving should be twisted the same way that the yarn is which is spun from it. If the frame is making rovings for 40 or 50 twist, the cleaters should be often picked and chalked; and the steel rollers should be well scoured once a week, and the stands tried once a month, with a line drawn over them, to see that they are level; and the stretcher be well watched that, in backing off, the roving is not strained. It is the opinion of many judicious spinners, that there never has been any machine constructed that would make rovings as level as the stretching frame; though they may be rather more expensive in the working, than some other machines used for that purpose,

Mule spinning is certainly a very complex business, which may still be considered in its infancy; for its machinery admits of endless improvement; and it is one of the disagreeable but unavoidable circumstances attending it, that the most ingenious spinner can never say, he is spinning upon the best principle for six months together. The rollers for the back and middle should be made of good clear wood, well dried, and turned as true as possible. The rollers for the front should be made of soft beaten iron, and should also be turned true. The cloth which covers them, should be good and stout, but soft, much the same, though not quite so strong, as that I have recommended for the drawing frame rollers. Perhaps it may be as well to have both the wood and iron rollers turned to an exact thickness; which will be necessary, if the spinner intends to use cement joints for the leathers. When these are well made and tightly put on, they may answer for middle numbers; but for fine yarn, I think there is nothing like drawing the seam with silk.

Cement joints are usually made with isinglass, mixed with brandy, vinegar, ale, or porter dregs, all which have a tendency to make the joint hard and stiff, and have therefore been given up by many fine spinners.

Roller seams made with silk and sewed at the ends with thread, are apt to turn round before the leather is half worn; and are then unfit for use. The best way to make the leather firm upon the roller, is to steep it in water, about new milk warm, for five or six minutes, and stretch it well with the finger before it is sewed on with silk; the end must be well sewed with thread; and if the seam is well made, it will stand as long as the leather will last. The leather which has been thus expanded, will contract again when dry, and thus become much tighter than it can be made if put on dry. The rollers should not be used for two days after they are covered; as they will not be dry in less time. Twelve or fourteen hours after they are covered, the seam should be well rubbed with a piece of polished iron, steel, or ivory, to make it smooth; for the contraction of the leather will make it rather rise between the stitches; but by rubbing, it may be made perfectly smooth again. The paste must be put upon the leather as usual, and will have the same effect as if it had been put on dry.

The distance between the front and middle rollers of the mule, for working Brazil and Demarara cotton, may be taken at one-eighth of an inch, but for Georgia cotton, rather more distance should be allowed; and if the pinion upon the back roller contains thirty teeth, and that on the middle twenty-six, perhaps this proportion for the draft cannot be much improved; and if one foot of roving is drawn nine and a half, or from that to ten feet, it may answer very well. Some judicious spinners will make a difference of five teeth in the pinions for the back and middle rollers, but this I think is too much. Every time the steel rollers are scoured, the stands should be tried with a line, to see if they are level and otherwise right.

If the master spinner wishes to have twist of the first quality, he must weigh his rovings accurately, and let his carriage come out slow; for when it comes out quick, the roving is forcibly drawn from between the rollers without giving it time to draw, which makes the yarn uneven, besides increasing the waste in an astonishing manner; and it does not allow time for the piecers to get the ends up, without which they cannot make good piecings. As little twist as possible should be put into the roving part of the stretch; if this part is not easy twisted, it will prevent its stretching freely, and break the ends down; for unless the twist be well stretched in the roving part, the yarn will not be level; but as much twist should be given at the head as can be got in.

For spinning 40 to 45 twist, I would recommend the following calculations; as they will give full speed enough for the carriage coming out.

The bevil wheel on the front roller should contain fifty-four teeth, the fore wheel on the run forty-eight, the wheel at the bottom of the lying shaft thirty-four; and the wheel at the top of the said shaft forty-eight teeth. The length of the stretch being five feet, the carriage stretching from three to three and a half inches in the roving, and from one and a half to two inches at the head, will require thirty-eight turns; and the spindles should make from forty-three to forty-four turns for the rim once.

The stretching gear should be so made and fixed, that the spinner cannot alter it, either in the roving part or at the head; which otherwise he will do the first oppoitunity; by which alteration, and the use of improper change wheels, many thousand tons of yarn have been greatly injured, and many a master ruined by it. His employer will be exposed to incalculable loss and disappointment, by the injury done to the yarn, and the loss of his best customers. The axles for the change wheels should be so made, that no one but the overlooker and the master can put on the wheels, or take them off; and there would be little difficulty in designing a wheel and axle for this purpose; and the stretching gear should also be on the same principle. The carriage should gain upon the rollers, in the roving part, full three inches, and one and a half inch at the head; and this proportion will answer, however high the numbers may go, by increasing the stretch one inch for every ten hanks, but for weft, one half inch will be sufficient; and it should have it all in the roving part, and none at the head.

Reeling is a good check upon the spinner, if the cops are reeled to the bottom, which should always be done every set; still it is not an infallible remedy against the evil; for there may be an understanding between the spinner and the reeler, consequently, there is no real safety, but in constructing machinery in such a manner, as that it cannot be altered by the spinner.

The overlooker should take care that the spindle point of the mule does not go too near the roller beam when the carriage runs in; and the spindles should not stand too upright; for in either case it will have a tendency to cause the twist to fly off the spindle point, and make the yarn crackly and unsound. The same effect will be produced, if the carriage is not kept steady by the catch at the head, till the twisting is finished, Running the machinery at a moderate speed is by much the best; as it is attended with much less waste, requires less oil, and makes the yarn much better.

Every mule that spins middle numbers should be wiped down four times a day; and the roller beam kept free from fly and waste. There is nothing in which the spinner is so liable to be mistaken as in the quantity of waste he makes; and I think a quick speed will produce almost double the quantity in the same time that a moderate speed would.

It is necessary to new band the mule, that spins middle numbers, every six weeks; and when any of the wharfs are worn down too much, they should immediately be replaced by new ones.

Fine spinning requires great heat at all times, and middle numbers need it in winter; and the cheapest and safest way of procuring it is by steam in cast iron pipes. There is a particular advantage in heating by steam, as it is certainly most effectual for extinguishing flame; and every room heated by it should have two large cocks to communicate with the said pipes, that when opened, would fill the room with steam in half a minute; and rods or chains should be fastened to them, and pass through the walls of the building, that any person on the outside might open or shut them in an instant; by which means a building might be saved, if the fire was in every room.

On the subject of water spinning I shall say but little, as the observations I have made on carding, roving, and drawing, are as applicable to water as to mule spinning. The use of the stretching frame is little known in water spinning, as the bobbin and fly are substitutes for it. The rovings cannot be weighed where the bobbin and fly are used, and for list numbers the hanks are all weighed separately; but I consider this a very imperfect way when compared with weighing the rovings. Suppose the number intended to be spun are 30 hanks in the pound; when the hanks are weighed, it is probable there will be 28, 29, 30, 31, and 32, that is, five different numbers. Now it is plain, that number 28 will have too much twist, and number 32 will have too little; but if the rovings had been weighed, and all those of the same number spun together, this inequality in the twist would have been prevented. I think the most improved plan of water spinning is, to have the spindle placed in an inclined direction, the point standing in a line drawn from it to the top side of the under steel roller.

There is another improvement of considerable importance, and that is, a small tin cap, soldered to the top of the fly, about an inch and a half long; and on the top of it a small eye of wire 3-8ths of an inch long, with a round hole in it; the thread is first put through the eye of the fly, without twisting it round the shaft (in the usual way); and from thence it passes through the said eye of the cap. The spinner will piece two ends this way while he can piece one the common way; both much better, and with far less waste. But so long as the speed of the bobbin is regulated by cloth washers, as they are called, there will be no uniformity in the twist; for some parts of it will have too much, and others too little. It would be of importance to water spinning, if an equality in the twist could be obtained; but upon the present principle, I think it is impossible; for, the improper tempering of the bobbin, partly occasioned by the inattention of the spinner, and partly from the imperfection of the principle, will frequently make a difference of from three to four hanks in the pound: there being no means of tempering them, so as to make the drag uniform at all times.

I have taken very little notice of working Bowdens and Orleans cottons as yet, although, in my opinion, they deserve more attention than any other, especially as there is more weight of them used than of all others put together. The machinery for working these cottons should be different from that for working Brazil, Demarara, and Georgia cottons; as their staples are so very short, but particularly that of Bowdens. For working Bowdens, the diameter of the front roller for the drawing frames, should be one inch, and that of the middle and back rollers three quarters each, but all bare measure; and the distance between the centre of the front roller and the centre of the middle roller should be seven-eighths of an inch. The first head should draw one into two, and the last head nearly one into three; and the length of the bosses for the rollers should be nearly four inches.

The diameter of the front roller for the spinning frames, that is, mules or throstles, should be seven-eighths, and the diameter of the middle and back rollers, full five-eighths; the distance from the centre of the front roller to the centre of the middle roller six-eighths, and the distance from the centre of the middle roller to the centre of the back roller six-eighths, and one-sixteenth of an inch. These small rollers will spin Georgia, or any other cotton equally well, if the slides are properly made. Having the rollers too thick is a general error, which probably pervades more than three-fourths of all the cotton machinery in the kingdom.

The carding engines for these cottons are generally from three to four feet broad, made double, and finish with one operation; and the common way of stripping them is twice a day, but six times is little enough; which will occasion much less waste and make stronger and more level twist. Grinding the cards once a week is the general practice, but the breakers should be ground gently every day, and the finishers every other day. Should the carding engine be a double one, grind the breaking part every day, and the finishing part every other day. It may be said, that stripping so often will be attended with loss, by increasing the strips; but this is a mistake, as they may be spun into weft; for the principal object of the spinner should be, to make the quality of twist as good as possible.

It is surprising what good 30 twist is made from Bowdens, though carded in the most improper manner. This twist, like that spun from Orleans, greatly improves by the size, and requires eight ounces less weft for a cut or piece, than any other cotton; it also finishes to great advantage. If this cotton is spun upon the best principle, it will make good 40 twist

But that justice may be done to the working of Bowdens and Orleans, the cards for the breakers should be from 90 to 100, and the finishers from 110 to 120, three and a half inches broad; and the stripping and grinding should be as often as for working the best Bourbon cotton; but I shall speak more fully of this hereafter. Bowdens and Orleans cotton can never be worked to the best advantage, upon double carding engines. They should be worked upon single ones with flats; but one roller may be used to keep the cotton light upon the swift cylinder. Though as great attention should be paid to the carding of these cottons as to Bourbon, yet I am aware it will be next to impossible to convince the generality of the spinners of these cottons of the truth of what I now state. By the working of these cottons upon single carding engines, and finishing them in the best manner, in every operation, six-pence per pound will be added to the value of the twist. It is the interest of every spinner to make the value of his yarn principally to consist in the labour bestowed upon it; and more especially as the raw material is purchased from foreigners; and a great part, when manufactured, sold to the same people.

Good Orleans is useful to mix with other cottons, provided the staples are nearly of equal length; if they are not, they will neither card nor draw well; but when they suit each other, it is surprising how it improves the yarn, by making it stronger and more level It is common now to spin weft from Orleans to 130, 140, or even to 150 hanks in the pound; and when picked clean and well managed, it looks nearly as well as Bourbon weft, and a great deal has been sold as such. But for cleaning Bowdens and Orleans cotton, I do not approve of the beating machine, the staple of these cottons being so very short; and have no doubt but a willey, with fine small teeth, set about four in an inch, and the length not exceeding three-fourths of an inch, would answer much better; but I would have it fed with rollers in the same manner as the beater is, for by them the cotton would be held fast, whilst the teeth combed and cleaned it from dust and motes. The willy should have four wings or ribs, and a row of teeth in each, and should not make more than three hundred revolutions per minute.

Were I to make new machinery, I would have the diameter of the front and middle rollers full one eighth of an inch less than the common size, which would then work the shortest Bourbon or Bowden cotton. If the rollers were made upon this principle, there is no kind of cotton but what they would draw, whatever difference there may be in the length of the staple. The advantage it would give the spinner, in having the rollers and slides made to draw any kind of cotton, is scarcely to be described; for he might with equal ease, spin up on the same wheels two hundred hanks in the pound as forty hanks twist, and spin both upon the best principle. But to do this would require a pair of change wheels, one for the rim, and the other for the top of the inclined shaft.

It is in low numbers that we shall be most opposed upon the continent; for unless some great improvement takes place, it will be years before we shall feel the weight of the French opposition in fine numbers, and as wages are so much lower there than in this country, we must spin our low numbers from cotton inferior in quality to that which they use, or how shall we meet them in the foreign market?

If better twist for low numbers cannot be spun from Orleans and Bowdens than has heretofore been, the sale of low numbers, I think, will soon be lost in the foreign market.

It is surprising, that there should be more weight of yarn spun from these two cottons, than from all others that come into the kingdom, as I have before observed; still more so, that there should have been so little improvement made in the spinning of them, but particularly in Bowdens. I do not wish to wound the feelings of any spinner, but my opinion is, that there are not three spinners in the kingdom, that spin Bowdens upon the best principle. The carding of it is altogether improper, and would spoil almost any cotton; for it is, in general, carded at least one-fourth too thick or heavy, and that too upon double engines, which makes it still worse. The cards are only stript twice in the day, and ground once in the week, but the breakers should be stripped six times in the day, and ground six times in the week.

The common way of carding would greatly injure any kind of cotton, but particularly Bowdens, as it is rather delicate, and I never could conceive why it should be thus treated, unless that its extreme cheapness has made it of no consequence in the estimation of the spinner. I wish I could convince him of his loss, by treating it in this manner; for I am of opinion, there is not a spinner that knows its intrinsic value; now, however, is the time to investigate and improve in the working of it, that we may be able to meet our opponents with advantage.

If the spinner, who has machinery proper for spinning Bowdens (which I am certain few have) could be prevailed upon to card, strip, draw and grind, as I have recommended, he would be astonished at the improvement of the yarn, as it would be much more level, and a great deal stronger. Twist from Bowden cotton takes size very well; and, I believe, the time is not remote, when good 40 twist will, in general, be made from it.

In my observations upon carding, roving, drawing, and spinning, I have endeavoured to explain them in such a manner, as I hope any spinner may understand.

Country spinners have seldom the means of getting information how their business should be conducted in the best manner, and are more exposed to imposition than those in large towns; and these instructions are particularly intended for their use.

The next thing to be considered is, whether the old water frames, or the throstle, is most proper for spinning Bowdens and Orleans. The great thickness of the water frame rollers renders them improper for spinning these cottons, while the lists are liable to stretch and become too slack; whereas, throstles are made with half the expense, work much lighter, and require little power compared with water frames. Bands too are much cheaper, more durable, and make the spindle run with more regularity; for the bad piecings which the spinner makes, when sewing the lists, causes a vibration in the spindle when passing over the wharf or haft. I have lately seen most excellent 80 hanks twist, spun upon a throstle, far superior to any twist of the same numbers, I ever saw spun upon a mule.

Before I enter upon the subject of fine spinning, it may be necessary to inquire, what kind of building and machinery are best calculated for that purpose. The building I would recommend to be sixteen yards within, and any length that may be required. The card room I would have on the ground floor, which would contain two rows of cards, the roving, drawing and skellets, and all other machinery that may be wanted for a card room; and still have much room to spare. I would have no more than four spinning rooms; but think three would be better; for it is difficult to estimate the loss of time, and consequently of expense, in going up and returning down, where a factory is seven or eight stories high; and should a fire take place in the roof, there is little chance of saving it. It is therefore much better to add to the width than to the height. Whether the building is made fire proof rests with the owner, though it would be much better if it was so; but certainly the Manchester plan of making a factory fire proof is capable of much improvement.

A building of the above width would contain two mules, each having 192 spindles; and admit of a passage up the middle four feet wide. I calculate upon sixteen rollers for each wheel, the length of them five inches, and the whole length of the machine twenty-two feet; twice this is forty-four, and a four feet passage makes in all forty-eight feet, as first proposed. The wheels I would recommend to work right and left, with the runs to the windows, which would preserve them, and prevent the piecers wasting their time in looking out.

That there might be no deficiency of light, the sashes should be four feet six wide, and six feet six inches high; and only one principal shaft pass through the middle of the room. Perhaps it will be said, that by placing the wheels in this direction, I am greatly increasing the length of the strap; so much the better, as it will last three times as long, and require much less power than a short tight one would.

And for working throstles, I conceive it much the best to have the passage through the middle of the room, and all the water pullies close to the windows, which certainly is by much the safest plan, as there will be neither straps nor pullies to incommode the passage. And it is lamentable to reflect, how many persons have lost their lives, by being entangled with straps, pullies, and gear work; which this mode of working is calculated to prevent. Perhaps it will be objected, that wheels of this size will be more expensive to work than those of three hundred spindles; but this I think will be found a mistake, as one piecer will be sufficient for a pair of small wheels, but two must be had for large ones; and if his wages are taken at 9s per week, and suppose the spinner to spin 120 hanks twist on large wheels, and forty pound per week, (but it is probable he will not spin so much) here is $2\frac{3}{4}$d per pound saved in the piecer's wages; and I think the twist spun by the small wheels will be more than that sum better.

One principal thing that has been the cause of these large wheels being made, is the recommendation they have received from the machine maker; because they are much more profitable to him than small wheels; add to this, the foolish idea the master spinner has entertained, of producing a greater weight of twist from them, at much less expense than from small wheels; but this is the mere delusion of fancy.

It is not in the power of man to make as good twist upon large wheels as small ones; this is so self evident, that it would be a waste of time to enter upon an explanation of it; and the advantage small wheels have over large ones in copping, is scarcely to be described. It is a mistaken idea, that a greater quantity of twist will be spun upon large than upon small wheels, supposing an equal number of square yards, as will appear from the following calculations:—

Suppose a room, thirty-six yards long and thirteen wide, will contain four hundred and sixty-eight square yards, and will hold twelve wheels each, consisting of 300 spindles, equal to 3600 spindles. A room of thirty yards long and sixteen wide, will contain four hundred and eighty square yards; and will hold twenty mules, having each 192 spindles, and making in the whole 3840 spindles. Here then we see four hundred and sixty-eight square yards are required for 3600 spindles with large wheels; and four hundred and eighty square yards for 3840 spindles with small wheels.

It must be admitted, that wheels, containing 300 spindles, are unfit for any but men to work them; and the spinner will be more fatigued with working them twelve hours, than he who works the lesser wheels will be by working them fourteen hours; moreover, the small wheels may be worked by girls of from sixteen to seventeen years of age, or by boys of fifteen, an advantage of no small importance to the master spinner.

From this statement I think it is clear, that a greater number of spindles, with small wheels, may be worked in a given number of yards, than with large ones; and it must be admitted, that small wheels are worked with much more ease and convenience, are far more durable, attended with much less wear and tear, and make much better yarn, especially cop twist.

I have entered more fully into this investigation, from a conviction, that the plan I recommend will be, by some, opposed, as it goes, in a great measure, to overthrow the system on which cotton factories are built in Manchester; and fortunate would it have been for the spinner, if this plan had been adopted twenty years ago; for the length and height in general are far too great.

I have estimated upon thirty yards in length for ten pair of wheels, as before stated, and all the four spinning rooms may be worked by one upright shaft, and two principal lying shafts; and if only the two last mentioned shafts are used, I think, it would be better to make the building ninety-one feet six inches long, and add nine inches in breadth to each corner head, which would allow room so to place the wheels, that the straps for those in the lower room would never come in contact with those in the upper;

but if the owner should prefer a small beaten iron shaft for each room, one of eighty feet in length, will be sufficient for the said wheels. The diameter of the drums, for the spinning room, I would not have more than eighteen inches; and the engine, or water wheel, should stand at one end of the building, and the door at the other.

How simple, safe, and useful would a mule factory be, if built upon this principle, and filled with small wheels; and how unlike cotton factories in general? What strange confusion of shafts, drums, and straps, present themselves upon entering many of these factories; which make it difficult for a stranger to pass through them with safety. And there is an insufferable nuisance connected with nearly all the factories, by making the conveniency a part of the building; whereas, it should be seperate from it three to four feet, to admit of a free circulation of air, which would carry off all the disagreeable smell.

Having considered what number of spindles each mule or wheel ought to contain, I shall now inquire into the best mode of working them. Different opinions are entertained, whether it is better to work the spindles with drums, as they are called; or with tin rollers the length of the machine. Working with drums makes a great inequality in the twisting of the yarn, as there is no means of keeping the diameter of the wharfs of equal size; for those next to the spindle board wear nearly twice as fast as those more remote from it. When the wharfs are worn down and renewed, there will still be an inequality in the size; for when put on, if they are not larger than those next to the bolster, they will soon become too little, and want renewing again.

Another inconvenience that attends the working with drums is, that the toes of those spindles, where the wharfs are the farthest from the spindle board, will scarcely be affected, while those that are the nearest to it will almost be worn away. When the toe of a spindle is much worn, it will affect the thread, which will not run so freely, nor so steadily as it ought to do, and the yarn will of course have too much twist. Moreover, where a wharf wears too quickly, it is sure to get out of the round, to cause the spindle to work irregular, and wear off the toe much quicker.

Upon the whole, it appears to me impossible to have an equality of twist given to the yarn from drums; and there are many more inconveniences attending them than I have time to enumerate. The principal objection to tin rollers, is their great length, which increases the difficulty of making them true, and subjects them to vibration; but these supposed imperfections vanish when impartially examined. I would have the axle of the roller as long as the carriage, and a neck turned in the middle an inch long; or coupled like a steel roller, which would require the sacrifice of only one spindle. If the roller is properly executed with an axle, as before described, it may be made true, firm, and free from vibration, even without neck in the middle.

By working with a roller, every wharf and spindle toe have an equal pressure; consequently the wear of them must be uniform; and will give an uniform twist to the yarn, which, upon the principle of drums, I think it is impossible to obtain.

For spinning 40 to 60 twist, I would have the wharfs rather thicker than they usually are, and the groove in the same proportion; the bands might be made rather stronger, but should all be made single, that is, only one length of band at once; with a noose at one end, while the other end will only require to pass through it; and a knot tied on the end to prevent it slipping back; and whenever it is too slack, the knot must be untied and removed a little back.

This is the way that some work their throstles, and I think it by much the best, as those bands frequently work from nine to twelve months.

I have already given my opinion upon the utility of small carding engines. The cards for the breakers, for working fine Georgia and Bourbon cottons, should be one hundred, and those for the finishers one hundred and twenty, and three and a half inches broad; made of fine hard elastic wire. The drums for the breakers should be twenty-eight inches diameter, the length of the lap seven feet, the weight, for 120 hanks twist in the pound, three and a half ounces; but for weft of the same numbers, a four ounce lap may be used. These cards should be oftener stript than those used for Brazil and Demarara cottons.

And if the spinner intends to make twist of the first quality, he should have the cotton for the breakers weighed with the greatest exactness; and spread even, the same length that the lap is intended to be, and afterwards, the laps should be weighed with great care; the piecing of which requires great attention, otherwise the carding will be uneven, and make the twist uneven also.

Those who have the care of drawing frames, should pay great attention and not let single ends run up; as this is ruinous to the yarn; and should be equally careful to make good piecings, and often clean their brushes and clearing cloths; otherwise waste will run up with the ends.

Suppose the spinner intends to spin 140 hanks twist, he should have his laps about three ounces, and not less than six heads of drawing, and three skellets with three rollers for each head, and the bosses four inches long, as I have before observed; and pass four ends through every head; but two only at the skellets. The first head of drawing should draw full one into three, and the last head one into nearly four and a half, but the skellets must not draw it at all.

The spindles I would recommend to be fourteen inches long, and stand five inches and three quarters above the bolster; and if good twist is expected, the cops must be made small, but above all things, let the carriage come out slow; and put as little twist as possible in the roving part, and as much as can be got in at the head, as I have before recommended for the spinning of Brazil cotton.

But it sometimes happens, that the master spinner has good machinery, while neither he nor his carder knows how to use it; and as I have suffered much from the ignorance and negligence of carders, I shall now give instructions to enable the master to know when his cotton is rightly carded and drawn; and also when it is over carded or left short.

The cotton should lie so light upon the great cylinder, as that it may be stroked off with the hand; and a small roller running at the front of it (as I have before recommended) will greatly assist in keeping it light.

To know when the cotton is too much or too little carded, take half a yard of the carding from the finisher, and shake it well, but gently, with the hand; and if it is properly carded, it will stretch out to a yard in length before it will break; then examine it carefully before the light, to see if the fibres are all in a straight longitudinal direction, and how much the ends of them lap over each other; which should be nearly half the length of the staple; there are some who calculate exactly upon one half.

Instructions how to examine the roving and drawing.

Break off two feet in length, and hold it before the light, (but not in the sun shine) to see whether it be clouded or not; and also whether it be drawn too much or too little. Should it be drawn too much it will be cloudy, and the ends of the fibres will scarcely lap over each other; if under drawn it will be cloudy, and the fibres will lap over each other nearly the whole length of the staple; the same experiment will shew whether it is too much or too little drawn. Should the thread, when spun, have any little round hard lumps upon it, or if, when stripped well between the fingers these should be raised upon it, the thread will break in some of those places; which is a proof that the cotton is either too much or too little carded. If the cotton is properly carded and drawn, the thread will be made stronger by being stripped between the fingers.

Instructions for placing the rollers, for roving, drawing, stretching, and spinning; and what should be the diameter and distance of the rollers from each other.

The diameter of the front roller for the drawing frames should be - - - - - - - - - - $1\frac{1}{4}$ inch,

The distance from its centre to the centre of the middle roller, - - - - - - - - - - - - - - $1\frac{1}{4}$ $\frac{1}{16}$ in.

The diameter of the middle roller, - - - 1 inch.

The distance from its centre to the centre of the back roller, - - - - - - - - - - - - $1\frac{3}{8}$ inch.

Stretching Frame Rollers.

Diameter of the front roller, - - - - - - $1\frac{3}{8}$ inch.

Distance from its centre to the centre of the middle roller, - - - - - - - - - - - - $1\frac{1}{4}$ inch.

Diameter of the middle roller, - - - - - - $\frac{7}{8}$ of an in.

Distance from its centre to the centre of the back roller, - - - - - - - - - - - - - $1\frac{3}{8}$ inch,

Diameter of the back roller, - - - - - - $\frac{7}{8}$ of an in.

The front roller should make four revolutions for the middle roller one ; and the middle roller gain upon the back roller one in seven, and draw one foot into four and a half feet ; the back roller pinion should contain thirty teeth, and that on the middle, twenty-six teeth. From a change of cotton, the rollers may want removing one-sixteenth of an inch closer or wider according to the staple of the cotton ; there is no necessity to alter the steel rollers, for it may be more conveniently done by shifting the leather rollers ; but their centres must stand over those of the steel rollers.

The Spinning Frame, or Mule Rollers.

The diameter of the front roller must be - 1 inch,

The distance from its centre to the centre of the middle roller, - - - - - - - - - - - $\frac{7}{8}$ $\frac{1}{16}$ inch,

The diameter of the middle roller - - - $\frac{3}{4}$ inch,

The distance from its centre to the centre of the back roller, - - - - - - - - - - - - - $1\frac{1}{16}$ inch,

The diameter of the back roller, - - - - $\frac{3}{4}$ inch, Its pinion should contain thirty teeth; that for the middle roller, twenty-six; the same as I have before recommended for working Brazil cotton.

If the cotton is carded until it is perfectly clear, and doubled, and drawn till the fibres lie longitudinally straight, and lap about half the length of the staple over each other; being free also from clouds, when it leaves the last frame or head, before it goes to the winding block, it will have arrived at its highest state of perfection; and more doubling and drawing would rather injure than improve it.

But to view the rove or coil properly, it should be gently untwisted with the finger, and great care taken that it is not strained; and a small magnifying glass would greatly assist the eye in forming a judgment.

Suppose there are six heads of drawing, (and less there should not be,) for fine yarn, and three at the skellets; and four ends run up at every head of drawing, when the ends or rove have all passed the heads, they will have been doubled four thousand and ninety-six times; and if two ends are run up at the skellets it will have been doubled eight thousand, one hundred and ninety-two; and from the skellets it should go in loose cans to another set of drawing frames, which should contain twenty-four heads, and be there doubled, and one inch drawn into four and a half inches; it will then have been doubled sixteen thousand three hundred and eighty-four times; afterwards two ends should be wound together, by which it will be doubled again, making in all, thirty-two thousand seven hundred and sixty-eight times; it should then be stretched two ends together.

It may appear strange to those who are not versed in calculation why twenty-four heads of drawing should be required to double the produce of only three heads of skellets. These three skellets give six ends, roves, or ribbons, and four times this makes twenty-four: the number of drawing heads required. The roving or ribbon must not be drawn at all, at the skellets, but, at the drawing frames; and it should be drawn one inch into full four and a half, as before observed.

Here then, it is plain, that four heads of drawing will be necessary for one rove or ribbon, and the frames will have to run one eighth part quicker than the skellets, owing to one inch being drawn into four and a half; but if it was only drawn one into four, equal speeds would serve. It requires great care to wind two ends together, so that neither be strained, nor any part left single; the doing of this should be committed to a steady girl, nearly upgrown.

Where fine twist is to be spun upon the best principle, the card room should be exceedingly capacious, that the master carder may have all the machinery, requisite for the card room, under his eye. The rove or ribbon should be drawn the same at the twenty-four heads, as at the stretching frame. It is probable that some, who are not experienced in spinning fine cotton twist, may question the truth of what I am going to state.

I will suppose a given quantity of cotton to be spun into twist of 120 hanks in the pound, which shall be drawn by six heads, and three skellets; and doubled eight thousand one hundred and ninety-two times, as before stated.

I will now suppose an equal quantity of the same cotton, to be treated exactly as the other, till it has passed the skellets; but, that afterwards, it shall go through the said twenty-four heads, and be doubled, drawn, wound, and stretched, as before directed; then let the value of these two yarns be ascertained, by some intelligent fine muslin maker; and I dare venture to assert that he will make a difference in the value of them, of from one shilling, to one shilling and six-pence in the pound; for when twist is worth from twelve to fourteen shillings in the pound, a shilling is a trifling object to a fine manufacturer, to have twist of the first quality. Some fine spinners draw their rovings or ribbon at twice; the first time it is drawn rather thick, with the least possible twist; but the second time it is drawn very small, and spun two ends together; yet I think this a very imperfect way, when compared with drawing it small enough with the frames.

There is risk in every operation with the stretching frame, from having the rove strained in backing off; and moreover, the rove will be smaller at the bottom than at the top, in the same manner as the cops are; and if the rove should, and sometimes it will, fly off at the spindle point, that part will have too much twist, and make the yarn uneven. It would much assist in making level twist, if it could be drawn small enough at the frames to require no other operation before it went to the spinner; but this I think cannot be accomplished.

There is another kind of carding engine, which I have not yet noticed, that some of the large cotton spinners in Lancashire make use of; but they only spin from 40 to 50 twist, it being all together unfit for fine numbers. The feeding part consists of two rollers, from three to three and a half inches thick; having iron axles covered with wood, and with cards or fillets. They run very slow to give the cotton as much work as possible; and above these rollers is another small roller, generally called the licker in, which takes the cotton from the feeding rollers, and gives it to the swift cylinder. Above this roller some have two, others three rollers, of from four to five inches diameter, which work against the swift cylinder; and afterwards the remainder of the cylinder is covered with flats. The doffing cylinder runs very slow to give the cotton the greatest possible quantity of work; as it is finished at one operation.

As there is no weighing of laps, there is a feeding cloth and table to lay them upon, from ten to twelve feet long; and the cloth is divided by black lines across, or otherwise, as fancy may direct, into three or four equal parts, every part containing an equal quantity of cotton. If the feeding cloth is twelve feet long, I should suppose it would be divided into four equal parts, and every part contain nearly three ounces of cotton; and by the time the cloth is empty there is another cloth spread over, and rolled up ready for use. There is one advantage which these rollers have, and that is, if the cylinder should not be stripped in due time, the thickness of the cotton will not be so soon increased; nor will they cause the cotton to knap so soon, when the stripping is neglected, as flats would.

But there are many objections against working cotton upon this principle, which far over balance any trifling advantage that can be derived from a carding engine, working too long before the cotton is injured. It is not possible for the carding to be so even in thickness, as where there are breakers and finishers; for even with these, and the utmost care in weighing the laps, it is extremely difficult to keep the carding of an even thickness; and if there is any inequality in it, nothing afterwards can correct it. Besides, when delicate cottons are worked at one operation, it is more than the fibres are able to bear without making them more tender; for breakers and finishers are necessary to preserve such cotton sound; and there are other cottons that cannot be worked sufficiently by one operation. Although there are many large spinners, who spin low numbers of twist from this kind of carding, yet not one of them, that I know of, spins a first rate article; for they are greatly inferior to many of their neighbours, who spin the same numbers from cotton of less value, and yet make much better twist. Suppose a spinner wanted to work Bowdens, or Orleans, upon the best principle, he could never attain it by this mode of carding.

There is another kind of carding engine, that has nothing but rollers of a considerable size, with which Bowdens, Orleans, and West India cottons are worked; and dreadful havock they make with them. These carding machines are called urchins by the workmen; the cotton standing upon the rollers much like the hair upon the back of that animal. But when every mode of carding has been tried, none is found to answer like the small box engine, eighteen inches broad; but especially for delicate cotton. One general evil, however, pervades both spinning and manufacturing cotton goods, that is, spinning and making too much in a given time, which will not admit of the work being done in the best manner. Much more money might have been got, in the last five years, if one third less business had been done; provided it had been done well.

Suppose it was intended to introduce machinery for spinning cotton, yarn, worsted, and flax, upon an extensive scale, into a country not very conversant with the use of it. The first step, in order to accomplish so important an object, would be to procure an intelligent person, who, with a practical knowledge of spinning, was well acquainted with the use and construction of machinery upon the best principle. This man's advice and assistance, would be useful in the erection of the buildings required, as well as the furnishing them with proper machinery. From the variety of objects which call for his attention, we will name him the inspector general, and appoint subordinate assistants to act under his direction. It will be his business to select a number of young men of ability, who, having been instructed in the art of spinning, and the use of machinery, might be distributed in the different factories.

To keep the inspector to his duty, and to excite the emulation of these young men, I would recommend the appointment of a committee, from among the master spinners, who should occasionally attend the examinations of the pupils by the inspector, and distribute medals to such of them as should distinguish themselves, by superior improvement and general good conduct. I would also recommend prizes of greater value, and bearing a proportion to the utility of the invention for every new discovery, in the construction or use of machinery.

In addition to the young men already mentioned, I would select double their number of ingenious boys, from 12 to 14 years of age, two or three of whom should be placed in each card-room; and every carder under whose government they are placed, rewarded with a medal, if meritted by their improvement.

Perhaps it might be worthy the attention of government to excite the greatest degree of emulation, by granting an exemption from personal services, or even from taxation for life, to such carder, as should qualify a given number of such boys, to conduct a card room within a given time.

These boys should go into the spinning room, at least, two hours every day, to be instructed in the art of spinning; and in a few years, they would be competent to conduct a cotton factory. And for the better instruction of these pupils, a mechanical school should be erected, where all newly invented machines should be examined, and tried upon the same scale as intended for use; for, trying mechanical powers by a small model, will be more apt to mislead than to instruct. This school, and all the expence attending it, should be paid by government; at least, for six or seven years.

Some men, no doubt, will object to this plan, and say, that government should never interfere with trade, any more than with religion; but this is an erroneous opinion; for, have not our government rescued our trade from inevitable ruin, during the awful struggle we have sustained, by lending the merchants eight or ten millions sterling at a time, and this repeatedly. The whole expense of such an institution, would be nothing, compared with that of a single regiment of horse.

These pupils, inspectors, and committees, would so much improve and extend the use of machinery, and the trade dependent upon it, that in a short time, millions sterling would be added to the national stock of wealth. And it is natural to suppose that such committees would spare no expense in procuring first rate mechanics and engineers from the neighbouring nations, where-ever they were to be found.

If these committees acted liberally, they would greatly promote the spread and knowledge of cotton spinning, and the use of machinery, by conversing together, and freely reporting what improvements they had made in their works, instead of pursuing the selfish plan that is too generally adopted by persons of this description. Were any of the governments in Europe, thus to unite in establishing the use of machinery, it is not possible to conceive what might be effected by it; as its influence would instantly be communicated to the neighbouring states, like an electrical spark; and the happy consequences soon spread over the whole civilised world.

Want of capital, of credit, and even of machinery, would soon vanish before such united efforts, like darkness before the rising sun.

But the frequent, and almost unavoidable misfortunes which happen in factories, discourage many parents from sending their children to be employed in them, and loudly call for the establishment of public funds, for the relief and support of the unfortunate sufferers, to which all masters of factories should subscribe liberally; and every one employed, should contribute a small sum in proportion to his earnings, to be paid when his wages were received. This subscription should not be solely applied to the support of those that were maimed, but of any that might for a short time be indisposed, and unable to work.

On this plan, every cotton factory would be converted into a sick club, and support its own members; which would remove that odious charge brought against them, that they are good for nothing, but to people the poorhouse.

And to give facility to the improvement and extension of machinery, government should subscribe liberally and assist in establishing funds for this purpose. It is meritorious to provide for the wounded soldier, who has bled in his country's defence; and would it not be equally so, to provide for the industrious and ingenious mechanic, by whose talents, commerce has been improved, trade extended, and national wealth increased.

The feeling mind revolts at the idea of an useful and industrious, but unfortunate mechanic, who has spent the prime of his life, in the improvement of the various arts of his country, being rendered unable to provide for himself, or his family, and having no asylum, but the poorhouse. Surely it is reasonable, that these men should be made as independent, as the defenders of their country; and were this the case, commerce, spinning, and manufactories, would soon become, not only the support of the revenue, but the pride and glory of the state. It would then be considered no more a disgrace to educate a son in a factory, than a young gentleman in the college, for the army, or navy.

And for the better instruction of youth in such factories, a sunday school should be erected, at or near them. What a pleasing picture would a commercial county present, if factories were conducted upon such a plan; and how effectually would it silence those unfounded charges, which land-owners have brought against them, of being burthensome to the parish.

I have before recommended a liberal conduct to the spinners in communicating one with another; and what I am going to relate, will shew the sad effects that may be produced for want of it.

In the spring of 1810, trade became brisk, and the Manchester spinners demanded a most unreasonable advance in wages; and turned out, as it is called, on that account. When some arrangements were made with them, and part of them were got to work again; it is said (and I believe with truth) that the master spinners, in Manchester, encouraged the labouring country spinners, for from ten to twelve miles round the town, to insist upon the same wages as were given in Manchester; alleging, that otherwise they could not meet them upon equal terms in the market.

This assertion was incorrect and unjust; for if the country spinners must give the same wages as those in Manchester, how are they to pay for carriage, postage, travelling expenses, and various other things? besides, the country spinners had an advantage over those of Manchester, of from 3s to 4s per week in the wages of their piecers; but all this availed nothing, the Manchester prices they would have; and accordingly turned out for them. In consequence of which, from sixty to seventy factories were instantly shut up; the greatest part of which remained shut up from six to eight months.

If the labouring country spinners could have gained their end, as soon as they were got to work, the Manchester spinners were to turn out for a further advance of wages; and those of the country in their turn were to support them. Those that were out of employment, received from 12, 15, 18, to 24s per week, from the Manchester spinners, and those in Scotland.

On September following, an awful change took place in trade for the worse, and wages sunk prodigiously; the master spinners in Manchester were the first to lower wages.

The club, which the spinners had formed on this occasion, was immediately dissolved; and all the stamped parchments by which they were bound, were committed to the flames. The money paid by the working spinners, in this short period, was upwards of £18,000, according to information which I received from one of the committee, who had been employed in disbursing the money.

The loss to the owners of the factories that were shut up, on a moderate estimate, could not be less than £80,000, and the loss in wages to the spinners out of employment, would exceed £50,000; which added to £18,000 paid, made a loss of £148,000 Now all this loss, the rioting and drunkenness, the poverty and distress that followed, would, in all probability, have been prevented, if an amicable meeting of the town and country spinners had, at that time, taken place. For, if the master spinners had refused to advance the wages, the spinners must, in a short time, have complied, as they could not have got employment elsewhere; and if the master spinners had agreed upon an advance, they must have accepted it, though much less than their demand.

If the masters in any trade, would occasionally meet, and preserve a good understanding among themselves, it would more effectually crush these combinations among their workmen, which are alike injurious to both sides, than a thousand acts of parliament.

A most mischievous combination took place in Yorkshire, a few years ago, among the shearmen or croppers, which spent from £8000 to £9000, in opposing the merchants and manufacturers in getting an act to repeal a number of old acts of parliament, which prohibited the use of gig mills, or any other machine for raising or shearing cloth. At length the merchants obtained an act for working the said machinery; and when a considerable quantity of shearing frames were set to work, the shearmen went in the night, and broke all they could meet with.

It was at this time that Mr. Horsfall, a respectable merchant, who had many of these machines at work, was shot, on his return from market, near Huddersfield; and the three murderers, and fourteen shearmen, fell a sacrifice to the injured laws of the country. Such are the dreadful effects of combinations!

I will now suppose cotton spinning intended to be established in a country where the people are entire strangers to it, but where provisions and labour are exceedingly cheap. The first and most important question would be, what kind of machinery would best suit such a people; and by what power should it be worked? My opinion is, that the most simple, the least expensive, and most useful, would be that which is worked by the hand; except, that in some instances, the carding might be performed by a horse. This is the way it first began in this country, and continued for some years; but when the demand for goods increased, the power of water, and afterwards that of steam were applied.

A stout man would work a carding engine, eighteen inches broad and two feet in diameter; which would work equally as well as if three feet in diameter; the doffing cylinder might be made in the same proportion. If light spinning wheels were made to contain from 70 to 80 spindles each, a man would work one of them at a moderate speed; there being a thousand instances in the kingdom, where jenny spinners and twisters of cotton yarn for warps work more spindles than these.

A horse would find employment for four spinners, and a room, six yards square, would be sufficient for the card room; another room, containing 60 yards, would be sufficient for the wheels. Here would be a factory large enough to employ a moderate family, and three or four additional hands; and how much better would it be for the children, to be employed under their parents than in a large factory, as they would be in no danger of contracting bad habits; and at how much less expense would they be maintained by eating with the family, than having their provisions carried to a factory.

The simplicity of cotton spinning, upon such a plan as this, would be much the same as that of the woollen manufactory before machinery was introduced; when the labouring class had ten times the happiness, in the pursuit of their business, they have ever enjoyed since; and moreover, the daughter, by this plan, would have an opportunity of receiving, from her mother, the education necessary to prepare her for being a wife, a mother, and a nurse.

The capital required for an individual to begin the spinning of cotton, would be trifling, compared with what is necessary for the present system upon the smallest scale; and it is much better to have capital divided, than to have so much wealth in the hands of an individual.

It probably will be said, that if cotton spinning was conducted upon this principle, goods would be made so dear, that they would have no chance in the European market; but this is a wrong conclusion, for are not all the cotton goods, manufactured in the East Indies, spun in single threads; and yet, there is no power in Europe that can make goods any thing nearly so cheap, as the reader may see, by attending to what the East India Company did in 1787.

Perhaps it will be said, that individual families cannot manufacture goods so well as they are made in large factories; but experience proves the contrary, for small manufacturers frequently make the finest goods, of every description. And there is little doubt, but there were finer goods manufactured in the East two thousand years ago, than were ever made in Europe, or probably ever will be.

If we turn our eyes to Russia, we shall find that all her cloths are spun by the finger in single threads; and though many of our flax spinners have attempted to drive them from our markets, they have all given up the contest, and declare it to be impossible.

Now if these two mighty empires can supply their own wants and those of their neighbours, among whom spinning by machinery is arrived at a high state of perfection, where the power of steam may be had to any extent; and who, with all these advantages, are not able to contend with the single thread spinner; what would be their situation if hand machinery were established in those two great empires, where any man, with a trifling capital, might convert his little cot into a spinning factory.

When I first determined to write a treatise upon cotton spinning, my intention was to make it very short, but the subject has swelled in my hands far beyond what I intended; and to keep it within moderate bounds, I have suppressed a considerable portion, lest I should trespass too much upon the patience of my readers.

In treating upon the nature and use of cotton spinning, a man can never want materials; for the subject is so copious and diversified, that he will find it more difficult to restrain his pen than employ it. And it must be admitted, that the subject is very amusing to the mind, and of unspeakable advantage to society. But I must beg leave to digress.

If a stranger, unacquainted with machinery, was shewn through some of our large spinning and weaving factories, with all their multiplied and complicated movements, the beauty, regularity, and exactness of all their motions, and the vast number of people employed; and was informed of the immense capital required to erect and conduct them, he would be filled with surprize, and conclude, that the effects produced by spinning and manufacturing, must far exceed any thing of the kind ever seen or heard of in the world before. But how much more would the surprize of this stranger be excited, if, when he left these factories, he could step into an eastern cottage, and see a simple maid at work, with her wheel, spindle, distaff, and fly, producing effects, which, for beauty, elegance, richness of colour, and fineness of texture, as far exceed any thing we can boast of, as the grandeur of the starry heavens exceeds the humble furniture of a shepherd's hut.

And would not his surprize be still much more increased, when he was informed, that the goods manufactured by this simple machine, embellished and decorated Solomon's palaces, and have remained (as far as we know) unrivalled for nearly three thousand years; and that through all the revolutions of time, neither the sap of years, nor the hands of violence, have in the least diminished their excellencies, which still remain unimpaired. The utility of this machine, and that of the potter's wheel, equally simple, though not quite so useful, are doubtless the most ancient machinery in the world, and have been a thousand times more beneficial to society than all Newton's science, and the more refined philosophy of the day.

But to return. After I had explained the nature of carding, roving, drawing and spinning, I had intended to have investigated the machinery employed in it, shewn the many imperfections with which it abounds, and given instructions how every movement should be made, and the diameter and number of teeth each wheel should contain, but this would have led to a more extensive investigation than at present I am prepared to undertake; I hope, however, shortly, to have it in my power to enter upon that subject.

At the same time, I could wish to give some information respecting the make and speed of water wheels, and the application of water upon them, which at present is not well understood. For the last twenty years, gentlemen have gone through the nation, giving lectures upon the application of water, and also upon mechanics, philosophy, astronomy, &c. who have exhibited small models of water wheels and steam engines, by which they have pretended to shew the best mode of applying the powers of those two great agents of nature. By these paltry models and the representations given of them, the public have been greatly misled; and large sums of money been expended to no purpose in making water wheels after such imperfect models.

I know of a number of good water wheels, judiciously constructed, well speeded, and the water systemically applied, that some of these ingenious gentlemen have persuaded their owners were unfit for use, because, in their opinion, they moved too quick, and consumed too much water; which they were prevailed upon to reject, and make others according to their models.

One of my friends was sometime ago induced to take out one of his best water wheels, (which worked his scribbling machinery) in expectation of having it replaced by another, upon a much better principle, which, unfortunately for him, possessed so little power as to compel him to reject it, and immediately to substitute a wheel, similar to that which had been taken out. This expense, my friend told me, amounted to upwards of four hundred pounds, and added, I have paid dear for my mechanical knowledge, but it will serve me for life, and I hope, the rest of my family. Another of my friends had one of these extraordinary wheels, which was to do every thing, but work miracles; when he had tried it not more than two days, such was his vexation and disappointment, that he instantly ordered it to be taken in pieces; this wheel cost nearly four hundred pounds. A third person had two water wheels made upon this improper plan, in a very little time; but they were unmade in much less.

These are the sad effects of representing mechanical power by small models; for, as I have before observed, there is no judging of the merit of any design unless the model is as large as the machine it represents is intended to be.

It may be asked, what need is there for introducing machinery into a country, that can manufacture goods, spun in single threads, cheaper than we can, with all our multiplied machinery. There is the same reason for the people in Russia and the East Indies having machinery to supply their wants, cheaper than they do now, as there was for us to apply it nearly fifty years ago, when wages, provisions, and the raw material were scarcely one third the price they are now. It should be the first consideration of every government to supply the wants of the subject in the cheapest possible manner, and the surplus, if any, may be sold or bartered, as may be most convenient.

As the East India trade is now thrown open, it is for the interest of that people to bring their goods into the European market, as cheap as they can; and no doubt, with good hand machinery, they may make them fifty per cent cheap- than they now do; but I am far from thinking that the quality of them will be improved by it. And notwithstanding Russia can make her cloths, spun in single threads, much cheaper than we can, yet, with the use of good hand machinery, she may make them from fifty to sixty per cent cheaper than she is making them at present. All countries that are strangers to the use of machinery, ought to begin with hand machinery, and afterwards, may apply the power of water; but it would be for the benefit of the subject, if government restrained them from building large factories, as small ones, on all accounts, are much more eligible.

Suppose a country, almost destitute of waterfalls, powerful mills may, notwithstanding, be erected upon a great number of rivers where there are no apparent falls, and a great deal of corn is ground upon many of them. These would work small factories very well.

I have before remarked, that machinery will soon become general, in all the civilized world, and the sooner the better; and recent events shew that an enlightened people, unacquainted with the use of it, will much sooner make themselves master of it, than bigots are apt to think, or willing to allow;—witness America. The cotton spinners here would never allow that the people in America were fit for any thing but the plough tail, not having either ability or inclination to become cotton spinners and manufacturers; it being their province to cultivate the ground, and ours to clothe them. But whoever will carefully read the late resolutions of the cotton spinners and manufacturers of Manchester, which have been presented to parliament, upon the state of the cotton trade, must admit that the people in America are neither wanting in ability, inclination, nor application; otherwise, how could they, in so short a time, have erected buildings, and set to work one hundred thousand cotton spindles; and if they could do all this, when involved in a most ruinous war, what will they not do in time of peace; and their improvements in the manufacturing of woollen goods are not inferior to those in cottons. It has been a great misfortune to this country that our spinners and manufacturers would not allow any people to be capable of meeting them in the foreign market, till now, when they find themselves nearly driven out of it.

America is now, and has been for some time, supplying Russia with low numbers of cotton twist, thirty per cent cheaper than we can serve them; this is stated by a Russian merchant, just arrived from that country; and if they can do this now, they will probably, three or four years hence, spin any numbers, as well as we can. The spinners in Lancashire have assigned another reason why spinning and manufacturing cannot thrive there, and that is, the high wages that are given for cultivating the ground, so that hands cannot be had; and yet, with these high wages, we find them selling cotton yarn much lower than we can, in a market that is more remote from them than from us; and is not this a proof how little we have known what has been doing in America, and will it not equally apply to France? Could any thinking man believe, that America would continue an idle spectator, and see the produce of her soil, sent three thousand miles, to be manufactured in a foreign country, and then conveyed back again to them; but more especially, as a number of her merchants have long resided in this country, and were seeing and hearing all that was said and done, in both the cotton and woollen business?

OBSERVATIONS

ON

CANALS, RESERVOIRS,

&c.

It is generally allowed by those who are conversant in canals, that there have been nearly thirty millions sterling expended upon those that have been projected within the last twenty-five years. After such an immense expenditure, and the sacrifice of so much land in making them, the public had a right to expect, that commerce and agriculture should have been served in the best manner; but the fact is the contrary; for at the time when the assistance of canals is most wanted, many of them are little better than so many dry ditches. While the same want of water has compelled the proprietors of others, after the expenditure of immense sums, to convert them into railways; and yet the most popular canal engineers in the kingdom, after having surveyed and resurveyed them, have assured the committee, that they might be amply supplied with water.

In the following pages, I shall investigate the cause, or causes, of the public disappointment and private loss arising from this source.

If the average of profit and loss, of all the canals that have been projected and executed within the last twenty-five years, were accurately taken, I am inclined to believe, that the balance would be found greatly against them; a truth that is readily admitted by some of the engineers themselves, but qualified with the observation, that, if the subscribers are losers, the public are great gainers, and therefore no one has a right to complain. This argument, though popular, is, in my opinion, fallacious, and proves how partially they have examined the subject.

Suppose one hundred subscribers to a canal should lose more in the interest of their money sunk, than any saving which the public derives from carrying upon it, such canal is, in the strictest sense of the word, a public loss, because the subscribers are a part of the body politic, and if one part of it loses more, in any speculation, than the remaining part gains, such scheme, is a public loss.

There are many canals, however, of great public utility, and very profitable to the subscribers, and wherever there is a prospect that this will be the case, such lines of canal ought to be encouraged, but not otherwise; for when the subscriber is a loser, the land-owner will frequently be so too.

To know the real cause why canals are so much in want of water in summer, is of the utmost importance, and the question, how it comes to pass, that the estimates, in general, have scarcely been sufficient to finish half the works, calls for the strictest examination; in order that these great evils may hereafter be avoided, and canal committees not be so much imposed upon, by false reports and estimates, as they have been.

It would therefore be of unspeakable advantage, if the committee, when they enter upon their office, were better informed than they usually are, as to the execution of the works, and particularly as to the designing, placing, and executing of the locks; upon which depends the future prosperity of the undertaking, and where a general error cannot be corrected. They should also be furnished with a perfect model of every part of the works before they are begun, by which means they would be able to detect any errors which the engineer or the overlookers may commit, and have them corrected in time.

To accomplish so desirable an end, and to furnish to the committees such a portion of knowledge, when they enter upon the undertaking, as will enable them to conduct the works with ease to themselves, and advantage to the subscribers and the public, is the only object I have in view in these observations.

But though I am ready to admit, that there have been canals designed and executed within twenty years, that all the ingenuity of man could never make beneficial to the subscribers, (having been designed in defiance of nature, and under difficulties and obstacles which rendered them unworthy of being executed,) notwithstanding it is a fact, that many canals that are completed, and others that are executing, will probably never pay five per cent to the subscribers; yet, there was nothing in the line to produce this dreadful effect, nor is the country, through which they pass, destitute of mines, minerals, and manufactories, sufficient to supply them with tonnage, but the principal cause of their failure, has been the want of skill in the execution of them.

Many of these canals, which have a summit level, and lock down at both ends, and some which lock down only one way, consume from twenty-five to forty-five, and some as much as sixty tons of lockage water, when the vessels return empty, in carrying one ton of goods; but where they are freighted both ways, in many instances, the consumption does not exceed from thirty-five to forty-five tons; whereas, not more than from twenty to twenty-one tons should be expended in carrying one ton of goods the whole length of the line, which may be from thirty to forty miles.

It is difficult to say, whether the estimates of canal engineers for supplying them with water, or their estimates for executing, are the more erroneous. When the Rochdale canal bill was in a committee of the house of commons, Mr. Jessop and Mr. Rennie stated as a fact, that a reservoir of sixty statute acres, average depth fifteen feet, would amply supply that canal with water, or almost any other canal; and that the promoters of this scheme might be fully satisfied of this, Mr. R. said he had a plan for building canal locks, by which one half of the lockage water would be saved; but I never heard he had favoured his employers with it.

For the information of the public, but particularly for those who may be hereafter engaged in making canals, that are to be principally supplied with water from reservoirs, I will give the admeasurement and the contents of each reservoir, that are made, or are now making, for supplying the said canal with water.

	TONS.
The Hollingworth Reservoir is 130 statute acres, average depth 10 feet, and contains - - - -	1,573,000
The Blackstonedge Reservoir is 50 statute acres, average depth 15 feet, and contains - - - - -	907,500

White-holme Reservoir is 92 statute acres, average depth 13 feet, and contains - - - - -	1,447,160
Chelburn Reservoir is 16 statute acres, average depth 15 feet, and contains - - - - - - - - - -	290,400
Light-hazzles Reservoir is 30 statute acres, average depth 6 feet, and contains - - - - - -	217,800
	4,435,860

and in times of excess, water runs into the canal at various places on the line, where no guages are fixed, which I have no doubt, is more than equal to the Chelburn reservoir.

There have been nearly two hundred statute acres of reservoirs finished for some years, and in a few years, there will be one hundred and twenty-two more acres of reservoirs, making in all three hundred and eighteen acres.

This canal is thirty-three miles long, and has ninety-two locks, (the rise on the east side the summit being three hundred and fifty-eight feet, and the fall on the west side five hundred and twenty-one feet) nearly all ten feet rise, and the number of acres of reservoirs, when the whole are compleated, will far exceed any thing in this kingdom.

The two said engineers were equally deficient in their calculations for the quantity of downfal water that might be drained from a given quantity of common.

Part of the water in the Hollinworth reservoir is lifted by steam from sixty-five to seventy-feet, and conveyed in a channel nearly four miles into the summit level, some of which must be lost in its passage to the canal. The water from the reservoir on Blackstonedge, and from that at White-holme, has to descend more than six hundred feet before it reaches the summit level, being a distance of full two miles, and therefore cannot all reach the canal. The whole length of these channels, including the catch-water drains, is full seventeen miles.

There are few commons in the kingdom, from which so much downfal water may be collected; as the highest part of Blackstonedge, being elevated nearly fifteen hundred feet above the level of the sea, the clouds frequently break in passing over it, and the surface principally consisting of black peat turf, of close texture, holds water surprisingly well.

Those commons that consist of loose sand and gravel, afford little downfal water, for it will be nearly all absorbed and dried up. And but a small quantity of downfal water can be collected from inclosed lands, for the grass land retains the greater part of it, and that under the plough will nearly absorb the whole. The average depth of rain that has fallen upon Blackstonedge for the last four years, I am informed, is nearly thirty-six inches, yet not more than about one-third of it can be got into the canal, though the reservoirs hold exceedingly well; the remainder is lost in leakage, soakage, and evaporation, &c. And with all the care that can be taken to keep the catch-water drains open, the reservoirs cannot be filled more than twice in the year. When the reservoirs are all finished, they will contain a quantity of water equal to 4,435,860 tons.

Admitting that ten vessels per day pass the whole length of the line, each carrying thirty-five tons, or a tonnage on various parts of it equal to this, which would be three hundred and fifty tons per day, and allowing two hundred and forty days in the year to navigate The amount of this supposed tonnage is 84,000 tons per annum; but I think it is rather over rated, for in the first place, there is not that number of vessels navigated per day, and in the second place, they do not average more than 30 tons burthen.

The reservoirs will be filled twice in the year, and will give 8,871,720 tons of water in that period. If 8,871,720 be divided by 84,000, the amount of the supposed tonnage, the product will be nearly 106 tons of water for every ton of goods supposed to be navigated on the line in one year. When the reservoirs are finished, they will contain nearly 26,170⅓ locks full of water, when twice filled; and if these are divided by 2,400, the number of vessels supposed to be freighted in one year, the product will be nearly 11 locks full of water for every vessel supposed to be navigated on the line.

A lock chamber is 81 feet 6 inches long, 15 feet wide, and 10 feet rise, and contains 12,225 cubic feet, equal to 339½ tons of water; but as some of the locks are 9 feet rise, I will call it only 339 tons. Two locks full of water are required to pass the summit, and three more should be allowed for leakage, soakage, evaporation, and the runs from the lock gates, cloughs, banks, &c.

If the average of the tonnage for the vessels be taken at thirty-five tons, nearly nine and two-thirds of a ton, (but I will call it only nine and a half tons) of lockage water will be required for every ton of goods that ascends the summit, and the same quantity will be spent in descending from it, and three more, as before stated; these multiplied by nine and a half, the product will be forty-eight and a half; but as many lime and coal vessels return empty, I will allow fifty tons of water for every ton of goods navigated upon the line, which supposes all the works in complete repair; for if they are not, there is no telling what may be required; but the reservoirs will hold more than double this quantity.

It is a painful reflection, that canals should have been so badly designed and executed, as to require more weight of water to navigate one single ton of goods, than the whole weight of the tonnage the vessel contains, but in some instances nearly twice this, as I shall hereafter shew; and does not this loudly call for improvement in the designing and executing of a canal, a business in which all the civilized world is greatly interested? If what I have said, and may say, on this subject, was not capable of mathematical demonstration, I think no one would believe me.

After I have allowed five locks full of water for every vessel that passes the summit, there still should remain considerably more than this quantity in the reservoirs undisposed of by any statement I have given, and yet, this canal is short of water in summer. If five locks full of water are sufficient to navigate a vessel from one end of the line to the other, including all the other waste, it is a question of great moment, to know what becomes of the remaining part, which is more than half the whole quantity the reservoirs contain. How is so vast a consumption of water to be accounted for?

The reservoirs cover 318 statute acres, and in the summer months sink one inch per day, when the cocks are shut close, and yet I think no reservoirs are more water tight than they are. But I will only estimate upon the reservoirs wasting half an inch per day, and confine it to those on Blackstonedge, as that at Hollingworth gives a certain quantity of water constantly to the mill owners, which makes it difficult to ascertain how much it wastes by evaporation, &c. The reservoirs on Blackstonedge cover 188 statute acres, half an inch on the surface of which, when full, amounts to 577,170 cubic feet, and is equal to forty-seven locks full of water per day; this evaporation will account for the surplus within nine locks full, when the canal has had the quantity of water I estimated upon; and a considerable part of these nine locks full is wasted, in conveying the water from the reservoirs to the canal or summit level. If it be admitted, that these reservoirs lose half an inch per day in dry seasons, by leakage, soakage and evaporation, it is more than should supply the canal the whole length of the line, and I have no doubt of there being nearly this loss.

This affords an useful lesson to canal subscribers, to be cautious how they undertake to supply a canal with water from reservoirs; but particularly so, if the rise and fall on the line is great, and the ground, through which it has to pass, unfavourable to a canal.

The reservoirs on Blackstonedge when filled, will contain 2,862,860 tons of water; but as they are twice filled in the year, the whole quantity will be equal to 5,725,720 tons of water; and the extent of the commons from which it is drained, 2204 statute acres, which gives full $3{,}045\frac{1}{2}$ tons per acre.

Admitting that 36 inches in depth of rain fall in one year, upon that part of the commons that is drained into the reservoirs, it is equal to 8,000,520 tons of water, and yet no more than 3,725,720 tons of water can be collected into the reservoirs; which plainly proves, that notwithstanding the close texture of the soil, little more than one-third of the rain that falls upon them can be got into the summit level; and were these commons cultivated, I do not think that more than one-sixth part of the rain, that would fall upon them, could be drained off.

The last year 26 inches in depth of rain fell in Manchester, and 20 inches of them were wasted by evaporation. This statement shews the amazing quantity of water necessary to be collected for the supply of a canal, that has its dependence upon reservoirs, and how difficult it is to meet with situations sufficient for the purpose, and also the necessity of making them as deep as possible with safety; for the evaporation will be nearly the same, whether they are made deep or shallow. It also proves the necessity of making canals with six feet depth of water instead of five; for much less will be spent in navigating a given quantity of tonnage upon a canal with the former depth, than with the latter.

But notwithstanding the large quantity of water used by this canal, and the ample provision which the present reservoirs will furnish when completed for a considerable increase of carriage, it is very satisfactory to know, that much more may be had, if required; and that the tonnage may be greatly increased, will appear from the following statement:—

If a railway was made to communicate with the Leeds and Liverpool canal a mile above Burnley, the distance from thence to the lime rock at Rainhall by canal is 12 miles, and from the place of communication to Todmorden is 9 miles, where lime may be delivered at 14s. per ton; admitting it to be carried on the railway at 7d per ton, per mile.

From Brotherton (which principally supplies Todmorden valley with lime) to Sowerby wharf, is 42 miles, and from thence to Todmorden 10 miles, making in all 52 miles. From this it is plain, that the lime from the said rock, will not only supply Todmorden valley, but also Halifax and its vicinity; as the distance from the said rock to Halifax is only about 33 miles, whilst that from Brotherton, including 2 miles of land carriage from Salter Hebble wharf, is 42 miles.

From Rainhall to Todmorden is only 21 miles, and from thence to Rochdale 10 miles; being 22 miles by water, and 9 by the supposed railway, making in all 31 miles. From the lime rock, in the Peak Forest, to the head of that canal, is full 6 miles of railway; from thence to Ashton, 14 miles; from Ashton to Manchester, 8 miles; and from thence to Rochdale, by that canal, 12 miles, making in all 40 miles; which is 9 miles in favour of the lime from Rainhall rock in the Rochdale market.

The Peak Forest lime, that goes generally to Bury and its vicinity, I understand, is taken off the canal at Manchester; but when the supposed railway is made, it will be afterwards supplied with lime from the said rock, by way of Todmorden and Rochdale, cheaper than from any other place, in either Lancashire or Yorkshire.

Perhaps it will be said, that lime may be brought from Enfield Common to Bury, as cheap as by way of Todmorden; but this is a mistake. From the said lime rock to Enfield by the canal is nearly 24 miles; and from thence to Bury by land is full 14 miles; making in all 38 miles. I have before stated, that the distance from the said lime rock by way of Todmorden to Rochdale is 31 miles; and from thence to Bury 6 miles, making in all 37 miles.

But in coming from Enfield to Bury, there is an ascent from Ackrington to Baxindale, as quick and nearly as long as the ascent on the North West side of Blackstonedge; and there is another long and quick ascent leading into Haslingden; but any rise in the road from Rochdale to Bury is easy; for two horses would draw more from Rochdale to Bury, than three from Enfield to Bury; and moreover the tolls from Enfield to Bury, are three times as much as from Rochdale to Bury. The length of land-carriage for the lime by way of Todmorden to Bury is nearly the same as that from Enfield; but then two-thirds of it will be by the supposed railway which makes it impossible for the lime from Enfield to meet that by way of Todmorden in the Bury market.

From an impartial survey of the country, I am of opinion, that the lime from the said rock, brought on a railway as before stated, will supply nearly 90 square miles, much cheaper than it can be had from any other place; and before the railway has been worked only two years, I think it will give one-third more tonnage to the Rochdale canal, than was ever yet carried upon it. The proposed railway will pass near a stone quarry, in which good slate-flags, sash-stones, wall-stones, and stones almost for every purpose are got; but the distance from Todmorden being 9 miles, its utility to the public is nearly lost for want of a road.

From Halifax and Sowerby wharf, great quantities of oats, beans, flour, potatoes, and various other articles of consumption, intended for Burnley and its vicinity, will go upon the proposed railway, in covered waggons, in which goods may be carried as dry as in a stage coach. That goods may go direct for Burnley, it would require a branch of nearly a mile long; but the best line for for the main railway would be direct from Burnley, and through Mr. Townley's park, which would make it rather shorter, and less expensive; and the lime in that case would be taken off at Burnley. A railway passing through that gentleman's estate would be of great advantage, in opening to him a new market for that immense field of good coal, which lies therein; and were it judiciously laid Todmorden would, in a few years, be equal to a small town, and have a regular market.

Wakefield is a great corn market, from which Burnley and its vicinity are principally supplied: the Leeds market being much inferior with respect to grain. From Wakefield to Todmorden by water is 32 miles, and from Todmorden to Burnley 9 miles; making in all 41 miles. From Leeds to Burnley, by the Leeds and Liverpool canal, is nearly 54 miles.

If this railway was executed, a vast quantity of minerals and merchandise would pass upon it; and from the great expense of keeping horses, and travelling in stage coaches, people would travel in waggons upon it, as they do in many other places. By this conveyance that great field of coal at and near Holmes Chapel would be opened; and I think the capital sunk in mak-

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ing this railway would pay three times the interest of an equal quantity of capital, sunk in making the Rochdale canal. This railway would be very beneficial also to the subscribers of the Leeds and Liverpool canal, by increasing the tonnage upon it.

I now appeal to the proprietors of these two canals, who are greatly interested in making this railway, and to an impartial public, who will be much benefited by it, whether such a plan is not worthy of being executed.

OBSERVATIONS

ON

THE LEEDS AND LIVERPOOL CANAL.

The idea of this canal was first suggested by the late Mr. John Hustler, of Bradford, and ably supported by his friends with a liberal subscription. The principal design was to open a communication between the ports of Hull and Liverpool, in one bottom, and thereby to avoid the injury and inconvenience attending transshipping; but in this he was much disappointed, for when the line was finished to Skipton it was found, that vessels built to navigate in the tide way were unfit for inland canals, in almost every respect, but particularly in their length, which subjected all the vessels coming from Hull for the interior to be unloaded at Leeds. It then appeared, that a narrow canal was much better calculated for the country through which it had to pass.

This canal, when finished, will be 131 miles long; and it is rather singular, that the rise and fall upon it is the same, as that on the Rochdale canal within one lock.

In order that this canal should have commanded the thoroughfare trade between the two said ports, three things were necessary:—

First. It should have been made as short as possible, and all communications with the neighbouring towns made by collateral branches or railways.

Second. The locks should all have been single, and so placed, as that no unnecessary time or water would be spent in passing them.

Third. The basins should have been made sufficiently large, that the shortest of them would not have been drawn down more than four inches by a lock full of water, but in many instances not more than one-fourth of that quantity.

But unfortunately for the subscribers and the public, it is the reverse of all this. For the number of combined locks on the Yorkshire side of the summit, I am inclined to think, far exceeds any thing of the kind in this kingdom; and I am sorry to say that so many errors of this kind were committed by the late Mr. Longbottom, engineer for that canal when it first began, as will perhaps for ever prevent that convenience and utility which the public would have derived from it, if the locks had been properly placed.

Nor did the late Mr. Whitworth Mr. Longbottom's successor shew much more judgment in the placing of his locks on this canal. With all the errors of his predecessor before his eyes, one would have thought it impossible that he could have committed the like; but the fact is the contrary.

The combined locks on the Yorkshire side of the summit stand, if I am not mistaken, in the following order:—

Between Leeds and the short branch that goes up to Bradford there are three combinations, each containing three locks, and one of two. Near the end of the said branch there is one combination of three locks, and another of two; and between the end of the said branch and Bingley, there are two other locks combined. At that place there is one combination of three locks, another of five, and one at the east end of the summit of two, making in the whole twenty-seven locks. On the Lancashire side of the summit, where the junction is made with the Lancaster canal, I am informed there is a combination of three locks, making in all thirty. All the combinations on the Yorkshire side were made by Mr. Longbottom, that at the east end of the summit excepted, which was made by Mr. Whitworth.

It is worthy of remark, that there is nothing in the nature of the ground at the different places where these combinations are made, but what might have been avoided when the line was laid out, without varying it in more than two or three places, and yet sufficient basins might have been formed between all the locks. I apprehend the greatest difficulty was where the junction is made with the Lancaster canal, yet even that might have been surmounted with proper attention.

In consequence of these combinations, the loss of time and of water, and the great injury done to the mercantile trade on the line is incalculable; for in times of a scarcity of water, vessels going from Leeds to Bradford, Skipton, &c. are not permitted to pass the locks at Bingley, until a sufficient number are collected, so that the second vessel may make use of the water which the first leaves in the lock, and the third that of the second, and so on; but in very dry seasons, the boatmen told me, vessels sometimes waited two or three days before they could pass A canal thus restrained in its navigation, is equal to a prohibition of the thoroughfare trade; for it is not to be supposed, that such a canal can command, or will have any part of it, if a shorter, more convenient, and less expensive water conveyance can be had.

Sometime ago, I observed a single vessel descend the combination of five locks at Bingley, and another ascend it, each being full fifty minutes in passing, and was greatly astonished with the loss of time, and waste of water that attended the two operations; for the rise of the locks is twelve feet four inches, and a lock contains nearly 380½ tons of water.

A descending vessel ought not to consume more than one lock full of water, yet full two are wasted; for after the first lock was filled, the cloughs remained considerably drawn, until the vessel had got into the fifth lock; and during all this time, a quantity of water ran out from the fifth lock equal to a powerful brook; and during the time the ascending vessel was passing single, I am confident that more than a lock full of water extra was wasted; so that more than six locks full were consumed in passing those five locks, in consequence of the runs from the cloughs and gates which had been improperly shut, and the boatmen being in so great a hurry to get through; and this I understood to be the constant practice.

I estimate upon two locks full of water being consumed in leakage, soakage, evaporation, and the runs from the gates, cloughs, and the banks, while the vessel is passing from Leeds to Skipton, making in all eight locks full of water; and if a lock contains 380½ tons of water, as before stated, the quantity consumed in lockage only, will be 2,283 tons, which divided by 35, the number of tons the cargo weighed, as I was informed, will be full 65 tons of water wasted for every ton of goods the vessel contained; and if two locks full more be added for the leakage, soakage, evaporation, &c. as before stated, the whole consumption will be nearly equal to 87 tons of water consumed in navigating every ton of goods through that combination of locks, when the vessel passes single, and carries them from one town to the other.

But should the vessel return empty, as many coal and lime vessels do, two more locks full of water must be added for the reasons before given, which makes the whole consumption equal to 108 tons in carrying a single ton of goods.

I will now suppose a vessel going from Bradford to Skipton, with a cargo of coal, to return empty, and will only estimate upon one lock full of water being spent in passing the three combined locks, at the bottom of the short branch, though it will be much more, six in ascending the combination at Bingley, two more when returning, three in ascending the combination near the end of the said branch, and two more for leakage, soakage, and evaporation, and the runs from the gates, cloughs, and banks, making in all fourteen locks full of water, equal to 5,327 tons, which divided by 35, the supposed weight of the cargo, will give 152¼ tons, the quantity of water consumed in navigating one ton of goods. That many coal vessels go from Bradford to Skipton, passing the locks singly when there is plenty of water, and return empty is a well known fact; and when this is the case, much more water is consumed than I have stated.

If the locks had been properly placed, and made of six feet rise (and they should not have been more) only 22 tons of water would have been required to carry one ton of goods from Leeds to Skipton; and this estimate includes all waste, which is but about one seventh part of what is at present expended.

Suppose the line finished, and the before mentioned restrictions continued in times of a scarcity of water, they would exclude all mercantile goods from coming upon it, and so defeat the great purpose for which the canal was designed; and if these restrictions are not continued in dry seasons, water cannot be found to supply it as the locks are now placed; which fully proves, that this canal on the Yorkshire side can never be made convenient and useful for the public, or beneficial to the subscribers, without an act of parliament for fresh powers to vary the line where it is found necessary, and to build new locks near the said combinations.

To build new locks, including every expense connected with them, the company must expend £40,000 at least, and when all this money has been spent, it will still be incomplete.

It is painful to shew how improperly the locks are placed on both sides the summit, but particularly the two that are combined at the east end, with a very small pool between them, and the single lock next below, which causes every ascending vessel to throw one lock full of water over the waste wear at the head of the single lock.

The contracted pools that Mr. W. made on each side the summit, are often drawn down from fifteen to nearly eighteen inches by a lock full of water, which is attended with a perpetual injury and inconvenience that cannot be estimated.

The mind revolts at the next error which Mr. W. committed in passing the summit, by sinking it seven miles in length two feet extra depth to serve for a reservoir, and this length included the tunnel. The extra digging and the land wasted by it cost several thousand pounds; but had he raised the head of the reservoir near the tunnel only nine or ten inches, he would have got more than double the quantity of water, and the whole expense would not have exceeded from seventy to eighty pounds. An equal quantity of water may be had from a reservoir, at one-fifteenth part of the expense it would cost to procure it by digging a canal an extra depth.

Considering the numerous inconveniences and disadvantages attending tunnels, I would earnestly recommend the avoiding them at an increased expense wherever it is practicable; but when it is considered, that they uniformly exceed the estimates, this caution appears the more necessary.

The tunnel on this canal, which is 1560 yards long, cost £40,000, some say much more, though the estimate was only £13,000. In this instance there is not the plea of necessity for tunneling, as the summit might have been passed with nearly half the expense, by sixteen feet extra deep cutting for four hundred yards in length; the remainder of the length would have been for the locks one hundred and twelve feet rise and fall, that is fifty-six feet for the rise at one end, the same for the fall at the other. Allowing 10d per cubic yard for the deep cutting, £110. per foot for the rise of the locks, building a steam engine to lift the water fifty-six feet £1000, cutting a drain from the canal £400. annual expense of working the engine £500 (for coal there is cheap) equal to sinking a capital of £10,000. makes in all £24,970.

From Gargreave to Enfield common is twenty-nine miles, the estimate for which was £3,032 9s per mile; but including loss of interest on the capital while executing, and all other expenses it has cost full £9,000 per mile. The locks estimated at £50 per foot rise, have cost £110.

This canal, which will shortly be finished, will be one hundred and thirty-one miles long, twenty-nine miles of which have cost nearly £70,000 more than the original estimate for the whole line: another proof how little the principle of canals has been understood.

After passing a pool of about twenty miles from Barrowford, the locking down commences at Blackburn, where the present engineer has followed the injudicious plan of his predecessors in the distribution of his locks; the distance from the head of some of them, where the masonry begins, to the tail of those next above, being little more than twenty-six yards; yet more than five times that distance might have been had, there being nothing in the situation of the ground to prevent it.

The aqueduct near Blackburn is a good firm piece of masonry, but there has been a great want of judgment in making the high embankment that is connected with it; as it was easy to foresee that the ground upon which it was placed, being spungy and water shaken, would slide, unless great care was taken in draining off the water.

I should think much lime will go from near the tunnel to Wigan and that neighbourhood, and that the vessels will frequently return empty; and should they pass the combination of three locks at the junction with the Lancaster canal singly, six locks full of water will be spent in lockage, and two locks full more being allowed each trip for leakage, &c. will make eight locks full of water that will be consumed in carrying one cargo, which is equal to one hundred and ten tons spent in carrying one ton of goods; but if the vessels are detained till a sufficient number are ready to pass together, the quantity will be reduced to seventy-six.

There are twenty-three locks near Wigan, which in general are about ten feet rise, having short contracted basins, some of them not much longer than the masonry of the locks, but there is one thing favorable in the ground which will admit of their being widened; yet this will be attended with a heavy expense.

The stone for the locks is very good, the scantlings large and well worked, and the same may be said of the timber for the gates; but if the rise of them had been only six feet, nearly half the lockage water would have been saved, and the works would have been more than twice as durable. The ground on which those locks are placed is the best I ever saw for turning water, it being all fine clay or marl; but there is a great deficiency in the breast of the locks, that is a want of a good counter arch of ashlar; without which it is next to impossible to make it stand firm, but particularly where the rise is great; for when the water is low in the lock chamber, there is often above five feet rise of masonry in the breast exposed to the stroke of the vessel.

In a lock of six feet rise, with six feet water, little of the masonry in the breast can be exposed to danger, and the lock cills will be best preserved from injury. And although contracted basins do not waste quite so much water as locks when combined, if the vessels pass them singly, yet they are far more injurious to the works by ploughing up the puddle, striking against the cills, and causing the upper gates to be so violently shut to the great injury of the works. The expense of repairing the lock gates and the wages of the lock keepers are great indeed, in consequence of having such basins, whereas, if the locks had been properly placed, not more than three (if any) would have been wanted for the whole line, but now nearly twenty I think will be employed after the canal is finished.

If a moderate trade should pass on the line near Wigan, I think five lock keepers will be required, one at the junction with the Lancaster canal, two at Blackburn, and one at Barrowford, making nine in all on the Lancashire side; except there should be one going from Wigan to Liverpool, which will make ten.

At the end of the summit on the Yorkshire side, there is one lock keeper, another at Bank-newton, one more at Gargrave, two at Bingley, two going up the short branch at Bradford, and from thence to Leeds four, making eleven, which added to the ten before mentioned, make twenty-one. I estimate the average of these men's wages at 18s per week, equal to £982 16s per annum, which is the same to the subscriber as sinking a capital of £19,656. I recommend this estimate to the candid examination of canal engineers, as an excellent antidote against combined locks and contracted basins.

I have before estimated the expense of removing the combined locks at £40,000; but upon more mature deliberation, if interest be allowed while the works are executing, the expense of obtaining an act, with that of engineers, surveyors, committee meetings, attornies, commissions, &c.

I think the whole expense will not be less than £50,000. By removing the combined locks, ten lock keepers' wages may be saved, which is equal to saving a capital of £9,860. It is of importance to ascertain the saving there would have been by making this canal narrow; the lowest statement of canal engineers is one-fourth of the whole; but many have estimated it at nearly one-third, and the late Mr. Whitworth was of that opinion.

It is now generally supposed, that when the canal and warehouse, wharfs and other works that may be required, are finished, they will cost one million sterling. One-fourth of this sum is £250,000, and if the expense of removing the combined locks be added, the amount will be £300,000. There is no doubt, but if this canal had been made narrow, the works well designed and properly executed, this immense sum would have been saved, and the public much better served; more especially as nine-tenths of the tonnage passing upon it will be stone, lime, and coal, all of which are carried as conveniently, and as cheap upon a narrow as a broad canal.

Although combining locks is so injurious to a canal, yet it is difficult to say who was the first inventor of it; but the first that were erected in the county of York were by the late Mr. Smeaton, at Salter Hebble, when he was engineer for that navigation. Three twelve feet rises were combined there; but when the trade increased, water could not be found sufficient for them, and the company took them up and placed basins between. It is singular to observe how long a bad plan may be continued in practice, if introduced by a popular character; for Mr. Smeaton's pupils have clung close to it; witness Mr. Brindley, Mr. Longbottom, Mr. Whitworth, and now Mr. Fletcher.

When a long line of canal is proposed, great attention should be paid, in surveying the country through which it is intended to pass, to see whether it may not, at some future period, be much injured by a rival canal.

As a line of general communication between the two seas, I think the Leeds and Liverpool canal was altogether improper, being too long and circuitous; for had any attention been paid to Todmorden valley, it would have appeared, to any considerate person, to be much better calculated for a general line than that of the Leeds and Liverpool canal, as will be shewn by a comparative view of them. And although the expectations of the company will be greatly disappointed with respect to the thoroughfare trade, yet they have great merit in executing so noble a design, and have shewn a good example to all canal committees, in acting both uprightly and liberally to the land owners whose estates they have cut through and divided.

To prevent the vast consumption of water, some persons, who pretend to understand the principle of canals, have recommended the making of side ponds or basins, in expectation of saving one third, if not one half, of the lockage water. But this plan proves, that they are strangers to the best mode of supplying canals with water.

Let us suppose side basins to be made for three or four locks on each side of the summit of a canal, and one-third, or nearly one-half the lockage water saved, the certain consequence would be, that the pools below would be rendered impassable, for want of the water thus left in the side ponds above. This plainly shews, that side ponds can be of no service, unless the whole line is supplied with them, and that placing them partially, would be a waste of money to no purpose.

This observation will equally apply to those canals where there are combined locks, for the destroying of one only of these combinations would be of no use. Contracted pools also are liable to the same objection as an incalculable quantity of water is wasted in flushing, to assist the vessels in passing them. I will suppose twenty of these contracted basins on a canal, and if nineteen of them could be removed, how would it benefit the line, for the extra quantity of water that would be wasted in passing the twentieth pool would have served all the rest.

I now leave the canal subscriber to judge, what good he has to expect from side basins, which are an expensive substitute for the ignorance and inattention of canal engineers.

As machinery and canals are become so general, and both distressed for water at the same time, it is not to be expected that the mill owner will part with any, except in times of excess; this will compel canal speculators hereafter to make reservoirs to supply their wants; (which being very expensive, and in many situations very uncertain with respect to the supply they will afford, as well as insecure with respect to durability) great care should be had in selecting proper situations for them.

It will give me great satisfaction to reflect, that I have been any ways instrumental in assist-ing the canal subscriber to judge of such reservoirs, as may be proposed, before he has plunged himself into such serious undertakings.

I will suppose a broad canal is intended to be made thirty miles long, with a summit to lock down both ways; suppose the rise and fall equal to five hundred feet, and estimate the tonnage at three hundred and fifty tons per day for the whole length of the line, or a tonnage on various parts of it equal to that amount, and calculate upon forty weeks in the year to navigate.

The next thing to be considered, is what number of acres of reservoir, of the average depth of fifteen feet, would be sufficient to supply one mile in length of such canal with six feet water, and locks of six feet rise. If the ground was rather favourable to a line of canal, and the pools of sufficient length between the locks, so as not to be drawn down more than from four to six inches to fill a lock, four statute acres and one third of reservoir, of the depth before mentioned, would supply one mile of such canal, supposing it to be filled twice in the year; and if these acres are taken collectively, the whole will be equal to a reservoir of nearly one hundred and thirty statute acres, with which I propose the whole line to be supplied with water; but the works must be finished in the best possible manner, and kept in that state, or no such quantity will supply it.

A reservoir of 130 statute acres, average depth 15 feet, will contain 84,942,000 cubic feet of water, but if twice filled in the year will give 169,884,000 cubic feet of water, equal to 4,719,000 tons. I estimate a lock chamber to be 75 feet long, 15 feet wide, 6 feet rise, and to contain 6,750 cubic feet of water equal to 187½ tons. If 4,719,000 tons are divided by 180½, the product will be 25,233, the number of locks full of water the supposed reservoir or reservoirs will give, when twice filled; and if the canal is worked 240 days in the year, the reservoir would give full 107 locks full of water per day, supposing there was no loss by evaporation, &c; but that a subscriber to a canal, that is proposed to be supplied from a reservoir or reservoirs, may not be misled, he must calculate upon as much water being wasted by leakage, soakage, evaporation, and conveying it to the canal for a month or six weeks in summer, as the canal will use, supposing all the works to be perfect.

I think a lock chamber 75 feet long is a reasonable length for a broad canal, but for a narrow one I would have it 80 feet long.

If a reservoir or reservoirs could be made in cultivated ground, and filled with the surplus water of a powerful brook, or river, it would be much better than making them on high grounds; there being much more risk in making them in elevated situations, than in low ones; for the inside of the bank is much more exposed, and the expense that attends the catch water drains very considerable; moreover the loss of water, occasioned by strong winds, from reservoirs so much elevated, is really astonishing. But it is difficult to meet with good situations for reservoirs in low grounds, where a great deal of surplus water may be had, without being subject to pumping it from the reservoirs into the summit level; and when this is the case, the expense of supplying a canal with water is great.

But I would caution the canal subscriber and the acting committee never to make any reservoirs in inclosed and cultivated ground, if it is intended to be supplied with down-fall water; as most certainly very little of the rain that falls upon the ground intended to be drained will ever find its way into the canal. I therefore consider the making of reservoirs in such situations to be as wild and romantic, as sinking a canal an extraordinary depth and width to serve as a reservoir.

Many schemes and plans have been adopted as a sustitute for canal locks, but thus far I think they have all failed. I have long been fully convinced, that there never will be any plan devised, for ascending from a lower to a higher level, equal to a canal lock, where a sufficient quantity of water can be had. But as I have before observed, the bad designing and executing of canals have caused double the quantity of water to be wasted, that was necessary, and this has made canal engineers' estimates for the quantity of water required to supply a canal as visionary, as their estimates for executing.

Comparative statement of the difference in expense of carrying goods from Leeds to Liverpool by that canal, and from Wakefield to Liverpool by the Calder and Hebble navigation, the Rochdale and Bridgewater canals, and also by the Huddersfield canal. As Leeds and Wakefield are at an equal distance from Hull, to save calculation, I have made the estimates to commence at the two last mentioned places.

	£.	s.	d.	Miles
From Leeds to Liverpool by that canal is 131 miles, the dues $1\frac{1}{2}d$ per ton per mile, and the freight I estimate at $3\frac{1}{2}d$ per ton per mile, making in all $5d$, to which add the expense of carrying the goods from the basin, at Liverpool, into the town, the average of which may be taken at 1s 6d per ton, making a sum total of	2	16	1	131

	£.	s.	d.	Miles
From Wakefield to Sowerby Wharf is 22 miles, the dues and freight 9s 4½*d* per ton; from thence to Manchester by the Rochdale canal is 33 miles, the dues and freight 15*s* per ton; from thence to Runcorn by the Duke's canal 30 miles, and from thence to Liverpool 20, on the river Mersey, in the tide-way; the dues and freight from Manchester to Liverpool 12*s* 6*d* per ton, making in all	1	16	10½	105
From Wakefield to Cooper-bridge is 13 miles, dues and freight 5*s* 5*d*; from thence to Huddersfield, by Sir John Ramsden's canal, nearly 4 miles, dues 1*s* 6*d*, freight 1*s*; from thence to Manchester by the Huddersfield and Ashton canals 28 miles, dues and freight 20*s*; from thence to Runcorn 30 miles; and from thence to Liverpool 20 miles, as before stated, dues and freight 12*s* 6*d*, making in all, - - - - - - - - - -	2	0	5	95

I will suppose, at present, there is an ample supply of water in these canals, and I estimate upon the large vessels, carrying 40 tons, and a narrow vessel on the Huddersfield canal 20 tons.

	£.	s.	d.
Carriage and freight of 40 tons of goods by the Leeds and Liverpool canal, from the former to the latter place, 2*l* 16*s* 1*d* per ton, - - - - - - - - - - - -	112	3	4
Carriage and freight of 40 tons of goods by the Rochdale canal, from Wakefield to Liverpool 36*s* 10½*d* per ton, - - -	73	15	0
Carriage and freight of 20 tons of goods by the Huddersfield canal, from Wakefield to Liverpool, 40*s* 5*d* per ton, -	40	8	4

The great saving the public will receive in the carriage of goods for the thoroughfare trade, by the Rochdale canal, is very striking indeed; for if only one vessel per day is freighted with them, and that for no more than forty-two weeks in the year, and the cargo of each vessel taken at thirty-five tons, it will not be less than £9,681 per annum; if the saving in time be added, which I think at all times will be two days per trip, but in summer, when water is scarce, partly owing to the locks being so improperly placed, and the restraint the vessels are laid under, three days loss, I think, may be fairly estimated upon, which will make the saving, I should suppose, equal to full £1,000 per annum more; and this loss principally falls upon the carrier, making in all £10,681 per annum; and if two vessels per day should be freighted for the thoroughfare trade, (which I think is more than probable) the saving will be double what I have estimated upon, and so in proportion. But at what sum shall the saving in time, and all the advantages connected with it be estimated? For the mercantile trade, this can hardly be valued; I therefore leave it to the consideration of those more immediately interested in it.

There is a new warehouse built at Cooper-bridge, on the banks of the river, by the Calder and Hebble navigation company, twelve miles from Leeds and nine from Sowerby wharf, where goods going for Liverpool may be put on board; from Cooper-bridge to Runcorn is seventy-two miles, by which fifty-nine miles of dues and thirty-nine miles of freight are saved. Dues and freight for one hundred and thirty-one miles, at 5*d* per ton per mile, will be 54*s* 7*d*, and 1*s* 6*d* per ton for carrying the goods from the basin to the town, making in all 56*s* 1*d*.

From Cooper-bridge to Sowerby wharf, dues and freight for a ton of goods are 3*s* 11½*d*, from thence to Rochdale by that canal 15*s*, and from thence to Liverpool by the Bridgewater canal 12*s* 6*d*, making in all 31*s* 5½*d*; and if 18*s* be allowed for the carriage of one ton of goods from Leeds to Cooper-bridge, it will be ample, and leave a balance in favour of the Rochdale canal of 6*s* 7½*d* per ton; and goods coming from either Leeds or Wakefield to Cooper-bridge, and going for either Manchester or Liverpool, are carried by the Rochdale canal 3*s* 7½*d* per ton cheaper than by the Huddersfield canal; besides that, they are not to unload at Manchester if going for Liverpool. This saving of money and nearly half the time by sending goods from Leeds to Cooper-bridge, will, I think, deprive the Leeds and Liverpool canal of the carriage of a great part of the mercantile goods from thence to Liverpool after the line is finished.

Bradford is nearly ten miles from Sowerby wharf, and goods from thence may be put on board in little more than six hours; and many will be sent, without doubt, as they will go to Liverpool in nearly half the time by the Rochdale canal that they can by water from Bradford; the distance between that place and Liverpool is nearly one hundred and twenty-one miles, but from Bradford to Liverpool, by the Rochdale canal, is ten miles by land and only eighty-three by water, making in all ninety-three miles, which is twenty-eight miles shorter than by the Leeds and Liverpool canal.

Carriage and freight of one ton of goods from Sowerby wharf to Manchester, by the Rochdale canal, 15*s*, and from thence to Liverpool, by the Duke's canal, 12*s* 6*d*, and I allow 16*s* for the carriage of one ton of goods from Bradford to Sowerby wharf, making in all 43*s* 6*d*; but if they went by the Leeds and Liverpool canal, the dues and freight, at 5*d* per ton per mile, would be 50*s* 5*d*, and 1*s* 6*d* per ton for the carriage of goods from the basin to the town, making in all 51*s* 11*d*, which leaves a balance in favour of the Rochdale canal of 8*s* 5*d* per ton.

The new turnpike road from Keighley to Hebden-bridge, being only a distance of eight miles, goods from Keighley and that neighbourhood for Liverpool, will go by way of Hebden-bridge, and there be put on board the Rochdale canal; and cotton and other goods coming from Liverpool for Keighley, and its vicinity, will be sent the same way.

From Hebden-bridge to Manchester, by the Rochdale canal, is nearly twenty-eight miles, the dues and freight are 12*s* 9*d*, and from thence to Liverpool, by the Duke's canal, they are 12*s* 6*d*, as before stated, making in all 25*s* 3*d* per ton.

From Liverpool to where the goods are taken off that canal near Keighley, I think, is one hundred and twelve miles, dues and freight at 5*d* per ton per mile 46*s* 8*d*, carrying the goods from the town to the basin 1*s* 6*d* per ton, and 3*s* 6*d* per ton for carrying them from the canal to Keighley, a distance of nearly three miles; and moreover, they have a toll-gate to pass through, making in all 51*s* 8*d* per ton. I had allowed 16*s* per ton for land carriage between Keighley and Hebden-bridge, but a common carrier having engaged to carry at 11*s* 8*d*, it leaves a balance of 14*s* 9*d* per ton in favour of the Rochdale canal; and I have no doubt, that goods will be carried between Leeds and Cooper-bridge, and between Bradford and Sowerby-bridge, at lower rates than I have mentioned

From Hebden-bridge to Liverpool, by water, is seventy-eight miles, and if eight miles of land carriage be added, it will make the whole distance from Liverpool to Keighley by Hebden-bridge equal to eighty-six miles; but Keighley is distant from Liverpool by that canal one hundred and twelve miles by water, and three by land, making in all one hundred and fifteen miles, which is twenty-nine miles in favour of the Rochdale canal.

From this statement I think it is clear, that the great saving in carriage, but especially that of time, will cause the principal part of the goods going from Keighley, Bingley, and that neighbourhood, for Liverpool, as well as those coming from thence, to be carried by the Rochdale canal.

But that part of the canal which extends from Wigan to Liverpool will always be better to the company than a gold mine; I wish I could say the same of all the rest.

THE
HUDDERSFIELD CANAL.

The Huddersfield canal is a narrow one, designed by the late Mr. Benjamin Outram. The length of this canal is full nineteen miles, but nearly five thousand seven hundred and twenty yards are tunnel. The estimate for the whole line was, I believe £183,000, of which, £56,000 were estimated to finish the tunnel; for that sum, it is said, the engineer offered to execute and find security to complete it, in five years; but some of the committee being of opinion, that it might be executed for less money, he fortunately was not the undertaker. The masonry and earth work of this canal were the worst executed of any I ever saw. This was the opinion of the late Mr. Whitworth, who was called in to survey the line, and said to me, the work will be nearly all to do over again, particularly the locks. There are, I think, on the Yorkshire side the summit, forty-two locks, some parts of all which have been taken down and rebuilt, except two; but how many have been rebuilt on the Lancashire side, I know not.

At the time the engineer proposed to undertake the execution of the tunnel, I heard his friend, Mr. Jessop, say, he might execute it in the time proposed, and get money by the contract. The committee have been hammering hard at it for near eighteen years, and have at last got through the hill. The expense of executing it, including loss of interest on the capital, I believe, has been nearly three times the original estimate; and I suppose this will apply to all the remainder of the line, which, in summer, is greatly distressed for want of water, its principal supply being from the tunnel; which I should think, will rather keep diminishing.

The company have been particularly unfortunate in their reservoirs, having had part of one taken down, and another quite swept away. One of these reservoirs, and by much the largest was made upon the common, near a mile from the canal, and such was the inattention of the engineer, that he laid the foundation of the bank upon nothing but the moss and ling that covered the soil; (but not so with the foundation of the reservoirs on Blackstonedge, which were all dug down to the rock) the foundation for the head of a large reservoir, should be as firm as that for a castle. When this reservoir was filled to the depth of about seven feet, the water found its way under the foot of the bank, and floated it away, as if it had been only a deal plank; this misfortune took place in the night time, and dreadful destruction it made. Had that reservoir been finished, and filled with water, it would have swept away the principal part of the mills and weirs for many miles on the river below it; for the water passed a descent of, I think, full two hundred yards, before it reached the river; and when it had run only a few hundred yards, it fell into a steep dingle, tearing up, and overturning the rocks in a most astonishing manner. After this, it swept away a cottage, with a man, his wife, and five children; the father perished in the deluge; but to the credit of the committee, they supplied the distressed family with every thing necessary, and became a father to the fatherless.

The great loss of interest on the capital and time in executing this canal, should be a lesson to all speculators in canals, how they meddle with such tremendous undertakings; but especially as they see that no confidence ought to be placed in the estimates of their engineers.

Where nature has thrown such impediments in the way, for making a canal, as this line abounds with, it is the height of folly to contend with them; for where the rise is great, the ground unfavourable, water scarce, and the principal supply of it to be had from reservoirs, fed with downfal water collected into them, I would recommend to the subscribers never to think of executing a canal, under so many unfavourable circumstances.

If the commons on Blackstonedge had not been so very extensive, the soil of such a particular texture as to absorb little water, and the reservoirs holding, like so many bottles, that canal could never have been supplied with water; but as I have already observed, it may be amply supplied with it.

The quality of the ground, from whence downfal water is intended to be collected, should be carefully examined, before any money is laid out; for reservoirs may be made almost any where, but not filled with water from any plot of ground. Good reservoirs may be made in inclosed ground, if there be neighbouring brooks or streams, from whence surplus water may be taken in times of excess, sufficient to fill them. The inside banks of all reservoirs should be lined with a thick coat of stone, to preserve them from injury by the dashing of water against them, in stormy weather.

The deepest part of the said tunnel is about three hundred yards from the surface; and the centre pit, which was sunk in a deep valley, from whence the water was drawn while executing it, is one hundred and sixty yards deep, and cost £11,000 sinking; pumping the water from it, for some time, cost £50 per week. Tunnels are liable to so many objections, that they ought to be avoided wherever it is possible.

The inconvenience of this tunnel is severely felt by the trade on the line, as vessels can only enter every twelve hours; and should any little accident happen to retard a vessel, it will have to wait twelve hours before it can enter; and moreover, the slavery of working vessels through the tunnel is much greater than working upon the hulks, as the men have generally to lie on their backs, and paw with their feet, against the top, or sides of the tunnel for three hours and upwards, till they have pushed the vessel through.

Mr. Outram laid the foundation of the abutments of the locks of this canal very short towards the hill, and kept setting them back, as the lock side advanced, until the extremity of the abutment at the top was, perhaps, nearly four feet beyond the original foundation, at the bottom; and though he was told what the consequences would be, he rejected all admonition.

The next great error he committed in the building of these locks was the conveying of the water, that passed over the waste weirs at the head of them, through a covered channel, perhaps two feet deep, or upwards, close to the backing of the lock; and as these channels were little better than a rubble wall for turning water, it got among the backing, and in some places forced its way through the face of the lock; and when the frost came, almost rent them in pieces; these miserable abutments broke off close on the back side of the lock, which, at last, became little better than a heap of rubbish, and were taken down in the manner I have before described. Besides, they are so improperly placed, that some of the pools are as short as the masonry of the locks.

The next injury done to the locks by the engineers was the improper placing of the cloughs, which have been taken out, and others put in, upon a better principle.

Does not all this prove the necessity of what I have so strongly recommended, that acting committees for canals should understand the principle of them, before the spade is put into the ground; for had that been the case with the committee of this canal, such ruinous work would not have been made, nor so many errors committed as there have been.

The business of an acting committee for a canal is laborious, and when they enter upon it entire strangers to the principle of a canal, the difficulties they labour under are many and great, and what is still worse, they have no means of getting instruction.

If a good practical treatise had been written thirty years ago, upon the principle of a canal, shewing how its works should have been executed, it is not possible to conceive what it would have been worth to the kingdom; as it would have saved a vast number of canal subscribers from ruin.

This canal is little more than nineteen miles long, as before stated, and yet, if interest is allowed on the principal while executing, I have no doubt but it has cost nearly if not more than £25,000 per mile. Such an expensive narrow canal as this, I think, was never heard of in the world before, and, I am inclined to think, the present generation will not split upon a similar rock.

It is well known that money doubles itself in less than fifteen years, and I calculate upon the whole estimate being spent in less than four years, so that at the end of eighteen years, nearly twice the estimate would be sunk, supposing no fresh calls had been made under a new act of parliament.

Twice the estimate will be £366,000, and if there has been only £109,000 advanced more than the original estimate, it will make the expense of executing nearly £25,000 per mile; but I should think there has been more than this sum advanced, and if so, the estimate is so much too low; and if sufficient reservoirs were made, and those parts of the tunnel arched that appear to require it, and all the locks and works properly repaired, I am of opinion, £30,000 would be inadequate for it. It is a question of great importance, whether it would be prudent to expend this sum upon it. If I am not mistaken, there is £30,000 of debt that the company wish to discharge, and which will require them to have £60,000 at command, if they mean to make any thing of the canal. The Rochdale canal will now be amply supplied with water, and the same must be procured for this canal, or the company had better shut it up, and I consider from £15,000 to £20,000 a low estimate for that purpose.

That the company have no means of raising this sum of money, or any thing like it, without a fresh act of parliament is certain; and the clauses which the mill-owners intend to have inserted in the bill, would be the ruin of the undertaking; for the company had better shut it up than comply with those demands; but by proper management, they may easily get rid of them.

There is one thing which requires the company's consideration, before they lay out such a sum of money upon their works as is necessary, if they are to be continued in a working state, and that is the new projected canal from the river Dun to Sheffield, which I understand is only about four miles long; but the act is obtained with a view to extend it to the Chesterfield canal, and then the water communication between Wakefield and London, it is stated, will be as short as the turnpike road.

That such an extension of the Sheffield branch will take place, I think there is not a doubt, which will prove most injurious to both the Huddersfield canal and the Calder and Hebble navigation, and to a much greater extent than those companies are aware of.

The competition among canals, which is great and still increasing, will be very injurious to them; for the country will soon, in my opinion, be as much over stocked with them as it is with machinery. Rival canals are serious things for the subscribers, as they are so expensive; and as they increase, the price of land, labour, and materials increase also, whilst the means of payment decrease in the same proportion, by dividing the tonnage; and the lowering of the dues follows, with a view to procure more tonnage.

From a careful examination of those canals, as well as river navigations that pay well, it will be found that they have, in general, been executed at an easy expense; the most striking instance of which in the kingdom, I am inclined to think, is the Ayre and Calder navigation, which is nearly sixty-four miles long, and when first opened cost only £17,000, about one hundred and twelve years ago. This small sum ruined the subscribers, who were Dutch merchants, and the navigation and its works were sold under a commission, and so became English property. The original shares have, for twenty years, paid full £100 per cent, and had it not been for an imprudent lease which the company granted to a person who had improved the navigation, the shares would probably have paid £130 per cent; but to get possession of the lease, they agreed to give him £10,000 per annum, as one of the share holders informed me

Duke of Bridgewater's Canal.

This canal is certainly one of the most extraordinary productions that was ever designed by any one man, or perhaps ever will be; and more especially, when it is considered, that it was executed by the private fortune of an individual. His numerous and lofty warehouses, extensive wharfs, docks and basins, are more like the storehouses and conveniences for a royal navy, than auxiliaries for a canal.

What is still more extraordinary, this great design originated in the mind of the noble Duke, and was executed at a time when the principle of a canal was very little understood; and so long as trade, commerce and agriculture remain, he will live in his works, which are the best monument that can be designed for that purpose. But what was most meritorious in that great personage, was his humanity and liberality in making provision for his servants, whom age or accident in his works had rendered unfit for service.

Although this canal is so much superior to canals in general, yet, like all other human inventions, it has its imperfections; for the principle upon which the locks at Runcorn are built, is extremely improper. The injudicious placing of them, and their great rise, prevent that facility to the trade which the public might reasonably expect, and which it will be the interest of the noble owner to afford.

At the top of that chain of locks there are four combined together, afterwards they are all single, except a double one that locks down into the river. Those locks appear to be twelve feet rise, and were designed by the late Mr. Brindley, who, in combining the locks, copied the errors of his predecessor Mr. Smeaton.

I estimate a lock chamber to be 81 feet 6 inches long, 15 feet wide, 12 feet rise, and to contain 14,670 cubic feet of water, equal to nearly 407½ tons; and if one vessel ascends the lock singly, that is, if the water is not left in the locks for a succeeding vessel, full 36 tons of water will be consumed in carrying 1 ton of goods through them supposing the weight of the cargo to be 45 tons; but were they disposed in single locks of 8 feet rise, and proper basins between them six tons of water would be sufficient to navigate one ton of goods. But as the water is generally left in the lock chamber for the succeeding vessel, this great waste is in some degree prevented; still a much greater portion is consumed in passing them than ought to be.

It has often surprised me that the late Duke did not make a new range of locks, and save the great loss of time, and the many inconveniences that attend navigating through the present locks. It was the want of due consideration in the engineer, and not any thing in the ground that required those combinations; for by changing the line a little, he might have had proper basins between each of them.

A new range of locks may be made without any loss, and if the rise of them was only 8 feet, with proper basins between them, not more than one-third the quantity of water would be required to navigate a quantity of tonnage, equal to what now passes. For in the first place, there would be one third saved in the rise of the locks, and one third more that is unnecessarily consumed by their being combined. So large a quantity of surplus water would then be to be disposed of, as would more than pay the interest of the money sunk in making the deviation; and the less the rise of the locks, the greater would be the quantity of disposable surplus water. That fall might be divided into three equal parts for three separate mills, each having twenty-four feet fall, and for the grinding of corn, slitting and rolling of iron, or working large forge hammers; for chipping and rasping dying wood, or grinding flint, and for a variety of other things that require great power, I think there is not such another situation in the county of Lancaster; as every article may be brought by water, and conveyed from thence to any part of the kingdom; moreover, it is nearly in a central situation between the towns of Liverpool and Manchester. A power equal to that which the surplus water would give, could not be had by steam for £1,500 per annum, including interest of the money sunk in erecting the steam engine, and all the requisite buildings.

I understand Mr. Bradshaw has the sole management of that canal, and as the many judicious arrangements which he has made, for the better accommodation of trade (for which the public are much indebted to him) bespeak him to be a man of business, I think he cannot be a stranger to the great and many inconveniences which the trade on that canal still labours under from the combined locks; and as this is the only imperfection in the works of his noble friend and patron, I make no doubt he will give the public another proof of his liberality and readiness, on all occasions, to accommodate trade in the best possible manner, by removing that great obstruction to it, and make that canal the most complete of any in the world.

This deviation would not be attended with any loss of time, nor in the least incommode the trade on the line whilst the new works were executing.

The whole fall at moderate water is seventy-two-feet, as I was informed when at Runcorn, twelve feet of which are already disposed of by locking down from the great basin into the river, so that only sixty-feet remain to be divided among eight locks, each seven feet six inches rise.

I estimate the whole length of the masonry for a lock at one hundred and twelve feet, eight times this will be eight hundred and ninety-six feet, equal to nearly two hundred and ninety-seven yards, these deducted from one thousand yards, the length that may be had for the locks and basins, leave full one hundred yards in length for each basin. The basins should be square at both ends and walled round, and should all be twenty-one yards wide, which would admit of two vessels in length being moored on each side, and leave a free passage to navigate between them; and would prevent the great basin from being over much crowded with vessels, as each pool would admit of four vessels to lie without any inconvenience to the trade, and thus render unnecessary any farther enlargement of the great basin, however much the trade might increase. If this line is judiciously laid out, I think it should be in the form of a crescent after the first lock, with its back rather towards the river, and the inside facing the present locks. This figure I think will best comport with the ground and the great basin below it, and the locks should be at an equal distance one from another, which will require some extra digging for the first lock pit, and from three to four feet extra digging from the first to the second lock pit, and probably a small portion from the second to the third lock. If this plan is not adopted, the first and second pools would be twice as long as they ought to be, and all the rest would be much too short, owing to the descent towards the bottom end of the line, being nearly double to that where it will commence. Thus the ground will be made to give way to the locks, and not the locks to the ground; for that fatal plan, upon which canal locks, in general, have been built, has caused many of those contracted basins with which they so much abound.

The line should end in the upper large basin, and not in that through which vessels generally pass into the river, for at present it would save a lock building; yet a convenience should be made, that at any future period an easy communication may be obtained with the lower basin. Thus may a safe, easy, and expeditious ascent be obtained, without any loss of time, or any extra waste of water ; and what a pleasing sight would it be to see the immense tonnage, that would be navigated through those locks, pass and repass with the greatest regularity, and without the least interruption.

If a new range of locks were made, as proposed, an equal quantity of tonnage, to that which is now navigated through the present locks, would pass the proposed new ones in one-fourth of the time that is now spent in ascending that summit.

This great improvement would seriously affect the old river navigation, which is subject to the inconvenience of entering the tideway so much higher up the river, and above Warrington, has to contend with the floods in winter and a scarcity of water in summer, two great enemies to navigation, yet both equally unknown to the noble marquis' canal.

Independent of the benefit arising from the letting of the surplus water, there is not the least doubt, but the additional tonnage that would come upon the canal, would pay ample interest for the money that might be sunk in making the proposed deviation.

The late Duke's canal has a summit level, as his servants informed me, of full sixty miles, and if the under ground tunnels at Worsley are any thing like what they are stated to be, there can be no doubt of that length of a level.

It is no matter of surprise, that such stupendous works should have paid his Grace so well, as all his coal is put into the vessels without extra expense; and moreover, his canal was executed at a time when land, labour, and materials were cheap, and his dues on freight were fixed to correspond with the times.

The Rochdale canal is thirty-three miles long, and has ninety-two locks, as before stated, yet here is a canal sixty miles long with only seven locks. What a vast difference there must be in the wear and tear, servants' wages, &c. of these two canals.

But so unbounded have the speculations in canals been, that neither hills nor dales, rocks nor mountains, could stop their progress, and whether the country afforded water to supply them, or mines and minerals to feed them with tonnage, or whether it was populous or otherwise, all amounted to nothing, for in the end, they were all to be Bridgewater canals. His

Grace's canal has operated upon the minds of canal speculators, much in the same manner as a large lottery prize does upon the minds of the inhabitants of a town, which has had the misfortune to be visited with such a calamity.

A few years ago, a bill was brought into the House, to enable the trustees of the Duke's canal and the proprietors of the Leeds and Liverpool canal to form a junction, by means of a canal of about eight miles, between Leigh and Wigan, or its neighbourhood, with a descent of two locks into the Duke's. Why the bill did not pass into a law, is not for me to enquire; but should that communication be made, it would give Mr. Bradshaw, (whom I have not the pleasure of knowing) such an extensive command of inland navigation, as no man in this kingdom ever possessed before; and assisted with the proposed alteration of the locks at Runcorn, would secure to that gentleman most of the carriage of merchandise between Manchester and Liverpool, and that of the packet boats also; for all opposition would be fruitless.

The benefit that would accrue to the public, and the great and many advantages that commerce would receive from it are not to be enumerated; for want of water, or any inconvenience from excess of it; contrary winds or neap tides would be no more known; as the time of the going and returning of vessels to and from Liverpool, would be as regular as that of the mail coach.

Should this plan be adopted, it would render coaches between Manchester and Liverpool almost unnecessary; for the packet boats would perform their business with equal regularity, with much more safety, and be far less expensive. It is said that ten coaches per day go from Manchester to Liverpool, and the same number return, besides the mail coaches.

This plan would save the keeping of nearly two hundred horses, and I estimate the average number of passengers at ten per coach equal to two hundred per day, and take the mean of their fare at 6*s*. each, which would produce £60 per day, and £420 per week; and allowing the coaches to run fifty-two weeks, that is all the year round, they would yield a revenue equal to £21,840, and one-fourth more I think should be added for the carriage of parcels, which is £5,460, making in all £27,300 per annum. Whether the sum set down for the carriage of parcels is not too much, I cannot say, but I think that for the passengers too little.

I will now estimate the average charge of those who may travel in the packet boats at 4*s*. and calculate upon three fourths of those that now go by the coaches going in the packet boats, though I have no doubt, but in a little time, they would nearly all go in them; and those that travel in the packets, as well as those that navigate on the old river, would be transferred to this canal.

Though I have estimated the loss at one-third of the coach passengers for a time, yet those that would be gained by the said transfer, would do much more than compensate for the loss; and therefore I shall estimate upon two hundred and forty persons per day going to Liverpool, and an equal number returning.

If two hundred and forty persons per day pass in the packet boats at 4*s*. each, they will produce a revenue of £48, for the week £336, for the year allowing forty-eight weeks to be navigated £16,128, and if one-fourth more be added for the carriage of parcels, the sum total will be £20,160.*

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* Above sixteen years ago, it was stated by a writer upon canals, that the packet boats which pass between Dublin and Munster haven a distance of forty-one English miles, pass through eighteen double and six single locks, which are equal to forty-two single ones; but notwithstanding this, the packet boats raise a gross revenue

If this communication should not be made, and a broad canal should be projected from Manchester to Liverpool, forty-eight to fifty feet water surface, six feet deep, (and I am inclined to think, a line might be found that would not require a lock) with a towing path on each side; and vessels going from Manchester taking the right hand side, and those from Liverpool the left, to prevent loss of time and inconvenience in meeting; and if nothing but cotton and the packet boats came upon it, probably no modern projected canal would pay like it; but if coal and merchandise were carried upon it, I think no canal in Europe would equal it.

I have stated the fare for the packets low; yet if such a canal was executed, I have no doubt but the revenue arising from them would far exceed my highest estimate.

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of £14,000. Now if such a revenue as this can be raised from packet boats that make one trip per day, through a rise and fall of about four hundred feet (for I suppose there is a summit) what may not be done with the packet boats that are proposed to pass on the Duke's canal, and that of the Leeds and Liverpool; and more especially, as the population of the towns of Manchester and Liverpool, and that of the country through which they may pass, is so great, and their trade and commerce so very extensive, having only to pass a rise of two locks, equal perhaps to twenty feet. With every effort that can be made to pass that immense rise and fall, it will require full three hours and a half, while passing the said two locks, according to this calculation, would only require about ten minutes and a half.

It is for the interest of the two parties to make the junction upon a liberal plan for the public; as the revenue that would arise from it, would far exceed their most sanguine expectations, and would supersede the necessity of another water communication; but it may be adviseable to have a short cut from the canal at the Liverpool end, to make the approach to and from the centre of the town as convenient as possible. This communication would, in my opinion, produce a greater revenue to the Leeds and Liverpool canal company, than ever will be raised from the west end of the tunnel to Wigan, a distance of nearly fifty miles, upon which I should suppose full £400,000 (including loss of interest on the capital) have been expended.

From the depredations committed upon cotton, when carried from Liverpool to Manchester by water, the cotton dealers have been under the necessity of having it carried by land, to the great loss and inconvenience of the trade. This is not to be wondered at, seeing it affords such an opportunity of pilfering, when vessels pass in the night from Liverpool to Runcorn, or are detained by neap tides and want of water.

But if the said short cut was made to join the Leeds and Liverpool canal, all the cotton might come from Liverpool to Manchester by water, and in less time than it now does by land, with one half the expense.

I estimate upon forty thousand tons of cotton annually coming from Liverpool to Manchester, by water, and if the dues and freight are taken at 5*d* per ton per mile, it will be a net average of 16*s*. per ton, equal to £32,000 per annum. And suppose the distance to be forty-two miles, if the dues are taken at $1\frac{1}{2}d$ per ton per mile, a revenue of £10,500 per annum would be raised from the carriage of cotton only, and the carriage of other goods would be great.

If the cotton were carried in narrow vessels, they might at all times, (frost excepted) make a trip from twelve to fourteen hours, and carry twenty-five tons burthen, which might be partly cotton, and partly other goods, as a vessel would not contain this weight of cotton, unless in bales; but that they might carry more than usual, I would recommend them to be made from eighty-one to eighty-two feet long, and add six inches extra to the width, and by changing the horses once, and having always two to a vessel, they would make a trip per day with ease, for a horse would not have to travel more than seven hours per day; and to say this distance cannot be travelled in the time I have allowed, would be to assert what daily experience confutes. Having two horses to a vessel, would not increase, but rather reduce the expense of freight.

Narrow vessels will navigate nearly one-fourth quicker upon a broad canal than upon a narrow one, having much more water surface and greater depth; and they will navigate full one-third quicker upon a broad canal than large vessels can.

I would recommend all mercantile goods that pass between the two said towns on these canals, to be carried in narrow vessels; and to prevent any time from being lost by two of them passing a broad lock together, or by waiting one for another, I would make two short side cuts near the broad locks, and build two narrow locks upon them, and then narrow vessels might pass singly without any loss in time or waste of water, and the large vessels would pass the broad locks as usual. Thus would a convenience be made for both broad and narrow vessels to pass without the least interruption, and enable the packet boats to travel at the speed of from five to six miles in the hour, by dividing the ditance into three stages. The number of packet boats that would be required to pass and repass per day, I should suppose would be two each way, but three may be found necessary; for they should not be made too large, and to assist them in sailing they should be either made of copper, or sheathed with it, which would make them move much quicker, and require less power to work them.

A very different arrangement should be made in packet boats, to suit persons of different taste and circumstances, by making separate divisions in them, for that purpose; as one half of them might be fitted up in a superior style, very different from what they are at present, and no more time should be wasted in stopping at various places than what is allowed for the coaches.

What a vast advantage would these packet boats have over the coaches with respect to personal safety; and how much more comfortable would the passengers be in winter, than being exposed to hail, rain, frost, and snow, on the out-side of a coach, and to the scorching beams of the sun in summer; and the luggage would be carried with much more safety, as it would not be so injured by being kicked and tossed as it is in the boot of a coach.

What makes travelling in packet boats so unpleasant and inconvenient is, the great waste of time in stopping at so many places, and the passengers being so promiscuously mixed together; for there is not that distinction made in them that the different gradations in society require, which prevents that social interchange of sentiment which, in travelling, makes time pass imperceptibly away. And perhaps the best way to remove this inconvenience would be to finish two packet boats in a superior style, and have a stove in them in winter, and charge each passenger, one shilling more for the fare. It ought to be the study of the owners of packet boats to make the situation of those who travel in them, as near like that of their own house as possible; and there would be little difficulty in doing this, if the plan was properly arranged.

These necessary regulations and accommodations have hitherto been too much neglected, the principal cause of which has been, that the revenue arising from packet boats, has been treated as a secondary, or accidental thing when compared with that which arises from the carriage of goods; but there is a capability of making the revenue arising from the packet boats of the first consequence to the proprietors.

Where a packet can only make part of a voyage in one day, being detained by natural causes, the utility of travelling in them is greatly diminished; but the packets that would pass upon these canals, would not be liable to this great inconvenience.

The approach to, and under, as well as going from the bridges, would require sinking from twelve to sixteen inches, but should descend gradually both ways toward the bridge; and the towing path under it should be sunk as above, to prevent misfortunes when passing so quickly under it, yet the towing path should then be as free from water as it is now.

A new system of designing, executing, and conducting canals, as well as for that of packet boats, is sure, ere long, to take place; and who is so proper to take the lead in this great work as Mr. Bradshaw?

Estimate of Capital required, and of the annual Expense of four Packet Boats.

I calculate the average weight of twelve persons at one ton, and that a packet boat will comfortably accommodate one hundred and twenty persons in the inside,* which will be ten tons, their luggage and parcels two, making in all twelve

* That this calculation is under-rated will appear from the fact, that, a packet, worked by steam and accommodating four hundred passengers, with many heavy packages, passes regularly between Hull and Gainsborough.

tons; not equal to half a boat load. As the packet boats will be freighted so light, there can be no doubt of their travelling at the speed I have stated. I estimate only on 48 weeks in the year to navigate, but allow wages for 52.

The weight of the cargoes of the four packet boats will be 48 tons per day, the length they will navigate 42 miles, and the dues at $1\frac{1}{2}d$ per ton per mile, £12 12*s*; per week £88 4*s*; and per year £4,233 12*s*.

	Capital.		£.	s.	d.
Tonnage as above,			4,233	12	0
Building five packet boats, £350 per,	£1,750	interest 8 pr. ct.	140	0	0
Twenty-four horses required, but will allow 36, £35 per,	£1,260	do.	100	16	0
Harness for 24 horses, £5 per,	£120	do.	9	12	0
Building four stables for the horses, £400 per,	£1,600	do.	128	0	0
Four men's wages for taking care of the horses, 28*s* per			291	4	0
Twelve boy's wages for riding the horses, 16*s* per,			499	4	0
Shoeing the horses, candles, &c.			175	0	0
Farrier's bill,			40	0	0
Saddler's bill,			50	0	0
Porter's wages, each 24s per,			124	10	0
Wages of 4 persons attending the packet boats, to receive money, 30*s* per,			312	0	0
Unforeseen contingences, 150 per annum,			150	0	0
To receipts, £20,160		Sum total of outgoings	6,353	18	0
Manure by the Horses 60		Net income	13,866	2	0
£20,220	£4,730		£20,220	0	0

I have estimated nothing for out-side passengers; they probably would be equal to forty each packet, being one-third the number of the inside passengers, and if these were only charged 2*s* 6*d* per, it would produce £6,720 per-annum. It may be said, that if such a number were added to a packet it would retard the speed, but this objection may easily be removed by an additional horse, which would increase the speed; for the addition of forty persons would only make the whole cargo equal to about fifteen tons burthen, which would be five tons for one horse; but daily experience proves, that upon many narrow canals twenty to twenty-two tons are drawn by one horse, which travels two and a half miles in the hour But I should prefer having six packets, one each way for the labouring class and heavy parcels; and have no doubt, if a thoroughfare canal between the said towns was made convenient for packet boats, and a proper system for the management of them adopted, that six packet boats would produce a net revenue of £20,000 per annum. I have allowed ample wages for the servants, that the passengers may not be called upon to give any thing, except for the carriage of luggage to and from the boat.

See further observations on the above canal, page 410.

LANCASTER CANAL.

LANCASTER CANAL.

This canal is one of the most extraordinary productions that ever was exhibited to public view, whether we consider the laying it out, the estimate for executing, or the quantity of tonnage, supposed to be upon it; and if the multitude of errors that have been committed will not make subscribers more cautious hereafter in chusing a line of canal, it will shew that they are not capable of being improved by the errors and misfortunes of others.

This canal is a broad one, about eighty-one miles long, including the branches; fifty-six on the south of the Lune, with the proposed branch to Chorley, and about twenty-five on the north of that river, leading to Kendal; the survey and estimate were made by Mr. Rennie. The estimate for executing the whole line and branches was *£372,777*, but the engineer informed the committee, that he had made it upon so liberal a scale, that there would be a surplus of £70,000 for the part south of the Lune, when all the works were completed; the estimate for which was £316,860 9*s.* equal to 85 per cent for that part, agreeably to the act; the remainder of 15 per cent was to finish the north side of the river to Kendal. It would have been a fortunate circumstance for the subscribers to this canal, if the engineer had surveyed the country with more attention; for if he had carefully examined the great advantages which would have attended the making this canal narrow, and that the communication with the Duke of Bridgewater's canal, might have been made so much more easy than by the line he laid down, (which was extremely inconvenient, and insupportable with regard to expense, by having to lift the water so high to supply the summit) he must have been convinced, that not only the level, but the principle of the canal was wrong.

Had this canal been made a narrow one, the saving to the subscribers (according to the difference in expense, calculated by the same engineer, in making the Rochdale canal narrow) would have been full £176,942, without including the extension; and if ever there was one canal in the kingdom rather than another that should have been made narrow, it was certainly that of the Lancaster for two reasons; 1st. as nearly all the tonnage will be lime, coal, and slate, a narrow canal would have been much more proper for the carriage of these articles than a broad one; 2d. as this canal communicates with no other, the expense of unloading goods could furnish no plea for making it a broad canal.

But perhaps it will be said, though the plan for this canal was not at first laid down to join any other, yet it was always the company's intention to make a communication with the Duke of Bridgewater's canal, and by that means with the Staffordshire canal, and all the southern parts of the kingdom. That this was the company's intention in the outset of the business I think there can be no doubt, and is the strongest reason why this canal should have been made narrow; for if ever it is made to communicate with his Grace's canal, goods must be unloaded when they enter upon the Staffordshire canal.

If this canal and the proposed extension had been made narrow, it would have saved the company nearly £200,000, and goods would then have gone from Kendal, and that part of the country, full two hundred miles without unloading; but by its being made a broad canal, they must now be unloaded about midway; and all goods going from south to north will, in consequence, be subject to the same inconvenience.

Suppose the low line that has been talked of had been taken at the first, and the canal made narrow, goods might have gone to Wigan, or Worsley, and Manchester, by his Grace's canal, or to Liverpool without unloading, or wasting any extra quantity of water in lockage; and still the canal from Wigan to Worsley might have been made a broad one; for nothing would have been required but making a short side cut, and a narrow lock near each broad one, and I think not more than four would have been required, and then narrow vessels might have gone to all the before mentioned places without any inconvenience. If the committee of this canal would seriously reflect upon the errors they have been led into, and the prodigious sums of money that have been wasted, I think they will be convinced, that the saving by a narrow canal would not have been less than what I have stated.

It is worthy of remark, that the engineer's estimate, if I am not mistaken, was about £25,000 for crossing the Lune valley, and for crossing the Ribble valley about £60,000; but experience has proved the fallacy of the former estimate, for it is now certain, that crossing the Lune, has cost near £60,000, not including the loss of interest on the capital, and it is the opinion of some able engineers, that crossing the Ribble will cost treble the estimate, for it is near three times as broad as the Lune valley, and about ten feet deeper; so that crossing the two vallies, though not a mile and half in breadth, is estimated at £240,000. I estimate on eight years being spent in crossing the Ribble valley, which is allowing much less time than has been spent in crossing the Lune valley, in proportion to the difference in the width and depth of them; four years interest on the capital for crossing the Ribble, and eighteen months interest on the capital for crossing the Lune. Four years interest on £180,000 is £36,000, and eighteen months interest on £60,000 is £4,500, making in all £40,500, which added to the principal, makes the whole expense equal to £280,500, and for less than this sum, I am certain the two vallies will not be crossed; but if the work in the latter be executed in the same manner as in the former, I am confident they will not be finished for any such sum.

Crossing the Ribble at Preston has, by most professional men that have seen it, been looked upon as one of the most wild, extravagant, and undigested schemes that ever was designed.

I think no man of experience and deliberation would ever propose to cross only two vallies at the expense I have just mentioned, or even one half of it; because no scheme of this kind can bear such an insupportable burthen, without being very injurious, if not ruinous to the undertaking; especially when, by a judicious deviation of the line, the greatest part of this unparalleled expense might have been avoided, and the canal much better supplied with water.

Every one may not perhaps know, that when the act was applied for, one of the members in the committee of the house of commons reprobated the fallacy of the estimate in question, and shewed the inutility of the scheme throughout; and time has fully proved what he then advanced.

The engineer estimated, that 300,000 tons would be annually carried upon this canal, and that the expense of lifting the water would be £1,700 per annum, which is equal to sinking a capital of £34,000; but if the expense of erecting steam engines, and putting down the pumps, driving a tunnel from the Ribble to convey the water past the last lock in the ascent, sinking pits for the engines, wear, tear, coal and wages for the engines, which must have been worked day and night in dry seasons, be taken into the account, this estimate for lifting water, will be found as fallacious as that for executing the canal, being only about one-third of what it will cost; however, I will only estimate it at £4,000 per annum, equal to sinking a capital of £80,000; but this sum would have been found very deficient for raising lockage water for the tonnage he estimated upon.

Here is a new phenomenon in the history of canals. From Preston, to where the canal has for some time remained stationary, is a fine level country, very friendly to a line of canal, crossing the Lune excepted, a distance of near forty miles, in which there is no lock, and many principal feeders are taken in to supply it with water; but notwithstanding this, when it was opened, the committee soon found that it could not be navigated without a better supply of water, for they were under the necessity of making a cut and tunnel from the Ribble to the head of the canal, and erecting a fifty horse engine to pump the water in dry seasons; and the person who takes care of it informed me, that it was with great difficulty he could maintain a proper depth of water in the canal. I estimate the expense of erecting the engine, and every other expense, including wear and tear, coal and wages, equal to sinking a capital of £15,000, which added to £80,000 before stated, would make the whole expense of supplying the canal with water amount to £95,000.

Obtaining the act, which was attended with great opposition and heavy expense, and afterwards getting fresh powers to alter and amend the line, and correct some of the many errors that had been committed in laying it out, and for raising more money, I estimate at £12,000, though I think it is much under rated, making in all £384,000. So far from the engineer having a surplus of £70,000, after finishing the works on the south side the Lune, his whole estimate, including the pretended surplus, would not have executed the line across the two vallies, supplied it with water, and allowed interest on the capital while executing.

The vessels are intended to carry fifty tons burthen, and I estimate a lock chamber to be seventy-six feet long, fifteen feet six inches wide, and ten feet rise, which will contain full three hundred and twenty-seven tons of water, and require six and a half tons of lockage water to navigate one ton of goods through a single lock; but not less than two locks full of water will be spent in carrying a vessel through that chain of locks, admitting both them and the cloughs to be in the best condition.

In consequence of the runs from the gates and the cloughs, and the upper gates not being shut in time before those of the lower gates are drawn, two locks full of water will be found necessary to carry a vessel through, including waste, by leakage, soakage, and evaporation, even with leaving the water occasionally in the lock chamber for the succeeding vessel. According to this statement, thirteen tons of water will be spent in carrying one ton of goods through those locks, and then there is the allowance to make for the coal and other vessels that will return empty, and the number of these will be great, as little lime will cross the Ribble after the Leeds and Liverpool canal is finished, supposing that of the Lancaster to be finished.

The coal vessels from Garstang and Preston would generally return empty; and that the waste of water occasioned by it may not be over rated, I will take the average at only two tons, making in all fifteen tons that would be consumed in carrying every ton of goods that passed those locks. The rise of the locks might be reduced two feet, which would require less lockage water; but it is a matter of doubt, whether for that situation such a plan would be adviseable, still that would not make the consumption much less than what I have stated, owing to the vast number of empty vessels that would pass them.

I estimate upon forty-two weeks in the year to navigate, equal to two hundred and fifty-two days, which would require 1190½ tons per day to pass on the line, according to the engineer's estimate of the quantity of tonnage, and if these are multiplied by 15, the supposed number of tons of water that will be required to be lifted per day for every ton of goods, the product will be 17,852½, per week 107,115, and per year 4,498,830 tons.

Admitting the coal to cost 6*s* per ton when laid down at the engines, I will thank the engineer to shew how he could raise this quantity of water, including every expense, for £6,000 per annum. I have entered more fully into these calculations, to guard canal subscribers from being misled and imposed upon by such plans, surveys, and estimates.

Let any reflecting man, that understands any thing about a canal, place himself at or near Redburn-brook, and view the proposed line of canal across the Ribble, and he will almost shudder at the proposal of such a wild romantic scheme, as crossing that valley by an aqueduct, and pumping water for that immense rise. There is but one excuse can be made for the engineer's proposal to pass that valley, which is want of experience and knowledge of the principle of a canal, the expense that attends the execution of them, and the quantity of water required to supply them, when he made that survey and estimate, which was nearly at the time he surveyed the Rochdale canal.

In a committee of the house of commons sitting upon the Rochdale canal bill, the engineer, in his cross examination, admitted that he never had executed a mile of canal, or built a single lock, and this may, in a great measure, account for his extraordinary surveys and estimates at that time.

Had not that valley been crossed by a railway, the canal must have been ruined; and I apprehend, the commmittee and the head clerk have not forgot who proposed the plan, and made the estimate gratis.

The engineer estimated upon an immense tonnage of lime for the country on the south side the Ribble; but that this estimate was as visionary as his others a few observations will shew. The place from whence the best lime comes on the north side the Lune to Preston, is nearly 40 miles, and from Preston to Mr. Hailey's house, where the Leeds and Liverpool, and Lancaster canals come nearly close together, is about six miles, making in all nearly forty-six miles; but from Rain-hall lime rock, by the Leeds and Liverpool canal, to the said house, is only about thirty-eight miles.

The coal to burn the lime north of the Lune, must be carried forty-six or forty-eight miles by water, or from ten to near twelve miles by land, but the coal for burning the lime at Rain-hall, is got within a few miles of the place; as the country from Colne to Burnley is all full of coal, and as the Leeds and Liverpool canal company get their lime at much less expense than that which is burned north of the Lune, they can afford to carry it much cheaper, having no water to lift.

Hence it appears, that when the Leeds and Liverpool canal is finished, the lime from Rain-hall may be sold, on the south side the Ribble, near 15 per cent cheaper than that by the Lancaster canal, (supposing the Lancaster canal to have been finished) and about 7 per cent. cheaper in Preston market; but it will not be the case now, as it will have to go by the railway. Here then is an end of the visionary estimate of revenue, supposed to arise from the carriage of lime for the country on the south side the Ribble.

But the public curiosity will still be much more excited, when I inform them, that there is a sufficiency of good lime a few miles from Preston, that would supply the country on the south side of the Ribble for a thousand years; for I have surveyed that part of the country where the lime-stone is got, at the request of a certain nobleman, who has large estates in that neighbourhood, and when going from Preston to the lime rock, not more than a mile from the town, I met six or seven carts loaded with lime, and soon after four or five more.

Surely there never was such infatuation as this before; to make a canal at such an enormous expense, and pump the water for carrying lime near forty miles, for Preston and that neighbourhood, and yet have such abundance of it within a few miles of the town; (exactly similar to the canal Mr. Chapman designed for supplying the country on the north side of the Tyne with lime) what is still more surprising, if any thing can be, is, that this canal runs the distance the lime is carried for Preston parallel with the sea coast, and in many places not far from it.

The carriage of lime was the grand pillar that supported the mighty fabric, but behold!

it is fallen, and all the engineer's pompous estimates of revenue to arise from the carriage of it, are buried in the rubbish?

If the carriage of lime by the Lancaster canal be cut off from the lands south of the Ribble by the Leeds and Liverpool canal, it must greatly increase the price of coal at Preston, Garstang, Lancaster, and Kendal, by the vessels north of the Ribble going empty one way, and the waggons on the railway south of the Ribble being in the same situation.

A very little attention was required to have satisfied the engineer, that his estimate of revenue to arise from the carriage of lime was without foundation; for there can be no doubt of his having the plan of the Leeds and Liverpool canal, with the Rain-hall lime rock marked upon it, and also the distance from thence to the said Mr. Hailey's house; and he might easily have got the price of the lime at both those places; for he must have the distance from the lime rock on the north of the Lune to the said house marked upon his own plan; and yet, with all this plain information before him, he made that fictitious estimate of large revenue to arise from the carriage of lime.

And was it not equally plain, that the great revenue the engineer calculated upon to arise from the carriage of coal would be nearly as visionary as that for the carriage of lime, as they must, in a great measure, stand or fall together; for if the carriage of lime be lost for the country south of the Ribble, it will greatly increase the price of coal by the vessels going empty for it.

But as the demand for coal was supposed to be so great for Preston, Garstang, Lancaster, and Kendal, and its vicinity, the engineer and the committee for this canal, began to be apprehensive (or at least they pretended to be so) that the coal mines on the south of the Ribble might be exhausted; more especially as the two canals run parallel to each other for seven miles, and at different places very near each other; and as the Leeds and Liverpool canal was likely to take a large quantity of coal from the same mines as the Lancaster canal, it was judged necessary to throw out the bill for the deviation of the Leeds and Liverpool line, and petitions were presented for that purpose; the engineer appeared to support the allegations, and to prove, that if the said bill was permitted to pass into a law, the coal mines, where the said canals run parallel, would soon be exhausted.

The friends of the bill anticipated the nature of the engineer's evidence before he gave it, and the trap in which he was caught was most judiciously baited. The first question was, what was the average thickness of the various coal mines in that part of the country where the two canals ran parallel, which witness stated to be about forty-two feet; and in this he was correct. The second question was, what might be the average distance between the two parallel canals for seven miles; and after a variety of questions being put respecting this, the witness admitted it to be three quarters of a mile.

The counsel then asked the witness, if double the quantity of coal estimated to be carried by the Lancaster canal were added to the large quantity proposed to be taken by the Leeds and Liverpool canal, what number of years would be required to get the coal that lay between the two said canals? The witness said, he was not prepared to give that information, as it depended upon calculation

Lord Derby, who was chairman of the committee, ordered the witness to withdraw into another room, to make his calculations, and inform the committee what time would be required to get the said quantity of coal, which he did, and after some time returned, and said, to his great surprise, he found it would take four thousand two hundred years; to this Lord Derby replied, with a smile, Mr. Rennie, it is quite long enough for a coal mine to last.

The quantity of tonnage estimated to be annually carried upon the Lancaster canal, was 300,000 tons, as I have before observed.

If the average of the dues is taken at $1\frac{1}{2}d$ per ton per mile, the dues for the carriage of one ton of goods the whole length of the line would be 10*s* $1\frac{1}{2}d$. but I will only call them 10*s*; and if the tonnage estimated upon was to pass on the whole line, it would produce a revenue of £150,000 per annum; but as that would not be the case, I will take the average length at one half of the whole, which I conceive to be a fair estimate, as the principal tonnage will always be coal; and there is no doubt but it will, on the average, pass more than one-half the length of the line; but more especially, as Lancaster is nearly half the length of the line, from the coal mines and Kendal, at the extremity of it.

Half the above revenue will be £75,000 per annum, and if the quantity of tonnage the engineers estimated upon, was to pass only one-half the length of the line, and take the tolls as before stated, the same as those for the Leeds and Liverpool canal, they would have paid off the whole sum estimated to finish the canal, and the supposed surplus in little more than five years, but I will call it six years. Suppose the whole of the dues were taken at only 1*d* per mile, which is probably lower than for any canal in Lancashire, the dues would then produce £50,000 per annum, and would pay off the sum in less than eight years.

It can be no matter of surprise, that the public mind should have been so much inflamed with canal speculations, when such visionary estimates as these were credited; and caused many, who were determined to become canal subscribers, chearfully to submit to sleep in barns and stables, when beds could not be procured at the public houses, where meetings were held to receive subscriptions for newly projected canals.

It is not possible to describe the injury such estimates have done to the public, for great numbers have been ruined, and many more greatly injured, by giving credit to them; and I know of no subscribers, taken generally, that have suffered so much as the subscribers to this canal; as many of them were maiden ladies and widows, who had little more than a certain annuity to live upon.

To shew the fallacy of the estimate, I will state the amount of the revenue arising from the dues of the Leeds and Liverpool canal for the year 1797, which was a very good year for trade.

		£.	s.	d.
Sum total of tolls for the	Yorkshire side,	9,229	6	7
Ditto ditto on the	Lancashire side,	13,804	11	8
Ditto ditto	Douglas navigation,	8989	15	9
Ditto ditto	Packet boats,	449	1	0
Rents, &c.	- - -	210	5	8
		32,683	0	8
	Sum total of out goings,	7,344	6	10
	Net income,	£25,338	13	10

I am not quite certain what number of miles goods were carried upon the canal and navigation to raise this revenue, but I think not less than one hundred and ten; and if this be the fact, the average of the tolls per mile is only about £236, and yet there is an immense quantity of coal exported from Liverpool, besides what the town consumes, which is carried upon this canal and the Douglas navigation.

Here then we see an old established navigation and canal nearly one hundred and ten miles being only part of their whole length, with a vast tonnage on the Lancashire side, and the tolls producing a net revenue of little more than £25,000 per annum, while the estimate of ton-page which the engineer calculated upon, would produce a revenue from only eighty-one miles, (and the tolls are taken much below par,) of £50,000 per annum. I now leave the subscriber to judge what credit should be given to such an estimate.

This I think proves what I observed when I first set out, that the Lancaster canal affords many useful lessons, to both canal engineers and canal subscribers; and it is on account of the latter that I have made so many observations upon this scheme, and for the sake of some of my friends, who have had the misfortune to be involved in it: 1st. To canal engineers, for it ought to be a warning to all how they lay out and recommend a line of canal, and in what manner they make their estimate for executing it; but particularly where it will be attended with such an insupportable expense as that of the Lancaster canal. 2d. It affords a great deal of useful information for the subscribers to it; though it must be acknowledged, it is very dearly bought, for such an example as this, ought to make all subscribers extremely cautious how they proceed, in making parallel canals to pass through a country; for where ever this happens, it is almost certain that one of them will fall a sacrifice to the other.

Had the engineer told the subscribers at first, what would be the fatal consequence of this canal running parallel with the Leeds and Liverpool canal, and with the sea coast also; and that it would not supply the lands on the south side the Ribble with lime, as was expected, on account of the said canal; and had he given them a true statement of the expense, and a rational estimate of the probable quantity of tonnage, most likely the spade would never have been put into the ground; but whether giving this kind of plain, useful information, is any part of the engineer's creed, I leave the subscribers to judge by his estimates.

Does not this also shew, that carrying a level through a country, has little to do with making a proper survey and estimate, and laying out a line of canal and its works with discretion? To find a level is the most trifling thing a canal engineer has to do, and yet, in their estimation, it is almost every thing.

Had this canal been finished according to the parliamentary line, the interest allowed while the works were executing, and every expense included; all the money sunk in erecting steam engines, and their annual expense estimated as so much capital sunk, it is probable, it would have cost nearly a million sterling, and the original subscription would never have paid one farthing interest, nor do I think the advanced loan would ever have paid 3 per cent.

It has been a matter of dispute between canal engineers and other professional men, whether crossing the Ribble upon the engineer's plan, (which would have required three steam engines, viz. one for lifting the water from the higher level, and two more for raising it from the Ribble, for the quantity required would have been too much to lift by one engine nearly one hundred yards) or making eight thousand three hundred and sixty yards of crooked tunnel at Red-moss, equal to nearly five miles long, which the engineer proposed, as I was informed, was the more wild, extravagant and impolitic; and some have given it as their opinion, that crossing the Ribble by an aqueduct, was the more irrational plan; but the greatest part have thought, that of the two plans, the crooked tunnel was the more absurd.

I estimate the making that crooked tunnel (a thing quite new in the history of canals) at £21 per yard, equal to £175,560, to which add £53,868, being six years interest on the capital, supposing it to be executed in twelve years, the amount will be £229,428. I think it is now clear, that finishing the Lancaster canal and the crooked tunnel, upon the engineer's plan, would have cost full £1,100,000.

It is difficult to say, which of these plans was the most unworthy of public notice; but what has often surprised me much more than the engineer prosing them, was, that there should be men, so extremely weak and credulous, as to subscribe for the execution of either of them; and that those who had got fortunes by pence, should thus throw them away by thousands.

Kennet and Avon Canal.

The Kennet and Avon canal is a broad one, about sixty miles long; the survey and estimate were made by Mr. Rennie. His first estimate was about £214,000; but, upon a second survey, he advanced it to £377,368 19*s* 6*d*, which includes making a tunnel of about five thousand yards long; and this estimate was delivered with the petition to parliament, when the act was applied for. The first estimate was equal to £3,576 13*s* 4*d* per mile, and the second equal to £6,219 7*s* 3¾*d* per mile; but it was made upon a liberal scale, in the engineer's opinion, who expected there would be a considerable surplus when the works were finished.

After the act was obtained, various disputes arose among the subscribers, whether the canal should be a broad or narrow one; and Mr. Jessop was called in to re-survey the line, and make an estimate of the saving there would be by making it a narrow canal. After he had made his survey, and consulted with his friend Mr. Rennie, they stated the saving at only £47,237 6*s* 11*d*; £41,000 of this was to arise from rejecting the tunnel, and the pumping water to supply the summit level.

According to this estimate, the difference in expense between executing fifty-seven miles of broad or narrow canal, (the other three being tunnel) and scouring out the river Kennet, and including sixty-seven locks, eleven aqueducts, (three of which are very large) seventy-six great and small public road bridges, twenty-five culverts, eighty-six occupation bridges, (but this number is, I think, too few by nearly half) besides an immense quantity of deep digging and embankments, would only be £6,237 6*s* 11*d*, which makes the saving only equal to £109 8*s* 6½*d* per mile.

The estimate for the occupation bridges should have been made for three in a mile, which would have required about one hundred and eighty; but so far from their allowing three per mile, that from Trowle-bridge to where the canal will fall into the river, above Bath, a distance of more than eleven miles, there is no such thing as an occupation bridge mentioned in their estimate; and yet these engineers were confident that their estimate would finish all the works.

The saving, by pumping the water for a broad canal, is supposed to be very large indeed; but where is the saving there would be by lifting it for a narrow canal? For surely, they will admit, if it would be a saving for a broad canal, it would be so for a narrow one; or they will be constrained to acknowledge, that making a wide tunnel would have cost £41,000 more than a narrow one.

They were well aware, that the expense of pumping the water for this canal, would be the same whether it was broad or narrow, but not so in making the tunnel; for they indirectly acknowledge, that there would be a saving in making a narrow tunnel of £41,000, and therefore very artfully avoided having any thing to do with making tunnels.

If Mr. Jessop was certain that there would be the saving he estimated upon, by pumping the water for the Kennet and Avon canal, why did he not recommend lifting the water for the Grand Junction canal, instead of making two large tunnels, which (I believe) he was executing at the time he made this estimate of the great saving there would be, by pumping the water for the Kennet and Avon canal?

The first tunnel at Blisworth-hill, which the engineer laid out, was about three thousand three hundred and forty yards long, and that at Braunston two thousand two hundred, making in all five thousand five hundred and forty yards of tunneling. Admitting £41,000, as before stated, to be gained by making five thousand yards of tunnel on the Kennet and Avon canal, by the rule of proportion £45,428 would have been saved by rejecting the tunnels, and lifting the water for the Grand Junction canal; but if the loss by the Blisworth tunnel tumbling down be included (and it certainly ought to be, for if it had not been made, that misfortune could not have happened) the whole loss to the company may fairly be estimated at £70,000.

If Mr. Jessop was right in his estimate of saving for the Kennet and Avon canal company, is it not plain that he caused £70,000 of the Grand Junction canal company's money to be laid out to no purpose, by advising them to make tunnels where they ought to have pumped the water? But if he was right in adopting tunnels, for that canal, why did he recommend a different plan to the Kennet and Avon canal company? He could not be right in both cases.

If the estimate of saving, by making the Kennet and Avon canal a narrow one, had been made in the same proportion as Mr. Rennie allowed for the Rochdale canal being made narrow, it would have been equal to £118,181 8*s* 6*d*, instead of £6,237 6*s* 11*d*, which is only equal to £109 8*s* 6½*d* per mile, and is not equal to one fifty-sixth part of Mr. Rennie's estimate per mile for executing the said fifty-seven miles; but on other occasions he has made the difference only one-fourth less.

These engineers estimate upon £15.000 for two steam engines, to supply the summit of this canal with water, where coal is exceedingly dear, when Mr. Rennie estimates upon £1,700 per annum for supplying the summit of the Lancaster canal with water, where it is but one-third the price it will be at the summit of the Kennet and Avon canal, which is equal to sinking a capital of

£34,000, not including the expense of erecting the steam engines; and that estimate I think is a great deal too low.

Admitting four hundred tons per day to pass the summit of the Kennet and Avon canal; and supposing the water to be raised one hundred and seventy-six feet from the lower level, if the price of coal be taken at 12*s* per ton, though I think it will be more if good, and allowing fourteen and one-half tons of water to navigate one ton of goods over the summit; but as great many of the coal vessels will return empty, including the runs from the gates and the cloughs, it is probable nearly twenty tons will be consumed; and allowing the water to be raised only forty weeks in the year, it will cost nearly £3,480 per annum, including wear and tear, interest of capital sunk in the engines, wages, &c. which is equal to sinking a capital of £69,600, instead of £15,000; but should it be lifted all the year round, it will cost full £4,080 per annum, which is equal to sinking a capital of £81,600; and is this the great saving there will be, by lifting the water nearly two hundred yards? And, in order that the saving, by making the canal narrow, might be reduced to a sum not worth notice, they calculate, that from Newbury to Crofton, a distance of fifteen miles, it will be twelve feet bottom, thirty-two feet top water, and six feet deep; but what occasion for six feet water in a narrow canal, to navigate from twenty-two to twenty-five tons burthen. From Crofton to Devizes, about twenty miles, they calculate upon it being eighteen feet bottom, forty-two feet top water, and seven feet deep. Now if they call this a narrow canal, I should be glad to know what they would call a broad one.

It is worthy of remark, that digging the canal, the extra width and depth they calculate upon, would cost more than they have allowed for erecting steam engines, and supplying the summit with water.

By expending in making a reservoir a sum equal to the expense of digging the canal in the manner before described, they would have got fifteen times the quantity of water, for the same money, that the extra width and depth of the canal would contain if only once filled in the year; but if twice filled, thirty times the quantity.

But suppose those parts of the canal that were common depth, to be drawn down in dry seasons from nine to twelve inches, and that part that was dug deep, would be drawn down near three feet six inches; have these engineers considered what the effect would be, of exposing the lining puddle for a month or six weeks to the sun and air.

Some time after, the tunnel at Blisworth, on the Grand Junction canal, tumbled down, and Mr. Rennie was called upon to examine it, and give his opinion, whether it would be more advisable to make a tunnel in fresh ground, or to lift the water by steam.

The engineer gave the most unequivocal answer, that it would be much better to make a tunnel in new ground, and have nothing to do with pumping water.

And after all, are not the company compelled to pump their water, when they have built the tunnel, twice over; why then not pump it in the first instance, and save all that unnecessary trouble and heavy expense?

And did not Mr. Rennie recommend to the Kennet and Avon canal company to make a tunnel, after having signed an estimate with Mr.

Jessop, that it would be attended with a loss to them of £41,000; and after having made the tunnel, are they not now pumping their water?

I am exceedingly glad that the company have made a tunnel; and although I do not know how much of the rise is cut off by it, yet I dare venture to assert, that pumping the water, with the assistance of the tunnel, will cost nearly double what the engineer estimated upon for lifting it the full height without a tunnel.

The second estimate, I have before observed, was £377,368 19s 6d, and the estimate for the line of extension from Bath to Bristol was £155,500 2s. making in all £532,869 1s 6d.

In 1796 I published a pamphlet at the request of the committee for opposing the extension of the Kennet and Avon canal, in which I endeavoured to shew, that the said company would throw away £121,906 4s 10d, by departing from the parliamentary line; for that if they would lock down into the river at Bath, and make use of so much of it as is there described, and afterwards cut a short canal of about five miles to Bristol, a good, useful, and expeditious water communication might be made between the two cities, and goods passed much quicker upon it than upon the line of extension; which plan, having been carried into effect, clearly proves the truth of my observation, and shews in what a superficial manner Mr. Rennie surveyed the river when he pronounced the improvement of those three pools impracticable.

The estimates for the canal have been found so extremely deficient for executing the canal, without the extension, that the company have been under the necessity of applying to parliament for fresh powers, to enable them to raise more money, and by their various acts, I understand, they are authorised to raise upwards of £800,000; but when the works are finished, including all necessary wharfs and warehouses, if the interest on the capital while the works are executing, the expense of erecting engines, the wear and tear, and the annual expense of working them are estimated as so much capital sunk, I am credibly informed that the amount will be nearly, if not more than a million sterling.

The engineer's first objection was, that the mill-ponds between Bath and Bristol could not be improved, and made fit to navigate upon; and his second, that if the canal was made narrow, it would subject all the goods to be unloaded at Newbury; but if made broad, they would pass from Bristol to London without unloading; a plain proof how little he knew about the Kennet navigation, and still less that of the Thames.

It is not a little extraordinary, that the engineer should, in his estimate for the Kennet and Avon canal, have set down £13,905 10s. for improving twenty mill ponds on the river Kennet, and yet object to the practicability of improving only three on the river Avon, which are naturally good, when compared with some of those that are to be improved on the river Kennet; this is a mystery, I freely confess, I am by no means capable of understanding.

I have already observed the great inconsistency in the conduct of the engineer, in proposing to alter and amend twenty mill ponds in about twenty miles, between Newbury and Reading, and some of them very bad and shallow; and yet he cannot amend three ponds on the river Avon, when by so doing, he would save his employers above £120,000.

But suppose the last mentioned sum is sacrificed to get rid of three mill-ponds on the river Avon, which are comparatively good; if the twenty bad ponds, between Newbury and Reading, be improved and made good, will the engineer then have removed every obstacle, and got rid of every difficulty that lies in the way of a free, useful and expeditious water communication, between the cities of London and Bristol? No; when the sum of £120,000, as before mentioned, is thrown away, and twenty mill-ponds on the river Kennet are improved; so far from the difficulties, obstacles, and dangers being removed, they will only be commencing.

From Reading to London is about eighty miles by water, and so many and great are the obstacles that lie in the way of a free water communication, that neither money nor ingenuity can either subdue or remove them; they will remain as long as the river is used for navigation. In the above eighty miles, there are about nine in the tide way, at some places very rapid, and when there is a small swell in the river, from twelve to fifteen horses are required to draw one barge, and about nine when the river is at a moderate height.

Between Reading and London, there are many shoals in the river, which, in the summer months or dry seasons, are not more than from two feet nine inches to three feet deep; and barges are frequently detained from twelve to fourteen days for want of water; and frequently the pools are drawn to flush them over the shoals, and the barges unloaded into small vessels.

How or by what means are the vessels that will navigate on this canal, with fifty tons burthen, and draw four feet water, to pass these shoals, or contend with the floods in winter? these difficulties will render it necessary to unload the goods at Newbury.

Another reason why goods from the Kennet and Avon will not go in one bottom to London is, that from Newbury to London, they will always be carried as much cheaper in the barges which are built to carry from seventy to ninety tons, as would more than thrice unload them at Newbury; and this I think clearly proves, that the canal, on all accounts, ought to have been made narrow; and more especially, as the principal part of the tonnage on it will always be coal.

If there had been a good and expeditious navigation from Newbury to London, that boats full loaded could have passed without being unloaded, there could not have been a question respecting a broad canal; but as this is not the fact, it entirely alters the case. I now leave the subscribers to this canal to judge, whether they have been benefited by that fallacious estimate, or irreparably injured by it.

Had a narrow canal been adopted, and the extension given up, nearly, if not more than £300,000 would have been saved, and goods would have been carried as cheap, and in one-fourth less time, as daily experience proves.

Having already shewn the many and great errors that have been committed in making estimates for canals, and also for designing and executing the works, I shall now proceed to shew how I think a canal should be designed and executed.

A broad canal should have forty-four feet water surface, twenty-four feet bottom, and six feet water. The locks, if possible, should be placed at such a distance from each other, as not to allow of the pools between them to be drawn down more than from two to four inches by a lock full of water.

I estimate a lock chamber to be seventy-six feet long, from fifteen to fifteen feet six inches wide, with a rise of six feet. Such a lock chamber will contain six thousand eight hundred and forty cubic feet of water, and would require a pool to be full fifty-four yards long, otherwise more than one foot in depth would be drawn down by taking a lock full of water from it. But if a pool was only six inches drawn down, it would require to be full one hundred and eight yards long, and if only drawn down four inches, must be one hundred and sixty-two yards long.

It will sometimes happen, though but seldom, if the country has been properly surveyed, and the line judiciously laid out, that for a pool or two this distance cannot be had, and where this is the case, those pools should be widened one-third, one-half, or even made double width, rather than have them drawn down more than four inches. But it often happens, that the length of a pool may be extended by a little extra digging and wheeling, and sometimes by a little extra embankment.

Suppose upon a line of canal, in eight hundred yards in length there is a rise of eighteen feet, which is all in the last two hundred yards (and similar cases are very common in all canals of moderate rise) the common way of placing locks would be to set those three almost as close together as they would stand, owing to the fall being in so short a distance, to save a little extra digging and wheeling, and thus make the locks bend to the ground rather than the ground to the locks; and by so doing, that part of the canal would be entirely spoiled.

Those eight hundred yards should have been divided into three equal lengths, and the locks placed at equal distances from each other; and from the first to the second lock there would have been some extra wheeling, if materials could not be got nearer than from the quick ascent, and some embanking would be required in the same length, and perhaps there might be a little above the head of the second lock; but when this was done, the canal would be made much more convenient to navigate, and all unnecessary waste of water prevented, nor would a lock-keeper be required; but according to the present system of placing locks, a lock-keeper would have been absolutely necessary.

The expense of a lock-keeper may be considered equal to sinking a capital of £1000 and the unnecessary waste of water occasioned by the improper placing of the locks would be equal to another £1000 at least; whereas, from £50 to £60 expended in extra digging and wheeling, would have prevented all this loss and inconvenience.

It is self evident, from all canals that have considerable rise and fall, that these important regulations by canal engineers in general have been entirely overlooked; hence comes the useless train of lock-keepers, and partly the want of water in summer, and a speedy destruction of the locks.

A narrow canal should have thirty-four feet water surface, eighteen feet bottom, and five feet water. I would recommend the locks to be eighty feet long, eight feet wide, and six feet rise; but should the canal join some other where the locks are shorter, this length would be found improper; but where not restrained by circumstances, I would not have them shorter. Such a lock chamber would contain three thousand eight hundred and forty cubic feet of water, and would require the pools to be forty yards long, if they are not drawn down more than one foot by a lock full of water; and if they are only drawn down six inches, eighty yards in length between the locks will be wanted; but if only four inches be drawn off the pool, it should be one hundred and twenty yards long.

Here, as in the former case, if this length cannot be had, the pool should be widened one half, or made double the width, if circumstances should require. But in these situations the rise of the locks must not be reduced that the pools may be less drawn down, for then they would not supply the next locks below; and moreover, it would cause the water to be flushed over the regulating wears to supply them; and widening pools is to prevent this evil.

A broad lock seventy-six feet long, fifteen to fifteen feet six inches wide, rise ten feet, would require the pools to be one hundred and twelve yards long, if not more than one foot in depth be drawn down by a lock full of water; and if they are not to be drawn down more than six inches, the pools should be two hundred and twenty-four yards long; and if not drawn down more than four inches, they must be three hundred and thirty-six yards long.

As much as possible, the locks should be placed at an equal distance on the whole line, or as near so as circumstances will admit; and for want of attending to this, what a sad spectacle do some of our canals present, by having them crowded at those very places where any reasonable distance between them might have been had. But seven locks each six feet rise might be placed at equal distances in one mile, which would require seven pools; and if the masonry of a lock be taken at one hundred and ten feet in length, it would admit of each pool being two hundred and twenty yards long; and with pools not shorter than these lock-keepers would be unnecessary, and flushing of water would not be wanted.

When from eighteen to twenty locks are placed near together, (like those near Wigan, or on the Kennet and Avon canal, or such as those would have been on the Lancaster canal, had they been built) before the boatman and the lock-keeper have opened and shut one half the cloughs and gates, they are exhausted, and then shutting them in proper time is neglected, and the unnecessary quantity of water that is wasted by it is incalculable; and in winter, when a horse comes bathed in sweat to such a chain of locks, before his assistance is wanted again, he will suffer more by this than by a moderate day's work; whereas, if the locks had been placed at a proper distance from each other, a horse would have had a reasonable breathing time, while the vessel was passing each lock, and that without any unnecessary loss in time or waste of water.

INSTRUCTIONS

FOR

LAYING THE FOUNDATION AND BUILDING OF A CANAL LOCK.

When the foundation of a lock is soft and spongy, something like a quick-sand, it is of importance to know which is the best way of treating it.

In all such strata, piling has a tendency to shake the ground, and make it more loose and spongy; and moreover, there is great danger of the water following the piles, and breaking out below at some considerable distance.

The best way, I think, would be to dig the two sides and the breast as low as can be conveniently got, and fill up the trenches with lime craps, lime dust, pebbles, and large gravel, and lay two whole deal balks up each side the whole length, but three for the breast, and cover the whole platform with good deal plank, three inches thick, and twenty-one feet long; but they should be laid low enough to admit of the counter arch being placed upon them.

There should then be two rows of good sheeting piles at the tail, and one at the head or breast of the lock; and a good deal balk, twelve inches square, and thirty feet long, should be laid across; and upon the middle of it should the heel of the lock-gate stand, and on the inside of it the sheeting be fixed, and when well driven, should be well spiked to the timber, and go five feet beyond the back side of the walls; and those five planks should be three feet longer than the rest, and stand that height above the timber, after all the rest of the sheeting is cut off; and those two parts standing so much higher than the rest would prevent the puddle from being washed away, should a run of water take place. There should then be two half balks laid the same length as the large one, and even with the top side of it, and five inches and a quarter screw pins should go through them all; one near each inside wall, one in the middle, and one near each end of the timbers; and they should all be well screwed together. Two more balks would be required the same length as the other, and laid at such a distance from them, as to admit of four feet in width puddle; and the sheeting should be spiked to one of the pieces, and the other half balk should be so placed as to have the sheeting between them, and they should have the same number of screw-pins, and be screwed together as the other sheeting; but inch pins will be sufficient, and those planks should stand three feet higher than the timber on the back side the walls. There should then be cross pieces let into the timber, and covered with good three inch deal plank, to preserve the puddle; and the breast of the lock will require a row of sheeting pile, finished in every respect like the last mentioned row, and the length of all the piles must be regulated by the goodness or badness of the ground it has to pass through; but the puddle trench should not be less than four feet deep, and about the same width.

This is the way I would recommend every lock to be sheeted, whether it stood upon marl, gravel, a quick sand, or a rock; and two inch deal plank will be strong enough for it, except the piles are required to be more than ten feet long; if more, three inch plank would be better.

The masonry of a canal lock is in general as deficient as the designing of it; though it requires more care and attention than any kind of stone work I know of. The execution of a lock is frequently committed to a mason who never was competent to build a cottage-house; yet none but the best workmen should be intrusted with it; for masons in general do not know that any more skill and care is required to build a lock than a barn.

The first course of stone in the lock side should be sixteen inches thick, and set fifteen feet wide; and the next course should be set full two inches back, and should batter back two inches in rising to the top; and the courses should gradually diminish in thickness to twelve inches at the top.

In the middle of each lock side there should be a course of ashlar, two feet broad and one foot six inches thick; and there should be twelve throughs in every rood, from four feet six inches to five feet long; and the backing should be four feet thick, with five abutments on each side, four feet broad, and from eight to nine feet long.

All the ashler should be from twenty-one to twenty-four inches on the bed, the ends and beds well dressed, and none of the ends square to less than one foot. From eight to nine feet in length, on the back side of the upper and lower gates, should be square backing from the foundation to the top of the lock, laid in good water mortar; bricks would be the best, if they can be conveniently met with, but if not, every stone in the course should be of equal thickness. The hollow quoins should be made of the hardest stone, from three feet six inches to four feet on the bed; and five of the top courses should be well cramped together on the bed, at that end which goes into the lock chamber, but the other end will not require it; and the same will be necessary for the upper gates, but only those in the inside of them.

I would recommend an upright bar of iron, two inches broad, half an inch thick, of sufficient length to reach from the middle of the top course of hollow quoins to the middle of the fifth course downwards; the bar should have the ends turned square two inches, and let into the stone; and it will require three square holes into it, to go on to three square bolts that must be let into the middle of the three courses of hollow quoins, and the ends of these three bolts must just come as far on the outside the bar, as to admit of being rivetted; but they may be made of sufficient length to admit of being screwed on the outside the bar, should that be preferred. The two square ends must be well soldered in with lead, and the bar should be sunk into the stone the thickness of itself, and two will be wanted for the heel of every gate, which will require eight for a lock.

A person unacquainted with the great stress that lock gates, and the masonry connected with them, are frequently exposed to, would probably think that all this caution and cramping is unnecessary; but one conversant with the great and sudden shocks they often receive, will allow, that if more could be done to strengthen them, it would still be much better. Canal locks are very expensive, but particularly so when properly made, and every means should be used to preserve them.

But the lower gates of a lock are frequently unshut when the cloughs of the upper gates are drawn; and should one of the gates be nearer shut than the other, by the water moving down the lock chamber with great velocity, it shuts that gate which was nearest being so with great violence, and the bottom cill and the hollow quoins have all the shock to bear, and it often raises three or four courses of them a quarter of an inch, sometimes more; when this has once happened, that part of the lock will never turn water again, until it has been taken down and rebuilt. And where a pool is very short between two locks (which is often the case) if the upper gates of the lower lock are not shut, when the cloughs are drawn to discharge the water from the lock chamber next above, the upper gates of the lock, are thrown to, with great force, by the water rushing down the pool with nearly a double velocity, occasioned by the water surface being so much contracted by the last descending vessel, drawing it down perhaps from eighteen to twenty-four inches; and should one of the gates be more shut than the other, they close with such violence, that the hollow quoins, and the masonry connected with them, and the cills also are more injured by it than those of the lower gates; but if pools of sufficient length had been made between the said locks, no part of this injury could have happened. Short pools are always attended with great loss of time and water. The shock sometimes given by the upper gates is such, as to raise two or three courses of the hollow quoins half an inch, and the joints of the adjoining

INSTRUCTIONS

FOR BUILDING THE BREAST OF A LOCK, AND HOW TO GUARD IT FROM BEING INJURED BY THE VESSELS AFTERWARDS.

All the stones in the breast after the first course should be four feet long, from fifteen to sixteen inches thick, and from two feet six inches to three feet broad; but the top course must not have more than five stones in it. On the back side of the breast there should be a counter arch, and the crown of it must come close to the end of the centre stone in the breast, and should not be less than three feet six inches broad in any one course. The counter arch must commence one foot above the foundation of the breast, and finish even with it, and all the stones for it must be two feet four inches broad, and of the same thickness as the stones in the breast.

The centre stone in the counter arch will require cutting down three or four inches, and a stone on each side of it should be a little cut down, about half the breadth, which will make about four feet in breadth of square stone at the crown, to meet the square ends of the stones in the breast. The centre stone in the breast must be cramped to the centre stone in the counter arch, with a cramp sixteen inches long, well soldered in with lead, and every course of stone in the breast and the counter arch must be thus cramped.

The space between the ends of the stone in the breast, and those of the counter arch should be filled up with well dressed stone, the same thickness as the stones in the breast, laid in good water-mortar; and in every joint both in the breast and the counter arch there should be an angular or circular groove cut through the stone, and these should all be well filled with roman cement. When the breast is finished, a good cramp should cross every joint in it. The inside of the counter arch should be filled up with well dressed stone, lineable with the springer, and covered with stones from five to six feet long, and four inches thick.

For preserving the breast of the lock there should be a cast iron plate two inches thick, five feet long, and twelve inches broad, made circular to fit the inside of the breast. having two pieces fixed in the middle of the front, the same thickness as the plate, six inches deep, and making a dove-tail of twenty-eight inches at the top edge of the plate, and twenty-four at the lower edge; and there should be two holes at each end of it, to admit of bolts full inch square, which should be let into the masonry six inches deep; the top edge of the plate should stand one inch above the top of the lock breast. On the back side the plate, there should be four ribs or lugs, half the depth of it, three inches square, and these must be let into the masonry. Two of these castings will be required for the breast of a lock; but only that for the top will require to be made with a dove-tail, for the bottom box need not be more than sixteen inches wide; but the plate should be the same length and strength as that for the top, to admit of two more lengths of narrow timber being fixed up.

There should be two pieces of good heart of oak, twenty-eight inches broad, six feet six inches long, and eight inches thick. These should have a groove made down the middle to admit of an iron bar, two inches square and six feet long, which should have a flue at the bottom, two inches deep, one inch wide, and have a cotter the same depth, one inch thick, and twenty-four inches long, the top end should have a stout thread, with a nut two inches thick; and there should be a hole cut in the front of the timber for it, and when well screwed, the place should be filled up again.

When the castings and the timber are thus fixed, it is plain the top stones in the centre of the breast cannot be raised, without raising six feet in depth of the breast; nor can the top course be driven back without removing all the centre of the breast with it, as the timber will go against it all the way up; and moreover, the counter arch will prevent it from being forced backwards.

It is of no consequence to the bolts how hard they may be screwed, as the ribs on the back of the castings will sustain the pressure; but it is of importance to the masonry to have it well screwed, as it will help to consolidate it.

By having the castings five feet long, and the bolts near each end, and four inches extra length, with two nuts for each, it gives an opportunity of fixing up two more timber uprights, eight inches by six, and will leave a space of about eight inches between them and the middle pieces when screwed together; and these should all be crossed on the front with two strong bars of iron, to prevent a narrow vessel from dividing them, and the bottom ends may be covered with strong rolled iron plate three feet high.

From the great speed of narrow vessels on a broad canal, I plainly see, that in a short time, the principal tonnage on them will be carried in narrow vessels, but especially coal, lime, slate, flags, dying wares, &c. which will require the breast of the locks to be guarded in the best possible manner, as every plan for that purpose has yet been found insufficient. This way of guarding the breast of a lock, makes the stroke of the vessel have an equal pressure upon it for six feet deep, by the timber always going against the breast.

There are four different ways of applying valves as a substitute for the present cloughs, but at present I shall only mention two, either of which would be vastly superior to the present mode, both with respect to saving of water and time in opening and shutting, and of expense in making, and would be much more durable.

There should be a cast plate, twenty-eight inches diameter, inch and half thick, cast very true, with a round hole in it twenty-one inches wide; and should be let into a stone half its thickness and screwed fast to it, which should be three feet square and one foot thick. Underneath the plate or stone it is let into there should go a lead pipe, two inches diameter, and end as soon as it gets into the passage for the water; and it should go from thence to a few inches above the surface of the water which would cause it to pass much more quietly into the lock chamber; and the bottom of the channel that conveys it into the lock should be even with the counter arch.

If two narrow vessels are in the lock when the chamber is filling, there is great danger in one of them being sunk, if care is not taken in drawing the cloughs; and sometimes a vessel is sunk.

But to return. Across the hole in the said plate there should be a thin bar of iron fixed exactly in the centre and even with the face of it, with a hole in the middle to admit of an half inch pin working in it. Another circular plate the same diameter as the other, but only inch thick will be wanted, which will require a groove casting round it, the centre of which should be three inches from the edge of the plate, sunk full inch deep, and two inches wide, to admit of a rope two inches thick being placed in it. There will want from six to eight small holes drilling through the hollow of the groove, on the top side the plate to admit of small pins passing through them and the rope to keep it in its place, which should be filled with pitch and tar, and more than one half of it should stand out of the groove; and a wood block should be turned the diameter of the groove to give the person that splices the rope the exact length; but it should be well stretched before a length is cut off.

The rod for lifting the valve should be inch and half diameter, until it gets through the masonry, made of good beaten iron; afterwards it should be two inches and a quarter broad, for sixteen to eighteen inches, and then turned for twelve to thirteen inches, working through a brass guider, near the top of it; and there must be an half inch pin turned from twelve to fourteen inches long fixed in the centre of the plate, to work in the hole of the said cross bar; with the pin thus fixed at the bottom of the rod, and the top working in the brass guider, it is not possible that the valve can be thrown off its seat; and when thus fixed, it will shut as true and turn as well as any brass valve.

A valve made upon this principle cannot be injured with either opening or shutting; for the moment it is lifted the least from its seat, the water will afterwards perform the principal part of the business in raising it; and it cannot be injured by being shut, for the water will break the fall; moreover, it will not be raised more than from eight to nine inches, and a boy of ten years old, would perform this work with ease.

The rack casting for the valve rod should be from fourteen to sixteen inches long, and face the lower gates; and the short shaft for the pinion should stand at a right angle with the canal, fixed in two castings, each having three screw bolts let into a stone three feet broad, four long, and one thick.

Upon the said short shaft there should be a rotch-wheel, as it is called, similar to that on the beam of a weaver's loom, from six to eight inches diameter, one inch thick, but not very fine toothed. This wheel will require a catch to work upon a centre pin, two inches from the end, that will work in the said wheel, and twelve inches from the other end, which should stand at a right angle with the canal, and have a parallel joint to admit of another at the end of a rod three quarters of an inch round, which may be any length required; at the end of it there must be another parallel joint fixed to the end of a bar of iron, that will move up and down like a way-beam, which may be from eight to nine feet long, and fixed in a casting for that purpose. Under the other end of the beam, three feet six inches, or from that to four feet below the heel of the gate, and from three feet to three feet six inches from the lock side, there should be a hole cut in the backing eighteen inches square, and the bottom of it should be sixteen inches below the surface of the water in the lock chamber when full.

At the bottom of the hole, there should be an opening cut into the lock chamber, twelve inches wide and four inches deep, and in this square cill there should be a cast iron cistern fixed, sixteen inches square in the inside, or round, as may be most agreeable, without bottom, half an inch thick, and thirteen inches deep, with four legs, three inches long, which will leave three inches from the under edge of the cistern to the masonry for the water to enter.

There should be a float fixed in the inside of the cistern, made of rolled iron, full one-eighth of an inch thick, or of good ash or elm, and in the centre of it there must be a rod fixed to the end of the said beam, with a parallel joint, and the end of it that will be fixed to the float, should have a thread cut upon it for some inches, and a screw nut should be rivetted to the float, by which it may be fixed any height that may be required. The float should be fixed at such a height, as will throw the catch out of gear the moment the lock chamber is filled. There will be no catch of any kind to support the valve when raised but that which works into the rotch wheel, and as soon as it is raised out of gear, the valve must fall, for the catch will always be in gear, except when raised by the float.

Any person that has the least idea of mechanics will, I think, understand the principle, and see, that when the lock chamber is filled with water the float will be raised, and discharge the catch from the said wheel and shut the valve.

Should it be considered an object of importance for valves to be fixed in the lower gates, to shut themselves as soon as the water is discharged from the lock chamber, this may be done by a float as effectually as for those of the upper gates; for it frequently happens, through the carelessness of the boatmen, that the upper cloughs are drawn long before those in the lower gates are shut; and thus a large portion of water is wasted.

I shall now explain the nature of the second valve I recommend, which probably may be preferred by the public, and I am partial to it; for its simplicity far exceeds any thing of the kind that has yet been used for the same purpose. This valve will not require raising, and it may be opened in a second of time, by a boy of from eight to ten years old. The valve may be made either round or square, as may be most agreeable; but I would make the opening twenty-four inches long and sixteen inches wide, and it should be made of stout rolled iron, three eighths of an inch thick, fixed in a cast frame; and the part against which it will shut should be ground perfectly true, and would not require to be more than two inches broad.

A strong oak frame, the timber six inches inches square, may be let into the masonry, even with the face of it, bolted fast, and the cast frame screwed to it, which may any time be easily taken out, if found necessary.

The valve should be fixed upon an upright spindle (in such a manner as may easily be taken off) two inches from the centre or middle of the valve, which would cause it instantly to shut as soon as the catch or latch was raised out of gear; as there would be near one-third more water pressed against one side than the other, and for the more speedy shutting of it, it should not be opened quite so far as to make the opposite edges stand at right angles; they should be a few degrees short of it, and it should be the side which was the largest that should not be opened to the full extent.

The valve rod should be round, one inch and a half diameter, and stand three feet six inches above the masonry, and should have a collar turned upon it there, and work through a brass guider, to keep it steady.

Two cast uprights should be screwed to a stone three feet square, and one foot thick, and a cast cap should be fixed upon them, through which the turned part of the spindle, near the top, should work in a brass guider, fixed in the cap, and have a square above to admit of a key, by which it may be turned; but will not need turning quite half round, which may easily be done by a boy.

Six inches below the cap, there should be a collar turned to support the rotch wheel, which should have the teeth upwards; and there will require an opening in one of the upright castings, six inches long and three quarters of an inch wide, through which the catch will work, and it should stand at a right angle with the canal; and the float, the long bar or way beam, the upright rods, and the parallel joints, will be exactly like those before described; these valves like those, will be instantly shut as soon as the lock chamber is filled with water.

Perhaps it will be said, that these valves cannot be made as water tight with grinding, as the other valves which have a rope fixed that will prevent any runs. That valves thus ground may be made to hold water exceedingly well is certain, but perhaps not quite so water tight as the other; yet, should any inconvenience be found, it may be removed by rivetting an even piece of stout leather round the edge of the valve, or to the frame, which would last a great number of years; for water-tight I will engage to make them.

The next thing to be considered is, the making, hanging, and balancing of the lock-gates for six feet rise; for having these upon the best principle is of the utmost consequence to the canal proprietors; though as yet, little attention has been paid to them.

The heel posts should all be made of good heart of oak, free from sap or shake, the breast posts and cills should all be the same; the length of the heel posts for the upper gates should be seven feet, (yet six feet nine inches would do for the common way of hanging them) eleven inches by twelve, and the breast posts ten inches square. The cross bars should be eight and a half inches by seven when finished, and the length of the cross bars, including the tenons, nine feet, and the distance from inside to inside one foot nine inches, and the cill for the upper gates to shut against, seventeen inches broad at the head, nine inches at the point next the heel, and eight inches thick; and the deal plank for the covering two inches thick. These bars are long enough, should the lock be made four inches wider than I have estimated upon.

The length of the heel posts for the lower gates should be sixteen feet ten inches, eleven inches by twelve; and the gates must each have six bars, the same length and strength as those for the upper gates; but the bottom cill for these should be full as strong as that for the upper gates, and the breast posts should be full ten inches square.

Nothing can be worse designed than the present plan for hanging lock-gates, as they frequently have from half an inch to three quarters space in the collar at the top to play in, and often full as much in the step at the bottom; and if any small matter get in between the heel post and the hollow quoin, the gate is forced into the lock, and the quantity of water that is wasted, while the heel post remains at such a distance from its place, cannot be estimated; and the same bad effects often happen by something getting in between the front posts; and thus the gates are forced first one way and then another, and soon get knocked and shaken in pieces.

The heel post of a gate should move as truly upon its pivot, as that of an upright shaft for a corn mill or a factory, and it may be easily made to do so. In the first instance, the heel post should be put into the lathe, and turned true for about six inches in breadth at the bottom and top; and the foot should be turned before it is fixed in, and put on with two hoops; the hoop for the turned part at the top should be full three inches broad, and the collar it is to work in should be the same breadth. Before the hoop is put on at the top, the turned part should be divided into four or six equal parts, and there should be as many grooves cut in it, six inches long, three quarters of an inch wide, and half an inch deep, and there should be six iron keys made to fill them well, and be gently driven within the hoop; and if the wood should afterwards dry in, so as to make the hoop loose, the keys may be hardened, and the hoop made fast again, and yet be as true as at the first.

When the heel posts are turned and hooped, there should be a bar of iron, two inches broad and three quarters thick, let into the outside of the heel post, for the lower gate even with it, and go six inches above the top bar, and as much below the bottom bar; and there should be as many short arms welded to it as there are bars in the gate each sixteen inches long, with two holes in, and of the same strength as the upright bar; and the joints of all the bars should be crossed with them, and the upright bar, as well as the short ones, should all be rivetted; and the inside of the upper heel posts, as well as the breast posts and bars for both the upper and lower gates should be plated in this manner.

The stones for the hollow quoins wear very fast by the gate heel working against them, and the sand and water assist in doing it; besides, the stones are frequently very different in their qualities, some hard, others soft, and often cut and worked the wrong way for lasting, as the circular part is many times cut from the bed of the stone; whereas it should always be cut from the end of it; for when they are thus worked and improper qualities mixed together, the circular part cannot wear uniformly, and this imperfection will, in time, cause a great loss of water.

To prevent this loss and make the circular part durable there should be three circular plates cast full half an inch thick, each four feet six inches long for the lower gates; but those for the upper gates may be cast in one length, with a sufficient number of lugs on the edge, by which they may be screwed fast to the masonry. And to prevent the plates from breaking there should be a piece of stout double-milled kersey, dipped in boiled linseed oil put under them, and a thin sheet of rolled lead on the top of it; and if the plates are well screwed to the wall they will be perfectly water-tight, wear uniformly, and last for ages.

For the better preservation of the plates, the heel posts, and the water, the collar that the hoop works in should be made in a manner different from the present mode; for there should be no shoulder upon it before it enters the eye of the anchor; if the post does not fill the collar, the shoulder prevents it from being drawn up properly; there should also be a square for three or four inches between the broad part of the hoop and the eye, and in this part there should be a flue an inch and half long, and half an inch wide, and have a cotter, and with it and that on the outside the eye, the gate post may be made to work as true as any other piece of machinery, which would prevent it from being chaffed away in the manner it now is, by the friction and vibration to which it is now subject.

I would not have it understood that cast plates are absolutely necessary for the hollow quoins, for a good lock may be made without them; still I think they would be a considerable improvement, and I leave every committee to form their own opinion.

How safe and easy to work, and how water-tight would lock-gates be if thus hung, and a canal lock built according to the plan before described, would, I believe, far exceed any thing of the kind that ever was erected; and certain I am, that ultimately, it would be much the cheapest.

Probably some of my readers would wish to be informed what I estimate the difference in expense to be, between building a lock upon this principle and the imperfect plan hitherto adopted. I have not overlooked the subject, and without entering into particulars, I think it would be near £15 per foot rise, that is, a lock of six feet rise would cost from £90 to £95 more, £60 of which would be expended upon the counter arch and the masonry connected with it, including a reasonable sum for the backing, which would have been used, provided there had been no counter arch.

Had the proprietors of the Huddersfield canal, or those of the Rochdale, the Leeds and Liverpool, and many more that I could mention, paid twice this sum extra for every lock, it would have saved some of them thousands of pounds, and others tens of thousands, by preserving more than half their water, and by being more than three times as durable, as well as much more convenient and beneficial to the public.

It is a circumstance that must strike an attentive observer with great surprize to be told, that according to the opinion of the best informed, there has been more money expended, within the last forty years, in making canals and rivers navigable than is equal to all the capital sunk in machinery for the spinning of cotton, worsted, and flax, including all the machinery used in the woollen business.

Canal locks are built nearly in the same manner as they were fifty years ago; and I often think there never was any piece of mechanism of such vast importance to the public that has been so long and so much neglected; and although passing from a lower to a higher level by a canal lock will, I think, never be improved, where water can be had, yet the saving of it and the construction of a lock is capable of great improvement; and still we find canal engineers adopting the same plan, without attempting the least improvement.

What increases the surprise much more is, that for the last twenty-five years, the value of water has kept increasing in proportion to canal speculations, and the difficulty and expense of obtaining a supply of it still keeps increasing; and yet the designers of canals have done little or nothing towards diminishing them, but, on the contrary, in many instances they have been increased.

How is it to be accounted for that in every year during the before-mentioned period of time, some great improvement has been made in one kind of machinery or another; and yet the designing and executing of canals have remained nearly stationary, while there are no mechanical men in the kingdom that have been so liberally paid as canal engineers?

It is strange that so great an advantage as supplying a town with the surplus water of a canal should have been so much overlooked; for in surveying a line of canal and setting out the locks, this should never be forgotten, whenever the canal ends at or near a town.

The town of Leeds is much distressed in getting a scanty supply of dirty water in summer; yet it might have been amply supplied with the spare water of the canal, had the two last locks been built for that purpose, and the canal have been made much more convenient than at present.

If the Rochdale canal company had made no agreement for the spare water of their last lock, they might have supplied the town of Manchester with it; and if the town had given the company £800 per annum for it, I presume it would have been much cheaper than it is now raised; and no doubt but the quality of it would be much better than that which they now have.

I am strongly inclined to think, that if the Grand Junction canal company were to divide the fall at their last lock near London, and make two of it, if all the locks on the Paddington canal were of equal rise with them, that canal would not want water if there is no locking up. This alteration in the last lock, would probably have saved the ingenious Colonel Congreve the trouble of constructing his balance lock, which, I fear, will possess more ingenuity than utility, for I am inclined to think the thread is too fine spun for general purposes; but if it would answer for that, the extraordinary expense of building, added to that of taking care of it, would probably prevent it from being of public utility; but in this I shall be glad to find myself mistaken.

I am sorry to say that the impolitic plan of combining locks, and making contracted basins, is not confined to England only, for in Ireland, upon one of the great national canals, near twenty years ago, there were not fewer than eighteen double or combined locks. From this it is clear, that canal engineers have been as deficient in the knowledge of the principle of a canal as those in England, and I am strongly inclined to think that they are much the same upon the European continent.

I have now a difficult task to perform, and sincerely wish it had fallen to the lot of some one more able to discharge it than I am; that is, giving such instructions to the canal committees, that may be entering upon the execution of the works, as will prevent them from being so much imposed upon and misled as canal committees have been, with fictitious estimates and visionary reports; for, furnishing them with the knowledge requisite for such undertakings will make the task easy to them and beneficial to those who may have honoured such committees with their confidence.

When the act is obtained, there should be the most accurate field plan drawn by some masterly surveyor, laid down with such exactness, that a land owner might, with safety, purchase or sell land by it, for every fence, spring, rivulet, brook, and feeder, that the line will intercept or affect, should be represented, and a correct profile made of the ground over which the canal will pass; eve- hill, valley, and level, being laid down with great exactness.

When this is done, the committee should procure the most intelligent joiner or cabinet maker, to make a model after the profile, representing every part of the works, and culverts for every brook, spring, and feeder that are to be conveyed under the canal. A three inch plank would be sufficiently thick to admit of all the lock chambers being cut out of it; the culverts and tunnels may be cut from the under side of it. Should the plank be too narrow to represent the basins that may be required for some situations, a piece may be put to the side of it at those places, to shew the width they should be.

After this, the resident engineer, the joiner, and the surveyor should begin at one end of the line, and place the locks at a proper distance from each other, make the basins, and put in the culverts, build the aqueducts, if any, and the public road and occupation bridges; also the canal and private road bridges, and any other masonry that may be wanted should be placed exactly as the works would be when finished.

When the works were thus represented, any man of common capacity might see if the locks were right placed, and the pools between them of sufficient capacity; and whether the occupation and road bridges were placed to the best advantage for the land-owner and the public. And if either mill or land-owner came to the committee, to complain of any particular injury, with the assistance of the model, they might judge whether the complaint was well founded, without sending, perhaps, from fifteen to twenty miles, to have the place complained of examined, and it would prevent other people from coming with frivolous complaints, as the model would disprove them if not well founded. When the neighbourhood knew the committee had a model and field plan, that impartially represented every thing that related to the canal, few complaints would come before them.

And the committee should, once in every quarter of the year, have a particular account given how every part of the work was going on; and by measuring the deep cutting and the embankments by a scale made for that purpose, placed near the model, they might see what progress was made in them since the last report, nearly as well as if they were actually surveying them upon the spot. These quarterly reports should be entered in a book for that purpose, and by referring to them the commmittee would see how much work was done in one quarter more than another.

If the model was made in one length, no moderate room would contain it, I would therefore make it in three or four parts, and have them placed near the committee room, ready to be referred to on all occasions. By this means the committee would see a true representation of the works when complete, before the spade was put in, and from the model would be able to judge what part of them should be entered upon first, and what part postponed for a certain time.

By adopting this plan, the canal and its works would be brought to the door of the committee-room, where they might survey them at pleasure; and it would render all those extraordinary surveys and reports of engineers unnecessary, and very probably would save the subscribers thousands, if not tens of thousands of pounds, as I have before remarked; but more especially so, if three or four hundred pounds are going to be laid out.

By thus going to work, how easy would be the situation of the committee; whereas now it is little else than toil, vexation, and disappointment; for the subscribers, if possible, should never change the acting committee during the execution of the works, (except for want of proper attention) and that is another reason why their labour should be made as easy as circumstances will admit of. In order that the knowledge of the said committee may be still more perfect, I would recommend an accurate model to be made of a lock, shewing every particular thing that relates to it, whether internal or external; for the general model would be upon too small a scale, to represent every particular part of a lock.

I estimate the length of a lock chamber for a broad canal at seventy-six feet, the width from fifteen to fifteen feet four inches, the rise six feet, with six feet water. This would require the model to be six feet four inches long, one foot seven inches wide, and one foot one inch deep, if made to a scale of one inch to the foot. By making the model this size every part may be distinctly represented, and it should be so made as that every part of it may easily be taken to pieces; the parts should all be numbered and entered in a book, with references to them; and opposite to every number the name of the part, and what use it is for, should be accurately stated. By such a model, the committee would soon understand the nature of a canal lock, and where and how it should be placed, much better than many canal engineers do.

I have given no instructions for executing a tunnel, because I wish another never may be made; for I have seen, and the public have experienced quite enough of the delay and inconvenience that attends navigating through one near this place which is more than three miles long.

For the better information of the committee, I would have them go one step farther, before they let any part of the work, and that is, for two or three of them to make a tour through a number of the counties where canals are most common, to see how they are designed and executed, to enquire what price was paid for various work, and in what manner contracts were made, and what kind of tools (if any) the committee furnished the contractors with, as well as what security they gave for the performance of them.

Where any extraordinary piece of work has been executed, they should go and view it, and make minutes upon it; a few weeks thus spent would be of unspeakable advantage both to the committee and the subscriber. After their return, they should walk over their own line before the contracts are made, and carefully examine the ground, and any part that is found wet and spungy, where a high embankment must stand, or where deep cutting is necessary, should be cut open and have the water well drained off; and perhaps it may be prudent to drive a small heading or two, and let the water be drawn from it for a few months before it is fairly cut open, or any materials laid upon that part where the embankment is intended to stand.

The same attention is necessary to be paid to the ground where the bank of a large reservoir is intended to stand; for if the ground is not perfectly sound, it should all be dug away until a firm foundation can be met with; and should it rise from thirty to thirty-six feet, the puddle trench should be twelve feet broad, and the bank should have two feet slope for one of rise.

In the execution of the canal avoid all iron aqueducts and bridges, if possible; for there is nothing so firm and durable as good masonry.

I have given a design for making and hanging lock gates superior to any I have yet seen, but they are not such as I would make for myself.

I would have the gate and heel post all in one casting made of good metal, the gate curved about threeinches, and nearly inch and half thick, with four light ribs on the outside, each lighter than that above it, and a two and a half inch oak plank eight inches broad screwed to the bottom, and the same at the top, with a stout piece screwed to the front to shut against; a square of eight inches long should be at the top of the heel to admit of a box being screwed to it, to hold the top bar which should cross the gate, to which the lever may be screwed.

For locks of six feet rise, I would make both the upper and lower gates of cast iron; but I should not be fond of making the lower gates of cast iron for a lock of ten feet rise, though I have no fear of them being made sufficiently strong; but all the upper gates for common canals, I would make of cast iron, as they will be much cheaper than wood ones, and I believe three times more durable.

I have before observed that one-half the lockage water may be saved by making locks of six rather than ten feet rise, and I assert it with equal confidence that if cast iron gates were made for a canal with locks of easy rise, one half the annual expense that attends canals made upon the present principle would be saved; which is a pleasing idea for a committee, who may be entering upon the execution of a canal.

Upon whatever canal the upper gates are worn out I would recommend to the company not to renew them with wood, but make castings for the hollow coins exactly fitted in the inside to the iron heels.

I have also given two designs for valves, but the latter I prefer; they should stand together on the contrary side the towing path; for if a man has to pass over to draw or open one valve he might as well open both at the same time, which will be done in half a minute, and the float will open both at once, as soon as one.

By placing both the valves on one side the canal the towing path is kept free from incumbrance; for the towing rope cannot catch the spindle valve; and moreover there is a particular advantage in delivering the water into the lock chamber at one side of it; more especially when it is carried from twenty to thirty feet from the breast of the lock. By this plan when the water enters the lock chamber the vessel gently floats to the opposite side of the lock, and rests there as quiet and as steady while it is filling as if it was chained to the wall; but by the water being delivered near the breast of the lock while the chamber is filling, the vessel is placed between two contending powers, and first driven one way and then another, and is never at rest, until the lock chamber is nearly filled.

Delivering all the water at one side of the lock and near the middle of it is not mere speculation, for daily experience proves it, and by running so far after it has passed the cloughs it enters the lock very quietly; nor is making cast iron gates an entire new plan, for I have recommended them strongly for many years, and have seen them worked nearly four years; and I think they will be good and firm four-score years hence; yet they are capable of considerable improvement.

Instructions for the Canal Subscriber.

Canals are certainly of the greatest importance to trade and commerce; and no man admires the utility of them more than myself, when laid out with judgment, in a country where trade, commerce, and the various minerals proposed to be carried upon them, will justify the undertaking, and leave the subscriber a reasonable interest for his money; for it is not possible, with the tolls as they now are generally fixed for canals, but the public will be great gainers, if the subscriber has a moderate interest; but I think there never was any scheme so much prostituted to the private interest of individuals and engineers as that of canals.

The canal speculator, who subscribes only to gain by selling his shares, I consider little better than a swindler; for all schemes in his estimation are extremely good, and he will ride from one county to another, to become a subscriber to the most ineligible plan, with no other view than that of selling his shares.

The public are little aware of the mischief which these men have done to the community; for subscribers to canals should be men of real property, who subscribe from no other motive but that of supporting the scheme; it is lamentable to see how many of these have been misled by the canal speculator.

To prevent engineers, as much as possible, from misleading the public in future with their fictitious estimates, I shall give some general instructions, which, if the canal subscriber will carefully attend to, I hope will enable him to form a tolerable judgment of the expense that attends the execution of a canal, and assist him in calculating what tonnage will be necessary to pay him five per cent interest; with some observations that may enable him to form an opinion whether the country, through which the canal is intended to pass, will afford such a quantity of tonnage as will indemnify the subscriber.

A canal with six feet water for navigating vessels of fifty tons burthen will require the digging to be about seven feet deep; and if the breadth be forty-four feet at the surface, and twenty-four feet at the bottom, the mean of these dimensions will be thirty-four feet. The cubic yards of digging in one mile of canal of these dimensions will be forty-six thousand five hundred and forty-two and two-ninths.

If the common digging be taken at 6*d* per yard, including that required to make room for the lining puddle, it will reduce the price to about from 4½*d* to 4¾*d* per yard; but if taking out the slips that will always attend the execution of a canal be included, the neat price for the digging will scarcely be 4½*d* per yard. But if 6*d* per yard be allowed for the digging, including that for the lining puddle, and taking out the slips, it will make the expense per mile for the common cutting about £1,163 11*s*.

The price for extra digging will be according to its depth and the quality of the ground, and will run from 7*d* to 9*d*, 12*d*, or 14*d* per yard; but where the digging is nearly thirty-six feet deep, a tunnel will, in general, be full as cheap as open cutting. One hundred yards in length of cutting thirty-six feet deep, with eighteen feet bottom, and a slope of two feet for one of rise, will contain thirty-six thousand cubic yards, and 1*s* 2*d* per yard, will be £2,100, which is equal to £21 per yard, running measure, and perhaps is full as much as a tunnel would cost in the same situation; but if open cutting should cost one-third more, still it would be preferable. The lining puddle should be taken at nearly 6*d* per yard superficial measure, (but should be done in the best possible manner) or at about £225 to £230 per mile, where the ground is moderately good for holding water.

If the embankments are of any considerable size, over vallies, or for the head of reservoirs, they should be estimated at not less than 7*d* per yard, where the materials are not convenient, allowing from one foot six inches, to two feet slope for one of rise, and the top of the bank on the towing path side should be full twelve feet broad, and the other full ten feet, and should stand fifteen inches above the surface of the water when the bank is become solid.

Making the fences and the bed for the towing path, graveling it, and resoiling the bank, should be taken at 1*s* 6*d* per yard, running measure ; making the regulating wears, trunks, back drains, stop gates, &c. at £65 per mile, but this estimate will vary according to the ground the canal will pass through.

The locks should be estimated at full £112 per foot rise, if the stone be convenient, but more according to the distance ; digging the lock pit and puddling it round £50; which will make the whole expense of finishing a lock nearly equal to £120 for every foot of rise; but this supposes it to be built upon the improved plan I have recommended.

The number of occupation bridges may be taken at three per mile, but will frequently over run this, and they may be estimated at from £62 to £68 per bridge; the public bridges may be taken at from £120 to £140 per bridge.

The quantity of land required to make a broad canal may be taken at nine acres per mile, but if there be a great declivity in the ground ten acres should be allowed; should the canal be principally supplied with water from reservoirs, if the locks are made six feet rise, from fourteen to fifteen acres per mile may serve; but if made with ten feet rise, from nineteen to twenty acres per mile should be allowed; if the catch water, and all other drains are included, it probably would be found rather too little; and whatever may be its real value, one-third more should be added for all inclosed ground for severing and dividing it.

It is worthy of remark, that should the canal be thirty miles long, and lock from a summit both ways, nearly eighty more acres of land would be wanted, (supposing it to be supplied with water from reservoirs) if the locks were made with ten feet rise, than if made with six feet rise; and purchasing this extra quantity of land, and making it into reservoirs, would probably cost £20,000; which would pay for making locks upon the best principal for one hundred and sixty-six feet rise Yet neither the quantity, nor the price of the deep cutting can be ascertained with accuracy, without knowing the depth and quality of the ground; but it will frequently be one-fourth of the common cutting, in some canals one-third, in others one-half, and in some particular lines it will be as much as the common cutting; but this will seldom happen, as the ground must be very unfriendly to a canal where it does.

Mr. Chapman's estimate of the common digging for the north canal is £13,538, and his estimate for the deep digging £15,923, which exceeds that of the common digging £2,383, and is the first instance of the sort I ever knew; and yet he has often informed the subscribers to that scheme by his vague reports, how very favorable the ground on the north side the river was to a canal; and his estimate for the embankments is nearly one half of what he has allowed for the common cutting.

The embankments for some canals will be one-fourth, of others one-third, and some one-half of the common cutting. But to return. When the subscriber has allowed the various prices for sundry work which I have set down, he should add ten per cent for unforeseen contingences, eight per cent for obtaining the act or acts, salaries for clerks, engineers, overlookers, committee meetings, expense of commissioners, attornies, juries, &c. and three years interest on the capital, if the work be a large one, which supposes it to require six years to finish; and I calculate upon the capital paying no interest for half the time, which is equal to £15 per cent, and should be added to the estimate, making in all £23 per cent, after such prices are allowed as will be sufficient to finish it; but £10 per cent will do for the loss of interest, where the works are finished in four years.

I never yet saw an estimate made by any canal engineer that allowed one shilling for any thing of this sort, which proves in what an erroneous manner they have been made, and this accounts, in part, for the terrible deficiency that does and always will attend the execution of canals, till these allowances are made, or an additional price put upon the work equal to them; for if the estimate was made to finish the work in the most complete manner, still the expense of obtaining the act, and carrying it into execution, besides the loss of interest on the capital remain, for this cannot be avoided.

I have given no estimate for building a large aqueduct which may be required for crossing a river; nor is it possible to make one with accuracy, without knowing the distance the materials will be to carry, and whether by land or water, and if difficult to procure; also whether the foundation may be very expensive; but when laid, if stone be at a moderate distance, the whole of the masonry may be measured, including the square backing, and if it is taken at 1*s* per cubic foot, the subscriber will not be far wrong; the company finding lime, centres, and scaffolding.

If the canal subscriber carefully attends to these instructions, it will not be in the power of any artful engineer to mislead him by any specious estimate; and when he has ascertained what the whole expense will be, he may easily find what quantity of tonnage will be required to pay him five per cent interest; and perhaps a better estimate cannot be than taking the average of the tolls at $1\frac{1}{2}d$ per ton per mile; and whatever the amount of them may be, one-fourth part should be deducted for wear and tear, clerks' salaries, and other incidental expenses; and the remainder will be the net revenue the subscriber should estimate upon, and not more; but if the canal should, on the average, have near three locks per mile, and a number of reservoirs, one-third the revenue should be allowed for wear, tear, &c.

I shall digress for a moment, while I give an instance of an extraordinary estimate for making a canal, and could give many more similar ones.

The engineer for the Thames and Medway canal (a distance of about eight miles) delivered his plan and estimate to the house of commons in the usual way, and the estimate was rather under £30,000; but owing to a certain person being called in to survey the line and make an estimate for it, the engineer's estimate was investigated at Lord Romney's, and he was shewn the insufficiency of it; and after defending it for some time, at last he said, my Lord, I dare undertake to finish the canal for £90,000; but it would have required nearly double this sum to finish it according to the engineer's plan, as was shewn in a committee of the house of commons; yet I think it may be finished before his tunnel under the Thames.

But to return. In forming an opinion, or making an estimate, of the probable quantity of tonnage that may come upon the proposed canal, the subscriber should carefully avoid estimating upon coal, lime, slate, flags, and other minerals, that can be carried only a short distance upon it; for if they cannot be conveyed more than five or even six miles, before they arrive at the place of consumption, in general they may be carried much cheaper by land than water; when the expense of conveying to and from the canal, loading into and from the vessel, loss of time in waiting for and disposing of a cargo, are all taken into the account; and it is really astonishing, how many and great errors canal engineers have fallen into, by estimating upon a short water conveyance.

Whatever may be the quantity of the various articles carried by land where the canal is proposed, the subscriber should not estimate upon more than two-thirds of them being carried by water, for if the canal has this proportion it will have a large share.

With respect to the revenue that may arise from packet boats, nothing certain can be inferred; for this will depend upon the nature of the canal, the extent of commercial trade, and the population of the country through which it will pass.

There is certainly a considerable degree both of judgment and attention required in laying out a line of canal to the best advantage; but this consists in what is but very little attended to in general; for if there be any mystery in a canal, it is in laying out the best and most useful line the country will afford, and placing the locks at a proper distance; for, 1st. That line should be carefully looked for that will be the least expensive, most durable when finished, do the least injury to private property, be the most convenient for the public, and pay the subscriber the best. 2d. Great care should be taken that the line be laid, as much as possible, to prevent any rival canal being afterwards made that may prove injurious to the undertaking; and the best way, in my opinion, to prevent this, is to lay it out in such a manner as will combine every local advantage, omitting no circumstance that will give the country, or individuals, an opportunity of making collateral branches to communicate with it; and this may supersede the necessity of, and make a rival canal not worth executing. 3d. If possible, the line should be so laid out as not to require a tunnel, because of the great expense that attends the execution of them, and the uncertainty of their durability; but the particular objection to them is the many lives that are almost constantly lost in the execution of them, and after they are finished, by the boatmen falling from the vessels in passing through them; besides the inconvenience, loss of time, and damage done to mercantile goods and bulky articles, by having the sheets and packages torn against the sides and top of the tunnel in passing through; and the water that leaks through the arch, is generally impregnated with mineral particles, and frequently injures the goods.

Upon river navigation I shall say but little; as so many delays and obstructions attend navigating upon them: I am inclined to think few more rivers will be made navigable, except a few pools occasionally; for as dispatch is now become necessary, owing to the great increase of trade, and of competition in it, add to this the many new canals that are making, and many more prejected, I am of opinion, that the trade upon many rivers will be much diminished; and to prevent this, many parts of them are already made canal, witness the Calderand Hebble navigation, which will soon be nearly all canal; and many more navigable rivers must be moulded over again, or they will but seldom be used.

The competition between canal and river navigation, will be much the same as that between stage coaches; for those that can navigate the quickest, and carry for the least money, will command the trade. The loss of time, inconvenience and expense that attends navigating upon rivers, that are part river and part canal, if the pools are bad, is great, as every succeeding flood or fresh chokes up the tail of almost every cut; and to remove this evil effectually, would require the cut to be continued, perhaps, more than half the length of the pool before it entered it. But rather than go to this expense, and that of erecting wears across the river, and of maintaining them, it probably would be better to make an entire canal in the first instance.

Another great inconvenience that attends river navigation is, that the many shoals and crooked windings they abound with greatly retard the speed of the vessel; add to this, the great want of water in summer, partly by the dryness of the season, but chiefly by the obstruction given to them by the mill owners drawing their dams so low, to the great injury of the navigation, and a still much greater to themselves.

If a general act of parliament was passed, to prevent the surface of any river that was navigated from being drawn down more than six inches, and not more than twelve inches below the top of the wear, if it was not navigable, it would be of the utmost consequence to the mill owners, no matter whether the river was navigable or not, as it would prevent them from wasting a great deal of their water to very little purpose.

From the great injury many navigations have suffered, by having the dams so much drawn down, the companies have been under the necessity of purchasing the greatest part of the mills situate upon them, at a most extravagant price, witness the Ayre and Calder navigation company, for I think they have paid more for mill property than any set of men in the kingdom.

The great expense and risque that attends the wears upon rivers by floods, and the breaking up of long frosts, are much greater than people in general are aware of.

If an act was now applied for to make a river navigable that had many mills upon it, unless they were the property of some great personage who was friendly to the scheme, I apprehend it would be so much fettered with protecting clauses, that it would not be worth the promoters' while to accept of it, as they would not have an opportunity of compensating the mill-owners with water from reservoirs, as canal companies have, by intersecting the country upon a much higher level upon all directions.

River dams, near the tide-way, are much longer, broader, and deeper than those from forty to fifty miles more remote from it; yet there are many crooked windings, which subject them to an equal number of shoals and sand banks; for a quick curve in a stream is as sure to raise a gravel bed, or sand bank, as a stone is to fall by its own gravity.

The many errors that have been committed by arbitrators chosen from the bar, imputing the raising of gravel beds and sand banks, to the raising of the wear next below them, are great indeed, when to any intelligent man conversant with the business, it was clear that they were occasioned by natural causes only. But the greatest error of this kind I ever saw has been committed, respecting some gravel beds being raised in Lord Dartmouth's estate, a few miles from Huddersfield; for the fact is now proved, by the wear complained of being lowered, and yet the gravel beds retain their height to the full, for I have lately examined them; and the counsel who was arbitrator, was told what would be the case in the most convincing manner, before he made that absurd and oppressive award, which will be a reflection upon his understanding so long as that wear remains; for a clearer case never came before any man, and a greater blunder was never committed by man; and even in public courts, I have known verdicts given for wears being charged with having raised gravel beds, where they had no more to do with them than the wind had.

What a strange fatality attends the conduct of some men! If the arbritrator had put this plain question to himself; if an easy curve in the banks of the said brook, where it is still deep water, has caused such a sand bed to be raised, will not the same cause operate much more powerfully near the mouth of the teil goit, where there is a strong stream and considerable fall, and where the curve in the brook is more that three times as great as that near the said wear? Had the arbitrator put this question home to himself, and patiently reflected upon it, I think his award would have been very different from what it now is.

But should the bed of a brook, or that of a stream or river, run in a straight line or nearly so, from a wear erected upon it, to the mouth of a tail goit next above it, and should there be a gravel bed or beds of any consequence, at some distance below the mouth of such tail goit, the supposition is strongly in favor of the wear having caused either all or part of them. The curves in a stream require the nicest discrimination before a conclusion can be safely drawn, whether they or the wear next below have been the cause of raising any gravel bed or beds between the two disputed points.

To elucidate this intricate subject more fully, I will suppose a case. Should there be a fall of from five to six inches beween a wear complained of, and the mouth of a tail goit, or the centre of a wheel race that delivers its water into such tail goit above the wear, or a fall equal to the depth of the stream in moderate seasons, when running over the wear, it will not cause any gravel bed to be raised that can do any injury; but wherever a stream ends at the top of any mill, dam, or pool, there a small portion of small gravel will always rest, (because the impelling force of the stream has ceased to act upon it) but the quantity will be so small, as scarcely to be perceived.

But should there be a gravel bed or beds of any considerable height, in a brook, where the fall is what I have supposed between the wheel race and the wear, I dare assert without fear of contradiction, such gravel bed or beds, have been raised by the crooked windings of the stream, either a little above or below the mouth of the tail goit; for a quick curve, a little above the mouth of the goit, may do it as effectually as below it, and this was the case in the said estate before mentioned.

If the curves in the bed of a brook are quick and large near the mouth of any tail goit, if there were five feet of fall between it and the wear, if the distance between them was from one hundred and fifty to two hundred yards, large gravel beds would be raised in the bed of the stream, for there are a thoufand instances in the kingdom that prove it.

There are frequent disputes respecting fixing the height of mill wears. Suppose a person is going to erect a mill in his own estate, and there is no mill upon the stream, either above or below, within a great distance; it is of great moment to the mill-owner, to know what fall he should leave between the mouth of his tail goit and the estate that joins upon him below.

The best and safest way to ascertain this, would be to take the depth of the stream once in the week, for a few months in the spring, and the same in autumn; add them together, and divide them by the number of times the stream has been guaged, and the product will be the mean or average depth of the stream, and whatever number of inches it is found to be, just so much fall should be left between the estate below and that of the supposed mill-owner, and the same quantity of fall should be allowed between the top of the supposed wear and the next estate adjoining, or from the point or place to where the water may be pent back to by it and the next land-owner's estate.

But where the depth of the stream is guaged, the plank or planks, and the top of the wear, if the water is to be guaged there, should be exactly level, or the real quantity of water cannot be found; and before any planks or timbers are fixed, the width of the stream should be taken at various places, to find the mean width of it.

If the mean width is not ascertained, justice cannot be done to all the parties interested, for should the place where the planks or timbers are fixed be wider than the mean width of the stream, the land owner, above and below, would be injured, by not having that fall allowed which they should have; and if the place fixed upon be too narrow, the supposed mill builder would not have justice done him, for the deeper the water ran over the planks or timber, and the greater would the fall be that is to be allowed." If this rule is carefully attended to, few disputes can arise about the quantity of fall that should be allowed between land-owner and mill-owner; for nothing more can be required of the mill-owner than what I have estimated upon, for the effect of floods and freshes are not within his controul, nor should he be made answerable for any part of them.

If the land owner were never to be in the least affected at any time by a wear being erected, not a water-mill in the kingdom could be worked; but such is the physical construction of things, that man must, in civilized society, give up many things for the accommodation of his neighbour, an equivalent for which he receives by a mutual exchange of interest.

But the land-owner often receives great benefit from the erection of a wear, especially upon large rivers, where the water-banks consist of a deep loamy soil, which is easily washed away, and the expense of repairing them is often very great; but where a wear is erected, this expense, in a great measure, is saved, as the water in the dam supports and preserves them. And any loss that may be occasioned by a wear, in flood time, throwing more water upon the adjacent lands, is not of much consequence, all things considered; for it is not easy to determine, whether floods do not improve and fertilize the lands adjoining a river, more than sufficient to compensate for any part of the crop, that may be occasionally carried off by them.

But in consequence of so many water mills, the country is never free from litigations and vexatious law suits, respecting erecting, repairing, or raising mill-wears, by which the peace and harmony of neighbours and friends are often destroyed.

Any person that is going to erect a new mill upon the scite of an old one, or relay an ancient wheel race; if he makes any alteration in the level of it, should, in the first instance, carefully ascertain the height of the wear next below, in three or four different places, if the crown of it is not level, and take the average of them for the mean height of it, and afterwards convey it to the front of his mill, or some adjoining building, and have a strong copper-plate engraved, stating the fall from the lower edge of it to the top of the said wear at that place where the mean height of it was found to be, and the day of the month, and the year of our Lord should be stated; and the plate should be firmly let into a large stone in the building, from ten to twelve feet above the ground.

Should the wear be taken down by a flood subsequent to this, the plate would determine what height the new one should be, and it would prevent any advantage from being taken when any future repairs were made. Had this precaution been observed fifty years ago, I am inclined to think it would have prevented law-suits that have since that time cost near half the value of all the water-mills in the kingdom at that period.

When the mean height of the wear has been found, the mean depth of the stream when passing over it should be ascertained by taking the depth from six to eight times, when the stream is at a moderate height; and whatever the average of them may be, lay the centre-stone in the wheel race so much above that part of the wear that was found to be the mean height of it.

Every mill-owner, from the tide way to the source of the stream, should thus ascertain the fall, if any, from the crown of the wear next below him and the centre stone in the wheel race, and also from the top of his own wear to the centre stone in the wheel race next above him, and have the levels engraved upon a strong copper-plate, and fixed as before stated, or law suits will most certainly take place. Some years ago, the annual expense of water causes and arbitrations, in consequence of them, in the counties of York and Lancaster, were estimated at £10,000, and should trade revive, it is probable in a few years they will exceed this sum, unless some such plan as I have recommended be adopted.

I shall now resume my observations on the speed and construction of water wheels, and the application of water upon them, and give instructions for erecting, what I consider, the most complete corn mill, with its requisite machinery; a subject of the greatest importance to the public, as so much depends upon preparing the grain in the best manner for grinding, and as grinding is so very imperfectly understood. I wish therefore, as much as possible, to assist the miller in the art of grinding; and also to shew the farmer by what means he may bring his grain perfectly dry to market, no matter how badly it may have been housed; for a wet harvest is frequently attended with millions sterling of loss to the public, by the quantity of grain that is rendered unfit for use, and the necessary application to the foreign market.

Those gentlemen who have been lately giving lectures upon the power of water, and shewing how it should be applied to wheels, have generally calculated upon the velocity of the wheel to be equal to one-third of that of the stream, and have estimated for a wheel to pass through a space of three and a half feet per second; but experience has long since proved, that this is a most improper speed; though it is what the French engineers and philosophers have generally estimated upon.

Suppose a water-wheel, fifteen feet diameter, worked by a powerful river, and suppose the fall to be from six to seven feet, with a float board of from twenty to twenty-four inches deep, and the width of it from eight to nine feet, designed to work five pair of grinding stones, (but it would be capable of working from nine to ten pair) such a wheel should make from eight to eight and a half revolutions per minute, equal to near six and a half feet per second, and with an equal quantity of water in a given time, would do much more work, and far better than if it only moved with a speed of three and a half feet per second.

I once applied water fifteen different ways, upon a wheel of sixteen feet diameter, the fall being equal to the diameter of the wheel, and found that it overcame the greatest resistance with a given quantity of water, when it moved with a velocity of full six feet per second

These gentlemen forget, that when a wheel moves only three and a half feet per second, if heavily loaded, a float board can scarcely be got sufficient to contain more than three-fourths of the water applied to it, and that which escapes greatly retards the movement of the wheel; and this holds good with respect to bucketed wheels; for if the wheel has a great resistance to overcome, its slow motion causes the buckets to be so much filled, that at the time the water should be doing the most work, they are turning it out.

It may be said, you should make the wheel twice as wide, and it would contain the quantity of water required; but I should be glad to know what is to be got by this? Will a cubic foot of water increase in its weight, by lying an extra second or two of time on the float? and if no real advantage is to be obtained, why go to such an extraordinary expense in increasing the width of the wheel, when it may be made to do its work much better, and with less water, by only increasing its speed.

But if a real advantage in the saving of water could be obtained by making a wheel move so very slow, it would be highly imprudent to do it, as the slow motion would unavoidably cause a great vibration in it, and of all the machinery dependent upon it; and if there is a considerable tremor in machinery, it can never do its work well; moreover it subjects it to a very speedy dissolution.

It is well known, that the power of a steam engine is obtained with great expense; yet nevertheless, nearly one-fourth of it is expended in working the fly wheel; but no regular motion could be obtained without it.

When a water wheel works so very slow, the least addition or diminution in the work creates a great irregularity in its movement, and is very injurious to the work that is upon it. A wheel of the dimensions before given, should be so much the master of its work, that the addition of four to five horse power would scarcely affect its movement. But was the wheel twelve feet broad, and only moved with a velocity of three and a half feet per second, the addition of one pair of grinding stones would nearly stop it, if no more water was applied. And high wheels that run so very slow can never be made to perform their work well, as the irregularity of the motion is more sensibly felt in high wheels than in low ones.

I think nearly all water wheels have a supply of water three-fourths of the year; would it not then be highly imprudent for any man to calculate his wheel for only the scarce time of water, which would prevent him from using any of the surplus water to make up for the want of power and loss of time when a sufficiency is not to be had.

It is probable the mill-owner would for nine months have abundance of water, no matter how he used it, and might do an extra quantity of work, that would amply make up for the power and time that was lost for the want of it the other three months; but if his wheel ran so very slow, he could avail himself of but little of the surplus water.

I wonder these ingenious gentlemen have not extended their fine spun ideas a little farther, and recommended one set of wheels for winter and another for summer.

With respect to the height of a wheel the fall in the stream, the nature of the trade dependent upon it, and its convenience, should determine that; and as no additional power can be obtained by making a wheel higher than the fall in the stream that works it; yet it would frequently be found that such a wheel would be very inconvenient.

I would not recommend a close bucketed wheel where the fall was not more than eight feet as an open wheel of from fifteen to sixteen feet diameter would be much better for a fall under that, and with an equal quantity of water would be much more powerful; as open wheels are not impeded for want of air, but close wheels always are in a greater or less degree. An open wheel worked by a river, should have the float boards from eighteen to twenty-four inches deep; and a flash board from eight to ten inches deep on the back edge would greatly improve it, but especially if it was heavily loaded; and such a wheel would be made cheaper with cast rims, eighteen inches deep and five-eighths thick, than with stout wood rims and off stands; and stout rolled iron plates for the floats would be cheaper in the end than strong oak boards; yet I should prefer them to cast iron floats which some have used.

Suppose a water wheel from twelve to fifteen feet broad, the axle should be of cast iron, and probably would be the best cast hollow, with forged pivots or necks, and three sets of forged arms; for all the weight might be taken off the middle of the axle, by fixing four spurs to each of the out castings, to which the two outside sets of arms are fixed, and they should be screwed to the under side of the middle rim, and these eight spurs would discharge all the weight from the middle of the axle.

For a wheel fifteen feet diameter, I would recommend forty-eight floats, but if sixteen feet diameter, with shut iron floats, it would very well admit of fifty-six; with respect to the weight of the wheel, if made with a cast axle, cast shields, forged arms, with rolled plates for the floats, such a wheel would weigh from two to near three hundred tons lighter than if made of good wood, stout and firm.

With respect to applying the water to the wheel, I have for more than twenty years always made use of two openings, the upper of them about ten inches from the surface of the water, when at a moderate height, and the second opening about two feet from the surface of it.

But certainly the best way of making a water wheel would be to have the rims of very stout rolled iron, and all the joints rivetted like those for the boiler of a steam engine, and equally well made as them; and the rise and cover of the bucket should be in one plate, nearly the same strength as that of the shield, and the ends of them should be rivetted to it. The arms should be made round and stout of beaten iron, and gradually diminish towards the points. A wheel made upon this principle in the end would be found much cheaper than if made with cast rims and arms; for cast arms for a water wheel should never be used.

Mr. William Greenup, merchant, of Sowerby-bridge, near Halifax, has lately made an iron wheel, which has no cast metal about it, except the axle, and I think there are only four screw pins in it. The wheel is five feet broad, fifteen feet diameter, the shield near seventeen inches deep, and there is a very ingenious but simple plan for supplying the buckets with air; the fall upon the river, by which it is worked, is nearly eight feet four inches. This wheel is by much the best and completest of any I have seen; and yet it has cost less money than if it had been made of good oak, and I think weighs near two tons lighter; and the remainder of this gentleman's machinery for either scribling, carding, spinning, or frizing, is upon a much superior plan to any woollen machinery that I have seen.

Where a water wheel works a great deal of complicated machinery, it would be much better if the speed of it was regulated by a governor in the same manner as for a steam engine; but particularly so where the owner has been so indiscreet as to employ a powerful river upon one wheel.

It is difficult to say, whether making such extraordinary broad water wheels and loading them so heavily, or that of building large factories is the more imprudent; but the time is fast approaching, when the former must give way to machinery less powerful, much more simple, a great deal more useful, and far less expensive; and as for many of the latter they will soon be found not worth using for the present purpose.

The openings for applying the water to the wheel are made in a circular cast plate full inch and a half thick, and admitting the wheel to be fifteen feet broad as before stated, the plate should be cast in two, and the two ends that meet in the middle should rest upon a circular casting for that purpose; and the top edge should rest against a strong piece of oak timber, which will require two or three iron rods screwing to it; and the other end of them should be firmly fixed to something that will not give way; and the bottom edge must be well fixed in the masonry of the race, and the wheel should run within a quarter of an inch of the plate. The shuttle should be made in two, and drawn with a cast iron shaft; and the gear and shaft must run the whole length on the back side of it.

If the wheel is an open one, no matter which way the water is applied, it should not fly through it; for if it does, it will greatly diminish the power. By applying the water through two openings, it gets higher upon the wheel, and will do more work than if conducted to it over a crown stone; and the common way is to divide the fall, and have one half upon it, and the other half in the race. Either way of applying the water may do, but I much prefer the former; for when it is applied from two openings, there is not so much thrown upon the float at once, consequently, it is not so liable to fly off; and moreover, the upper opening is of singular advantage when the river is high, and the wheel contending with back-water. But if the water is conducted to the wheel over a circular crown stone, I would have only one third above it, and two-thirds below it.

I would recommend the same speed for bucketed wheels as for open ones, except they are very high, and in that case, they should have a little more speed, or they may not work steadily; but care must be taken to admit a sufficient quantity of air into them through the sole of the wheel near the rise of the bucket, by leaving an opening of one inch wide and four feet in length, on each side the middle rim; and some persons fix a thin piece of rolled iron plate on the lower side the opening two and a half inches broad, nicely turned up, to prevent the water from flying through, which answers very well, and the wheel through these openings gets amply supplied with air.

This may be admitted as a rule, that if the rims are from sixteen to seventeen inches deep, they will admit of a rolled plate cover full fifteen inches broad, and one half this for the rise; for there is nothing like making the bucket roomy for receiving and delivering its water freely.

No matter what height the wheel may be, full three buckets may be estimated upon for one foot of diameter; for the wheel might as well be made to use a large quantity of water when it is there, as let it run waste, as a large bucket will use a small quantity of water as well as a large one; and there is no great extra expense in making the bucket capacious; but when millrights take the work, they generally recommend narrow shields or rims.

Were I to make a wheel thirty feet diameter, if there was a moderate quantity of water, I would make the shield at least twelve inches deep, as the bucket should never be more than half filled with water; but I would not extend the height above forty feet; yet there are wheels sixty feet high, but rather than have it much higher, I would make it in two wheels, and let the upper discharge its water into the lower; but there is a serious objection to the gear running wet, which cannot be avoided without considerable expense.

With respect to gear, it should not, on any account, be connected with the shield of the wheel, if it can be avoided; for it will soon shake it out of truth, and in process of time will injure it very much; and this is the principal objection to high wheels working one into another.

A millright cannot shew his inattention in a more striking manner, than by connecting gear with the rim of a water wheel, if there is a possibility of avoiding it; for I never saw any that worked well for any length of time, and it is next to impossible to prevent its running wet; when the water is muddy the sand grinds it fast away, and soon works it out of truth; and moreover, whatever grease is applied to it avails nothing, for the sand and water soon remove it.

The next bad plan is fixing the pit wheel to the water wheel arms, as it keeps the gear constantly wet, which injures it very much; for the only way of having any kind of gear to work well and last long, is to have a pit wheel, with loose facings fixed upon the axle, independent of every other thing; and it should have a box made perfectly water tight for the rim to work in; but it will require a cock near the bottom, to let the water out after a flood; for if iron gear is not kept dry, it will neither last long nor work easy; as the sand and water not only grind it away, but keep the teeth rough; and moreover, it is seldom that all the teeth are of equal hardness, and when the soft ones work wet, they are soon ground out of truth, and afterwards they cannot work well. It is for the interest of the millright and the caster that iron gear should work wet, but not for the owner of it.

Was the power of a water wheel equal to that of a forty horse steam engine, I would not make the gear for the first motion more than from eight to nine inches broad on the face.

Iron gear is in general much too strong and heavy, and the pitch too coarse; for there is no occasion for that extraordinary weight of metal if properly made; for the teeth should work near the bottom when first set to work, and if it will not work easy when so fixed, it is a plain proof of its being improperly made. Iron facings, when out of truth, should be well chipped and filed, so as not to require packing with iron wedges when put on; but should the facings or the rim be much out of truth, they may be packed with boarings, such as are used for making the joints of a steam engine, and when dry they will be as hard as iron.

These few general observations I hope will prevent those who, in a great measure, may be strangers to the use of machinery, from being imposed upon, and led into many fatal errors, with respect to the speed of their water wheels; which for some years has been but too much the case with those who engage in mill-works, who may not have had the means of being instructed in the proper use of machinery.

I have before observed, how many have been fatally misled in speeding their water wheels too slow; and it is with pleasure I mention the change of opinion of a worthy ingenious friend of mine, Mr. William Pilling, of Mirfield, corn miller, whom, in the art of grinding and dressing, I have long considered the first in the county of York, and second to none in the kingdom, who had been an advocate for the slow motion of water wheels. Lately he has had the misfortune to be deprived of nearly one-fourth of his fall (which was nearly eight feet) a considerable part of which has been, I think, unjustly taken from him.

His wheel is fifteen feet wide, and thirteen feet high, and was made close and speeded very slow; and to enable him to do his usual quantity of work, he has nearly doubled the speed of it, by enlarging the wallow wheel, so that no alteration was made in the speed of any part of the machinery, except in the water wheel. His wheel is now the same width and height it was, and yet notwithstanding the loss of one-fourth of the fall, the wheel does much more work in a given time, and with less water, besides doing it much better than before; for now it works steadily, but before the alteration, it was at all times upon a tremor, and constantly shook the nuts and pins loose. It now grinds in a manner so much superior to what it did before, as can hardly be described. Should it be asked, how it comes to pass that it now works so much better than it did before the alteration was made? I answer; because the buckets in the first instance were nearly filled with water, when they should not have been more than half filled; and at the time the water should have been doing the most work, the buckets were turning it out; and this would have been the case if the wheel had been made open; for a great part of the water would have run off the floats, or flown over them.

I believe Mr. Pilling was the first that brought the balance rine into this neighbourhood; and though not the original inventor, yet I know of none that works it upon so simple and useful a plan.

The utility of this simple piece of mechanism is almost, if not altogether, as great as that of the spring shuttle; for the time and labour that is saved by it is almost incalculable, besides doing its work much better than the fixed rine ever can

A mill hurst that contained four pair of grinding stones, when the fixed rine was in use, frequently had three pair of them standing while the fourth was hanging, which would frequently require from three to four hours; and often before it had worked an hour, it would have been thrown off the hanging by some hard substance that had got mixed with the grain, which required the same time and labour bestowing upon it again; and after all, it could never be hung any thing like so true as by the balance rine.

But with the balance rine they hang themselves; and was a stone thrown off the hanging by something getting under it, the moment it was taken out, the stone would instantly rehang itself without any assistance.

All that time and labour that was wasted in brigging, that is, in setting the spindle upright, is now done away; for the spindle must be set upright before the stone is laid down, and a few minutes only are necessary to do it. The best way of doing this is to have a small bar or rod of iron three quarters of an inch square, that will reach from the centre of the stone to the edge of it. At one end there should be a square hole that will go into the top of the spindle, with a hole tapt on one side, and have a thumb-screw to fasten to it, and a short arm of from three to four inches long, with a square hole at one end that will go on to the said rod; and this will require a thumb-screw also to fasten it to the rod occasionally, and it must be placed at a right angle with the rod; the other end must have a hole in it to admit of a pin a quarter of an inch thick, with a fine thread, and the point should be steeled and rather sharp, and the other end should be like that of a thumb-screw to turn it with.

When the rod is fixed upon the spindle, slide the short arm first near the eye of the stone, screw it fast, and turn the spindle round, and it will shew whether it is upright; and if it is not, some of the screws that fix the brass step in which the spindle foot works must be altered, so as to make it upright. Then slide the short arm half way between the eye and the edge of the stone, and turn the spindle round, to see if the surface of the stone at that place agrees with that near the eye; and afterwards remove the short arm to the extremity of the stone, turn the spindle round, and see if the surface of it be true there; and all this may be performed in a few minutes. When the rod is fixed upon the spindle top, there will be no need of altering it while these experiments are making, as the pin in the short arm may be either raised or lowered by turning it round.

Every time the low stone is dressed, it should be tried with a good plumb rule, but a spirit level would be much better, set upon the edge of a piece of wood two feet six inches long, made true for that purpose. If the face of the stone should not be true when the spindle is fixed by it, it would throw the gear out of truth, and grind the wood teeth very fast away; but the best and readiest way of fixing the spindle upright is by the face of the stone, provided it be true.

One great advantage resulting from this plan is, the miller can dress his stones twice as often as he used to do before; for so much loss in time in hanging the stones could not be dispensed with; which frequently caused them to be worked much too long, to the great injury of the grain, and a heavy loss to the owner.

The gain to the miller by the balance rine, when every circumstance connected with it is impartially considered is estimated by many intelligent millers at 1*s* 6*d* per quarter; and if 15,000,000 of quarters are annually ground in the three united kingdoms, which I should suppose to be rather a low estimate, when it is considered what a vast quantity of flour is consumed by the army and navy, the annual saving will be £1,125,000. But this supposes the whole of the grain to be ground by the balance rine; but I do not suppose one-fiftieth part of it is, for few millers know of it, and still fewer know how to use it; which shews the necessity of making its utility as public as possible.

The general estimate of the most experienced and intelligent master millers is, that there are 2*s* per quarter difference between grinding well and but in a middling way, and more than 4*s* per quarter difference between grinding very well and ill; and these estimates, which to my certain knowledge are very fair ones, will be readily admitted by all that know any thing of the subject. I may venture to assert, with the greatest confidence, that there is not one miller in twenty that knows any thing about grinding well.

The annual loss by grinding, according to the first estimate, will be £1,500,000; and if an accurate average could be made of the two supposed losses, I have not the smallest doubt but it would much exceed the last mentioned sum.

Grinding and dressing well is of much more importance to the master miller and the public, than men in general are aware of; and it is truly surprising that it should have been so little attended to, considering the high price of grain, for so long a time. There is no manufactory in the kingdom that is of half that consequence to the public as that of grinding corn; yet there is none that stands so much in need of improvement.

I shall now give instructions for building a corn mill, upon what I suppose to be the most improved plan, and shew how its various works should be constructed.

A building to contain four pair of grinding stones (for I have before observed the shilling stones should be in a separate building) should be from fifteen to sixteen yards long within, and from twelve to thirteen yards wide, containing three chamber floors, also an attic floor in the roof. The height of the beams for the first chamber from the ground floor should be nine feet, and from the top side of the first chamber floor to the under side the beams of the second floor ten feet, and from the top side of the second chamber floor to the under side the beams of the third floor nine feet.

There should be a strong rough string course three feet long, and eight inches thick; and the walls should be three feet thick to the ground floor with twelve throughs per rood, from three feet three to three feet six inches long. At the ground floor there should be another course of stone like those for the foundation; and the walls should then be reduced to twenty-six inches thick, and afterwards should be reduced two inches at every floor; and should contain twelve throughs in every rood. The walls should be well grouted from the foundation to the top of the building.

The wheel race bottom should be in whole stones, and go from five to six inches under the walls at each end; and the ashlar for the sides of the race should be eighteen inches on the bed, with twelve throughs in a rood, from three to four feet long.

The building is supposed to be for a powerful water wheel, or for a steam engine equal to twenty-five horse power; and in either case, the grinding stones should be placed at one end of the building. Should the water wheel be supplied with a powerful stream, though the fall should not exceed from six to seven feet, there will be no occasion to make it more than from eight to nine feet broad, as before stated.

There should be another building erected close to the side of the mill, from fourteen to fifteen yards long, ten yards wide; and the said wall of the mill would serve both buildings; but from six to seven yards at the end next the grinding stones, it should be one story lower than the mill, or the remainder of the building; and in the top chamber the ventilator should be placed; and by its being a chamber lower, the grain would descend of its own accord from the mill chamber, or from a chamber in the said building upon the hair cloth. By placing the ventilator upon a level with the second floor of the mill, the grain will descend from it to the grinding stones without much labour.

A warehouse is much better to lodge grain in than a mill chamber; for, with the vibration of the floor and the walls, it soon gets shaken sad and close; and moreover, it is much more exposed to the dust with which a corn mill abounds, than when kept clean in a separate room.

Should a miller, that has a ventilator, make a good deal of shilling, the shudes or seeds would nearly supply it with fuel. The diameter and width of the water wheel should be determined by the power of the stream, its fall, and the work it is intended to perform, and I will suppose it equal to work five pair of grinding stones, and the requisite machinery; and take the diameter at fifteen feet, the width nine feet, but I have sometimes made them much more; but it is highly improper to have more than five pair of grinding stones worked by one wheel, for if more are required, two wheels would be much better; and take the speed of the wheel at eight and a half revolutions per minute, equal to six and a half feet per second, as I have before stated; the upright shaft should make twenty revolutions per minute.

The diameter of the pit wheel should be ten feet, that of the wallow wheel four feet four inches and the spur wheel nine feet diameter; and the nuts for the French stones should be two feet diameter, and make one hundred revolutions per minute; but those for the grey stones should be from two feet two to two feet three inches diameter.

The crown or fly wheel at the top of the upright shaft should be six feet diameter, and work a nut of sixteen inches diameter; and upon the same shaft with the nut, there should be a drum for working the dressing machine, which should make from four hundred and fifty to five hundred revolutions per minute.

The pit wheel, the spur wheel, and the fly wheel, should all have loose facings screwed to the rim; but there is no necessity for having loose facings for the wallow wheel And there should be a cast iron rim for the spindles to stand upon, eight inches broad, one and three quarters inch thick, and ten feet four inches diameter, which may be fixed upon six cast iron pillars, about four feet from the ground floor, or upon six stone pillars; and it should have as many round holes through it, two inches diameter, as there are to be mill stones; and each spindle foot should stand exactly over each hole.

There should be a casting over every hole fourteen inches long, seven broad, and the plate inch thick, with a hole near each end, to screw them to the circular casting; and in the middle of it there should be a round protuberance, shaped like a hatter's block, six inches diameter, and four inches deep; but the inside of it must be a square box, and contain another cast iron box, four inches square in the inside; and the bottom and sides should be half an inch thick, and should fill tightly, yet work easily up and down it.

Through the middle of every side of the inner box there must be a hole three quarters of an inch wide, well tapped, and have a good thread; and opposite to these four holes there must be four mortisses cut through the round part of the casting two inches deep, and three quarters of an inch wide, to admit of four pins going through them and the inner box also. The inner box must not have a hole in the bottom, and the brass step for it should be two and a half inches square, and stand even with the top edge of the box, and have a space of three quarters of an inch between the brass step and the inside of it.

The four said pins should project about an inch and a half on the outside of the round part of the casting, and have square heads to admit of a small screw key, to turn them while the miller is brigging the spindle, as it is called, that is, setting it perpendicular.

The foot of the upright shaft will require a plate with a square box cast upon it, three inches deep, and four inches wide, but should be stronger than that for the spindle, and must have a screw pin in every side to adjust the brass step; but no inner box will be required, nor any spindle to raise it, for when the step is too much worn, it may be raised by putting a piece of rolled iron plate under it, and the cast plate may be screwed to the brig tree with a couple of screws.

It is full twenty years since I first introduced this plan, and I believe it was the first of the kind; and though so much superior to the old way of brigging with a few wooden wedges, and raising the stone with a long clumsy wooden lever, and a string at the end, which was pulled when the stone required either raising or lowering, it lay in obscurity for some years, but now is become universal in this part of the country. This shews how slow the progress of mechanical improvements is; and a greater proof cannot be given than in the use of the balance rine and ventilator. While on the other hand, we see the most trifling and insignificant improvements, if such they should be called, make rapid strides, and, for a time, arrest the attention and mislead men of sound judgment; witness the numberless plans that have been designed for steam engines, and for the make and movement of water wheels, which are vanished like a dream.

The spindle will answer very well, if made of good cast metal; but where the nut will be fixed, and eight inches above, it should be turned as true as possible, and the hole in the nut should be bored true to fit it; and when the spindle is in the throw or lathe, the nut should be put upon it, and the spindle should run in the nut for an hour, in oil and emery dust, till they are polished as fine as possible, to make the nut slide easily when raised out of gear.

A groove should be cut in the spindle, full half an inch wide, and five eighths of an inch deep; the bottom end should begin a little below where the nut should be fixed and continued, and eight to nine inches above it when in gear, that when it is raised out of gear, still the key in the spindle should be some inches above the top of the nut. The key should be made of soft steel, and firmly fixed in the spindle; and there must be a groove cut in the nut that will exactly fit the key, or it will shake when working, and should be half an inch thick and six-eighths of an inch deep. There should be a hoop, half an inch thick, fixed upon the spindle with two screw pins, to prevent the nut from sliding too low when let fall into gear. The nuts for the spindles will work most easily, if cogged with wood six inches broad.

The gear for the pit wheel should be nine inches broad, for the spur wheel seven, and for the fly wheel four inches.

The bearers for the hurst should be made of cast iron, covered with four castings, with holes in to admit of the spindles to pass through, and for the upright shaft also.

The top side of the under grinding stone should be laid three inches above the chamber floor, and the girders for the stones should be of cast iron, but the casings for them of sheet iron; and the hoppers should be made circular of rolled sheet iron, and the shoes for them should be the same. Making a hurst upon this principle will prevent it from taking fire, and the cost would not be above £25 or £30 more than a wood one.

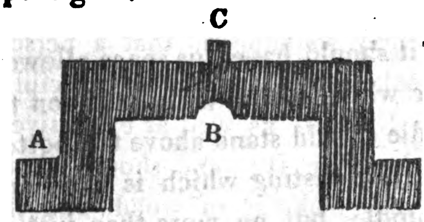
But it may so happen, that a person might wish to make a hurst upon this principle, where it may be difficult, as well as expensive, to procure castings for it; and should that be the case, he may make it of wood, and the circle for the spindles to stand upon also, and it may be made to work equally as well as if made of cast iron; but the gear must be cast iron, except the cogs for the nuts, let it cost what it may.

I have no doubt but there will soon be corn mills built in Russia, and on the continent, upon the principle I recommend.

Both the water wheel shaft and the upright shaft I would recommend to be made of cast iron; but for a wheel only nine feet broad, it is not worth while to cast the shaft hollow. The upright shaft should be cast hollow in one length, sixteen inches diameter at the bottom, and twelve at the top, with a shoulder upon it to support the spur wheel.

I shall now explain the nature of what I consider the most simple and useful, as well as the best balance rine.

The balance rine I recommend is a cast iron bar, as per figure.



The two ends are sunk into the stone, till that part at A is even with the back side of the bur stone, or nearly so, that the stone may be entirely worn before the inside of the bar can obstruct the working of it.

The round cup at B must be exactly in the centre of the stone, and the round ball that is turned on the top of the spindle, must not be more than three-fourths of an inch diameter. When the bar is fixed exactly in the centre of the stone, it should be soldered on with lead as fast as possible; and the width between the inside of the arms of the bar should be equal to the width of the eye of the stone. The bar should be full two inches deep, and one and a half thick, made of good beaten iron.

There will require a round casting six inches deep, and of the same diameter, with a square hole in, neatly fitted to the square of the spindle, and a groove in the top of it, of equal depth with the bar; but the width of it should be a quarter of an inch more than the thickness of the bar, for it should have this space allowed to play in. The whole of the ball that is on the top of the spindle should stand above the bottom of the groove in the casting which is fixed on the top of the spindle, but no more than just what will clear it to admit of its filling the cup B. It is plain, that when the bar is in the groove in the round casting, it will carry the stone round with it.

The letter C represents a square protuberance on the top of the bar, upon which a smsll spindle is fixed, that works the shoe which feeds the stone; and when it is laid down, if it should not exactly balance itself, and it is a hundred to one it does not, it must be adjusted with lead, which should be firmly fastened to it; for the balance must be retained with the greatest exactness, or the stone will not grind well; and it is the want of this precaution that has made many millers miscarry in the use of the balance rine.

Another thing in which the millwrights have greatly erred is in not having the cup at B in the centre of the stone with respect to the depth of it; for this should be as carefully attended to as to have it in the centre in a longitudinal direction.

I hope these instructions for fixing the balance rine, and also those for brigging the spindle and raising it are sufficiently plain, that any master miller, or millwright of common capacity, may understand them

A grinding stone may be balanced with much more exactness by the balance rine, than it can possibly be by the fast rine when fixed upon the spindle; and if this be the fact, the consequence will be, that grinding may be performed with much more exactness by the balance rine than by the fast one. The nuts upon the spindles may with safety be taken out of gear when the water wheel is running; but it must stand while they are put into gear.

French stones four feet eight inches diameter (for this I take to be the best size) will not grind more than three bushels in the hour, if ground in the best manner; yet there are many millers that grind nearly five bushels in the same time; but all such grain is greatly injured. French stones should always be dressed once in the week; and all the clammy paste that adheres to them taken off three days before or after the stone is dressed, with an old card made of strong wire; for this is as beneficial to the stone as half dressing it.

Having the works properly put into the stone is of the greatest importance for grinding well; but the difficulty lies in knowing which is the best way of setting out the works for a grinding stone.

An intelligent man, upon a very superficial view of the works as they are generally put into a grinding stone, will see the impropriety of all such divisions and subdivisions as are commonly used in the land and furrows of a stone.

The works in a grinding stone, as thus set out, plainly shew that some parts of them keep the grain much too long in, by which it is greatly injured; and there are other parts of them so improperly constructed, that they throw it out before it is three-fourths ground. Those works must be the best constructed that commence grinding at an equal distance from the eye of the stone, and uniformly discharge the flour at the edge of it, after the grain has passed through an equal space in an equal time; but to accomplish this, the draft must keep increasing as it approaches the edge of the stone in a given ratio.

As the works are now put into the stone, some of the lines recede from the centre three times as much in a certain length as some others; and there are some lines that approach it five times as fast as they should do.

The next thing to be considered is the raising of the stone, which, in general, is very imperfectly performed. Some are raised by wedges, some by levers and weights, others by screws, and some few by gear; but nearly all of them are imperfectly raised, because they do not lift the spindle perpendicular.

To do this will require a pin or short upright to be nicely forged, two feet six inches long, or any other length that may be required, one inch and a half diameter, and turn four or five inches in the middle, having a fine thread cut of eight in an inch, with a nut for it to work in, fixed firmly in a piece of timber, under the circular casting, in a perpendicular line with the foot of the spindle, but the top must go through the circular casting to the under side the iron box the brass step is placed in, where the spindle foot works; and the bottom of the short upright need not go more than five or six inches through the said timber, which should be strong, as it will have the weight of the stone to carry when working.

Upon the upright pin there should be a square, a little above the said timber, upon which a spur wheel two feet diameter should be fixed containing one hundred teeth. And there must be another short shaft, the same strength as the last, and one end may be fixed near or upon the ground floor, but the other end must rise four inches above the circular casting, upon which a nut must be fixed, containing ten teeth, two inches broad, to work the wheel that contains one hundred teeth; and on the top of the shaft there must be a face wheel fixed, containing sixty teeth, which should stand upwards, and this wheel must be worked by a lying shaft, upon one end of which there must be a nut with ten teeth, to work into the wheel with sixty teeth; and the other end must go through the front of the hurst, and have a handle, by which the stone may be raised the hundred and sixtieth part of an inch, by moving it one tooth; and by the addition of two more wheels, one containing six the other thirty-six teeth, the stone would be raised one thousandth part of an inch, if the handle was only moved one tooth. On the back side of the handle there should be an index, divided into one hundred and sixty or one thousandth parts, if the stone should be raised so little at once; and a hand like that for a clock face should be fixed upon the lying shaft, which would always shew how much the stone was raised at once.

The whole expense of gear work for raising one stone, including that of the balance rine, would not exceed £5; but were they to cost ten times the sum, the money would be well laid out. A cast iron spindle must pass through the hurst, and stand upon the circular casting like the other spindles, and be worked by the spur wheel with a drum at the top; and work the shilling stones by a strap, for they work much better this way than any other.

More than seventeen years ago I designed Warrington corn mills, in which there were nineteen pair of mill stones, but two pair of them were for shilling with, and are worked by straps of extraordinary length.

That raising the stone by gear in the manner described, and lifting the spindle perpendicular, is greatly in favor of grinding well is certain; still one great difficulty remains, and until it is removed, considerable imperfection will attend the machinery of a corn mill, and I think there is nothing more difficult in mechanism than correcting this imperfection. What I allude to is the expansion of the spindle when heated by friction, which is common to all, but much more to some than to others; and the more the spindle is heated, and the greater is the danger of the grain being injured in the grinding; which shews the necessity of, as much as possible, keeping the spindle foot from heating. A spindle foot that is given to heating requires great attention; for it is surprising how much the expansion will raise the stone, and if the miller neglects to lower the foot in proportion, bad grinding is the inevitable consequence.

When the clough or shuttle is set down at night if the stones were not lowered, they would be found too high in the morning to grind well, as the spindles would be much contracted, which would require them raising; but they are generally lowered when the clough is put down, though they are frequently allowed to work an hour or two in the morning, before the miller attends to the raising of them, notwithstanding the spindle may have been considerably extended. Was there no variation in the length of the spindle, the mill might be set to work in the morning; and after the stones were set to work and fixed a proper height, they would require no more looking after for the day. Something simple is wanted to lower the spindle in exact proportion to the expansion of it, which is extremely difficult to discover, if not impossible; and until it is accomplished, there will always be great imperfection in the working of a corn mill.

With respect to the speed and diameter of a French stone, millers are nearly agreed, that from ninety-five to one hundred revolutions per minute is as good a speed as can be found, when the grain is moderately dry; and four feet eight inches is allowed to be the most proper size.

The diameter of a grey stone is generally from five feet six inches to six feet, and the speed from seventy to seventy-five revolutions per minute; and the speed of a dressing machine may be taken at from four hundred and fifty to five hundred revolutions per minute, as before stated; but the flour should not be dressed of near a week after it is ground, for it makes the bran separate more freely from the flour.

The flour should all be raised by elevaters, into a chamber or large bin for that purpose; and the dressing machine should stand upon the next floor below. Elevaters are a number of small square tin cans, and the back side projects full one inch above the mouth, and that part is fastened to a leather or sacking strap, which is worked by rollers; and as these cans pass through the meal ark or trough, they fill themselves, and ascend; and after passing over a roller nearthe top of the room where the meal is laid, they discharge their cargoes, and descend with the mouth downward.

Dressing the grain well before it is ground is of the utmost importance; for if it is not well cleansed from the sand and dust that adheres to it, the colour of the flour will not be good, and its value will consequently be diminished.

The next thing should be to have the grain properly dried by a ventilator, which I shall explain more fully hereafter. The grain should then pass through a screen or riddle, that will admit of nothing to pass through larger than a grain of corn, which might greatly injure the face of a French stone; such for instance, as small nails or broken ones, or small bits of old iron, which foreign grain is much subject to, and this machine is for the purpose of taking them all out. After this it is taken up by elevaters to another screen and passed through it; and from thence it descends into a box fan, in a thin sheet nearly as broad as the fan is long, which is closed on every side, except where air is admitted; and a pipe goes from it in an horizontal direction through the out wall of the building, and separates the dust and sand from the grain, blowing them away through the pipe while the grain descends into a bin, or into the hoppers of the stones, but not until it has frequently undergone five or six of these operations; but I think there is no necessity for all this, as a much better and less expensive plan may be adopted.

After the grain has passed the screen for taking out all hard substances, I would have a circular box to contain a cylinder, upon which four, or from that to six brushes should be fixed, and work against three more brushes fixed against the back side of the box, which should be fixed as near those on the cylinder as can be without touching; and the space between the brushes should be filled up with wood nearly even with the face of them, to prevent the grain from lodging there, and escaping the operation of the brushes.

The grain should descend from the screen in a thin sheet, and fall between the brushes; and if the cylinder moves quick, by only passing once through, it would be more effectually cleansed than by passing ten times through any screen; from the bottom of the cylinder it should descend to the box fan, and from thence to a large bin or hopper, from whence all the lesser hoppers might be supplied. A quantity of air may be admitted into the box where the brushes work, which would take off part of the dust; and it might be easily conveyed into the pipe that goes from the fan.

But when the grain has been dried and dressed in the best possible manner, still much judgment and attention is necessary in the dressing of a French stone. The more kind and open the stone is, and the finer the cracking should be; for if the lines could be made as fine as a hair, they would be the best, but for a close hard stone they should be rather more open.

Cracking the stone is filling the lands of it with fine lines, all of which should run parallel with the furrows; and these lines are made with a two edged tool, fixed upon a short shaft like a mason's hammer, from inch and a half to near two inches broad, which should be made of the best tempered steel, and have an edge as sharp as a joiner's chisel.

When the dressing of a stone is finished, all the lands in it (which should be about sixty in number) should appear filled with fine lines, running parallel with the furrows, from the eye of the stone where they commence to the extremity of it; but such is the carelessness and inattention of the working miller, that unless he is well observed, he will put them in as is most convenient for him. These furrows may be considered as so many large shears that are clipping or cutting the grain, and the fine lines or cracking as so many extremely small scissors that are still carrying on the same operation, until the meal quits the stone.

How much better are the works in a French stone now calculated for grinding, than when dressed by pricking with a small pointed tool, which reduced the face of it to nothing but hills and holes, more uneven and rough than a grater, by which both grain and bran were tore in pieces, and much loss was the consequence of it; and yet strange to tell, this miserable way of dressing, like that of hanging and brigging instead of the balance rine, is the general practice.

I have no doubt, but the grinding of corn, bad as it is, is much better performed in the west riding of the county of York, than in any other part of the kingdom.

I would recommend to the master miller to attend to the following observations.

When the stone is at work, stop it, and take it carefully up without disturbing any of the grain or flour upon the lower stone. Then begin six inches from the eye, and take a small quantity of grain (for it will be little else there) from a number of the furrows, put the quantities upon separate plates, and let them be all numbered, and the furrows from whence they were taken. Six inches more remote from the eye, repeat the same experiment, and attend carefully to the numbers and the distance they were taken from the eye; after this, run over six inches farther from the eye, and proceed exactly in the same manner; and lastly move within an inch or two of the edge of the stone, and take a grain from the same number of furrows; then place the whole before a good light, and with a powerful glass examine every sample, for the naked eye is not sufficiently powerful for so nice an investigation, and it will create much surprise, to find the difference in the state of the grain and meal in some of the furrows, when compared with that in some others, where the distance may be equal from the eye of the stone.

If the grain is found very differently cut in one furrow from that of another, and yet the distances from the centre equal, it is plain, either that the drafts of the furrows are different, or the furrows differently cut, or that the cracking of the stone is imperfect at those places; for the investigation should inform the miller from whence such a difference in the state of the meal arises, or he will profit nothing from the inquiry.

But the shape of the furrow should be carefully attended to, that both the fore and back edge are sloped equally alike; for if the back edge is cut more perpendicular than the fore edge, which is but too commonly the case, the meal will lodge there, and be very injurious to the grinding; both sides should be an inclined plane of equal declivity.

But so imperfect is the knowledge of corn-grinding, that I much doubt whether any one can say, with certainty, which is the best way of putting works into a French stone; and perfection in the art I think cannot be obtained but by repeated experiments, similar to what I have recommended.

A perfect knowledge of the mechanism of a mill stone, and the best mode of grinding, I consider by much the most difficult to obtain of any kind of machinery whatsoever; and this, in a great measure, accounts for its being so imperfectly understood.

To bring two parallel surfaces together, the circumference of each being equal to nearly fifteen feet, consisting of such a number of lands and furrows, and filled with such an infinite number of fine lines, in equal contact in pulverizing the grain, and moving with a velocity, at the extremity, of nearly a mile in three minutes, with a density equal to nearly two thousand pounds, to a reflecting mind will appear next to impossible, and it will excite little surprise, that grinding should be so much involved in ignorance and prejudice; more especially when putting the works into a grinding stone, is constantly committed to the care of the millwright, who has little or no interest in the perfection of them. For it is the master miller, that is, the owner of the works, that should aim at perfection of knowledge in this most intricate business; if he will not take pains to learn it, he has no right to expect another will learn it for him.

What an invaluable source of wealth lies yet unexplored in the drying and grinding of grain; and the prince, the peer, and the peasant are all equally interested in it.

I have already observed, that no corn mill can be complete without a ventilator; and the farmer is equally interested in having one, that he may bring his grain to the market perfectly dry, and at a time when it will be the most beneficial for him.

I hope the following observations will convince the cultivator of the ground, of the necessity, utility, and advantage he will receive from having a ventilator; more especially, as he may procure one at an easy expense, as I shall hereafter shew.

Any chamber may be converted into a ventilator that has a moderate good floor. If a chamber is used for that purpose, a counter floor will be necessary, the beams of which should be laid from twelve to fifteen inches above the present floor, but they will not require to be very strong, seeing they may be supported from the under floor, and should go into the wall, as if intended for a corn warehouse, and the joists should not be placed at more than three inches from each other; for they should be so near, that a person's foot cannot get between them, and they may be cut out of inch and a half, or inch and three quarters board, and from five to six inches deep; and if they should spring a little, they may be supported from the under floor, for the thinner they are, and the more room there will be for the hot air to expand.

It would have been a desirable thing, if the covering of the timber could have been made of cast iron or copper-plate; but experience proves that grain is too delicate to bear it; for it is found impossible to dry it upon any metal plate or even tile, without greatly injuring it, both in taste and colour, and yet it is astonishing the quantity that is dried now upon kilns of every description.

Should it be put upon a tile kiln, it should not be until the fire is quite out; but this will not suit the miller, as he can get very little dried by so slow a process; and experience has fully proved, that as yet nothing artificial that is known of that will dry wheaten grain without injuring the quality, but rarified air blown through it when spread upon a hair cloth, which must be nailed to the joist. The grain will grind much better if it lies two or three days after it is dried.

But I would not recommend a ventilator to be made of wood above twelve feet square. Should there be any broken or open places in the under floor, they should be well made up; and if the walls are not plaistered, they should be; and if it is made in the top chamber, which is by much the best for a mill for discharging the grain from it, it should be under-drawn to the spars, and have three copper pipes fixed in the roof, shaped like a funnel, with the wide end down, and have valves at the top end, which should be from four to five inches diameter; but the wider end should be from twelve to fourteen inches, to let out the steam, and when it ceases to rise, they should be shut to prevent the warm air from escaping.

There should be two small windows opposite to each other to admit of fresh air, for the relief of the men while the grain is taking off, and fresh putting upon the hair cloth.

The next thing to be considered is the best way of rarifying the air, in the most simple and least expensive manner.

I would recommend a caravan stove, as they are called, from three feet to three feet six inches long, two feet wide, twenty inches deep, and the bottom should be made about three inches concave, and the top as much convex.

There should a branch go from one of the sides near the end, eighteen inches long, six inches diameter in the inside, and another the same size at the end most remote from it, to let out the hot air. And there should be two lead pipes, each eight inches long of the same diameter as the cast ones, which should have a flange at one end, and be screwed to the cast flange; but the other end should be without, to admit of a stout tin pipe of the same diameter being soldered to it, and go from thence through the floor and under the hair cloth, and should be continued the whole length of the room, and have the end closed, but should have a great many holes made in it the whole length of the pipe, an eighth of an inch wide, to prevent any extra heat being applied to any part of the grain.

The fan should stand on the same floor with the stove, and as near as circumstances will admit; but if this cannot be had, the air may be carried from it to the stove, if the distance should be from eighteen to twenty feet; but the nearer they stand together and the less power will be required to work the fan.

The wood pipe that will convey the air from the fan should keep gradually diminishing, until it is five and a half inches square in the inside; and should have a strip of leather put round the out side, and the end of the tin pipe should be made square and slide upon it, and nailed to the wood pipe, by which it may be made perfectly air tight.

The fan should be from thirty-two to thirty-four inches wide in the inside, with four stout tin wings or webs, from ten to twelve inches deep, and should make nearly three hundred revolutions per minute; and should it give too much air, the quantity may be reduced by contracting the slides in the end that lets it in.

The tin pipe that conveys the hot air should be inclosed in a wood tube from the stove, until it enters the floor; and there should be two inches of space round it, which should be filled up with sand to prevent any heat from escaping. Tin pipes may be made with one-fifth expense that iron ones would cost, and will answer every purpose, as they will always be kept dry; and there is no fear of them bursting; for I know a factory that has been heated by steam with tin pipes for more than ten years.

The stove should have a flue round it, and a brick and a half wall on the out side of it, and the same thickness of brick should be on the top, and afterwards covered with a thick coat of mortar, to prevent any loss of heat. The chimney for the stove should be from twenty-six to thirty-six feet high; for if the draft is good, any kind of inferior coal may be used; and the bottom of the stove should be from fifteen to sixteen inches from the grate bars, and have a damper to regulate the draft.

It is easy to see, that if the first floor is air tight, the space between it and the hair cloth will be filled with hot air in a few minutes; and there is no possible way for it to escape but through the grain, for by being rarified it becomes much lighter, and its natural tendency is to ascend, were it not compelled by the power of the fan, which will be constantly dislodging it from the stove with air much more dense.

The advantage of having a large fan quickly speeded is great, as much coal may be saved by it; for, as I have before observed, grain made soft and unfit for grinding, by laying too long on ship board, or in the warehouse, by being placed upon the hair cloth from eight to ten hours, when the atmosphere is dry, may be perfectly restored, and made to grind well; but if an ample quantity of cold air was not applied, it would be too weak, and hot air would then be required.

INSTRUCTIONS

FOR ERECTING A BUILDING FOR A VENTILATOR, TWENTY-FOUR FEET SQUARE.

Was I going to erect a building for a ventilator for any person, I would use good sound flags, four feet long and three inches thick, could they be had at a moderate price; and if the owner was not inclined to have cast iron beams, five deal ones might be used, fourteen inches deep and nine thick, and each have a cast pillar to support them in the middle, with a small protuberence on each side of it, upon which a spur might be placed, and a wooden brace, four feet long, nine inches broad, and four thick, should be fixed upon the top of each pillar; and the spurs should go within four inches of the end, and a three quarters screw pin should go through the brace and the beam, and these would make the floor firm and strong. The joints of the stone should be made wide on the top side, and filled with lime, and the whole covered with a rough coat of plaister, to make the floor air tight.

But if good stone could not be procured at a moderate expense, I would recommend three deal beams; pillars, spurs, and braces the same as before mentioned, if the owner did not chuse to have cast iron beams, with flanges on each side for the arch to spring from; for these beams might be cast in two, and would only require one pillar to support them.

If wooden beams are used, there must be a piece of timber, five inches broad and three thick, screwed to each side of the beam, and even with the under side of it, to serve for springers to the arch. And there should be two flat bars of iron, two and a half inches broad, and full half an inch thick, across all the beams; and the floor should be divided into three equal parts; and the bars should have a hole in over the middle of the beams, to admit of an inch pin going through them and the beam, which should be well screwed together; but it would make the gads more easy to manage, if they were in two lengths, and they might lap over each other, and one pin would serve for both; but the other end would require rounding for five inches, made full inch diameter, and have a stout thread, with a nut two inches thick, and have a cast iron washer, of equal thickness, fifteen inches diameter, placed on the out side the gable end wall; and the bars must go through the walls, and the round part through the washer, and should be very firmly screwed.

These bars would be required if there were cast beams, or the arches would throw down the gable end walls; this is the way floors are made in some large cotton factories.

When a brick in length arch has been turned, the spondrels should be filled up with broken bricks and mortar, and a strong coat of rough plaister cover the whole, by which it may be made perfectly air tight. This floor would be much stronger than if made with timber and flags, or of one that is made all of timber; for when it is exposed to great heat it soon becomes weak and tender, having lost its elasticity; if a wood floor is used for a ventilator, I would recommend it to be covered with a coat of plaister.

The farmer and the miller will now see how they should proceed with making a building for a ventilator, and also how they should heat the air, make, and work the fan; and they should know how many degrees the air is heated, which may be done by soldering a small pipe to the tin tube, and have a cock to let out the hot air into a vessel made air tight, of either tin or copper; but the front should be glazed, and have a thermometer fixed in it, and the heat should be kept of an equal temperature.

I shall hereafter give an estimate for a wood floor, that may be made over a chamber floor that is already laid, which includes the hair cloth; also for a floor made of cast metal, which is as applicable to a wood floor as for any other that may be yet to make; and this I consider by much the best, and the expense will not much exceed that of a wood floor if any. From these estimates and directions I hope, that if either the farmer or the miller should make a ventilator one-fourth, or one-third, or even one-half less than that I have been giving instructions for, they will know how to proceed with it, and proportion its various parts in a proper manner.

But I would caution them how they reduce the size of the stove, for if the room should only be four yards square, instead of eight, they should not reduce it more than one-third; and the diameter of the pipe in the inside should not be less than four and a quarter inches, which will be nearly in proportion to a pipe six inches diameter for a room eight yards square.

A fan will be the most simple, useful, and least expensive for raising air, and may be worked by the horses that work the farmer's thrashing machine, and the room for drying the grain should stand near to it; but it will not make much difference if the air is drawn from ten to twelve yards, provided the pipe is well lapped round to keep the air from cooling it, or it may be inclosed in a wooden pipe; and the hot air should be driven so forcibly through the grain, as not to require turning more than once while drying, which should be the last thing at night, and taken off in the morning; but some persons never turn it at all, and yet lay it upon the hair cloth three times as thick as I have estimated upon. In the space of twenty-four hours, though the grain might be very soft when put upon the hair cloth, it would be as dry as possible, and might be dried much sooner, but it is far better to allow it a reasonable time. The higher the roof or top of the room is above the grain, and the more freely will the steam ascend and pass through the pipes.

But perhaps it will be said, that, in a very wet harvest, the corn is unfit for thrashing until it has been stacked for a short time; and during that period it often heats and is very much injured, and sometimes is worth little or nothing; this is lamentable, but the fact is undeniable; yet a ventilator would prevent all this loss, anxiety, and disappointment; for the sheaves might be placed upon an end upon the hair cloth, one above another, and in a day and a night would be fit for stacking or immediate thrashing.

If the room was under drawn to the spars, and this is another reason why the ventilator should be next to the roof on account of height, a row of strong streakers might be placed across it, and a large quantity of sheaves laid upon them, which would dry nearly as well as those upon the hair cloth; which is fully proved by the drying houses for woollen cloth, as the second chamber always dries better than the first, by the heat ascending. In a wet harvest, when grain is badly housed, a ventilator would save the large farmer, in one year, more than three times the sum it would cost.

I estimate upon two hundred statute acres to produce six hundred quarters of grain, which would at least be improved 3*s* per quarter, admitting the grain to be fairly housed; but should the harvest be wet, it would increase its value more than five times the sum; but taking it at the lower estimate, it would be £90; and surely this is worth the attention of a small farmer.

But should the harvest be very wet, a ventilator would be productive of much greater profit to the farmer than the higher estimate; as he might have his grain made perfectly dry, and not be compelled to throw nearly the whole of it into the market at once, to avoid the final loss of it.

For in such calamitous times as these, the opulent corn miller and the rich corn speculator rush into the market, and purchase all the grain they can, no matter what state it is in; scraping together all the bad housed grain they can meet with, they hurry it off to various drying kilns; and after scorching it up, mix a little good grain with the bad, and by so doing, the whole mass is entirely spoiled; for this is the common practice in a wet harvest, or when the grain is housed soft and unfit to keep. The consequence of this is that an uncommon quantity of bad meal and flour is poured into the market, and is frequently very injurious to the health of the community; and notwithstanding the bad quality, an immediate advance in the price takes place, of from fifty to perhaps one hundred per cent; for this I have known to be the case.

I shall now give the farmer a list of the different sized ventilators, by which he will be able to judge what dimensions are the best calculated to suit him.

I estimate upon ten cubic feet of grain being equal to one quarter of wheat, and the ventilator to be filled once every twenty-four hours, the grain lying twelve inches deep upon it. According to this calculation, a room six feet square would dry full three and a half quarters of grain per day, twenty-one per week, and per month of thirty days, one hundred and five quarters would be dried.

A room nine feet square, would dry full eight quarters per day, forty-eight per week, and two hundred and forty per month; a room twelve feet square, would dry nearly fourteen and a half quarters per day, nearly eighty-seven per week, and four hundred and thirty-five per month; a room fifteen feet square, would dry twenty-two and a half quarters per day, one hundred and thirty-five per week, and six hundred and seventy-five per month; a room eighteen feet square, would dry nearly thirty-two and a half quarters per day, one hundred and ninety-five per week, and nine hundred and seventy-five per month; a room twenty-one feet square, would dry forty-two quarters per day, two hundred and fifty-two per week, and one thousand two hundred and sixty per month; a room twenty-four feet square, would dry fifty-seven and a half quarters per day, three hundred and forty-five per week, and one thousand seven hundred and twenty-five per month; a room twenty-seven feet square, would dry seventy-three quarters per day, four hundred and thirty-eight per week, and two thousand one hundred and ninety per month; and a room thirty feet square, would dry ninety quarters per day, five hundred and forty per week, and two thousand seven hundred per month.

I am of opinion, that a ventilator thirty feet square, would be ample for the largest farmer in the kingdom; and if he has a thrashing machine, he may work a fan with it, from thirty to thirty-six inches broad, or a small cylinder made upon the same principle as those for a blast furnace; but the former machine is much more simple, and I think, in general, better adapted to the genius of the farmer.

A ventilator of from six to nine feet square, might be taken from a chamber in the house, or placed in a small out building near it; and a boy of fourteen years might work a fan or bellows, that would supply it with hot air, and the latter would be large enough for a farmer that had seventy acres of wheat. If the chimney for the furnace was raised a good height, it would assist the draft, and inferior coal might be used for that purpose.

A respectable corn miller who has a ventilator, but a very inferior one indeed, informed me, that a bushel of coal dried from twelve to fourteen quarters of grain, which is scarcely a halfpenny per quarter; and coal at 6*d* per bushel is rather high.

If any gentleman farmer would undertake the erection of a ventilator upon a liberal plan, in manner as I shall hereafter describe, and have all the work well executed, I think they would soon become general; and in a wet harvest, were they in the hands of every farmer who occupied a considerable quantity of land, they would save themselves and the public millions sterling, by giving the labouring class sound wholesome food, and at a reasonable price, which, under such circumstances, could not be had by any other means; and they would prevent those ruinous speculations that always attend a wet harvest; moreover, we should be independent of the foreign market.

The great scarcity and high price of grain, occasioned by a wet harvest, does not so much arise from any deficiency in the quantity, as from the loss and waste by its being housed and stacked soft, and the farmer not being able to get it thrashed out in time before it begins to heat; and yet, exposing so much soft grain to public sale at once, is next to giving it away.

But what can the farmer do else than sell it, if he has not sufficient chambers to lay it in; but if he had, no means could be used to keep it from heating in some degree.

Another dreadful loss attends grinding soft grain, as the meal cannot be separated from the bran as it ought to be; for the face of the stone is covered with a thick tough dough or paste, and it is very surprising how hot it will be; and to avoid this loss as much as possible, when grain is in this state it is scorched upon drying kilns; but the colour and taste of it is much injured, as I have before observed; and yet without this method being used, it would be impossible to grind it.

The great loss that attends grinding soft grain, shews the necessity of the corn miller and the farmer being compelled to have ventilators.

If government would pass an act, and compel both the farmer and the miller to use ventilators made upon a proper principle, it would in my opinion, be the most humane and benevolent law that was ever enacted; and surely they will not think such a great national improvement unworthy their attention.

To procure an equivalent of grain lost by a wet harvest, government have frequently been under the necessity of sending millions sterling to the foreign market in a single year; but if ventilators had been in general use, nearly all this loss would have been prevented; for the poor would have had a sufficiency of bread, and at a moderate price; and the subscriptions for soup shops, and the cry of the poor would not have been heard in our streets.

I will not estimate upon all the grain being seriously injured by a wet harvest, though little escapes, but only upon what I suppose may be two-thirds of it; and take the quantity that may have been injured equal to ten millions of quarters, which at 10s per quarter, will amount to £5,000,000, and I estimate the loss on all other kind of grain to be £3,000,000, making a total loss of £8,000,000.

It is a well known fact, that the loss in grain in only one year by a wet harvest, was near twice this sum, and yet nearly all the loss that attends a wet harvest, may in future be prevented with only expending a trifling sum when compared with the great object that would be obtained by it.

I shall now give a brief estimate for making a ventilator, and take it for granted, that the farmer has a chamber which he can spare for that purpose, and calculate upon a room twenty-four feet square. Such a room will contain sixty-four square yards; but the timber for it will require no dressing.

	£.	s.	d.
I estimate the floor and hair cloth at 13*s* per yard, equal to - - -	41	12	0
Underdrawing the roof to the spars, one hundred yards, 1*s* per, - - - - -	5	0	0
Plaistering the walls, - - -	3	12	0
Building a hovel, from nine to ten feet square, for the stove to stand in, - -	12	12	0
Expense of a cast iron caravan stove, which includes grate, bars, door, and brick-work, (but it may be something more) -	21	10	0
Making a fan £10 10, fourteen yards of six inch tin pipe 42*s*, two short lead pipes 41*s*,	14	13	0
Making a crane to lift the grain to the ventilator,	5	10	0
	£104	9	0

Such a ventilator as this would dry forty-eight quarters of wheat in twenty-four hours, with a slow fire, as I have already shewn; but it may be dried in half the time, though I would caution the farmer and the miller against drying it too fast.

I estimate the coal at 2*s* per day; but in some situations it will not cost more than half the sum, and the man's wages for taking care of it at 3*s* per day, and allow the same for the power of the horse, and one penny per quarter for bringing the grain to, and taking it from the ventilator, making in all 12*s* per day, which is equal to full $2\frac{3}{4}d$ per quarter; but it is probable that some of the men that wait upon the thrashing machine would look after the fire, as it would require feeding but very seldom; which would reduce the expense to near 2*d* per quarter.

Was the same quantity of grain lodged in a public corn warehouse, and proper care taken of it for only two months, I am inclined to think it would cost nearly twice the last mentioned sum, and by expending little more than 2*d* per quarter in drying it, it would keep sweet and good for years; and turning it over twice in the year would be quite sufficient, and every quarter of that grain would be worth from 3*s* to 4*s* per quarter more in any public market; and if the farmer chose, he might have a large screen fixed in the middle of the pipe that conveys it from the hair cloth to the sack, which would make it much cleaner, and look far better; and no extra labour would be required in doing it.

I am aware of the farmer's objection to drying his grain, because, says he, it will make it much lighter; but he has nothing to fear from this; for when it has lain a few weeks, he will find little variation in the weight of it, except being from three to four pounds heavier. But let that be as it may, no miller would purchase any of his grain that was undried, so long as he had any of the dried to dispose of, and at the advanced price.

Who ever heard of a corn miller refusing to purchase Dantsic wheat because it was too light, and is it not all dried? and yet our millers will purchase it in preference to any grain that is grown in this, or any other country, because it is drier than any they can meet with.

Some years ago, I was conversing with a public baker in the north, upon the utility of ventilators, and he informed me, he would give from 2*s* 6*d* to 3*s* per pack more for flour, if the grain had been dried by a ventilator, supposing it to have been in good condition before it was dried, than he would give for it in its natural state, and added, I can get much more by it than the extra price, as it takes much more water to knead it, consequently, I get a much greater weight of bread from it; and it may be carried round the globe, either in flour or in bread, without producing any kind of vermin.

It is well known, the corn in Poland is dried in barns that have flues in the walls, and are heated with lumber wood, and the excrements of the cattle when dried by the sun, also with stubble, roots, &c; and the sheaves are placed upon the end on the ground floor, from twelve to fifteen hours, or longer if required, and afterwards taken out and stacked. This prudent practice I understand is not peculiar to a wet harvest, but is general in nearly every part of the country; though there is little variation of season there, being only winter and summer, and their commencement and conclusion are known to within a few days.

Now if the people in Poland judge it so necessary to dry their grain where the summer is so very fine, and subject to little variation; does it not shew, in the strongest light, the absolute necessity of our farmers being provided with the best possible means of drying their grain, seeing the weather is much more variable in England than in any other part of Europe?

In the present state of things, the farmer's capital is more insecure than that of any other class of men; and what makes it much more so, is, because he cannot insure himself against the sad effects of high winds and excessive rains, which frequently take place both before and in the time of harvest; by which all his fond hopes of an abundant crop are blasted, and himself and family plunged into utter ruin; nor can his situation be made more permanent, until he has the means of drying his grain, and disposing of it at those times when it will be most for his interest.

Although I have shewn the great advantage there is in drying grain by a ventilator, it is probable some farmer may think, that if drying grain in a barn answers so well in Poland, it would do equally so here, and perhaps be less expensive than a ventilator. But this will be found a great mistake, as the following statements will shew.

I will suppose a barn built, to dry sheaves in, twenty yards long and twelve yards wide. Such a building would contain two hundred and forty square yards; but ten of them should be deducted for the space the flues would occupy, which should be placed on the floor, and not in the wall. I estimate upon eight sheaves standing in one square yard, but they will stand very close; and according to this calculation, one thousand eight hundred and forty would stand upon the supposed floor; and if ten sheaves are allowed for a hattock, and thirty-five of them per acre, each acre producing three quarters of grain, and the sheaves are to be dried in two days time; such a floor would contain nearly five acres of hattocks, and I will suppose five beams placed across the barn, eight feet from the ground floor, and a sufficient number of loose streakers placed upon them, capable of containing three acres more sheaves, making in all eight acres. From this statement, twenty-four acres of sheaves are estimated to be dried in six days, which is the utmost that should be calculated upon, and is supposed to be equal to seventy-two quarters of grain.

A ventilator eight yards square will contain sixty-four square yards and would dry three hundred and forty-five quarters of grain in six days, which is nearly five times as much as could be dried in the sheaf, in the supposed barn, and the room required to dry it in is only about one-fourth of that required to dry seventy-two quarters in the sheaf; and yet the barn contains nearly four times the space the ventilator does; moreover, there will be much more fuel consumed in drying seventy-two quarters of grain in the barn than three hundred and forty five by the ventilator, for three reasons; 1st. A large quantity of fuel would be expended in heating the flues and in rarifying the air for a space including length, breadth, and height, near six times as large as that required for the ventilator. 2nd. The immense quantity of steam that would evaporate from the straw would, for a considerable time, descend upon the ears of corn, which would require great heat to dissipate it. 3d. As the grain will be dried in the ear, it will require much more heat than if it was freed from it; and as the bottom of the sheaves cannot dry half so fast as the ears, I should think it would require one day more to dry it, than grain dried by a ventilator, and the barn would be more than four times as expensive as the ventilator.

I am fully satisfied there never will be any thing designed for drying grain equal to rarified air, when properly applied; and moreover, it has this particular advantage over every other plan of drying grain, that nothing can be set on fire by it.

It is strange that the American farmers should be so much inferior to the poles in the management of their grain, and that they have paid so little attention to this subject, considering the large quantities of flour that turn sour before the barrels are opened ; and how soon that which was sweet when opened becomes unfit for food, if not quickly used.

Some corn factors, who deal largely in American flour, and are competent judges of this loss, state the average of it at ten per cent, which, though great, I think, is not over-rated ; but there are others that estimate it much higher. And although the American grain is housed much drier than ours, or even than that of the Poles, yet experience proves, that, however dry it may be when housed, flour, and bread made from it, cannot be preserved sweet for any considerable length of time, if it has to pass through much change of climate and a great distance by water.

The dryest grain that can be produced by the sun and air contains a portion of moisture, which must be extracted from it by artificial means, if the flour made from it is intended for a long sea voyage; and any grain that is intended to be preserved pure for a long time must have its natural moisture separated from it, either by long, tedious, and expensive shifting and turning, or by a method much more simple, less expensive, and far more effectual ; that is, by a ventilator.

The American farmers have abundance of lumber wood, in every province, and in some of them there is a vast quantity of coal, with which they might dry their grain; but from their neglecting to do it, one would think they were strangers to the plan and use of a ventilator.

Was the American grain put twelve or fifteen hours upon a ventilator, either flour or bread made from it, might be carried from thence to the East Indies, and brought back; and afterwards go to the Spanish main and still would be perfectly sweet, and free from all kind of vermin; and so would the flour and bread be that was made from our own grain, if it was properly dried with hot air. The atmospheric air which is so necessary for the growth and nourishment of both man and grain, contains the seeds of dissolution for both; still a long reprieve may be procured for the latter, the decay of which, like that of the oak, commences with the heart.

From all the experiments that have been made with grain, to preserve it sound and sweet, while passing through great changes of climate, there has nothing as yet been found, that will extract that perishable quality, its natural moisture, except hot air; but when once effectually deprived of it, it will remain pure for many years; but no one I presume, can tell how many, as sufficient experiments have not been made to ascertain the fact with accuracy.

There is however sufficient proof, that grain has been kept pure one hundred and twenty-nine years. For Henry the second of France and his retinue, eat bread baked of wheat, which had been kept for this length of time, after the siege of Metz.

Though grain is so extremely perishable, as daily experience proves, yet I have no doubt, but it may be kept perfectly sweet for one hundred years, if put into strong wooden boxes, made air tight, and when covered with quick lime, sprinkled over with water, and lodged ten or twelve feet in the earth; for there are facts I believe to support this opinion; and though we possess more ample means for drying grain, than any nation upon earth, we frequently suffer in the space of one year many thousand quarters to be entirely lost, and millions more to be greatly injured.

The corn miller is equally interested in having a ventilator as the farmer; for grain that has been dried with hot air grinds much more freely than in its natural state; for the meal can never be so effectually separated from the bran as when dried, though a quarter of grain may weigh something lighter when dried; but if the miller weighs the meal he gets from it, and grinds another quarter from the same bulk undried, and postpones the dressing of them for four or five days, and then weighs the flour each quarter has produced, he will find the dried flour nearly, if not full, four pounds heavier, for this I know to be the fact; and the miller gains 1*s* extra by it.

Grain that has been well housed is frequently made soft by lying too long in the factor's warehouse, or by being too long on board a vessel; and when this is the case, such grain will only require putting upon the hair cloth, and the wind blowing through it ten or twelve hours when the atmosphere is clear and dry, and it will bring it back to its natural state, and make it fit for grinding; but should the atmosphere be soft and damp, it will still make it more soft.

Another great advantage the miller gets by drying his grain is, its making the meal dress so much cleaner than if undried; and if he grinds by steam, more than one-tenth of the power will be saved in the grinding.

I was lately conversing with a corn miller, who grinds a large quantity of wheat, who informed me that a quarter of grain, properly dried with hot air, was worth full 2*s* more to a miller than when in its natural state; supposing the grain to be in proper condition before it was dried.

If this estimate is correct, and I think there is no ground for calling it in question, except for its being too low; and if 1*s* 6*d* per quarter be allowed for the saving there is by using the balance rine properly; and I have not heard any respectable miller that is working with it state it at less; if the average value of the grain is taken at 80*s* per quarter, one twenty-third part of the whole value of all the wheat grown in the three united kingdoms, may be saved by this new plan of manufacturing it; and then there is the great saving to add, which the public will receive, by having a much greater weight of bread from a given quantity of flour, as I shall hereafter shew. This is a most striking circumstance indeed; yet I think it will be difficult for any one to disprove it.

How lamentable a consideration, that two such great national improvements should be so little understood. But if the saving the farmer would have by drying his grain, was added to that which may be made by the improvements which I recommend in the manufacturing of grain, especially in a wet or soft harvest, few would be disposed to believe it.

What are all the improvements in our manufactories and spinning, when compared with those that may be made in the simple manufacturing of grain; and what still makes them of infinitely more importance is, that all the civilized world is deeply interested in them.

There is no manufactory of any kind, that I know of, in which so little improvement has been made for the last thirty years, as that of grinding, and the reason is obvious. 1st, Those in general that have been employed in it, have not been men of either family, fortune, or education; hence they have been almost excluded from the society of the gentleman and merchant; add to this, that the trade itself has frequently been very unpopular, and those employed in it persecuted when they deserved the greatest encouragement and protection. 2d. When want of education, of capital, and a regular association with men of science prevail, improvement will make slow progress; but the clouds of ignorance and prejudice that have governed the unthinking multitude are passing away very fast, and the farmer and the miller will soon rank with the more polished part of the community.

"There are not two characters in the kingdom upon which the necessary comforts of life so much depend; and yet there are no two classes of men in the community, that have been so much neglected and persecuted by lawless mobs, or had so much of their property taken and wilfully destroyed.

I have before remarked, what pains the Poles take in drying their grain, that it may resist all the change of climate it may have to pass through; and also to preserve it good when stowed so very thick in these immense warehouses at Dantzic, which are by much the largest and most numerous of any in Europe.

From the vast length of time the grain is kept in them, and the small attention that is paid to it at the time, was is not dried, it would perish in one-fourth of the time it frequently lies there; yet, when taken out, it is perfectly sweet and sound.

And can a people, so destitute as the Poles are of materials to dry their grain with, and which are collected with so much toil and expense, preserve it sound and good for so many years, while in the short space of three or four months after an unfavourable harvest, many million quarters of our grain are become almost unfit for any thing except the dunghill.

The want of understanding and attention in our farmers and master millers in neglecting to have ventilators will appear very striking, when it is considered, that nearly all the north of England abounds in coal, which, in general, may be had at an easy expense; for all the grain in the kingdom might be dried for less than 3*d* per quarter.

But what is still more astonishing, is, that millions of acres of grain are raised annually from the grounds under which these immense coal mines lie; and yet, in a wet harvest, a great part of it is suffered to perish for want of drying; and the quantity lost is to be replaced from the foreign market, and at an increased expense of frequently more than £60 per cent. Will the future historian credit this? Yet where is the man that can disprove it.

Surely this most important subject will be taken up by some of the agricultural societies, and ventilators erected for public inspection; for if they are once introduced, they are sure to become general.

It would be a most fortunate circumstance, if Earl Fitzwilliam, Lord Harewood, and a few more of the nobility in this county, would each erect a ventilator, to shew their tenants the beneficial effects of them. And I hope Lord Grenville, Lord Darnley, Earl Grey, Lord Stanhope, His Grace the Duke of Bedford, the Duke of Norfolk, and many more great land owners, will each build a ventilator; and thereby set a noble example to their tenants; and surely these noblemen are the most proper persons to take the lead in so great a national improvement, and assist and encourage their tenants to improve their situation, and make their precarious capital more permanent.

There is nothing that I know of is of so great importance to the farmer and the public, as making provision to prevent the dreadful effects of a wet harvest; and the only plan by which it can be accomplished, is as simple as binding sheaves by the reapers.

If making a ventilator was either expensive or complex, the farmer might be deterred from making one, but I can asure him it will not be attended with either of these discouraging circumstances.

There have been some millions of quarters of grain greatly injured and a great deal entirely lost, within the last eight months, partly by being housed too soon, and partly by such vast quantities having been stowed together, that sufficient attention could not be paid to it: the sad effects of unbounded speculation from the great advance that was expected to have taken place, in consequence of the new corn law; but fortunately for the public, it had a contrary effect.

The greatest part of the wheat that is sold in Wakefield and the surrounding markets is so extremely soft, that a great deal of it is grown together, and the miller is under the necessity of drying nearly one half of it upon his kiln, and mixing an equal quantity of undried grain with it before it is ground; but mixing it thus greatly injures the whole.

Nearly all the malt kilns in the country have been, and are employed in drying grain thus injured, and to destroy the vermin with which it so much abounds; for the bulk lifts with them, and if a stranger was to view it, he would think the whole was going to remove.

When all this soft grain has been scorched upon these kilns, as much of it will be preserved as can be until new grain comes into the market, with which it will be mixed; and the quantity of new grain that will be spoiled by it is incalculable. If the farmer had dried all this soft grain upon ventilators, the loss they and the public will sustain would have been prevented.

Drying wheat upon common kilns is attended with great care and risk, for if it is not kept constantly turning, it is sure to be burnt: I have lately seen a quantity of wheat which was good but soft, that a farmer had got dried upon a common kiln, and it was so much burnt that the grower was glad to take 30s per quarter for it. Purchasing so much grain in expectation of a great advance has ruined many speculators, and the same grain will ruin many of its present holders.

Since large corn warehouses have been erected at Wakefield, and other towns, I am informed by respectable farmers, that five times more grain is spoiled than formerly, when the miller bought it direct from the farmer, and this I can easily conceive to be the fact; for the trade is now entirely changed, great factors are in general the first purchasers, and buying largely upon speculation, send it to be stowed in these warehouses, and afterwards sold by commission to the best advantage.

But when there is so much grain in the warehouses, it cannot have that attention paid to it that the state of it requires; and moreover, it is frequently very soft when warehoused: no matter of surprise then that so much of it should be greatly injured.

I am fully satisfied, that if one of the owners of those warehouses would make a ventilator in one of their top chambers, that would dry from one hundred and thirty to one hundred and fifty quarters of grain at once, and erect a three or four horse engine to work it, it would raise a quantity of hot air that would do more than supply two such ventilators; and the engine would draw up all the grain from the vessels, and remove it from one room to another, when required, by elevators, and probably would save the wages of five or six porters in every such warehouse; and I think the grain might be dried by a ventilator in such warehouses, cheaper than it now can be proper care taken of for a single month; and I have no doubt but the owner would receive £30 per cent interest for the capital he might sink.

Every large corn warehouse should have a ventilator and a small engine; and such a convenience would give the owner a great command of business; for at all times he might warrant the grain he sold to be dry, or he might keep it till it suited the interest of the owner to sell; for after being dried, it would not require turning from six to nine months, though five or six feet thick.

I have before observed, that where a ventilator exceeds twelve feet square, I would make it upon a plan different from that which I have already described.

Suppose a great farmer or corn miller should require a ventilator twenty-four feet square; instead of wood beams, I would recommend cast iron plates, half an inch thick, in two lengths, screwed together in the middle, and have five inches of hold in the wall at each end; and the depth should be seven inches, with a flange half an inch broad on each side the bottom edge, and the distance between them not more then four feet. On each side the plate there should be cast brackets, made dovetail for the ends of the cast joints, which should fill them very tightly, to prevent the beams from moving sideway; and the depth of the joists should be full two inches and a half thick, with a flange on each side the top edge, three-eighths of an inch broad, which would make the top edge inch and quarter broad, and should stand level with the top edge of the plates or beams; the distance between them should be near two inches and a half. A short cast iron pillar, from twelve to fifteen inches long, should be fixed to the floor, for the joints of the plates to rest upon; and it would be adviseable to have a similar pillar, but rather lighter, to support the middle of each plate, which would divide the length into four equal parts, each six feet long.

Should the joists be found to spring, but I do not suppose they will, as there will always be two to support the foot when treading upon them lengthway, but three when stepping across; seven short pillars may be screwed to the floor, and have a mortise at the top half an inch wide, and one and a half deep, and have eight castings half an inch thick, two and a half deep, and one edge should fill the mortise, and the other go against the under edge of the joists, which would make them strong and firm (as the bearings would only be three feet) and more than sufficient to carry three times the weight proposed to be put upon them.

At one end of the room there should be half a deal plank fixed to fasten the hair cloth to, and at the other end there should be a cast iron roller (which will not require turning) two inches diameter, made in three lengths, and so jointed, that any one part may be worked while the other are standing; for such a roller will probably be found necessary, as some part of the hair cloth may stretch more than another. The roller will want a rack wheel, from five to six inches diameter, and a catch also.

There should be three pipes to discharge the grain from the hair cloth, which may be fixed either in the middle of the room or on one side of it, as may be most convenient; but they should have mouth pieces or covers that fit very tightly, to prevent the cold air from entering, or the hot air from escaping.

Estimate for a Cast Iron Floor for a Ventilator.

	Cwt.	qr.	lb.		£.	s.	d.
Six cast plates for beams, each 24 feet 10 inches long, 7 inches deep, but including the flanges, are equal to 8 inches,	15	3	6				
Twenty-four cast joists, 24 feet long, 2 inches and ¾ broad, including the flanges,	21	0	24				
Six pillars for the joints of the plates, each weighing 24lb,	1	1	4				
Twelve pillars for the middle of the plates, each weighing 16lb,	1	2	24				
Eight pillars for the joists, each weighing 12lb,	0	5	15				
Eight bearing plates for the joists, each weighing 14lb,	1	0	0	at			
	41	3	14	16s	33	10	0
Making the joint plates, fixing up the pillars, and laying down the castings,					4	14	0
					38	4	0

This estimate is near 12s per yard, and is something more than a wood floor would cost, still I think in the end, it would be by much the cheapest, as it would be three times as durable; wood in a drying house, in a few years, becomes extremely brittle, and the room would be heated with less fuel than if the floor was made of wood, for the hot air would have much more room to expand in. And upon more mature consideration, I would recommend all ventilators to be made of cast iron.

Near twenty years ago, some of the great farmers in Somersetshire, urged me very much to employ my thoughts upon something that would enable the farmer to dry his grain that might have been housed soft; and stated, in the strongest language, the great advantage the farmer and the public would derive from it.

I then saw the necessity and utility of such a plan; but my engagements at that time were such as would not permit me to attend to it; for my ideas of a ventilator were then nearly what they are now; but the principal thing that discouraged me was the want of understanding in the farmers with respect to the use of machinery; for at that time there were no thrashing machines established; though something had been attempted, which entirely failed; and I found it was the general opinion among the farmers, that they could not be made to answer. Fortunately for themselves and the public, they were agreeably mistaken, and by the introduction of them, the way is made plain and easy for erecting and using ventilators.

For whatever farmer has a thrashing machine, he will only require a nut to work in his larger spur or face wheel fixed upon the end of a small shaft, and a moderate sized drum on the other end of it, and from thence a strap to turn the pulley upon the end of the axis of the fan, which should run at near double the speed as that for a corn mill; and this is the whole of the machinery he will have to prepare.

The alarming state of the grain that is thrashed out, and of the meal and flour, calls for the serious consideration and assistance of the great land owners, to introduce something that will, in future, prevent a return of a similar calamity; and, if possible, to adopt some plan that will deliver the farmer from that inevitable ruin with which he is threatened.

The great advantage the farmer, the corn miller, and the public will receive from the introduction of ventilators, will, I hope, not be confined to the drying of wheat only; for I think there is the greatest probability, that in a little time, all our malt and oats will be dried with them upon hair cloth; for I can assure my readers, it means nothing how wet and soft the grain is when put upon the hair cloth, it will soon dry it without in the least injuring it, or affecting either its flavour or colour any more than if dried by the sun.

It is well known, that a considerable part of the malt that is made in this kingdom is spoiled in the drying, by its being so much parched and baked by excessive and unnatural heat; that all that rich nutriment, flavour, and colour it originally possessed is destroyed, and most of the insipid liquor distilled from it is as red almost as poppy, and destitute of that rich flavour and animating quality which it ought to possess.

I hope a total change in the drying and grinding of our grain will soon take place. The heat for drying wheat should not be more than about eighty degrees, and that for malt from eighty-five to eighty-six degrees.

I have dwelt long upon this most important and interesting subject; but the many and momentous objects it embraces will, I hope, be deemed a sufficient apology for trespassing so much upon the patience of my readers.

Observations UPON PUBLIC DRAINS.

That drains have been of great public utility no one can deny, and it would have been well if many more of them had been made; though the principle, like that of canals, has as yet been very imperfectly understood. I have seen many of them in various parts of the kingdom; and it appears to me, that there is a great want of judgment both in the designing and executing of them, particularly in two respects;—1st. want of sufficient width and slope for the sides where the ground is very wet and swampy;—2nd. making the gates or cloughs too narrow to admit of the drain being cleared of its water before the tide returns, especially in spring tides, by which a great deal of their utility is lost.

In many instances that I have met with, it would have required from an hour and a half to near two hours more to have cleared the drain of its water. This large quantity of water remaining undischarged is not all owing to the contraction of the gates; for part of it is occasioned by the gates not being shut in time, owing to their being so imperfectly hung, that the tide must rise to a considerable height before it has acquired power to shut them.

So long as this plan of making, hanging, and shutting gates is continued, no drain can ever be of that utility which the public have a right to expect from it.

Nearly all the gates I have yet seen for public drains, are at least one-third too narrow, and some one-half; but making them this extraordinary width would avail nothing, unless provision was made to shut them as soon as the drain is cleared of water; for if wide gates are useful for discharging the water quickly from the drain, they are also capable of admitting an extra quantity of salt water, during the time that they remain unshut after the tide returns.

There are only two ways of preventing this evil, and that is by appointing a person to shut them in proper time, which would be attended with great expense; or constructing a float to shut them, which would never fail of doing it, if properly made, when the tide has risen to that height which the engineer has fixed upon for closing them.

Whenever a public drain is cut through flat swampy ground, supposing it to be of sufficient capacity in those parts where the ground is firm and sound, it should be made from one-third to full one-half wider; and after the width has been thus extended, in twelve or fourteen years time, it is more than probable, at those very places and in the middle, but particularly at and near the bottom, it will be by much the narrowest part of the drain.

Of this there are many instances, and two causes may be assigned for the contraction. 1st. As the stagnant water is drained from those swamps, the surface of the ground keeps gradually sinking, until sometimes the surface of the ground is below that of the water, and requires embanking to keep it within the cut.

And in all such situations, engineers have erred as much in digging the depth as in the width of the drain; for it almost invariably happens, that in proportion as the surface of the ground sinks at and near the sides of the drain, the bottom will rise, though perhaps not quite in equal proportion. 2nd. The drain is frequently much contracted in many of these marshy places, by having the materials which have been dug from it laid too near the edge, which has a tendency of not only contracting the sides, but of raising the bottom also, and in many instances the latter injury is the greater.

If the slope at those places had been nearly double, and the materials removed to a proper distance, the contraction of the sides, and the raising of the bottom would, in a great measure, have been prevented.

When I examined Sedgmore drain, which takes the water off from forty-five thousand acres the principal commissioner shewed me many places that were nothing but swamps and bogs before the drain was made, which were then in a high state of cultivation, being chiefly water meadows let at £5 5*s* per acre. I gave full credit to what he said respecting how much the ground had sunk at those places, as the drain was there extremely narrow, and the bottom appeared to have been much raised. The drain was laid out by the late Mr. Jessop, and the gates much too narrow, for when the tide returned, there was always a large portion of water undischarged, as I had frequent opportunities of observing.

From the information the commissioner gave me, the drain discharged its water tolerably well at first, but he complained of the contraction of the sides and the raising of the bottom, which he imputed more to the materials having been laid too near the sides than the sinking of the surface, and pointed out many errors that had been committed, in not making it of sufficient width, and not having more collateral drains; which would have made many parts of the inclosure much more valuable.

When these contractions take place in a drain, and the bottom is much raised, it is not possible that it can be effectually cleared of its water, for the raising of the bottom alone would prevent it, no matter what width it was; but when both these misfortunes are combined, and the gates are too narrow, its utility is greatly diminished; and I think there are but few modern drains which are not in this situation.

In all such swampy situations, there is nothing will answer well, but allowing an extra width and slope to the drain. Drains in general are dug much too deep.

When Mr. Jessop laid out the said drain, and some others nearly twenty-five years ago, I do not wonder at some of these errors being committed, as he might not have seen the effect of a drain made in a swampy situation ten years after it was finished, or probably at those places his drains would have been differently designed; but for engineers to commit the like errors now, when they have such ample means of profiting by the mistakes of others, no excuse can be made; and yet, from an impartial examination of our modern drains, I believe they will be found to have been designed and executed much in the same manner as they were twenty-five or thirty years ago. In nearly all those swampy places, there is a great want of collateral branches to drain the adjoining lands.

If a large portion of water remains in the drain when the tide returns, probably one half of it is salt water; and as the drain fills while the tide is in, a portion of it gets pent back into the fresh water dikes, from which the cattle are supplied, and it is found very injurious to them; for in many parts, the farmer is under the necessity of having from fifteen to eighteen inches in depth of water in his dikes all the summer months; as it is as requisite to supply them with fresh water in dry seasons, as to relieve them from it in wet ones.

The gates for a drain may be made to shut themselves by a certain mode of hanging, but they are then liable to be shut too soon; there is nothing therefore so safe and certain as a float to shut them, which will not act until the water is at such a height as may be considered the most proper for them to be closed.

I do not recollect seeing any modern drains on the Lancashire coast, or on the opposite side at or near Hull, or in any other part of the kingdom, but what I think are greatly wanting in capacity, and in collateral branches also.

If a stranger, unacquainted with agriculture, were to view the vast number of channels in a water meadow, he would naturally conclude, that a large portion of it was wasted to little or no purpose; but especially so, were he informed that the ground was let for £5 5*s* per acre per annum; and yet this supposed waste is the most certain way of increasing the value of the whole, and this will equally apply to making a principal drain and its collateral branches. Making the main drain capacious, and the collateral branches numerous, is not wasting land, but the most effectual way of increasing the value of all the lands so drained.

Could the land owner have the water entirely taken off from a large drain that has been made from sixteen to twenty years, he would be astonished to find how much the sides were contracted and the bottom raised; and when this has taken place, it is no matter of surprise that the water should be so much obstructed, and prevented from running freely off; and moreover, these swells in the bottom of the drain never fail of being productive of many weeds, which are extremely injurious to the drain by impeding the velocity of the water, and causing it to stand much deeper than it ought to do, by which means the general drainage is greatly affected. In many such situations, I have seen the surface of a drain, that at a small distance appeared like a grass meadow ready for cutting.

When conversing with a commissioner respecting the size of various drains in the western part of the kingdom, experience, said he, has proved, that public drains in general are made one-third too narrow; and added, the loss of land and waste of money occasioned by it cannot be estimated.

Perhaps, however, it would be adviseable to finish a mile or two at the bottom, and allow sufficient time for the water to drain off from the remainder of the cut. The grounds would then, for that distance, be ready for cultivating when the execution of the remainder of the drain was resumed; and cutting and cultivating might afterwards go hand in hand.

I think there is no doubt but public drains may be executed with much less expense than they hitherto have been, and may be made to drain the lands much more effectually than they generally do. The trunks and valves that are employed for conveying the water in different directions are strangely designed, and frequently defeat the end they were intended to accomplish.

In general, the water stands too deep in great drains, which prevents the ground from being well cleared of it; for if possible, the surface, in moderate seasons, should be from two feet to two feet six inches below the surface of the ground, for the less depth of water there is in the drain, and the more effectually would the grounds be cleared of water.

If a situation for making a reservoir, of from three to four acres, could be met with near the gates, or within a mile of them, that would require little more than the head raising, which should communicate with the drain, and have gates to discharge the water at the same time it was let out of the drain; or if a reservoir could be made from two to three miles from the gates, but near the drain, which would require a cut making to and from it to the drain, and from thence to the gates, either measure would make the drainage of the lands much more complete, by reducing the depth of water in the drain probably one-third or one-fourth. The cut, in the latter plan, should be made considerably wider, as a much greater quantity of water would pass through it in a given time, than in any part of the main drain.

The collateral branches for a large drain require much more judgment, care, and attention in laying them out than that of the trunk; and in many situations, the best line for them cannot be found without boring, and the instrument for which should be of large diameter.

The water in many public drains is much obstructed by the bridges being too narrow, for when it is nearly upon a level, few men are competent to judge of the great injury they do; for all the bridges should be of greater capacity than the main width of the drain.

To give the water in a drain every possible facility for clearing it, the sheet should be as thin as possible, and all obstructions removed, and the gates made one-third wider than the main width of the drain.

Suppose a drain to have eighteen feet water surface and twelve feet bottom, the mean of these is fifteen feet; and for such a drain I would have three gates, each six feet wide, and of equal depth; for the larger the quantity of water that passes through them at once, and the less sand and mud will rest on the out side of them. A capacious drain, with as little depth of water in it as circumstances will admit of, with wide gates quickly shut, will be found the most effectual for draining a flat swampy country; and all quick curves and windings in the cut should be carefully avoided.

But as I have just hinted, making a small drain in the line of the large one would be attended with the most beneficial effects.

A small cut or drain is frequently made in a line of canal where the ground is wet and spongy, and from six to nine months allowed for the water to drain off, and much good has always attended such cautious proceeding; for those parts, after the water was drained off, have probably not cost one half the sum they would have done, suppose the execution to have been effected before those parts were drained. For want of draining some parts of the line of a canal, vast sums of money, loss of time, and much disappointment have never failed attending where this prudent foresight has been wanting; and few more striking instances of this have occurred than on the line of the Kennet and Avon canal, near Bath, that of the Leeds and Liverpool canal, near Blackburn and also on the Bolton and Bury canal, as I have before observed.

Now if much money and time have been saved, and the works made much more permanent, by making small drains in a line of canal, and allowing sufficient time for the water to subside, is not such a plan much more applicable to a large drain, where the ground for many miles may be extremely wet and boggy, than for a line of canal, where the extent of the swampy ground may not be more than from six hundred to eight hundred yards? Was such a plan as this adopted for large drains, and from twelve to fifteen months allowed for the water to drain off, it is probable that from fifteen to twenty per cent might be saved in the cutting, and a great part of the heavy expense that attends taking out the slips, turning off, and penning up the water in so many places would be avoided.

And were a few of these small drains cut in the line of the collateral branches, the water would be so much drained off in the before mentioned time, as to enable the commissioners to form a correct judgment, whether the lines adopted were the most proper, and if not, they might be changed for others more suitable with little expense. A great saving in the interest on the capital would be the happy consequence of adopting tbis plan, in as much as the lands would, in general, be so much drained as to admit of the plough being immediately applied, after a mile or two of the great drain was finished; and it would prevent the loss of time that is now unavoidable in waiting for the grounds being cleared of the stagnant water after the drain is finished.

Greater gain may be obtained by making drains upon the most improved plan from a certain capital sunk, than in general can be made from an equal capital employed in making a canal, as there is no risque of loss from competition. This is a loss arising from a cause the canal subscribers never once thought of; but its effects will not, on that account, be the less fatal. When large fens and bogs, that are useless to the public, nay, much worse, for they are often very injurious to the health of the inhabitants, are made fit for agriculture, I consider the capital sunk in them the most permanent wealth in the kingdom; and all such improvements are by far the most meritorious.

By a trifling expense, all the public drains might have been made navigable for vessels of from one to two tons burthen, without in the least affecting the utility of the drain; and it has often surprised me that nothing of this kind has been attempted, as it would be of the utmost consequence to the country, but particularly so, as the roads are generally bad in a flat swampy country; for with a few one horse engines (for no towing path would be required) the whole produce of the country might be carried upon them with one-fifth of the expense that now attends it; and collateral branches might be made to communicate with the towns and villages. Here is a capacious field big with immense improvement, which may be acquired at an easy expense.

APPENDIX.

APPENDIX.

By mistake the sheet that contained instruction for balancing lock gates got misplaced and was left unprinted; and as I conceive this as essentially necessary for their preservation, I shall now describe how it should be done.

The top bar of the gate and the lever should never be in one piece of timber, as it is attended with unnecessary expense; but the bar should project twelve or fifteen inches over the heel post, and the lever should be screwed to it, which may be made of an inferior piece of timber, and will not require to be so long as levers in general are by three or four feet. And for three feet at the end of it, there should be two pieces of timber pinned to it, one on each side, with wooden pins, three feet long, and from three to four inches thick, and the same depth as the lever.

A number of weights should then be placed near the end of the lever, to see what weight will balance the gate; but the weight should do rather more than balance it, as it will be the means of keeping the heel post in the hollow quoin; and when the weight required is found, it will determine the size of the stone, which should be well dressed, and have two holes, three quarters of an inch diameter, drilled through it, by which it may be screwed to the top or rather on the under side of the lever. There should then be an iron pin, inch and a half diameter, and twenty inches long; four inches at the thicker ends should be flattened, and have two holes in, by which it may be screwed to the lever; and with the assistance of this pin, a boy of from ten to twelve years old would open and shut the gates with the greatest ease.

And although the upper gates are much lighter than the lower ones, yet, nevertheless, I would balance them; for the more light and easy they are made to work, and the longer they will last, and also the masonry connected with them.

By the present plan of hanging, opening, and shutting lock gates they are soon knocked and shook in pieces; for the longer the lever is, and the greater the injury is that is done to them in opening and shutting.

As lock gates are now hung, for want of being balanced, great power is required to put them in motion, and an equal power is required to stop them; and if this is not exerted when the gate is nearly opened, it will strike with great force against the lock side; and the same power is required to restrain the motion when shutting, or it will strike with great force against the cill when shut; and as opening and shutting are generally performed in great haste, no attention is paid to breaking the velocity of the gate in either of these operations. But when lock gates are hung light, well balanced, and move easy, little power is required to put them in motion, and as little to stop them; for if the gates are moved in the least by the agitation of the water when it enters the lock, they will continue to move easily, and be gently shut.

But if the water was carried thirty-feet down the lock side as I have recommended, before it enters the chamber, and it had three or four openings, five feet from each other, and the bottom end of them turned towards the breast, making an angle of forty-five degrees, the gates could scarcely be moved with any agitation there would be in the lock chamber; for this way of delivering the water would not produce any that would affect the movement of the gates.

Another thing, by mistake, has been omitted, and that is, conducting the surplus water at the head of the upper gates in an open channel, and at a sufficient distance from the puddle, so that it may not be affected by it.

I appeal to any who may have paid the least attention to the delivering of water into a lock chamber, whether a much worse plan can be devised than that which is now used for filling a lock with water.

Every thing that tends to lessen the great agitation in the water while the lock is filling will increase the durability of the gates, and preserve the vessel from injury; for whoever will examine the inside of lock gates that have been in use for seven or eight years may see how the planks are battered and shattered from six to eight feet from the bottom, by the vibration of the vessels, and they must be convinced, that a better plan for delivering water into a lock chamber is highly necessary; for no change in the make, shape, or hanging of the gates will remove this evil, it can only be affected by a different delivery of the water into the lock; and I think nothing will be so efficacious as discharging it all at one side of the lock, and at different openings.

Some persons may perhaps object to the cross bar over the round hole in the plate for the circular valve; but the valve will work as well without it as with it, by fixing a guider for the valve rod to work in, nine or ten inches above the plate.

I cannot conclude my observations on canals without further remarking, that the Rochdale canal company have great merit in executing such a vast expensive line of canal in the manner they have done; and had it not been for the princely fortunes many of the gentlemen and merchants in and near that town possess, my opinion is, it never would have been finished.

Their numerous and extensive reservoirs serve as so many storehouses to retain the watery cargoes that are deposited upon the adjacent hills, which are treasured with great expense, as a security for and preservation of the mill property; but the happy effects of them are not confined to the mills on the line only, for all those below, where the canal communicates with the Calder and Hebble navigation to the tide-way, as well as those on the Lancashire side, are greatly benefited by them. Nor do their beneficial effects terminate here, for this canal may fitly be compared to a high elevated light-house, erected at a vast expense, to shew the canal speculator and canal committees the way to walk in, so far as respects supplying a canal with downfal water from reservoirs.

From these reservoirs, and the grounds that are drained to fill them, various conclusions may now be drawn with the utmost certainty; for the great quantity of water required to supply a canal with water this way is now by them fully established; but before the execution of it, the engineers for canals were as much in the dark as any other men; witness the erroneous estimates the engineers made for it.

There is no canal in the kingdom that affords the canal subscriber, the mill-owner, the acting committee of a canal, the canal engineer, and the public, that useful information which the Rochdale canal does, whether it respects the money required to execute it, or the quantity of water to supply it.

When this canal was first proposed, the mill-owners were greatly alarmed, lest their property should be injured; but so far from that being the case, when taken collectively, it has been much improved; nor can it be otherwise, so long as its supply is taken by gauges, and at those times when the surplus water would be injurious to the mills; but more especially, as there are between three and four hundred acres of reservoirs; and also the canal itself may be considered as a reservoir, equal to one hundred and sixty acres, making in all nearly five hundred acres of reservoirs; and these may be taken as so many securities for the mill-owners' property.

Although gauges are fixed upon many brooks and feeders, and the quantity of water collected for the supply of this canal is without a parallel, it is pleasing to reflect, that yet there are no gauges placed or fixed upon some of the most powerful brooks, from which the company have a right to take water; for these are reserved until an increase of tonnage require their assistance.

When the water has been thus treasured up, and millions of tons drawn off in summer, and at a time when the mills are much in want of it; the leakage and soakage water which they receive from the canal is great, nor can the company, or their agents, prevent it, were they desirous of so doing.

No body of mill owners need fear of being injured by the making of a canal, if their property is as well protected by clauses in the act, as the mill owners' property is on the line of this canal, and the reservoirs as well executed; and as I have had two appointments under the act ever since it was obtained, for the protection of the mills on the line in both counties, I may be allowed to know a little what effect it has had upon them; and taking the agregate, I do aver, they are much benefited by the making of this canal, as I have before observed; and I mention this circumstance only to prevent any unnecessary alarm being given to mill owners, by any line of canal that may hereafter be projected.

To remove some complaints which two or three of the mill owners have lately made, the company have voluntarily agreed for them to chuse their engineer to remove the grievances complained of, and they would not only pay him, but all other expenses that might be incurred in making any alterations in the conducting of the water to their mills that might be judged necessary; a thing which I think few canal committees would have done, and especially so, as these alterations would be so beneficial to these mill owners.

In page 46, I have recommended a powerful magnifying glass being necessary to inspect the drawing, and the state of the carding before it goes to the drawing frames.

Those observations should have gone a little farther; for in order that the master spinner may know the real state of his carding engines, drawing frames, and every thing that relates to the working of cotton, he should be provided with a glass, (and it would be well if the overlooker and the carder had each one); for without it, he cannot know the real state of the cards, and how they are ground; but particularly in winter a glass is then absolutely necessary, for the naked eye cannot judge with certainty.

The ends of the teeth should be ground, as the carders term it with a diamond point, that is shaped like the point of a tool for cutting or turning iron; or in other words, it should be an inclined plane, of easy declivity. But in consequence of the tooth being thus shaped, it is next to impossible to finish it with a fine smooth sharp point; for it will be rather rough and bearded, as it is called, when finished with the hand emery, let the wire be ever so hard; for grinding it to the greatest perfection with emery, is as impossible as to give a razor a fine smooth edge with a grinding stone. If the point of the tooth is not ground both sharp and smooth, carding cannot be performed in the best manner.

After the hand emery has done all it can, there should be two fine Turkey stones got, and have the ends ground square where they join in the middle, to be equally as long as the fillet is broad, and let into a piece of deal three inches broad, inch and a half thick, and the fillet should be gently ground with these for two or three minutes, and the swift cylinder also.

But to know the effect this produces, the state of the teeth should be examined before and after the Turkey stones are applied, and if these do not make the teeth as sharp and smooth as could be wished, for working the best Georgia or Bourbon cotton, I would recommend two of the best barber whet-stones that can be met with, and fix them in the same manner as the Turkey stones, and finish with them; for the point of the tooth should be as smooth as that of a needle, if possible. If the wire is soft, it is next to impossible to make the teeth smooth and sharp; but if this could be done, it would not continue in that state a single hour.

Whoever will examine the finest cotton fibre with a glass, will find it enclosed in a coat, as compactly as the stubborn oak is enclosed within its bark; and if that coat is broken into, it will produce a roughness along the fibre, and its strength will be greatly diminished.

Any one who reflects upon the carding of cotton must see the necessity of as much as possible keeping the coat of the fibre entire; but this cannot be done by the present mode of grinding the cards; and the naked eye cannot perceive whether it is effected or not.

I have in vain asked many fine spinners and manufacturers of muslins, what is the reason the East India muslins increase in their smoothness and beauty by wearing and washing, while our muslins are the very reverse of all this; but as yet I have met with no one that could give me a rational reason.

I make no doubt, but the roughness that is invariably interwoven with our fine muslins, is principally occasioned by our improper carding; and till the coat of the fibre is kept perfectly free from being injured in the carding, in vain may we look for our fine muslins improving by wearing and washing.

Some persons say they have better cotton in the East Indies than any that comes here, and that enables them to make better goods; but this is a great mistake, for are not the finest cottons grown in those provinces the company occupy, and if they have to bring fine cotton twelve thousand miles for the supply of our manufacturers, will not their own interest compel them to bring the best, especially as neither the people in the East Indies, or those on the European continent, can afford to give so high a price for it as the spinners in this country can?

Others say, the water in the East Indies is much finer, and better for bleaching than any in England; but this is a most gross mistake, for our water in general is much superior to theirs.

Others again say, they bleach with India corn, which greatly improves their goods; and are we precluded from using it in bleaching, for there is no doubt but we should use it, if it possessed any such qualities as some persons pretend it does.

And many persons will have it, they use much milk in bleaching, which improves the colour and the texture; I really wonder they have not added a little cream also.

But another cause is assigned by some of our fine manufacturers, and that is, that they work only one thread in a reed, but we work two, and the roughness of the texture in our muslins, say they, is produced by the threads in the reed being so much chaffed against each other in the weaving; and cannot we work one thread in a reed as well as they, if that will remove the imperfection complained of?

An ingenious cotton spinner I travelled with in the packet to Worsley, pretended to untie the Gordian knot at once, by saying, that the smoothness of the East India muslins was produced by the single thread spinner constantly wetting her fingers with her tongue while the thread passed through them, which laid all the fibres close down; but query, will they not rise again with bleaching and washing?

But all such childish suppositions and conjectures, and the erroneous inferences drawn from them, are too weak to excite laughter.

That some particular cause or causes produce a beauty, symmetry, and richness, and which time greatly improves, in the East India Muslins, that we at present are unacquainted with, is a fact that cannot be denied, and probably it is occasioned by our improper treatment of the cotton in the carding; or the great advantage their muslins have over ours, may arise from their cotton not being carded, which I apprehend to be the case.

I can see no advantage that can be obtained by carding for the single thread spinner, for yarn spun from it would be good for nothing; and moreover, if carded, it would require sufficient doubling and drawing by machinery, to reduce it to a proper thickness, or the yarn would be weak and uneven; and we know this is not the way cotton yarn is spun in the East Indies.

The cotton must be exceedingly well batted, picked, and made as light as possible, and afterwards, it may easily be shaped into a sliver, and lapped round the distaff, and spun similar to the flax yarn in Russia, which no doubt is the case.

From these observations, I think it is sufficiently explained, why the East India muslins are so much superior to ours; and it is equally plain, they will maintain it so long as the spinning of cotton in the two empires is prosecuted upon the present plan, as the fibres of the cotton for the one are preserved whole and entire, while those of the other are cut into a million of fractions.

It is stated by the importers of East India cotton, that three-fourths of all that comes here is in ballast, as the inferior kind would not pay for bringing any other way; and this is not to be wondered at, seeing the distance is so very great.

But does not this prove a great want of understanding in the cotton dealers, the spinners, and manufacturers, who blamed government so much for not encouraging the East India company to multiply cotton plantations, and supply all the demands of this country with it when the war commenced with America.

Suppose this had been done, what then would have been the situation of the cotton spinners and manufacturers here, admitting them to have been bound to use that cotton ; and if they had not taken it, what must the company have done with it, and who was to make good their loss ; would they not have been entirely driven out of the foreign market ?

France and the European continent, after the peace, would have got their cotton from America, perhaps 8*d* per pound cheaper than we could get it from the East ; as the distance in going to and returning from thence, exceeds that to and from America nearly eighteen thousand miles. And how could we meet the goods manufactured in America, as their cotton is close at the door, while our raw material would have to be carried twelve thousand miles, and the goods manufactured from it three thousand miles more before they would arrive in America. Does not prudence direct that government should, if possible, procure large cotton plantations nearer home, than either the East or West Indies, or even America ; and what country so likely as the vast continent of Africa ; for, when compared with the East Indies, it is nearly at home.

There is no doubt but that immense continent would produce any article we import from the East, but particularly cotton.

In page 1, I recommend the swift cylinder to make twenty-six revolutions for the doffing cylinder one; but from subsequent experiments, I find that if the swift cylinder makes thirty revolutions for the doffer one, it will be much better for working fine cotton; and the doffer should make four revolutions for the feeding roller one; but the speed of the swift cylinder should not be altered.

Perhaps the master spinner would wish to know from what part of the machine I measure, when I state what the distance should be from the centre of one roller to that of another, I would say; from the centre of one stand to that of another.

In page 11, I say the cotton beater makes much less fly than the blowing machine, still it makes twice too much; for what does the fly principally consist of but broken fibres of the cotton; and if this be the fact, it is an alarming consideration for the spinner; for whatever weight of broken fibres there may be made from a given weight of cotton, there is little doubt but five times as much more is greatly injured. The cotton beater has two bars of iron, with rather a sharp edge, and these give the cotton from two thousand two hundred, to two thousand four hundred severe blows per minute. The fibres of the cotton are too delicate to bear such blows as these, without suffering much injury; for one of them would break a man's arm. If these two bars had four holes drilled in every inch, and some nice shaped steel teeth, made with shoulders, rivitted in, from three quarters to one inch long on the outside the bar; they would open the cotton equally as well, and take the motes and dust out much better, and that without injuring it.

A friend of mine, a member of a canal committee of no small magnitude, informs me, that an ingenious gentleman of Birmingham, (but with his name I am not favoured) has got a patent for making an hydrostatic lock, which will require but a very small quantity of water to pass from a lower to a higher level; but at the same time acknowledges he does not understand the plan; and states the patentee's estimate for building a lock of seven feet rise at £2,000.

My friend requested me to favor him with a comparative estimate of the expense for supplying a canal of a given length and moderate rise with water from reservoirs; and also for supplying one upon the patentee's plan, that the canal subscriber may judge whether it would be more for his interest to subscribe to a canal made with locks upon this new plan, rather than for one made with common locks.

As I wish to give my friend, and all other canal subscribers, the best information I can, I readily comply with his request, and shall confine my observations to the expense of executing only, without meddling with the principle of the said lock, having seen no description of it.

I will suppose a broad canal made thirty miles in length, with six feet water, and take the rise and fall at only five hundred feet.

In page 108 I have shewn that four and three quarters acres of reservoirs, average depth fifteen feet, will amply supply one mile on a canal that has a tonnage equal to three hundred and fifty tons per day for forty weeks in the year, and when taken collectively are equal to one hundred and thirty statute acres. Suppose one half of these reservoirs are made on common or waste ground, and take them at £10 per acre, which is very high; the amount of sixty-five acres, at this valuation, will be £650; and the other sixty-five acres I suppose to be inclosed and cultivated ground, which I estimate at £65 per acre, and probably would not be land of greater value; for where there is an opportunity of making a reservoir in cultivated land, and supplying it with surplus water from a brook or stream, it is generally low and swampy; and as this reservoir would require fencing off, I will allow £5 per acre more, and call it £70 per acre, the amount will be £4,550, making in all for the land £5,205; but no fence will be required for a reservoir made on the common.

I estimate making the reservoirs much higher than for any I ever did before; and is a great deal higher than some of the large reservoirs for the Rochdale canal.

I allow £200 per statute acre for making the reservoirs, which includes finishing them in every part, and is equal to £36,000, which makes the sum total of expense for land and executing equal to £41,205.

If the canal subscriber in estimating the expense for executing a canal makes this estimate a rule, should he err, it will be on the safe side; but large reservoirs will generally be made for much less per acre than small ones.

Building eighty-three locks, each full six feet rise, upon the principle I have recommended for five hundred feet rise and fall, at £120 per foot, equal to £60,000. Sum total of expense for purchasing land, making reservoirs, and building the locks £101,205.

It is possible the water may be to lift from forty to fifty feet into the summit level, from the reservoir that may be made in the inclosed ground, from two to three months in summer, for which I allow £20,000, which includes erecting the engine, wear and tear, and makes the whole expense of building the locks, and supplying the canal with water equal to £126.205.

I will now suppose hydrostatic locks made for this canal, and calculate upon their rise being seven feet, which would require seventy-one, and a small fraction will remain.

If I am not mistaken, the patentee's estimate for one of his locks is £2,000, but I think it will cost £3,000 at least; and I form my opinion from the great sum Colonel Congreve's balance lock has cost; but notwithstanding this I will take it at his own estimate, which is £2,000, this multiplied by seventy-one, the supposed number of locks, the product will be £142,000, and each of these locks will require a man of good mechanical abilities to take care of it; and will estimate his wages at 31*s* 6*d* per week, equal to £81 18*s* per annum, and if multiplied by seventy-one, will give the annual expense of all their wages equal to £5,814 18*s*, and is the same as sinking a capital of £119,000.

As the expense of building one of these hydrostatic locks will be more than three times what one of those locks I propose building would cost, the wear and tear will be fully in proportion to it; and I conceive will, at least be £2,000 per annum more than that of common locks, but I will only call it £1,500, which is equal to sinking a capital of £30,000, and the loss to the trade on the canal while these repairs are making may be equal to the expense of the repairs; and then there is the expense of procuring water to add for these hydrostatic locks, which I will suppose to be one-fourth of what I have calculated upon for locks of six feet rise, which is £10,301 5*s*, (and if they save three-fourths of the lockage water, it is a great deal) making the whole expense of building the locks, supplying them with water, the annual expense of wages, wear and tear, (without including any thing to the patentee for his ingenuity) equal to sinking a capital of £291,000, and exceeds the sum required for making the proposed reservoirs and locks full £164,795.

From this statement, I think it is clear that there is little or no chance for Colonel Congreve's balance lock, or that lately designed by the ingenious gentlemen at Birmingham ever being generally used; for with respect to the expense of executing, annual wear and tear, and attendance, I consider them nearly similar. I have entered more fully into the investigation of this plan, to guard the canal subscriber from being misled by such locks and estimates for them as these; for I repeat it again, that where water can be obtained from reservoirs, or from brooks and streams, there never will be any thing designed to equal a canal lock for passing from one level to another, nor for its simplicity, utility, and durability.

If these ingenious gentlemen, who thus rack their brain, and torture their minds with such fine spun theories, would but calmly sit down and calculate the extra wages that are inseparably connected with nine-tenths of them, they would see that all such multiplied, complicated and intricate designs as these are ill calculated for the use of boat and barge men, who take much more pleasure in destroying canal works, than in preserving them; and they would save this gentleman the trouble of sinking his Avocater, (the name he gives to the vessel) for they would soon sink it to rise no more; and moreover, whatever ingenuity there may be in the design for such locks, the great annual expense in wear, tear, and taking care of them, would prevent them from being of public utility; and if they are not beneficial to the community, they will not be profitable to the designer.

If an accurate account was taken of all the patents that have been got within the last twenty years, and also how many of them have been useful to the public, I much doubt whether one in a hundred would be found to have been so. What infinite mischief has many of these pretended improvements done to society, by inflaming and misleading the public, and many individuals into irretrievable ruin.

Exactly similar to the annual expense of these hydrostatic locks were Mr. Rennie's plan for saving one half the lockage water for the Rochdale canal, which if done, must have been by side basins, (for that was the plan, as Mr. Jessop informed one of the committee of the Calder and Hebble navigation) and one for each lock would have cost £300 if well executed, including the land to be purchased for it, but some canal engineers have estimated the expense at more.

The number of locks on that canal are ninety-two, but through mistake have been called ninety-four; at £300 for the basins, the amount will be £27,600,, and each would require a man to take care of it and the basins; and if the wages of the men are taken on the average at 20*s* per week per man, the annual expense in wages will be £4,784, and equal to sinking a capital of £95,680, and if added to the expense of making the basins, the sum total will be £123,280, and is full £60,000 more than all the reservoirs for that canal have cost (for the commons on which they are made, cost only about 10*s* per acre) and is a plain proof, that when the engineer proposed to save one half of the lockage water for that canal by side basins, he knew but little what he was about, for saving one half of it would have been nothing like one-sixth part of the whole consumption. I have made no allowance for the expense of lock-keepers for the supposed canal, with five hundred feet rise and fall, for it is probable none would have been required if the locks were judiciously placed.

Perhaps some men may think I have something personal against canal engineers, but this

I deny; for was that the case, I might have mentioned a variety of circumstances respecting many of them that would have surprised the public; for I have been sparing in may observations upon their conduct. But so far from having any thing personal against canal engineers, that I think there are numbers of them that would be an ornament to any profession, and in whose company I shall always feel myself happy, and for their friendship I shall ever have the highest esteem.

I have just received information from unquestionable authority, that although the Kennet and Avon canal will cost near, if not more, than a million sterling, when all the works are finished, including loss of interest; yet goods are now carried cheaper coast-wise between the cities of London and Bristol, than by that canal. What thinks Mr. R. and his friends now of the recommendation so strongly urged, for making that canal narrow before the spade was put in; for doubtless £250,000 would have been saved by it, as before stated, and goods carried as cheap, and in one-fourth less time between Bristol and Newbury. And is not this another awful proof, of the necessity there is of a reformation in surveying, estimating, designing, and executing canals.

I have before stated the supposed saving to the baker, by making his bread of flour made from grain dried by a ventilator, at from 2*s* to 2*s* 6*d* per pack, than if made of common flour, according to the information I have received. But from consulting different persons, I had various estimates given of this saving, some of whom might probably have a particular interest to serve; and finding them so much at varience with each other, and next to impossible to obtain information I could rely upon, and considering an accurate account of the utmost consequence to the public, I determined to judge for myself, by procuring a quantity of wheat, and by drying, grinding, and dressing it in the following manner.

I got some wheat, which I carefully weighed before it was dried, and preserved an equal quantity of the same bulk undried, and by drying, I found it lost full one-sixteenth part in weight, but it was rather too hard dried; yet notwithstanding this, I knew that it would regain its natural weight, were it permitted to lye from twelve to sixteen days before it was ground.

I dried the grain in two dripping pans before the fire, and turned it twice in the hour for about fourteen hours, and left it before the fire all night, and in the morning removed it; I waited three days before it was ground, but more time would have been better; and the same time was allowed before it was dressed after it was ground.

The undried wheat was ground and dressed at the same time the dried wheat was; and then I weighed four pounds of each flour with the greatest exactness, and got good barm to raise them; and each of the four pounds were made into two separate loaves, and baked in the most cautious manner; and I allowed a quarter of an hour more time for the loaf to bake in that was made from the dried grain than the other, as it had taken much more water to knead it.

After the loaves were properly cooled, which required twenty-four hours, I weighed them with the greatest exactness, and found that the loaf made from the dried flour weighed nearly six ounces more than that from the undried flour.

From this experiment, it appeared that full one-eighteenth part more weight was obtained by the flour made from the dried grain, than from that which was not dried; and it nearly corresponds with what a public baker stated it to be nearly twenty years ago.

But the flour I tried these experiments with was not of the first quality; for the better the flour and the more weight will be had; and therefore the mean average of the whole saving should not be taken at more than one-eighteenth part for the consumer, seeing there is such a great difference in the quality of grain.

But if to the above be added what the miller will gain by the grain grinding more freely, and separating so much better from the bran, they may fairly be taken at nearly one-sixteenth part of the whole. But if no saving was obtained by drying the grain when soft, except that of enabling the miller to grind it in the best manner, and that of the farmer when his grain is not fit for keeping, these are savings, the intrinsic value of which is not to be estimated. But I will take the whole saving of the miller and the consumer at only one-eighteenth part, which is much lower than I have heard any miller or baker state it, yet this will produce an amazing sum.

I have before estimated the whole annual consumption of wheaten grain, in the three united kingdoms at fifteen millions of quarters; but according to a particular account given lately in the public papers, of all the grain grown in England and Scotland, my estimate appears to be at least two millions of quarters too low; for the estimate of the growth much exceeds mine of consumption, and yet we are annually purchasing large quantities of grain; nevertheless, I will take it at fifteen millions of quarters, as before stated; and I suppose two-thirds of it to be made into bread, and the remaining third part to be used in pastry, &c.

I calculate the whole value of these ten millions quarters of grain at £4 per quarter, equal to £40,000,000 sterling, and one-eighteenth part of it will be £2,222,222 4*s* 5¼*d*, equal to the supposed saving, if all the wheaten grain was dried with rarified air; and if the saving by a proper use of the balance rine be taken at 1*s* 6*d* per quarter, as before stated, and the saving to the farmer, by drying and dressing his grain, be only estimated at 2*s* per quarter, though it before has been calculated at 3*s*, and no doubt it will be that or more, they will be equal to £2,725,000 per annum, which added to £2,222,222 4*s* 5¼*d*, before stated, will make the whole annual saving to the public equal to £4,967,222 4*s* 5¼*d*. Should the average price of grain for the year be less than I have stated, it will make the saving less in proportion; but should it be higher, it will make the saving greater in the same proportion.

According to the price of grain at present, the saving by drying it would not be equal to £1,649,074 1s $1\frac{3}{4}d$, but the saving of £2,725,000 would not be affected by it.

From the many experiments I have made in drying wheaten grain, I am fully satisfied, that however cautiously it may be performed, if it is not dried by rarified air, the colour will be affected and the quality injured, which proves the necessity of the millers having ventilators; for so long as the practice is continued of stowing grain so thick in commission warehouses, (particularly in winter), and so little attention paid to the turning of it, the miller will be under the necessity of drying a considerable part of it, or he cannot grind it without much loss.

All these warehouses should be put under the excise law, or an inspector appointed for that purpose, and make the owner answerable for all the grain that is damaged therein; and this would be the means of having ventilators in all of them.

The immense quantity of grain that is damaged in these warehouses is become a great national evil, and will require the aid of government to remove it; and I hope it will undergo an investigation the ensuing parliament.

I maintain that full one-eighteenth part of the weight of bread may be saved, if made from grain that has been dried by a ventilator; and it is most gratifying to reflect, that the principal part of this saving will be shared among the labouring class.

But it may be necessary to remark, that grain may be dried too hard by a ventilator, and thereby injured, but there must be great negligence indeed when this the case; and it may also be injured by being dried too slow; when this is the case, the bran will be dried before the heat has reached the heart of the grain; and if the slow fire is continued until the grain is dried to the heart, the bran or coat of the corn will be dried too much, and break in pieces before it will cut.

The heat, as I have before observed, should be of an equal temparature, or some parts of the grain may be injured. If a temparature of heat, of from seventy-five to eighty degrees be constantly maintained, the grain will not be injured; and it is sure to grind well.

Here is an amazing field for improvement laid open, in the drying, dressing, and grinding of grain; and no class of men in this kingdom, I think, are so much interested in it as the London bread bakers; and I hope they will pardon me for the freedom I may take, in pointing out the plan which I think is their interest to pursue, if they should commence grinding their own flour.

The London bakers are now delivered from that oppressive and impolitic system, of having the price of their bread fixed by the Lord Mayor, which prevented a fair competition, and entailed an extra price of perhaps from five to seven and a half per cent upon the consumer; but though the public will receive the said advantage, yet the baker, upon the new system, may have a better profit than heretofore.

It does appear to me, but it is possible I may be mistaken, that it would be greatly for the interest of the London bakers to grind their own grain; and two or three of them might join at a water mill, or a steam engine.

If they grind by water, it may in the first instance be cheaper than steam, as coal is dear in London; but there are many circumstances in favour of steam, which a water mill cannot possess, such as going constantly when trade requires it; but the greatest perhaps is that of drying the grain with the heat of the boiler, without any additional expense in fuel, and little or no expense in building; as the boiler house will serve to make a ventilator in, as I shall shew.

I will suppose a thirty horse engine erected to work six pair of French stones, four feet eight inches diameter, and to make the revolutions I have recommended; five pair of them may be supposed to be constantly working and one pair dressing.

The boiler house I would make thirty-six feet long and thirty-one wide, which would contain two boilers, each twenty-four feet long and nine wide, and the room should be parted from the bottom with a brick and a half wall, which would allow a room for each boiler, thirty feet six inches long, and eighteen feet wide. The pipe for discharging the surplus steam should be carried under the floor and through the side wall; and care must be taken to have every part of the boiler steam-tight.

There should be three cast beams over each boiler, each of which may be cast in one length, thirteen inches deep in the middle, and ten inches at each end, inch and half, or from that to inch and three quarters thick, which would make four openings for the joists, seven feet six inches long, and the distance between them two feet; and the cast plates should be the same length, eighteen inches broad. The joists should be half an inch thick, four inches deep, and have flanges on each side the top edge half an inch broad for the plates to rest upon, which will make the whole breadth on the top side inch and half.

A friend of mine is making a ventilator with cast beams, joists and plates, to be heated by rarified air, which I hope will answer; and should they not injure the grain, they will have greatly the advantage over hair cloth with respect to durability.

All corn mills that are worked by steam may dry the grain by the heat of the boiler, and it will not require a close under floor; for if one was made it would answer no purpose, as I think a fan would be found necessary; for most probably a sufficiency of air could not be procured, without one to dry grain for six pair of wheat stones; and a pipe six inches diameter may convey the air from the fan, made full of holes on the top side, but the end should be made up and go under the iron plates, from one foot to eighteen inches below; and the heat of the boiler, I make no doubt, will rarify it so much as to make it pass freely through the grain, if the boiler-house is made air-tight, and have an inner door which should always be shut before the outer one is opened. But I would fix an air flue in the outer wall, and the under side should be six feet six inches above the flags, round the boiler, and it should project six feet into the room. The width of the opening for the air should be two feet, depth on the outside three inches, but only two where the air is delivered; and this may perhaps make a fan unnecessary.

Ventilators made for farmers, and water corn mills must have counter floors; and from more mature consideration, I am confident that the fire and air that supplies one would serve two, one over the other; for heat would ascend from the first to the second as it does in drying-houses for wool and cloth. When the hot air has passed through the grain it must go somewhere, and its natural tendency is to ascend; and should two ventilators be required for a large corn mill, or a commission grain warehouse, or for government to dry grain for the army and navy, one fire may be made to serve both; for any steam that may arise from the grain in the first room would ascend through the second in pipes, without doing any injury to the grain in it; for this plan I adopted more than twenty years ago.

Had government made large and numerous ventilators in the late war, many hundred thousand pounds would have been saved, by preventing such a vast quantity of grain from being lost, owing to the bad state it was in, from a variety of circumstances that might be unavoidable. But to return.—

The following observations I would recommend to the bread bakers in London, and those in other cities and towns I think are interested in them, though perhaps not quite so much as those in London; for they are now at liberty to procure grain or flour in any way that may be most convenient for them.

I have before observed how few corn-millers grind well, still I think fewer know how to dress the grain in a proper manner before it is ground. For making flour of the finest quality grinding well is necessary, and dressing the grain in the best manner before it is ground is equally necessary; for if both are not combined, flour of the first quality cannot be made; for an imperfection in the dressing of it will be fatal, as it will always injure the colour of the flour; and after all, proper wire and good brushes must be used by the dressing machine for the flour, or its quality will be injured.

INSTRUCTIONS

FOR MAKING AND SPEEDING MACHINERY FOR DRESSING GRAIN BEFORE IT IS GROUND.

In the attic story a good corn screen should be placed over a box fan, from two feet nine, to two feet ten inches long, with an iron axle, and four wings or webs, each twelve inches deep; and it should make from two hundred and eighty, to three hundred revolutions per minute; and the screen should be so fine as not to admit of any thing passing through, and injuring the face of the stones.

When the grain first comes into the mill, it should be taken up by the elevators to the said screen, and pass through it into the fan box, in a thin sheet, nearly as broad as the fan is wide, and it will blow the light grain, the sand, and dust also, into a bin prepared for them. The grain should then be hoisted up again by the elevaters, and pass through a machine made for dressing it, with a cylinder six feet long, twenty-one inches diameter, and should make three hundred and twenty revolutions per minute.

This cylinder should work in a wood box, five feet deep, two feet six inches wide, and should have a wood or tin hopper at the lower end of it, twelve inches wide, the top of which should stand even with the bottom of the box; and a pipe should go from the bottom end, five inches square, to the mill floor, and a sack may be hung to the end of it; and all the trucks, sand, and dust, may be removed without making any dust in the mill.

The cylinder should have a great declivity, to make the grain pass freely through it; and four feet in length at the bottom end should be covered with wire, nine lines in the inch, and the remaining two feet at the top end should be covered with a sheet of tin made like a grater, and the rough side should be in the inside of the cylinder; but perhaps it may not be improper to rub the holes over in the inside with a fine smooth stone, and take off a little of the sharp points, lest they should injure the bran when first set to work.

There should be ten brushes fixed in the inside of the cylinder, in the same manner as those are for dressing flour; and five of them should be made of stout bristles, and the other five of cane. The cane brushes are for flattening and bursting the trucks, that they may be the more easily driven through the wire into the box and the grater at the top is to rub loose and shake off the sand and dust that adheres to the grain; and the brushes are to sweep it away. This cylinder will more effectually cleanse the grain at one operation, than passing one hundred times through any screen.

After the grain has passed the cylinder, it must be hoisted up again, and pass through the fan to blow off any dust or sand that may have escaped the brushes; and then it descends to the grinding stones, or into a large hopper, from which they may all be fed.

The lightest corn that is blown from the grain at first, should be removed to the shelling fan, or one made for that purpose, when eight or ten quarters are collected into the bin; for was it to be dressed in the mill chamber, it would fill it with dust; and the lightest of the grain is fit for nothing but poultry; and the better should have a little good grain mixed with it, and ground into seconds.

Many millers I know mix their light grain with the good, and by so doing spoil the whole; and they palm it upon the consumer for a first rate article; but this can never be, for when thus mixed, it is not possible to make flour of the first quality from it, for it will only make good seconds, as the light grain always spoils the colour of the whole; and moreover, the flour will be poor and insipid, and destitute of all that fine colour it ought to possess. This light grain may fitly be compared to shambles meat, or poultry that are ill fattened, the flesh being ill coloured, and still worse flavoured; and moreover, contains little nutriment.

When grain has been dressed as before described, no one would believe how much it is improved, unless he saw it, for it is made to look finer than the best of Dantzic wheat; and if it has been gently dried by a ventilator, it will slip in the hand like so many glass beads.

This is the way I would have every farmer of any consequence to dress his grain, who has a thrashing machine, before it comes to the market; and if it is in the least soft, blow the cold air freely through it with the fan for a few hours; but should the atmosphere be damp, light up the fire for the ventilator.

I will mention a circumstance that has lately taken place, which proves how grain may be improved by drying and dressing.

A certain miller, a friend of mine, purchased lately a considerable quantity of wheat in the market, and he dried and dressed it, but not so well as I have recommended; and the next market day he took a sample and shewed it to many farmers, who had previously seen the grain, and he represented it as sent for his inspection, and requested their opinion, how much more per quarter it was worth than the grain they had seen before; and there was not one but what valued it at 5*s*.

If the London bakers should grind their grain, as recommended, and attend to the instructions for the dressing of it, they may serve the public with bread and flour, such as I think they have not done before; and the poor will have it constantly sweet and sound.

But a great deal of flour is spoiled by being dressed too soon after grinding; and it is the miller's loss as well as the consumers; for while it lies a few days undressed, it is getting weight.

If the best of grain was dried upon a ventilator, and ground and dressed soon after, and then immediately packed in barrels as the American flour is, it would turn sour and be greatly injured.

I have before observed the great loss that attends American flour, and I suppose there never was any year in which the loss by it was so great as the year 1815; for, the quantity that is neither fit for starch, paste, or size, is really astonishing; and probably a great part of it may have been occasioned by the flour being dressed and packed before it was sufficiently cooled: Is it then any matter of surprise that so much of it should have been spoiled, if thus treated?

In the American provinces, where the heat is great in summer, an upper chamber is the most improper place that can be, to put the meal in to cool, (though the most proper here); it should be laid upon a ground-floor made of wood, and then it might be sufficiently cooled.

I shall now mention another great improvement that may be made in grain, for want of which, immense loss is frequently sustained, and that is, by wheat becoming fusty, and unfit for use; yet it may be made sound and sweet again by the simplest of all means, and with the least possible trouble and expense. Take a few quarters of fusty grain, and lay it a moderate thickness upon a common drying kiln, either made with cast plates or tile, and let the kiln be pretty well heated when it is put upon it, and have a couple of large watering cans ready, and from ten to twelve gallons of fine soft spring water and sprinkle it well, then turn and mix it until it is equally wet; a quarter of grain will take from six to eight quarts. After this, keep a brisk fire, and turn it frequently to keep it from burning, and in two hours, or from that to two hours and a half, it will be ready for taking off. The steam raised from it will be great, and will require four or five large tubes, or openings in the roof to discharge it, for the smell is most offensive while drying, which requires the kiln to have all the air that can be given it.

It is by being thus heated and put into a state of fermentation, that the steam draws from and carries off, by evaporation, all that corruptible and offensive matter which the grain has imbibed. How simple the process that restores the grain to its natural state again!

When the grain has been sufficiently cooled, which will require four or five days, let a quarter of it be sent to the market without being dressed, along with a quarter from the same bulk, in its fusty state, and I will maintain it will sell for from 10*s* to 15*s* per quarter more than the other grain; but if dressed, as before described, it is not easy to say how much it would be improved.

Still the grain may be purified much more conveniently and not liable to injury, with one-third the trouble by a ventilator; and it may be steeped in a tub a few minutes only for that purpose, if judged necessary, and then it will be equally wet. The tub should have a wire screen in the bottom, and a large cock under it, by which the water may be quietly discharged and the grain instantly put upon the ventilator.

If the grain thus steeped is dried upon a ventilator, the heat should be from eighty-five to ninety degrees; for it must be great, or it will not raise a sufficient quantity of steam to purify it; the greater the quantity of steam that is raised and the sweeter the grain will be. But the grain may be put dry upon the ventilator, and sprinkled with water, but it is rather a partial way of doing it.

A great deal of fusty grain has been bought within the last eighteen months, on and near the eastern coast of the county of York, by millers, and frequently for a trifle, which they have purified; and the flour made from it has been warranted good. If the previous treatment of this grain was known, probably it would be proved that the injury it had received was by lying in a commission warehouse too long without turning, and the farmer at last is compelled to take such a price for it as the commissioner can get, or that he may purchase it himself at perhaps little more than half its original value.

Now if such foul grain can be purified, and made fit for use, the farmer, who is the great sufferer, should do it himself.

From the experiments I have lately made in drying grain, and consulting with various millers respecting the great saving there is of power in the grinding when dried, they are of opinion, that in summer more than one-sixth part of the power will be saved, but in winter, when the weather is soft and wet, and the grain tough, one-fourth of the power will be saved, yet I have stated it at one-tenth; and this estimate of the saving in power, I am inclined to think, is not much over rated. The power for working a pair of French stones, is well worth from £75 to £80 per annum. Surely this great saving in power, is sufficient to induce the miller to have a ventilator, independent of every other consideration.

When I consider that there is annually near, if not more than one hundred millions sterling of the farmers' capital, in grain, in the three united kingdoms, exposed to all the vicissitudes of such a changeable climate, where the raging winds and excessive rains frequently destroy a great part of it; I stand amazed that nothing has been done to lessen the calamity.

It appears singular, that a ventilator has been so imperfectly understood, and that nothing has been done to reduce it to a regular system; for as yet it is little more than conjecture.

I have before recommended a caravan stove for heating air for a small ventilator, and it may answer; but then it would require a fan, or some substitute, to supply it with air; but since I printed the instructions for setting it, I have thought upon different plans, and have tried many experiments, and I think a better and a more simple one may be contrived for a small ventilator; but the scantlings I shall now give are for a large one, yet they may be reduced to suit the size of any room; and for a small ventilator, I am confident no fan will be required if made with an air vault. I am desirous, if possible, to make a ventilator for the former, that will not require a fan, as the power of a horse is expensive; but as for the miller it is of small moment, as he can work a fan by his water wheel.

INSTRUCTIONS

FOR MAKING A HOT AIR VAULT FOR DRYING GRAIN WITH RARIFIED AIR.

There should be two bricks in length walls, raised two feet nine inches high, as if intended to contain ashes for the boiler of a steam engine, the distance between them three feet; and these should be continued across the room to the out wall of the building; and if circumstances will admit, it would be much better if the ground was dug out for the foundation, from two feet six inches, to three feet deep; and have the grate bars nearly level with the ground floor, as it would lengthen the draft so much between the air vault and the ventilator, by which much more cold air would be got. Sinking the air vault thus is only necessary where the ventilator is made upon the first chamber floor, for was it made upon the second, there would be no occasion for it; and if the ground floor will not admit of being thus sunk, it may be made without it.

When the said walls are got two feet nine inches high, the grate bars should be laid upon them, and seven inches above them there should be a cast plate put on, five feet four inches broad, six feet long, inch and a half to inch and three quarters thick in the middle, but only inch and a quarter at the sides, and be made three inches concave; and have four stout lugs on the back-side in the middle, with holes in to admit of three quarters screw pins, with a parallel joint at one end to be fixed to them, and on the other end there should be a strong thread cut, and it should go through the arch, and have a strong nut and large washer tightly screwed on the top side of it, to keep the plate from sinking in the middle when hot.

And on the under side of the plate, there should be two side plates or cheeks, cast the same length nine inches deep, full inch thick, and the distance between them three feet four inches, which must be placed upon the brick walls when raised seven inches above the grate bars, and each of these plates should stand two inches from the face of the said wall, and on the back side of each of them there should be an air flue eight inches wide, and the same depth as the side plates; the walls should be raised to the plate, and the edge of it should go four inches upon the walls on each side the flue, and the distance between the under side the plate and the grate bars will then be sixteen inches.

At the end of the side flues there should be an opening left in the brick work, near the end of the plate, as wide as they are, to let the hot air pass into the air vault. The plate should have eight lugs on the back side of it, and four on each side, near the edge, and they should stand across it and have holes in, like those for the middle of the plate to admit of the like screw-pins, nuts, and washers, but the washers should be eight inches diameter, and curved to suit the arch, and should be firmly screwed to prevent it and the brick walls from being opened by the heat or expansion of the plate.

When the plate is put on there should be a space of an inch and a half left, between the brick work and the edge of it, to allow room for the expansion, or it will force the brick work out, notwithstanding the eight screw-pins, and there should go an inch bar across the front of the brick work, with a stout thread nut and large washer tightly screwed, to keep the walls from opening.

When the side walls are got even with the top side of the plate, there should be two courses of fire brick walled down each side of it, three feet two inches wide, and an arch of fire brick should be made as air-tight as possible, a brick in length, and from the plate to the under side the crown it will be nearly two feet.

In the front of the brick work there must be two openings left in the wall, at the end of the flues, the same width, for to allow of two circular valves being fixed to admit of cold air; and the wall on each side should be carried up square six inches above the crown of the arch, and the space should be filled up with sand and covered with a strong coat of mortar, to keep in the heat. But if at the end of the plate there was another laid, from three to near four feet broad, and five feet four inches long, and the side flues extend to the end of it, more heat would be got with the same fuel; and, but for the expense, it would be the best if those plates and flues were extended within four feet of the end of the arch.

Should one plate be laid after the large one, it will not require to be more than three quarters of an inch thick, and the remainder would do half an inch thick by thus extending the length of the plates and flues; for more heat and more cold air would be obtained, but the plates would not be one-third as hot. But where the plate or plates end, there the flue for the smoke should commence, and should be from eighteen to twenty inches high, fifteen wide, and covered with cast plates three-eighths of an inch thick, and the length may be from two feet six inches to three feet.

The frame for the doors should have a flange in the inside, two inches broad, and be even with the top edge; and there should be a plate on the back side, five and a half inches broad, inch thick, with a bracket on the under side to keep it from sinking; and upon this plate and frame a brick and half wall should be raised, to fill up the end of the arch or air vault; and when it is got within four inches of the under side the arch, there should be a cast funnel, two feet in breadth, and twenty-two inches long, and the width of the opening on the out side three inches, but the inside should not be more than two inches, and it should be cast as light as possible, and have a slide before it of rolled plate to admit of more or less air, as circumstances may require.

Near the end of the air-vault there should be a stout tin pipe, twelve inches diameter at the bottom where it will go through the arch and taper to eight inches in four feet length, and be continued this width till it gets through the floor, and then be made twelve inches wide, for one foot in length, and made up at the end, and have four nossels each six inches wide and three long, to admit of ten pipes being put upon them, to convey the air and distribute it equally along the space under the ventilator, by the pipes being full of holes on the top side. The upright pipe may be made of tin, at one-fourth the expense of cast ones, and will answer every purpose.

By adopting this plan I have no doubt but a sufficient quantity of rarefied air may be had for a moderate sized ventilator without the aid of a fan; but as this is intended for a large one I would prepare a hole in the arch, within four inches of the plate to admit of a pipe six inches diameter, in case one should be wanted.

A caravan stove will only contain about six feet of rarefied air; and if a large stove is made in the shape of a boiler from six to seven feet diameter, such a stove would cost thrice the expense of such an air vault as I have described; if only made with one large plate it would not contain one-half the quantity of rarefied air that the said vault will.

I have had great fear that cast plates would injure the grain, though they might be heated with rarefied air; but within these few days I have seen a common pot tile kiln covered with hair-cloth, and grain spread moderate thick upon it, yet I could not perceive that it suffered the least injury, for the hair-cloth prevented it.

I am now fully satisfied, that the farmer may have a ventilator from five to six yards square, well heated with rarefied air, without the assistance of a fan; and both he and the corn miller may make use of cast plates with safety; for should they have any fear of injury, they may cover them with hair cloth, and then no damage can be done to the grain; and should they want to dry oats, they may take it off, and only use it for drying wheat and malt; but it will always be prudent for the miller to have a fan for drying the grain with cold air that does not require heat, as I have observed before.

There will be no money lost by carrying the arch nearly across the room, for by raising a few heads upon it, it will assist in supporting the first floor, supposing a new building to be erected.

But if the arch is not continued across the room, it may end about two feet beyond the six feet plate, and should be walled up with a brick and a half wall, and the upright tin pipe for conveying the hot air must be placed near the end of it, and it will deliver the air near the middle of the ventilator; but the flue for the smoke must be carried to the wall, and rise up there.

By cutting the arch thus short, a considerable quantity of heat will be lost, and the draft for the cold air much diminished, as I have before observed; for here the flue for the smoke cannot be returned with advantage, as in drying houses, and therefore it will be the most beneficial to continue the arch across the room, no matter what size the ventilator may be.

As soon as the said ventilator that is making with cast plates, and a forged stove, nearly in the shape of a seven feet boiler, is got fairly to work, I intend to inform the public how it answers, and of any additional improvement that can be made in it; for it is too much to suppose that it will not admit of any, nor am I so sanguine as to expect it.

Time, experience, and mature consideration are required to reduce a chaos, that contains the seeds of immense improvement to a regular system; and experience, in many instances, has shewn how slow the progress of great improvements have been, and perhaps this may be considered one of the greatest in magnitude of any that has yet been brought forward in this kingdom; and its importance is greatly increased, and the necessity of it becomes more urgent by the perpetual change in our climate.

From the description and instructions given, I make no doubt but any intelligent bricklayer, or mason, may erect such a ventilator.

Although I have said much upon the beneficial effects of drying grain by rarefied air, yet the application of it is not confined to grain only; for it is capable of being made very useful in many different ways.

The time I think is not remote, when it will be generally used for warming churches, public rooms, vineries, drying houses for wool and cloth, and for all kinds of cotton goods. And hot air will be of singular use to public breweries, for warming the room where the liquor is worked, and especially in frosty weather, as it may be kept of an uniform temparature most convenient for it. For want of having the room properly warmed where the liquor is worked in frosty weather, large quantities of it are often much injured; and by the said room being too hot in summer, much liquor is often spoiled. Now there will be no more difficulty in having this room in a proper temparature both in summer, and winter; and in hot weather, it is of no small consequence to the brewer to have the said room sufficiently cool, which may be done by making a communication with the air vault, or by blowing the air with a fan; but the great advantage of drying the malt by rarefied air will far exceed both these; and all these improvements may be combined in a common ventilator.

The heat that is given to drying houses by brick flues is often most injurious to both wool and cloth, being from fifteen to twenty degrees too hot, by which the fibres of the wool is much weakened, but especially when dyed either brown or black; and the cloth made from it handles extremely harsh and unkind; and no subsequent treatment whatever can restore the fibres of the wool to their natural strength; and moreover, it will require nearly one half more oil to work it than if dried with sun and air. By the cloth being thus heated, it becomes loose and slabby, and there is no firmness in it; it will never turn rain afterwards as it ought to do, nor admit of a kind soft face being given to it. Cooling it out of doors will not restore that fineness it once possessed; nor will steaming it, and afterwards cold pressing, restore the stamina it has lost by excessive heat.

In winter, when the weather is wet or damp, I think one half of the dyed wool and cloth manufactured in the west riding of the county of York, are much injured by drying, as before mentioned; and yet, both wool and cloth might be dried by hot air without being in the least injured, and much cheaper than by brick flues, or even steam.

There is too much humidity in steam to dry any thing perfectly, the metal being so exceedingly porous, and subject to much extension and contraction, by which the joints are frequently broke, and much steam will then enter the room.

The heat in a drying house for drying wool or cloth, should never exceed that of summer, but if any thing, it should be rather less; as there is not that quantity of air to assist in drying as out of doors.

OBSERVATIONS

ON IRELAND.

It is probable that my observations upon the immense sums of money that have been imprudently expended upon canals in Great Britain will excite considerable surprise in the minds of my readers; but how much more will it be increased, when I submit my observations to the public upon the designing and executing of canals, river navigations, harbours, docks, &c; and also on the various lines of canals that have lately been surveyed, and approved of by the directors general of inland navigation in Ireland, upon which I intend to publish a treatise in two or three months.

Nothing but surveying the canals and navigations in Ireland could have made me believe, that such immense sums of money had been so foolishly squandered, and its many local advantages so much neglected. It is a country capable of immense improvement, and the peasantry are brave, bold, and generous; and, though a high spirited people, are capable of being moulded to any form, if properly treated. But one thing greatly surprised me that nearly all the grain that is grown in that kingdom, and used for bread, has to be kiln dried before it can be ground, however fine the harvest may be, and though the coal for drying it is exceedingly dear; for there is only one kind in the kingdom, as I was informed, that is fit for the purpose, which is got in the county of Kilkenny. On this account, ventilators would be of singular advantage, as they might be heated with turf, or inferior coal, or with turf and coal mixed together; for though the smell from them is very unpleasant, yet it could not, in the least, affect the grain; and it is probable it might be dried with one half the expense it now costs.

On the Bridgewater Canal.

Since the estimate was printed commencing in page 145 of this work, I have learned with surprise, that the communication is now intended to be made with the Leeds and Liverpool canal at Wigan; which will deprive the towns of Liverpool and Manchester of a short and easy water conveyance; for the public had a right to expect that the union would be made at a different place, as the distance between the two towns, by that line, will be from fifty-four to nearly fifty-six miles. I am informed that a junction may be made between the two canals where they are upon a level, or within a few inches.

Was the communication so made, that the distance between the said towns should not exceed from forty-two to forty-four miles, (and I can see little difficulty in doing that) it would be of the utmost consequence to the Leeds and Liverpool canal; as the principal part of the trade between the towns of Liverpool and Manchester, would pass upon it, and which I apprehend, will not be secured by the proposed line of conveyance.

If the junction was made with the said canal twenty miles from Liverpool, that part would, I think, produce ten times the revenue it will ever raise, suppose the junction to be made at Wigan, by carrying goods to and from Liverpool to Manchester.

It is not to be expected that the noble Marquis will make the communication, as he cannot increase his dues, how far soever he might extend his line, being restrained by his acts; and should the Leeds and Liverpool canal company refuse to execute it, I have no doubt the public would be glad to make it, though the distance might be from twelve to fifteen miles.

Should the present plan be executed, it is probable that a new line of canal will be projected between the two towns, which may not require a lock; and I think it may be made nearly ten miles shorter than by Wigan.

But it by no means follows, that Leigh is the most proper place to form the junction; if the new line is to be made convenient for the public this would depend upon circumstances; it might be found most advisable to leave the Duke's canal two or three miles from thence. I by no means intimate, that the two parties should be precluded from making a junction, for this may be done, and still another line made for the accommodation of the public; but it should not be made so circuitous, as to exclude the trade of the two said towns, which will be the case, if the junction is made at or near Wigan.

If the line, that is proposed to unite these two canals, was twenty miles long, the noble marquis would not be injured; for by his acts, he is empowered to take the whole of his dues, though the goods do not pass one mile upon his canal. And it would be greatly to the advantage of the Leeds and Liverpool company, if the canal was from ten to twelve miles shorter than by Wigan, as there will be a saving in expense of lock building, and much less lockage water will be required; but if the junction is made near Wigan, in coming from Liverpool a lock full of water will be consumed, and another in descending into the Bridgewater canal.

Should there be an extensive trade on the proposed line (but that is not probable) I think it is very doubtful, whether the company can supply it with water by any natural means; would it not then be most advisable to make the junction where the least water will be consumed, and the greatest revenue procured? For a vessel, in passing from Wigan to Leigh, a distance of six miles, will consume as much lockage water as in passing from the summit to Liverpool, the distance of eighty-six miles.

FINIS

Hartley, Printer, Rochdale.

11.

ERRATA.

PAGE

7 10 lines from the top, read *sheet*, not *shut*.
16 18 lines from the top, read *coil*, not *card*.
20 6 lines from the bottom, read *face wheel*, not *fore wheel*.
34 Top line, read *fifteen*, not *five*
[illegible] [illegible] lines from the top, read *and*, not *on*.
141 7 lines from the top, read *saving*, not *average*.
170 7 lines from the top, read *proposing*, not *proving*.
175 5 lines from the bottom, read 200 *feet*, not 200 *yards*.
191 Top line read *inch*, not *inches*.
225 12 lines from the top, read *shut*, not *open*.
241 2 lines from the bottom, read *than*, not *that*.
254 13 lines from the bottom, read *sheet*, not *shut*.
254 8 lines from the bottom, read 3 *tons*, not 300 *tons*.
267 4 lines from the bottom, read £1,125,000, not £1,500,000.
289 8 lines from the bottom read *picking*, not *pricking*.
332 13 lines from the bottom, read [illegible]*ts*, not *joints*.
361 13 lines from the top, read [illegible], not *it*.