PREPARING FOR PUBLICATION,

IN ONE VOLUME OCTAVO,

THE

PLOUGH-WRIGHT'S ASSISTANT;

OR,

A NEW PRACTICAL TREATISE

ON

VARIOUS IMPLEMENTS

MADE USE OF IN

AGRICULTURE.

BY

ANDREW GRAY,

"AUTHOR OF THE EXPERIENCED MILL-WRIGHT."

JUNE 1806.

THE

EXPERIENCED MILLWRIGHT;

OR, A

TREATISE

ON THE

CONSTRUCTION OF SOME OF THE MOST USEFUL MACHINES,

WITH

THE LATEST IMPROVEMENTS.

TO WHICH IS PREFIXED,

A SHORT ACCOUNT OF THE GENERAL PRINCIPLES OF MECHANICS,

AND OF THE

MECHANICAL POWERS.

ILLUSTRATED WITH FORTY-FOUR ENGRAVINGS.

By ANDREW GRAY, Millwright.

SECOND EDITION.

EDINBURGH:
Printed by D. Willison,
FOR ARCHIBALD CONSTABLE & CO. EDINBURGH; AND
JOHN MURRAY, 32. FLEET-STREET; J. TAYLOR, HOLBORN; AND J. HARDING, ST. JAMES'S STREET, LONDON.
1806.

TO THE

RIGHT HONOURABLE AND HONOURABLE

THE HIGHLAND SOCIETY OF SCOTLAND.

MY LORDS AND GENTLEMEN,

YOUR *attention having been uniformly directed to the improvement of the internal Resources of the Country, and to the encouragement of Industry and Ingenuity, as the most certain means of promoting this great national object; I have presumed to lay before You the following Work, which is* intended *to give a view of the improved state of some very important Machines, now employed to facilitate and abridge manual labour in some of the most useful Arts. And, trusting that the design at least is not altogether unworthy of your countenance and patronage,*

I am,

With the utmost Respect,

MY LORDS AND GENTLEMEN,

Your most obedient

And most humble Servant,

b

ANDREW GRAY.

PREFACE.

THE object of the following Treatise is to exhibit, not only to the practical Mechanic, but to the general Reader, some of the more important and useful Machines in that state of improvement and perfection to which they have been carried by the ingenuity of the Moderns; and thus to enable them to understand the nature and construction of Machinery on the same, or a similar plan, as circumstances may require.

THE Author, who is a practical Mechanic, has been for at least forty years employed in erecting different kinds of Machinery; and the greatest part of the Descriptions given in this Work are taken from Machines which he has either Planned, or the Construction of which he has directed or immediately superintended. The Machines, of which he has been careful to give accurate Drawings and concise Explanations, are to be considered, not as Plans founded on the speculative principles of Mechanics, whose success is always doubtful till they are put to the test of experiment, but as cases of practical knowledge, the effects of which have been fairly tried and long approved: And indeed most, or all, of the Machines here represented, are still employed for the different purposes for which they were originally erected.

IN the descriptions of the different Machines, short references are only made to the Engravings. This, it was thought, was preferable to a minute detail and circumstantial account of the powers and effects of each part; which probably would have served rather to distract the Reader's attention, than to convey clearer views or a fuller knowledge of their importance and uses. The only deviation from this which the Author thought necessary to make, was in specifying the number of teeth in the wheels and pinions; every other part, it is hoped, will be fully understood from the Plans, Elevations, and Sections, which have been accurately drawn, according to the Scale annexed to each.

PREFIXED to the whole is a short abstract of some of the more general principles of Mechanics, and a brief illustration of the Mechanical Powers (as being the foundation of all Machines); which will enable the Reader, who is not familiarly acquainted with these subjects, to acquire some knowledge of their nature and uses, without having recourse to other works.

CONTENTS.

THE

EXPERIENCED MILL-WRIGHT.

CHAP. I.

General Principles and Definitions in Mechanics.

MECHANICS form an important branch of Natural Philofophy, and are commonly divided into Theoretical and Practical.

The theoretical department is a mathematical fcience, which explains the nature of powers or moving forces, the proportion of thefe powers, their motions and velocities, the way in which one body acts upon another, the manner of conftructing machines for raifing given weights by given powers, or for performing various motions.

The practical part is the art of erecting machines for fome ufeful purpofe, which requires a great deal of manual labour and exertion of fkill. Before we proceed to confider the mechanical powers, it may not, perhaps, be unacceptable to fome readers if we endeavour to define fome terms that are employed in works of this kind.

Thefe terms are—body, denfity, force or power, weight or refiftance, motion, direction of motion, quantity of motion, centre of motion, velocity, vis inertiæ, gravity, fpecific gravity, centre of gravity, equilibrium, machine or engine, ftrefs, friction.

Body is any quantity of matter fufceptible of motion, extenfion, and folidity. A body which gives way to the preffure of another, but afterwards refumes its former pofition, is termed *elaftic;* fuch bodies as remain under the change produced upon them by means of others are called *inelaftic.*

Denfity is the adhefion of different particles of matter to one another. One body is faid to be more denfe than another when the particles of matter in the one adhere more clofely than thofe in the other.

Force or power generally denotes whatever acts upon a body fo as to move it; and if motion is produced fuddenly, the moving power is called *percuffion* or *impulfe.* That which moves a body with increafing velocity is termed *accelerative force;* and if it moves it with equal increafing motion, the moving power is called *uniform accelerative force.*

Motion is a perpetual and fucceffive change of place. It is termed *uniform* when a body paffes over a given fpace in a given time with equal velocity. Motion always increafing is called *accelerated;* but if decreafing, *retarded.* Equally accelerated motion is that to which, in equal times, equal degrees of increafing velocity are added continually; equally retarded motion is that whofe velocity in equal times diminifhes in equal degrees. Motion is alfo faid to be abfolute or relative: The former is the change of abfolute place, and its velocity is afcertained by abfolute fpace; the latter is the change of relative place, its velocity being meafured by relative fpace.

Direction of motion is the line a moving body defcribes.

Momentum, or quantity of motion, is the proportion that the velocity of a body bears to its magnitude.

Centre of motion is a ftraight line drawn through the centre of a body, around which it moves. This is termed alfo its *axis.*

Velocity is the quantity of motion with which a body paffes over a given ſpace in a given time. It is ſaid to be more or leſs according to the pace paſſed over in a ſhorter or longer time.

Vis inertiæ is the tendency of every body to remain in its preſent ſtate, either of motion or of reſt, and to reſiſt all attempts made to change its place.

Gravity is that which makes a body always endeavour to deſcend. It is divided into abſolute and relative: The former is the inclination of a body to fall to the earth in free ſpace; the latter is the force whereby a body tends downwards when immerſed in a fluid.

Specific gravity is the proportion that the weight of one body bears to the weight of another. It is ſaid to be double or triple according to the denſity of the body.

Centre of gravity is that point in a large body to which all bodies of leſs bulk incline; and from which, if a body were freely ſuſpended, it would remain at reſt in any poſition.

Power and Weight are generally oppoſite terms: Power points out the agent which acts upon or communicates motion to any body; Weight denotes the body acted upon.

Equilibrium is thus defined: When bodies of an equal weight are freely ſuſpended, they remain at reſt without acting upon one another, and are then ſaid to be in equilibrio.

A machine is any mechanical inſtrument conſiſting of different parts, employed for the purpoſe of putting bodies in motion.

An engine is the largeſt and moſt complex machine; conſiſting of levers, wheels, axles, pulleys, ſcrews, &c. Its uſes are various; but it is generally employed in raiſing great weights of different ſorts.

Streſs is the effect produced on one body by the preſſure of another to break or diſplace it.

Strength is the reſiſtance or force which one body makes to another acting upon it.

Friction is the reſiſtance which one part of a machine makes to another in conſequence of ſome great weight upon it, or the rubbing of one body upon another.

Nothing has contributed more to improve nations than the knowledge of Mechanics. To the progreſs of this ſcience we are indebted for ſeveral great diſcoveries in machinery; ſo that we can employ every power or force in nature, and even make the elements of water, fire, and air, ſubſervient to the great purpoſes of life.

Man, unable by the exertion of his own ſtrength alone, to remove objects that prevent the gratification of his deſires or the ſupply of his wants, is naturally led to call in the aid of Mechanics. By means of the lever he can raiſe weights much greater than his own bodily exertions could of themſelves overcome. By the aid of the wheel and axle, the pulley and inclined plane, he is enabled to raiſe thoſe weights to very conſiderable heights; and to produce effects which would aſſume the appearance of enchantment to an uncultivated ſavage. By the aſſiſtance of of the ſcrew, bodies, formerly ſeparated, can be firmly united together; and by means of the wedge, ſuch bodies as were united in the cloſeſt manner can be torn aſunder, and thus rendered portable.

The ancients were far from being deficient in mechanical knowledge. The ſtones which travellers have examined on the ſummits of the Egyptian pyramids, and which are of ſuch prodigious weight and magnitude, prove clearly their acquaintance with Mechanics. Had the conſtruction of the machinery they employed in raiſing ſuch ponderous bodies been tranſmitted to poſterity, it would probably have been of ſignal ſervice to the modern mechanic.

Practical Mechanics have two great ends to promote: Firſt, the producing a certain effect by a given power, through the medium of a machine. Second, the controuling the impetus of a given power, or the quantity of a known effect. The ſkill of the artiſt has a large field for exertion in the ſolution of the following problems. Prob. 1. To proportion the acting power to the body acted upon, ſo that both may remain in equilibrio. Prob. 2. To proportion the power or force to the reſiſtance, ſo that the greateſt effect may be produced in the ſhorteſt time.

In an engine or machine three things claim our attention: Firſt, a paſſive body or weight which is to be moved; ſecond, an active power which is to put the paſſive body in motion; and, third, the inſtrument by which this is to be effected.

Engines or machines are various inſtruments uſed to make a given power produce the greateſt effect in the ſhorteſt time. Their

Their ſize and ſtructure are as different as the ends for which they are deſigned. They are a combination of mechanical powers; which are ſo termed becauſe they are of great utility in abridging manual labour. Bodies can be put in motion, or great weights raiſed by theſe powers when united, which could not be effected by them individually. Thus, a power unable to produce the above purpoſes of itſelf, may effect its end by transferring a certain degree of the preſſure upon the fulcrum or prop of a lever, or by the aid of pulleys, of the inclined plane, or of the ſcrew. Great attention is neceſſary, however, in employing ſuch a number of agents, that the weight ſuſtained by each power may bear a ſmall proportion to the whole.

POSTULATA. To explain the mechanical powers mathematically, the following poſtulata are neceſſary.

1. That a ſmall portion of the earth's ſurface may be conſidered as a plane. Though this is not ſtrictly true; yet ſuch a ſmall portion of it as we have any occaſion to conſider does not ſenſibly differ from a plane.

2. That heavy bodies deſcend in lines parallel to each other. Though all heavy bodies tend to a point, viz. the centre of the earth; yet the ſpace which they paſs over in their deſcent is ſo ſmall, conſidering their diſtance from that centre, that their inclination is inconſiderable.

3. That any given power or weight acts with the ſame force in all points of its direction; or if a body be acted upon by any power in a given point, the action will be the ſame in whatever point it be applied.

4. That though bodies be rough, and machines imperfect; yet, for the eaſe of calculation, we may ſuppoſe all planes perfectly even, all bodies ſmooth, all lines ſtraight, inflexible, without weight and thickneſs; all cords to be extremely pliable, and all bodies and machines to move without friction or reſiſtance. Theſe poſtulata imply the notion that we reaſon concerning perfect inſtruments: but as none ſuch exiſt, we muſt therefore inveſtigate the difference between theory and practice; which, when found, allowance muſt be made for it.

5. A power or weight acts with equal force in every point of its direction. If a body is acted upon by a piece of wood, ſuppoſed inflexible and without gravity, this body is put in motion with the ſame force, whether the wood be long or ſhort; or if one body were ſuſpended by a long ſtring and another by a ſhort one, there would be no greater difference in the weight of theſe bodies than what was occaſioned by the weight of the ſtring. Gravity varies according to the diſtance of a body from the earth; but this difference is imperceptible in a cord by which bodies are ſuſpended from a machine. We may conſider bodies in motion, and compare them together, either with reſpect to the quantity of matter they contain, or the velocity with which they move; for the greater quantity of matter that is in any body, the greater power is neceſſary to move it or ſtop its motion. Likewiſe its force is greater according to the degree of velocity with which it moves: ſo that the whole force of a moving body is the product of the quantity of matter multiplied by the velocity with which it is moved. The product of the particular quantities of matter in any two bodies, multiplied by their reſpective velocities, being equal, the ſum of their forces are ſo too. Thus, one body weighing 50 lb. and moving at the rate of two miles in a minute, and another weighing only 4 lb. but moving at the rate of 25 miles in a minute, the ſum of the forces with which theſe two bodies act upon any reſiſtance are equal to each other: Therefore, to bring theſe bodies to a ſtate of reſt, an equal power is neceſſary; for $50 \times 2 = 100$, the force of the firſt body, and $25 \times 4 = 100$, the force of the ſecond body. The knowledge of mechanics depends entirely upon the underſtanding of theſe evident and plain principles. It will always be found a fact, that two bodies being ſuſpended from any machine, but acting in oppoſition to each other, and the machine being put in motion, the perpendicular aſcent of one body, multiplied into its weight, is equal to the perpendicular deſcent of the other body, multiplied into its weight. Theſe two bodies, though unequal in their weights, will balance one another in all points; for as the aſcent of the one is performed in the ſame time as the deſcent of the other, their reſpective velocities muſt be exactly as the ſpaces through which they paſs; and the exceſs of weight in the one body is counterbalanced by the degree of velocity in the other. Hence it is eaſy to aſcertain the power of any engine, either ſimple or compound. This is done by finding the exact degree of velocity with which the power moves quicker than the weight does; and in the ſame degree is the power aided by the machine.

CHAP. II.

Of the Mechanical Powers.

THE Mechanical Powers are reckoned ſix in number, viz. 1. The lever; 2. The wheel and axle; 3. The pulley; 4. The inclined plane; 5. The ſcrew; and, 6. The wedge.

I. OF THE LEVER.

THIS is an inſtrument which, conſidered mathematically, is an inflexible line without gravity, but in fact is a bar of wood or iron, both flexible and weighty. One part of it is ſupported by a prop, all the others turn upon that as their centre of motion; and the velocity of every part is exactly as its diſtance from that centre. Therefore, when the weight at the one end of the lever is to the power at the other, as the diſtance of the power from the fulcrum is to the diſtance of the weight from the ſame, then the power and the weight will balance each other; and as a common lever has little friction, a very ſmall additional force will be ſufficient to raiſe the weight.

There are three ſpecies of levers. The firſt kind is when the fulcrum is placed between the power and the weight, but much nearer to the weight than to the power; which in this country is commonly denominated a *prize*.

The ſecond kind is when the fulcrum is at one end of the lever, the power at the other end, and the weight between them, which is generally denominated a *miller's lift*.

The third ſpecies is when the fulcrum is at one end, the weight at the other, and the power placed between them. The two firſt kinds aſſiſt the ſtrength, while the third obliges the mechanic to act at a diſadvantage; ſuch as the raiſing a piece of timber or a ladder upon end, where the man's ſtrength is between the fulcrum and the weight. To form a proper eſtimate of the advantages of a power over a reſiſtance, it is neceſſary to aſcertain what force will preſerve an equilibrium between them, becauſe an increaſe of power will overcome the weight.

From theſe obvious principles the following inferences may be deduced:

1. That a power acts with more advantage againſt a weight in proportion to the diſtance of the power from the fulcrum.

2. That two equal weights, acting in oppoſite directions on the ſame lever, cannot balance each other, except when they are equidiſtant from the fulcrum.

3. That two unequal weights exert equal forces when the diſtance of the leſſer weight from the fulcrum exceeds the diſtance of the greater weight from the ſame, as much as the greater weight exceeds the ſmaller one; or, in other words, when their diſtances from the fulcrum are reciprocally as their maſſes.

There are conſiderable difficulties attending all experiments on the mechanical powers, chiefly reſulting from the weight of the materials; but as it is impoſſible to find any entirely deſtitute of weight, it ſhould be carefully attended to, whether the levers are perfectly balanced before the application of the weights and powers.

Firſt kind of Lever.—A lever of the firſt kind is repreſented by the bar ABC (Plate I. fig. 1.), ſupported by the prop or fulcrum D. Its principal uſe is to looſen large ſtones in the ground or quarry, or to raiſe great weights to ſmall heights, in order to have ropes put under them for raiſing them higher by other machines. The parts AB and BC, on different ſides of the prop D, are called the arms of the lever; the end A of the ſhorter arm AB being applied to the weight to be raiſed or to the reſiſtance to be overcome, and the power applied to the end C of the longer arm BC.

In

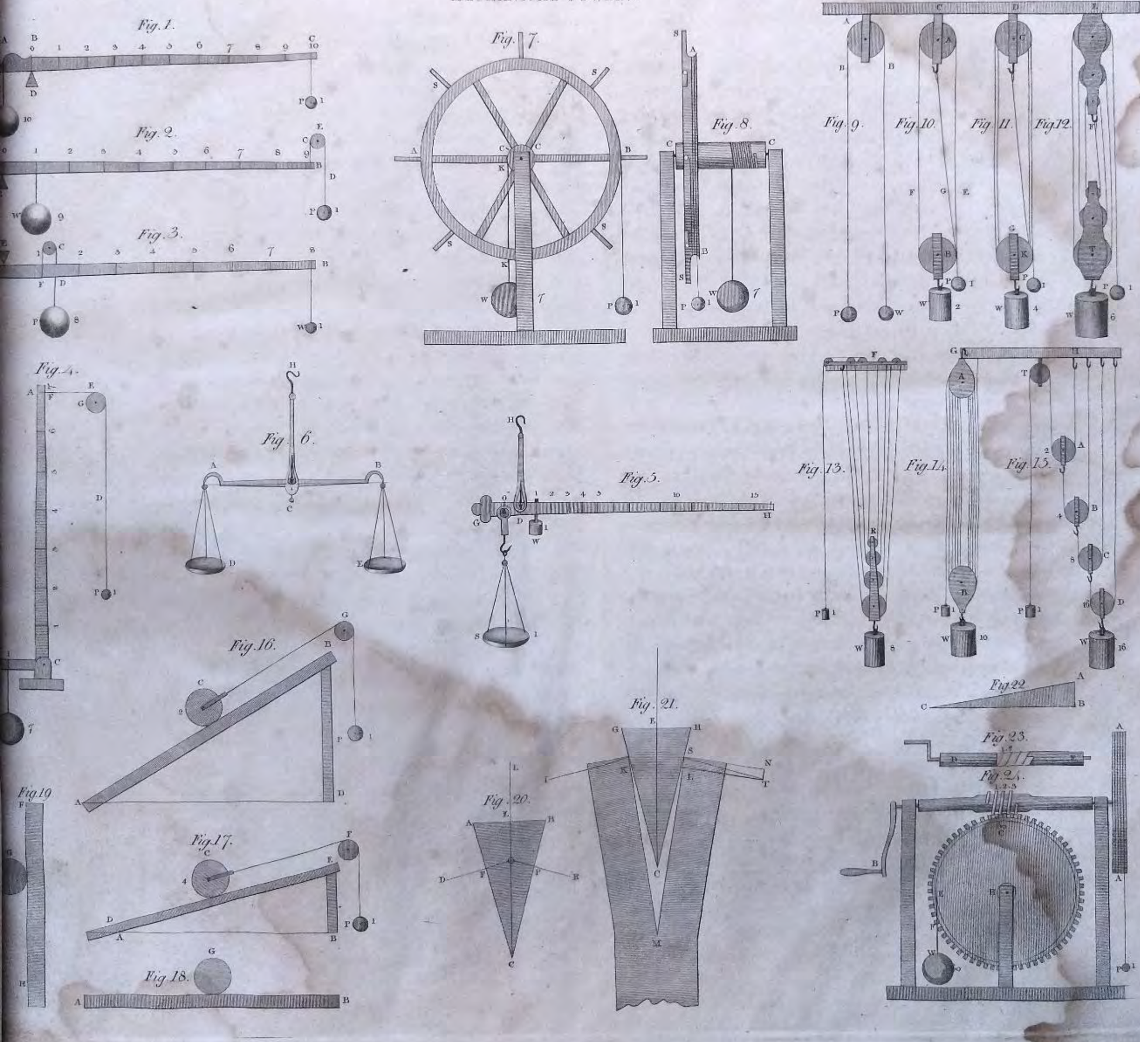


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
Fig. 24.

In making experiments with this inftrument, the fhorter arm AB is made fo heavy as juft to balance the longer arm BC on the prop D. Thus the lever is reduced to an horizontal pofition; and being in equilibrio with itfelf, may be confidered as without weight. Therefore let P reprefent a power whofe gravity is equal to one pound, and W a weight whofe gravity is equal to ten pounds. Now, if the power be ten times as far from the prop D as the weight is, they will exactly counterpoife; and a fmall addition to the power P will caufe it to defcend and raife the weight W; and the velocity with which the power defcends will be to the velocity with which the weight afcends as ten to one; that is, directly as their diftances from the prop D, and confequently as the fpaces through which they move; the weight being as much nearer to the prop as the power is lighter than the weight. A man therefore who can, without the help of any machine, fupport one hundred weight, will be enabled by this lever to fupport ten hundred weight. If the weight be lefs, or the power greater, the prop may be placed fo much farther from the weight, and then it can be raifed to a proportionably greater height: For, univerfally, if the intenfity of the weight multiplied into its diftance from the prop, be equal to the intenfity of the power multiplied into its diftance from the prop, the power and weight will exactly balance each other, and a little addition to the power will raife the weight. Thus, in the prefent inftance, the weight W is ten pounds, and its diftance from the prop is one inch, and ten, multiplied by one, is ten; the power P is equal to one pound, and its diftance from the prop is ten inches, which, multiplied by one, is ten again; and therefore there is an equilibrium between them. So if a power equal to two pounds be applied at the diftance of five inches from the prop D, it will juft balance the weight W of ten pounds; for five, multiplied by two, is ten as before; and fo on in proportion to the diftance of the power from the prop to the diftance of the weight or refiftance from the prop.

To this kind of lever may be reduced feveral forts of inftruments; fuch as fmiths' tongs, pincers, fciffars, candle-fnuffers, &c. which are made up of two levers acting contrary to one another; their prop or centre of motion being the pin or rivet which keeps them together.

Second kind of Lever.—In this kind of lever the weight or refiftance is placed between the prop and the power. And in this, as well as in that of the firft kind, the advantage gained is as the diftance of the power from the prop to the diftance of the weight or refiftance from the prop; or the refpective velocities of the power and weight are in that proportion; and they will alfo balance each other, when the intenfity of the power, multiplied by its diftance from the prop, is equal to the intenfity of the weight multiplied by its diftance from the prop.

Thus, if AB (fig. 2.) be a lever, on which the weight W of nine pounds hangs at the diftance of one inch from the prop G, and P a power equal to the weight of one pound hangs at the end B, nine inches from the prop; by the cord CD, going over the fixed pulley E, the power P will juft fupport the weight W: and a fmall addition to the power will raife the weight one inch for every nine inches that the power defcends; becaufe the power P being placed nine times as far from the prop G as the weight W, the power muft pafs through nine times the fpace in the fame time, or move with nine times the velocity of the weight when they are put in motion. This lever fhews the reafon why two men, carrying a load upon a pole between them, bear unequal fhares of the weight in the inverfe proportion of their diftances from the load; for it is well known, that the nearer either of the men is to the load, the greater fhare he bears of it; and if he goes directly under it, he bears the whole. So, if one man be at G and the other at B, having the pole or ftick AB refting on their fhoulders; if the load or weight W be placed eight times as near the man at G as it is to the man at B, the former will bear eight times as much weight as the latter; and in this the prop G carries eight pounds, while the fixed pulley E carries only one pound.

Upon this principle, horfes of unequal ftrength may be made to draw equally in a coach or plough; for by dividing the bar by which they pull unequally, the point of traction may be as much nearer to the ftronger horfe than to the weaker horfe, as the ftrength of the firft exceeds that of the fecond. To this kind of lever may be reduced oars, rudders of fhips, doors turning upon hinges, cutting-knives which are fixed at the points, &c.

Third kind of Lever.—In this machine, the power is between the prop and the weight. It may be confidered as the fecond kind of lever reverfed; for the power in this muft exceed the weight as much as the diftance of the weight from the prop exceeds the diftance of the power from the prop. Thus, let E (fig. 3.) be the prop of the lever AB, and W a weight of one pound placed eight times as far from the prop E as the power P acts at F, by the cord D going over the fixed pulley C. In this cafe, the power P muft be equal to eight pounds, in order to fupport the weight W of one pound.

As this kind of lever is a difadvantage to the moving power, it is ufed as little as poffible; but in fome cafes it cannot be avoided; fuch as that of a ladder, which being fixed at one end, is, by the ftrength of a man's arms, reared againft a wall, &c.

The ufe of the third kind of lever can only be fully contemplated in the animal body. Animals move their limbs with great velocity, by applying the power of mufcles very near the centre of motion, giving the mufcles, at the fame time, fuch a very great force, as to perform their office fuddenly, raifing their limbs even when great weights hang at their extremities, as when we lift weights with our hands. There is fcarcely a bone in the animal body which acts not as a lever of the third kind. In what manner, or by what means, power is communicated in the animal frame, we are totally ignorant. It is not to be accounted for upon mechanical principles; for there is no perceptible lofs of time to compenfate for the increafe of power.

The Hammer Lever.—This differs in nothing but its form from a lever of the firft kind, it being bended for the fake of convenience. Its name is derived from its ufe, that of drawing a nail out of wood by a hammer.

Suppofe the handle of a hammer feven times as long as the iron part which draws the nail, the lower part refting on the wood as a prop; then, by pulling backwards the end of the handle, a man will draw a nail with one feventh part of the power that he muft ufe to pull it out with nippers; in which cafe, the nail would move as faft as the hands: but with this hammer, the hand moves feven times as much as the nail, by the time that the nail is drawn out.

ABC (fig. 4.) is a lever of this fort, whofe arms AC and BC are at right angles to each other. The heel turns on a pin at C, which is its prop or centre of motion; P is a power acting upon the longer arm AC at F, by the cord DE going over the fixed pulley G; and W is a weight or refiftance acting upon the end B of the fhorter arm BC. If the power P is to the weight W as CB is to CF, they are in equilibrio. Thus, fuppofe W to be a weight of feven pounds, acting at the diftance of one foot from the centre of motion C, and P to be a power equal to the weight of one pound, acting at F, feven feet from the centre of motion C, the power and weight will exactly balance each other.

The Steelyard.—The fteelyard is a lever of the firft kind, and is ufed for finding the weights of different bodies, by one fingle weight placed at different diftances from the prop or centre of motion D (fig. 5.) The fhorter arm DG, with the fcales fufpended at O, muft exactly counterpoife the longer arm DH. If this arm be divided into a number of equal parts, each part equal to DO, the fingle weight W (which we may fuppofe to be one pound) will ferve for weighing any thing as heavy as itfelf, or as many times heavier as there are divifions in the arm DH, or any quantity between its own weight and that quantity. As, for example, if the weight W be one pound, placed at the firft divifion 1 on the arm DH, it will balance one pound in the fcale at S. If it be removed to the fecond divifion at 2, it will balance two pounds in the fcale; if to the third at 3, it will balance three pounds in the fcale; and fo on to the end of the arm DH. If each of thefe integral divifions be fubdivided into as many equal parts as a pound contains ounces, and the weight W be placed at any of thefe fubdivifions, fo as to balance what is in the fcale at S, the pounds and odd ounces therein will by that means be afcertained.

The Balance.—The balance is a lever of the firft kind, whofe arms are of equal length; or, in other words, the points from which the weights are fufpended are equally diftant from the centre of motion. It is an inftrument of very extenfive ufe, being applied to eftimate the weights of bodies; that is, to compare the weight of any given fubftance with ftandard weights

weights previoufly determined. In treating of the balance, four parts are principally to be confidered: 1. The beam itfelf; 2. The centre of motion; 3. The arms of the beam; 4. The points of fufpenfion.

To conceive more clearly the principles of the balance, it is confidered theoretically as an inflexible mathematical line. A point in the middle of the line reprefents the fulcrum or prop; and the nearer the balance in practice can be brought to this abftracted view of it, the more perfect is the conftruction thereof. In practice, the beam of a balance is a folid bar, and is made of the moft homogeneous and inflexible materials; and fhould be proportioned in ftrength according to its length and the weight it is intended to fupport. The arms fhould be exactly of the fame length.

The two pivots which form the axis or prop fhould be in a right line, and at right angles to the beam.

The axis fhould be very hard and well polifhed. Its fupporting part fhould be thin; and yet not fo fharp as to cut, but a little rounded to avoid friction.

The edge of the axis muft be more or lefs blunt in proportion to the weight it has to fupport.

The rings, or the pieces on which the axis bears, fhould be hard and well polifhed, parallel to each other, in order to prevent friction; and alfo of an oval figure, that the axis may keep its proper bearing, or always remain at the loweft point.

Particular care fhould be taken that the points of fufpenfion on which the fcales hang are in the fame line with the centre of motion; for if the points of fufpenfion are higher than the axis, the balance will vibrate too much; if they are below the axis, the vibration will be too flow. The nearer the centre of gravity is to the centre of motion, the jufter will be the balance.

The index ought to be fixed directly above the centre of motion, and fet at right angles to the beam, in order to afcertain when it is horizontal; becaufe this pofition is the only one by which we can well judge of the weight of bodies.

Let AB (fig. 6.) be a beam or lever, C the middle point or centre of motion, DE the fcales hanging at the ends A and B; then let the beam and fcales be fufpended at H: and fuppofe the beam and the fcales to be turned upon the centre C, then the points of fufpenfion of the fcales at A and B, being equidiftant from the prop or centre of motion C, will defcribe equal arches, and therefore their velocities will be equal; and if the weights D and E be equal, then the motion of D will be equal to the motion of E, as the quantities of matter and velocities are equal; and confequently, if the beam and weights are fet at reft, neither of them can move the other, but they will remain in equilibrio. If one weight be greater than the other, that weight and fcale will defcend, and raife or caufe the other to afcend.

To have a pair of fcales perfect, they muft have the following properties:

1. The points of fufpenfion of the fcales, and the centre of motion of the beam A, C, B, muft be in a right line.

2. The arms AC, BC, muft be of equal lengths from the centre of motion C.

3. The centre of gravity muft be in the centre of motion C.

4. There muft be as little friction as poffible.

5. And they muft be in equilibrio when empty.

When the arms of a balance are unequal, the balance is faid to be falfe, as not giving the true weight of the body weighed, whether it be fufpended from the fhorter arm or from the longer one. To difcover a falfe balance, make the weights in the two fcales to be in equilibrio; then change the weights to the contrary fcales; and if they be not in equilibrio, the balance is falfe. Hence a good pair of fcales will be in equilibrio when empty, and likewife in equilibrio with the two weights; then if the two weights be changed to the contrary fcales, the equilibrium will ftill remain if the balance is good.

II. OF THE WHEEL AND AXLE.

THE fecond mechanical power is the wheel and axle, which is applied to a variety of purpofes, and in a variety of forms. The power acts on the circumference of the wheel; the weight is faftened to one end of a rope, whofe other end winds round an axle that turns with the wheel. Let AB (fig. 7. and 8.) be the diameter of a wheel; CC the axle on which the wheel is faftened, fo that the one cannot move without the other; and fuppofe the circumference of the wheel to be feven times as great as the circumference of the axle; then a power P, equal to one pound, hanging by the cords PB, which go round the wheel AB, will balance a weight W of feven pounds hanging by the ropes KK, which go round the axle CC. To turn the wheel once round, pulling at the cords TT, as much cord muft be drawn off as winds once about the wheel, or through a fpace equal to the circumference of the wheel; but whilft the wheel is turning once round, the axle is alfo turned once round, and of courfe the rope by which the weight W is fufpended will wind once round the axle, and the weight will be raifed through a fpace equal to as much rope as will go round the axle, that is, equal to its circumference.

Since, therefore, in the time the machine is turned once round, the fpace which the power P defcribes is equal to the circumference of the wheel, and the fpace which the weight W defcribes is equal to the circumference of the axle, and as the velocities are as the fpaces defcribed in the fame time; it follows that the velocity of the power P is to the velocity of the weight W as the circumference of the wheel is to the circumference of the axle.

Hence, in the wheel and axle, the weight and power will be in equilibrio when the power is to the weight as the circumference of the wheel is to the circumference of the axle; and the momentum of the power, or its weight multiplied by its velocity, will be equal to the momentum of the refiftance or weight multiplied by its velocity.

Now, geometricians prove that the circumferences of circles are as their diameters; confequently, if the power bears the fame proportion to the weight as the diameter of the axle bears to the diameter of the wheel, the power and weight will balance each other. Thus, fuppofe the diameter of the wheel AB to be feven inches, and the diameter of the axle CC to be one inch, then one pound acting as a power P will balance feven pounds as a weight W; and a fmall additional weight will caufe the power to defcend, and turn the wheel with its axle, and fo raife the weight W; but for every inch the weight rifes, the power P will defcend feven inches: fo that the wheel and axle may be confidered as a lever whofe prop is a line paffing through the centre of the wheel and the middle of the axle, whofe longeft arm is the half diameter of the wheel where the power acts, and the fhorter arm is the half diameter of the axle where the weight acts, which are parallel to the horizon, and from whofe extremities the cords hang perpendicularly.

Suppofe that the power does not act by a rope winding round a wheel, but that it is moved by a man's ftrength applied immediately to the handles SS, the power will be increafed according to their length. Hence the wheel and axle may be confidered as a kind of perpetual lever, on whofe arm the power and weight always act perpendicularly, though the lever turns round its prop or centre of motion; and in like manner, when wheels and axles move each other by means of teeth on their circumferences, fuch a machine may be confidered as a perpetual compound lever.

III. OF THE PULLEY.

THE third mechanical power is the pulley, which is a fmall wheel turning about its axis, with a drawing rope paffing over it. The fmall wheel is commonly called a fheeve; and is fo fixed in a box or block as to be moveable round a centre pin paffing through it.

Pulleys are of two kinds: 1. Fixed, which do not move out of their place; 2. Moveable, which rife and fall with the weight.

A rope going round one or more pulleys, to raife a weight, is called the running rope of the fixed pulley. This kind only turns on its axis, but does not move out of its place. Thus A (fig. 9.) is a fingle pulley; and if it fupport equal weights P and W, the cords B, B, to which they are appended, are equally ftretched by the weights, and the pulley A fuftains them both. And if either of them be pulled down through any given fpace, the other will rife through an equal fpace in the fame time; and confequently, as the velocities and the weights are equal, they muft balance each other.

This pulley gives no mechanical advantage, the parts being equally diftant from the centre of motion. It acts only as the beam of a balance, whofe arms are of equal lengths and weight. It is properly but another form of the balance. And though a man can raife no greater weight by means of this pulley than he can raife without it by his natural ftrength; yet it is a fource of great conveniency, as it takes off the neceffity a man would otherwife

otherwife be under of afcending along with the weight, and thus leffens his labour; befides having this further convenience, that by means thereof the joint ftrength of feveral men may be made ufe of to raife any weight.

The Moveable Pulley.—This kind of pulley, the lower of which rifes or falls along with the weight, adds to the momentum of the power. The beft and moft natural method of computing the proportion of any power to the weight it fuftains by means of a fyftem of pulleys, or of explaining their effects, is by confidering that every moveable pulley hangs by two ropes equally ftretched, and which muft, confequently, bear equal parts of the weight; and therefore, when one end of the fame rope goes round feveral fixed and moveable pulleys, as all the parts on each fide are equally ftretched, the whole weight muft be equally divided among all the ropes by which the moveable pulleys are fufpended.

Hence, if the power which acts on one rope be equal to the weight divided by the number of ropes, that power muft fuftain the weight; or, in other words, the power and weight balance each other, when the power is in proportion to the weight, as one is to the whole number of ropes. Upon this principle, the proportion of the power to the weight it fuftains by means of a fyftem of pulleys, may be computed in a manner fo eafy and natural as to be obvious to any one.

It is neceffary to obferve here, that in making the computation, the weight of the moveable pulley muft be balanced before the power and weights are applied, or elfe it muft be included in the weight fupported.

Let us now confider the pulley C (fig. 10.) whereof A runs in the fixed block, and B in a moveable block which rifes and falls with the weight W, and one end of the cord goes round the pulley B in the moveable block, and is fixed to the hook in the block C, while the other goes over the pulley A, and is fuftained by the power P, fufpended at the end of the cord E. Now, it is evident that the two ropes F and G fupport the whole weight W, the cord F fupporting the one half and that of G the other half; confequently, whatever holds the upper end of either rope fuftains half the weight.

If I take hold of the cord F, and pull upwards, I only feel half the weight of W, the cord G fupporting the other half. If I pull the rope E over the pulley A, this only changes the direction; and therefore, in pulling the rope downwards, I only feel half the weight: and if P be a power equal to the weight of one pound fufpended by the cord E, it will balance W, a weight of two pounds fufpended by the cords F and G; and a man will be enabled to lift twice as much weight, by the affiftance of a fingle moveable pulley, as he could raife by his own natural ftrength.

The power P moves twice as faft as the pulley B with the weight W; for to raife the weight one foot, each of the cords F and G muft be fhortened one foot; and twice the quantity, or two feet, muft be drawn over by the cord E, to which the power P is affixed: therefore, the fpace defcribed by the power will be equal to twice the fpace defcribed by the weight, or the velocity of the weight is to that of the power as one to two; and to raife the weight W two feet, the power P muft defcend four feet.

When the upper or fixed block D (fig. 11.) contains two pulleys C, which only turn upon their axes; and the lower or moveable block G contains alfo two pulleys K, which not only turn upon their axes, but rife with the block G and weight W, the advantage gained is as four to one.

In fig. 12. there is a combination of pulleys in a perpendicular direction to one another. EF is a fixed block, in which are three pulleys below each other; and T is a moveable block, in which are three pulleys, the number of cords fix, and the power as fix to one: the advantage is the fame whether the pulleys are placed parallel or under each other.

In fig. 13. there are five pulleys placed in the horizontal fixed block F, and four in the moveable block R, the number of cords eight, and the power as eight to one.

Fig. 14. is another combination of pulleys; whereof five are placed in the fixed block A, fufpended by the hook G, and alfo five in the moveable block B, the number of ropes ten, and the power as ten to one. The block B, with the weight W, is raifed by pulling the cord at P, which goes fucceffively over the pulleys, and is faftened to the block above. The purchafe of this machine is known by confidering that the rope is equally ftretched throughout, and by putting two fuch weights P and W as will balance each

other; for P is fuftained by the fingle rope, and W by tenfold of the fame; fo that if P be one pound, W will be ten pounds.

The velocity of the power is as ten to one. To raife the weight W one foot, the power P muft defcend ten feet.

The combination in fig. 15. is of four moveable pulleys A, B, C, D, connected by four diftinct ropes, each faftened at one end to the hooks in the fixed block at H. The power of the whole is difcovered by fuppofing two fuch weights P and W fufpended as will keep the machine in equilibrium; and then beginning with the leaft weight P, and confidering what force each feparate pulley fuftains. Thus, if P be one pound, the rope which fuftains it, by going over the pulleys T and A, acts at its other end upon a hook in the fixed block H, and is confequently reacted upon by the hook with a force equal to one pound, and the pulley A is drawn with a force equal to two pounds.

By tracing the fecond rope in the fame manner, it will appear that the pulley B is drawn with twice the force of A, or four pounds; C is drawn with twice the force of B, or eight pounds; and D is drawn with twice the force of B, or fixteen pounds: fo that the purchafe of this machine is fuch, that if P be a power equal to the weight of one pound, it will balance or be in equilibrio with W, a weight of fixteen pounds.

The velocity of the weight to that of the power is found in a fimilar way. Thus, if the power P defcends fixteen feet, the pulley A will afcend eight feet, B four feet, C two feet, and the pulley D with the weight W will afcend one foot; fo that the velocities are reciprocally as the power and weight. Though this fyftem be very powerful, yet as it takes up a confiderable fpace it is very feldom ufed.

In like manner may the purchafe of any other combination of pulleys be determined. And it will always happen that the momenta of the weight and power will be as in the other mechanical powers; that is, if any power will raife one pound with a certain velocity, it will raife two pounds with half that velocity, or one thoufand pounds with one thoufandth part of that velocity, &c.

But a fyftem of pulleys has no great weight, and lies in a fmall compafs; it is therefore eafily carried about, and can be applied in a great many cafes for raifing weights where other engines cannot. But they have a great deal of friction on three accounts: 1. Becaufe the diameters of their axes bear a very confiderable proportion to their own diameters; 2. Becaufe, in working, they are apt to rub againft one another, or againft the fides of their blocks; and, 3. Becaufe of the ftiffnefs of the ropes that pafs over and under them.

IV. OF THE INCLINED PLANE.

THE fourth mechanical power is the inclined plane. The advantage gained by it is as great as its length exceeds its perpendicular height. It is employed in raifing weights where other machines cannot be fo readily applied.

If it were required to raife a heavy body to the height D B, (fig. 16.), and perpendicular to the horizon, it is evident we muft employ a power equal to that of the weight; and it would even then be very inconvenient. But if an inclined plane AB be elevated to the height B, where the weight is to be raifed, a lefs power than the weight will ferve the purpofe. The weight is always moft eafily either drawn or pufhed in a line parallel to the plane, and paffing through the centre of the weight.

Thus, if C be a weight of two pounds, laid on the plane AB, whofe length is twice the perpendicular height DB, it will be counterbalanced by a weight P of one pound, drawing the other in a direction parallel to the plane by means of the cord affixed to the weight C, going over the fixed pulley G, and to which P is appended. In the inclined plane the weight and power move with equal velocity; but ftill what is gained by the power is loft by the perpendicular height; for if the weight C be moved from the point A to the point B, that is, the whole length of the plane AB, the power P muft defcend an equal fpace in the fame time. But when the weight has arrived at B, it has only afcended in perpendicular height from D to B, equal to half the length of the plane AB. Therefore the power P has defcended twice the perpendicular height that the weight C has afcended.

If the line AB (fig. 17.) be parallel to the horizon, and DE a plane inclined to it, whofe length is four times as great as the perpendicular height BE; if the cylinder C of four pounds weight be laid upon the inclined plane DE, it will be kept from rolling down

down upon it by the power P equal to one pound, fufpended by a cord going over the fixed pulley F, and its other end faftened to the cylinder C. Therefore a weight may be rolled up this inclined plane with a fourth part of the power required to draw it up the fide of an upright wall. If the plane was five times as long as its height, a fifth part of the power would be fufficient, and fo on in the proportion of the length of the plane to its height. Suppofe a man has occafion to raife a weight to any height, and the weight is fo great that he cannot lift it by his natural ftrength: he will take a long ftout plank, or fomething equivalent thereto, and, fetting it floping, will pufh or roll the weight up the plank to the place defigned to fet it in. Such plank, or other contrivance like it, is an inclined plane. Now, it is evident that the fhorter this inclined plane is, the fteeper is the afcent; and the longer the plane is, the afcent muft be eafier. It is well known, that it is much eafier to pufh a rolling weight up a hill that rifes gently, than up a hill that is very fteep. This is quite familiar to every perfon.

The force with which a rolling body defcends upon an inclined plane is to the force of its abfolute gravity, by which it would defcend perpendicularly in free fpace, as the height of the plane is to its length.

For fuppofe the plane AB (fig. 18.) to be parallel to the horizon, the cylinder G will remain at reft upon any part of the plane where it is placed. If the plane be fo elevated that its perpendicular height from B to E (as in fig. 17.) is equal to one fourth part of its length DE, the cylinder C will roll down upon the plane with a force equal to one fourth part of its weight; for it would require a power (acting in the direction of DE) equal to one fourth part of its weight, to keep it from rolling.

If the plane FH (fig. 19.) be elevated fo as to be perpendicular to the horizon, the cylinder G would defcend with its whole force of gravity; becaufe the plane contributes nothing to its fupport or hinderance; for which reafon it muft require a power equal to the whole force of its gravity to keep it from defcending.

The inclined plane is a very ufeful inftrument in raifing heavy bodies. It may be eafily reduced to a lever of the firft kind. The power is in the proportion of the length of the plane to its height. To calculate the power of the inclined plane, take the long arm of a lever equal to the length of the plane, and the fhort arm equal to the height. To the inclined plane belong all kinds of wedges and cutting inftruments which act as wedges.

V. OF THE WEDGE.

The fifth mechanical power is the wedge, which may be confidered as two equally inclined planes joined together, fo as to form the wedge thin at one end and thick at the other. The thin end is applied to the timber to be cleft, and the thick end ftruck upon by a mallet or hammer. There are many difficulties in forming a complete theory of the wedge, fuch as friction, the elafticity and tenacity of the materials. Indeed, the theory thereof will probably remain for a long time a matter of ufelefs fpeculation, fince it is connected with a part of phyfical knowledge of which we are at prefent wholly ignorant; that is, the nature and force of adhefion in bodies, their tenacity, and the flexibility of the fibres. All thefe circumftances, with many others, fhew that the experiments, where preffure is ufed as a power, cannot be adduced as illuftrating the theory of this inftrument; becaufe a wedge, when loaded with a vaft weight, will have fcarcely any effect in cleaving wood, whereas a ftroke upon the head of the wedge will drive it eafily into a hard body. It is evident that when wood or any other fubftance is fplit by a wedge which does not fill the cleft, (that is, when the angle of the cleft is more acute than that of the wedge), the refiftance of the cleft muft be refolved into two; the one in the direction of the fides of the cleft, which tends to thruft it forward, and the other perpendicular to that direction, which tends to tear it afunder.

Let ACE and BCE (fig. 20.) be two equally inclined planes, joined together in the middle CL. In the plane of this fection, and at right angles to its fides AB, BC, and AC, if three powers be applied fo that their directions may all mutually interfect in the axis or centre O, and their effects fuftain the wedge in equilibrio; then thefe three powers are as AB, BC, and CA, refpectively. Let LE, DF, and RP be the directions of thefe three powers; which produced interfect each other and the axis in O. Since by hypothefis thefe three powers, directed to the fame point, are in equilibrio, and the three fides of the triangle ABC are at right angles to their directions; therefore, by a well known ftatical principle, the intenfities of thefe powers are as AB, BC, and CA, refpectively.

When an impelling power applied to the head of a wedge is in equilibrio with the refifting power of a cleft, the angle of which is more acute than that of the wedge inferted; then, univerfally, the impelling power applied to the head of the wedge, the action of the wedge on either fide of the cleft, the part thereof which tends to thruft it forward, and the remaining part which tends to tear it afunder, are as twice the fine of half the vertical angle of the wedge; the radius, the fine of the angle contained by the fides of the wedge and cleft, and the cofine of that angle refpectively; the fame radius being common.

Let fig. 21. reprefent a vertical fection of the wedge and cleft, fimilar in pofition to that of fig. 20. If the two fides of the cleft LM, KM be equal, and in contact with the fides of the wedge GC, HC, at equal diftances KC, SC from the vertex C, in which cafe the fides of the wedge make equal angles with thofe of the cleft; through the point S draw ST at right angles to HC; alfo through the point S draw SN at right angles to SM, and complete the parallelogram SN, TL: Then the line GH reprefents in quantity the impelling power applied to the head, and the line ST reprefents in quantity and direction the whole action of the fides of the wedge on that of the cleft, which by hypothefis is balanced by its refiftance; but the power ST is reprefented in quantity and direction by SL, SN refpectively;—the one being in the direction of the cleft, tends to thruft it forward; and the other, being at right angles thereto, tends to tear it afunder.

To the wedge are referred the axe or hatchet, the fpade, chifels, needles, &c. and all kinds of inftruments which, beginning from edges or points, grow gradually thicker. A faw is a number of chifels fixed in a line; a knife may be confidered as a chifel when employed in fplitting; but if attention be paid to the edge, it is found to be a fine faw, as is clear from its producing a much greater effect by drawing a ftroke than would have followed from a direct action of the edge.

The wedge is a very powerful mechanical inftrument, fince not only wood, but even rocks, can be fplit by it, which could not be effected by the lever, the wheel and axle, the pulley, or the fcrew; becaufe the force of the blow or ftroke fhakes the cohering parts, and thereby makes them feparate more eafily.

VI. OF THE SCREW.

THE fixth mechanical power is the fcrew; a machine of great efficacy in raifing weights or preffing bodies clofer together.

The fcrew confifts of two parts. The firft is called the *male* or outfide fcrew, being cut in fuch a manner as to have a prominent part going round the cylinder in a fpiral manner, which prominent part is called the *threads* of the fcrew; the other part, which is called the *female* or infide fcrew, is a folid body, containing a hollow cylinder, whofe concave furface is cut in the fame manner as the convex furface of the male fcrew, fo that the prominent parts of the one may fit the concave parts of the other.

One part is commonly fixed whilft the other is turned round; and in each revolution the moveable part is carried in the direction of the cylinder through a fpace equal in length to the interval between two contiguous threads; and thus the body to be moved is carried through a fpace equal to that interval, which therefore expreffes the velocity of the weight or refiftance; while the circumference, which is defcribed by the power whereby the moveable part of the fcrew is turned round, expreffes the velocity of the power.

The fcrew may be conceived to be made by cutting a piece of paper ABC (fig. 22.) into the form of an inclined plane, and then wrapping it round a cylinder DE (fig. 23.) The inclined plane, rifing round the cylinder in a fpiral manner, forms what is called the thread of the fcrew. Now, it is evident that the fcrew muft be turned once round before the refiftance can be moved from one fpiral winding to another, as from 1 to 2: And therefore as much as the circumference of a circle defcribed by the handle of the winch is greater than the interval or diftance between the fpiral or threads, fo much is the force of the fcrew. Thus, fuppofing the diftance of the fpirals to be half an inch, and the length of the winch to be 12 inches, the circle defcribed by the handle of the winch where the power acts is nearly 76 inches,

or

or 152 half inches, and confequently 152 times as great as the diftance between the fpirals; and therefore a power at the handle of the winch, whofe intenfity is equal to no more than a fingle pound, will balance 152 pounds acting againft the fcrew; and as much additional power as is fufficient to overcome the friction will raife the 152 pounds. There is therefore an equilibrium on the fcrew when the power is to the weight or refiftance as the diftance between two contiguous threads is to the circumference defcribed by the power.

A very confiderable degree of friction always acts againft the force of the power in a fcrew: but this is fully compenfated by other advantages; for on this account the fcrew continues to fuftain a weight, or preffes upon the body againft which it is driven, even after the power is removed or ceafes to act. Hence the fcrew will fuftain very great weights; fo that feveral fcrews, properly applied, would fupport a large building while the foundation is repairing or renewed.

A machine for fhewing the power of the fcrew may be contrived in the following manner: Let the wheel AA (fig. 24.) have fixed on its axle the fcrew 1, 2, 3, commonly called the *endlefs fcrew*, working in the teeth of the wheel C, which fuppofe to be 60 in number; it is plain, that for every time the wheel AA and fcrew 1, 2, 3, are turned round by the winch B, the wheel C will be moved one tooth by the fcrew; and therefore in 60 revolutions of the winch, the wheel C will be turned once round. Then, if the circumference of a circle, defcribed by the handle of the winch B, be equal to the circumference of a groove E round the wheel C, the velocity of the handle B will be 60 times as great as the velocity of any given point in the groove; confequently, if a line F goes round the groove E, and has a weight W of 60 pounds fufpended by it, a power equal to one pound at the handle B will balance or fupport the weight W.

To prove this by experiment, let the circumference of the grooves of the wheels AA and C be equal to one another; and then if a weight P of one pound be fufpended by a line going round the groove of the wheel AA, it will balance a weight of 60 pounds hanging by the line F in the groove E of the wheel C; and a fmall addition to the weight P will caufe it to defcend, and fo raife the weight W; but the velocity with which the weight P moves will be 60 times as great as the velocity of the weight W, or as 60 to 1.

If a rope F, inftead of going round the groove E of the wheel C, goes round its axle H, the power of the machine will be as much increafed as the circumference of the groove exceeds the circumference of the axle; which fuppofing to be eight times, then one pound at P will balance eight times 60, or 480 pounds hung to the rope on the axle H; and hence the power and advantage of this machine will be as 480 to 1; that is to fay, a man who, by his natural ftrength, could lift an hundred weight, will be able to raife 480 hundred weight by this engine. If a fyftem of pulleys be applied to the rope P, the power is increafed to an amazing degree: but it would be here as in all other mechanical cafes; for the time loft is always as much as the power gained; becaufe the velocity with which the power moves will ever exceed the velocity with which the weight moves as much as the intenfity of the weight exceeds the intenfity of the power.

The fcrew is of excellent ufe, not only in itfelf for raifing great weights and other purpofes, but in the conftruction of feveral forts of compound engines. The fcrew in a moving body acts like an inclined plane; for it is the very fame as if an inclined plane were forced under a body to raife it, the body being prevented from flying back, and the bafe of the plane being driven parallel to the horizon. This power is applied to various purpofes: It is of great fervice for fixing things together by the affiftance of the lever; it is likewife very ufeful for fqueezing things clofer together. The very friction of this inftrument has its peculiar ufe; for when a weight is raifed to any height by it, if the power be removed, the fcrew will remain in its pofition, and prevent the weight from defcending, merely by its friction, without the affiftance of any other power.

CHAP. III.

Of Friction, the Application of Powers, Uniform Motion, &c.

I. OF FRICTION.

In the lever, the friction is nothing; in the wheel and axle, it is as fmall as the diameter of the gudgeons (added to the power required to bend the rope), and is lefs than the diameter of the wheel; but it increafes in proportion to the weight with which the axle is charged. The fame might be affirmed of the pulleys if they did not rub one againft another, or againft the fides of the mortifes in the block into which they are inferted. A new rope of one inch diameter, going over a pulley three inches diameter, and pulled with a force equal to five pounds, requires a force of one pound or upwards to bend it; and a rope two inches diameter requires four times as much force.

The friction of the fcrew itfelf is very confiderable; and there are few compound engines which, on account of the friction of the parts againft one another, will not require a third part more of the power to work them when loaded, than what is fufficient to conftitute a balance between the weight and the power.

Wood greafed, or metal oiled, have nearly the fame friction; and the fmoother they are, their friction is the lefs: yet metals may be fo highly polifhed as to have their friction increafed by the cohefion of their parts.

Wood flides eafier upon the ground in wet weather than in dry, and eafier than an equal weight of iron in dry weather; but iron flides eafier than wood in wet weather. Iron or fteel running in brafs has the leaft friction of any. Lead makes a great deal of refiftance. In wood acting upon wood, greafe makes the motion at leaft twice as eafy. Wheel naves, greafed or tarred, go four times as eafy as when wet. Smooth foft wood has a friction equal to about a third part of the weight. In rough wood the friction is almoft equal to half the weight. In foft wood upon hard, or hard upon foft, the friction is equal to about a fifth part of the weight.

In polifhed fteel, moving upon polifhed fteel or pewter, the friction is about a fourth part of the weight; on copper, a fifth part; and on brafs a fixth part of the weight. Metals of the fame fort have more friction than different forts.

In general, the friction increafes in the fame proportion with the weight. The friction is alfo greater with a greater velocity; but not fo great in proportion as the increafe of velocity.

To have the friction of machines as little as poffible, they ought to be made of the feweft and fimpleft parts. The diameters of the wheels and pulleys ought to be large, and the gudgeons of the axles as fmall as may be confiftent with the required ftrength. The fides of the pulleys ought not to be all over flat, but to have a fmall rifing in the middle to keep them from rubbing againft each other's fides, and againft the fides of the mortifes at a diftance from their axle. All the cords and ropes ought to be as pliant as poffible; and for that reafon rubbed with greafe. The teeth of the wheels fhould juft fit and fill the openings, fo as not to be fqueezed or fhaken therein. All the parts which work into or upon one another ought to be fmooth; the gudgeons ought juft to fit their holes; and the working parts muft be greafed. The rounds or ftaves of the trundles may be made to turn upon iron fpindles fixed in the round end boards, which will take off a great deal of friction.

II,

II. OF THE APPLICATION OF POWERS.

When any motion is to be long continued, contrive the machine fo that the working power may always move to act one way, if it can be done; for this is better and eafier performed than when the motion is interrupted by the power's being forced to move firft one way and then another; becaufe every new change of motion requires a new additional force to effect it; and a body in motion cannot fuddenly receive a contrary motion without great violence and danger of tearing the machine to pieces. But when the nature of the thing requires that a motion fhould fuddenly be communicated to a body, or fuddenly ftopt, let the force act againft fome fpring, to prevent the machine being damaged by a fudden jolt.

When a machine is moved by two handles or winches on the ends of an axle, the handles are fo placed, that when the one is up the other is down; which is the worft way poffible of placing them, excepting when they are both up or both down together; for when a man raifes a weight by means of turning a winch, he lofes half his force when the winch is upward, becaufe he pufhes himfelf as much backward as he pufhes the winch forward; and when the handle of the winch is down, directly below the axle, he lofes half his force, becaufe the winch pulls him as much toward it as he pulls it toward him: and therefore the greateft effect of his force on the machine is when he either pulls the winch upward on the fide of the axle next to him, or pufhes it downward on the fide fartheft from him; yet, even in thefe cafes, the pulling force is ftronger than the pufhing.

In order to remedy this defect as much as poffible, the handles fhould be fo placed as to ftand at right angles to one another; fo that when there is a man at each handle, the effect of the one man's force will be greateft when the effect of the other man's is leaft upon the machine. Whereas in the common way of placing thefe handles, when the effect of one man's force is the greateft, the other man's is fo too; and when the effect of the one is the leaft, fo alfo is that of the other, which is working at the greateft difadvantage poffible.

III. OF UNIFORM MOTION.

A uniform motion is continued by the application of the heavy wheel (or a crofs bar loaded with equal weights, termed a *fly*) to the machine; which being made to turn round its axis, keeps up the force of the power, and diffufes it equally in every part of its revolution; and by moving through equal fpaces in equal times, or going on at the fame rate, it makes the motion uniform; for by reafon of its weight, a fmall variation in force does not make any fenfible alteration of its motion, while its friction and the refiftance of the machine hinder it from accelerating. If the motion diminifhes it helps it forward, and retards it when moving too faft.

Every regulating wheel ought to be fixed on that axis where the motion is fwifteft: it fhould be heavy if the motion is to be flow, and light when it is to be fwift. The centre of motion in every cafe fhould agree with the centre of gravity of the wheel. The axis may either be upright, or parallel to the horizon.

The greater part of mechanical operations confifts in giving motion to bodies at reft, or in overcoming refiftance. Motion is often firft produced, and afterwards employed in effecting the refult. Hence aftonifhing mechanical effects may be produced by fmall velocities, generated in heavy bodies by fmall moving forces. If a cylinder of lead or iron be moveable around its axis, and in a vertical plane, a fmall force applied to turn it, and continued for a confiderable time, will raife fuch weights as the force firft applied could never have accomplifhed.

It has been demonftrated by Mr Atwood, that a force of 20 pounds applied to the periphery of a cylinder for 37 feconds, whofe radius meafures 10 feet, and weighs 4713 pounds, would give an impulfe to a mufket-ball, one foot from the centre, equal to what it could receive from a full charge of powder.

Such an accummulation of mechanical force appears at firft view aftonifhing, and might beget erroneous ideas of the fubject, if not attentively confidered; when it is evident that the cylinder has no principle of motion in itfelf, and confequently can have no more than what it receives.

An accumulation of motion in heavy wheels is of great utility in actual practice—as in thraſhing mills, flax or lint ditto, machines for lifting great weights, as pile engines, &c.—having a large heavy wheel, denominated a fly, attached to ſome part of their machinery, ſo that it may revolve about its axis. This is found to produce much greater effects than could have been accompliſhed without ſuch an additional maſs of matter.

In every machine in which flies are made uſe of, more force muſt be applied than what would move the machine independent of it, or the fly muſt have been put in motion before its application to the machine.

Suppoſe a wheel and axle, with a heavy wheel attached to it, moveable round an axis by a handle, impelled by muſcular force. In this caſe the utility of a heavy wheel is evident; for ſuppoſe a uniform motion generated therein, this will raiſe the weight for ſome time, although the force of the arm be removed, which muſt in ſome meaſure happen when the arm is aſcending. Now, were there no motion in the heavy wheel to continue the aſcent of the power, the reſiſtance would begin to preponderate as ſoon as the moving power was in the leaſt diminiſhed; from which it is evident how much motion would be loſt without the fly.

In any work which requires alternate ſtrokes, ſuch as the pumping of water and the like, the utility of flies muſt be very apparent. If a peſtle of 30 pounds weight is to be raiſed one foot ſix times in a minute, let the diameter of the fly be ſeven feet, and the peſtle raiſed one foot at every revolution of the fly. We have then to conſider how much weight moving through 22 feet in a ſecond will be equal to 30 pounds moving through one foot in a ſecond. Thus $\frac{30}{22} = 1\frac{4}{11}$. Should a fly of this ſpecies be applied, and the machine be put in motion, the fly could raiſe the peſtle once after withdrawing the moving power; and were the weight of the fly augmented to 20 pounds, the machine would make a number of ſtrokes though left to itſelf; and leſs labour would be requiſite than without the addition of the fly.

IV. THE MILL-WRIGHT'S TABLE.

This Table exhibits the velocity of a wheel every ſecond, and the number of revolutions it performs in a minute; the calculations being made for a wheel of 14 feet diameter, which is a medium ſize, and the fall of water being from 1 to 20 feet.

Height of the fall of Water.	Velocity of the Fall of Water per Second.	Velocity of the Wheel per Second.	Revolutions of the Wheel per Minute.
Feet.	Feet.	Feet.	
1	8.02	2.67	3.65
2	11.34	3.78	5.17
3	13.89	4.63	6.31
4	16.04	5.35	7.22
5	17.93	5.98	8.16
6	19.64	6.55	8.61
7	21.21	7.07	9.64
8	22.68	7.56	10.31
9	24.05	8.02	10.96
10	25.35	8.45	11.53
11	26.59	8.86	12.09
12	27.77	9.26	12.63
13	28.91	9.64	13.10
14	30.00	10.00	13.63
15	31.05	10.35	14.11
16	32.07	10.69	14.59
17	33.06	11.02	15.27
18	34.02	11.34	15.46
19	34.95	11.65	15.91
20	35.86	11.95	16.30

The above Table was calculated by the following rules:

1. Meaſure the perpendicular height of the fall of water in feet above that part of the wheel on which the water begins to act, and call that the height of the fall.

2. Multiply this conſtant number 642.882 by the height of the fall in feet, and the ſquare root of the product ſhall be the velocity of the water at the bottom of the fall, or the number of feet that the water there moves per ſecond.

3. Divide the velocity of the water by 3, and the quotient ſhall be the velocity of the float-boards of the wheel, or the number of feet they muſt each go through in a ſecond when the water acts upon them, ſo as to have the greateſt power to turn the mill.

4. Divide the circumference of the wheel in feet by the velocity of its floats in feet per ſecond; and the quotient ſhall be the number of ſeconds in which the wheel turns round.

5. By this laſt number of ſeconds divide 60; and the quotient ſhall be the number of turns of the wheel in a minute.

N. B. When the velocity of the water and wheel per ſecond is aſcertained, all the other calculations are readily found, as the number of revolutions will always vary according to the diameter of the wheel.

CHAP.

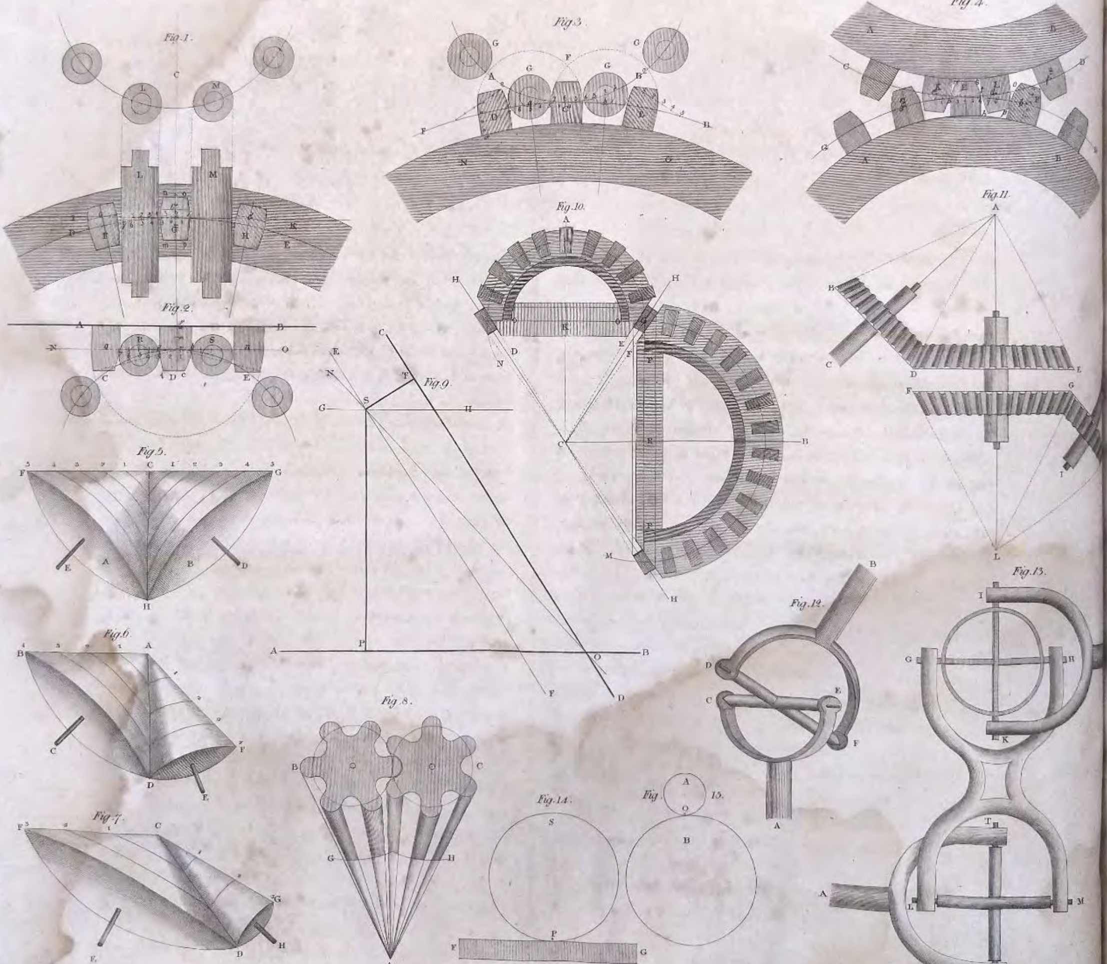


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.

CHAP. IV.

Practical Directions for the Construction of Machinery.

1. THE *method of setting out a face-wheel and trundle or wallower.*—All machines or engines consist mostly of wheels and pinions, trundles, or lanterns, which act upon or drive one another. The different parts of any machine must be accurately formed and nicely adjusted before the whole is connected together. Wheels, pinions, and trundles, ought to be made perfectly round, of equal thickness; and whatever number of teeth or cogs any wheel is to contain, both sides of the holes or mortices which are to receive these teeth should be in a direct line to the centre of the wheel, all equally distant from that centre and from each other, and all of the same form and size. When a large wheel is to drive a small trundle or pinion, the staves in the trundle, or teeth in the pinion, are made thicker than the teeth in the great wheel. One reason for making this difference is, that the trundle making more revolutions than the wheel, is subject to more wear in proportion to their diameters. Sometimes the pitch, or distance betwixt the middle of two teeth in the wheel, is divided into five equal parts; two of these parts are allowed for the thickness of the teeth, and the other three for the thickness or diameter of the staves of the trundle. The height of the teeth is equal to three and a half of these parts. But more frequently the pitch is divided into seven equal parts; three of which are allowed for the thickness of the teeth in the wheel, and the remaining four parts for the diameter of the stave of the trundle. But if the wheel and pinion or trundle be nearly of equal diameter, the teeth in the wheel, and staves of the trundle, may be of the same thickness. Thus, suppose the wheel to be well made, the teeth all put in their holes or mortices, and cut or dressed to the intended height;

Then draw the pitch-line, as DE (Plate II. fig. 1.), in the middle, and round on the tops of all the teeth or cogs in the wheel, also the pitch-line through the centre of all the staves in the trundle, as LM in the staves of the trundle C; then divide the pitch-line DE equal on the tops of all the teeth in the wheel, as FGH. Divide the pitch or one of those distances into seven equal parts, as 1, 2, 3, 4, 5, 6, 7; allow three parts for the thickness of the teeth, as 1, 2, 3, in the cog G; and four for the thickness or diameter of the stave, as 1, 2, 3, 4, in the stave L; the breadth of the teeth is equal to four and a half parts. To shape the sides of the teeth, draw the line CG through the middle of the cog G to the centre of the wheel; then draw the line IK at right angles to the line CG; and intersecting that line at the pitch-line on the cog G, extending it through the teeth F and H, cutting the centre line in the point *c* on the cog F, and in the point *d* on the cog H; then place one point of a pair of compasses in the intersection C in the cog F, and with the other strike the curve line *o p* on the cog G; remove the point of the compasses to the intersection *d* in the cog H; and with the other describe the curve line *m n* on the other side of the cog G, which forms both sides of the teeth G; and so of all the other teeth. The points from which the sides of the teeth in a face wheel are drawn will be at a greater or lesser distance from the pitch-line, according to the different diameters of wheels; but whatever is the diameter, these points must be at right angles to a line passing through the middle of the cog to the centre of the wheel; as the line IK, on which are the points *c d* on the teeth F and H, from which the sides of the cog G are drawn, is to the line CG, which passes through the middle of the tooth G in a direction to the centre of the wheel.

2. *To draw the edge of teeth in a face-wheel.*—Let the line AB (fig.

(fig. 2.) reprefent the face of a wheel, CDE the edge or thicknefs of the teeth in the wheel, and RS the ftaves or rounds of the trundle; the pitch being divided into feven equal parts, three of which are allowed for the thicknefs of the teeth, as 1, 2, 3, in the cog D, and 4, 5, 6, 7, in the ftave R; the teeth fhould be four and a half parts in height, as 1, 2, 3, 4 $\frac{1}{2}$, in the cog D. Take two and a half of thefe parts for the bottom of the teeth, from the face of the wheel or line AB to the line NO; and the remaining two parts, or half the diameter of the ftaves RS, for the cycloid or curved portion of the cog. To draw this curve, place the point of a pair of compaffes in the dot *a* on the cog C, and defcribe the curve *b c* on the tooth D; remove the compaffes to the point *n* on the cog E, and ftrike the curve line *f g* on the other fide of the cog D; which forms the tooth fo as to work freely upon the ftaves or rounds in the trundle, which may be feen by the dotted line drawn from the middle point on the cog D.

3. *The method for a spur-wheel* is thus:—Let NO (fig. 3.) reprefent a fpur-wheel, and F a trundle or wallower; draw the pitch-line FB on the teeth of the wheel, and the pitch-line A2, B2 of the trundle; then divide them into the number of teeth and ftaves required, as D, C, E, in the wheel NO, and GG in the trundle. Divide one of thefe diftances, as CG, into feven equal parts, 1, 2, 3, 4, 5, 6, 7; allow three of thefe parts for the thicknefs of the teeth, as 1, 2, 3, in the cog C; and the remaining four parts for the diameter of the ftave, as 1, 2, 3, 4, in the ftave or round G. The height of the teeth fhould be equal to four and a half parts of the pitch, as 1, 2, 3, 4 $\frac{1}{2}$, in the cog D. Allow two and a half parts from the wheel to the pitch-line FB for the bottom of the cog, and the remaining two parts for the epicycloid or curved portion of the cog. To draw the curve of the teeth, extend a pair of compaffes to five parts of the pitch, as 1, 2, 3, 4, 5, at the cog E; then place one foot of the compaffes in the point *a* at 5 on the pitch-line FB, and ftrike the curve line on the cogs D, C; remove the compaffes to the point *b* at 2, and defcribe the curve line on the other fide of the cog C, likewife on the cog E, which forms both fides of the cog C, fo as to fit and bear equally upon the rounds or ftaves G, G. This is plain by the two dotted curve lines AF, BF; which curve lines take in the three teeth D, C, E. The breadth of the teeth fhould be equal to five parts of the pitch.

4. *The method of setting out two spur-wheels.*—Let AB, AB (fig. 4.) be two fpur-wheels nearly of equal diameters. Draw the pitch-lines CD, GD; then divide the pitch-lines into the number of teeth intended in each wheel; divide one of thefe diftances, or the pitch, into eight equal parts, as 1, 2, 3, 4, 5, 6, 7, 8, on the pitch-line GD; allow four of thefe parts for the thicknefs of the teeth in each wheel, as 3, 4, 5, 6, in the cog E. The breadth of the cog fhould be equal to fix parts of the pitch; the height four and a half parts, as 1, 2, 3, 4 $\frac{1}{2}$ in the cog F. There are two and a half parts from the wheels to the pitch-lines CD, GD; the other two parts are allowed for the curve or epicycloid; to defcribe which, put the foot of a pair of compaffes in the point *c* on the cog K, and pitch-line CD; draw the curve line *o p* on the cog L; remove the compaffes to the point *l* in the cog S, and ftrike the curve line *t h* on the other fide of the cog L; then place one foot of the compaffes in the point *a* on the tooth G, and defcribe the curve line *s t* upon the cog E; remove the compaffes to the point *b* in the cog F, and draw the curve line *q r*. Thus the teeth in both wheels are formed fo as to act freely upon one another when the wheels are revolving on their axes.

5. *Of conical wheels.*—Conical wheels, or what is called *bevel geer*, confift of two cones rolling on the furfaces of each other; as the two cones A and B (fig. 5.) revolving on their axes CE, CD. Their bafes being equal, they will perform their revolutions in one and the fame time; or any other two points equally diftant from the centre C; as F1, F2, F3, F4, &c. will revolve in the fame time as the points G1, G2, G3, G4, &c. Therefore as both cones are equal, they muft move with the fame velocity when rolling on the furface of one another, and revolving on their axes.

In like manner, if the cone ABD (fig. 6.) be twice the diameter at the bafe BD as the cone ADF is at the bafe DF, then if thefe two cones turn on their axes AC and AE, and their furfaces are in contact with each other, when the cone ADF has made

made one revolution, the cone ABD ſhall have made but half a revolution; or when the cone ABD has made one revolution, the cone ADF ſhall have made two revolutions; and every two points equally diſtant from the centre A, as F1, F2, F3, &c. ſhall have made two revolutions to B1, B2, B3, &c. and ſo on in proportion to the diameters of two cones at their baſes when rolling on the ſurface of one another.

Therefore if the cone CFD (fig. 7.) be five times the diameter at the baſe of the cone CDG, then if theſe two cones be turned round on their centres CE and CH, and their ſurfaces are in contact when the cone CFD has turned once round, the cone CDG ſhall have turned five times round, and every two points equally diſtant from the centre C, as G1, G2, &c. ſhall have revolved five times to one revolution of the points F1, F2, &c.; and if the cones were fluted, or had teeth cut in them diverging from the apex to the baſe, they would then become conical wheels or *bevel geer*, as in the following.

Let B and C (fig. 8.) be the baſes of two cones turning on their centres, having teeth cut in them diverging from the apex A to the baſes B and C. Theſe teeth will work freely into one another from the apex A to the baſes B and C when turned round; but the teeth near the point of the cone being ſmall and of little uſe, may be cut off at G and H. Theſe teeth may be made of any breadth, according to the ſtreſs they are intended to bear; and this is of vaſt importance, becauſe by this method they may be made to overcome a much greater reſiſtance, and work ſmoother, than a face-wheel and trundle of the common form. Beſides, this kind of wheels is of ſingular uſe to communicate motion in any direction, or to any part of a building, with the leaſt trouble, and the ſmalleſt quantity of friction, which it would be very difficult to accompliſh with wheels of a different conſtruction.

6. *The method of communicating motion in any direction, and proportioning or forming wheels for that purpoſe.*—Let the line AB (fig. 9.) repreſent a ſhaft or axle coming from a wheel. Draw the line CD to interſect the line AB in the angle or direction in which the motion to be communicated is propoſed; which line will now repreſent a ſhaft to the intended motion. Suppoſe it neceſſary that the ſhaft CD revolve four times whilſt the ſhaft AB revolves once. Draw the parallel line EF at the diſtance ST; ſuppoſe one foot, or half the diameter of the leſſer wheel. Then draw the parallel line GH at the diſtance PS, four feet or half the diameter of the larger wheel; after which, draw the line NO through the interſection of the ſhafts AB and CD, and likewiſe through the interſection of the parallel lines EF and GH in the points O and S; which will be the pitch-line of the two conical wheels, or the line where the teeth of the two wheels act on one another when working, as may be ſeen in fig. 10. and 11. where the motion is communicated in different directions.

A and B (fig. 10.) repreſent two conical wheels whoſe axles are at a right angle to each other, and their teeth acting on one another at G, where the pitch-lines M and N of the two wheels meet; K is the centre from which the wheel A, the pitch-line NG, and ſides of the teeth are drawn; R the centre that the wheel B, the pitch-line MG, and teeth are drawn; C the point from which the cones or bevel of the wheels AB and tops of their teeth are drawn, and alſo the point where a line drawn through the centre of the two ſhafts meet; OO the edge of the wheel A, and CDE the cone or bevel of it; PP the edge of the wheel B, and CF the cone or bevel; HHH are lines paſſing through the teeth of the two wheels in the points from which the epicycloid or curved portion of the teeth is drawn.

The lines AC, AL, and LH (fig. 11.), repreſent three ſhafts or axles in different directions; on which are fixed wheels, as the wheel BD and DE acting upon one another, and the wheels FG and GK taking into each other. From this figure it muſt appear obvious how motion may be communicated in any direction by means of conical wheels, which are of vaſt importance in erecting machinery.

7. *Single and double univerſal joints.*—In fig. 12. a ſingle univerſal joint is repreſented, which may be applied to communicate motion inſtead of conical wheels, where the angle does not exceed 30 or 40 degrees, and when the two ſhafts are to move with equal velocity. The ſhafts A and B being both connected with a croſs, will move on the rounds at the points CE and DF; and thus if the ſhaft A is turned round, the ſhaft B will likewiſe turn with the ſame motion.

The double univerſal joint (fig. 13.) conveys motion in different directions, if the angle does not exceed 80 or 90 degrees, being at liberty to move on the rounds at the points GH, IK, connected with the ſhaft B, and alſo on the points LM, NT, connected with the ſhaft A; for the two ſhafts thus connected, the one cannot turn round without turning the other. This joint may be conſtructed by a croſs of iron, as repreſented in the figures, or with four pins faſtened at right angles upon the circumference of a hoop or ſolid ball.

8. *To deſcribe the cycloid and epicycloid.*—If a point P, on the circumference of the circle S (fig. 14.), proceeds along the plane FG in a right line, and at the ſame time revolves round is centre, it will deſcribe a cycloid.

And if the generating circle A (fig. 15.) roll round on the circumference of another circle B, by turning round its centre at the ſame time, the point O will deſcribe an epicycloid.

CHAP. V.

Of the Strength of the different Parts of Machines; of proportioning the Power to the Effect; and of the Method of calculating the Velocity of Machines.

When conſtructing any piece of work or machinery, regard ſhould always be had that every part be made in proportion to one another; therefore if ſeveral pieces of timber be applied to any mechanical uſe where ſtrength is required, not only the different parts of the ſame pieces, but the ſeveral pieces, in regard to one another, ought to be ſo adjuſted for ſize, that the ſtrength may be always in proportion to the ſtreſs each of them has to endure. This proportion is the foundation of all good mechaniſm, and ought always to be regarded, not only in all kinds of machines or engines, but even in all ſorts of tools and inſtruments we work with; becauſe it would be fooliſh for a man to overload himſelf with his work-tools, or have them larger and heavier than his work requires; neither ſhould they be too ſlender or light, ſo as not to be ſufficient for the purpoſe for which they are intended. In all machines, it ought to be conſidered what weight or ſtreſs every part is to bear, and the ſtrength ought to be proportioned accordingly. All levers ſhould be made ſtrongeſt at the place where they are the moſt ſtrained. A lever of the firſt kind ought to be ſtrongeſt at the fulcrum, prop, or ſupport; thoſe of the ſecond kind at the reſiſtance; and thoſe of the third kind ſhould be ſtrongeſt at the power: and theſe levers ought to diminiſh proportionally from that point. All wheels, ſhafts, or axles of wheels and pulleys, the teeth or cogs of wheels which bear the greateſt ſtreſs, or act with greateſt force, muſt be made ſtronger than thoſe that have leſs to bear. Ropes ought to be ſo much ſtronger or weaker according as they are to be more or leſs ſtrained; and, in general, all the different parts of any machine or engine ſhould have ſuch a degree of ſtrength as to be ſufficient for the purpoſe for which they are deſigned; neither ought the ſeveral parts of a machine to have any exceſs of ſtrength; becauſe that would anſwer no valuable purpoſe, but add unneceſſary weight to the machine, and retard its motion; but, on the other hand, a defect of ſtrength, where it is needful, will be a means of making the machine fail in that part, which will alſo endanger the other parts connected with it. So neceſſary it is to adjuſt the ſtrength of all the different parts in any machine to the ſtreſs they are intended to endure, that a good mechanic will endeavour to make every part nearly in proportion to the reſiſtance. From the general

neral rule, it follows that, in feveral pieces of timber of the fame fort, or in different parts of the fame piece, the breadth multiplied by the fquare of the depth muft be as the length multiplied by the weight to be fupported; for then the ftrength will be in proportion to the ftrefs. The breadth multiplied by the fquare of the depth, divided by the product of the length, muft be the fame in all cafes.

The fcience of mechanics teaches how to eftimate the power to be employed fo as to produce a certain effect. To this end it is neceffary, in the firft place, to know accurately the nature and value of the power; then to confider the means and manner of applying this power to the bodies that are to be put in motion, fo as to obtain moft advantageoufly the defired effect. And if this effect can be obtained by fimple machines, it would be unneceffary to employ thofe that are compound; becaufe the more fimple any machine is, or the fewer parts it confifts of, there muft always be the lefs friction. But if a fimple machine be not fufficient to anfwer the intended purpofe, we muft then have recourfe to thofe that are compound; and as the mechanical powers, according to their different ftructure, ferve for different purpofes, it is therefore the bufinefs of the fkilful mechanic to choofe or combine thefe powers in the manner that may be beft adapted to produce the effect required. It may, however, be proper to obferve here, that machines or engines feldom owe their origin or improvement to confiderations deduced from the laws of motion. They are derived from other fources. It is from long experience, and repeated trials, errors, deliberations, corrections, &c. continued throughout the lives of individuals, and by fucceffive generations of them, that the practical fciences derive their gradual advancement from awkward beginnings to their moft perfect ftate of excellence. To be a good mechanic requires the labour of a whole life. It is an art rather perfected by practice than theory. The principles of mechanifm may be learned in books; but the art muft be acquired by experience. In treating of fimple machines, it is clear that what is gained in force is loft in time; fo that the effect produced by a given power in a given time is always the fame, whatfoever machine is made ufe of: and this holds good in all compound engines; that is, in whatever proportion the power is lefs than the weight, in the fame proportion will the motion of the weight be flower than that of the power.

In order, therefore, to obtain a juft idea of the advantage gained by machines, let us fuppofe that a man, by means of a fixed pulley, raifes a beam of wood to any height in five minutes; it is clear that at the fame rate he will raife eight fuch beams to the fame height in forty minutes; but by means of a tackle with four lower pulleys or fheeves, he will raife thefe eight beams at once, with the fame eafe as he before raifed one of them; but then he will be eight times as long in performing it, that is, forty minutes. Thus the work was completed in the fame time, whether the mechanical power was ufed or not. But the convenience gained is very great; becaufe, were it neceffary to raife a beam equal in weight to thefe eight beams joined in one, this may be performed by means of the tackle, though it would be impoffible to move it by the unaffifted ftrength of one man.

Confequently, if a power is able to raife one pound weight with a given velocity, it will be impoffible, by the help of any machine whatever, with the fame power, to raife two pounds with the fame velocity; but by the affiftance of a machine, the fame power will raife two pounds with half that velocity, or even ten thoufand pounds weight with the ten thoufandth part of that velocity. But ftill there is no greater quantity of motion produced when the ten thoufand pounds weight is moved, than when one pound is moved, becaufe the ten thoufand pounds muft move proportionably flower. The power of machines confifts only in this, that by their means the velocity of the weight may be diminifhed at pleafure; fo that with a given power a given weight may be raifed, or that with a given force any given refiftance may be overcome.

The motion of the weight is not at all increafed by any engine; its velocity is only thereby fo much diminifhed, that the quantity of motion of the weight may not exceed the quantity of motion in the power. Therefore, by machines, a power incapable of communicating motion to a body, or fupporting the preffure of it, may effect its purpofe, by transferring a part of the weight upon a fulcrum or prop, diftributing it amongft a number of pulleys, or placing it upon an inclined plane or fcrew.

And by this contrivance a power may keep a weight ſuſpended which exceeds it in any aſſigned proportion, though without any acquiſition of momentum in a given direction; for motion is only communicable according to the eſtabliſhed natural relations ſubſiſting between matter and motion; and the magnitudes of two powers in equilibrio are always inverſely as their velocities.

It is, therefore, in vain to think of moving a greater weight by a ſmaller power, and with the ſame velocity, as with a greater power. No real gain of force is acquired by mechanical contrivance; on the contrary, force, from friction, &c. is always loſt. Hence will appear the impoſſibility of a perpetual motion, or ſuch a motion as is to continue the ſame for ever, or at leaſt as long as the materials will laſt that compoſe the moving machine; becauſe ſuch a motion as this muſt return undiminiſhed, notwithſtanding any reſiſtance it meets with, which is impoſſible. For although any machine once put in motion, and moving freely without any reſiſtance, or any external retarding force acting upon it, would for ever retain that motion, yet in fact we are certain that no machine can move at all without ſome degree of friction or reſiſtance; and therefore it muſt follow, that from the reſiſtance of the medium, and the friction of the parts of the machine upon one another, its motion will gradually decay, till at laſt all the motion is deſtroyed, and the machine is at reſt. Nor can it be otherwiſe, except ſome new active force, equal to all its reſiſtance, gives new motion to it. But that cannot be from the machine itſelf; for then it would move itſelf, or be the cauſe of its own motion, which is abſurd.

Therefore the advantage obtained by machines is confined to convenience; becauſe by means of them we are enabled to give a convenient direction to the moving power, and to apply its action at ſome diſtance from the body to be moved, which is a circumſtance of vaſt importance. By machines we can likewiſe ſo modify the energy of the moving power as to obtain effects which it would not produce without modification.

Machines or engines do not teach us to make, but to apply powers ſuch as we find them in nature; for we deceive ourſelves if we think that by means of any engine one man ſhall do the work of two in the ſame time, ſuppoſing him to employ the ſame ſtrength.

In the performance of ſeveral works where we have ſufficient ſtrength, we often want time; and where we have time to ſpare, we want ſtrength. In theſe caſes the mechanic has an opportunity of directing the application of the powers according to time. Thus in making harbours, carrying on dikes, moles, or banks, where at every tide the ſea may damage the work, and a ſtorm or high tide overſet it, the greateſt number of hands muſt be employed that can work one by another. But in ſome caſes, as raiſing great beams of wood, large ſtones, blocks of marble, or heavy goods out of a ſhip to lay them on a wharf, many hands cannot be employed: here, then, an engine may be uſed, by means of which one man may do the work of twenty or thirty men; but he will be twenty or thirty times longer in performing it. Here the engine is abſolutely neceſſary, becauſe without it the work could not be performed; a ſufficient time muſt therefore be employed, without which great ſtrength would be of little uſe; and without a machine that ſtrength could not be properly applied. In draining mines, we are generally confined to time, becauſe the ſubterraneous ſprings ſupply the water while a force is employed to draw it out. Here, then, the intenſity of the power muſt be ſuperior to the quantity to be raiſed in a certain time; and for this purpoſe ſome of the mechanical powers muſt be applied, either ſimple or compound. However, although a few or all of theſe ſimple powers may be combined in one engine, they ſtill preſerve their properties. Therefore, to diſcover the mechanical power of any machine, it will be ſufficient to meaſure the ſpace deſcribed in the ſame time by the power and the reſiſtance; for the power will always balance the weight when it is in the ſame proportion as the velocity of the weight to the velocity of the power: Or, by ſetting down the ratios of the power to the weight on each mechanical power, the ſum of theſe will be the ratio of the power to the weight; for when the ratio of the power to the weight is equal to the ſum of the ratios expreſſing the power and weight, there will be an equilibrium on each mechanic power: Or, divide the machine into all the ſimple ones of which it is compoſed; then begin at the power and call it one; and by the properties of the mechanical powers find the forces in numbers which the firſt ſimple machine exerciſes upon the ſecond. Call this force one, and find the force in numbers

numbers with which it acts upon the third; and putting this force as one, discover its action on the fourth in numbers, and so on to the last. Then multiply all these numbers together, and the product will be the force of the machine, supposing the first power one.

For wheel-work, take the product of the number of teeth in all the wheels that act upon or drive others for the power, and the product of the teeth in all the wheels moved by them for the weight; or instead of the teeth, take the diameter. Otherwise thus:

In wheel-work there are always two wheels fixed upon one shaft or axle; or there is one wheel and a pinion, or a barrel that supplies the place of a wheel.

Of these, call that wheel the flyer, leader, or runner, which is acted upon by the power, or some other wheel; and call the other, which is upon the same axle, the pursuer, follower, or driver, driving another wheel forward. The flyer receives the motion, the driver gives it.

Then having the number of teeth, or the diameter of each wheel, take the product of all the flyers for the weights, and the product of all the drivers for the power.

The product of all the flyers gives also the velocity of the power; the product of all the drivers the velocity of the weight.

Wheels with teeth are used in a variety of ways; and from the nature of the wheel and axle, it is clear that the power or force on the pinion is to that on the circumference of the wheel, on the same axle, as the diameter of the wheel is to that of the pinion.

Whether a wheel drives a pinion or a pinion drives a wheel, the number of turns of the wheel, multiplied by the number of its teeth or cogs, is equal to the number of turns that the pinion makes in the same time multiplied by its teeth; so that the number of contemporary turns of a wheel and pinion are reciprocally proportional to the number of teeth each of them contains. Thus, if the number of teeth in a wheel be 72, and those in the pinion 8, then the pinion will turn round 9 times to once of the wheel; therefore the quotient of the wheel, divided by the pinion it drives, is the ratio of the turns to unity; thus $\frac{72}{8}$ gives 9. Wheels and pinions are therefore generally expressed by fractions, the numerator being the wheel, the denominator the pinion.

Hence if there be any number of wheels acting upon so many contiguous pinions, if we multiply the number of teeth in all the wheels by each other, and also the number of the teeth in all the pinions by one another; then divide the product of the teeth in the wheels by the product of the teeth in the pinions, the quotient will be the number of turns of the last pinion for one turn of the first wheel. The number of turns may therefore be expressed by a fraction whose numerator is the number of teeth in the first wheel, multiplied by its number of revolutions, and the denominator the number of teeth in the wheel that is driven. Thus a pinion of 6 teeth, acting on a wheel of 57, will make it turn 2 times while it turns 19 times itself, $\frac{6 \times 19}{57} = 2$; or suppose a pinion of 9 teeth acting on a wheel of 81 teeth, it will make it turn 3 times while itself turns 27 times, $\frac{9 \times 27}{81} = 3$; or if a pinion of 12 teeth turn a wheel of 96 teeth, this pinion must turn 32 times to turn the wheel of 96 teeth 4 times round, thus, $\frac{12 \times 32}{96} = 4$; or if a pinion of 15 teeth work on a wheel of 110 teeth, this pinion will revolve 44 times to make the wheel turn 6 times round, thus, $\frac{15 \times 44}{110} = 6$.

If this machine be wanted to perform a particular motion, suppose a pinion to turn 120 times for one revolution of the first wheel, this may be performed by one wheel and one pinion, or several wheels and several pinions, provided the number of turns of all the wheels bears the same proportion to all the pinions which that one wheel bears to its pinion.

Thus to make a pinion of 6 teeth revolve 120 times to one turn of a wheel, this wheel must contain 720 teeth, which is clear by dividing that number by 6, $\frac{720}{6} = 120$. But although this be the most simple method, it is not so convenient on account of the wheel being so very large; besides the impropriety of such a large wheel acting on so small a pinion.

Therefore it will be here necessary to have recourse to two or more wheels and pinions, which will be more convenient, and answer the same purpose. Thus if a wheel of 144 teeth act on a pinion of 12 teeth, on whose axle there is a wheel of 60 teeth taking into a pinion of 6 teeth, the number of turns made by this last pinion, while the first wheel revolves once round, will be expreffed by this fraction, $\frac{144}{12}\times\frac{60}{6}=\frac{8640}{72}=120$. Or if we take different numbers: Thus if a wheel containing 180 teeth act on a pinion having 15 teeth, upon whofe axle there is a wheel containing 70 teeth to turn a pinion of 7 teeth, as $\frac{180}{15}\times\frac{70}{7}=\frac{12600}{105}=120$. Or let us take three wheels and three pinions: Thus if a wheel containing 48 teeth act on a pinion of 9 teeth, upon whofe axle there is a wheel of 40 teeth taking into a pinion of 8 teeth, upon whofe axle there is a wheel of 27 teeth to turn a pinion of 6 teeth, as $\frac{48}{9}\times\frac{40}{8}\times\frac{27}{6}=\frac{51840}{432}=120$. Hence it is evident that different numbers of wheels and pinions, or that any number of teeth on the wheels and pinions having the fame ratio, will give the fame number of revolutions to a pinion at a given diftance from the firft wheel. Thus $\frac{96}{18}\times\frac{80}{16}\times\frac{54}{12}=\frac{414720}{3456}=120$, like the preceding combinations, gives the laft pinion the fame turns in one revolution of the firft wheel; and fo on in any other motion required. The mechanic muft thus determine what numbers will beft anfwer the general defign and circumftances of his machine.

In all mills, it is neceffary that a competent power be employed in order to accomplifh the intended purpofe. Water is the moft common power, and it is alfo the beft, as being the moft conftant. Wind is often made ufe of for moving mills; but this power is not fo equal, and therefore is not adopted where water-falls can be had. Steam is alfo a ready power for driving mills where fuel is to be got at a low rate; but as that article is high-priced in moft places, that will be a means of preventing this mode of working mills from ever becoming general. Horfes or oxen are fometimes employed for turning different machines; but this method is alfo expenfive, and it is not fo conftant or regular as water: But whatever kind of power is employed for driving any fort of mill or machine, it is neceffary to make the moft of that power by applying it to the beft advantage. The beft methods of conftructing mills have been inveftigated by thofe who were moft converfant in the principles of mechanics; but fo difficult is the inveftigation, that the principles are far from being clearly fettled.

CHAP. VI.

Of Water Mills.

THERE are four kinds of water mills; that is, balance mills, overfhot mills, breaft mills, and underfhot mills. In the balance mill the water is conveyed in a fpout (called the mill troughs) above the wheel, and falls into the bucket about one foot before the centre, where it acts by gravity, or weight of the water, on nearly one half of the circumference of the wheel. The overfhot mill is moftly the fame with the former; only in this the water is conveyed over the top of the wheel, and conducted into the bucket on the backfide of its centre, but acts alfo principally by gravity. For here the impulfe muft be fmall, as the fall upon the upper part of the wheel cannot be great, becaufe that would only tend to dafh the water out of the bucket, and lofe part of its effect on the wheel. In the breaft mill the water falls down upon the wheel nearly at right angles to the bucket, and acts by impulfe, and alfo by gravity, on one fourth part of the circumference of the wheel. In the underfhot mill the wheel is driven merely by impulfe, or the force of the current of water running under it; therefore it is evident that an underfhot mill muft require a larger quantity of water than any of the other three kinds. Authors indeed have greatly differed on this fubject. M. Belidor preferred underfhot wheels to thofe of any other conftruction; and he had even concluded that water applied

plied in this way will do more than ſix times the work of an overſhot wheel; while Dr Deſagulier, in overthrowing Belidor's propoſition, determined that an overſhot wheel would do ten times the work of an underſhot wheel with an equal quantity of water. Between theſe two celebrated authors, therefore, there is a difference of no leſs than ſixty to one. In conſequence of ſuch monſtrous diſagreement Mr Smeaton began his experiments; and from them has proved that the effect of water on an overſhot wheel is nearly double to that of underſhot wheels, which ſeems to be neareſt the truth.

But with reſpect to the difference of velocity between the water and underſhot wheels, authors have nearly agreed. Dr Deſagulier, Mr Ferguſon, Mr Imiſon, all agree that the velocity of an underſhot wheel ſhould be no more than one-third of the velocity of the water, to work to the beſt advantage, which varies, according to Mr Smeaton, between one-third and one-half; but in all great works the maximum, ſays he, lies nearer to one-half than one-third. M. Parent, of the Royal Academy of Sciences, has ſhewn that an underſhot wheel can do the moſt work when its velocity is equal to the third part of that of the water; becauſe then two-thirds of the water is employed in driving the wheel with a force proportional to the ſquare of the velocity. In the fifty-firſt volume of the Philoſophical Tranſactions, Mr Smeaton has conſidered at great length the beſt methods of conſtructing all theſe mills from machines and models made on purpoſe; but, conſcious of the inferiority of models to actual practice, did not venture to give his opinion without having ſeen them actually tried, and the truth of his doctrines eſtabliſhed by practice.

Having deſcribed the machines and models uſed for making his experiments, he obſerves, that, with regard to power, it is moſt properly meaſured by the raiſing of a weight; or, in other words, if the weight raiſed be multiplied by the height to which it can be raiſed in a given time, the product is the meaſure of the power raiſing it; and, of conſequence, all thoſe powers are equal whoſe products made by ſuch multiplication are equal: for if a power can raiſe twice the weight to the ſame height, or the ſame weight to twice the height, in the ſame time that another can, the former power will be double the latter; but if a power can only raiſe half the weight to double the height, or double the weight to half the height, in the ſame time that another can, the two powers muſt be equal. This, however, is underſtood only of a ſlow and equable motion without acceleration or retardation.

To compute the effects of water wheels, it is neceſſary to know, in the firſt place, what is the real velocity of the water which impinges on the wheel, the quantity of water expended in a given time, and how much of the power is loſt by the friction of the machinery. To aſcertain the force or impulſe of any moderate ſtream of water, let the ſame be obſtructed by a dike or dam acroſs the ſtream, ſo as to force all the water through a trough or open ſpout into a ſquare veſſel or reſervoir, and, meaſuring the quantity of water that ſhall run into this reſervoir in any given time, ſuppoſe a ſecond or minute, multiply the ſame by the number of ſeconds or minutes in an hour. Thus the whole impulſe of ſuch ſtream of water at any given height and a medium breadth may be readily aſcertained. In rivers that are too large to be meaſured as above, the force or impulſe may be calculated thus: Let a narrow oblong ſquare ciſtern or reſervoir be faſtened in the river with one end of it to the ſtream, having its upper edge a little above the ſurface, that no water can get into it over the top. In the end of this ciſtern facing the ſtream of the river is fixed a long ſpout of wood open above, the upper edges of it being equal with the ſurface of the river, and at the ſame declivity with the current. The water will have the ſame velocity within the ſpout as the river on its outſide; therefore by meaſuring the quantity of water that ſhall run into the reſervoir through the ſpout in a given time, ſuppoſe a minute, and multiplying the ſame by the minutes in an hour, the whole force or impulſe of the river at any given height and known breadth may be aſcertained.

Mr Smeaton has alſo given tables of the velocities of a whee with different heights of water; and from the whole deduces the following concluſions: 1. The virtual or effective head being the ſame, the effect will be nearly as the quantity of water expended. 2. The expence of water being the ſame, the effect will be nearly as the height of the virtual or effective head. 3. The quantity of water expended being the ſame, the effect will be nearly as the ſquare of the velocity. 4. The aperture being the ſame, the effect will be nearly as the cube of the velocity of the water. Hence if the water paſſes out of an aperture in the ſame ſection, but with different velocities, the expence will be proportional to the velocity; and therefore if the expence be not proportional to the velocity, the ſection of the water is not the ſame. 5. The virtual head, or that from which we are to calculate the power, bears no proportion to the head water; but when the aperture is larger, or the velocity of the water leſs, they approach nearer to a coincidence: and conſequently, in the large openings of mill-ſluices, where great quantities of water are diſcharged from moderate heads, the head of water, and virtual head determined from the velocity, will nearly agree; which is alſo confirmed by experience. 6. The moſt general proportion betwixt the power and the effect is that of 10 to 3; the extremes 10 to 3.2, and 10 to 2.8. But it is obſervable, that where the power is greateſt, the ſecond term of the ratio is greateſt alſo. Hence we may allow the proportion ſubſiſting in great works to be as 3 to 1. 7. The proportion of velocity between the water and the wheel is in general about 5 to 2. 8. There is no certain ratio between the load that a wheel will carry at its maximum, and what will totally ſtop it, though the proportions are contained within the limits of 20 to 10 and 20 to 15; but as the effect approaches neareſt to the ratio of 20 to 15, or of 4 to 3, when the power is greateſt either by increaſe of velocity or quantity of water, this ſeems to be the moſt applicable to large works. But as the load that a wheel ought to have, in order to work to the beſt advantage, can be aſſigned by knowing the effect that it ought to produce, and the velocity it ought to have in producing it, the exact knowledge of the greateſt load it will bear is of the leaſt conſequence in practice.

Having made ſuch alterations in his machinery as were neceſſary for overſhot wheels, he next gives a table of experiments with the apparatus ſo altered. In theſe the head was 6 inches, and the height of the wheel 24 inches, ſo that the whole deſcent was 30 inches; the quantity of water expended in a minute was $96\frac{2}{3}$ pounds; which, multiplied by 30 inches, gives the power = 2900; and, after making the proper calculations, the effect was computed at 1914; whence the ratio of the power to it comes to be nearly as 3 to 2. If, however, we compute the power from the height of the wheel only, the power will be to the effect as 5 to 2: But the effective power of the water muſt be reckoned upon the whole deſcent; becauſe it muſt be raiſed to that height in order to be able to produce the ſame effect a ſecond time. The ratios between the power ſo eſtimated and the effects, at a maximum, differ nearly from 4 to 3, and from 4 to 2; where the heads of water and quantities of it expended are the leaſt, the proportion is nearly from 4 to 3; but when the heads and quantities are greateſt, it comes nearer to that of 4 to 2: ſo that by a medium of the whole, the ratio is nearly as 3 to 2. Hence it appears that the effect of overſhot wheels is nearly double to that of underſhot ones; the conſequence of which is, that non-elaſtic bodies, when acting by their impulſe or colliſion, communicate only a part of their original impulſe, the remainder being ſpent in changing their figure in conſequence of the ſtroke. The ultimate concluſion is, that the effects, as well as the powers, are as the quantities of water and perpendicular heights multiplied together reſpectively. By increaſing the head, it does not appear that the effects are at all augmented; for by raiſing it from 3 to 11 inches, the effect was augmented by leſs than one-ſeventh of the increaſe of perpendicular height. Hence it follows that the higher the wheel is in proportion to the whole deſcent, the greater will be the effect; becauſe it depends leſs upon the impulſe of the head, and more upon the gravity of the water in the buckets. And if we conſider how obliquely the water iſſuing from the head muſt ſtrike the buckets, we ſhall not be at a loſs to account for the little advantage that ariſes from the impulſe thereof, and ſhall immediately ſee of how little conſequence this is to the effect of an overſhot wheel. This, however, as well as other things, muſt be ſubject to limitation; for it is neceſſary that the velocity of the water ſhould be ſomewhat greater than the wheel, otherwiſe the latter will not only be retarded by the ſtriking of the buckets againſt the water, but ſome of the power will be loſt by the daſhing of the water over the buckets.

To determine the velocity which the circumference of the wheel ought to have in order to produce the greateſt effect, Mr Smeaton obſerves, that the more ſlowly any body deſcends by the

the force of gravity when acting upon a piece of machinery, the more of that force will be ſpent upon it, and conſequently the effect will be the greater. If a ſtream of water falls into the bucket of an overſhot wheel, it will be there retained till the wheel diſcharges it by moving round; and of conſequence the ſlower the wheel moves, the more water it will receive; ſo that what is loſt in velocity is gained by the greater preſſure of the water upon the buckets. From the experiments, however, it appears, that when the wheel made about twenty turns in a minute, the effect was greateſt; when it made only $18\frac{1}{4}$, the motion was irregular; and when loaded ſo as not to admit its turning 18 times, the wheel was overpowered with the load. When it made 30 turns, the power was diminiſhed by about one-twentieth; and when the number of turns was increaſed to 40, it was diminiſhed by one-fourth. Hence we ſee that in practice the velocity of the wheel ſhould not be diminiſhed farther than what will procure ſome ſolid advantage in point of power.

The maximum load for an overſhot wheel is that which reduces the circumference of the wheel to its proper velocity; which is known by dividing the effect it ought to produce in a given time by the ſpace intended to be deſcribed by the circumference of the wheel in the ſame time: the quotient will be the reſiſtance overcome at the circumference of the wheel, and is equal to the load required, including the friction and reſiſtance of the machinery. The greateſt velocity that an overſhot wheel is capable of, depends jointly upon the diameter or height of the wheel and the velocity of falling bodies; for it is plain that the velocity of the circumference can never be greater than to deſcribe a ſemicircumference, while a body let fall from the top deſcribes the diameter, nor even quite ſo great; as the difference in point of time muſt always be in favour of the diameter. Thus ſuppoſing the diameter of the wheel to be ſixteen feet one inch, a heavy body would fall through this ſpace in one ſecond: but ſuch a wheel could never arrive at this velocity, or make one turn in two ſeconds; nor could an overſhot wheel ever come near it; becauſe, after it has acquired a certain velocity, great part of the water is prevented from entering the bucket, and part is thrown out again by the centrifugal force. Though, in theory, we may ſuppoſe a wheel to be made capable of overcoming any reſiſtance whatever; yet as, in practice, it is neceſſary to make the wheel and buckets of ſome certain and determinate ſize, we always find that the wheel will be ſtopped by ſuch a weight as is equal to the effort of the water in all the buckets of a ſemicircumference put together. This may be determined from the ſtructure of the buckets themſelves: but, in practice, an overſhot wheel becomes unſerviceable long before this time; for when it meets with ſuch an obſtacle as diminiſhes its velocity to a certain degree, its motion becomes irregular: but this never happens till the velocity of the circumference is leſs than two feet in a ſecond, when the reſiſtance is equable.

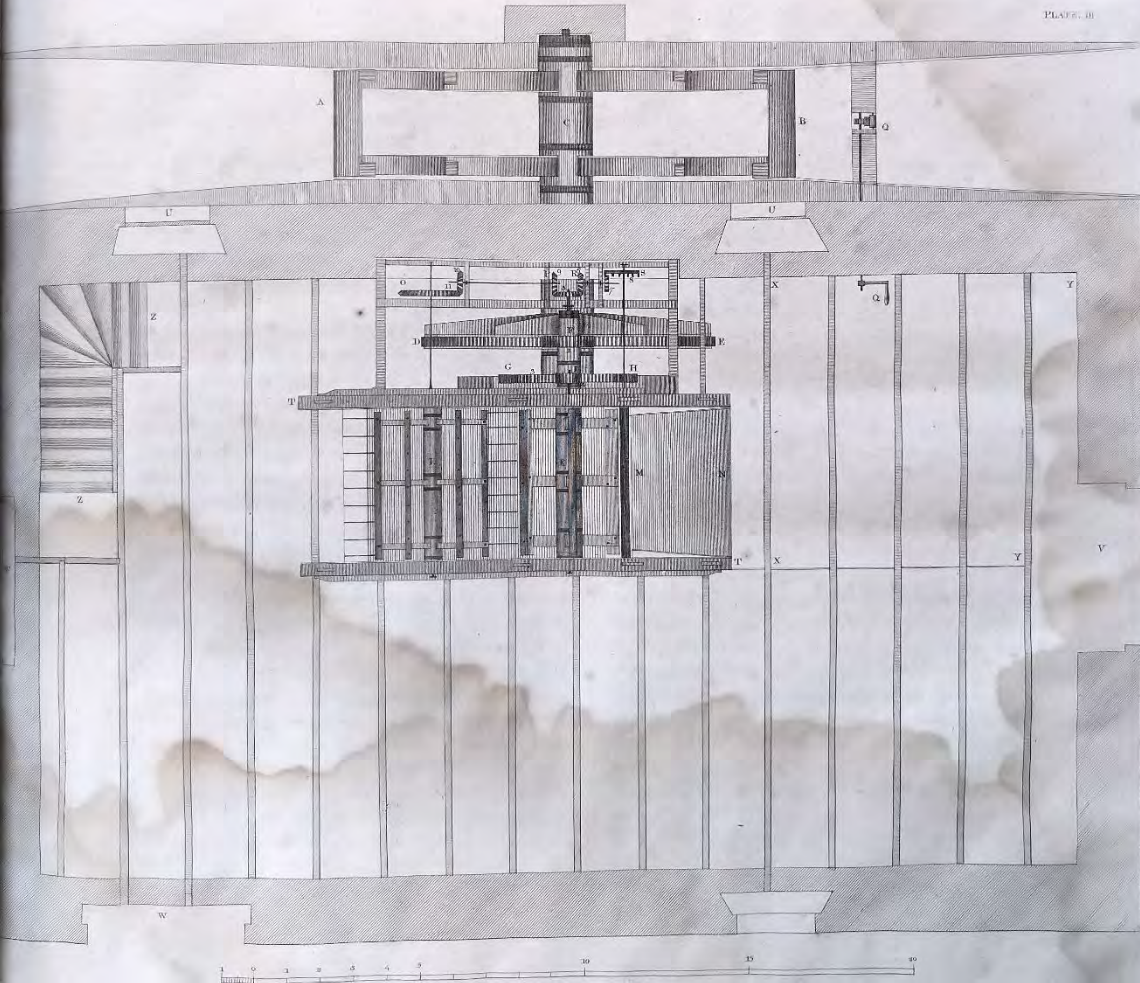
From the above obſervations we may eaſily deduce the force of water upon breaſt-wheels, &c. But, in general, all kinds of wheels, where the water cannot deſcend through a given ſpace unleſs the wheel moves with it, are to be conſidered as balance or overſhot wheels; and thoſe which receive the impulſe or ſhock of the water, whether in an horizontal, oblique, or perpendicular direction, are to be conſidered as underſhots. Hence a wheel on which the water ſtrikes at a certain point below the ſurface of the head, and after that deſcends in the arch of a circle, preſſing by its gravity upon the wheel, the effect of ſuch a wheel will be equal to that of an underſhot, whoſe head is equal to the difference of level between the ſurface of the water in the reſervoir and the point where it ſtrikes the wheels, added to that of an overſhot, whoſe height is equal to the difference of level between the point where it ſtrikes the wheel and the level of the tail water.

Plan of a Thrashing Machine to be driven by Water.

PLATE III.

THERE is fufficient evidence for concluding that machines for thrafhing corn are of very remote antiquity; but their particular conftruction cannot now be accurately afcertained. The period indeed is not very diftant fince thefe valuable machines were introduced into Britain. Without doubt they have received confiderable improvements fince their firft introduction; but ftill it may be prefumed that they have not yet reached their utmoft perfection.

AB, The water-wheel, fixed upon its fhaft or axle CC; on which axle is likewife faftened a fpur-wheel DE, containing 150 teeth or cogs, to turn the pinion No. 2. having 25 teeth, and is placed upon the axle F. On this axle is alfo fixed the wheel No. 3. containing 72 teeth, that drives the pinion No. 4. in which are 15 teeth, and is faftened upon a fquare on the end of the gudgeon in the axle K of the thrafhing drum. When the beaters are to ftrike or thrafh upward, the fcutch muft be covered all round with boards on two wheels faftened upon the arms or fpokes in the axle K, and infide of the beaters or thrafhers, which are fixed with fcrewed bolts on the extremities of thefe arms; but if the fcutch is to ftrike downward, which is thought preferable, then there is no need for any covering on the fcutch, only the thrafhers muft be faftened upon their arms. Along the ftriking fide of each beater is fixed a plate of iron to hinder them from wearing, which muft be a little rounded on the outer edge to prevent it from cutting the ftraw as they thrafh out the corn. No. 5. A wheel faftened upon the gudgeon in the axle F, containing 22 teeth, to turn the wheels R, S, and P, O. No. 6. A wheel fixed upon an iron axle or fpindle driven by No. 5. and having 18 teeth. On the fame iron axle is placed the pinion No. 7. containing 17 teeth, that turns the wheel No. 8. which is faftened on an iron fpindle, having in its end at H a fquare hole or focket that takes in a fquare on the gudgeon in one of the feeding rollers M, by which means the rollers are turned round. Thefe rollers are commonly made of caft-iron, and are fluted, or have fmall teeth their whole length, that keep hold of the unthrafhed corn; and as they turn on their pivots, feed it regularly in to receive the ftrokes from the thrafhers. In No. 8. are three rows of teeth, as 13, 17, and 21; and the pinion No. 7. is made fo as to fhift on its axis, in order that it may be placed to work into any of thefe numbers, and turn the rollers quick or flow according as the corn requires to be fed when thrafhing. No. 9. is a wheel containing 17 teeth, driven by No. 5. and is fixed on an iron axle, upon the other end of which is faftened the wheel No. 10. having 24 teeth to turn the wheel No. 11. in which are 34 teeth, and fixed on an iron fpindle connected with the axle L, in which are fpokes or arms, upon whofe points are faftened rakes, having fmall teeth that clear the ftraw off the heck or fearce, while the grain goes down through into the fanners below. The arms of the ftraw-fhaker in the axle L fhould be covered with thin boards from the axle outwards to the rakes, to prevent the grain from flying off amongft the ftraw. N is a platform, called the feeding-board or table, on which the corn muft be equally fpread and introduced betwixt the feeding rollers M. QQ, The machine and handle, by turning of which the fluice is raifed to let the water on the wheel A to drive it round. The gudgeons in fhafts or axles, rounds of fpindles, and pivots, fhould all turn in cods or bufhes of brafs, as being lefs fubject to wear, and having leaft friction. GH, The large frame that fupports the axles that carry the wheels. TT, Frames in which the feeding rollers, thrafhing fcutch, and ftraw fhaker turn. V, is a door in the gable or end wall of the mill-houfe, at which the unthrafhed corn is conveyed into the loft or fecond floor, where the thrafhing part of the machine is placed. WW, are doors on the ground floor of the mill-houfe. XY, a place on the ground floor, enclofed to contain the chaff and refufe as it flies from the fanners, which cannot be fhewn in this, as they are placed below the thrafhing fcutch and ftraw fhaker (but are plainly feen in Plate IV.) ZZ, Is a ftair leading to the loft. UU, Windows in the fide-walls to light the houfe.

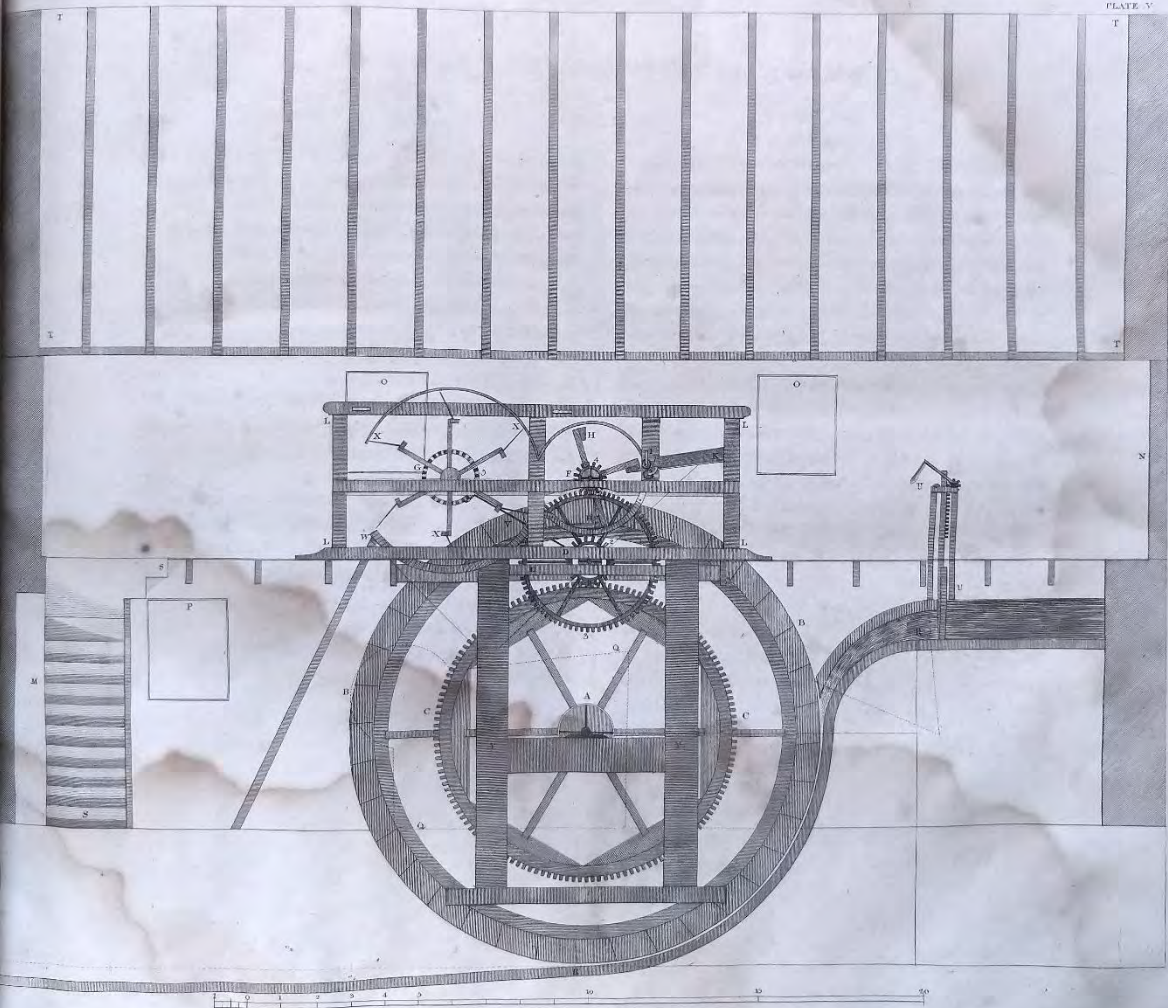

A
B
C
Q
U
U
O
D
E
F
G
H
T
T
L
K
M
N
X
X
Y
Y
Z
Z
V
W
1 0 1 2 3 4 5 10 15 20

Elevation of a Thraſhing Machine to be driven by Water.

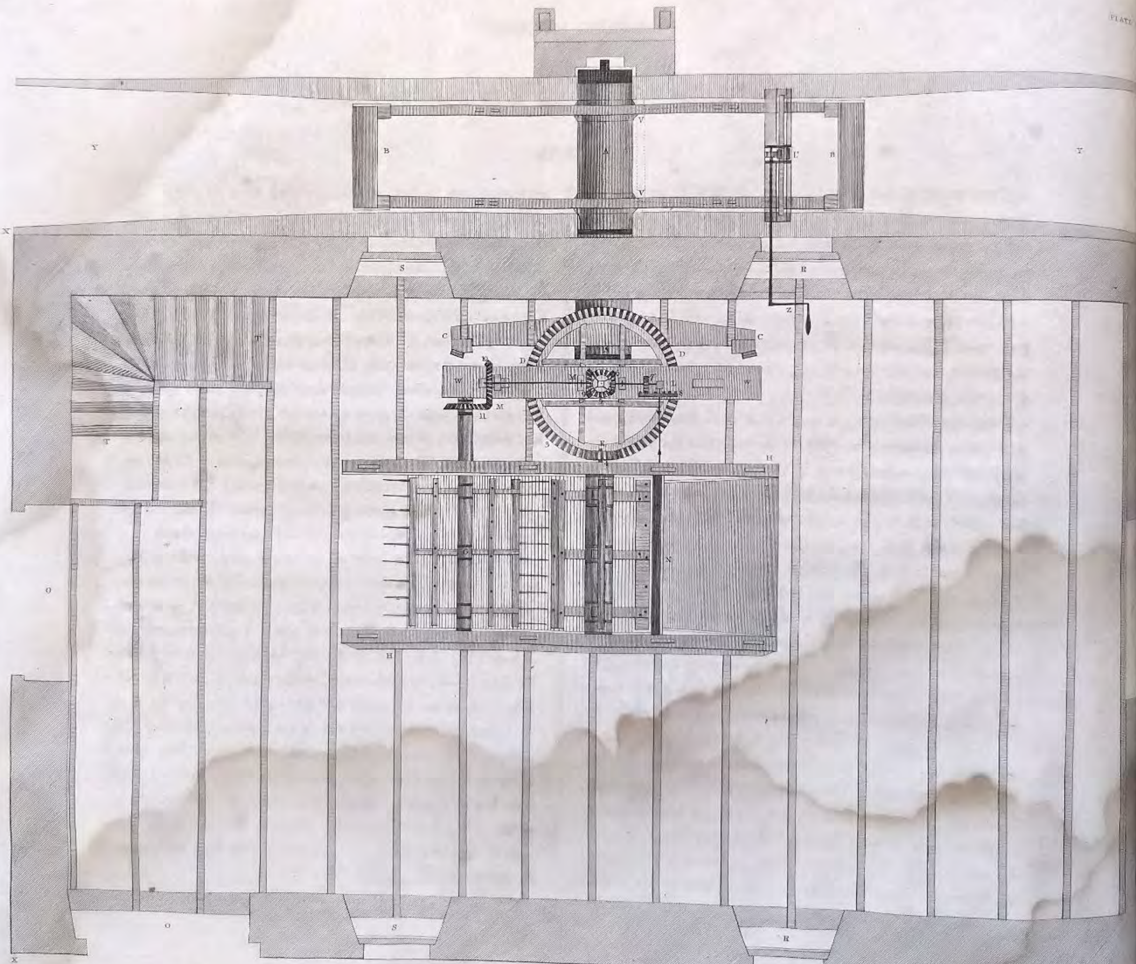
PLATE V.

A, The ſhaft or axle that carries the breaſt-wheel BB, containing thirty-ſix buckets, that receive the water to turn it round. And, by the Table in page 16. its circumference moves nearly eight and a half feet in a ſecond, or the wheel makes about eleven revolutions and a half in one minute; the water fall RR being 10 feet. U, U, The ſluice and machine that raiſe it to let the water on the wheel. C, C, A ſpur-wheel faſtened upon the axle A, containing 150 teeth or cogs, to turn the pinion No. 2. having 25 teeth, and fixed upon an axle; on which axle is alſo faſtened the ſpur-wheel No. 3. containing 72 teeth, to drive the pinion No. 4. having 15 teeth, and fixed upon a gudgeon or pivot in the axle F of the thraſhing ſcutch. H, H, The thraſhers, which are faſtened with ſcrews both upon the arms fixed in the axle F. I, Are two caſt-iron rollers, having ſmall teeth, their whole length taking into each other, in order to feed the unthraſhed corn regularly into the thraſhing ſcutch. The gudgeons of theſe rollers turn round into long mortiſes in their frames, the uppermoſt roller having liberty to riſe up in its mortiſe, and the undermoſt one freedom to recede from the thraſhing ſcutch, according to the thickneſs or quantity of corn paſſing through betwixt them. The wheels of the feeding rollers are not ſhewn in this, but they are plainly repreſented in Plates III. and IV. DV, Is an iron axle, that has a wheel fixed upon each end. One of which, having 17 teeth, is turned by a wheel on the axle of the pinion No. 2. (ſeen in Plate IV.); and the other, containing 24 teeth, taking into the wheel No. 5. having 34 teeth, and is faſtened upon the axle G. In this axle are alſo placed ſpokes or arms; on the extremities of which are fixed racks, as X, X, X, to clean the ſtraw off the heck HW as they go round, while the grain falls down through the heck into the hopper, repreſented here by the lines K, W, that conducts it into the fanners, which the dotted lines Q, Q, repreſent. The hopper and fanners are plainly ſeen in Plate IV. L, L, The frame that ſupports the feeding rollers, thraſhing ſcutch, and ſtraw ſhaker. YY, A ſtrong frame for ſupporting the croſs bearer in which the gudgeon of the ſhaft A turns. The gudgeons of axles and rounds of ſpindles ſhould have cods or buſhes of braſs to turn in. N, A door in the *gable* or end wall of the mill-houſe, at which the unthraſhed corn is carried into the loft where the thraſhing part of the machine is placed. M, A door on the ground floor and other end of the houſe, at which the ſtraw is conveyed out, as it falls from the machine when thraſhing. O, O, Windows to light the loft. P, P, Windows for lighting the lower part of the houſe. S, S, A ſtair leading from the ground floor to the loft. T, T, The couples or framing of the roof of the mill houſe.

PLATE V



PLATE



Plan of a Thrafhing Machine to be driven by Water.

PLATE VI.

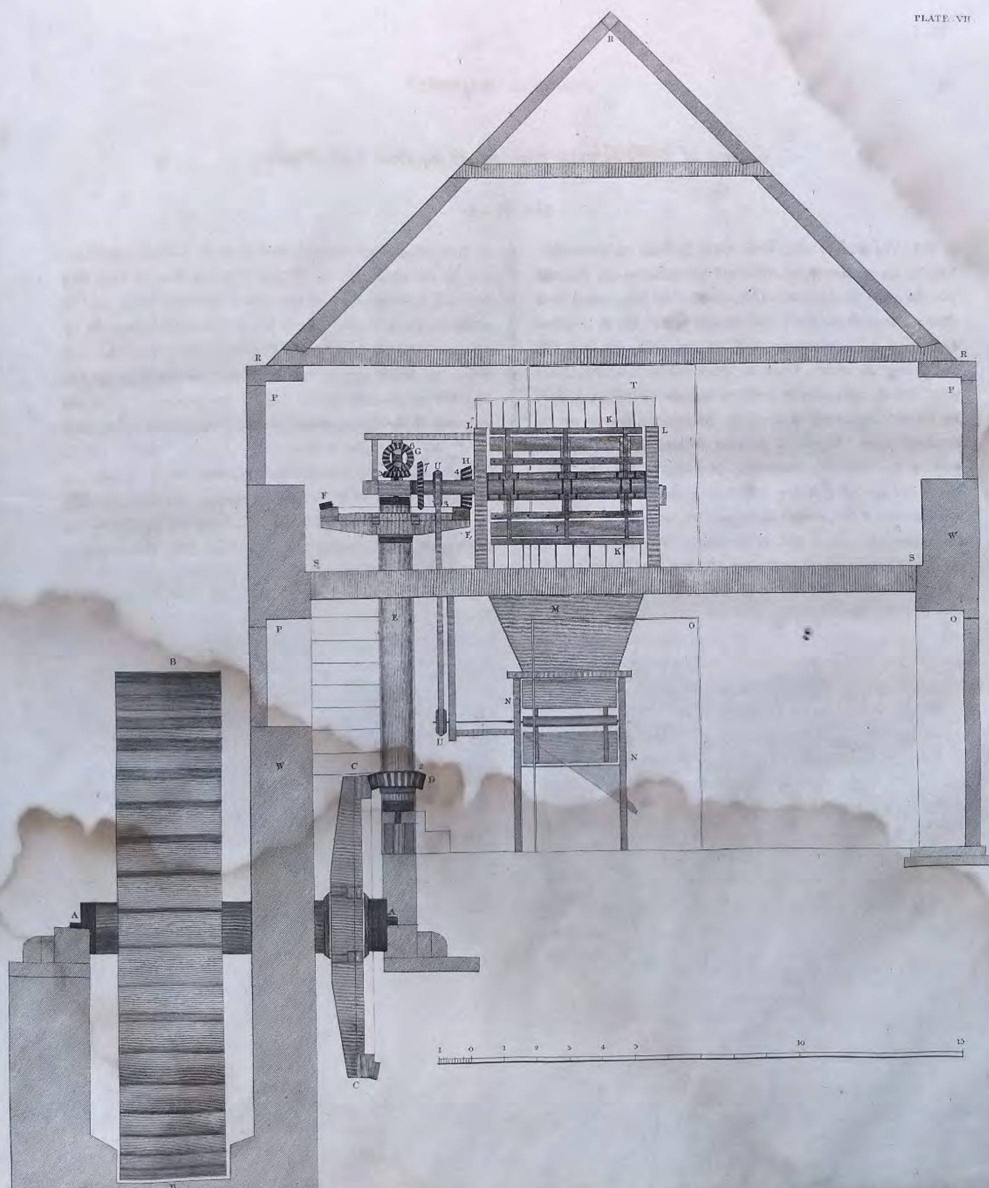
Spur wheels, fuch as are reprefented on Plate V. are the moft approved for thrafhing machines driven by water; but fuch wheels will not anfwer in every fituation, becaufe they convey the motion no higher than their diameters; and it being neceffary, in fome cafes, that the motion be raifed up to the thrafhing drum or fcutch, a confiderable way above the firft wheel—to accomplifh this a perpendicular fhaft or axle muft be made ufe of; and by this means the motion can be carried to any convenient height that may be found requifite.

AA, The fhaft or axle, upon which is fixed the balance wheel BB, having buckets placed upon its circumference that receive the water to drive it round, which is clearly feen in Plate VIII. CC, A conical or bevel wheel, fixed upon the fame fhaft, and containing 198 teeth or cogs, to turn a pinion having 27 teeth, and fixed upon a perpendicular fhaft (feen in Plates VII. and VIII.) Upon this perpendicular fhaft is alfo faftened the wheel DD, containing 86 teeth, to drive the pinion No. 4. having 15 teeth, and is fixed upon the gudgeon or pivot E in the axle of the thrafhing fcutch. No. 5. A wheel faftened upon the gudgeon in the upper end of the perpendicular fhaft, containing 24 teeth, to drive the wheels that turn the feeding rollers and ftraw fhaker. No. 6. is a wheel having 19 teeth turned by No. 5. and is fixed on an iron fpindle; upon which are alfo placed the pinion No. 7. having 18 teeth, to drive the wheel No. 8. which contains three different rows of teeth, viz. 14, 18, and 22 teeth. This wheel is fixed upon an iron fpindle, in one end of which is a fquare hole or focket to take in a fquare on the gudgeon or pivot in one of the feeding rollers N to turn them round. Thefe rollers being fluted, or having fmall teeth their whole length, taking into each other, and as they revolve feed the unthrafhed corn regularly into the machine to be thrafhed. The pinion No. 7. is made fo as to fhift eafily on the fquare of its axle, that it may be placed to act upon any of the rows of teeth in No. 8. according as the corn requires to be fed quick or flow, or the feeding rollers moved with a greater or leffer velocity. No. 9. A wheel fixed upon the iron axle M that conveys motion to the ftraw fhaker, driven by the wheel No. 5. and having 22 teeth. No. 10. Is a wheel faftened upon the other end of the fame iron axle containing 28 teeth, to turn the wheel No. 11, having 33 teeth, and fixed upon the axle G, having in it arms, upon which are faftened rakes with long fmall teeth, to clear the ftraw off the heck placed under it while the grain falls down into the fanners below. H, H, Are frames that fupport the platform or feeding board I I, feeding rollers N, the thrafhing fcutch, and ftraw fhaker. W W, A large frame that carries one end of the great fhaft, the perpendicular axle, and wheels. YY, The courfe or run of the water, which is carried in a box or trough above the wheel in the direction of the dotted lines, and falls into the buckets at the opening V V, about one foot before the centre of the wheel, which is plainly reprefented in Plate VIII. UZ, The machine and handle, or crank, by which the fluice is raifed to let the water on the wheel to turn it round. XX, Walls of the mill-houfe that contain the thrafhing machine. P, A door in the gable or end wall of the mill-houfe, at which the unthrafhed corn is conveyed into the loft or fecond floor, upon which the thrafhing part of the machine is placed where the corn is fed into the fcutch and detached from the ftraw. OO are doors on the ground floor of the houfe. R and S, Windows in the fide walls to light the houfe. TT, A ftair leading from the ground floor to the loft.

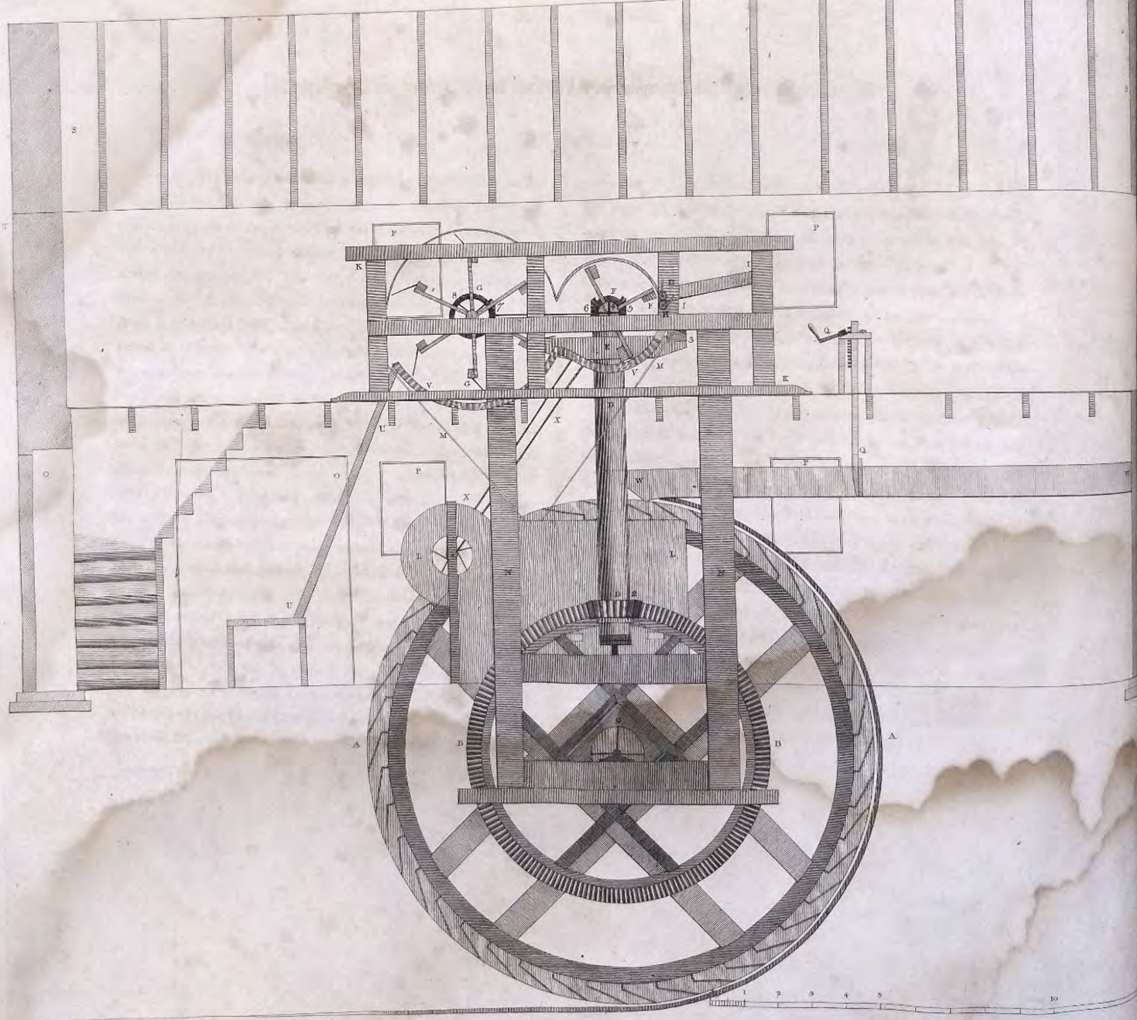
Section of a Thrashing Machine to be driven by Water.

PLATE VII.

AA, The shaft or axle, upon which is fixed the great wheel BB, having buckets placed all round its circumference, that contain the water to drive it. CC, a conical or bevel wheel fixed upon the same shaft, and containing 198 teeth. No. 2. a pinion fixed upon the perpendicular shaft DE, driven by the wheel CC, and having 27 teeth. Upon the shaft DE is also fastened the wheel No. 3. containing 86 teeth, to turn the pinion No. 4. having 15 teeth, and is fixed upon the gudgeon in the axle of the thrashing scutch II. No. 5. A wheel fastened upon the top-gudgeon of the shaft DE, containing 24 teeth, to drive the wheel that turns the straw shaker KK, having teeth for clearing the straw off the heck above the hopper M, while the grain falls down into the fanners NN, to be cleared or separated from the chaff. No. 6. A wheel containing 19 teeth, and fastened upon an iron spindle that conveys motion to the feeding rollers driven by the wheel No. 5. (which is plainly seen in Plate VI.) No. 7. Is a wheel fixed on the axle of the straw shaker, and to which motion is conveyed from No. 5. (which is represented by the wheels Nos. 9. and 10. on Plate VI.) UU, Two sheeves or barrels, on which goes a band or leather belt that drives the fanners NN to clean the grain. LLH, Are frames on which the gudgeons of the feeding rollers, thrashing scutch, and straw shaker turn. WW, The side walls of the mill house. TT, A door in the gable or end wall, at which the unthrashed corn is carried into the loft SS, where it is fed into the machine and thrashed. OO, Two doors on the ground floor. PP, Windows for lighting the house. CS, A stair leading up to the loft. RR, The couples or frame of the roof of the mill house.


R
R
R
T
P
P
L
K
L
G
H
U
F
E
K
S
S
W
E
M
P
O
O
B
N
U
N
W
C
D
A
A
C
B
1 0 1 2 3 4 5 10 15

PLATE



Elevation of a Thrafhing Machine to be driven by Water.

PLATE VIII.

AA, Is a balance wheel fixed upon its fhaft or axle C, and containing 42 buckets to receive the water. WW, The box or troughs that carry the water to the wheel, where it falls into the buckets through an opening at the bottom of the troughs at W, and is retained in thefe buckets until the wheel having turned almoft half round, it is difcharged immediately below the centre of the axle C, where the bucket begins to afcend, which is clear by their pofition. The circumference of this wheel is fuppofed to move nearly five feet per fecond, or to make about feven revolutions in one minute. QQ are the machine and handle that raife the fluice to let the water on the wheel A to turn it. BB, A conical or bevel wheel, alfo faftened upon the axle C, and in which are 198 teeth or cogs, to turn the pinion No. 2. having 27 teeth, and fixed upon the perpendicular fhaft DD. There is alfo faftened upon the fame fhaft a conical wheel No. 3. containing 86 teeth, that drives the pinion No. 4. having 15 teeth, and is fixed on the gudgeon in the axle F of the thrafhing fcutch. HH are two caft-iron rollers, which are fluted, or have teeth for feeding the unthrafhed corn into the thrafhing fcutch. Thefe rollers turn on their pivots in long mortifes; the uppermoft roller having liberty to rife in its mortife, and the under one freedom in its mortife to recede from the thrafhing fcutch, according to the quantity or thicknefs of the parcel of corn paffing through betwixt the feeding rollers. I I, A floping platform, called the *feeding board*, upon which the unthrafhed corn muft be equally fpread, and introduced betwixt the feeding rollers HH, to receive the ftrokes from the thrafhing fcutch as it turns round. No. 5. An intermediate wheel, containing 19 teeth, and fixed upon an iron axle, to convey motion to the feeding rollers. The other wheels for turning the rollers are not fhewn in this, but are plainly feen in Plate VI. No. 6. A wheel containing 22 teeth, which is fixed upon an iron axle driven by a wheel faftened upon the gudgeon in the fhaft DD, which is feen on Plate VII. No. 7. A wheel fixed upon the other end of the fame iron axle, containing 28 teeth, to turn the wheel No. 8. having 33 teeth, which is faftened upon an axle in which are the arms GG, upon whofe extremities are faftened rakes for clearing the ftraw off the heck VV, while the grain falls down through the heck into the hopper MM, which conducts it into the fanners LL to be feparated from the chaff. The fanners LL fhould have been reprefented before the large frame (which is feen by the fanners NN on Plate VII.) KK, The frame that fupports the feeding board, feeding rollers, thrafhing fcutch, and ftraw fhaker. UU, A floping heck for conducting the ftraw down from the machine to the ground floor. TT, The gables or end walls of the mill houfe. SS, The couples or framing of the roof. R, A door in the end wall of the mill houfe, at which the unthrafhed corn is conveyed into the loft, where it is fed into the thrafhing fcutch, and detached from the ftraw. OO, Are two doors on the ground floor. PP, Windows for lighting the houfe.

Plan of a Thrashing Machine to be driven by Four or Six Horses.

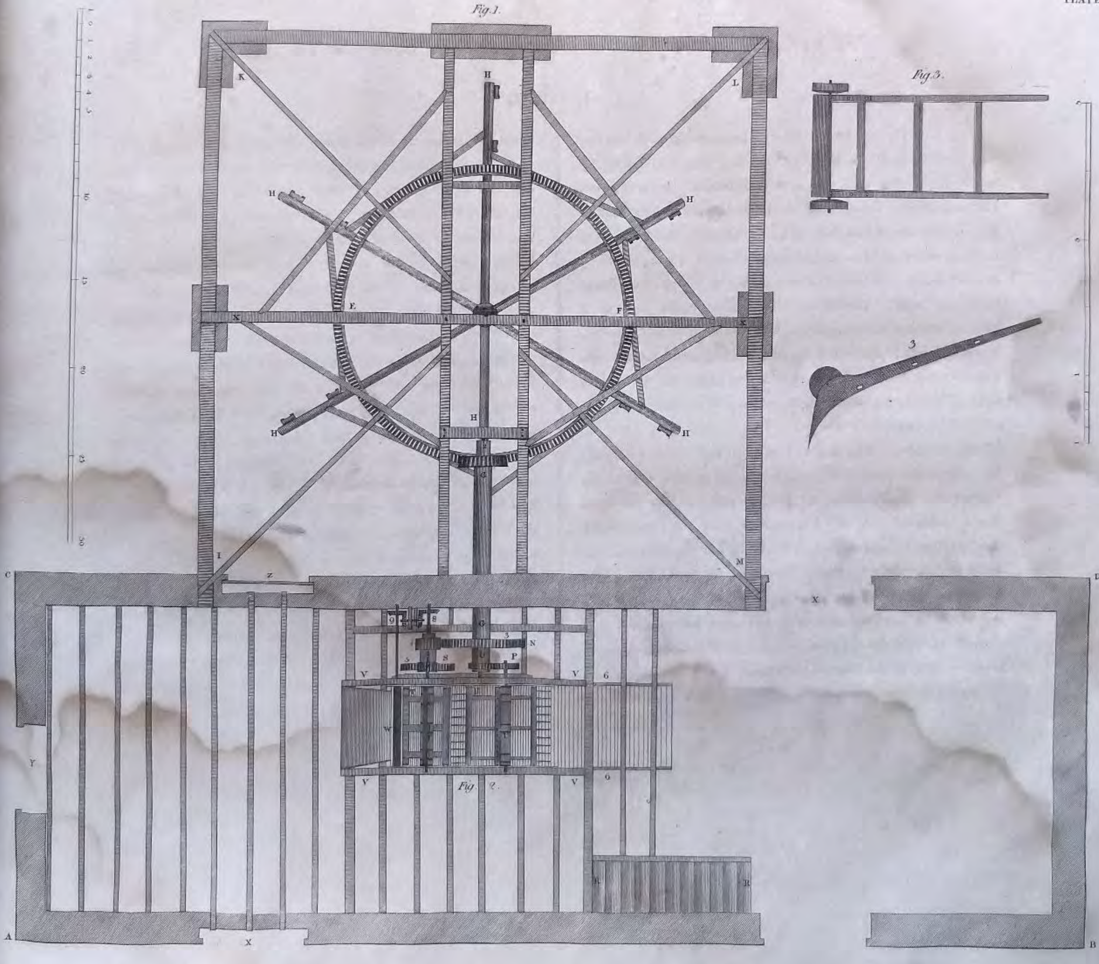
PLATE IX.

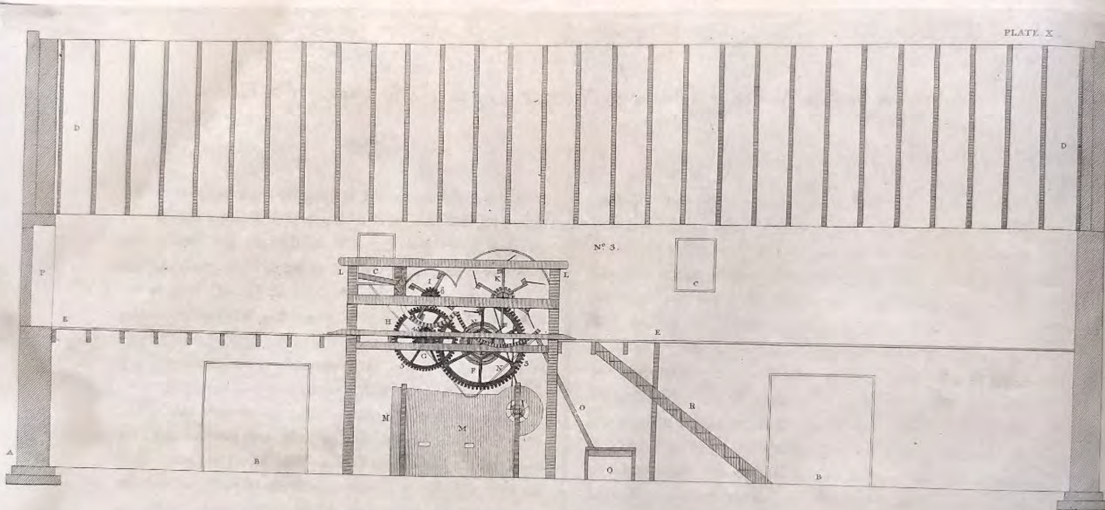
Fig. 1. HH, Are arms fixed in a perpendicular ſhaft or axle; and to theſe arms the horſes are attached with iron hooks, by which they pull or draw and turn the machine. Upon the arms HH are likewiſe faſtened the wheel EF, containing 270 teeth or cogs to drive the pinion No. 2. having 40 teeth, and is fixed on the horizontal ſhaft GG, which conveys motion to the thraſhing drum or ſcutch. IKLM, The ſtone pillars that ſupport the ſtrong beams and roof of the courſe, in which the horſes walk when working the thraſhing machine. XX, A croſs beam, to which is faſtened a buſh, in which the uppermoſt gudgeon of the axle which carries the wheel EF turns. The horſes are ſuppoſed to walk, at their ordinary working ſtep, about three times round this courſe in a minute.

Fig. 2. ABCD, The barn walls or houſe that contain the thraſhing part of the machine. Upon the horizontal ſhaft GG is alſo faſtened the wheel No. 3. containing 84 teeth, to turn the pinion No. 4. having 24 teeth, which is placed on the axle S; upon which axle is likewiſe fixed the wheel No. 5. containing 66 teeth, that drives the pinion No. 7. having 15 teeth, which is faſtened on the gudgeon in the axle of the thraſhing ſcutch. TT, Are the thraſhing beaters faſtened on their arms with ſcrew bolts. No. 8. is a wheel fixed upon the gudgeon in the axle S, containing 25 teeth, to act on one of the intermediate wheels, having 24 teeth, which is faſtened upon an iron ſpindle; on which ſpindle is alſo fixed a wheel containing 22 teeth, to turn the wheel No. 9. having 21 teeth, which is placed upon an iron axle connected with the gudgeon in one of the feeding rollers No. 10. to turn them round. The wheel No. 9. is made ſo as to be eaſily taken off its ſpindle, that a larger or leſſer wheel may be put on in its place to move the rollers with a greater or leſſer velocity, according as the corn is required to be fed into the thraſhing ſcutch. W is a platform on which the corn is ſpread, and introduced in betwixt the feeding rollers. O, a wheel fixed upon the axle G, containing 38 teeth, to turn the wheel P, having 14 teeth, which is faſtened on the axle of the ſtraw ſhaker UU, in which are teeth that throw the ſtraw off the heck or ſearce down the ſloping heck C to the ground floor. VV, Are frames on which the feeding rollers, thraſhing ſcutch, and ſtraw ſhaker, turn. The gudgeons of the axles and rounds of ſpindles ſhould turn in cods or buſhes of braſs. Y, a door in the end wall of the barn, at which the unthraſhed corn is put into the loft, on which the thraſhing part of the machine is placed. RR is a ſtair leading up to the loft. X and Z are doors in the ſide walls and ground floor of the barn.

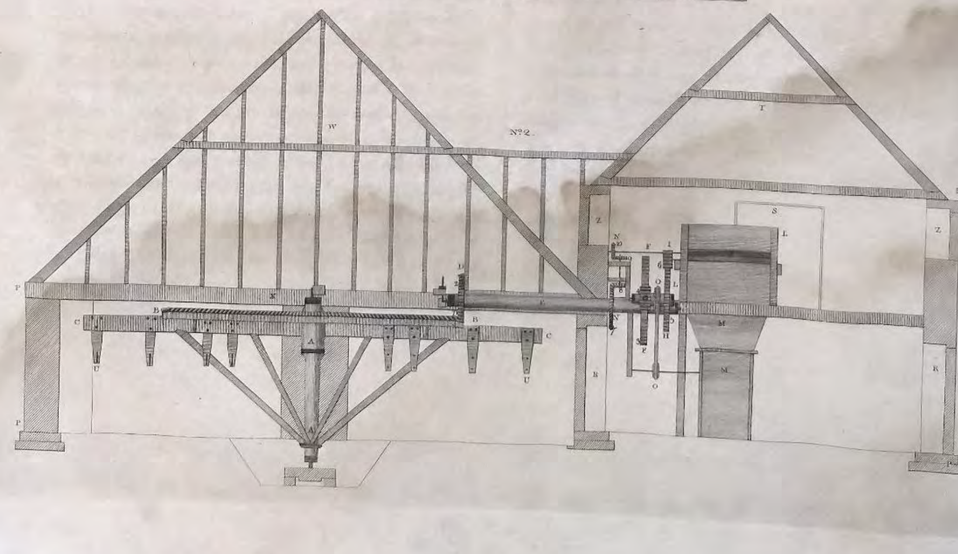
Fig. 3. and 3. A mill or barn barrow, which is a very uſeful and ready inſtrument; becauſe, by means of it, one man can with eaſe convey a ſack or bag of grain from one place of the houſe to another; and in this way he will remove a conſiderable quantity of ſacks in a very ſhort time without any other aſſiſtance.

PLATE. IX.




N° 3.


1 0 1
5
10
15
20
25
30


N° 2.

Elevation and Section of a Thrashing Machine to be driven by Four or Six Horses.

PLATE X.

No. 2.—AA, The ſhaft or axle, in which are fixed the arms CC, called the horſe poles; and upon the poles are faſtened with ſcrew-bolts the ears or hanging pieces UU, to which the horſes are yoked with iron hooks, by which they pull or draw when working the machine. Upon the arms CC is alſo fixed the wheel BB, containing 270 teeth, to turn the pinion D, No. 2. having 40 teeth, which is faſtened on the horizontal ſhaft EN. No. 3. is a wheel likewiſe fixed upon the axle EN, containing 84 teeth, that drives the pinion No. 4. having 24 teeth, which is faſtened on the axle G; upon which axle is alſo fixed the wheel No. 5. containing 66 teeth, to turn the pinion No. 6. having 15 teeth, which is faſtened on the gudgeon in the axle of the thraſhing ſcutch. No. 7. a wheel fixed upon the gudgeon in the axle G, containing 25 teeth, that drives the wheel No. 8. having 24 teeth, which is placed on an iron axle; upon which is likewiſe fixed the wheel No. 9. containing 22 teeth, that turns the wheel No. 10. having 21 teeth, which is placed on the iron ſpindle F, which is connected by a coupling box with the gudgeon in one of the feeding rollers K to turn them round. No. 9. is made ſo as to be eaſily taken off its axle, that a wheel with a greater or leſſer number of teeth may be put on in its place, becauſe the rollers require to be moved with more or leſs velocity according to the quality of the grain that is thraſhing. OO is a leather belt or band that turns the fanners, by going round on a ſheeve or whorl fixed upon the axle G, and on a ſheeve faſtened upon the axle of the fans. L, L, H, Are frames on which the feeding rollers, thraſhing ſcutch, and ſtraw ſhaker turn. MM, The hopper for conducting the grain down from the ſcutch and fanners, to ſeparate it from the chaff. PP, The ſide walls of the barn and pillars that ſupport the large beams and roofs TW of the barn and horſe courſe. S, A door in the gable or end wall of the barn, at which the unthraſhed corn is carried into the loft. R, R, Are doors in the ſide wall and ground floor of the barn. ZZ, Windows to light the barn.

No. 3.—AA, The gables or end walls of the barn. BB, Are doors in the ſide walls. DD, The couples or frames of the roof. P, a door at which the unthraſhed corn is conveyed into the loft EE, where it is fed into the machine, and ſeparated from the ſtraw. R is a ſtair leading up to the loft. CC, Windows to light the barn. F, No. 3. a wheel containing 84 teeth, to turn the pinion No. 4. having 24 teeth, which is fixed upon an axle, on which is alſo faſtened the wheel No. 5. containing 66 teeth, that drives the pinion No. 6. having 15 teeth, which is faſtened upon the axle of the thraſhing ſcutch. LL, The frames, on which are fixed buſhes of braſs, that the gudgeons of the axles and rounds of the ſpindles turn in. C is the platform on which the corn is ſpread, and introduced betwixt the feeding rollers. I I, The thraſhing ſcutch or the beaters fixed on their arms. K, a wheel having 28 teeth turned round by F, No. 3. and is placed upon an axle, in which are arms with rakes faſtened on their extremities, that throw the ſtraw off the heck HN down the ſloping heck OO to the ground floor; while the grain paſſes through the heck into the hopper GN, that conveys it into the fanners MM, where the corn is ſeparated from the chaff.

Plan, Elevation, and Section, of a Thraſhing Machine to be driven by Two or Three Horſes.

PLATE XI.

No. 1.—AA, The barn walls and pillars that ſupport the large beams and roof of the courſe in which the horſes walk to work the machine. C, The ſhaft or axle in which are fixed the arms or horſe poles BB. To theſe arms the horſes are attached by iron hooks, by which they pull or draw; ſuppoſed, at their ordinary working ſtep, to walk about four times round the courſe in one minute. Upon the arms BB are fixed the wheel DD, containing 166 teeth or cogs, to turn the pinion No. 2. having 19 teeth, which is faſtened upon the horizontal ſhaft EE; upon which axle is alſo fixed the wheel No. 3. containing 80 teeth, to drive the pinion No. 4. having 9 teeth, which is faſtened upon the gudgeon in the axle of the thraſhing ſcutch GG. HH, Are the rakes fixed on their arms, and having ſmall teeth to clear the ſtraw off the heck or ſearce, while the grain paſſes down to the fanners. No. 5. Is a ſheeve or whorl fixed upon the axle E; on which goes the leather belt or band L, and paſſing over the ſheeve No. 8. placed upon the axle of the ſtraw ſhaker HH, by which means it is turned round. No. 6. a ſheeve, likewiſe faſtened upon the axle E, on which is put a leather belt extending over the whorl No. 7. that is placed upon an iron rod L, connected by a coupling box with the gudgeon in one of the feeding rollers R. By this means the rollers are turned round, and feed the corn into the thraſhing ſcutch. The ſheeve No. 7. is made ſo as to be eaſily taken off its axis, that one of a greater or leſſer diameter may be put on in its place when neceſſary. S, The board or table on which the unthraſhed corn is ſpread, and introduced betwixt the feeding rollers. FKK, The frames that ſupport the feeding rollers, thraſhing ſcutch, and ſtraw ſhaker. MM, Are doors in the ſide walls and ground floor of the barn.

No. 2.—AA, The perpendicular ſhaft, having placed in it the poles or arms MM, upon which are fixed the ears or hanging pieces TT, to which the horſes are yoked. Upon the arms MM are alſo faſtened the wheel BB, containing 166 teeth to turn the pinion C, No. 2. having 19 teeth, and is fixed on the ſhaft D; upon which ſhaft is likewiſe faſtened the wheel E, No. 3. containing 80 teeth, that drives the pinion No. 4. having 9 teeth, which is fixed on the gudgeon in the axle of the thraſhing ſcutch. No. 5. is a ſheeve placed upon an iron ſpindle, connected with the gudgeon of the pinion No. 4. and on which goes the band N that drives the fanners by paſſing over the whorl No. 6. fixed upon the ſpindle of the fans. Upon the ſhaft D is placed the ſheeve No. 7. over which goes a leather belt, alſo paſſing over a ſheeve fixed in the axle of the ſtraw ſhaker to turn it round (plainly ſeen in No. I.) On the axle D is alſo faſtened the whorl No. 8. having a leather belt that paſſes over the ſheeve No. 9. placed on the iron ſpindle F that turns the feeding rollers. CFG, Frames that carry the thraſhing ſcutch and ſtraw ſhaker. H, a hopper that conveys the thraſhed grain down into the fanners I I, to be ſeparated from the chaff. V V, The ſide walls of the barn. S, The couples or frame of the roof. OO, Are doors; and UU the pillars that ſupport the large frame and roof P of the horſes walk.

No. 3.—AA, The gables or end walls, with joiſts, ſtair, and couples, or roof of the barn. N, is a door in the end wall of the barn, at which the unthraſhed corn is put into the loft C. No. 2. a pinion, containing 19 teeth, and fixed on the axle EE, coming from the wheel DD (ſeen in No. I.) B, No. 3. is a wheel faſtened upon the ſame axle, and containing 80 teeth, to turn the pinion No. 4. having 9 teeth, and is fixed upon the axis of the thraſhing ſcutch. D, Are the thraſhing beaters faſtened on their arms with ſcrew bolts. E, The ſtraw ſhaker driven by a leather belt from a whorl on the axle C, to clear the ſtraw off the heck or ſearce, that the corn may paſs through, and run down in the hopper H that conveys it into the fanners GG, which are turned by the band K from a ſheeve on the gudgeon of the thraſhing ſcutch. FF, The frame that ſupports the feeding rollers, thraſhing ſcutch, and ſtraw ſhaker. The gudgeons of the axles and rounds of ſpindles ſhould turn in buſhes of braſs,

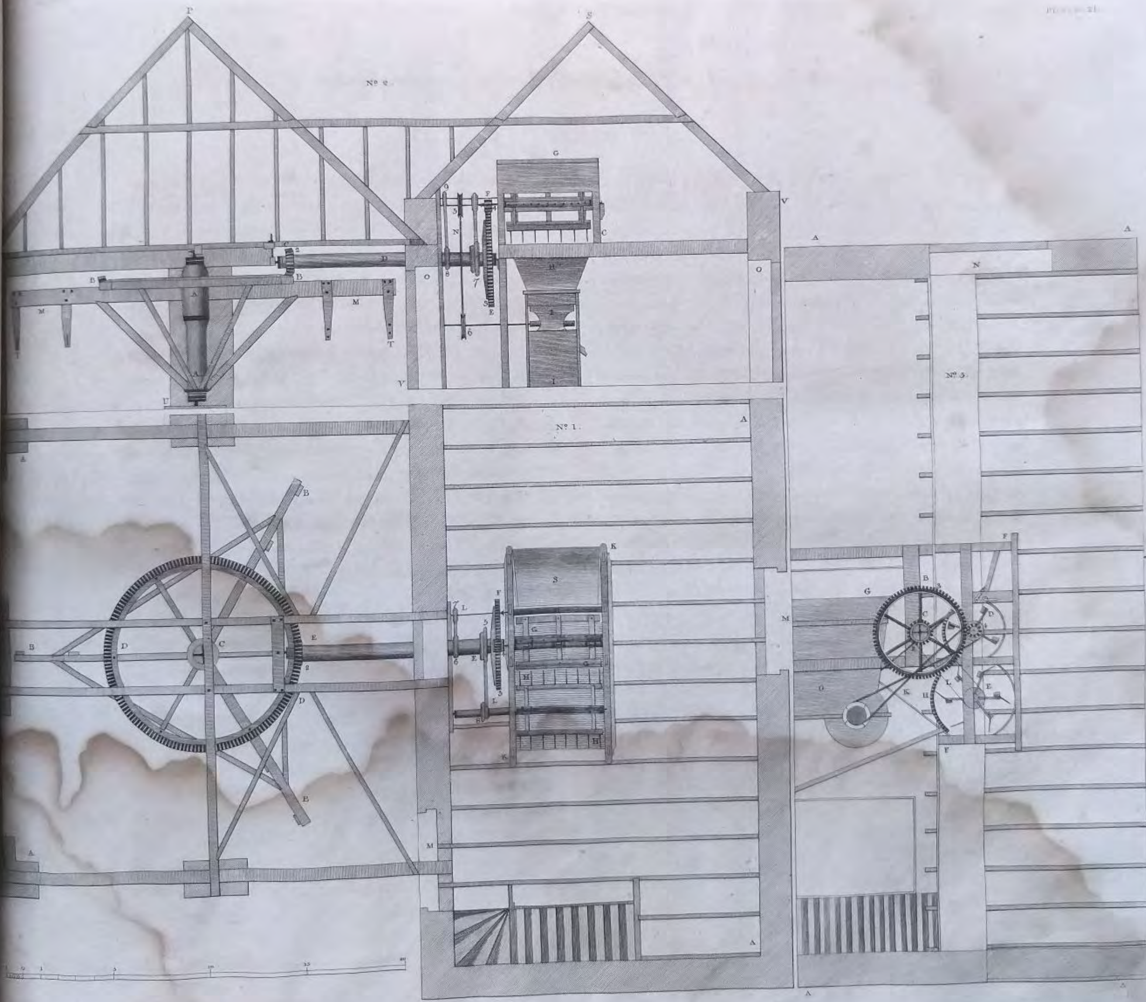
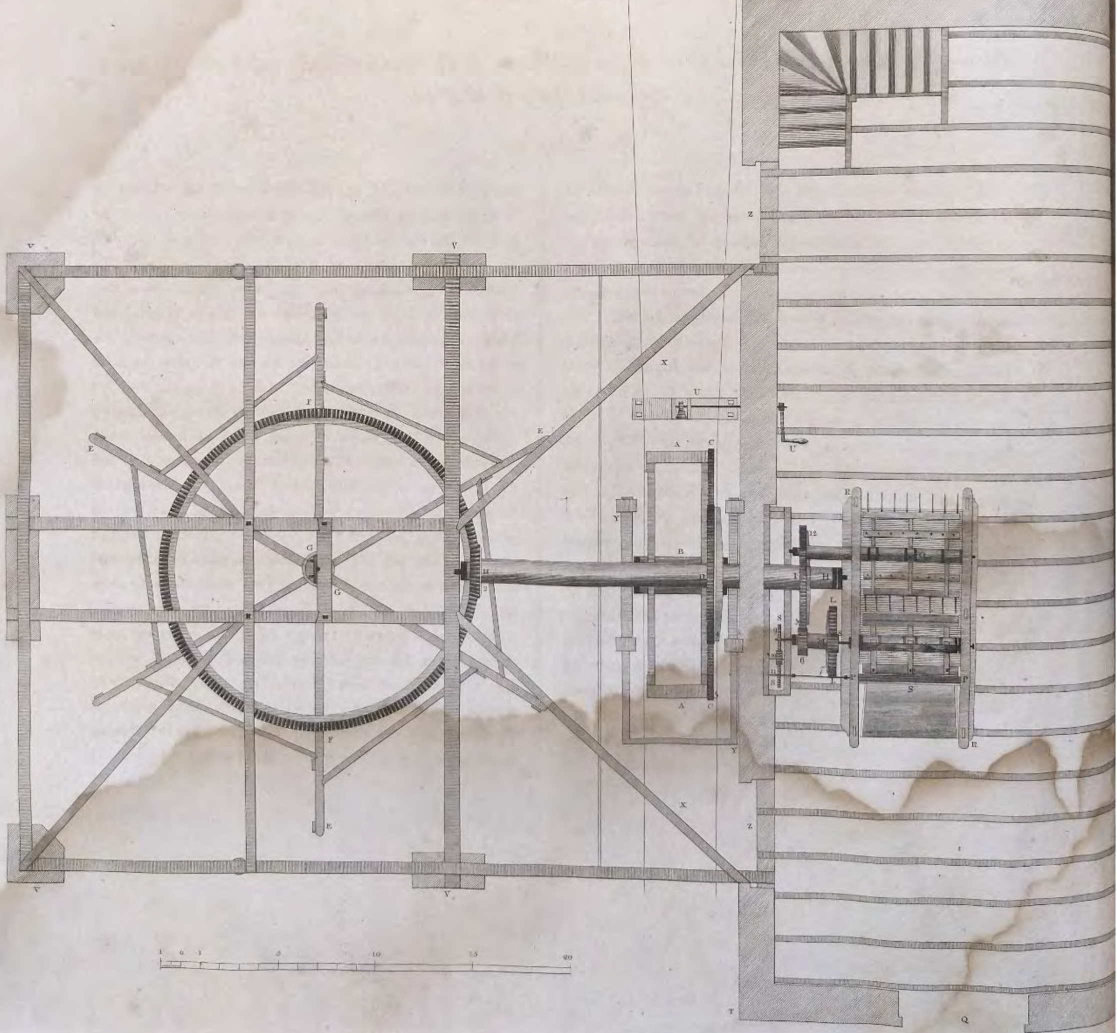

Nº 2.
Nº 1.
Nº 3.

PLATE XII.



Plan of a Thrafhing Machine to be driven by Water, or Horfes occafionally, when there is not a conftant Supply of Water.

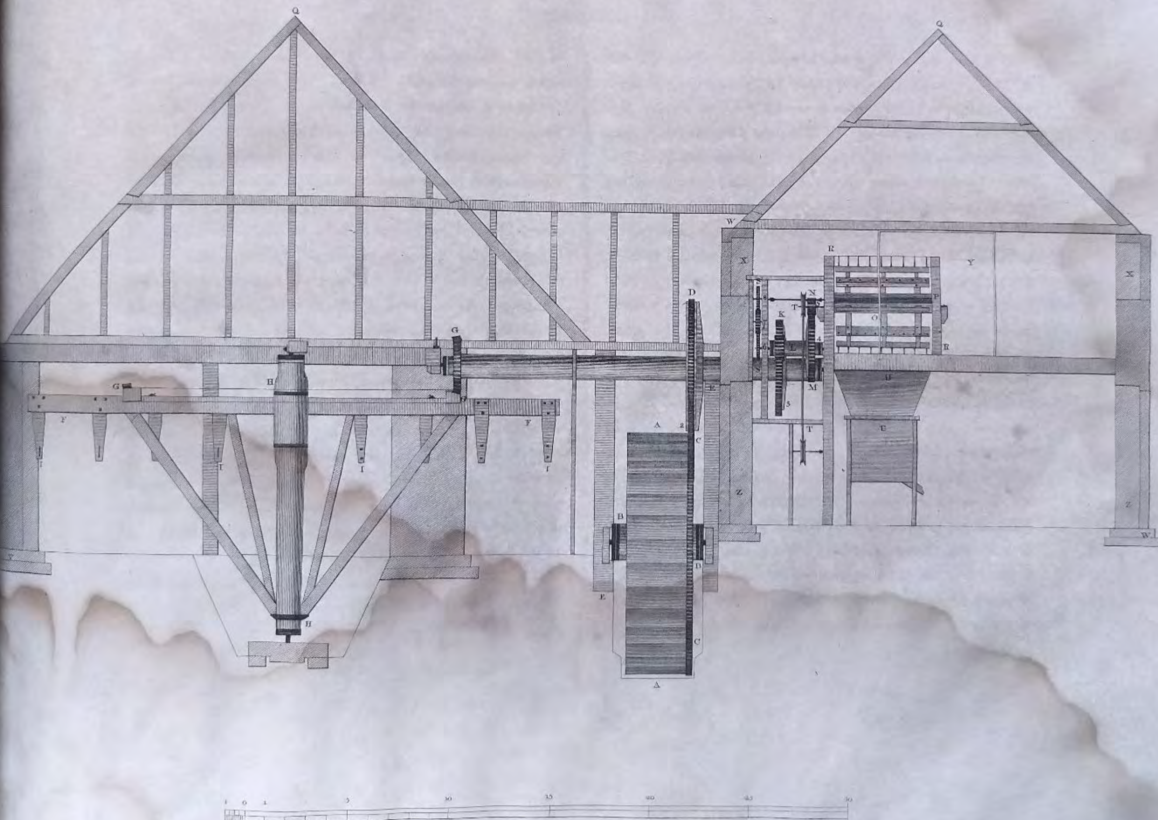
PLATE XII.

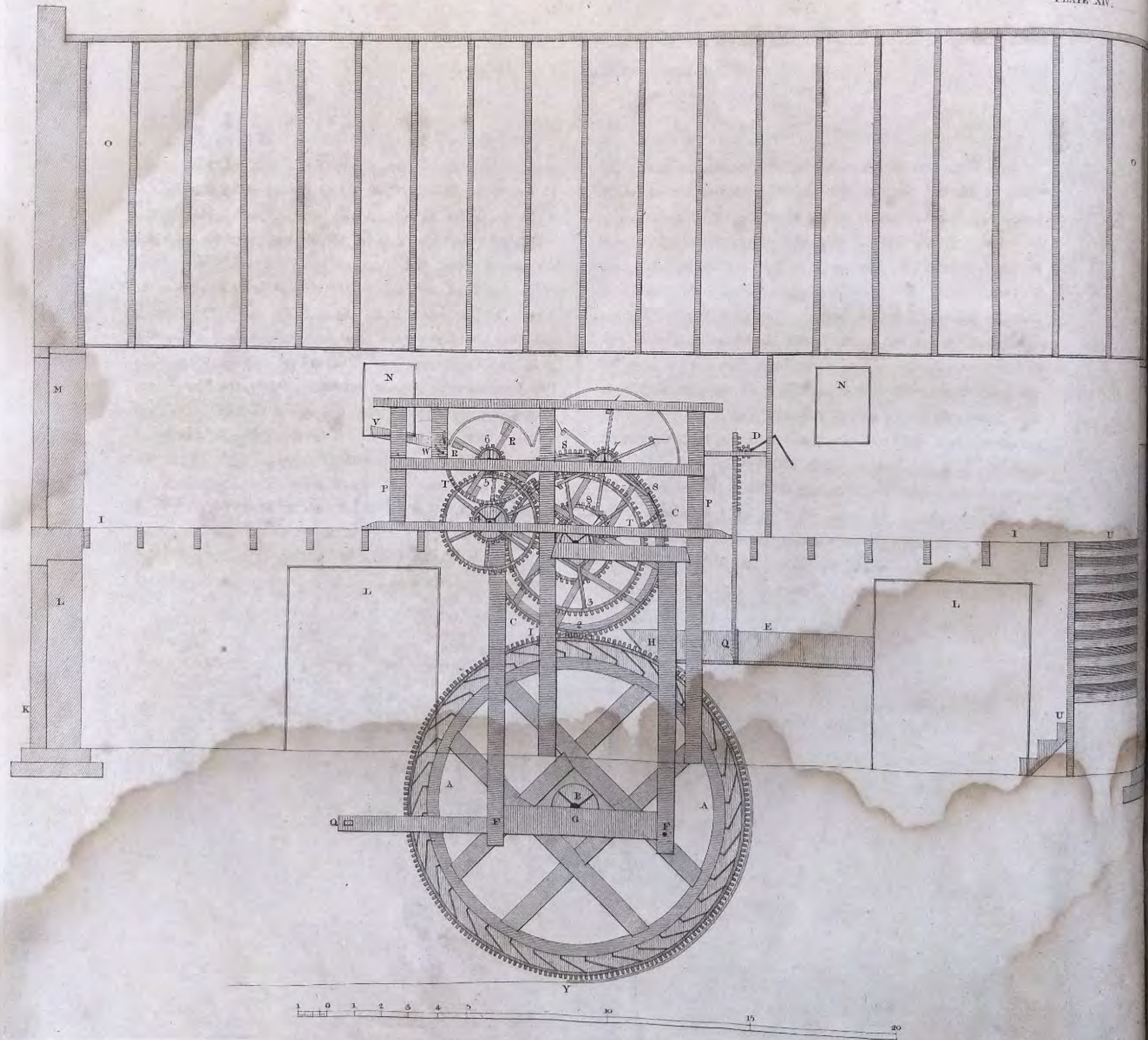
AA, The water wheel fixed upon the fhaft or axle B. On the extremities of its fpokes or arms are faftened a wheel No. 3. upon which are fixed with fcrewed bolts 12 caft-iron fegments CC, each of them containing 17 teeth, in all 204, to drive the wheel No. 4. having 94 teeth, which is placed at D, on the horizontal axle HH. Upon this axle is likewife faftened the wheel No. 5. containing 80 teeth, to turn a pinion No. 6. having 21 teeth, which is fixed on the axle M; upon which axle is alfo faftened the wheel No. 7. containing 60 teeth, to drive the pinion No. 8. having 14 teeth, which is fixed on the gudgeon or pivot in the axle N of the thrafhing drum or fcutch. No. 9. is a wheel faftened upon the gudgeon of the axle M, and containing 24 teeth, to act on the intermediate wheel No. 10. which turns the wheel No. 11. having 22 teeth, which is placed upon the iron fpindle L. This fpindle has a hole or focket that takes in a fquare on the gudgeon in one of the fluted rollers PP. By this means the two rollers are turned round to feed the corn in to the thrafhing fcutch. No. 11. is made to be eafily taken off its axis and another put in its place, having either a greater or leffer number of teeth to turn the feeding rollers flow or quick according as the corn requires to be fed. The frame in which the axle of No. 10. turns muft have liberty to fhift a little to one fide, according to the different diameters of the wheels placed on the fpindle L. No. 12. is a wheel fixed upon the axle O, containing 26 teeth, on which the wheel No. 5. acts to drive it round. In the axle O are alfo faftened fpokes or arms, having rakes faftened upon their extremities to throw the ftraw off the heck or fearce below it, while the grain falls down into the fanners underneath. RR, The frames that fupport the feeding rollers, thrafhing fcutch, and ftraw fhaker. S, a table or platform, on which the unthrafhed corn is equally fpread and introduced betwixt the feeding rollers. XX, The courfe or run of the water. UU, The machine and handle that raife the fluice to let the water on the great wheel to drive it round. YY, Are frames in which the gudgeons of the axle B, carrying the great wheel, turn. Gudgeons of axles and rounds of fpindles fhould turn in bufhes of brafs. TT, Walls of the barn, with joifts and ftair leading up to the loft or fecond floor. Q, a door at which the unthrafhed corn is carried into the loft. ZZ, Doors on the ground floor of the barn. VV, Are ftone pillars which fupport the large beams and roof of the courfe in which the horfes walk round to drive the machine at any time when the water fails. GG, The fhaft or axle, in which are faftened the arms or poles EEE. To thefe arms the horfes are yoked with chains and hooks of iron, by which they draw or pull and work the machine. EF, A wheel placed upon the arm E, containing 238 teeth or cogs to turn the pinion No. 2. having 38 teeth, which is faftened on the horizontal axle HH, which conveys motion to the thrafhing fcutch and other parts of the machine placed in the barn.

Elevation of a Thraſhing Machine to be driven by Water, or Horſes occaſionally, when there is not a conſtant Supply of Water.

PLATE XIII.

AA, The water wheel fixed upon the ſhaft or axle BB, and on its arms are alſo faſtened the wheel CC, upon which are fixed with ſcrew-bolts twelve ſegments of caſt-iron (and in each ſegment are 17 teeth, in all 204), to drive the wheel D No. 2. having 94 teeth, which is placed upon the horizontal ſhaft MS. The wheel No. 3. is likewiſe faſtened on the axle M, containing 80 teeth, to turn a pinion having 21 teeth, which is fixed upon the axle L. On this axle is alſo faſtened the wheel No. 4. containing 60 teeth, to drive the pinion No. 5. having 14 teeth, which is fixed on the gudgeon in the axle O that carries the thraſhing ſcutch. No. 6. a wheel faſtened upon the gudgeon in the axle L, containing 24 teeth, to act on the intermediate wheel No. 7. that drives the wheel No. 8. containing 22 teeth, which is placed upon an iron ſpindle N, having a ſocket that connects it with the gudgeon in one of the feeding rollers P, to turn them round, and feed in the corn to the thraſhing drum or ſcutch. RR, Are frames in which the feeding rollers, thraſhing ſcutch, and ſtraw ſhaker turn round. KS, Frames that ſupport the ſpindles and ſmall wheels. TT, a band that drives the fans by paſſing round on a ſheeve fixed on the gudgeon of the pinion No. 5. and another ſheeve faſtened upon the ſpindle of the fans. UU, The fanners and hopper below the thraſhing ſcutch that conveys the grain down to be cleaned or ſeparated from the chaff. W W, The ſide walls of the barn, Q, The couples or frame of the roof. Y, a door in the gable or end wall of the barn, at which the corn is conveyed into the loft or ſecond floor, where the thraſhing parts of the machine are placed. ZZ, Doors in the ſide walls; and XX, Windows to light the barn. V V, Are pillars that ſupport the large beams and roof Q of the courſe in which the horſes walk when working the machine. HH, The perpendicular ſhaft or axle in which the arms or poles FF are faſtened. Upon the arms F are fixed with ſcrewed bolts the ears or hanging pieces I I; to which the horſes are attached by iron hooks to draw the machine round. GG, Is a wheel placed on the arms F, containing 238 teeth or cogs, to turn the pinion G having 38 teeth, which is faſtened upon the horizontal ſhaft MS, by which motion is conveyed to the thraſhing ſcutch. When this machine is driven by water, the pinion G muſt be raiſed up clear of the wheel GG, or a few teeth taken out of the great wheel, or elſe a coupling box in the axle MS. Any of theſe methods may be adopted that is thought beſt. And when there is no water, the wheel AA muſt be dropped down a little in its frame EE clear of the wheel No. 2.; or a ſegment taken off the wheel CC, that No. 2. may have freedom to revolve when the machine is turned by horſes. But at any time when there is a ſmall quantity of water, a few horſes or oxen may be employed to aſſiſt the water in turning the machine.




O
O
M
N
N
Y
W
R
6
R
S
D
P
P
T
5
8
C
T
I
I
U
L
L
L
K
C
I
2
3
H
Q
E
U
A
A
B
Q
F
G
F
Y
1
0
1
2
3
4
5
10
15
20

Section of a Thrashing Machine to be driven by Water, or Horfes occafionally, when there is not a conftant Supply of Water.

PLATE XIV.

AA, The great wheel, containing 36 buckets, to receive the water at H, and retain it until the wheel having turned nearly half round, it is difcharged at Y, where the empty bucket begins to afcend. B, The fhaft or axle of the great wheel and gudgeon on which it turns. E, The trough or box that conveys the water above the wheel. DD, The fluice and machine, with a handle to raife the fluice and let the water on the great wheel. FF, Are pillars that fupport the bearer G that carries the great wheel, upon the circumference of which are fixed, with fcrewed bolts, 12 caft-iron fegments No. 1. each containing 17 teeth, in all 204, to turn the wheel No. 2. having 94 teeth. No. 3. is a wheel faftened on the fame axle with No. 2. and containing 80 teeth, that act upon the pinion No. 4. in which are 21 teeth; and on its axle is placed the wheel No. 5. having 60 teeth, to turn the pinion No. 6. that contains 14 teeth, which is fixed upon one of the gudgeons in the axle of the thrafhing fcutch R. No. 7. a wheel faftened on the axle of the ftraw fhaker SS, driven by the wheel No. 3. and having 26 teeth. No. 8. is a wheel containing 38 teeth, which is placed upon the fame axle with No. 3. to convey motion to the thrafhing fcutch from the wheel, to the arms of which the horfes are attached when working the machine. (This is plainly feen in Plates XII. and XIII.) V, A platform on which the corn is fpread, and introduced betwixt the rollers W that feed it into the thrafhing fcutch R, by which it is detached from the ftraw. TT is a heck or fearce, placed below the thrafhing fcutch and fhaker, to prevent any ftraw from falling down among the grain into the fanners. (The fanners are feen in Plate XIII.) PP, Are frames that fupport the feeding rollers, thrafhing fcutch, ftraw fhaker, and feveral other parts of the machine. The gudgeons of axles and rounds of fpindles fhould all turn in bufhes of brafs. K, K, Gables or end walls of the barn. OO, The couples or frame of the roof. M, a door in the end wall, at which the unthrafhed corn is conveyed into the loft or fecond floor I I, upon which the thrafhing part of the machine is placed. LLL, Are doors on the ground floor. UU, a ftair leading up to the loft. NN, Windows to light the barn.

Plan, Elevation, and Section of a Thraſhing Machine to be driven by Wind or Horſes occaſionally.

PLATE XV.

Fig. 1. AA, The circular houſe that contains the machinery driven by wind; and from which motion is conveyed to the thraſhing part of the machine. BB, A ſhaft or axle that carries the vanes or ſails. Upon this axle is alſo fixed the wheel No. 2. containing 84 teeth or cogs, to turn the wheel No. 3. having 34 teeth, which is faſtened upon an axle, on which is likewiſe fixed the wheel No. 4. that contains 72 teeth, taking into a pinion placed upon the axle HH, having 24 teeth (ſeen in Fig 2.) Upon the axle H is alſo faſtened the wheel NN, containing 60 teeth, to drive the pinion No. 6. having 14 teeth, which is fixed on the gudgeon in the axle of the thraſhing *drum* or *ſcutch*. CC is a wheel laid upon rollers, as 7, 8, 9, 10, that turn on their pivots in frames placed on the tops of the walls. Upon the wheel CC is fixed with ſcrew bolts the frame EE; on which the ſhaft, BB, carrying the vanes, revolves. Upon the under ſides of the frame EE is likewiſe faſtened the wheel No. 5. having teeth in its inner edge; on which a pinion acts to move it, and of courſe the wheel CC, round upon its rollers with the frame EE and axle BB; by which means the vanes are turned to face the wind in any direction. DD are upright rollers that turn on their pivots in frames fixed in the walls; and on theſe rollers the circumference of the wheel No. 5. bears when moved round, to prevent the wheel CC and frame E from going off to any ſide when moving round. GG, Pillars that ſupport the platform or gangway placed round the walls of the mill-houſe.

Fig. 2. II, KK, Walls of the circular houſe that carry the machinery driven by wind to turn the thraſhing machine. LL, a ſhaft or axle, upon which are fixed the arms of the wind vanes MM. Upon theſe arms are placed the rollers VV, on the gudgeons of which are ſmall wheels turned by the wheel D, which is fixed upon an iron rod that paſſes through a hole in the middle of the axle L and centre of its gudgeon. On the other end of this iron rod is faſtened the ſheeve or barrel C, to which two cords are attached, ſuch as B. By pulling one of theſe cords the rollers VV are turned, and ſpread the ſails or canvas; and pulling the other, the ſails are *furled* up, or wrapt round the rollers at any time when the machine is to be ſtopt. UU are ropes faſtened to the extremity of the vanes to aſſiſt them in bearing the preſſure of the wind. No. 2. is a wheel fixed upon the ſhaft LL, containing 84 teeth or cogs, to turn the pinion No. 3. having 34 teeth, which is faſtened on the ſhaft OO. Upon this ſhaft is alſo fixed the wheel No. 4. containing 72 teeth, to drive the pinion No. 5. having 24 teeth, which is placed upon the horizontal axle PP. Upon this axle is likewiſe faſtened the wheel No. 9. containing 60 teeth, to turn the pinion No. 10. in which are 14 teeth, and is fixed on the gudgeon in the axle of the thraſhing ſcutch EF (ſeen in Fig. 4.) II is a half wheel ſuſpended in a frame, and let down at pleaſure to bear on the upper half of the wheel No. 2. at any time when the machine is to be ſtopt. WW are rollers that turn on their gudgeons in frames placed on the top of the walls. Upon theſe rollers are laid the wheel YY, which is eaſily moved round, carrying the roof NN, and frame that carries the ſhaft LL with the vanes M. In one end of the axle L is fixed a gudgeon which turns in the frame, and its neck rolls round upon the friction roller X, which alſo turns on its gudgeons in the frame. TT, An iron ſpindle with a handle or crank to turn it round; and on this ſpindle is a perpetual ſcrew that acts on the wheel No. 6. placed upon the perpendicular axle RR. On the upper end of which is alſo fixed a pinion that takes into the teeth in the inner edge of the wheel SS, which is faſtened to the frame and wheel YY. By this means the wheel and frame are eaſily moved round, ſo that the vanes may be turned to face the wind in any direction. ZZ, Are rollers that keep the wheel SS, and of courſe the frame and wheel YY, from going aſide when moved round. This is plainly ſeen in Fig. 1. HH, Bearers which ſupport the ſhaft OO, and one end of the axle P. GG, Doors in the walls, and Q a window to light the houſe.

Fig. 3. SSS, Are pillars that ſupport the beams TT, and roof of the courſe in which the horſes walk to work the thraſhing machine at any time when the wind fails. AAA, The arms or poles fixed in the ſhaft or axle C, by which the horſes pull or draw. Upon the arms A are placed the wheel BB, containing 208 teeth or cogs, to turn the pinion No. 2. having 36 teeth, which is placed upon the ſhaft DD, on which axle is alſo fixed the wheel No. 3. containing 84 teeth, to drive the pinion No. 4. of 20 teeth, which is faſtened upon the axle K. On the ſame axle is likewiſe fixed the wheel No. 5. containing 60 teeth, to turn the pinion O of 14 teeth, which is faſtened on the axis of the thraſhing drum or ſcutch FF. No. 7. a ſheeve or whorl faſtened upon the axle K. Upon this whorl is put the leather belt or band M that turns the barrel No. 8. which is fixed on the iron axle L. There is alſo faſtened on the axle L a ſheeve No. 9. upon which goes a leather belt to drive the whorl No. 10. placed on an iron rod that takes hold of the gudgeon in one of the rollers EE, and turns the rollers to feed the unthraſhed corn into the machine. GH, Are the two ſtraw ſhakers turned by the leather belts M and N. II, A platform upon which the corn is ſpread, and introduced betwixt the feeding rollers. RR, The frames that ſupport the thraſhing part of the machine. WW, The barn walls, and VV doors in the ſide walls of the houſe.

Fig. 4. AA, The ſhaft or axle, in which are fixed the arms CC; and on theſe arms are faſtened with ſcrew bolts the ears or hanging pieces DD, to which the horſes are yoked to work the machine. BB, A wheel fixed upon the arms CC, containing 208 teeth, to act on the pinion No. 2. having 36 teeth, which is faſtened on the axle E. Upon this axle is alſo fixed the wheel No. 3. containing 84 teeth, to turn the pinion No. 4. having 20 teeth, which is placed upon the axle H. On this axle is likewiſe faſtened the wheel No. 5. containing 60 teeth, to drive the pinion No. 6. of 14 teeth, which is fixed upon the gudgeon in the axle of the thraſhing ſcutch FF. V, Are two iron rollers fluted or having ſmall teeth to feed the corn into the ſcutch. No. 8. a ſheeve fixed on the ſpindle of the feeding rollers turned by a leather belt, clearly ſeen in Fig. 3. No. 7. a whorl, on which is a band going round the ſheeve I, to turn the fanners GG, that clean the grain as it falls from the thraſhing ſcutch. HH, Frames in which the rollers, thraſhing ſcutch, and ſtraw ſhaker turn. KK, The ſide walls of the barn. L, The couples or frame of the roof. NN, Windows to light the barn. RR, Are pillars that ſupport the beams SS, and the couples or roof TT of the courſe in which the horſes walk to turn the machine. When this machine is driven by wind, No. 3. muſt be diſengaged from No. 4.; and when driven by horſes, No. 9. is cleared of No. 10. by the bearer of the axle P being dropt a little down.

PLATE. XV.

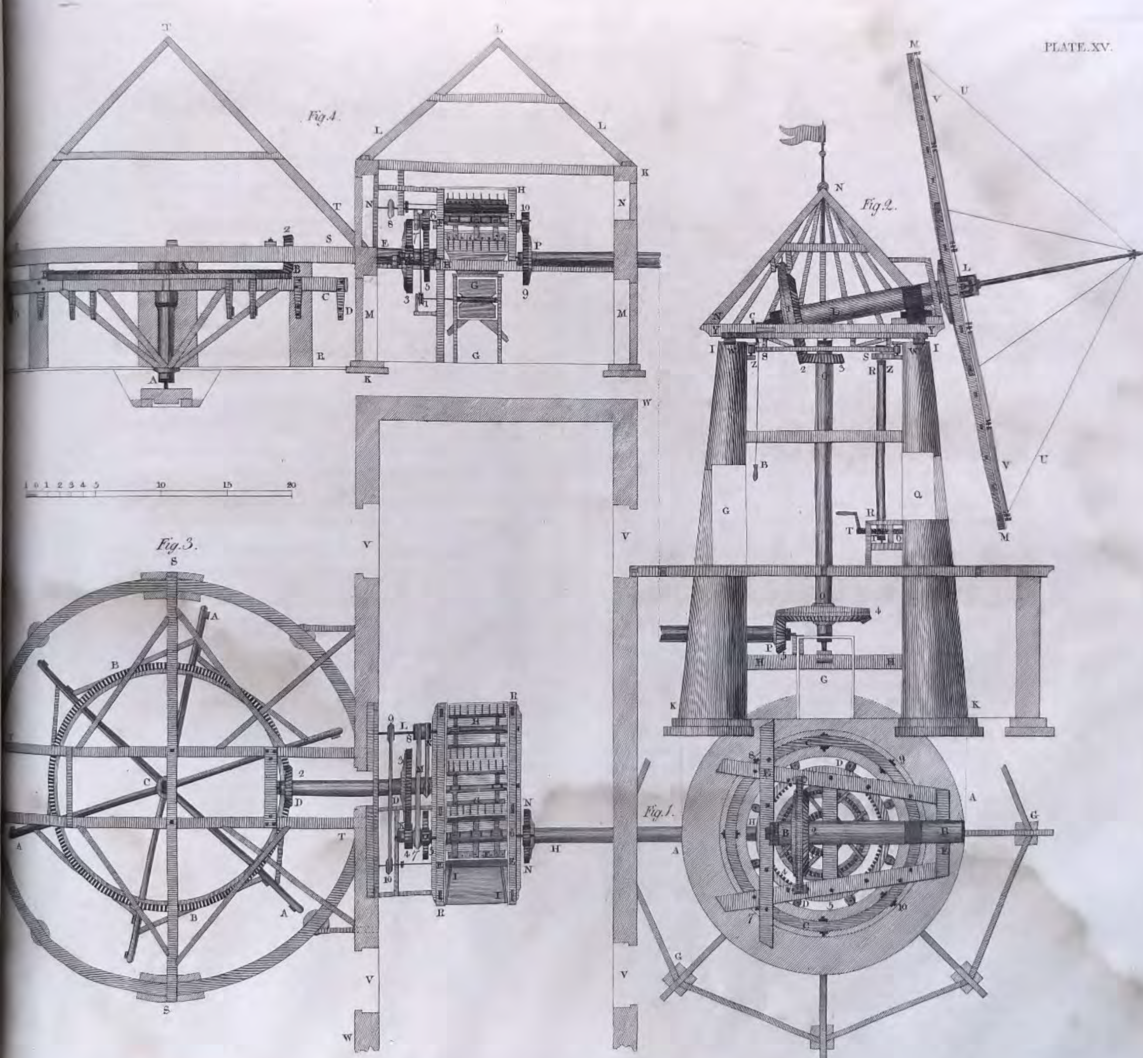
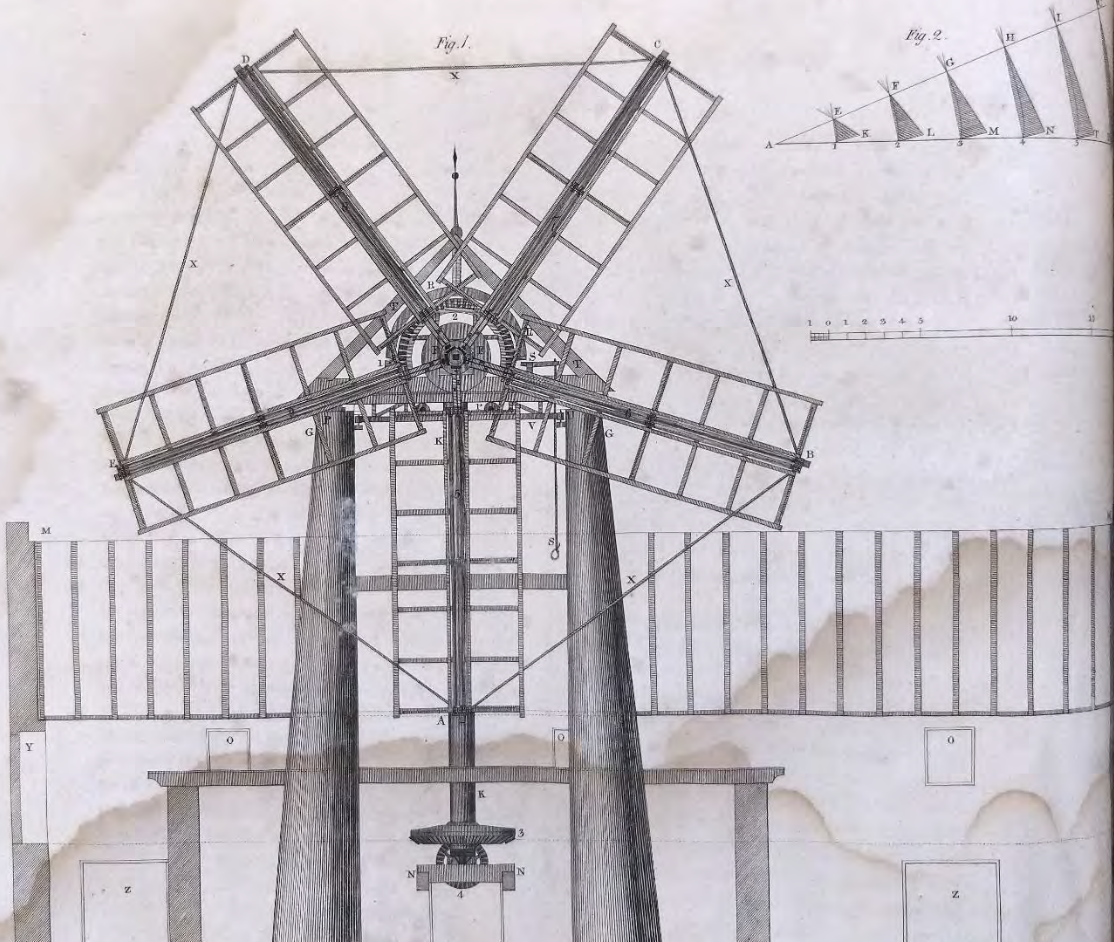


Fig. 1.


D
C
X
X
X
R
T
2
E
F
1
S
T
P
G
G
E
B
K
V
5
M
S
X
X
A
Y
O
O
O
K
3
N
N
4
Z
Z
H
W
W
Fig. 2.
E
F
G
H
I
C
A
K
L
M
N
T
1
2
3
4
5
1 0 1 2 3 4 5 10 15

Elevation of a Wind Mill to turn a Thrafhing Machine.

PLATE XVI.

ABCDE, Arms of the oars or vanes, one end of which is fixed in the fhaft or axle FF, being alfo faftened with fcrew bolts to a wheel fixed upon a fquare on the fame fhaft, and round this wheel is an iron hoop. In thefe arms are holes or mortifes to receive the fpars or pieces of wood that form the vanes. Each of the vanes muft be alike inclined to their common axis, and be turned round in the order ABCDE. Thefe vanes are ferved with fails of cloth, which may be fpread out for the wind to act on, or rolled up at pleafure by pulling a rope that goes round a fheeve or barrel fixed upon an iron axle or fpindle, that paffes through a hole in the centre of the gudgeon and middle of the fhaft FF. Upon the other end of this iron fpindle is fixed a wheel nearly in a line with the face of the vanes, having teeth to turn the wheels that are fixed upon the gudgeons of the rollers 5, 6, 7, 8, 9, round which the fails are rolled when the machine is to be ftopt, or fpread out on each fide of the arms by one edge of the fail being faftened to a fpar of wood having teethed rods of iron fixed in it; and a fmall wheel fixed upon the pivots of the rollers, in which are teeth to act upon the teeth in the iron rods. Thus the fails are fpread out or rolled up when neceffary; the rollers being all turned round any way by the wheel upon the iron fpindle in the middle and whole length of the fhaft FF, upon which the arms of the vane are fixed. No. 2. a wheel fixed upon the fhaft FF, and containing 84 teeth, to turn a wheel that is fixed upon the uppermoft end of the perpendicular fhaft KK, and having 34 teeth. No. 3. is a wheel fixed upon the lower end of the fhaft KK, containing 72 teeth, to turn the wheel No. 4. having 24 teeth, which is fixed upon an horizontal fhaft that conveys motion to the thrafhing machine placed in the barn, which is feen in Plate XV. Fig. 1. NN, Two beams that fupport the crofs bearer upon which the gudgeon of the horizontal and perpendicular fhafts turn round. PP, Are horizontal rollers that turn on their gudgeons in frames faftened on the tops of the walls WG, WG; upon which rolls a wheel moved round with the frame, the fhaft FF, and roof TT, along with it. By this means the vanes are turned to face the wind in any point or direction. RR, a half wheel called the *brake*, which encircles the uppermoft half of the wheel No. 2. and by moving on an iron bolt in the frame at I, is let down to bear on the wheel to retard its motion when the mill is to be ftopped, or raifed up off the wheel by the lever and rope SS at any time when needful. V V, A wheel fixed to the frame that carries the fhaft FF and roof TT, having teeth on its innermoft edge, upon which a pinion acts to turn it round (which is feen in Plate XV. Fig. 2.) UU, Are perpendicular rollers, that turn round on their pivots in frames faftened at proper diftances all round the walls. Thefe rollers prevent the wheel V V, and of courfe the frame to which it is fixed, from going to any fide as they move round. XXXXX, Are ropes faftened to the points of the arms to prevent them from bending. HH, The end walls of the houfe or barn that contains the thrafhing part of the machine. MM, The couples or frame of the barn roof. Y, a door in the end wall, at which the unthrafhed corn is conveyed into the loft or fecond floor where the thrafhing part of the machine is placed. ZZ, Doors in the barn. OO, Windows in the fide walls to light the barn.

Fig. 2. To determine the angle of weather of the vanes at different diftances from the centre of the axis, take the intended length, breadth, and angle of weather at the extremity of the vane. Thus if AB be the length of the vane, BC its breadth, and BCD the angle of weather at the extremity of the vane equal to ten degrees. With the length AB and breadth BC conftruct the ifofceles triangle ABC. From the point B draw BD perpendicular to BC; then BD is the proper depth of the vane. Divide the line AB into any number of equal parts, fuppofe fix. At thefe divifions draw the lines 1K, 2L, 3M, 4N, and 5T, all of them equal in length to BD. Join EK, FL, GM, HN, and IT; then the angles 1EK, 2FL, 3GM, 4HN, and 5IT, are the angles of weather at thofe divifions of the vane; and if the triangles be conceived to ftand perpendicular to the plane of the paper, the angles K, L, M, N, T, and D, becoming the vertical angles, the hypothenufe of thefe triangles will give a perfect idea of weathering the vane as it recedes from the centre of the axis.

Plan, Elevation, and Section, of a Mill for grinding Snuff.

PLATE XVII.

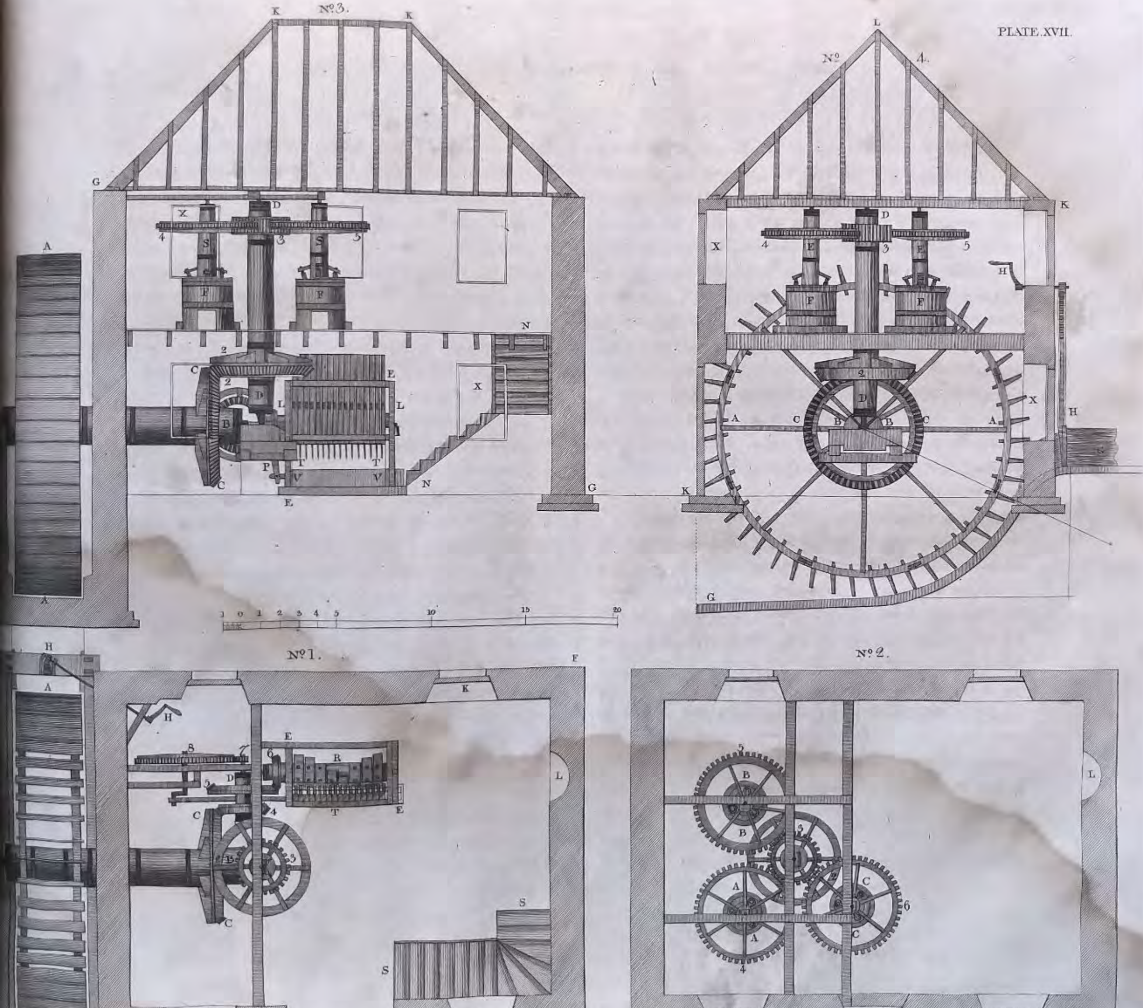
No. 1. *Plan.*—AA, The water wheel fixed upon its ſhaft or axle BB; on which axle is alſo faſtened the wheel CC, containing 54 teeth or cogs to drive the wheel No. 2. having 44 teeth, which is fixed upon the under end of an upright ſhaft (ſeen in No. 3. and 4.) No. 3. a wheel faſtened on the ſame axle, containing 26 teeth, to turn the other wheels. No. 4. a wheel fixed upon the axle D, driven by the wheel CC, and having 24 teeth. On this axle is likewiſe faſtened the wheel No. 5. containing 36 teeth, to turn the wheel No. 6. having 17 teeth, which is fixed upon the axle R; on which axle are faſtened, with ſcrewed bolts, weepers or tripping pieces, that raiſe or lift the ſtampers or peſtles T, having knives or chiſels fixed in the ends for cutting the tobacco. EE, Are the frames of the cutting engine. No. 7. a pinion fixed on the gudgeon of the axle D, containing 10 teeth, to act upon the wheel No. 8. having 82 teeth, which is faſtened on an iron axis or ſpindle, in which is a bend or crank, which being turned round moves the box with the tobacco forward and backward below the cutting ſtampers. HH, The machine and handle that raiſe the ſluice to let the water on the great wheel to drive it round. FF, The walls of the mill-houſe. G, A door in the ſide wall. L is a fire-place. SS, A ſtair leading up to the loft. KK, Windows to light the houſe.

No. 2. *Plan.*—The ſecond floor, on which are placed the mortars A, B, C. Into theſe the tobacco is put, and ground to ſnuff by three iron peſtles or rollers, bearing on the ſloping ſides of the mortars, and turning on their pivots as they are carried round along with the axles that carry the wheels No. 4, 5, and 6, each of them containing 48 teeth, and turned by the wheel No. 3. having 26 teeth.

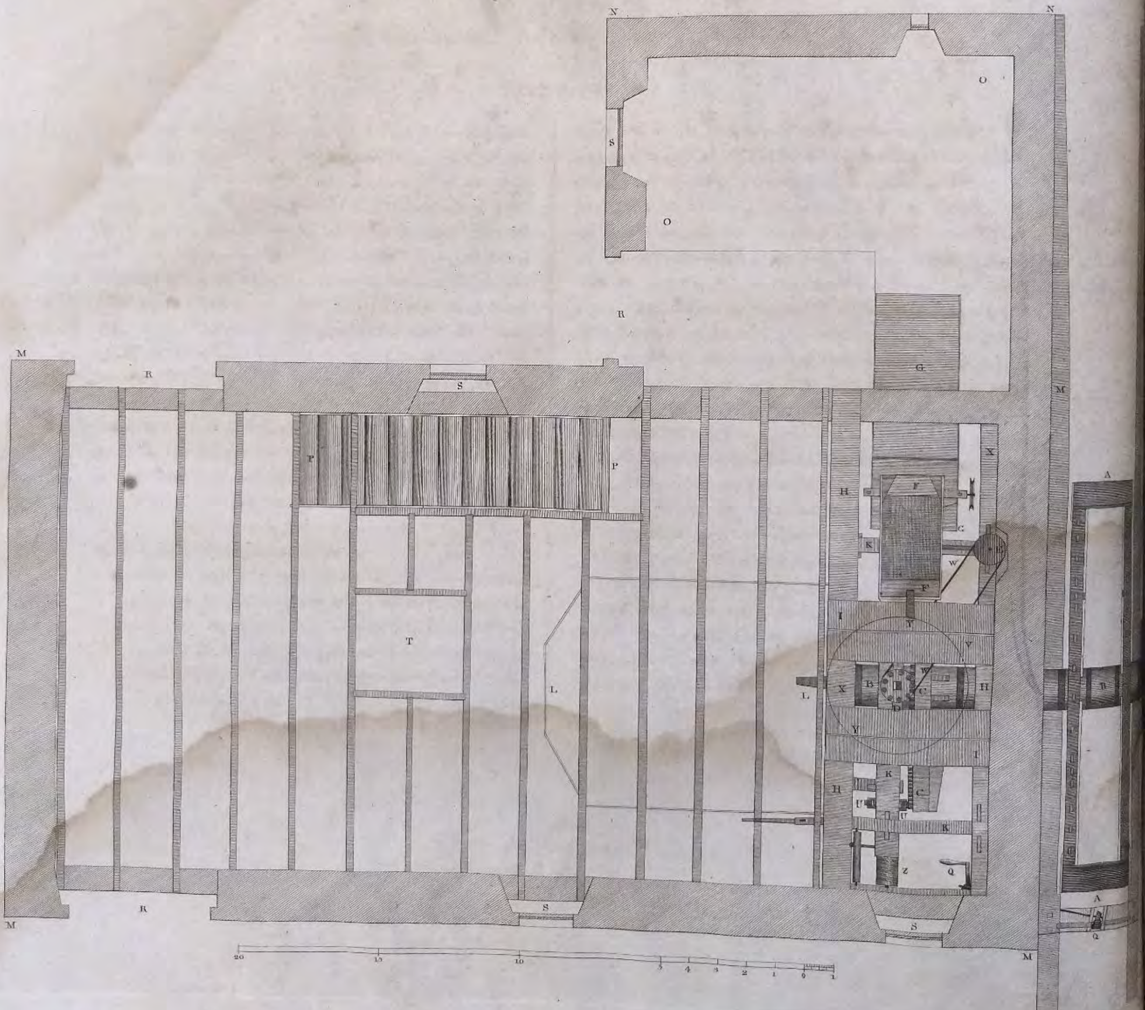
No. 3. *Elevation.*—AA, The water wheel fixed on its ſhaft BB; upon which axle is likewiſe faſtened the wheel CC, containing 54 teeth, to turn the wheel No. 2. having 44 teeth, which is placed on the perpendicular ſhaft D. EE, The frame of the peſtles or ſtampers; in the under ends of which are fixed knives or chiſels TT that cut the tobacco, being raiſed up by the weepers fixed on the axle LL, and fall down amongſt the tobacco in the box V V, which is moved forwards and backwards by the lever P from the crank in the iron axle of the wheel No. 8. (ſeen in the Plan.) Upon the upper end of the axle D is fixed the wheel No. 3. containing 26 teeth, that drives the wheels No. 4. and 5. having each of them 48 teeth, and faſtened on the axles SS, which carry round the peſtles or iron rollers that grind the ſnuff in the mortars EF; in the bottom of which are openings, having ſhutters that open at pleaſure to allow the ſnuff to paſs through when ſufficiently ground. GG, The end walls of the mill-houſe. KK, The couples or frame of the roof. NN, A ſtair leading up to the loft. XX, Windows to light the mill-houſe.

No. 4. *Section.*—AA, The great wheel, containing 48 floatboards, to receive the water to turn it round. BB, The ſhaft or axle of the water wheel, upon which axle is alſo fixed the wheel CC, having 54 teeth, to drive the wheel No. 2. containing 44 teeth, and faſtened on the ſhaft DD. Upon this axle is likewiſe fixed the wheel No. 3. having 26 teeth to act on the wheels No. 4. and 5. In each of theſe wheels are 48 teeth, which are faſtened upon the axles EE, by which the iron rollers or peſtles are carried round in the mortars FF, where the ſnuff is ground. GG, The fall of water to turn the great wheel. HH, The machine that raiſes the ſluice to let the water on the wheel. KK, Side-walls of the mill-houſe. I, The couples or frame of the roof. XX, Windows to light the houſe.

PLATE XVII.



PLATE



N
N
O
S
O
R
M
R
S
P
P
G
M
X
H
F
G
K
W
F
I
Y
V
T
L
L
X
B
C
D
H
Y
I
H
K
C
U
U
K
Z
Q
A
B
A
R
S
S
M
Q
M
20
15
10
5
4
3
2
1
0
1

Plan of a Corn Mill for Oats, Barley, and Peas.

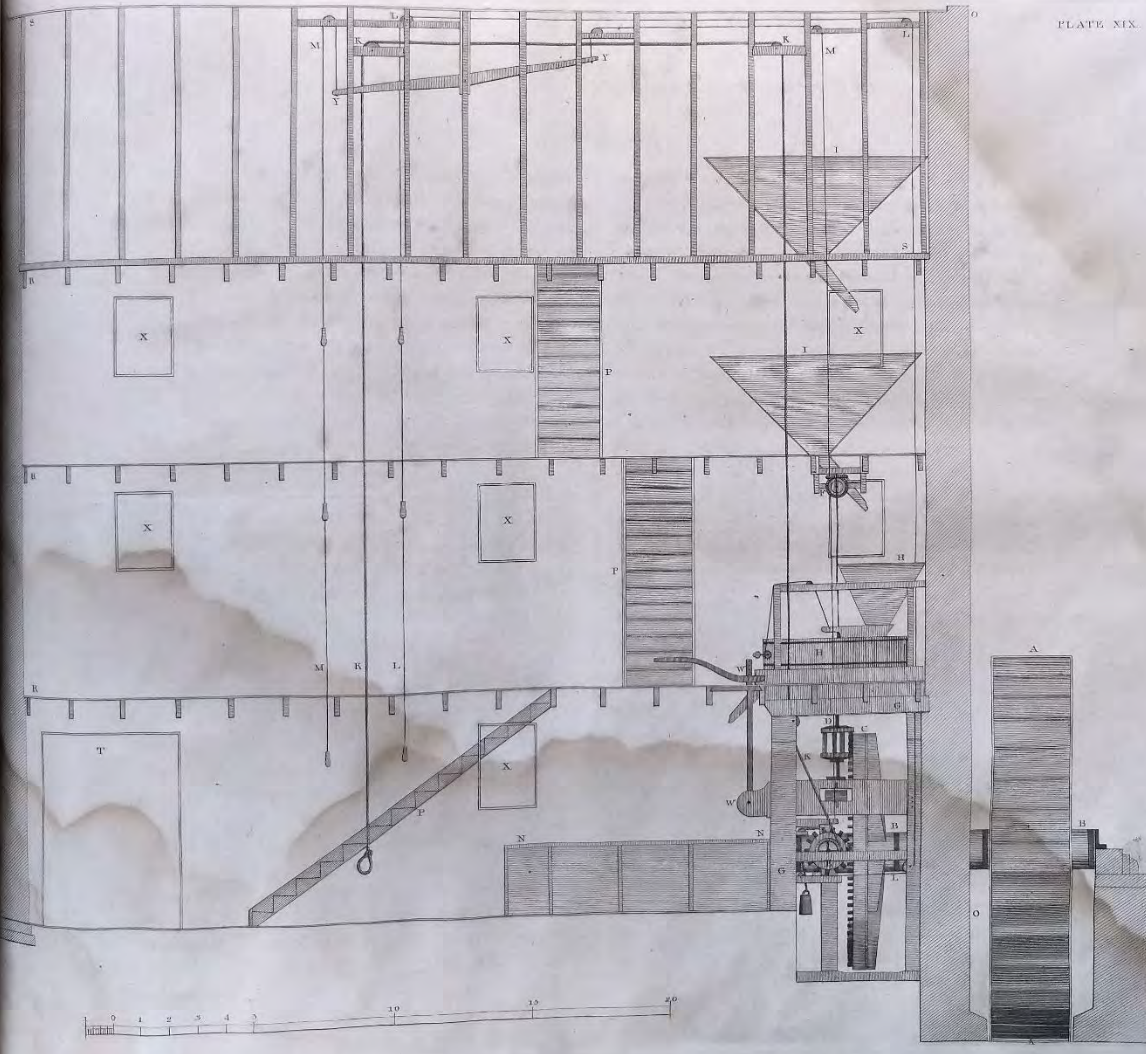
PLATE XVIII.

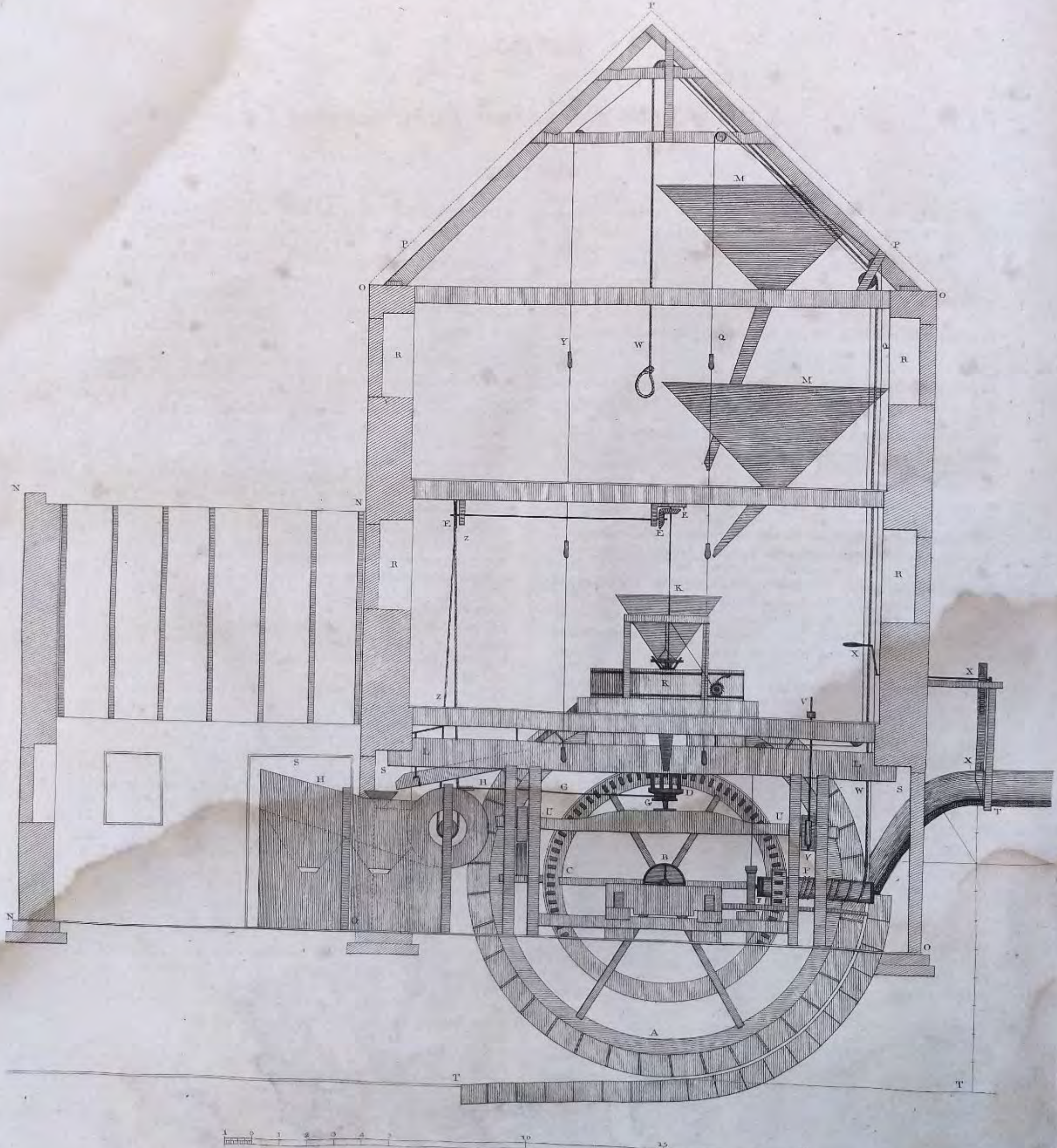
AA, The water wheel fixed upon the ſhaft or axle BB; upon which axle is alſo faſtened the wheel CC, containing 78 teeth or cogs, to turn the trundle or wallower D, having 9 rounds or ſtaves, which being fixed upon an iron axle called the *mill ſpindle*, on the top of which ſpindle is an iron croſs admitted into an excavation in the lower ſide of the upper millſtone, carries the ſtone round along with the trundle D. E, a ſheeve or whorl fixed upon an iron axle or ſpindle, having a bend or knee in it called a *crank;* which being turned round by the band WW, paſſing from a ſheeve faſtened upon the ſpindle of the trundle D, gives the wire ſieve FF a ſhaking motion; by which means a conſiderable part of the ſmall duſt falls down through as the grain runs from the millſtones at the opening or ſpout Y, over the ſieve to the fanners GG, in order to be cleaned or ſeparated from any looſe or light refuſe, and is thus properly prepared for being ground into meal. HH and X are the ſills or large beams that ſupport the bearers I I, upon which the bed or under millſtone is laid, repreſented by the circle YY, and ſuppoſed to be four feet ſix inches diameter. There is an opening at Y, in which is fixed a ſpout to convey the grain from the millſtones to the wire ſieve FF. This opening muſt be ſhut when the mill is grinding. There is alſo an opening at X called the mill-eye, where the meal iſſues out from the millſtones when grinding down in the box or trough LL. This opening muſt be ſhut when the mill is ſhealing or clearing the huſk from the grain. KKK, Are the croſs bearers and bridge tree, on which the lower end of the iron ſpindle that carries the upper millſtone turns. UU, a wheel having 14 teeth, turned by the wheel CC; and is fixed upon an axle round which the rope Z rolls, to carry the ſacks or bags of grain from the ground floor up to the lofts. QQ, The machine and crank, that raiſe the ſluice to let the water on the buckets or float boards of the wheel AA to turn it round. MM, Are the walls of the mill-houſe. PP, A ſtair leading up to the loft. NN, The walls of a ſmall houſe adjoining to one ſide of the mill-houſe for containing the duſt and refuſe as it flies from the fanners G. This form of the houſe is very convenient for a common meal mill, becauſe it not only holds the duſt at a diſtance from the clean grain and meal, which muſt be an advantage, but likewiſe the mill-houſe may be made of leſs dimenſions than in the ordinary way. OO, a place encloſed with boards to contain the refuſe as it comes from the fanners. RRR, Are the doors; and SS, Windows to light the mill-houſe. T, An opening or hatchway in the floors, through which the bags of grain are carried up to the hoppers by the rope Z coiling round on the axle of the wheel UU. The opening T is furniſhed with two doors moving on iron hinges: theſe doors are opened by the ſack in the rope paſſing up betwixt them, and falls down to ſhut the hatchway as ſoon as the bags of grain are clear of them above,

Elevation of a Corn Mill for Oats, Barley, and Peas.

PLATE XIX.

AA, The water wheel fixed upon its ſhaft or axle BB; upon which axle is alſo faſtened the wheel CC, containing 78 teeth or cogs to turn the trundle or wallower D, having nine rounds or ſtaves. This trundle is faſtened upon the iron axis, having upon its upper end an iron croſs that is put into grooves in the middle and under ſide of the upper millſtone, by which means the ſtone is carried round. GG, Are large frames that ſupport the bed or under millſtone. H is a hopper on the frame above the millſtones that contains the grain with a ſpout, or what is called the *mill-ſhoe*, for conveying the corn from the hopper into the hole or *eye* in the middle of the upper millſtone. H, The caſes that encloſe the upper millſtone, to prevent the grain from flying off at any place when grinding, but only at an opening at one ſide, in which is a ſpout to convey the meal down to the box or trough NN when ground. WB, A croſs bearer that ſupports one end of the bearer or bridge tree, on which is fixed a braſs ſtep or cod for the lower end of the iron ſpindle that carries the upper millſtone to turn in. W, a lever called the *mill-hand*, with a rod of wood or iron, the lower end of which moves on an iron bolt in the bearer WB. This bearer alſo moves on an iron bolt at the end B. Then by moving the longer arm of the lever W up or down, the bridge-tree and upper millſtone are either raiſed or depreſſed at pleaſure according as the meal is wanted to be ground coarſer or finer. E, a wheel having 14 teeth, and fixed upon an axle, on which the rope KK rolls round to carry the ſack of corn up to any of the lofts RRR. This wheel is driven by the wheel CC, and can be eaſily put in motion, and alſo quickly ſtopped when the wheel CC is revolving. The wheel E is ſet agoing at any time by pulling the cord L, hanging down through the floors or lofts for that purpoſe; the ſame cord paſſing over the ſheeves LLL. The other end is faſtened to the longer arm of a lever that moves on an iron bolt; its ſhorter arm being connected with the perpendicular frame in which the pivot of the axle of the wheel E turns. When the longer arm of this lever is pulled by the cord L, its ſhorter one puſhes the upper end of the frame towards the wheel CC, the lower end of which moves on an iron bolt; by this means the wheel E is put into the *grip* or hold of the wheel CC. There is likewiſe a piece of wood called a *catch*, one end of which moves on an iron bolt in the pillar at N. Near the other end, upon its lower ſide, is a *notch* or *ſhoulder*, that falls down in the off-ſide of the perpendicular frame, and keeps the wheel E into the *grip* of the wheel CC, which drives it while the rope KK rolls round its axle. When the ſack of grain, hanging to the other end of the rope K, is raiſed up to the lever YY, which moves on an iron bolt, one end of the lever is puſhed up by the ſack, and of courſe the other falls down, and pulls the cord YMD, whoſe other end being faſtened to the *catch* lifts it up clear off the frame. Then the weight at G, hanging by a rope going over two ſheeves, and its other end faſtened to the upper end of the perpendicular frame, pulls the frame, and of courſe the wheel E, off the hold of the wheel CC. Thus the wheel E ſtops of itſelf in an inſtant: But when the grain is to be put into any of the lower floors, this machine is ſtopped at any time by pulling the cord MM, hanging down through the floors for that purpoſe. This is a very ſimple kind of ſack-tackle, and may be added to any wheel having teeth to turn it. This machine is alſo contained in very little room. F, Two ſmall wheels for conveying motion to the fanners: one of them fixed upon the perpendicular iron ſpindle, which has a ſocket in its lower end to take in a ſquare on the upper end of the iron ſpindle, that carries the upper millſtone. I I, Two large hoppers into which the corn is put when carried up by the ſack tackle, and may be conveyed from either of them down into the hopper H placed upon the frame above the millſtones. OO, The gables or end walls of the mill-houſe. SS, The couples or framing of the roof. T, a door in the ſide wall. PPP, The ſtairs leading up to the lofts or upper floors. XX, Windows to light the mill-houſe.


S
L
M
K
Y
I
R
X
P
F
H
W
G
D
C
B
N
T
O
A
0 1 2 3 4 5 10 15 20


P
P
P
O
O
M
M
Y
W
Q
Q
R
R
R
R
N
N
N
E
E
E
Z
Z
K
K
K
X
X
X
V
L
L
S
S
S
H
H
G
G
D
U
U
W
B
C
V
F
T
O
A
T
T

Section of a Corn Mill for Oats, Barley, and Peas.

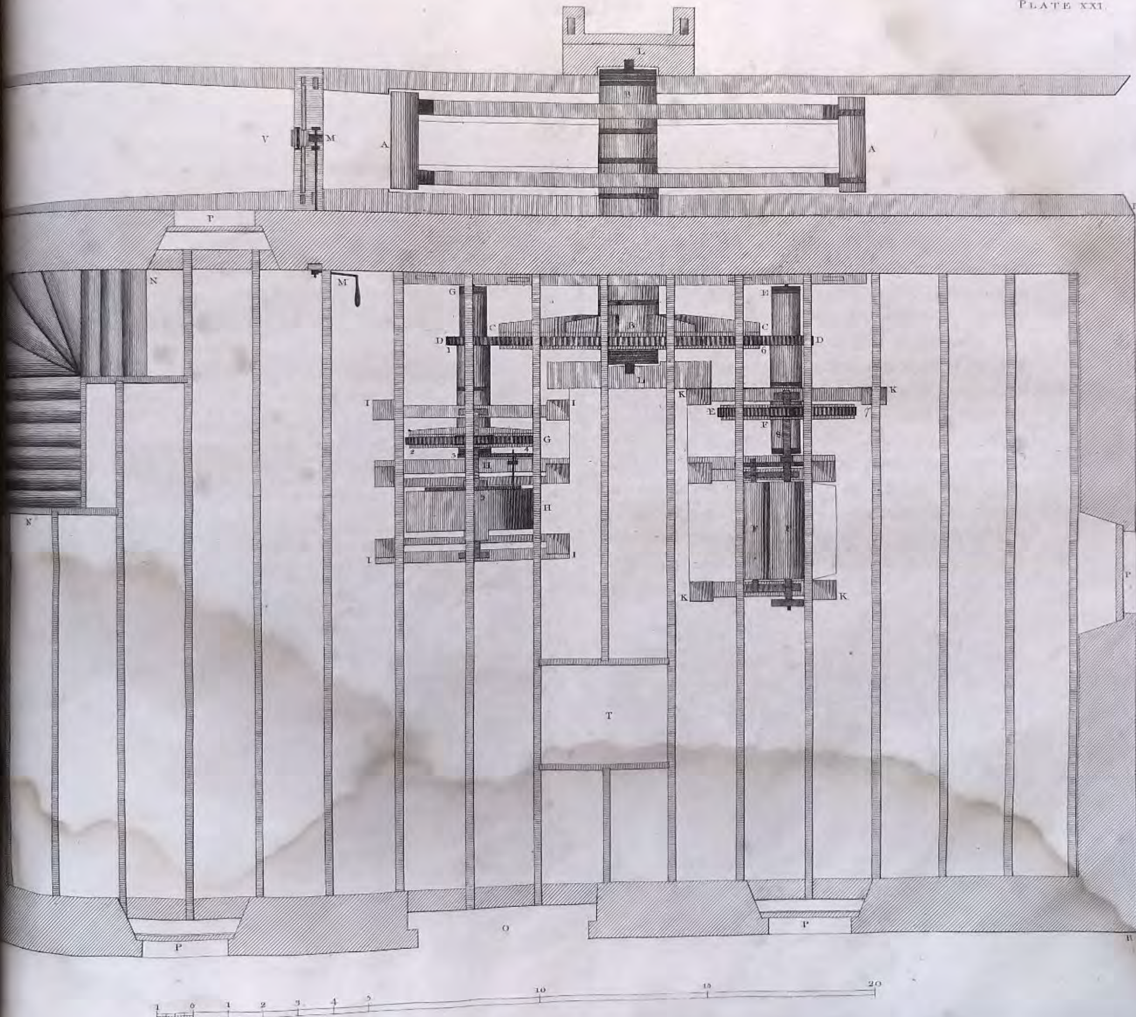
PLATE XX.

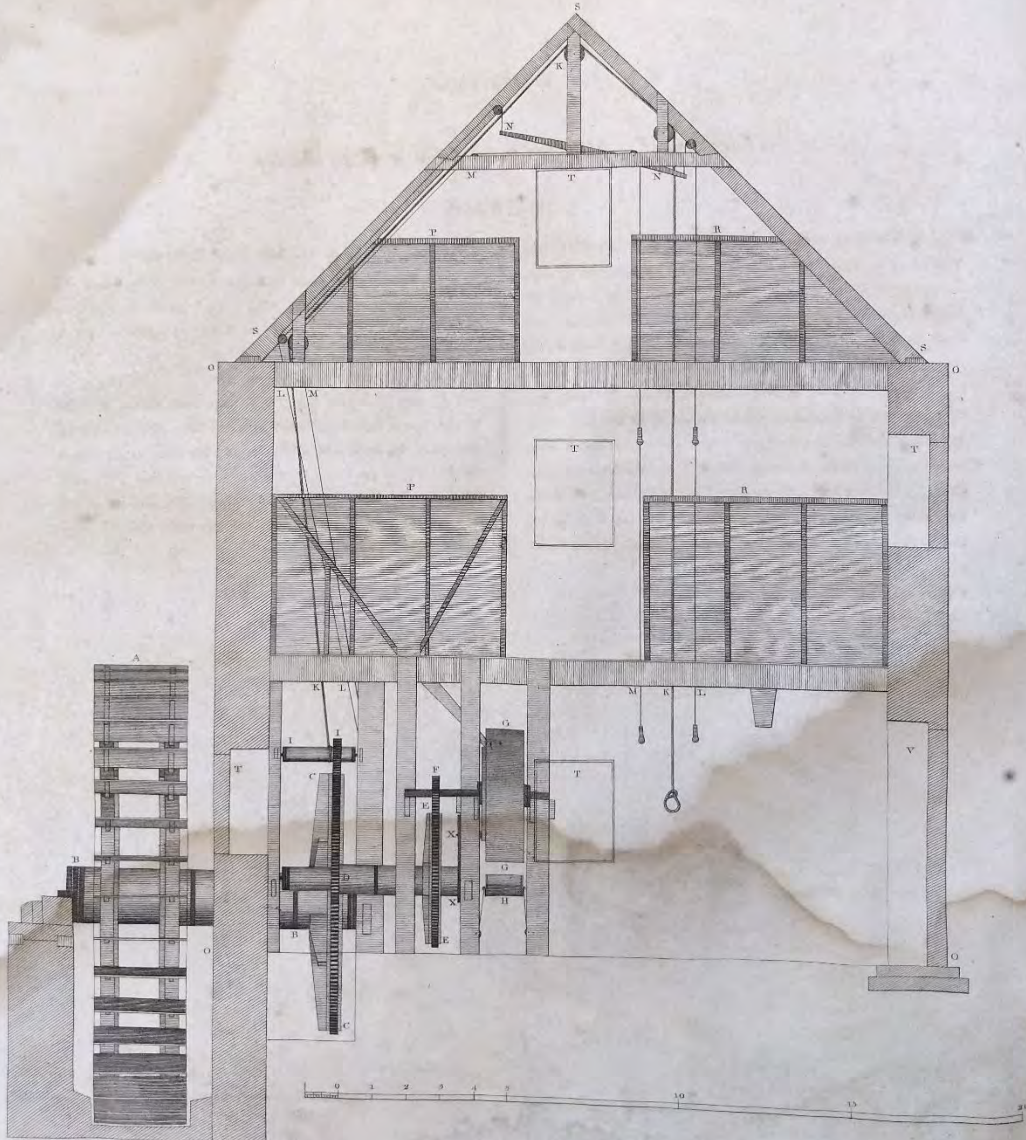
AA, The great wheel fixed upon the ſhaft or axle B, containing 36 buckets to receive the water to turn it round. TT, The fall or courſe of the water. XX, The machine and handle that raiſe the ſluice to let the water on the great wheel. On the axle B are likewiſe faſtened the wheel CC, having 78 teeth or cogs to drive the trundle or wallower D of 9 ſtaves or rounds. LL, The ſtrong frame that ſupports the bearers, which carry the bed or under millſtone, ſuppoſed to be four feet ſix inches diameter. Above it is the running millſtone, of the ſame diameter, and encloſed by the crib or caſe K, to prevent the grain from flying off at any part except the opening in one ſide called the mill-eye. The ſurface of the lower millſtone ſhould be perfectly flat or ſtraight, and part of the upper millſtone concave, or about half an inch hollow at the centre; ſo that the two millſtones are farther from each other at the middle, and approach nearer and nearer towards the outſide, which gives room for the corn to go in between the millſtones about 16 or 18 inches of the radius, where it begins to be ground by the remaining part of the radius, which ought to be parallel or equally diſtant from the lower millſtone. The trundle D is faſtened upon an iron axle called the mill-ſpindle, which paſſes through the middle of the lower millſtone, and its lower end turns round in a braſs pot fixed on the ſtrong bearer UU, called the bridge-tree. The round near the upper part of the ſpindle turns in a buſh of end wood fixed in the lower millſtone; the top part of the ſpindle above the wooden buſh is ſquare, and goes into a ſquare hole in a ſtrong iron croſs called the *rind*, which is admitted into an excavation, or enters into grooves in the middle and under ſurface of the running millſtone; and thus turns it round along with the trundle D by means of the cog-wheel CC. One end of the bridge-tree UU, that ſupports the iron ſpindle of the trundle D, and running millſtone, remains faſt in a mortiſe in the fixed croſs bearer, while the other end goes into a mortiſe in the croſs bearer V, one end of which moves on an iron bolt in the perpendicular frame, and its other end hanging by the rod VV, that goes up through the floor, and has a lever on its upper end called the *mill-band*. By pulling the longer arm of this lever up and down, the croſs bearer V is raiſed or depreſſed at pleaſure, likewiſe along with it the bridge-tree UU and upper millſtone. Thus the upper millſtone may be raiſed as high from the lower one, or let down as cloſe to it as the miller thinks proper; by which means the meal is ground either coarſe or fine at pleaſure, or what is commonly called greater or ſmaller. Upon a frame above the millſtones is placed the hopper K that contains the corn; being open at bottom, and having a ſpout below it, or what is called the *mill-ſhoe*, which is open at the fore-part to convey the grain from the hopper into the hole in the middle of the running millſtone, termed the *eye* of the ſtone. The upper millſtone is encloſed in a round box K called the *crib* or *caſes*, which leaves a vacant ſpace of about an inch and a half all round, to allow the running millſtone freedom to work when ſhealing or clearing the huſk from the grain. The ſquare on the upper end of the iron ſpindle riſes a little above the rind, upon which is put the feeder, having three or four branches that ſtrike on the ſhoe as they revolve, and give it a ſhaking motion; by this means the corn runs conſtantly and equally down from the hopper K through the ſhoe into the eye of the running millſtone, where it is introduced betwixt the ſtones; and by the violent circular motion of the upper one, the grain acquires a centrifugal force; which proceeding gradually from the eye of the millſtone towards the circumference, is thrown at laſt out in meal at the opening called the eye of the mill, in which is fixed a ſpout to convey the meal down into a box or trough placed below to receive it. GG, a belt or band of leather going on the ſheeve or whorl fixed upon the ſpindle below the trundle D, and upon the ſheeve at H, which is faſtened upon an iron ſpindle having a bend or crank, that when turned round by the band moves or ſhakes the wire-ſieve SH to and fro. By this means a good part of the ſmall refuſe paſſes through the ſieve as the grain runs from the millſtones along it to the hopper of the fanners HH. The lower end of the perpendicular iron ſpindle KE is fixed to the feeder, and turned round along with the trundle D. Upon the upper end of this ſpindle, at E, is fixed a ſmall wheel, having teeth to turn a wheel faſtened upon the horizontal ſpindle EE; and upon its other end is fixed a ſheeve or whorl, on which goes the rope or band ZZ, paſſing round a ſheeve on the axle of the fanners below, to drive them round and clear the duſt or refuſe from the grain. FF, An axle, upon which is fixed a wheel having 14 teeth, and is turned by the wheel CC. By one end of the rope WW, rolling round this axle, a ſack or bag of grain is carried in its other end up to the loft. By pulling the cord QQ, the wheel and axle FF is ſet agoing, and by pulling the cord Y it is ſtopped at any time; but when the bag of grain is raiſed above the uppermoſt loft, then the machine ſtops of itſelf (which is plainly ſeen in Plate XIX.) MM, Two large hoppers placed on the upper floors for containing corn, from either of which it may be conveyed down to the ſmall hopper K, and ſo through the ſpout ſhoe into the eye of the upper millſtone, where it is introduced betwixt the ſtones, and ground into meal. Some have ſuppoſed the ſpringing of the bridge-tree UU, upon which the iron ſpindle turns, carrying the running millſtone, and giving the ſtone a dancing motion, helps to grind the corn; but this muſt be a great miſtake, becauſe the ſtiffer the bridge-tree and the firmer it is kept, the ſteadier the millſtone will revolve, and of courſe execute the work more equally, which is ſeen in practice, when the bridge-tree is not of ſufficient ſtrength in proportion to the weight of the upper millſtone. Neither the ſpringing of the bridge-tree, nor the extraordinary weight of a running millſtone, does at all contribute to the grinding of a greater quantity of corn. A ſtone five inches thick will grind as much corn in the ſame time as a ſtone of ten inches thick, ſuppoſing the grain equal, the millſtones of the ſame quality, the ſame diameter, and moving with equal velocity.

Plan of a Mill for making Pot and Pearl Barley, and Cylinders for Bruiſing Malt.

PLATE XXI.

AA, The water wheel, fixed upon its ſhaft or axle BB; upon which axle is alſo faſtened the wheel CC, containing 108 teeth or cogs, to turn the wheel D, No. 1. having 25 teeth, which is fixed upon the axle GH. On this axle is alſo faſtened the wheel G, No. 2. containing 66 teeth, to drive the pinion No. 3. having 17 teeth, which is fixed upon an iron axle or ſpindle that carries the millſtone. There is likewiſe a wheel faſtened upon the axle GH at H, containing 21 teeth, to turn the wheel No. 4. having 33 teeth, which is fixed upon an iron ſpindle, on which is likewiſe faſtened a pinion containing 9 teeth, to drive the wheel No. 5. having 86 teeth, fixed upon the frame or caſe H, that ſurrounds the millſtone, leaving a ſpace about two inches all round and on each ſide, to contain the barley. This caſe is covered with milled or plate iron, pierced pretty thick of ſmall holes, to allow the duſt and ſmall refuſe to eſcape through as it is rubbed off the grain by the circular motion of the millſtone and caſe that encloſe it. II, Are pillars that ſupport the bearers upon which the gudgeons, iron axles, and caſes of the millſtone turn. LL, The headſtocks that the gudgeons of the axle BB revolve on. No. 6. a wheel fixed upon the axle DE, containing 25 teeth, driven by the wheel CC. On the ſame axle is faſtened the wheel No. 7. in which are 66 teeth, to turn the pinion No. 8. having 14 teeth, which is fixed upon an iron axis that has a coupling box to take hold of a ſquare on the gudgeon in one of the cylinders FF, to drive them round and bruiſe the malt as it paſſes down betwixt them. Theſe cylinders are made of caſt iron and hollow; their gudgeons and themſelves muſt be perfectly round, and equidiſtant from each other their whole length, in order that the malt may be equally bruiſed. KK, The pillars which carry the bearers that the gudgeons of the cylinders turn on. VV, The courſe of the water that drives the wheel. MM, The machine and handle to raiſe the fluice to let the water on the wheel. RR, The walls of the mill-houſe. T, An opening at which the ſacks of grain are conveyed up to the loft or hopper. OO, a door in the ground floor. NN, a ſtair leading up to the lofts. PP, Windows to light the mill-houſe.




S
K
N
M
T
N
P
R
S
S
O
O
L
M
T
T
P
R
A
K
L
M
K
L
G
I
I
C
F
T
V
E
X
B
D
G
X
H
B
E
O
O
C
0
1
2
3
4
5
10
15
20

Elevation of a Mill for making Pot or Pearl Barley.

PLATE XXII.

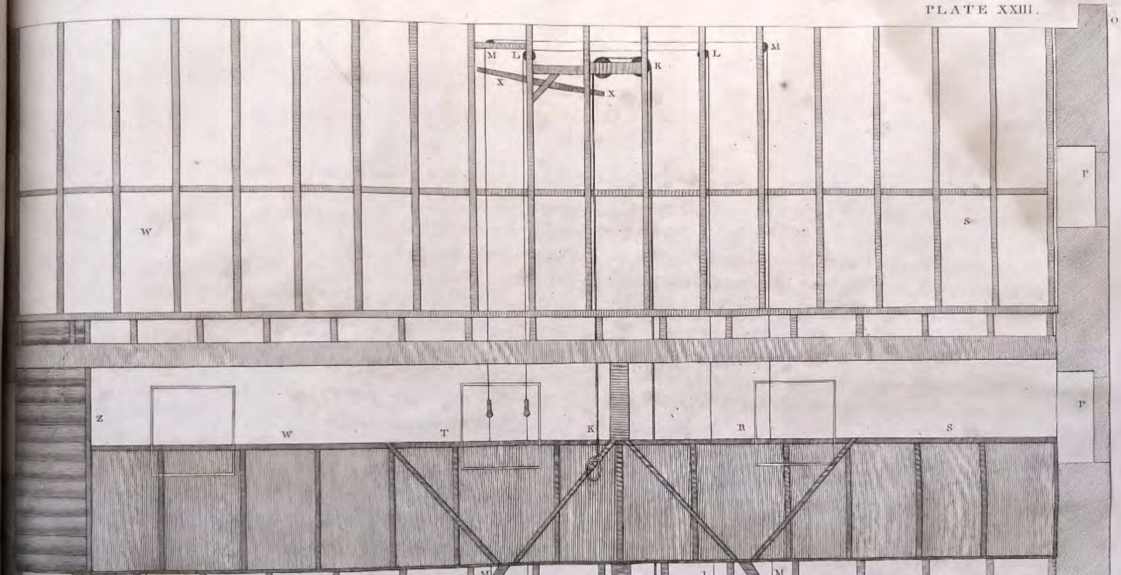
AA, The water wheel, fixed upon its ſhaft or axle BB; upon which is alſo faſtened the wheel CC, containing 108 teeth or cogs, to turn a pinion having 25 teeth, which is placed on the axle D. Upon this axle is likewiſe fixed the wheel EE, containing 66 teeth, to drive the pinion F of 17 teeth, which is faſtened on the iron axle or ſpindle that carries the millſtone. XX, Two wheels, one of which is fixed upon the axle D, having 21 teeth, that turns the other of 33 teeth, which is faſtened on an iron axis, upon which is placed a pinion of 9 teeth to drive a wheel having 86 teeth, which is placed on the frame or caſe GG that encloſes the mill-ſtone. There is a flench of caſt-iron fixed upon each ſide of the caſe, through which the iron axle which carries the ſtone paſſes, and on theſe flenches the caſe revolves in the frames. H, is a wire ſieve below the caſe, by which the great barley may be ſeparated from the ſmall. II, a wheel and axle turned by the wheel CC. Round this axle the rope KK rolls, to carry up the bags of grain to the boxes or hoppers P, R; from either of which it may be conveyed down to the machine. By pulling the cord MM a little, the wheel and axle II are ſet agoing; and by pulling the cord L, they are ſtopped at any time: But when the bag of grain, hanging by the rope K, is raiſed up to the lever NN, it puſhes up one end of the lever, and of courſe down the other end, to which the cord LL is attached. By this means the machine ſtops itſelf. OO, Are the ſide-walls of the mill-houſe. S, The couples or frame of the roof. V, a door in the ſide-wall; and TT, windows to light the houſe.

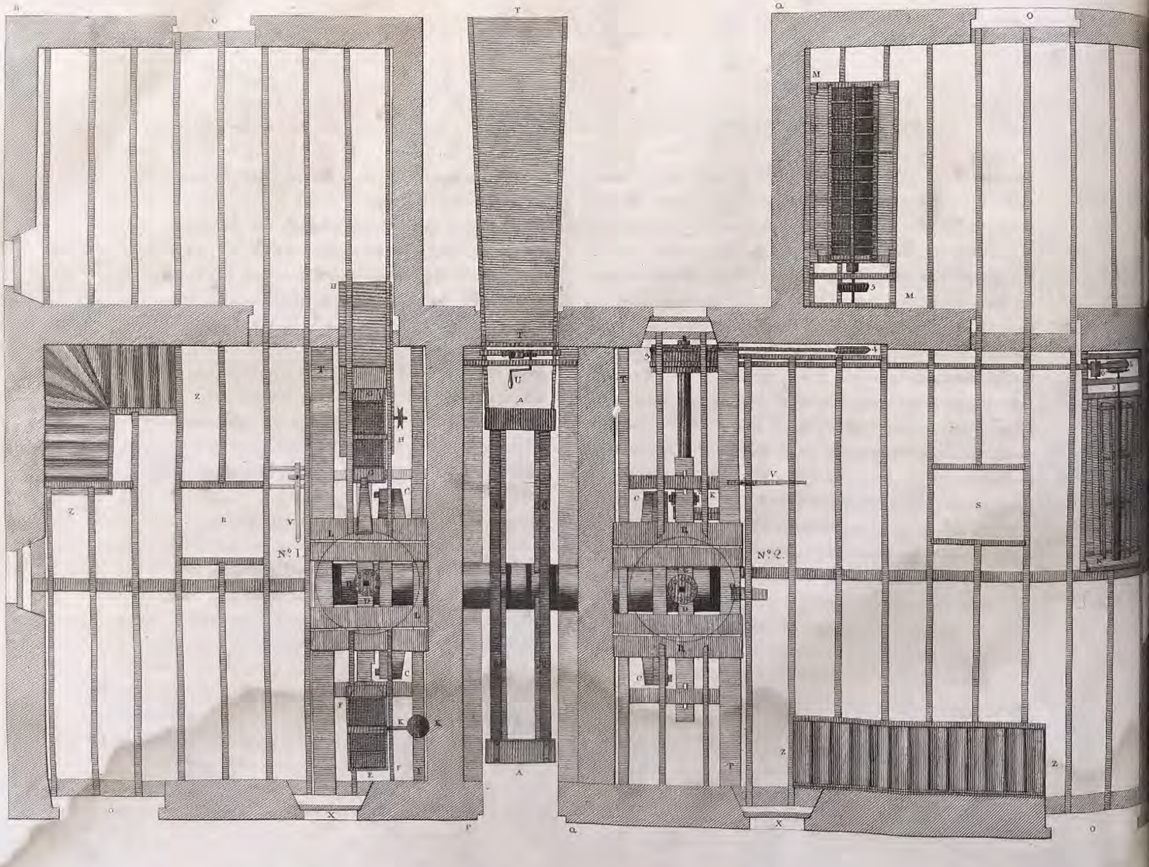
A a

Section of a Mill for making Pearl Barley, and Cylinders for Bruising Malt.

PLATE XXIII.

AA, The great wheel containing 36 floatboards or oars, on which the water acts to drive the wheel round. C, The shaft or axle of the water wheel. BB, a wheel fixed on the same shaft, having 108 teeth, to turn the wheel G No. 2. containing 25 teeth, which is fastened upon an horizontal axle. On this axle is also fixed the wheel No. 3. having 66 teeth, to drive the pinion No. 4. containing 17 teeth, which is fastened upon the iron axle or spindle that carries the millstone represented by the circle I I. D, No. 5. a pinion having 25 teeth, turned by the wheel B, which is fixed on an axle that carries the wheel E, No. 6. containing 66 teeth, to drive the pinion No. 7. having 14 teeth, which is fastened upon an iron axis served with a coupling box that connects it with the gudgeon in one of the bruising rollers to turn it round; by which motion is communicated to the other cylinder F, when screwed up to the one on the axle of No. 7. Above the cylinders are placed a hopper and spout to convey or feed the malt constantly in betwixt the rollers to be bruised as the cylinders revolve. It is evident, that if two straight smooth rollers are opposed to each other at a distance which can be regulated at pleasure, when set to the proper distance, malt or any other similar substance cannot pass between them without being bruised. No. 8. a pinion, having 15 teeth, turned by the wheel B, which is fixed upon an axle, round which the rope KK rolls to carry the sacks of grain up to the boxes WS, or to the hoppers TR. This machine may be easily set agoing and quickly stopt at any time when the wheel is revolving. By pulling the cord LL, the pinion No. 8. is put into the grip or hold of the wheel B, and is kept in by a catch, to which a cord is fastened; and, passing over a sheeve at its other end, is suspended the weight No. 9. that pulls the catch on above one end of the bearer, in which the gudgeon of the pinion turns. By pulling the cord MM, this catch is taken off the bearer; then the weight No. 10. hanging by a cord going over two sheeves, and its other end fixed to the bearer of the pinion, pulls up that end of the bearer, and of course the pinion clear of the wheel B. But when the sack in the rope K is raised up to the lever X, the machine stops itself. YY, The frames that support the axles, the gudgeons of which and rounds of spindles should all turn in bushes of brass. NN, The sluice, machine, and handle that raises the sluice to let the water on the great wheel to turn it. OO, The gable or end walls of the mill-house. ZZ, a stair leading up to the lofts or upper floors. PP, Are windows to light the house.


M
L
K
L
M
X
X
W
S
P
P
P
Z
W
T
K
R
S
M
L
L
M
Y
Y
K
10
I
I
F
A
R
G
E
9
C
N
Z
H
D
B
B
N
A
O
O
0
1
2
3
4
5
10
15
20


N° 1.
N° 2.

Plan of a Flour Mill.

PLATE XXIV.

No. 1. *The Sheeling Mill with Wire Sieves and Fanners for cleaning or preparing Wheat to be ground into Flour.*—AA, Reprefents the water wheel, and BB its fhaft or axle. CC, a wheel faftened upon the fame fhaft, containing 84 teeth or cogs, to turn the trundle or pinion D, having 9 ftaves or rounds, which is fixed upon an iron axis called the *fpindle*; on the upper end of which is a fquare that goes into a fquare hole in a ftrong iron crofs called the *rind*, which being admitted into a groove in the under-fide of the running or upper millftone, carries the ftone round along with the trundle D. The under end of the iron fpindle turns in a brafs pot or ftep fixed on the bridge-tree; and the round near its upper end turns in a bufh of end-wood fixed in the hole through the middle of the under millftone. E is a coarfe wire harp, or fearce, that the wheat paffes through to the wire fieve FF; through which any fand or fmall feed falls down while the wheat runs along the fieve into a fpout that conveys it into the *eye* or hole in the middle of the upper millftone, where it is introduced betwixt the millftones; and by the circular motion of the upper ftone, any duft is rubbed off the grain, called *fheeling*. GG, a wire fieve, upon which the wheat runs from the millftones to the fanners HH, where it is cleaned or feparated from duft or any loofe refufe. Thus the grain is prepared to be ground into flour. KK, a fheeve or whorl fixed upon an iron fpindle having a bend or crank, which being turned round moves or fhakes the wire-fieve: by this motion the fand and fmall feed fall down through the fieve. This is clearly reprefented on Plates XXV. and XXVII. TT, The ftrong bearers or *fills* that fupport the lower millftone and cafes. The circle LL, reprefents the millftone and frame upon which it is laid. V, The lever or *handle* for raifing or depreffing the upper millftone when neceffary; fometimes a fcrew-nut is made ufe of for this purpofe. UU, The machine and handle, or crank, for raifing the fluice when the water is to be let on to drive the wheel AA, and turn the machine. PR, The walls and joifts of the fheeling mill-houfe. OO, Are doors in the mill-houfe. ZZ, Stairs leading up to the lofts. XX, Windows to light the houfe.

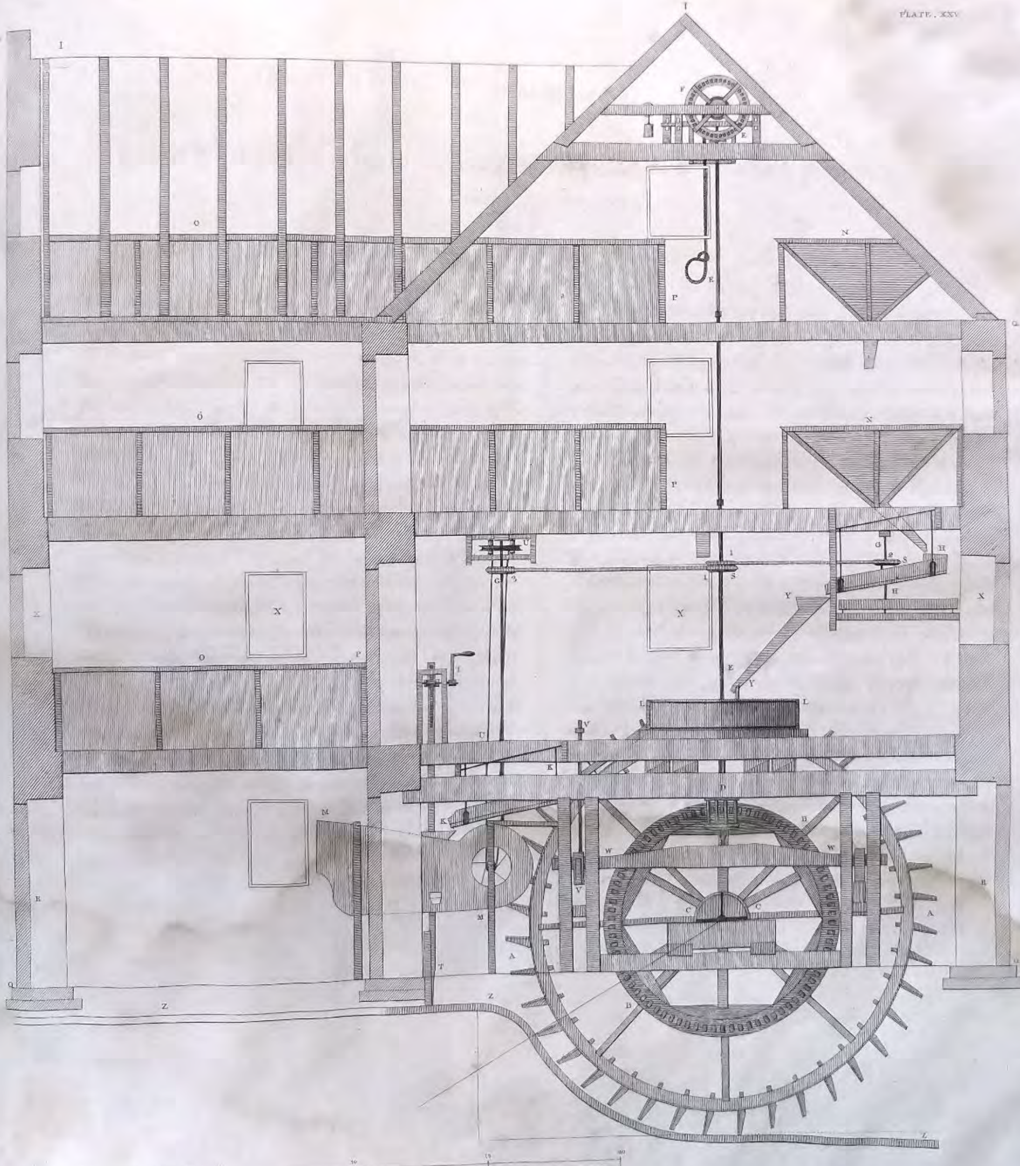
No. 2. *The Grinding Mill driven by the fame Water Wheel, with Bolting Mill and Bolting Wire Engine.*—CC, a wheel fixed upon the fhaft BB, containing 84 teeth or cogs, to turn the pinion or trundle DE, having ten ftaves or rounds, which is faftened upon an iron axis called the *mill-fpindle*; on the upper end of which is a fquare that takes on an iron crofs: This crofs is put into a groove in the under furface of the upper millftone, and by it the ftone is carried round along with the trundle. DE, The ftrong frames that fupport the under millftone are reprefented by TT; and the circle RR reprefents the millftone, with the frames upon which it is laid. V is a lever by which the upper millftone is raifed or depreffed at pleafure. K, No. 2. a pinion containing 15 teeth, and driven by the wheel CC. This pinion is fixed upon an horizontal axle, on which axle is alfo faftened the barrel No. 3. and on this barrel goes two leather belts or bands, one to drive the bolting wire engine, and the other to turn the bolting mill, according as the one or the other is to be made ufe of for bolting or feparating the flour from the bran or hufk. No. 4. a fheeve or whorl fixed upon an iron axis, and turned round by a leather belt from the barrel No. 3. There is faftened upon the fame iron axis a pinion No. 5. having 24 teeth, to drive the winch or reel of the bolting wire engine MM (which is plainly feen on Plate XXVI.) No. 6. a fheeve faftened upon the gudgeon in the axle of the winch or reel NN of the bolting mill, driven round by the leather belt L going upon the barrel No. 3. QQ, The walls and joifts of the grinding and bolting mill-houfe. S, a hatch or opening, at which the bags of flour are conveyed up to the bolting machines. X, Windows to light the mill-houfe.

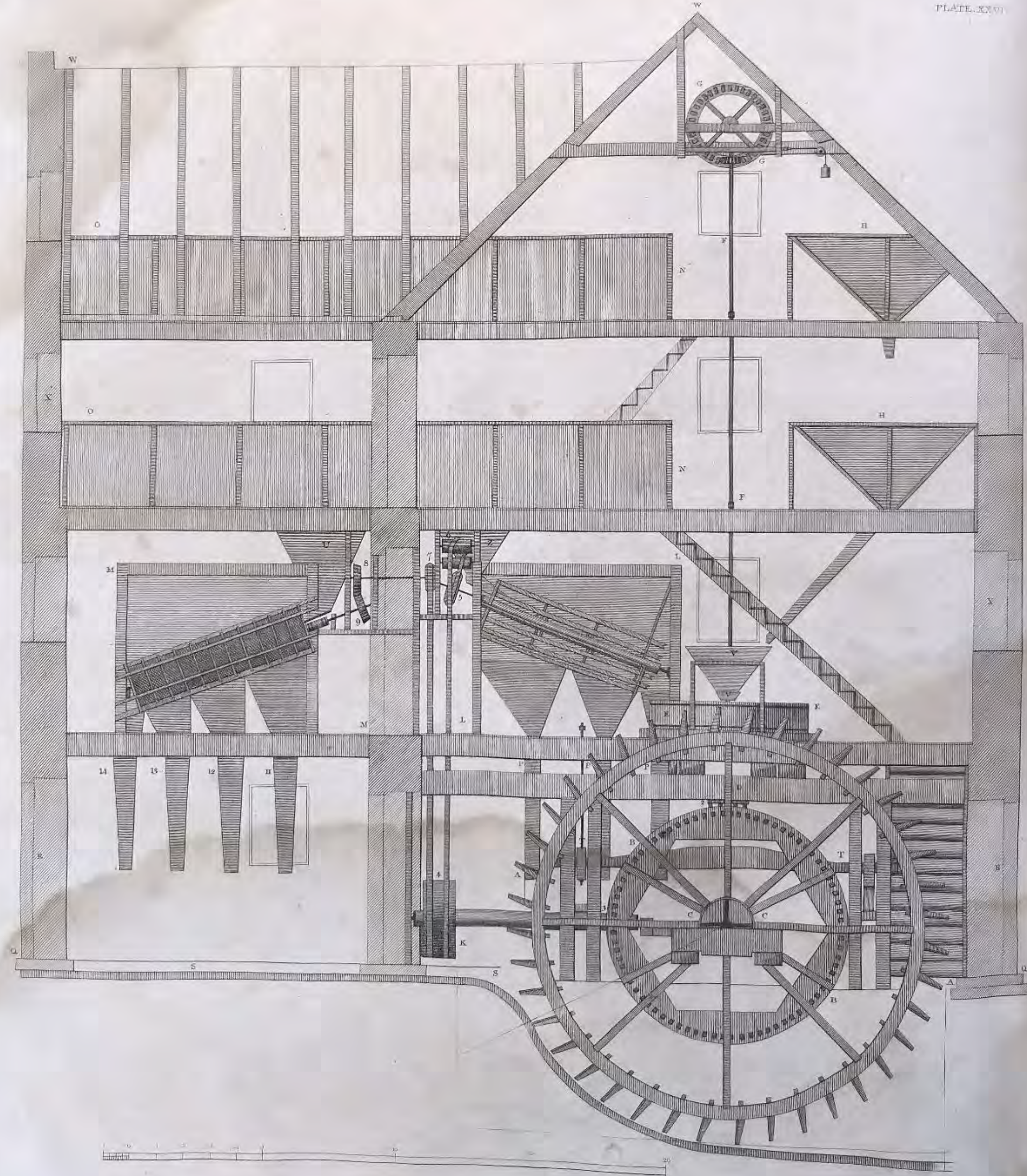
Section of a Sheeling Mill with Wire Sieves and Fanners for Clearing or Preparing Wheat to be Ground into Flour.

PLATE XXV.

AA, The great wheel, fixed upon the ſhaft CC, containing 40 floatboards, or *aws*, to receive the impulſe of the water to turn it round. BB is a wheel faſtened upon the ſame ſhaft, having 84 teeth or cogs to turn the trundle or wallower D of 9 ſtaves or rounds, which is fixed upon the iron axis or ſpindle which carries the upper millſtone round along with the trundle. ZZ, The fall or courſe of the water that turns the wheel AA, which drives the machinery. EE, An iron ſpindle for conveying motion to the windlaſs, ſack tackle, wire ſieves, and fanners. The ſpindle EE is turned round, by having a ſquare ſocket in its under end to take in a ſquare on the upper end of the iron axis that carries the trundle D. Upon the upper end of the ſpindle E is fixed a pinion containing 7 teeth, to drive the wheel FF, having 36 teeth, which is faſtened upon an axle, round which the rope rolls or coils (ſeen in Plate XXVII.) to carry the ſacks of wheat up to the lofts or hoppers. NN, Are two large hoppers for containing grain, from either of which it may be conveyed down to the wire ſieve HH; by which the wheat is ſeparated from any ſand or ſmall ſeed as it runs along upon the ſieve to the ſpout YY, which conveys it into the hole or eye in the middle of the running millſtone, and by the circular motion of the millſtones is ſheeled, or great part of the refuſe is rubbed off the grain. The upper millſtone, ſuppoſed four feet ſix inches diameter, is encloſed in a round box LL, called the *hoops* or *crib*, which leaves a vacant ſpace of about an inch and a half all round the circumference: this ſpace is neceſſary to give the ſtone freedom to work. GH, An iron ſpindle, upon which is fixed the ſheeve or whorl No. 2. In this ſpindle is a crank or bend, that when turned round by the leather belt S, going from the ſheeve No. 1. round the ſheeve No. 2. moves or ſhakes the wire-ſieve H, which motion aſſiſts to clear the wheat of ſmall refuſe. No. 3. a ſheeve or whorl faſtened upon the ſpindle G, turned round by a leather band from the whorl S, and having a crank near its under end to move the wire-ſieve KK, upon which the wheat runs from the millſtones to the fanners MM, to be cleaned of all looſe refuſe, and prepared to be ground into flour. UU, a rope or band which turns fanners, by paſſing round a ſheeve on the ſpindle G. WW, The bridge-tree, on which the ſpindle that carries the upper millſtone turns round in a cod or pot of braſs. One end of the bridge-tree goes into a mortiſe in the fixed frame, and its other end in a moveable one. VV is the bearer, iron rod, and lever or mill-hand for raiſing or depreſſing the bridge-tree WW; by which means the upper millſtone is lifted farther up or let down nearer to the under one when neceſſary. TT, The ſluice, machine, and handle for raiſing the ſluice, to let the water on the wheel AA, to drive it. OP, Different boxes in the lofts for containing grain. QQ, The walls of the mill-houſe. II, The couples or framing of the roof. RR, Are doors in the walls. XX, Windows to light the mill-houſe.

PLATE . XXV




W
W
G
G
O
N
H
F
X
O
N
H
F
U
M
L
M
L
Y
E
E
14
13
12
11
P
P
P
R
A
B
T
B
C
C
K
Q
S
S
A
Q
B

Section of a Flour Mill with Bolting Machines.

PLATE XXVI.

AA, The great wheel, containing 40 floatboards or *aws*, on which the water falls to turn it round. CC, The ſhaft or axle upon which the water wheel is fixed, and gudgeon on which it revolves. BB, a wheel faſtened upon the ſame ſhaft, containing 84 teeth, to drive the trundle No. 2. of 10 ſtaves or rounds, which is fixed upon an iron ſpindle, having on its upper end a ſtrong iron croſs let into a groove in the middle and underſide of the running millſtone, by which the ſtone is carried round along with the trundle or pinion. D, The ſtrong frame upon which the under millſtone, ſuppoſed four feet eight inches diameter, is laid. The upper or running millſtone, being the ſame diameter with the under one, is encloſed in the round box EE, which leaves a ſpace of about two inches all round to allow the ſtone room to work. HH, Are two hoppers into which the clean wheat is put; and from any of theſe hoppers it may be conveyed down in a ſpout into the ſmall hopper V, under which is the ſpout or ſhoe V, to be ground into flour. FF, An iron ſpindle, having a ſquare ſocket in its lower end, which takes in a ſquare on the upper end of the iron ſpindle above the ſtrong iron croſs that carries the upper millſtone. On the upper end of the ſpindle F is fixed a pinion containing 7 teeth, to turn the wheel GG, having 36 teeth, which is fixed upon an axle round which the rope rolls to carry the bags of ground flour up to the cooling benches N and O; from which it may be conveyed down either to the bolting wire engine MM, or to the bolting machine LL, to be ſeparated from the bran. K, An horizontal axle, upon one end of which is fixed a pinion No. 3. driven by the wheel BB, and having 15 teeth. No. 4. is a barrel faſtened upon the other end of the axle K, on which there are two leather belts or bands that drive the bolting machines; the one going on the ſheeve No. 5. fixed upon the gudgeon in the axle of the winch or reel, upon which is put the bolting cloth that ſeparates the flour from the bran. No. 6. Are rollers for conducting the leather band to the ſheeve No. 5. and ſtraitening it when neceſſary. Z, The hopper, having a ſpout or ſhoe affixed to it, for conveying the flour into the bolt-cloth on the reel, through which cloth the flour eſcapes while the bran runs out at the lower end. PPP, The ſpouts to which ſacks or bags are hooked to receive the flour and bran as it falls down from the machine. No. 7. a ſheeve fixed upon an iron axis, driven by a leather belt going round on the barrel No. 4. Upon the ſame iron axis is fixed a wheel No. 8. containing 24 teeth, to turn the wheel No. 9. having 25 teeth, which is faſtened upon the gudgeon in the axle of the winch or reel of the bolting wire engine. U, a hopper and ſpout for conducting the flour into the wire engine. 11, 12, 13, 14, Are ſpouts in which the flour and bran run down from the engine into ſacks or bags hooked to their lower ends. SS, The fall or courſe of the water to drive the wheel AA, which turns the machinery. QQ, The ſide walls of the mill-houſe. WW, The couples or framing of the roof. RR, Doors in the walls. XX, Windows to light the mill-houſe.

Elevation of a Flour Mill.

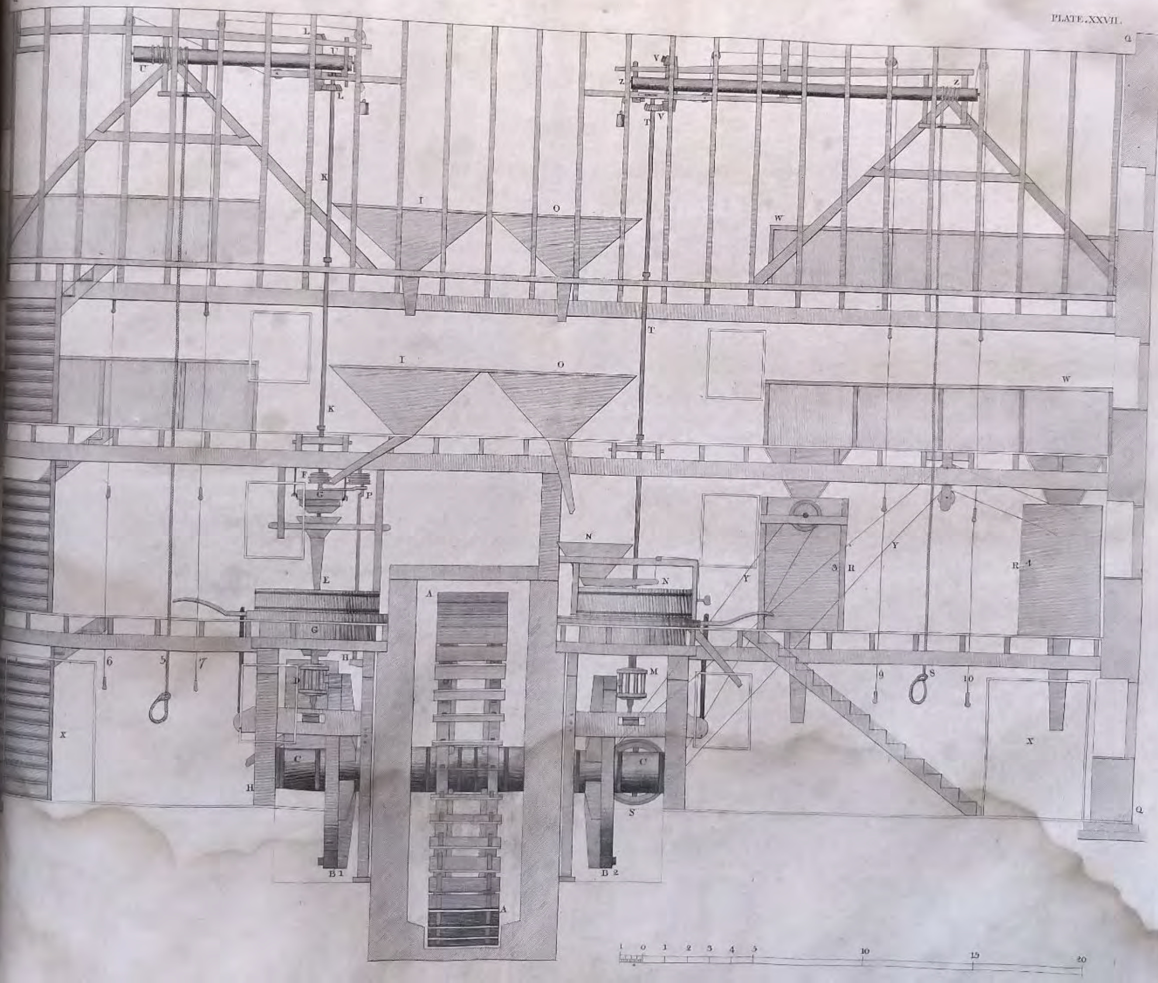
PLATE XXVII.

AA, The water wheel. CC, The ſhaft or axle of the water wheel. B, No. 1. a wheel fixed upon the ſame axle, containing 84 teeth or cogs, to turn the pinion or trundle D, having nine ſtaves or rounds, which is faſtened upon the iron axis or ſpindle, having on its upper end an iron croſs that carries the upper ſheeling millſtone round. There are two of the ſtaves in the trundle D, made ſo as to be eaſily taken out when the ſheeling machines are to be ſtopt, while the grinding mill is at work. HH, The frame that ſupports the under millſtone G, and the box or caſe that ſurrounds the upper millſtone. KK, Is an iron ſpindle, having in its lower end a ſquare ſocket that takes in a ſquare on the upper end of the iron ſpindle that carries the trundle D; and upon its upper end is fixed the pinion L, containing 7 teeth, to turn the wheel UL having 36 teeth, which is faſtened upon the axle UU, round which the rope No. 5. rolls to raiſe up the ſack or bag of wheat to the lofts or to the hoppers II. From either of theſe hoppers it may be conveyed down to the wire-ſieve G, ſuſpended by rods of iron, and moved by the crank P, being turned round by a leather belt going on the ſheeve F, fixed upon the ſpindle K and on a ſheeve upon the iron ſpindle P. Thus the wheat is cleared of ſand and ſmall ſeed by paſſing over the wire-ſieve G before it enters the ſpout E, which conducts it into the *eye* or hole in the middle of the upper millſtone. The wheat having gone through the operation of ſheeling iſſues out at an opening in one ſide of the caſe upon a wire-ſieve, over which it runs into the fanners, and is cleaned. The wire-ſieves and fanners are plainly ſeen in Plates XXIV. and XXV. The wheat, thus cleaned, is received into a bag from the fanners, and carried up by the rope No. 5. to any of the hoppers OO. From either of theſe hoppers it will run down in the ſpouts into the ſmall hopper N placed on the frame above the millſtones.

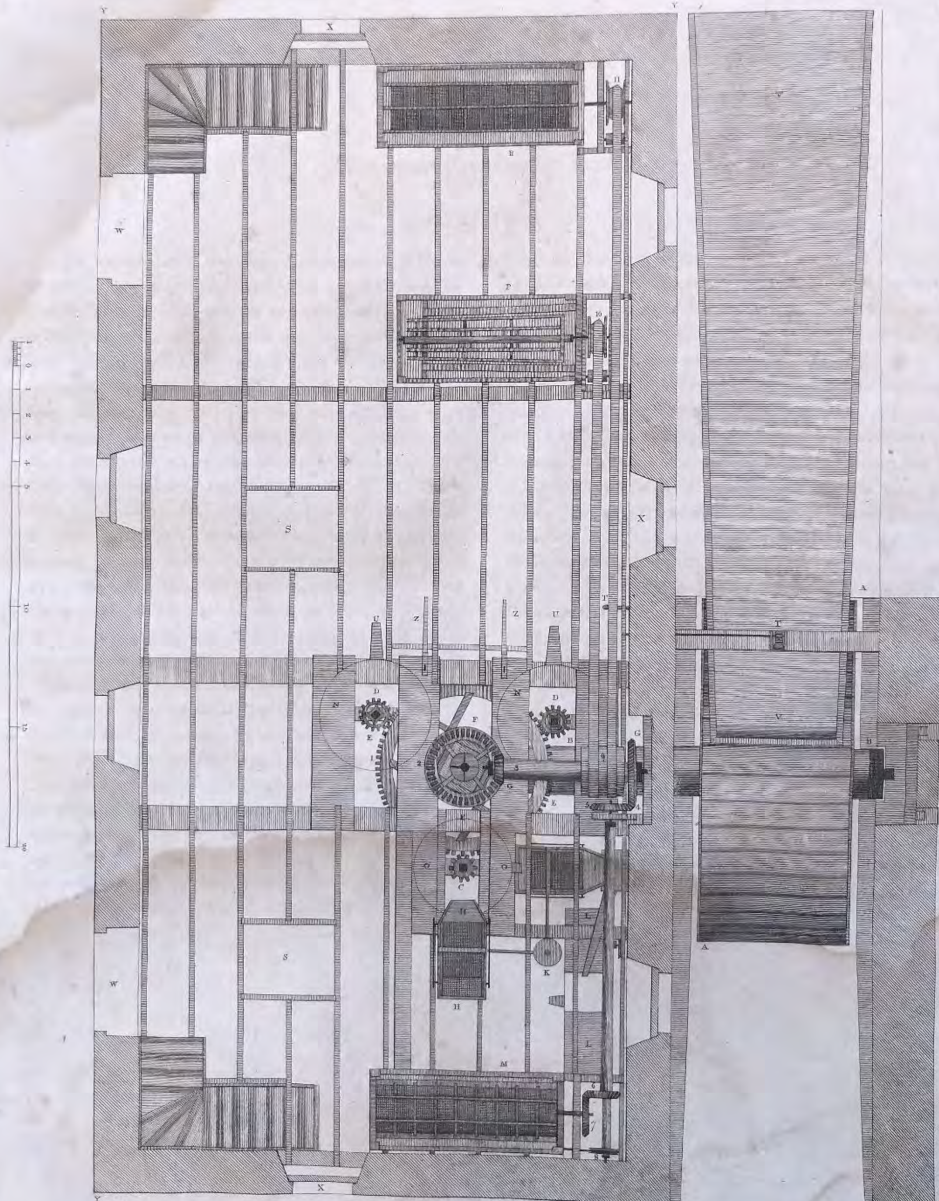
By pulling the cord No. 6. the wheel UL and axle UU are ſet agoing; and by pulling the cord No. 7. it is ſtopt at any time. But when the ſack of wheat is to be carried to the uppermoſt floor, the machine ſtops itſelf.

B, No. 2. a wheel fixed upon the other end of the axle C, containing 84 teeth, to drive the trundle M having 10 ſtaves or rounds, which is faſtened upon an iron axis called the mill ſpindle, the under end of which turns in a braſs pot or ſtep fixed on the upper ſide of the bridge-tree; and its round near the upper end turns in a buſh of end-wood faſtened in a hole through the middle of the under millſtone. There is a ſquare on the top part of this ſpindle above the wooden buſh, that goes into a ſquare hole in an iron croſs, called the *rind*, which enters into a groove in the middle and under ſurface of the running millſtone. Thus the ſtone is turned round along with the trundle M, and is alſo raiſed or depreſſed at pleaſure by a rod of wood or iron connected with the bearer that ſupports the bridge-tree and a lever called the *mill-hand*; by which means the upper millſtone is raiſed up from the under one, or let cloſe down to it, according as the flour is wanted coarſe or fine. There are wads or channels cut in the ſurface of the millſtones which aſſiſt in grinding and throwing out the flour. The manner of laying out theſe wads is repreſented in Plate XXX. The upper millſtone is encloſed in a round box or caſe, which leaves a vacant ſpace of two inches all round. Upon the top of this box is a frame on which are placed the hopper and ſpout or ſhoe NN, by which the wheat is conveyed into the *eye* or hole in the middle of the upper millſtone. TT, Is an iron ſpindle having in its under end a ſquare ſocket that takes in a ſquare above the rind on the top of the ſpindle that carries the trundle M; by which means the ſpindle T is turned round, and by it the ſhoe N is jogged three or four times every revolution to feed the grain conſtantly down from the hopper through the ſhoe N into the eye of the millſtone, where it is introduced betwixt the ſtones, and by the violent motion of the upper millſtone acquires a centrifugal force; and, proceeding gradually from the eye of the millſtone towards the circumference, is thrown out at laſt in flour at a hole in one ſide of the caſe called the *eye* of the mill, in which is fixed a ſpout to convey it down to the trough or box below. Then it is put into a bag and carried up by the rope No. 8. to be laid in the cooling boxes WW, from which it may be conveyed down either to the wire-bolting engine No. 3. or to the cloth-bolting machine No. 4. and cleared from the bran. There is fixed upon the upper end of the ſpindle T a pinion, containing 7 teeth, to turn the wheel VV having 36 teeth, which is faſtened upon the axle ZZ, round which the rope No. 8. rolls to carry the ſacks of flour up to the cooling boxes WW. By pulling the cord No. 9. the wheel V with the axle Z is ſet agoing, and by pulling the cord No. 10. it is ſtopt at any time; but when the ſack is raiſed to the uppermoſt box W, then the machine ſtops itſelf. S, a barrel upon which go the leather belts YY, to turn the bolting machines. Theſe are clearly repreſented in Plate XXIV. RR, The frames of the bolting machines, having ſpouts fixed in their under ſides, in which the flour and bran run down. Theſe are plainly ſhewn in Plate XXVI. QQ, The gable or end walls of the mill-houſe, with windows to light the houſe. XX, Doors in the ſide walls.

PLATE XXVII.



L
U
L
K
I
O
W
V
Z
T
V
K
I
O
W
F
G
P
E
N
N
A
Y
3 R
Y
R 4
G
H
D
M
6
5
7
9
S
10
X
X
C
C
H
S
B 1
B 2
A
Q
Q
1 0 1 2 3 4 5 10 15 20



Plan of a Double Flour Mill.

PLATE XXVIII.

AA, The water wheel fixed upon the ſhaft or axle BB, upon which is alſo faſtened a wheel containing 90 teeth or cogs, to turn a wheel having 32 teeth, and is fixed upon the under end of the upright ſhaft, which carries the wheel E No. 1. containing 82 teeth. C, a pinion fixed upon the iron axis or ſpindle, that carries the ſheeling millſtone, driven by No. 1. and having 11 teeth. DD, Two pinions faſtened upon the ſpindles that carry the two grinding millſtones, turned by the wheel No. 1.: each of theſe pinions has 15 teeth. F, No. 2. a wheel faſtened upon the upper end of the upright ſhaft, containing 42 teeth, to turn the pinion No. 3. fixed upon the axle G, having 15 teeth. No. 4. is a wheel faſtened on the other end of the axle G, containing 36 teeth, to drive the wheel No. 5. having 17 teeth, which is fixed upon an horizontal axle, on the other end of which is faſtened the wheel No. 6. containing 26 teeth, to turn the wheel No. 7. having 19 teeth, which is fixed upon the gudgeon or pivot in the axle of the wire engine M, for cleaning the wheat in place of ſheeling millſtones. No. 8. a ſheeve or whorl on the axle of No. 5. upon which goes the rope or band to turn the fanners placed below, to ſeparate the grain from any duſt or looſe refuſe after paſſing through the engine. HH is a wire ſieve to clear the wheat of any ſand or ſmall ſeed before it is introduced into the eye of the ſheeling millſtone, repreſented by the circle F, ſuppoſed four feet diameter, and is laid upon the frame OO. From the millſtones the wheat paſſes over the ſieve I, into a ſpout that conveys it into the fanners LL, to be cleared of any light refuſe. K, a ſheeve or whorl fixed upon an iron ſpindle, having in it two bends or cranks to move or ſhake the two wire ſieves H and I, driven by a leather belt from a ſheeve on the iron ſpindle above the ſheeling ſtone, which is clearly ſeen in Plate XXIX. NN, The frame upon which the two under millſtones are laid. Theſe ſtones are repreſented by the two circles, and are ſuppoſed to be four feet ſix inches diameter. UU, Two ſpouts for conveying the flour from the millſtones down to the trough or box below. ZZ, The two levers for raiſing or depreſſing the running millſtone. This is often done by an iron ſcrewed nut. VV, The troughs or box that conveys the water to the great wheel. TT, The ſluice and machine to raiſe it, and let the water on the wheel AA to turn it round. No. 9. Is a barrel fixed upon the axle G, on which goes two leather belts to drive the bolting machines. No. 10. a ſheeve faſtened upon the gudgeon of the axle of the winch or reel of the bolting machine P, driven by one of the leather belts from the barrel No. 9. There is alſo a bolt cloth put upon the reel of this machine, through which the flour flies as the winch is driven round, and the bran runs out at the lower end of the bolt-cloth. No. 11. Is a ſheeve faſtened upon the gudgeon of the axle of the winch or bruſhes of the wire-bolting engine R, driven by a leather belt from the barrel No. 9. Both theſe machines may be uſed at once, or only one of them, as may be found requiſite. SS, Two openings in the floors, at one of which the ſacks of wheat are carried up by a machine to the upper lofts or hoppers, and at the other the ſacks of flour are carried up to the cooling benches above the bolting engines. YY, The walls of the mill-houſe, including the joiſts, ſtair, and machinery. WW, Are doors on the ground floor. XX, Windows to light the houſe.

Section of a Mill for Sheeling or Preparing Wheat to be Ground into Flour.

PLATE XXIX.

AA, The water wheel. BB, The ſhaft or axle of the water wheel. CC, a wheel fixed upon the ſame axle, containing 90 teeth or cogs, to turn the pinion No. 1. having 32 teeth, which is faſtened upon the perpendicular ſhaft H. No. 2. Is a wheel fixed likewiſe on the ſhaft H, containing 82 teeth, to drive the pinion D having 11 teeth, which is faſtened upon the iron axis or ſpindle, on the top of which is a ſquare that goes into a ſquare hole in an iron croſs. This croſs being admitted into a groove in the under ſide of the upper millſtone carries the ſtone along with the pinion D when turned round by the wheel. No. 2. EE, Are frames that ſupport the bearer in which the under gudgeon of the ſhaft H turns. SS, The bearers that ſupport the bridge on which the lower end of the iron axis that carries the upper millſtone turns round. One of theſe bearers S is fixed, having in it a mortiſe to take in one end of the bridge; the other bearer S having a mortiſe to receive the other end of it. This laſt bearer moves on a bolt at one end, its other end hanging by a rod of wood or iron, which has either a lever to raiſe it, or a ſcrewed nut which, being turned one way, raiſes up the bearer S with the bridge, and of courſe the iron ſpindle and millſtone; and being turned the other way, depreſſes the bridge and ſtone when neceſſary. F, a beam that ſupports the frame upon which the under millſtone is laid. In the middle of the under ſtone is a hole or eye, in which is fixed a buſh of wood for the upper end of the iron ſpindle that carries the running millſtone to turn in. GG, The caſe or box that ſurrounds the upper ſtone, leaving a ſpace of about two inches clear of the ſtone all round. PP is an iron ſpindle, in the lower end of which is a ſquare hole or ſocket that takes in a ſquare on the upper gudgeon of the axle H. On the upper end of this ſpindle is fixed a pinion, having 9 teeth, to turn the wheel RR containing 48 teeth, which is faſtened upon the axle round which the rope UU rolls to carry the ſacks of wheat up to the lofts or to the hoppers. By pulling the cord QQ, the wheel R with its axle is ſet agoing; and pulling the cord ZZ, the wheel and axle are ſtopt. But if the ſack be raiſed up to the lever at QZ, it puſhes that end of the lever up, and of courſe down the other end: by this means the machine ſtops itſelf. O, is a hopper to hold the wheat, and from which it runs down upon the wire ſieve L, which clears it of ſand and ſmall ſeed before it be introduced into the hole or eye in the middle of the upper millſtone. M, a ſpout in which the wheat runs from the millſtones to the under ſieve and fanners N to be cleared of duſt or ſmall refuſe. No. 3. a wheel fixed upon the ſhaft H, containing 42 teeth, to turn the pinion No. 4. having 15 teeth, which is faſtened upon the axle K. No. 5. is a wheel fixed upon the ſame axle, containing 36 teeth, for conveying motion to the ſheeling wire engine, which is plainly ſeen in Plate XXVIII. No. 6. is a ſheeve or whorl faſtened upon the iron ſpindle T, driven by a leather belt going on the ſheeve No. 7. In this iron ſpindle are two bends or cranks to move or ſhake the wire ſieves as they turn round. YY, The machine and handle that raiſe the ſluice to let the water on the wheel A to drive it round. XX, The ſide walls of the mill-houſe. V, The couples or frame of the roof. U, a ſtair leading to the upper floors. WW, Windows to light the houſe.

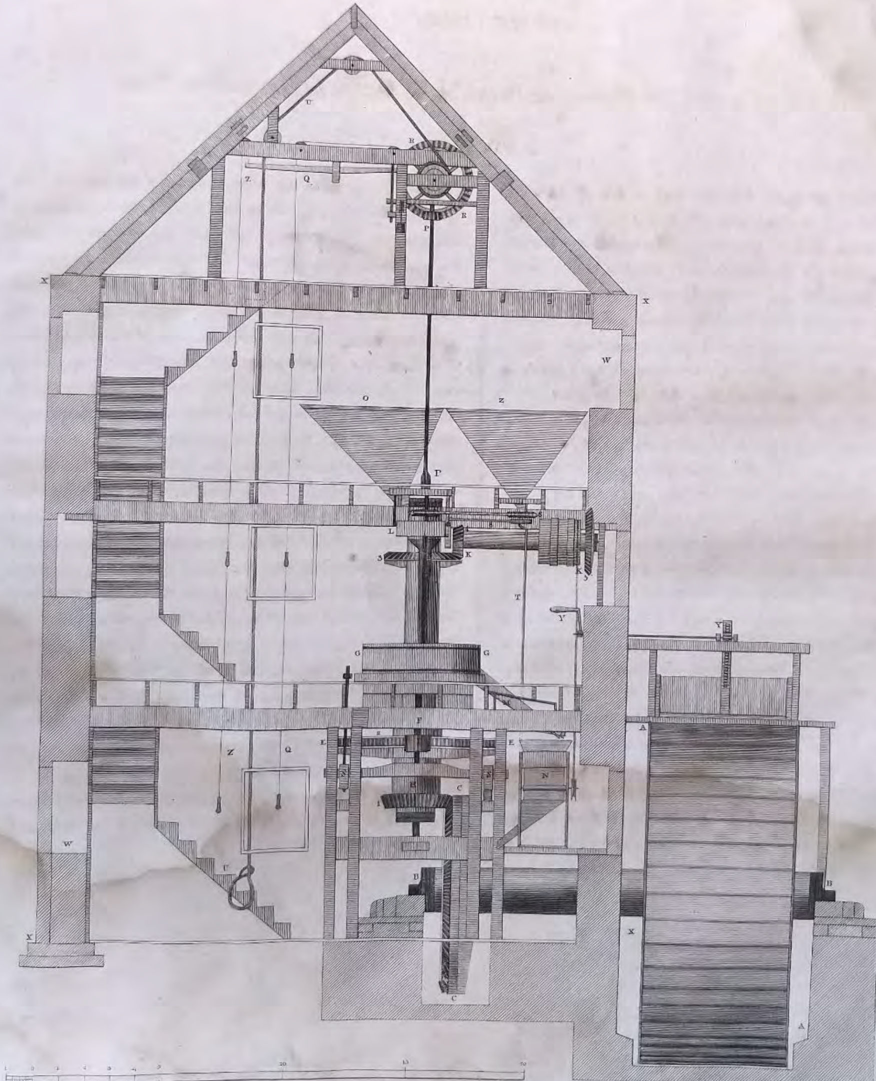
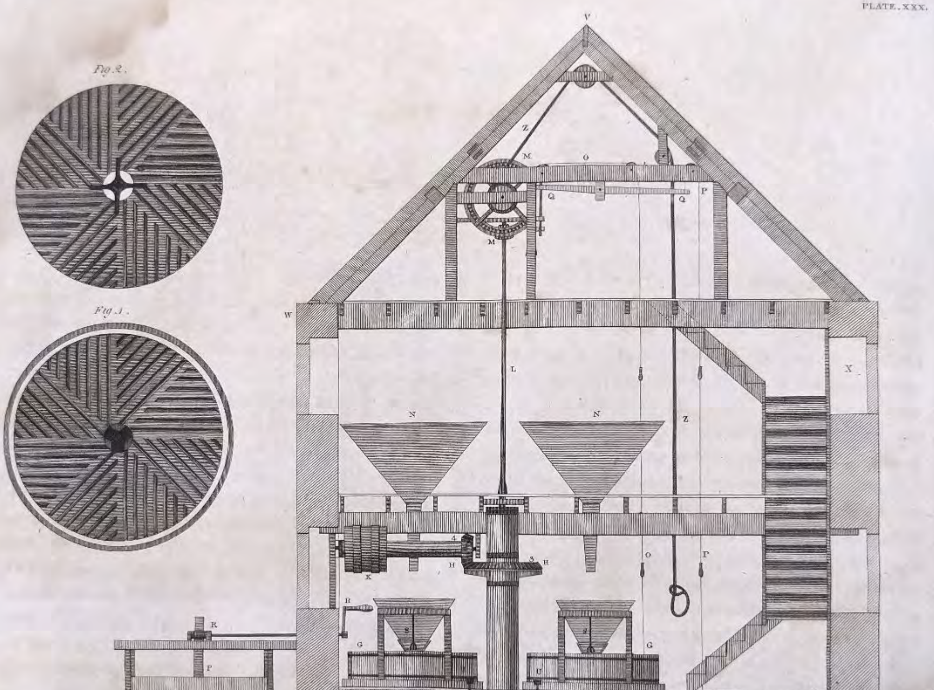


Fig. 2.

Fig. 1.



Section of a Double Flour Mill.

PLATE XXX.

AA, The water wheel. BB, Its ſhaft or axle. CC, A wheel fixed upon the ſame ſhaft, containing 90 teeth or cogs to drive the pinion No. 1. having 32 teeth, which is faſtened upon the perpendicular ſhaft D. No. 2. a wheel fixed upon the ſhaft D, containing 82 teeth, to turn the two pinions FF, having 15 teeth, which are faſtened upon the iron axles or ſpindles that carry the two upper millſtones. EE, the beam or ſill that ſupports the frame on which the under millſtones are laid. GG, The caſes or boxes that encloſe the two upper millſtones, which ſhould be two inches clear of the ſtone all round its circumference. TT, the bearers, called the *bridge*, upon which the under end of the iron ſpindles turn; theſe ſpindles paſſing up through a hole in the middle of the under millſtones, in each of which is fixed a wooden buſh that their upper ends turn in. The top part of the ſpindles, above the wooden buſh, is made ſquare, and goes into a ſquare hole in an iron croſs, which is admitted into grooves in the middle and under ſurface of the upper millſtone. By this means the ſtone is carried round along with the trundles FF, when turned by the wheel No. 2. One end of the bridges TT, is put into mortiſes in fixed bearers, and the other end into mortiſes in the bearers that move at one end on iron bolts, their other ends hanging by iron rods having ſcrewed nuts, as UU, ſo that when turned forward or backward they raiſe or depreſs the upper millſtones, according as the miller finds it neceſſary. SS, The feeders, in the under end of which is a ſquare ſocket that goes on upon the ſquare of the ſpindles, above the iron croſs or rind, and having three or four branches that move the ſpout or ſhoe, and feed the wheat conſtantly from the hoppers into the hole or eye of the upper millſtone, where it is introduced betwixt the ſtones; and, by the circular motion of the upper ſtone, acquires a centrifugal force; and proceeding gradually from the eye of the millſtone towards the circumference, is thrown at laſt out in flour or meal. RR, The ſluice, machine, and handle to raiſe the ſluice, and let the water on the wheel A to drive it round. No. 3. is a wheel fixed upon the ſhaft D, containing 44 teeth, to turn the pinion No. 4. having 15 teeth, which is faſtened upon the horizontal axle H. On this axle is alſo fixed the barrel K, on which go the two leather belts that turn the bolting wire engine and bolting mill (plainly repreſented in Plate XXVIII.) L, An iron ſpindle, in the under end of which is a ſquare ſocket that takes in a ſquare on the top of the gudgeon of the perpendicular ſhaft D. There is a pinion M, fixed on the upper end of the ſpindle L, containing 9 teeth, to turn the wheel MM, having 48 teeth, which is faſtened upon the axle, round which the rope ZZ rolls, to carry the ſacks of flour up to the cooling benches. (This is clearly ſeen in Plate XXXI.) By pulling the cord OO a little, the wheel MM and its axle are ſet agoing; and by pulling the cord PP, the wheel with its axle are ſtopped at any time. But when the ſack of flour is raiſed up to the lever Q, it puſhes up that end of the lever, and of courſe the other end down; by which means the pinion M is diſengaged, and thus the machine ſtops itſelf. NN, Are two large hoppers, into which the clean wheat is put to be conveyed down to the hoppers SS, placed on the frame above the millſtones. WW, The ſide walls of the mill-houſe. V, The couples or frame of the roof. XX, Windows to light the houſe.

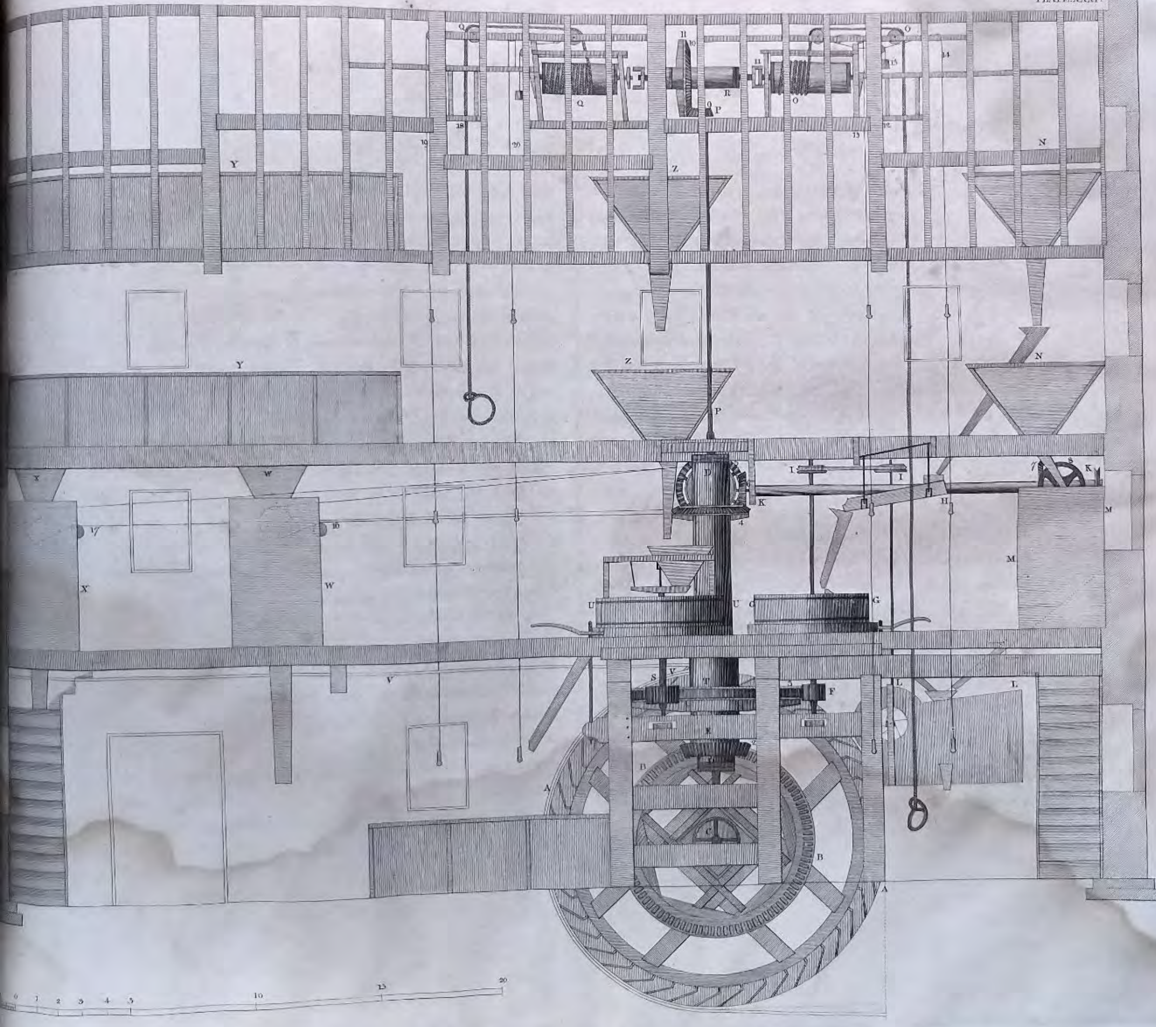
Fig. 1. Repreſents the ſurface of the under grinding millſtone; the way of laying out the wads or channels; the wooden buſh fixed into the hole in its middle, in which the upper end of the iron ſpindle turns round; and the caſe or hoops that ſurround the upper one, which ought to be two inches clear of the ſtone all round its circumference.

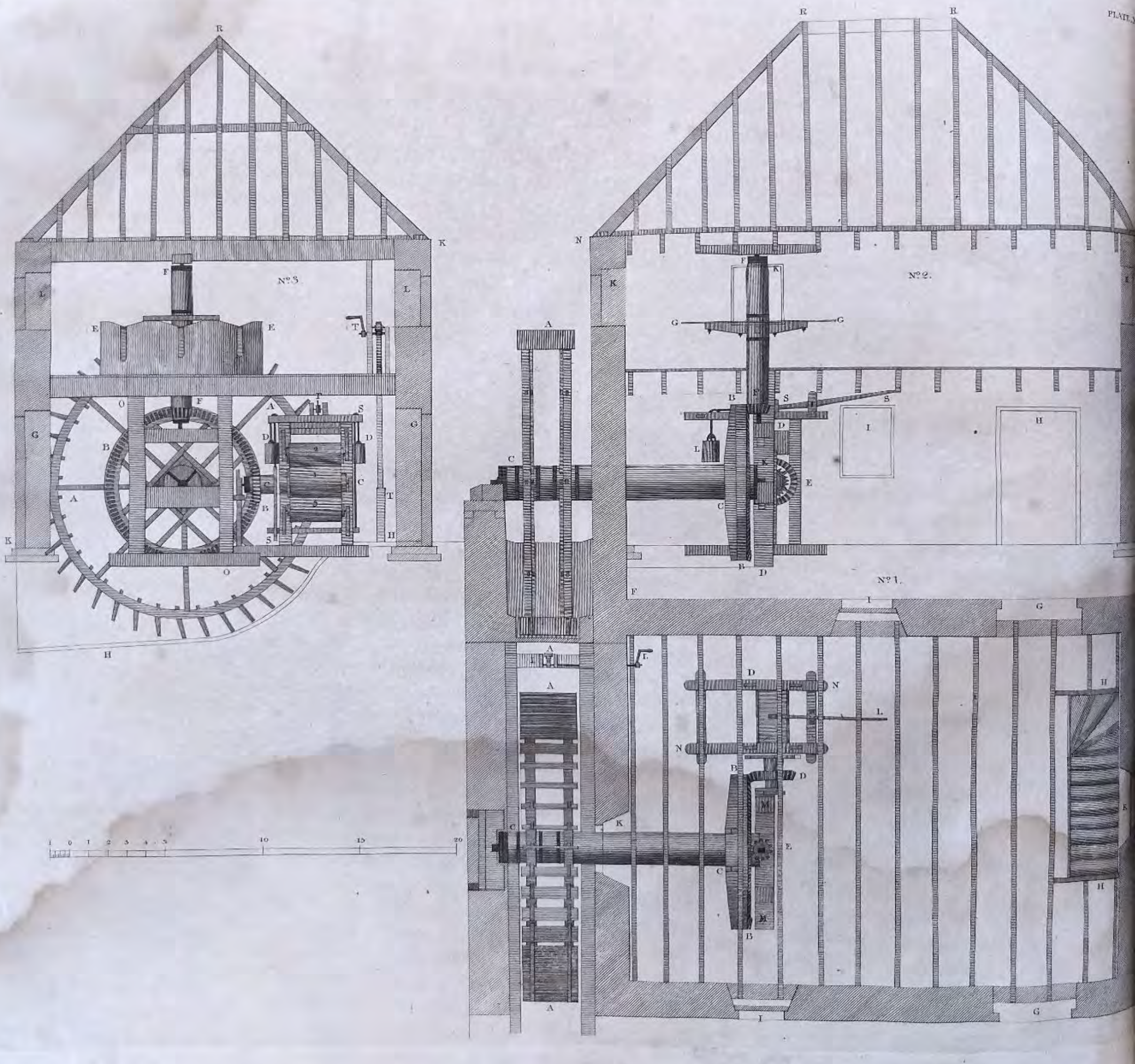
Fig. 2. The upper grinding millſtone, and iron croſs or rind in its middle; in the centre of which is a ſquare hole that takes in a ſquare on the top of the iron ſpindle, to carry the millſtone round. When the working ſides or faces of the millſtones are laid uppermoſt, the roads muſt lie in the ſame direction in both, that when the upper ſtone is turned over, and its ſurface laid on the under one, then the channels croſs each other, which aſſiſts in grinding and throwing out the flour. The roads are alſo laid out according to the way that the upper ſtone revolves. In theſe the running millſtone is ſuppoſed to turn *sun-ways*, or what is called a right handed mill; but if the ſtone revolves the other way, the channels muſt be cut the reverſe of this, and then it is termed a left-handed mill.

Elevation of a Double Flour Mill.

PLATE XXXI.

AA, a wheel containing 42 buckets, to receive the water carried above it by the trough or ſpout VV. The water falls into the bucket at VS. Theſe buckets retain the water until the wheel, moving round, diſcharges it immediately below the centre of the ſhaft, where the bucket begins to aſcend. C, The ſhaft upon which the wheel A is fixed, and gudgeon on which it revolves. BB, a wheel faſtened upon the ſame ſhaft, containing 90 teeth, to drive the pinion No. 2. having 32 teeth, which is fixed upon the perpendicular axle DD. No. 3. is a wheel faſtened on the ſame axle, containing 82 teeth. F, a pinion fixed upon the iron axis that carries the upper ſheeling millſtone, having 11 teeth, and driven by the wheel No. 3. GG, The crib or caſe that encloſes the ſheeling millſtone. H, The upper wire ſieve, which clears the wheat of ſand or ſmall ſeed as it comes from the hopper NN, to the ſpout that conveys it into the eye of the upper millſtone. II, Two ſheeves or whorls, fixed on two iron ſpindles, with a leather belt paſſing round both, to move or ſhake the wire ſieves. (This is plainly ſeen in Plate XXIX.) LL, Are fanners for cleaning the wheat, after paſſing through betwixt the ſheeling millſtones and over a wire ſieve. MM is a wire engine for cleaning the wheat, in place of ſheeling millſtones (which is ſeen in Plate XXVIII.) No. 4. a wheel fixed upon the ſhaft D, containing 44 teeth, to turn a pinion having 15 teeth, upon the axle of which is faſtened the wheel No. 5. containing 36 teeth, to drive the wheel No. 6. having 17 teeth, which is fixed upon the axle KK, on which axle is alſo faſtened the wheel No. 7. containing 26 teeth, to turn the wheel No. 8. having 19 teeth, which is fixed upon the gudgeon in the axle of the wire engine. PP, An iron ſpindle, in the under end of which is a ſquare ſocket that takes in a ſquare on the gudgeon of the axle D. On the upper end of the ſpindle P is fixed the pinion No. 9. containing 9 teeth, to drive the wheel No. 10. in which are 48 teeth, which is fixed upon the axle R, having on its gudgeon a croſs to turn the axle, upon which the rope OO rolls to carry up the ſacks of wheat to the hoppers NN; from either of which it may be conveyed down to the ſheeling machines to be cleaned, or to carry the ſacks of clean wheat from the fanners LL to the hoppers ZZ; from which it is conducted down into a hopper placed upon the frame UU, that encloſes the upper grinding millſtone, into the eye of which the wheat runs, and is introduced betwixt the millſtones, where it is ground into flour, and thrown out at the mill-eye down a ſpout into a trough or box below. It is then put into ſacks, and carried up by the rope QQ to the cooling boxes YY; from which it may be conveyed down, either to the bolting mill WW, or to the bolting wire engine XX to be cleared of the bran. By pulling the cord No. 15. the axle on which the rope OO rolls is ſet agoing; and by pulling the cord No. 14. it is ſtopped at any time. But if the ſack of wheat be carried up to the lever No. 12. it raiſes the catch; and then the weight No. 13. pulls the croſs at No. 11. clear of the croſs on the gudgeon of the axle R; and thus the wheel ſtops itſelf. The axle on which the rope QQ rolls is ſet agoing by pulling the cord No. 19.; and by pulling the cord No. 20. it is ſtopt; but when the ſack of flour is raiſed up to the lever No. 18. the machine ſtops itſelf.




No. 3
No. 2
No. 1
1 0 1 2 3 4 5 10 15 20

Plan, Elevation, and Section of a Lint or Flax Mill.

PLATE XXXII.

No. 1. *Plan.*—AA, The water wheel. CC, The ſhaft or axle upon which it is fixed. BB, a wheel faſtened upon the ſame ſhaft, containing 102 teeth, to drive the pinion D having 25 teeth, which is fixed upon the middle bruiſing roller. E, a pinion, in which are 10 teeth, turned by the wheel B, which is faſtened upon the under end of the perpendicular ſhaft that carries the ſcutchers. MM, The large frame that ſupports one end of the ſhaft C, and the perpendicular axle. NN, Are frames in which the rollers turn to break or bruiſe the rough flax. IA and L, The machine and handle to raiſe the ſluice when the water is to be let on the wheel AA to turn it round. GG, Doors in the ſide walls of the mill-houſe. IK, Windows to light the houſe. HH, a ſtair leading up to the loft.

No. 2. *Elevation.*—AA, The water wheel upon its ſhaft CC; and on which ſhaft the wheel BB is alſo fixed, containing 102 teeth, to turn the wheel E having 25 teeth, which is faſtened upon the middle bruiſing roller. FF is a perpendicular ſhaft, upon the under end of which is fixed a pinion having 10 teeth, which is driven by the wheel B. There are two arms that paſs through the ſhaft F; and upon theſe arms are faſtened, with ſcrewed iron bolts, the ſcutchers that clear the refuſe off the flax. DD, The frames that ſupport one end of the axle C, the perpendicular ſhaft, and breaking rollers. L, a weight ſuſpended by a rope, the other end of which is faſtened to a bearer below the rollers, as is ſeen in No. 3. SS, a lever, the ſhort arm of which is attached to the frame that the gudgeons of the upper roller turn in; and by puſh-ing down the long arm, the upper roller is raiſed clear of the middle one when neceſſary. NN, The end walls of the mill houſe. RR, The couples or frame of the roof. H, a door in the ſide wall. IK, Are windows to light the houſe.

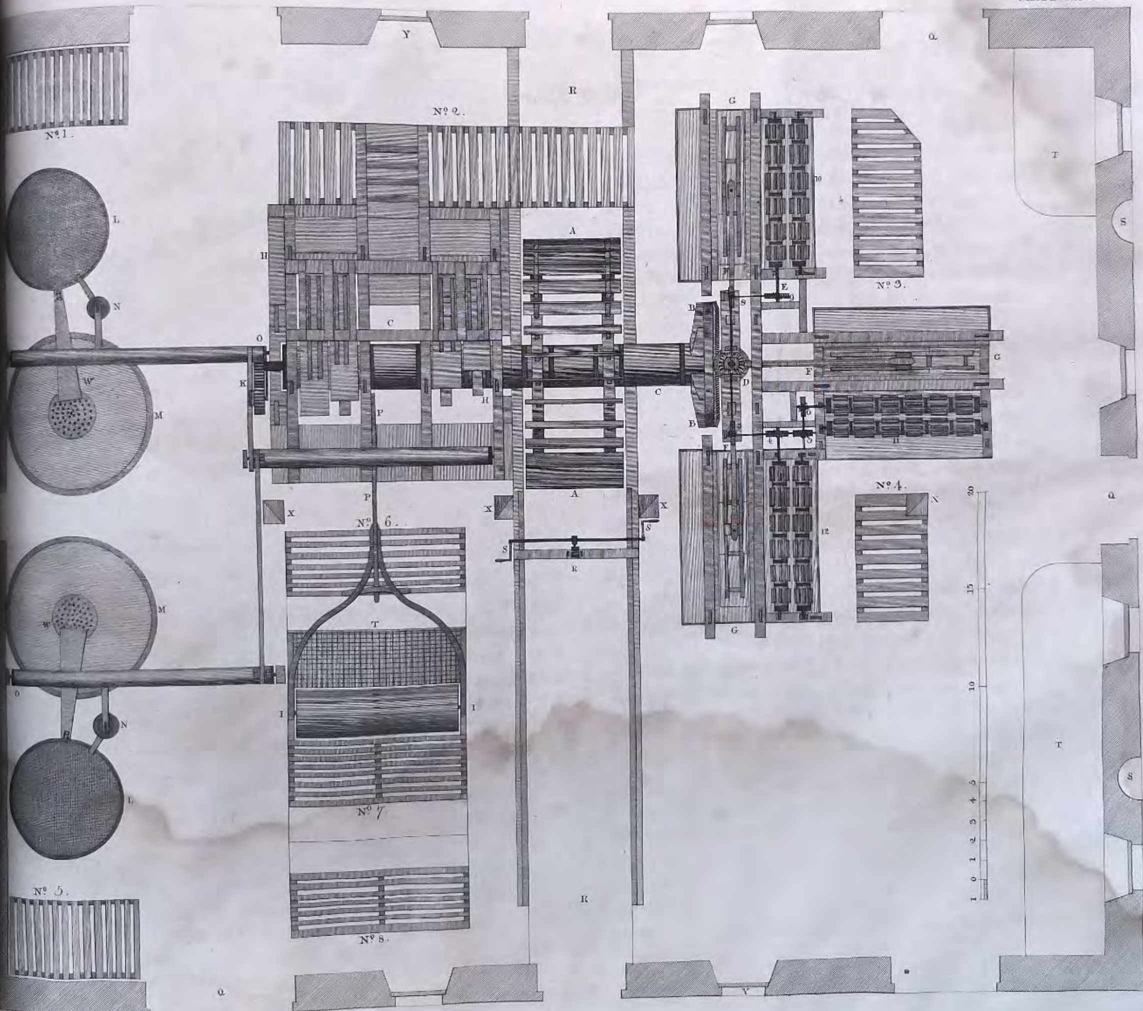
No. 3. *Section.*—AA, The great wheel fixed upon its ſhaft, and containing 40 aws or floatboards to receive the water to turn it round. BB, a wheel faſtened upon the ſame axle, having 102 teeth or cogs, to drive the wheel C, in which are 25 teeth, which is fixed upon the middle roller No. 1. The thick part of this roller is fluted, or has teeth all round its circumference. Theſe teeth are of an angular form, being broad at their baſe, and thin-ner towards their points, which are a little rounded, to prevent them from cutting the flax as it paſſes through betwixt the rollers. The other two rollers Nos. 2. and 3. are fluted, or have teeth in them, of the ſame form and ſize of thoſe in the middle roller; and, by its teeth taking into the flutes or teeth of theſe two rollers, turns them both round. The rough flax is made up into ſmall parcels or handfuls, which, being introduced betwixt the middle and upper rollers, paſſes round the middle one; and it having either rollers placed on its off-ſide, or encloſed by a curved board that turns the flax out through betwixt the middle and under rollers, when it is put in again betwixt the middle and upper one round the ſame courſe until it be ſufficiently broken or ſoftened and prepared for the ſcutching machine. The bearer in which the gudgeon of the roller No. 1. turns is fixed in the frame at C; and the gudgeons of the rollers Nos. 2. and 3. turn in ſliders that move up or down in grooves in the frames SS. The under roller is kept up to the middle one by the weights DD ſuſpended by two ropes going over two ſheeves in the frames SS; their other ends being faſtened to a croſs bearer below the ſliders in which the gudgeons of the roller No. 3. turn. The weights DD muſt be conſiderably heavier than the under roller and ſliders, in order that its teeth may be preſſed in betwixt the teeth of No. 1. to break or bruiſe the flax when paſſing through between the rollers. The whole weight of the roller No. 2. preſſes on the flax going through between it and No. 1. There is alſo a box fixed on the upper edge of its two ſliders to contain a parcel of ſtones or any heavy metal, ſo that more or leſs weight can be added to the roller as is found neceſſary. OO is the large frame that ſupports one end of the ſhaft that carries the two wheels AB and perpendicular axle FF; on the under end of which is fixed a pinion, turned by the wheel B, and having 10 teeth. In the axle F are alſo arms, upon which the ſcutchers are faſtened with ſcrewed bolts (ſeen by GG in No. 2.) Theſe ſcutchers are encloſed in the round box EE, having in its circumference holes or porches, at which the handfuls of flax are held in, to be clean-ed by the ſcutchers as they revolve. HH, The fall or courſe of the water. TT, The ſluice, machine, and handle, for raiſing the ſluice to let the water on the great wheel. The gudgeons of the axles ſhould all turn in cods or buſhes of braſs. KK, The ſide walls of the mill-houſe. R, The couples or framing of the roof. GG, Are doors; and LL, windows to light the houſe.

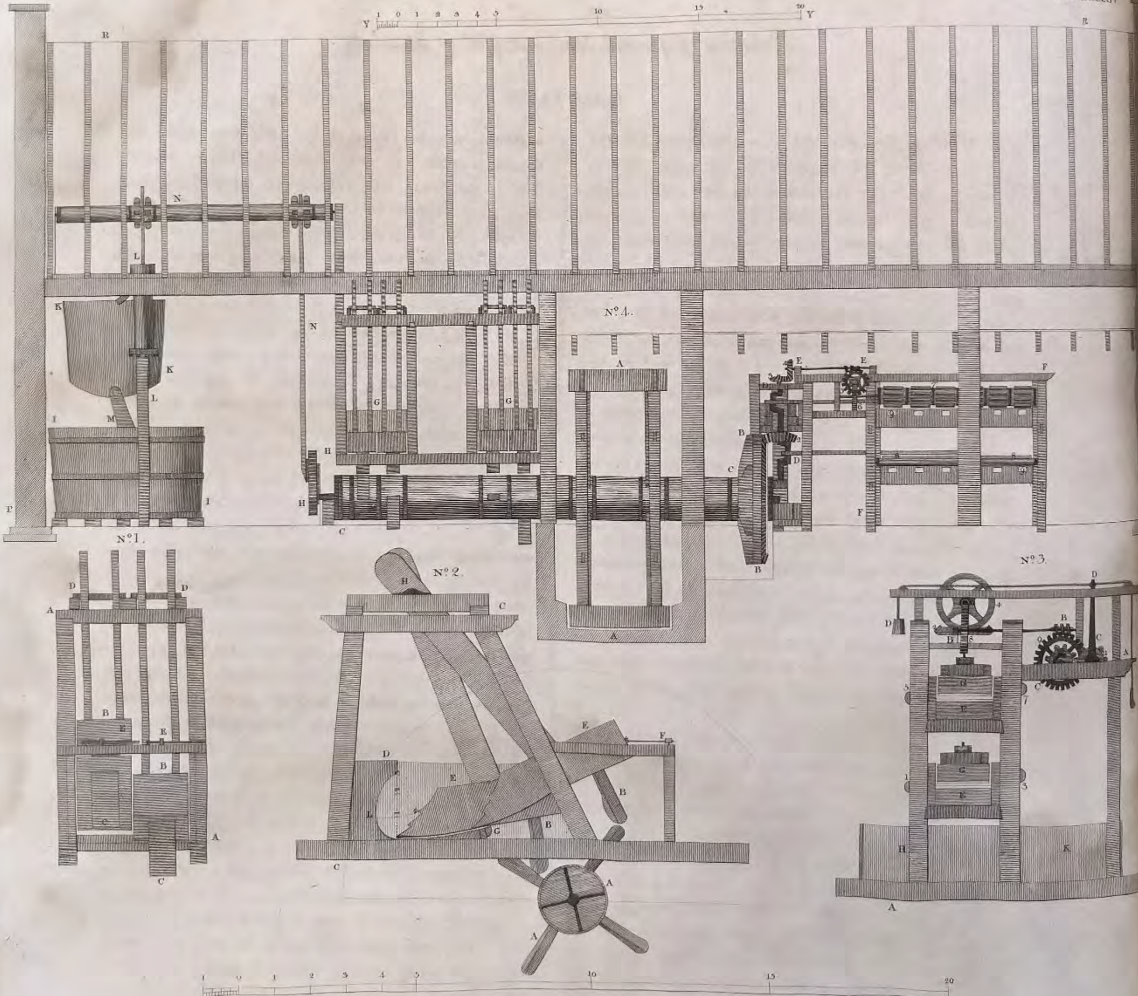
Plan of ſeveral Machines made uſe of in Bleaching.

PLATE XXXIII.

AA, The water wheel, fixed upon the ſhaft CC; on which ſhaft is alſo faſtened the wheel BB, containing 84 teeth or cogs, to turn the pinion D, having 24 teeth, which is fixed upon an iron axle or ſpindle, in which are bends or cranks to move the upper rub-boards. GGG, The frames that ſupport the rub-boards, and upon which the under ones are faſtened. FFF, Are rods of wood, called *crank poles*, one end of which goes upon the iron crank that carries the pinion D, and the others upon an iron bolt fixed in the frame above the moving boards. No. 1. is a wheel fixed upon the upper end of the iron axle, containing 22 teeth, to drive the wheel No. 2. having 23 teeth, which is faſtened upon an iron ſpindle, on which is a perpetual ſcrew to turn the wheel No. 3. containing 22 teeth; and upon its axle is a perpetual ſcrew to turn the wheel No. 4. having 23 teeth, which is fixed upon the gudgeon in one of the drawing beams No. 12. in which beams are broad teeth that take into each other, and convey the cloth through between them. From the wheel No. 3. motion is carried to the wheels No. 5. and 6. to turn the drawing beams No. 11. The wheel No. 7. contains 23 teeth, and is driven round by No. 1. and having on its axle a perpetual ſcrew to turn the wheel No. 8. in which are 23 teeth, and upon its axle is a perpetual ſcrew to turn the wheel No. 9. having 22 teeth, which is fixed upon the gudgeon in one of the beams No. 10. the teeth of which act upon each other. By this means they are both turned round, the cloth paſſing through between them.

HH, The frames of two mills for waſhing or cleaning linen cloth, moved by lifters, and arms or weepers, in the ſhaft C. K is a wheel fixed upon the gudgeon of the axle C, to move the waſhing roller II forward and backward upon the yarn or thread laid on the platform T, among which a ſtream of clean water runs conſtantly; while the roller II, moving or rolling upon the goods, preſſes out the ley and foul water, by which means yarn or thread are cleaned with ſafety and deſpatch. PP, a rod or pole that conveys motion to the waſhing roller (which is ſeen in Plate XXXV.) LL, Are two boilers, having an opening near their bottoms, at which the hot liquor iſſues through the ſpouts WW, and ſpreads upon the goods in the large veſſels or caves MM. There are two caſt-iron pumps NN placed in ciſterns, at the bottoms of the caves, to raiſe the liquor up again into the boilers ſo often as is found neceſſary. OO, The moving beams and rods or poles, that work the pumps either from a crank or revolving wheel. RR, The courſe of the water that turns the great wheel. SS, The ſluice, machine, and handle for raiſing it, to let the water on the wheel to drive it round. The gudgeons of ſhafts, iron ſpindles, and rounds of cranks, ſhould all turn in cods or buſhes of braſs. TT, Are tables on which the cloth is laid to be ſoaped. No. 1. and 2. are frames or racks near the waſhing mill for laying the cloth on; No. 3. and 4. frames by the rub-boards for the ſame purpoſe; and No. 5, 6, 7, and 8, frames near the waſhing roller to lay the yarn or thread on. RS, Fire-places in the walls. QQ doors, and YY windows to light the houſe.


Nº 1.
Nº 2.
Nº 3.
Nº 4.
Nº 5.
Nº 6.
Nº 7.
Nº 8.
Y
Q
R
A
B
C
D
E
F
G
H
I
K
L
M
N
O
P
S
T
X
20
15
10
5
4
3
2
1
0
1


N° 1.
N° 2.
N° 3.
N° 4.

Elevation of ſeveral Machines uſed in Bleaching.

PLATE XXXIV.

No. 1. *An end View of a Mill for waſhing Cloth.*—AA, The frame which ſupports and encloſes the box that contains the cloth and waſhing feet. BB, The waſhing feet fixed on their arms. DD, Iron gudgeons faſtened in theſe arms, by which the arms and waſhing feet are ſuſpended. CC, Are hanging pieces fixed in the feet, for the weepers or arms to act on. EE, Are iron hooks and levers, by pulling of which the waſhing feet are ſtopped at any time.

No. 2. *A ſide View of the ſame waſhing Machine.*—AA, The ſhaft or axle, with its gudgeon and arms or weepers, that act on the hanging heads BB, which are fixed in the waſhing feet. DL is the box or receptacle in which the goods are placed to be waſhed; to form the curve of which, divide its height into three equal parts, as 1, 2, and 3: One of theſe parts allow for the lower curve, and the other two for the upper one. From the point 1 deſcribe the curve line from the bottom to L, and from the point 4 draw the curve from L to 3, which forms the ſhape of the box or receptacle to contain the cloth when waſhing. EE, The waſhing feet faſtened upon their arms, having iron gudgeons fixed in them, upon which they hang at H, on the upper part of the frame CC. There is a ſtop fixed in theſe feet at G, that prevents them from ſtriking on their points to damage the cloth in the box when waſhing. F, Are iron hooks and levers for raiſing the hanging pieces BB clear of the weepers in the axle A, when the waſhing feet are to be ſtopped while the axle is revolving.

No. 3. *An end View of the Rub-boards.*—AA, The frame that contains the boards, and ſupports the wheels and drawing beams. BB, Wheels and perpetual ſcrews to turn the drawing beams or rollers B. No. 2. a wheel containing 22 teeth, to drive the wheel No. 4. having 23 teeth, which is faſtened upon an iron axis, on which is the perpetual ſcrew No. 6. to turn the wheel No. 8. containing 22 teeth; and upon its axle is a perpetual ſcrew at B to act on the wheel No. 9. having 23 teeth, which is fixed upon the gudgeon of the drawing roller No. 10. in which are teeth taking into the teeth of the roller No. 11. to turn it round. CD, a lever in which the gudgeon of the roller No. 11. turns. The ſhort arm of the lever moves on a bolt in the frame, and a cord is faſtened to its long arm, by which the weight D is ſuſpended to keep the teeth of the two beams No. 10. and 11. in the hold of one another while the cloth is paſſing down betwixt them. EE, The under rub-board fixed in the frame. GG, The upper or moveable rub-boards. H, a box in which the cloth to be rubbed is laid, and going over the ſmall rollers No. 1. and 5. paſſing through betwixt the boards, and under the two rollers No. 3. and 7. going over the toothed roller No. 10. and down through between it and No. 11. falls down into the box K.

No. 4. *An Elevation of the Mill-houſe, and the Machines placed in it.*—AA, The great wheel fixed upon the axle CC; on which ſhaft is alſo faſtened the wheel BB, containing 84 teeth, to turn the pinion No. 2. having 24 teeth, which is fixed upon the iron axle or crank DD, on which go the poles or rods that move the upper rub-boards by the crank turning round. No. 3. is a wheel faſtened upon the upper end of the iron axis D, containing 22 teeth, to turn the wheel No. 4. having 23 teeth, which is fixed upon the horizontal iron axle EE, on which axle is a perpetual ſcrew to turn the wheel No. 5. containing 22 teeth; and on its axle is alſo a perpetual ſcrew to turn the wheel No. 6. having 23 teeth, which is faſtened upon the gudgeon in one of the drawing beams or rollers No. 7. having teeth that takes into the other beam, by which means both beams are turned round. FF, The frames that ſupport the rub-boards and drawing rollers. No. 8. a ſmall roller that the cloth goes over from the porch No. 9. to the rollers or drawing beams No. 7. having broad ſmooth teeth betwixt which the cloth paſſes. GG, Are two waſh-mills, moved by the arms or weepers in the ſhaft CC, as it is turned round. HH, Are two wheels, one of which is fixed upon the gudgeon in the ſhaft CC; the other, revolving round it, and being fixed upon a pole N, moves the horizontal beam N, and works the pump LL; which raiſes the liquor from the bottom of the veſſel or bucking cave II up to the boiler KK, from which the hot liquor iſſues out at an opening near its bottom, and, running in the ſpout M, ſpreads upon the goods in the veſſel II, where it paſſes down amongſt the goods to the bottom, and is raiſed again into the boiler by the pump L as often as is found neceſſary. PP, Are the walls of the mill-houſe. RR, The couples or framing of the roof.

Section of a Washing Roller and Rub-boards.

PLATE XXXV.

No. 1.—AA, The roller for wafhing or cleaning lint, yarn or thread. It confifts of a ftrong wooden axle, having three rows of arms paffing through it. Upon the extremities of each row is fixed a wheel; and on the circumference of thefe wheels are faftened pieces of wood, placed about one fourth part of an inch diftant from one another; which muft be made fmooth that they may not damage the yarn or thread in the wafhing.

No. 2.—BB, An end view of the wafhing roller. CD, a floping platform of plank, upon which the hanks or parcels of yarn or thread are laid to be wafhed. CE, The horizontal part of the platform on which the roller refts when ftopped.

No. 3.—AA, The fize and form of the flutes or teeth in the uppermoft rub-boards. BB, The fize and form of the teeth in the undermoft or fixed boards.

No. 4. *Section of one Set of Rub-boards.*—UU, The fhaft or axle which carries the water wheel; and upon which is fixed the wheel AA, containing 84 teeth or cogs, to turn the pinion B No. 2. having 24 teeth, which is faftened upon the iron axis D; in which are two bends or cranks at CC, which being turned round move the upper rub-boards NN, by the poles or rods V V; one end of which goes on upon the crank CC, and their other ends upon an iron bolt fixed in the frame upon the moving rub-boards. LL, Are two ftrong planks refting on the frame KK. Upon thefe planks, and alfo on the upper boards NN, are fixed fquare pieces of end wood, as XX, commonly of lignum vitæ, as being the moft durable. In the furface of thefe pieces are cut flutes or teeth, as in No. 3.; the tops of which muft be a little rounded, and made very fmooth. The upper boards are made in three pieces or divifions, in order that each divifion may have liberty to work freely upon two pieces of goods. PP is a large frame that carries one end of the axle U and iron crank; upon the upper end of which, at D, is fixed the wheel No. 3. containing 22 teeth, to drive the wheel E No. 4. having 23 teeth, which is faftened upon the iron axis, on which is a perpetual fcrew at E, to turn the wheel F No. 5. containing 22 teeth; and upon its axis, at No. 6. is a perpetual fcrew, to turn the wheel G No. 7. having 23 teeth, which is fixed upon the gudgeon in one of the rollers HH, in which are teeth to turn the other rollers (as is feen in No. 3. Plate XXXIV.) Annexed is a fcale of feet and inches for Numbers 1, 2, 3, and 4.

No. 5. *An end View of a House to contain the Washing Roller and Rub-boards.*—AA, The great wheel, containing 36 float boards or *aws*, on which the water acts. UU, The courfe or fall of water that turns the wheel. BB is a wheel fixed upon the axle of the great wheel, and in which are 84 teeth or cogs to turn the pinion No. 2. having 24 teeth, which is faftened upon the iron axis G having two cranks or bends; which, being turned round, move the upper rub-boards by the poles or rods V V, one end of which is put upon the crank of the iron axis G, and the others upon iron bolts fixed at V, in the frame that connects the three divifions of the upper boards. No. 3. is a wheel fixed upon the iron axis at G, containing 22 teeth, to drive the wheels NO. 4. and 4. having each of them 23 teeth, which are faftened upon the horizontal iron axles, on each of which is a perpetual fcrew CC to turn the wheels No. 5. and 5. each of which contains 22 teeth, and on each of their axles is a perpetual fcrew to turn the wheels No. 7. and 7. having each 23 teeth, and are faftened upon the gudgeons of the drawing beams or rollers No. 8. and 8. which, having broad teeth taking into one another, by this means the cloth is conveyed from the boards, out at the holes or porches No. 9. and 10. through betwixt the rollers. DD, Are the frames that fupport the wheels and rub-boards. No. 12. is a fmall fmooth roller that conducts the pieces of cloth from the porches 9 and 10 to the drawing beams No. 8. and 8. which convey the cloth from the boards. KK, The roller for wafhing lint, yarn or thread, with its moving frame, which is fufpended by an iron gudgeon fixed in it near the upper end, on which it moves when pufhed or pulled by the rod or pole GH. The end G of the pole moves on iron bolts in the frame K; and near the other end, in its under edge, is a notch or flit, that takes hold of a bolt in the arm Y, which arm is fixed in the fame moving beam with the arms QE. Near the extremity of this arm the perpendicular pole E moves on a bolt; the pole being pufhed up and down by a crank, or by a wheel revolving round another wheel, which is fixed upon the gudgeon in the fhaft or axle of the water wheel AA (feen in Plate XXXIV.) By this means the arm QE is moved up and down; and of courfe the arm Y, by the pole GH, moves the hanging frame, and along with it the roller K, rolling upon the yarn or thread. The hanks being equally laid on the platform L, at their full length, and at right angles to the roller; then a net of fmall cords, fixed at the fide next to the roller, is fpread all over above the yarn or thread, to keep them from floating away with the water while the roller is moving upon them. O is a narrow ciftern placed along the higheft edge of the platform L, and the fame length of the roller. This ciftern is kept full of clean water, conveyed into it by a pipe or fpout. The fide of the ciftern next to the roller is a little lower than the others, that the clean water may run over its whole length among the goods, while the foul water is preffed out by the weight of the roller, and runs off at the lower edge of the platform L. The gudgeons or pivots in the axle of the wafhing roller K, as they turn round, muft have liberty to move up and down in the mortife, according to the quantity of goods laid on the platform. SS is a rope, one end of which being faftened to the pole at H, and paffing over two fheeves, by pulling the other end the pole H is raifed up clear of the iron bolt in the moving arm at Y. By this means the wafhing roller is ftopped at any time. But when the wafhing roller is to be fet agoing, the pole H is let down, and the notch in its lower edge takes hold of the iron bolt in the arm at Y, which moves the frame, and of courfe the wafhing roller upon the goods. NU, a rack to contain the yarn or thread to be wafhed. NR, a rack on which the goods are laid when lifted off the platform L from the roller. P is a ciftern of clean water, in which the goods are rinfed after being rolled. RR, Are fpouts for carrying off the wafte and foul water. The wafhing roller is both an expeditious and alfo a very fafe machine for cleaning yarn or thread, becaufe it does not at all damage the goods in the operation. XX, The walls of the houfe. WW, The couples or frame of the roof. TT, Are doors in the walls.

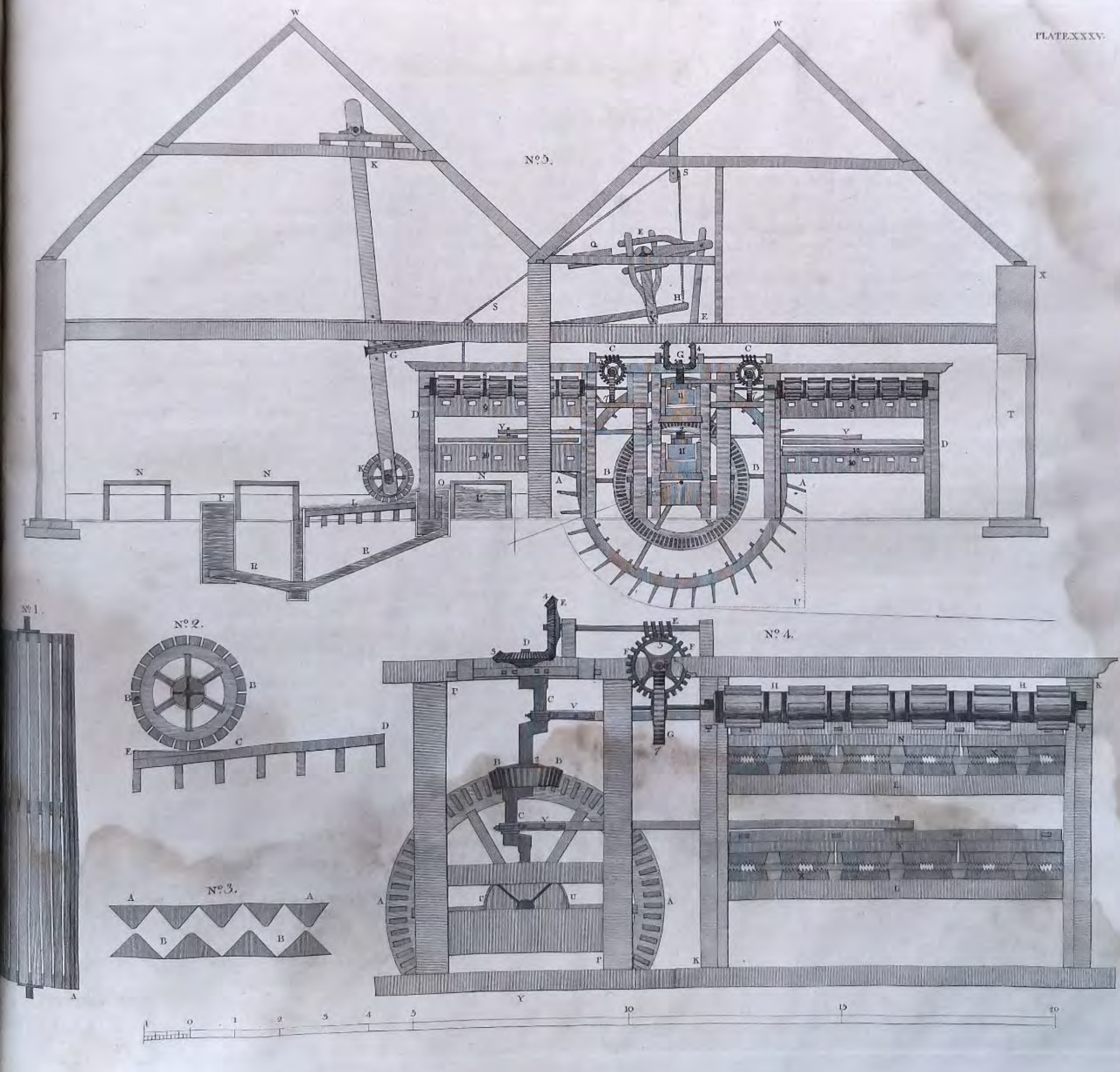
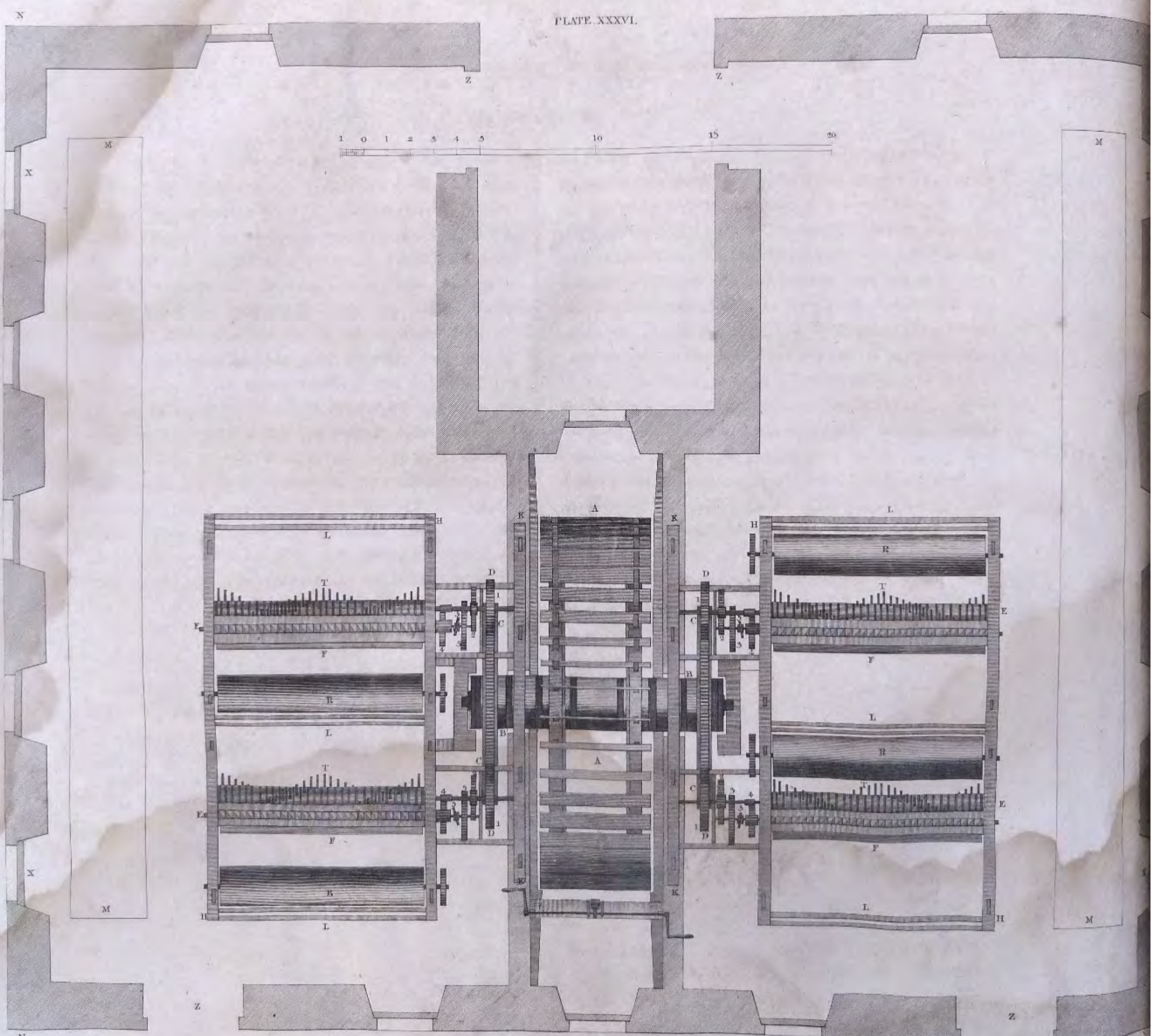

Nº 5.
Nº 1.
Nº 2.
Nº 3.
Nº 4.

PLATE XXXVI.


N
Z
Z
1 0 1 2 3 4 5 10 15 20
M
M
X
A
K
K
H
H
L
L
R
T
T
D
D
E
E
C
C
F
F
B
B
R
L
L
R
A
T
T
E
E
F
F
D
D
X
M
M
H
H
L
L
Z
Z
N

Plan of Two Double Machines for Beetling Linen Cloth.

PLATE XXXVI.

AA, The water wheel fixed upon its ſhaft or axle BB; on which axle are alſo faſtened the two wheels CC and CC, each of them containing 108 teeth or cogs, to turn the four wheels DD and DD, which have each 30 teeth, and are fixed upon iron axles, which have coupling boxes that connect them at pleaſure with the iron gudgeons in the axles EE and EE to turn them round. In theſe axles are faſtened the weepers or tripping pieces TT and TT, which lift the beetles or peſtles. There are likewiſe faſtened upon the gudgeons of the axles E, pinions, each of them containing 14 teeth, to drive the wheels No. 2—2. and 2—2. having each 38 teeth; and are fixed upon iron axles, on which are alſo faſtened pinions containing 9 teeth, to turn the wheels No. 3—3. and 3—3. in each of which are 38 teeth, and fixed upon iron axles, on which are likewiſe faſtened pinions containing each 11 teeth, to act upon the wheels No. 4—4. and 4—4. having each 28 teeth. Theſe wheels are fixed upon the gudgeons of the beams FF and RR. By this means the beams with the cloth upon them are turned ſlowly round on their gudgeons; and at the ſame time traverſed or moved a little on end forward and backward, by half perpetual ſcrews or ſnail wheels, as No. 5—5. which are fixed upon the axles of No. 3—3. and turned round betwixt two upright rollers (plainly ſeen in Plate XXXVIII.) The weepers or tripping pieces TT and TT are fixed into mortiſes in the axles EE and EE, cut in the direction of a perpetual ſcrew, that the beetles may be lifted by rotation, and as few of them on the lift at the ſame time as poſſible. HH and HH, Are the frames that ſupport the weepers, axles, beetles, and cloth-beams. LL, LL, and LL, Are ſmooth rails for the cloth paſſing over, and to hold it ſtraight as it rolls round the beams. The beams FF and FF are in the place where the teeth work on them; and the beams RR and RR are in the place where the undreſſed cloth is rolled or wrapped round upon them, and prepared to be put in below the beetles in place of the beams F, which are removed when thought neceſſary. KK and KK, The frames that carry one end of the weeper axles. MM, Two tables placed along by the end of the beetling engines for ſtretching the cloth upon. NN and NN, The walls of the engine houſe. ZZ and ZZ, Are doors in the walls of the houſe. XX and XX, Windows to light the houſe.

Section of a Double Machine for Beetling Linen Cloth.

PLATE XXXVII.

AA, The great wheel containing 40 floatboards or *awes*, upon which the water acts to drive the wheel round. C, The fhaft or axle of the great wheel, with gudgeons on which it revolves. BB, a wheel fixed upon the fame axle, having 108 teeth or cogs, to turn the wheels Nos. 2. and 2. each containing 30 teeth, and faftened upon the two axles DD, called *weeper beams*, in which are fquare holes or mortifes that take in weepers or tripping pieces that lift the beetles or peftles when the axles are turned round. There are fixed upon the gudgeons of the axles DD, pinions, having each 14 teeth, to drive the wheels Nos. 3—3. containing 38 teeth, which are faftened upon iron axles; on which are alfo pinions, having each 9 teeth, to turn the wheels Nos. 4—4. containing 38 teeth; and upon their axles are fixed pinions having 11 teeth, to turn the wheels that are faftened on the gudgeons of the beams EF (which is clearly feen in Plate XXXVI.) GG, The frame that fupports the axles with their wheels and cylinders EF, and on which the cloth is rolled to be beetled or dreffed, called the cloth-beams. Thefe beams are turned round upon their gudgeons by the wheels, and likewife traverfed or moved a little on end while the beetles are going. HH, Are the beetles or peftles with moveable frames at their upper ends. To thefe, ropes are faftened, which go over the fheeves in the fixed blocks RR, and round on the axles of the wheels KK; by pulling the handles of which, the beetles are raifed up clear of the weepers in the axles DD at any time when neceffary, and are kept up by ratchet wheels faftened on the arms of the wheels KK; and let down when the beetles are to be fet a-going. MM, The fall or courfe of water to turn the great wheel. L, The fluice machine, and handle to raife the fluice, and let the water on the wheel A to turn it. NN and OO, Walls of the engine-houfe. PP, The couples or frame of the roof. ZZ, Are doors in thefe walls. XX, Windows to light the houfe.

Fig. 2. and 3. *Elevation and Profile of a Machine for calendering Cloth, which may be added to any Machine having a Wheel with Teeth to turn it round.*—AA is a ftrong wooden frame for the rollers to turn in. C, The middle cylinder made of caft iron, which muft be ftraight, well polifhed, and likewife hollow to receive the bars of red-hot iron that heat it when the goods require to be hot calendered. BB, Are cylinders of hard fmooth wood, to which the cylinder C communicates its motion. Thefe cylinders ought to be of equal diameter from one end to the other. D is an iron bar, bent at each end to a right angle, which goes into grooves in the perpendicular frame. AA, The ends of the bar, which are made to contain brafs bufhes for the gudgeons of the upper wooden roller to turn in: the gudgeons of the under wooden cylinder alfo turn in brafs bufhes fixed in the frame. EE, The preffing fcrews, having their nuts fixed in the under fide of the upper frame, and a fquare on their upper end, upon which are put a fcrew-key or iron lever to turn them round. By this means the bar D, and of courfe the upper wooden cylinder, may be preffed more ftrongly againft that of the caft-iron cylinder C, according as it is required that the cloth fhould be more or lefs acted upon. There is a fquare on one end of the cylinder C, upon which is fixed the wheel FF, having teeth for a wheel to act on to drive it round.

Fig. 3.—AA, The frame in which the cylinders turn round. B, a wheel faftened upon the fquare on the caft-iron cylinder, which communicates its motion to the two wooden cylinders. CC, Are two fmall rollers or rails fixed in the frame for the cloth going over, and which direct it betwixt the cylinders.

Fig. 4.—A, The frame in which the gudgeons of the roller B turn, that the cloth may be equally rolled round upon it, and prepared for the calender or mangle. C, a handle of iron, in which is a fquare hole to take in a fquare on the gudgeon of the roller B to turn it round.

Fig. 5.—*A large Calender or Mangle for calendering Cloth.*—AA, The frame that fupports the axles, wheel, and pinion that move the calender. B is a roller, round which the cloth is rolled to be calendered. C, The box that is moved upon the rollers by a man turning the handle G, being faftened upon an iron axle; on which is alfo fixed a pinion D, containing 8 teeth, to drive the wheel D having 82 teeth, which is faftened upon the axle E; round which the rope coils, and moves the calender by paffing over a fheeve in the fixed block F, and on two fheeves or whorls in the frame C. Thus the calender is eafily moved forwards and backwards upon the rollers, and cloth wrapped round them.

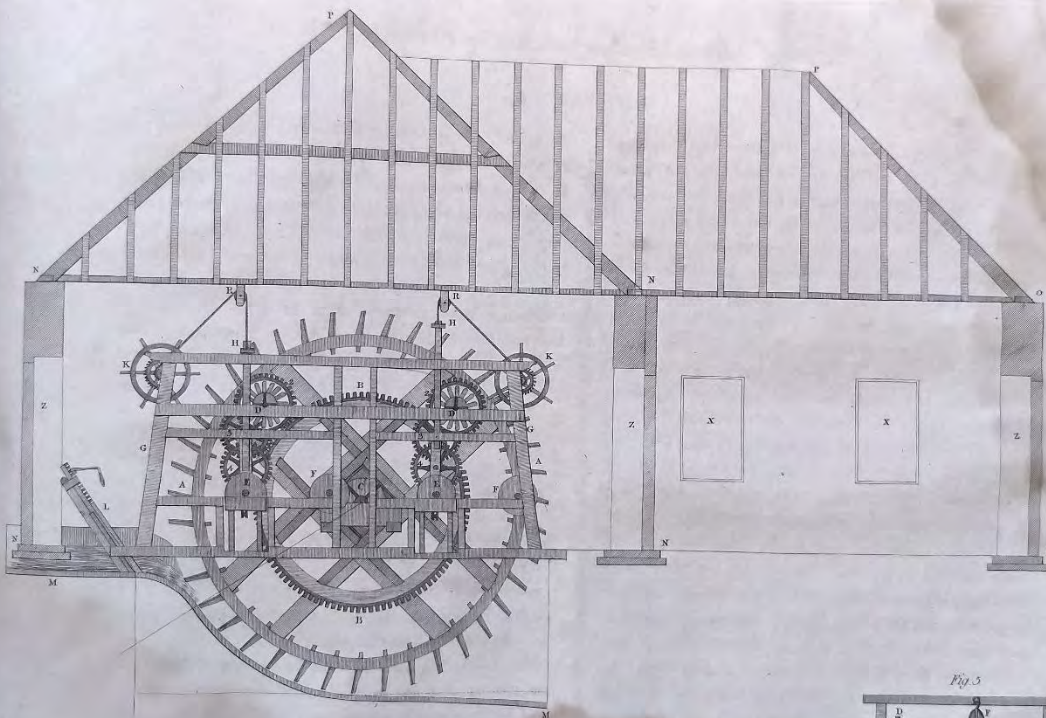


Fig. 2.

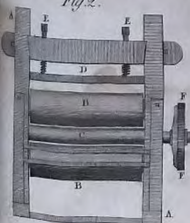


Fig. 3.

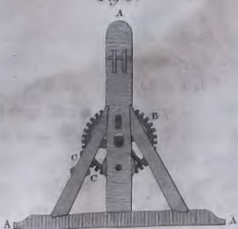


Fig. 4.

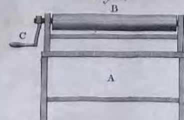
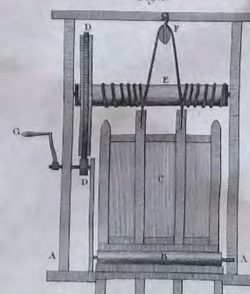


Fig. 5



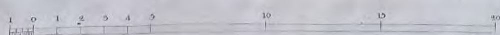
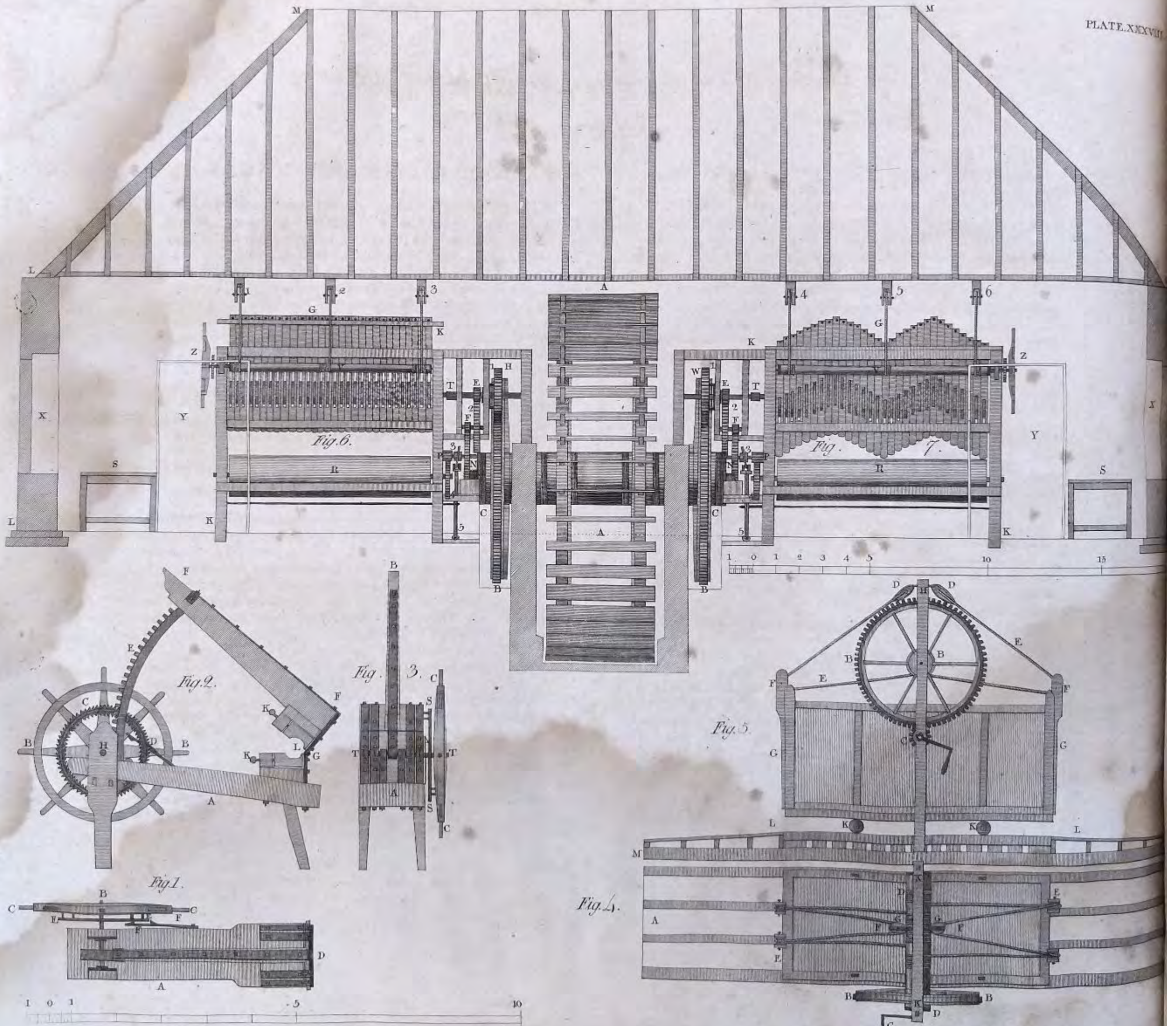


PLATE XXXVIII.



Elevation of Two Machines for Beetling Linen Cloth.

PLATE XXXVIII.

AA, The water wheel fixed upon its ſhaft or axle CC; on which axle are likewiſe faſtened the two wheels BB, each of them containing 108 teeth or cogs, to turn the wheel No. 1—1. having each 30 teeth, and fixed upon iron axles, on which are coupling boxes, to connect them at pleaſure with the gudgeons TT, to turn their axles, on which are fixed weepers or tripping pieces to raiſe the beetles. There are alſo fixed on theſe gudgeons the pinions EE, containing 14 teeth, to act upon the wheels No. 2—2. having 38 teeth. They are faſtened on iron axles, upon which are likewiſe fixed the pinions FF, containing 9 teeth, to drive the wheels NN, having 38 teeth, which are faſtened upon iron axles; on which are alſo the pinions PP, containing 11 teeth, to turn the wheels No. 4—4. having 28 teeth, which are fixed upon the gudgeons of the beams RR, round which the cloth is rolled to be beetled. On the axles of the wheels NN, are faſtened half perpetual ſcrews, or what is termed *ſnail-wheels*, that by turning round between two upright rollers, on the upper ends of the iron rods, No. 5—5. traverſe or move the beams RR a little forwards and backwards, to prevent the cloth from being creſſed when dreſſing. The beetles G, Fig. 6. are ſuppoſed to be ſtopped, and alſo raiſed up clear of the weepers in the axle T, by ropes, one end of which is faſtened to the moveable frame K, and paſſing over ſheeves or whorls in the fixed blocks 1, 2, 3, and round on the axle V; on which is faſtened the wheel Z, having ſpokes or handles to pull by, and raiſe the beetles clear of the weepers. Upon the arms of the wheel Z is fixed a ratchet wheel of iron, with a catch to keep the beetles up until the cloth beams be ſhifted. The beetles G, Fig. 7. are ſuppoſed to be going, but may alſo be raiſed clear of the tripping pieces at any time, by ropes that have one end faſtened to a moveable frame, and going over ſheeves in the fixed blocks 4, 5, 6; their other ends rolling about the axle V, when turned round, by pulling at the handles in the wheel Z. The gudgeons of all theſe axles ſhould turn in cods or buſhes of braſs. WK and KH are the frames that ſupport the axles, wheels, and beetles. SS, Tables on which the cloth is laid to be ſtretched. LL, Walls of the engine houſe. MM, The couples or frame of the roof. YY, Are doors; and XX, Windows to light the houſe.

FIG. 1. *The Plan of a Preſſing Machine, in which the finiſhed piece of Cloth, when made up, is put, and preſſed hard together to be tied.*—A, Is a ſtrong plank, on which the preſſing machine is fixed. B, a wheel faſtened upon an iron axle; on this axle is alſo fixed a ſmall pinion, taking into a teethed rod (ſeen in Fig. 2.) CC, Are ſpokes or handles, by which a man turns the wheel. D, a ſtrong iron hinge, on which the lever moves. Upon the arms of the wheel B is placed the ratchet or catch wheel EE, ſerved with a catch FF, that goes into its teeth, and holds the lever in any poſition.

FIG. 2. *A Profile of the Clipſe.*—A, The ſtrong frame that carries the moving parts of the machine. BB, Are ſpokes or handles to pull by, and are fixed upon the axle H. On this axle is alſo faſtened a pinion of 5 teeth, that takes into the iron rod E, one end of which is fixed in the lever FF. By pulling the handles B, one end of the lever is either raiſed or depreſſed, while its other end moves on the ſtrong iron hinge G. There are two boxes, as L, betwixt which the goods rolled up are put. Theſe boxes are made ſo as to be eaſily taken out, that others of a different form and ſize may be put in at pleaſure. KK, Two ſcrew pins to keep the boxes faſt; and alſo allow them to be taken out when neceſſary. C, The ratchet wheel, having two rows of ſmall angular teeth, into either of which the catch D goes, to hold the lever F in any poſition.

FIG. 3. *Elevation of the Clipſe.*—A, The ſtrong frame on which the machine is placed. B, The lever, having fixed in one on end an iron rod with teeth (ſeen in Fig. 2.); and its other end moving on a ſtrong iron hinge. TT, An iron axle, on which is fixed a wheel, with the handles CC, to pull by to turn the wheel. SS, The ratchet wheel with its catch.

FIG. 4. *The Plan of a large Mangle or Calender for calendering Cloth.*—AA, The bearers that carry the platform, on which the rollers with the mangle are moved. BB, a wheel fixed upon an axle, round which axle the ropes FF roll to move the mangle by; the ſame ropes going over the ſheeves or whorls EE, and ſheeves that turn on their axles in the blocks GG, which are fixed to the frame KK. The wheel B and its axle are turned by a pinion faſtened on the axle of the handle or crank E; ſeen in Fig. 5.

FIG. 5.—BB, a wheel fixed upon an axle, on which the rope EE rolls. DD, Are fixed blocks, having ſheeves that turn on their axles; and on theſe ſheeves are the ropes EE, going over ſheeves in the frames FF, and round on the axle B, being turned by the handle or crank and pinion C; by which means the mangle or ſtrong box GG is moved forwards and backwards upon the rollers KK, round which the cloth is rolled or wrapped. The rollers K, the bottom of the box G, and platform LL, upon which the rollers K roll, ſhould be made of ſmooth hard wood, well poliſhed. MN, Are ſtrong frames, on which the platform LL is laid. H, a perpendicular frame, that carries the wheel and pinion, the upper end of which muſt be ſecured by ſpurs from ſome part of the houſe where it is placed; it being neceſſary to have free acceſs below for putting the rollers K under the mangle. Theſe large calenders may have a conſiderable weight when the box GG is filled with ſtones: ſome of them made uſe of at large works are at leaſt ten or twelve tons weight.

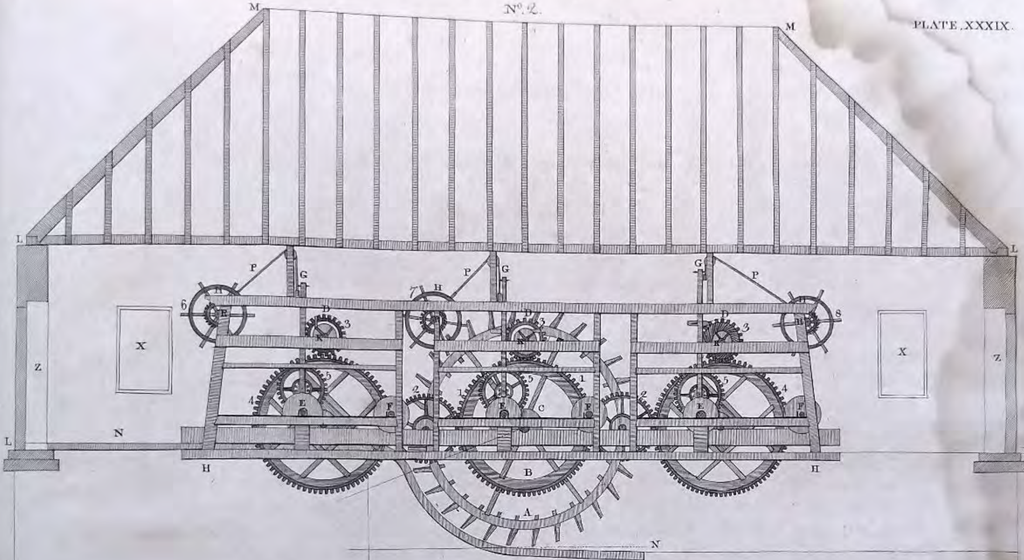
Plan and Elevation of a Triple Machine for Beetling Linen Cloth.

PLATE XXXIX.

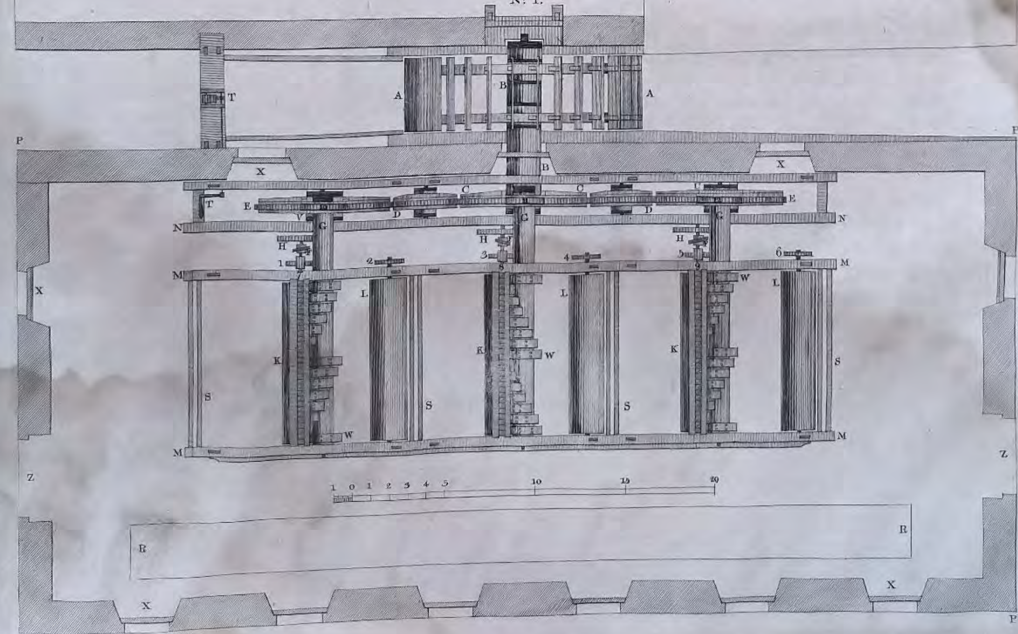
No. 1.—AA, The water wheel, fixed upon its ſhaft or axle BB; on this axle is alſo faſtened the wheel CC, containing 78 teeth, to turn the intermediate wheels D and D of 39 teeth, placed on each ſide of the wheel CC to drive the wheels EE, having each of them 78 teeth, which are fixed upon the axles U and V. There are faſtened upon the axles GGG the wheels 10, 11, 12, each containing 23 teeth, which are driven by the wheels ECE. Upon the axles G are likewiſe fixed, with ſcrew bolts, the weepers or tripping pieces W, which raiſe or lift the beetles, as the axles GGG turn round. There are placed on the gudgeons of the axles UBV, pinions, containing 10 teeth, to drive the wheels HHH, having 42 teeth, which are faſtened upon iron axles; on which are alſo fixed the pinions 7, 8, 9, containing 9 teeth, to turn the wheels 1, 3, 5, having each 28 teeth, which are faſtened upon the gudgeons of the beams KKK, called the cloth-beams, round which the cloth is rolled to be beetled. Upon the iron axles of the wheels H are likewiſe fixed half-perpetual ſcrews, or what are termed *snail-wheels*, as FFF, which, by turning round betwixt two upright rollers, traverſe or move the cloth-beams a little endwiſe, while the ſmall pinions 7, 8, and 9, at the ſame time turn them round. There are different methods of turning and traverſing the cloth-beams; but this is a very ſimple one, and anſwers the purpoſe very well. When the cloth on the cylinders KKK is ſufficiently beetled, they are removed; and the cloth-beams LLL put in their place. Upon the gudgeons of the beams L are faſtened the wheels 2, 4, and 6, having each 28 teeth, that the ſmall pinions 7, 8, and 9 act on, and turn the beams when below the beetles. MN, MN, Frames that carry the axles, wheels, and cloth-beams. SS, SS, Are rails, over which the cloth paſſes when rolling round on the beams. RR, The ſtretching table, on which the cloth is laid. TT, The ſluice machine, and handle that raiſes it, to let the water on the wheel. PP, Walls of the engine-houſe. ZZ, Doors; and XX, Windows to light the houſe.

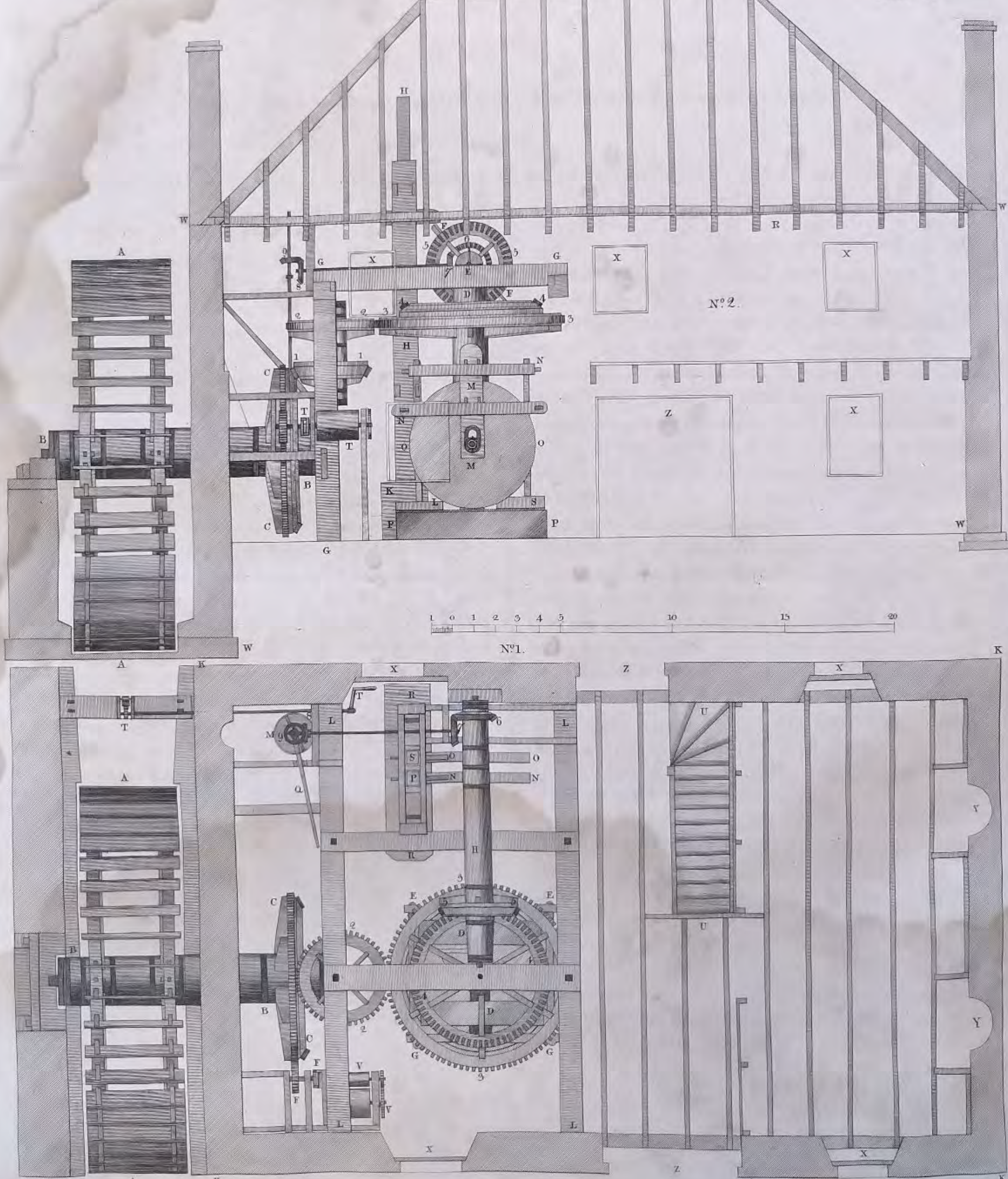
No. 2. *Elevation of the Machinery and Engine-house.*—A, The great wheel containing 30 float-boards, on which the water acts to drive the wheel. C, The ſhaft or axle of the water-wheel, upon which axle is alſo fixed the wheel B No. 1. having 78 teeth or cogs, to turn the wheel No. 3. in which are 23 teeth, which is faſtened on the axle K, upon which are fixed weepers D to raiſe or lift the beetles GGG as the axles revolve. No. 2. and 2. are intermediate wheels, driven by the wheel No. 1. and each of them having 39 teeth to turn the wheels No. 4. and 4. each containing 78 teeth, to drive the wheels No. 3. and 3. having each 23 teeth, which are faſtened upon the axles KK; on which are fixed the weepers or tripping pieces DD, that raiſe or lift the beetles GG, that beetle the cloth on the beams EEE. When the cloth on theſe beams is ſufficiently dreſſed, they are removed from the beetles, and the other cloth-beams FFF put in their place. Upon the gudgeons of the axles that carry the wheels No. 1. and 4—4. are faſtened pinions, containing 10 teeth, to turn the wheels Nos. 5. 5. 5. having each 42 teeth, and fixed on an iron axis; upon which axis are alſo faſtened pinions, containing 9 teeth, that act upon wheels which are fixed on the gudgeons of the cloth-beams E and F (which are plainly ſeen in the Plan No. 1.) GGG, Are the beetles or peſtles, having ſtops in their upper ends, that reſt on moveable rails, to which one end of the cords PPP are faſtened; and paſſing over ſheeves in the fixed blocks at GGG round on the axles RRR, upon which are the wheels 6, 7, 8, that have ſpokes or handles to pull by and raiſe the beetles clear of the weepers or tripping pieces on the axles KKK, at any time when neceſſary. HH, Are frames that ſupport the machinery. NN, The courſe or fall of the water that turns the great wheel. LL, Walls of the engine-houſe. M, The couples or frame of the roof. ZZ, Doors in the walls; and XX, Windows to light the houſe.

Nº 2.



Nº 1.




Nº 2.
1 0 1 2 3 4 5 10 15 20
Nº 1.

Plan and Elevation of an Oil Mill, with Rollers for bruifing the Oil Seed.

PLATE XL.

NO. 1. *Plan.*—AA, The water wheel fixed upon the fhaft or axle BB; on which axle is alfo faftened the wheel CC, containing 84 teeth or cogs, to turn a wheel placed upon the fame axle with No. 2. (which is feen in the *Elevation*). No. 3. is a wheel containing 96 teeth, driven by No. 2. and is fixed on the perpendicular fhaft that turns the two grinding millftones DD. There is likewife faftened upon the fame arms the wheel No. 4. containing 72 teeth, to drive the wheel No. 5. having 44 teeth, which is placed on the horizontal axle H, upon which axle is alfo fixed a wheel No. 6. containing 23 teeth, to turn the wheel No. 7. having 15 teeth, which is faftened upon an iron axle; on the other end of which is placed a wheel No. 8. containing 10 teeth, to drive the wheel No. 9. having alfo 10 teeth, which is fixed on an iron fpindle, in the under end of which is a crofs to turn over the ground feed in the chaffer M when heating EE. GG, A frame fixed upon the axle of No. 3. which moves the two millftones DD round. Upon the circumference of the wheel CC are fixed with fcrewed bolts feven fegments of caft iron, each fegment containing 13 teeth, in all 91, to drive the pinion E, having 14 teeth, which is fixed upon an iron axle, having a crofs with toes at F, that takes hold of a crofs faftened on the gudgeon in one of the caft-iron rollers VV. By this means it is turned round, and communicates its motion to the other roller; and by their furfaces rolling upon one another, they bruife the feed as it paffes down betwixt them, and affift the millftones in grinding. NN, An arm or weeper fixed in the axle H, which by the axle turning round lifts or raifes the driving ftamper P. In the axle H is likewife faftened the weeper OO, that raifes the difcharging ftamper S. By pulling the longer arm of the lever Q, the wheel No. 9. is ftopped at any time, and its fpindle raifed up clear of the chaffer pan M, that the ground feed may be taken out of it when at a proper heat for preffing. RR, The prefs in which the oil is extracted from the feed. TT, The machine and handle to raife the fluice to let the water on the wheel A to drive it round. KK, Walls of the mill-houfe. LL, Strong beams to which different parts of the machine are fixed, and in which the gudgeons turn. ZZ, Are doors in the fide walls. UU, a ftair leading up to the lofts. YY, Fire places in the end wall. XX, Windows to light the houfe.

No. 2. *Elevation.*—AA, The water wheel. BB, The fhaft or axle upon which it is fixed. CC, A wheel placed on the fame axle, containing 84 teeth, to turn the wheel No. 1. having 40 teeth; and upon its axle is faftened the wheel No. 2. containing 48 teeth, to act on the wheel No. 3. having 96 teeth, which is fixed upon the perpendicular fhaft D; on which axle are alfo faftened the frames NN, and in thefe frames are fixed the hanging pieces MM; in which, and in the axle D, are mortifes to receive a ftrong round iron axle, that paffes through them, and a hole in the bufhes fixed in the middle of the millftone OO. By this means the ftones are rolled round upon the furface of the horizontal ftone PP, called the *bed-ftone*. TT, Are cylinders of caft iron, driven by the wheel CC. Betwixt thefe rollers the oil-feed paffes, and is a little bruifed before it is laid on the furface of the bed-ftone PP, to be ground fmall by the rolling millftones. S, The outer rake or fweeper that collects the feed under the runners. L is the emptying fweeper, which is kept up from the fixed ftone, and let down at pleafure to fweep the bruifed feed off its furface when neceffary. No. 4. a wheel fixed upon the axle D, containing 72 teeth, to turn the wheel No. 5. having 44 teeth, which is faftened on the axle E; upon which axle is alfo faftened the wheel No. 6. containing 23 teeth, to drive the wheel No. 7. in which are 15 teeth, which is fixed upon an iron axle, and on this axle is alfo placed the wheel No. 8. containing 10 teeth, to turn the wheel No. 9. having 10 teeth, which is faftened upon the perpendicular iron fpindle, that turns the feed in the chaffer pan when heating. FF, Are arms or weepers fixed in the axle E, that lift the ftamper H, to drive the wedges in the prefs K; upon which the frame HO, that guides the ftampers, is placed. GGG, Strong frames that fupport the axles and wheels, the gudgeons of which fhould all turn in cods or bufhes of brafs. WW, The end walls of the mill-houfe, with couples or frames of the roof placed upon them. Z, A door in the fide wall. XX, Windows to light the mill-houfe.

Section of an Oil Mill, with Cylinders for bruifing Seed.

PLATE XLI.

FIG. 1.—AA, The great wheel, containing 40 floatboards or *aws* to receive the water to drive it round. CC, The fhaft or axle, upon which the great wheel is fixed. BB, a wheel faftened on the fame fhaft, having 84 teeth or cogs, to turn the wheel No. 1. of 40 teeth, which is fixed upon an upright axle; on which is alfo faftened a wheel, containing 48 teeth (feen in Plate XL.), that drives the wheel No. 2. having 96 teeth, which is fixed upon the axle DD; on which axle are alfo faftened frames in which the ears or hanging pieces KK are fixed. In each of thefe hanging pieces is a hole or mortife to receive the iron axle that paffes through them, and likewife through the bufhes fixed in the middle of the two millftones HH, and alfo through a mortife in the fhaft D. By this means the ftones are rolled round upon the furface of the horizontal millftone GG. The bufhes in thefe ftones that the iron axle paffes through are made to move eafily round, fo that the ftones may have freedom to turn round their axes as they revolve round upon the furface of the bed-ftone GG. The holes in the fhaft D, and in the two ears KK, which carry the ends of the iron axle, are made oval in direction lengthwife of the axle D, to allow the two ftones HH to rife and fall according to the thicknefs of the grain on the furface of the bed-ftone. Upon the wheel BB are faftened feven fegments, each having 13 teeth, in all 91, to drive the pinion M of 14 teeth, which is fixed upon an iron axle that turns one of the rollers MM, which communicates its motion to the other roller. To ufe this machine, the backfide roller muft be fcrewed up to the foremoft one. It is evident, that when two ftraight fmooth cylinders are oppofed to one another at a diftance that can be regulated at pleafure; and if fet to a proper diftance, neither fmall feed nor any fimilar fubftance can pafs between them without being bruifed; and by this means the feed is fooner ground by the millftones. NN, The hopper that contains the feed, and fpout that conveys it down to the rollers. No. 3. is a wheel fixed upon the axle D, containing 72 teeth, to turn the wheel No. 4. having 44 teeth, which is faftened on the axle EE; upon which axle is alfo fixed the wheel No. 5. that contains 23 teeth, to drive the wheel No. 6. having 15 teeth, to convey motion to the iron fpindle FF, having a crofs head for ftirring about the oil feed in the chaffer-pan No. 14. The feed being properly ground, and heated in the chaffer-pan, is put into two ftrong woollen bags, wrapped longwife either with leather belts or hair-cloths, and placed between the iron plates Nos. 15. and 15, in caft-iron boxes, which are fixed in the prefs LL; the inverted wedge No. 13. is raifed a little, and kept up by a rope affixed to it. Then the driving ftamper No. 7. is let down upon the top of the wedge No. 12. and raifed again by arms or weepers in the axle E (as DD in Fig. 7.) Thus the driving ftamper is raifed up, and let fall upon the wedge until the oil be extracted from the feed. It is then ftopped by pulling the rope No. 9.; and the difcharging ftamper No. 8. is let down upon the top of the inverted wedge No. 13. which being driven down loofens the prefs. By pulling the rope No. 10. the difcharging ftamper is ftopped. No. 16—16. are veffels placed below the prefs L to receive the oil as it runs from the feed. PP, An iron fpindle, having in its under end a fquare hole or focket that takes in a fquare on the gudgeon of the axle D, by which it is turned round; and upon its upper end is fixed a pinion, containing 7 teeth, to drive the wheel R having 44 teeth, which is faftened upon an iron axis connected with the axle on which the rope rolls to carry up the bags of feed to the lofts. By pulling the cord S, this machine is fet a-going at any time; and by pulling the cord T it is ftopped; but when the bag is raifed up to the lever R, then the machine ftops itfelf. VV, The fall or courfe of the water that turns the great wheel. OO, The fide walls of the mill-houfe. WW, The couples or frame of the roof. ZZ, Doors in the fide walls; and XX, Windows to light the houfe.

FIG. 2.—AA, An end view of the upright axle, and upper frame BB upon it; in which are mortifes CC, that take in the ears or hanging pieces which carry the ends of the iron axle on which the millftones turn.

FIG. 3.—AA, The iron axle paffing through the ears or hanging pieces, of which BB is the broad fide, and CC the edge view. DD, Are iron rings or wafhers that go on the iron axle, one on each fide of the ears.

FIG. 4.—GG, The horizontal or bed-ftone. BB, The runner or grinding millftones. KK, The iron axle that paffes through the ears and bufhes in both the millftones and upright axle, upon which the frames DD are fixed. One of the ftones BB is placed farther from the axle than the other, or revolves in a larger circle. EE, The outer rake or fweeper that collects the feed under the inner ftone. FF, The inner fweeper that collects the feed under the outermoft ftone. In this manner the feed or grain is always turned over and over, and crufhed in every direction. Thefe fweepers are fitted clofe to the nether millftone, to fweep it fo clean that not a fingle particle fhould be left on any part of it. AA is a frame or wheel enclofing the bed-ftone, having a border hoop to prevent any feed from being fcattered, as in Fig. 5. AA, The nether millftone, having the frame and border CC all round it. BB is a piece of wood fixed in the middle of the bed-ftone, in which is faftened a brafs pot for the gudgeon of the upright axle to turn in.

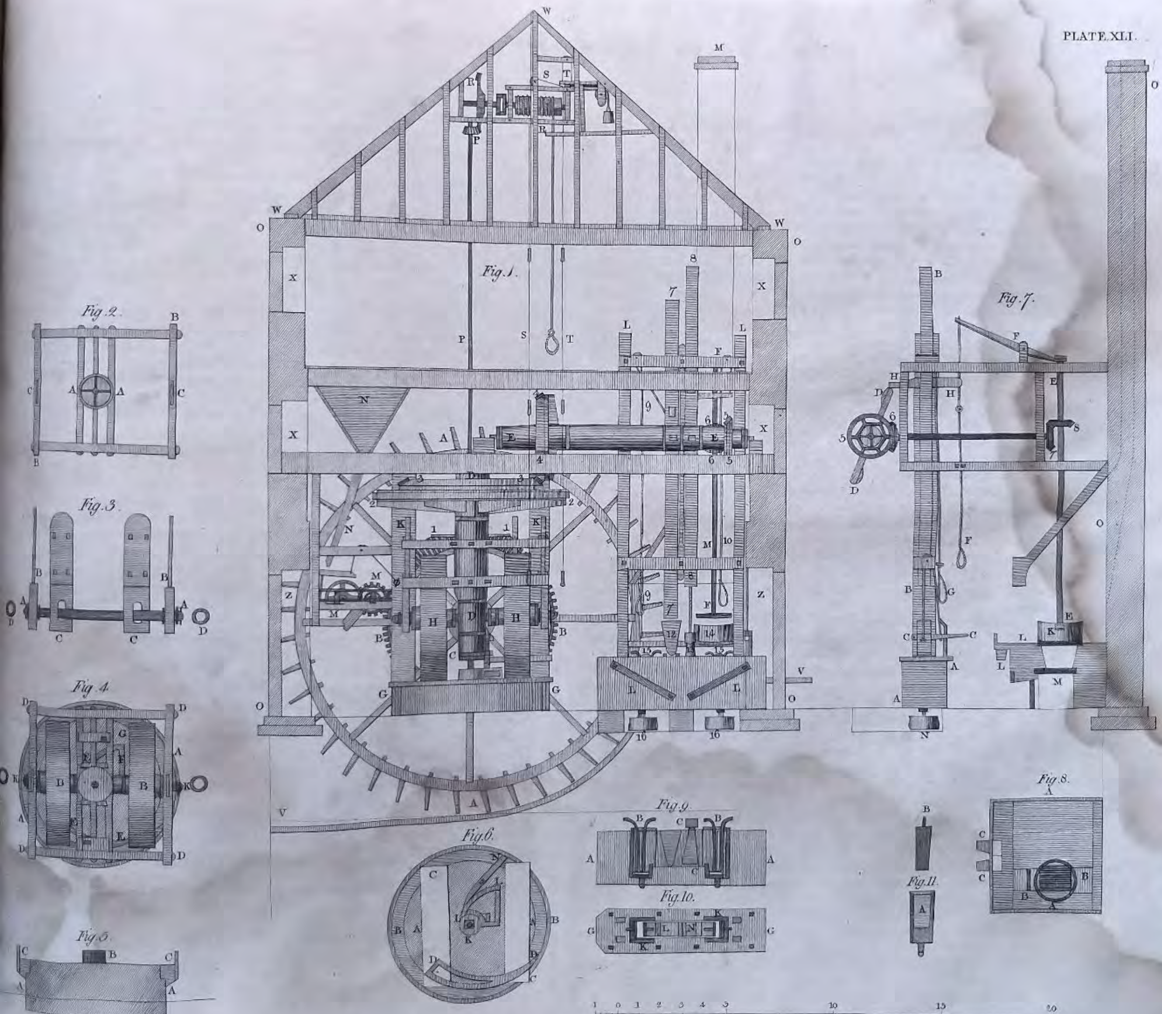
FIG. 6.—AA, The bed-ftone. BB, A frame which furrounds it. CC, Running ftones. DD, The outer fweeper. LL, The inner fweeper that moves round the piece of wood K fixed in the centre of the horizontal millftone. There is a trap-door in the frame that goes round the nether millftone, which can be opened or fhut at pleafure; when open, it allows the bruifed feed, fwept off by the emptying fweeper N, to pafs down into a trough placed below to receive it.

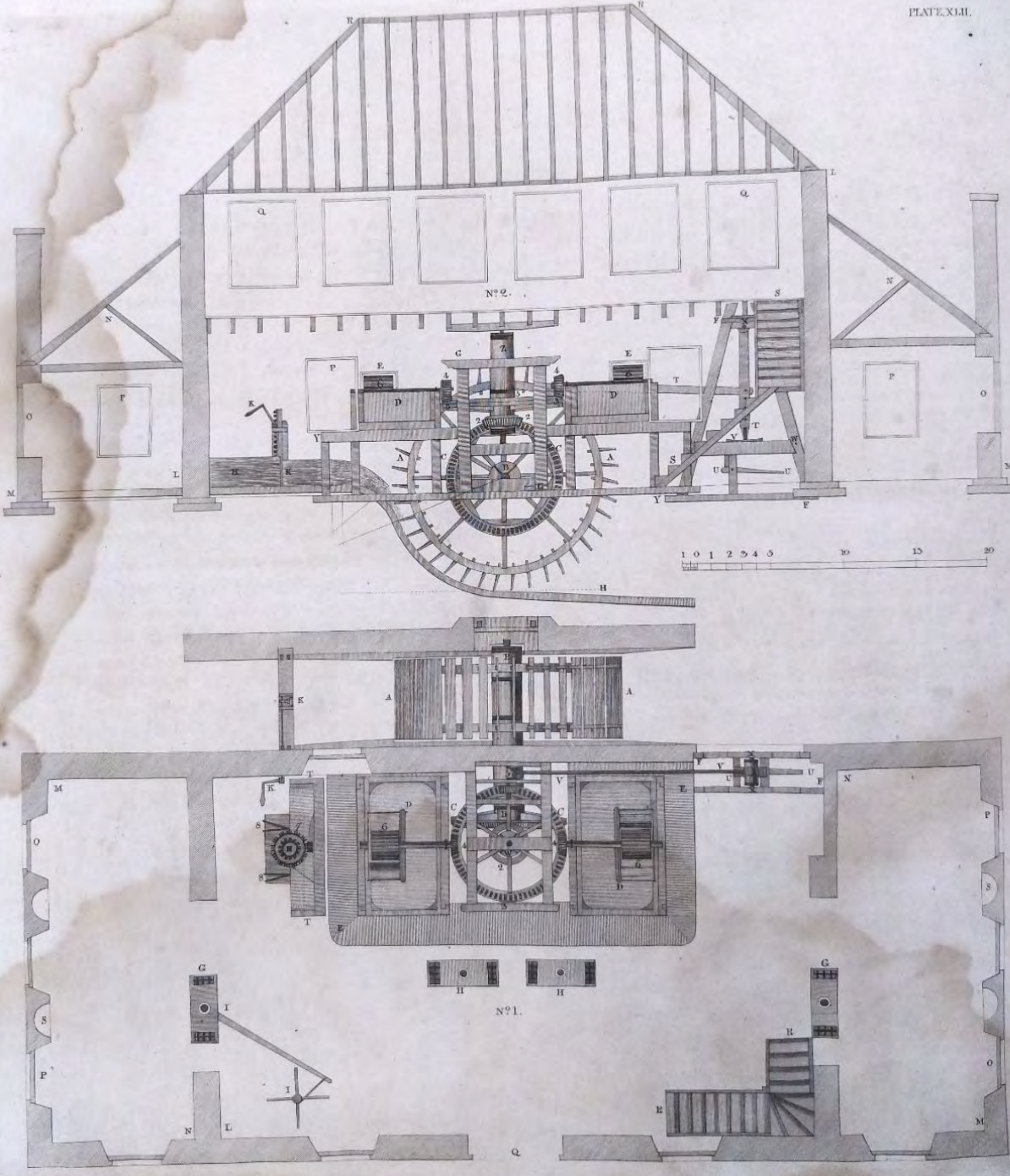
FIG. 7.—The wheel No. 5. which is placed on the axle E, Fig. 1. containing 23 teeth, to turn the wheel No. 6. of 15 teeth, which is fixed on an iron axle; upon this axle is alfo faftened the wheel No. 7. having 10 teeth, to drive the wheel No. 8. of 10 teeth, which is fixed on the iron fpindle EE, to turn over the oil feed in the chaffer-pan K, placed on the furnace M to be heated. OO, The vent. F, A lever, at the longer arm of which is a rope hanging at the workman's hand to raife the fpindle E clear of the chaffer-pan K, when the hot feed is to be taken out of it. LL, The platform on which the chaffer is emptied with the fpouts, to which are hooked fmall bags to receive it. AA, The oil prefs with the veffel N below it to receive the oil. CC, A lever and rope to raife or let down the difcharging wedge. BB, The ftamper raifed up by the arms or weepers DD, acting on the lifter HH fixed in the ftamper. By pulling the rope G, the lifter H is kept up clear of the arms D, or let down when neceffary.

FIG. 8.—AA, Plan of the furnace. BB, The grate upon which the fire is put, above which the chaffer-pan is placed. CC, Are two fpouts, to which the woollen bags are hooked to receive the oil feed when prepared for the preffing. Fig. 10. GG, Plan of the oil prefs, containing the caft-iron boxes KK with their iron plates, alfo the preffing wedge L and difcharging wedge N, and the other blocks.

FIG. 9.—AA, Elevation of the oil prefs. BB, The iron plates, betwixt which the woollen bags that contain the feed is put, and the oil preffed out of it. CC, The preffing and difcharging wedges with the other blocks in their places. Fig. 11. The caft-iron preffing box. A, Its infide, into which the bags of oil feed are put to be preffed. B, The iron plate that goes into the prefs box.

PLATE XLI.




Nº 2.
Nº 1.
1 0 1 2 3 4 5 10 15 20

Plan and Elevation of a Paper Mill.

PLATE XLII.

No. 1. *Plan.*—AA, The water wheel fixed upon its ſhaft or axle BB; on which axle is alſo faſtened the wheel CC, containing 78 teeth or cogs, to turn the wheel No. 2. having 27 teeth, which is placed upon the lower end of the axle W. Upon the ſame axle is fixed the wheel No. 3. containing 72 teeth, to drive the two pinions No. 4. and 4. each of them having 14 teeth, which are faſtened upon the iron axles or ſpindles, on which axles are likewiſe fixed the cutting or beating rollers No. 6. and 6. DD, are the engine troughs or boxes in which the beating rollers revolve. EE, a platform round the engines. TT, An elevation of the engine troughs. No. 7. The beating roller, round the circumference of which are fixed plates of ſteel that cut or beat the rags, by paſſing over ſeveral ſteel plates ſcrewed together, and fixed in the bottom of the trough with their edges facing the roller. No. 8. and 8. The blinds, or ſlip-boards and waſhers. FF is the frame of the glazing machine. XX, The axle and pivots on which the glazing pole is ſuſpended; the pole being moved by the rod VV, one end of which goes upon a bend or crank in the iron ſpindle that carries the pinion No. 5. having 15 teeth, which is turned by the wheel No. 3. UU, a lever for raiſing the glazing plate to the pole, or depreſſing it at pleaſure. GG and HH, Are the ſcrew preſſes. II, The windlaſs and lever for ſetting the preſs. NN, The mill-houſe; and MM, The vat-houſes adjoining to it. RR, a ſtair leading to the lofts. SS, Furnaces or fire-places in the wall. Q, a door in the ſide wall of the mill-houſe. OP, Windows to light the mill-houſe.

No. 2. *Elevation.*—AA, The great wheel, containing 40 float-boards or *aws*, upon which the water impinges to drive the wheel. B, The ſhaft or axle of the great wheel. On this axle is alſo fixed the wheel CC, in which are 78 teeth or cogs, to turn the wheel No. 2. having 27 teeth, which is faſtened upon the perpendicular axle ZZ; on which ſhaft is likewiſe placed the wheel No. 3. containing 72 teeth, to turn the pinions No. 4. and 4. having each 14 teeth, which are fixed upon the iron axles or ſpindles, on which ſpindles are faſtened the cutting or beating rollers No. 6. and 6. DD, The engine troughs in which the beating rollers revolve. EE, Are covers that encloſe the rollers. GG, The frame that carries the axles with the wheels. FF, The frame of the glazing engine. XT, The glazing pole ſuſpended on its gudgeon at X, and moved by the horizontal rod T, from a crank or bend in an iron ſpindle that carries a pinion at No. 5. driven by the wheel No. 3. (which is ſeen in the *Plan*, No. 1.) V, The glazing plate, made of caſt-iron, fixed upon a bearer that moves on an iron bolt in the frame at W; and the plate V is raiſed up at pleaſure to the glazing pole XT, by preſſing down the longer arm of the lever UU, which moves on an iron bolt in the frame. The gudgeons of axles and rounds of ſpindles ſhould all turn in buſhes of braſs. HH, Fall or courſe of the water. KK, The machine and handle that raiſe the ſluice to let the water on the great wheel to turn it round. YY, Are frames that ſupport the engines and platforms round them. LL, Walls of the mill-houſe. RR, The couples or frame of the roof. MM, The walls of the vat-houſes. NN, Their roofs. OP, Windows to light the lower part of the houſe. SS, a ſtair going up to the lofts. QQ, Windows in the upper part of the mill-houſe, commonly made uſe of for drying the paper.

Plan and Elevation of a Saw Mill for Cutting Wood.

PLATE XLIII.

Fig. 1. *Plan.*—AA, The water wheel fixed upon the ſhaft or axle BB. No. 2. a wheel faſtened upon the ſame ſhaft, containing 96 teeth, to drive the pinion No. 3. having 22 teeth, and fixed upon an iron axle or ſpindle, furniſhed with a coupling box on each end, to connect the axle at pleaſure with the cranks that work the ſaws. There is one coupling box at I, which connects the iron axle and the crank or bended axle DD, that, by turning round on its pivots, puſhes the frames EE, with the ſaws fixed in them, u and down to cut the wood. There is alſo a coupling box at K, which takes hold of the crank CC to turn it round, and move the frames FF up and down, having likewiſe ſaws fixed in them. GG, Are fixed pillars, that regulate the moving frames EE and ſaws. HH, Are fixed pillars that conduct the moving frames FF with their ſaws. When one frame with its ſaws is to be ſtopped whilſt the others are going, the coupling box ſlips on the ſquare end of the crank, and connects or diſengages it from the axle at any time when neceſſary. No. 5. An iron wheel, having ſmall angular teeth cut all round in its circumference; into which teeth two catches fall to turn it round, having upon its axle a pinion No. 6. taking into teeth on the under edge of the iron bar VV, to move the frame PP, with the wood upon it, forward to the ſaws to be cut. No. 7. is an iron wheel, round the circumference of which are ſmall angular teeth for two catches to work into, and turn the wheel and axle round with the pinion No. 8. fixed upon the ſame axle, to act on the teeth in the lower edge of the iron bar UU, and move the frame RR, with the wood laid upon it, forward to the ſaws. In the underſide of theſe moving frames are rollers turning on their pivots, that roll along the fixed frames OO and QQ. No. 4. a wheel fixed upon the axle L, containing 24 teeth, driven by the wheel No. 2. Upon this axle L is alſo faſtened the ſheeve or whorl M, on which is a rope or band paſſing from it to the ſheeve N, to turn it round with the pinion No. 9. fixed upon its axle, and acting on the teeth in the under edge of the iron bar VV, to move the frame PP backwards when empty. No. 10. a pinion faſtened upon the other end of the ſame iron axle to work on the teeth in the under edge of the iron bar UU, and roll the frame RR backwards when empty, or when the wood is cut. No. 11. An axle or windlaſs, upon which the rope YY rolls round, for pulling the logs of wood in at the door W, to be laid on the moving frames, and cut by the ſaws. X, a door at which the wood is conveyed out when cut. SS, The machine and handle that raiſe the fluice to let the water on the wheel AA to turn it round. TT, The walls of the mill-houſe. ZZZ, Windows to light the houſe.

Fig. 2. *Elevation.*—AA, The ſhaft or axle, upon which is fixed the wheel BB, containing 40 buckets to receive the water to turn it round. CC, a wheel fixed upon the ſame ſhaft, containing 96 teeth, to drive the pinion No. 2. having 22 teeth, which is faſtened upon an iron axle or ſpindle, having a coupling box on each end that turns the cranks, as DD, round; upon which crank one end of the pole E is put, and its other end moving on a joint or iron bolt at F, in the lower end of the frame GG. The crank DD being turned round in the pole E, moves the frames GG up and down, which having ſaws fixed in them, by this motion cut the wood. No. 3. An iron wheel, having angular teeth, which one end of the iron catch K takes hold of, and its other end rolling on a bolt in the lever HH. One end of this lever moves on a bolt at I, the other end is puſhed up and down by the frame GG. Thus the catch K pulls the wheel round, while the catch L falls into the teeth, and prevents it from going backwards. Upon the axle of No. 3. is alſo fixed the pinion No. 4. taking into the teeth in the under edge of the iron bar that is faſtened upon the frame TT, on which the wood to be cut is laid; and by this means the frame TT is moved on its rollers SS, along the fixed frame UU; and of courſe the wood faſtened upon it is brought forward to the ſaws as they are moved up and down by the crank DD, being turned round. VV, The machine and handle to raiſe the fluice when the water is to be let upon the wheel to turn it round. By pulling the rope at the longer arm of the lever M, the pinion No. 2. is put into the hold or grip of the wheel CC, which drives it, and by pulling the rope R, this pinion is cleared from the wheel. No. 5. a pinion containing 24 teeth, driven by the wheel CC, and having upon its axle a ſheeve, on which is the rope PP, paſſing to the ſheeve No. 6. to turn it round; and upon its axle is fixed the pinion No. 7. acting on the teeth in an iron bar upon the frame TT, to roll the frame backwards when empty. By pulling the rope at the longer arm of the lever N, the pinion No. 5. is put into the hold of the wheel CC, and pulling the rope O it is taken off the hold. No. 8. a wheel fixed upon the axle No. 9. having in its circumference angular teeth, into which the catch No. 10. takes; and being moved by the upper part of the frame G, puſhes the wheel No. 8. round; and the catch No. 11. falls into the teeth of the wheel, to prevent it from going backwards while the rope rolls on its axle, and pulls or drags the logs or pieces of wood in at the door Y, to be laid upon the moveable frames TT, and carried forward to the ſaws to be cut. The gudgeons in ſhafts, rounds of the cranks, pivots, and ſpindles, ſhould all turn round in cods or buſhes of braſs. Z, a door in the other end wall of the mill-houſe, at which the wood is conveyed out when cut. WW, Walls of the mill-houſe. QQ, The couples or framing of the roof. XX, Windows for lighting the houſe.

Fig. 2.

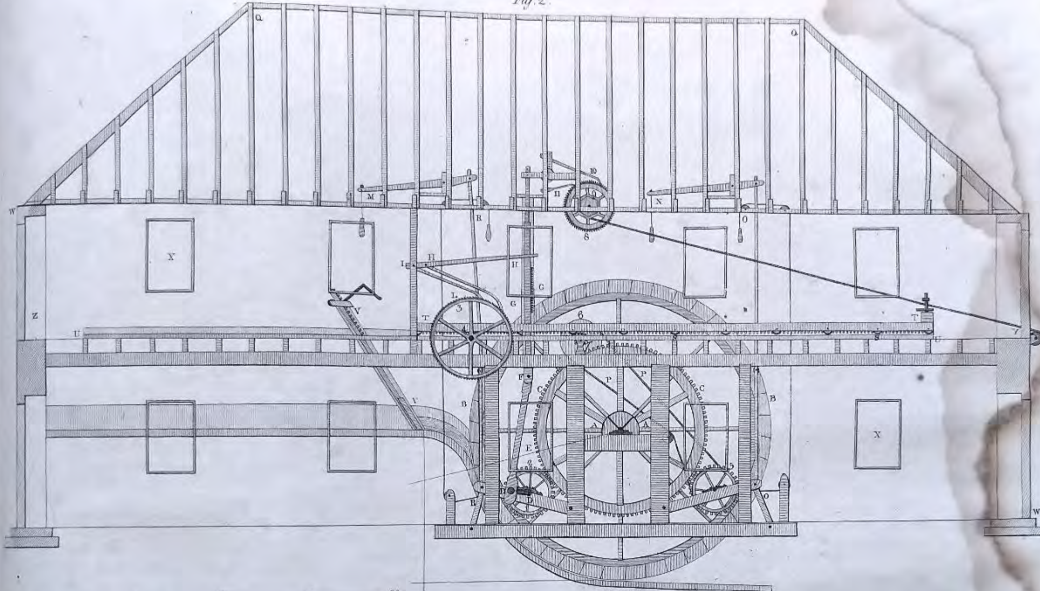


Fig. 1.

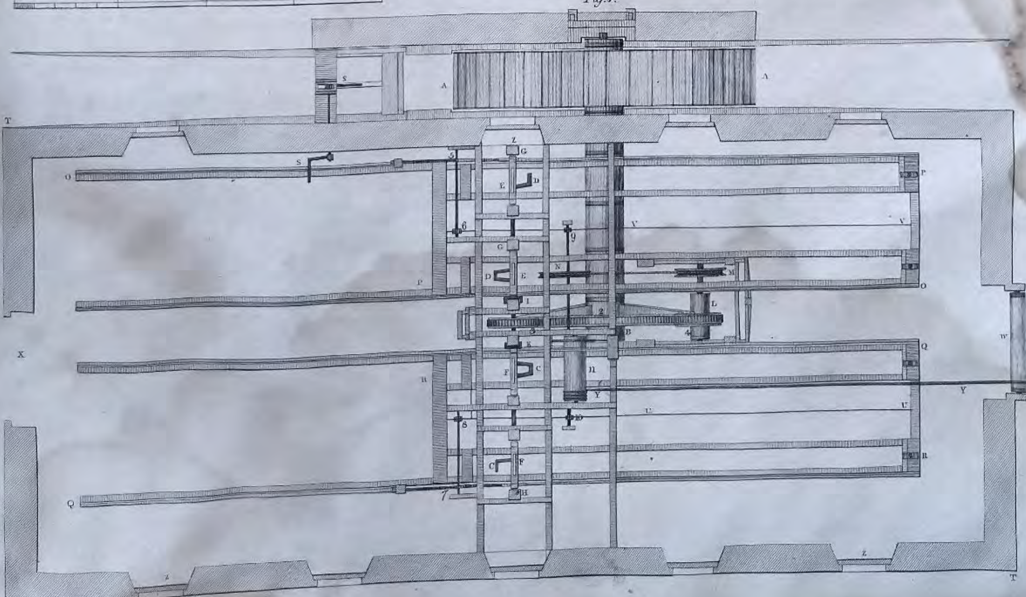


PLATE XLIV

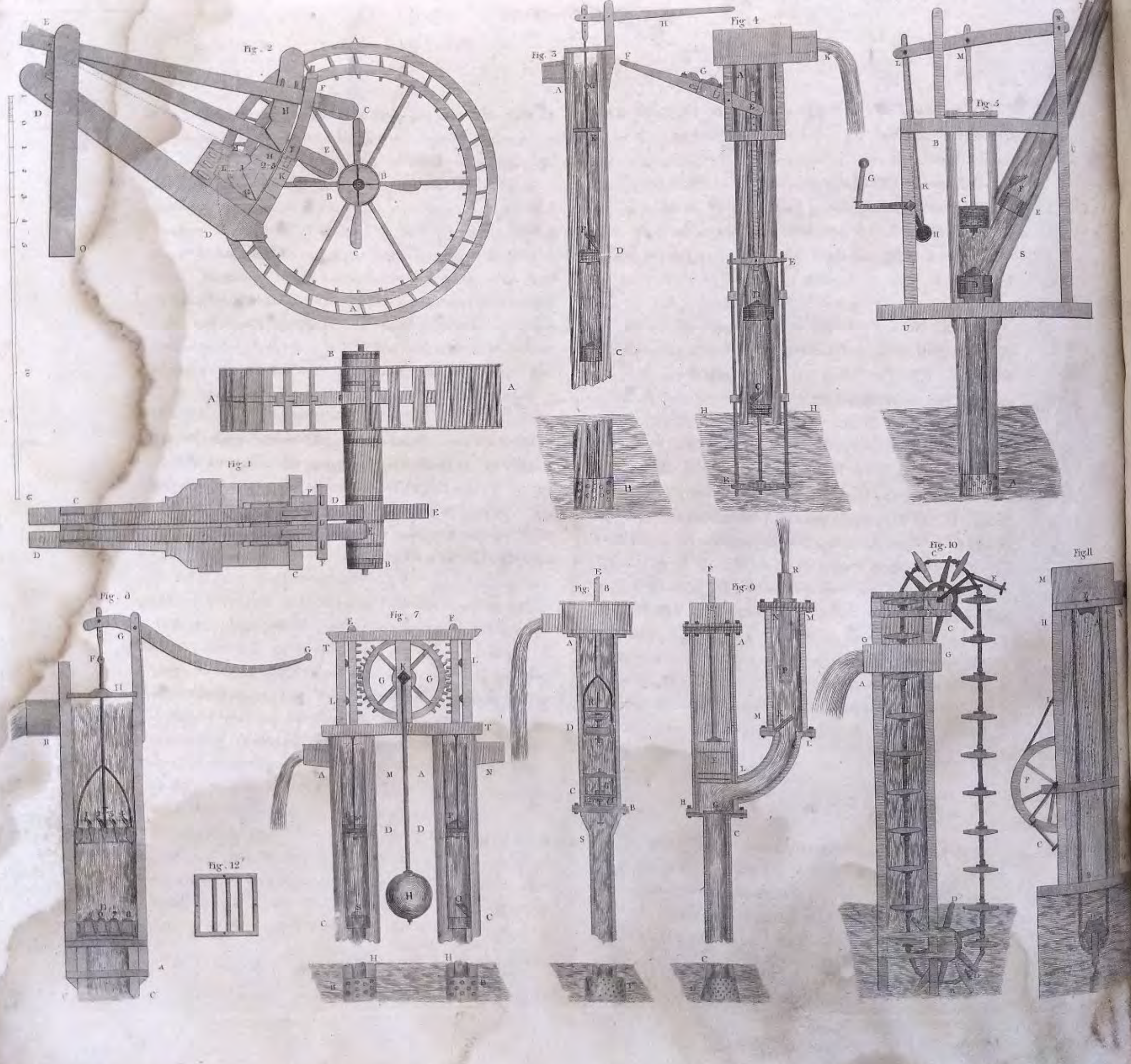


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
Fig. 9
Fig. 10
Fig. 11
Fig. 12

PLATE XLIV.

FIG. 1. *Plan of a Wauk or Fulling Mill for Woollen Cloth.*—AA, The water wheel fixed upon its ſhaft or axle BB; in which axle are alſo faſtened the arms or weepers EE, which lift or raiſe one end of the levers DD when the axle is turned round, while the other end moves in the ſtrong frame CC; on which frame is placed the fulling box or receptacle that contains the cloth. FF, The frames that regulate the levers DD, and *poſſing* or fulling feet.

FIG. 2. *A Profile of the Wauk or Fulling Mill for Woollen Cloth.*—AA, The great wheel, containing 36 float boards, on which the water acts. BB, The ſhaft or axle of the great wheel; in which axle are likewiſe placed the arms or weepers CC, which, being turned round along with the great wheel, lift or raiſe one end of the levers DE, in which are fixed the fulling feet HH, that, being raiſed up with the levers E, fall down in the fulling box among the cloth, and turn it a little over in the receptacle at every ſtroke. DOD, The ſtrong frame called the *millſtock*, upon one end of which is placed the fulling box or receptacle GL, that contains the cloth. FF is a frame which regulates the levers EE, and prevents the fulling feet from going to any ſide when moving up and down. To form the receptacle or fulling box, divide the horizontal line LK into three equal parts, as 1, 2, and 3. Take two of theſe parts; and from the point 2, as a centre, deſcribe the curve GL up to the dotted line M, which forms the curved part of the fulling box, and the angle of the fulling feet H is drawn from the under end below G to the point 1 on the dotted horizontal line LK in the fulling box.

MACHINES OR PUMPS FOR RAISING WATER.

ENGINES or machines for raiſing water are of different kinds: Some are ſimple, as the ſyphon, ſyringe or ſingle pump, ſcrew pump, and the like. Others are more complicated, when to the ſimple pump are added other contrivances; as the chain pump, crank work or vibrating lever, &c. The moving powers may be either the ſtrength of men, of horſes, or of oxen; or water, wind, or ſteam. Whatever the moving power is, the parts of an engine for raiſing water ſhould be few, and very ſimple; for although in all other machines, ſuch as thoſe for raiſing great weights, and thoſe which move with great velocity, a number of wheels and pulleys are neceſſary either to retard or to accelerate the machine in performing ſome particular motion, as to make the aſcent of heavy bodies more eaſy and uniform; yet in engines for raiſing water the caſe is different, becauſe ſuch machines are not limited to any certain degree of velocity; for the like quantity of water can be raiſed in the ſame time, and with as great eaſe, by a large pump, with a ſlow motion, as can be raiſed by a ſmall one with a greater motion.

OF THE PUMP.—This is a very uſeful piece of mechaniſm; of which there are ſimply three kinds, *viz.* the *Sucking*, the *Lifting*, and the *Forcing Pump.* By the two laſt, water may be raiſed to any height with proper apparatus and ſufficient power; by the former it may, by the preſſure of the atmoſphere on the ſurface of the water, be raiſed about 33 feet.

The moſt common kind is the *Sucking Pump*, which conſiſts of a wooden pipe open at both ends, as AB, Fig. 3. in which is the piſton D, fixed on the under end of the iron rod FF, connected by an iron bolt with the lever H; by means of which, or ſome other contrivance, it may be moved up and down without ſuffering any air to come between it and the ſides of the pipe, which is otherwiſe called the *barrel* of the pump. If the lower end B of this pipe were put into water, and the piſton D raiſed by raiſing up the column of air, a vacuum will be made in the pipe, upon which the atmoſphere preſſing on the well water will force it to follow the piſton to the height of 33 feet, if the ſtroke were of that continued length; and if there be a valve or *clack* to ſhut downward, placed in ſome convenient part of the pipe below the water ſo raiſed, as at C, then the water above it will be retained there; but if this valve be wanting, upon pufhing down the pifton again, the water will recede along with it towards the fpring; fo that by the motion of the pifton up and down, the water would rife and fink in the barrel at every ftroke: but without an under valve to keep the water up when raifed, none can be drawn in the common way. When the pifton D of this machine defcends, if the bore of the pipe be already full of water, the refiftance thereof will pufh open the moving valve F, and part of the water will rife above; and whenever the pifton D is drawn upwards, this valve F will fhut under the incumbent weight, and the water will be raifed by the force applied: So that whenever the moveable valve, by being raifed, is made to lift the column as well of air as water refting upon it, the valve of the fixed box C is difcharged of all preffure, and then a quantity of water, precifely equal to that by the pifton lifted or drawn off, will, by the ordinary preffure of the atmofphere on the water in the well, be forced into the pipe, to replenifh the barrel DC. But if the bore of this machine be full of air only before any water can be drawn, that air muft be exhaufted, which may be done if the pifton valve be tight by the ordinary motion thereof; but for the greater certainty and expedition, a little water is commonly poured down the barrel, called *fetching the water*, or *priming the pump*, which is of no other ufe than to wet the valves and fupple the collar of leather fixed to the bucket or pifton, that it may fpread and lie clofe to the fides of the barrel, and fuffer neither the upper air nor water to efcape betwixt them when the pifton is moved up and down. The firft ftroke of the pifton D, if fufficiently long, will make a vacuum in the barrel; if otherwife, an approach is only made towards it, and but a part of the contained air lifted away; upon which the air remaining in the cavity of the barrel, from its natural fpring, is confiderably dilated. To reftore the equilibrium, the atmofphere preffes with a greater force on the well water within the barrel than does the dilated air on that in the barrel, and caufes the water to rife till the enclofed air (yet a little rarefied by the depending weight of water), fhall juft counterpoife the weight of the outward air. The very fame thing will again happen on a repetition of the ftroke of the pifton, till by degrees the water fhall have reached the moving valve F; and then the procefs will go on fteadily. The preffure on the pipes in pump-work is in proportion to the perpendicular height of the fluid above the part confidered; but the weight incumbent on the bucket or moving valve F in action is nearly proportional to that of the column of water raifed: for though the preffure of the atmofphere on the furface of the fpring, when the bucket rifes, be really equal to the weight of 33 feet of water, yet is this affiftance counterbalanced exactly by the weight of the atmofphere ever incumbent on the furface of the water thereby raifed; fo that all the advantage to be obtained by, or expected from hydraulic machines or engines to raife water, as well indeed as from all other pieces of mechanifm whatever, is only the putting matters into a convenient method of being executed; for the performance depends on the moving power entirely, under the difadvantage of friction always againft it.

A pump therefore intended to raife water to any height whatever will work as eafy, and require no greater power to give motion to the pifton, if both the valves be placed towards the bottom of the pipe, than if they were fixed 33 feet above the furface of the water. The way of leathering the piftons of thefe machines is always fo as to face their work, that when the ftrain comes, the leather being a ftrong and tough yet yielding fubftance, may fpread, and fuffer neither air nor water to pafs between the piftons and the fides of their barrels when they are moved. The fole-leather of a fhoe is found fufficiently ftrong to refift any moderate preffure from above, as in the cafe of the fucking and lifting pump piftons; or to overcome any thruft made below, as in the cafe of the pifton of the forcing pump, if the pump be to work in hot liquor, coarfe cloth is commonly ufed in place of leather, or a pump of caft iron is made ufe of for that purpofe.

The ftructure of the *Lifting Pump*, Fig. 4. differs from that of the fucking pump in nothing but the placing of the piftons; as the fucking pump has its fixed valve below, and the moveable one above in the barrel. This is juft the reverfe; C being the moving pifton, and D the box and valve fixed above in the barrel A. As the bucket or pifton of the firft is moved by and within the box of the pipe, this is moved by means of the frame

EE, without the barrel; to which are fixed the rod of the moveable piſton and valve C, moved by the lever FF; upon which is fixed a weight G, to balance the rod and frame EF, which when moved raiſe the water from the ciſtern HH up the pipe A, where it runs out at the ſpout K. From the name and ſtructure of this machine, it may be imagined perhaps that the atmoſphere's preſſure is not of equal ſervice to this kind of pump: but it is quite otherwiſe; for if both valves be not perfectly air-tight, water cannot be well raiſed thereby: but in caſe neither of them is defective, water will be raiſed to very good purpoſe by much the ſame proceſs as that of the ſucking pump before explained: nor is there any doubt but that if two machines, a ſucking and a lifting pump, were made of equal bores, wrought with equal force, and were in every circumſtance alike, they would be found of equal ſervice in raiſing water as the forcing pump.

Fig. 5.—As the weight of the atmoſphere is the principle on which the ſucking and lifting pumps depend, it is alſo applied to the *Forcing Pump*, which conſiſts of a barrel AB and a piſton or forcer C, leathered upwards, that it may withſtand the preſſure of the atmoſphere from above, and by ſucking when raiſed it may bring up the water to ſupply the barrel; and it is alſo leathered downwards, that when depreſſed it may reſiſt the weight of the water to be forced up or raiſed for uſe. There are always two fixed boxes with moveable valves in this kind of pump; one in ſome convenient part of the ſtrait, otherwiſe called the ſucking pipe, as at D; the other as at E, in the branching or forcing pipe ST. Theſe ought in like manner to be air-tight, and ſo diſpoſed as to let the water riſe freely, but muſt prevent its return. When the forcer C is moved upwards in the barrel B, the air between that and the water below, having room to dilate by its natural ſpring, will of courſe be rarefied therein. The preſſure of the atmoſphere then being intercepted by the forcer C in the barrel B, on one hand, and by the upper valve F, in the branching pipe ST, on the other, the water will riſe from the ſpring into CDE, for the reaſons already given; and repeated ſtrokes of the piſton will fetch up the fluid to the forcer, and at length fill the cavity of the pipes between CD and E. This done, the water in this manner ſucceſſively raiſed being hindered from going down again by the valve at D, will be preſſed by the forcer C every time it deſcends, and be thereby forced to make its way where the leaſt reſiſtance is, *viz.* through the upper valve F; and whenever the forcer C is raiſed, the preſſure intermits; then the valve F will immediately cloſe under the weight of the upper water, and prevent its return that way while the piſton is riſing with a freſh ſupply; and this is repeated at every ſtroke of the forcer C, which is moved up and down by turning the winch or crank handle G, connected with the crank H, upon which goes the under end of the rod or crank pole K; its other end moving on a bolt in the lever at L; the other end of which moves on a bolt in the frame at N; and the rod of the forcer C on a bolt at M; this rod having in it a pin, on which it yields with the lever when moved up and down; while the lower part of the rod is kept in the centre of the barrel B, by moving in a croſs bar fixed on the top of the pump. UU, Are frames which ſupport the machine and branching pipe.

Fig. 6. Is a *Sucking Pump* on a large ſcale, conſtructed ſo as to be eaſily taken to pieces and carried from one place to another. Theſe pumps are made of a ſquare form, and may be of any ſize according to the quantity of water intended to be raiſed, and to the power that can be applied to raiſe it to the height required. This pump conſiſts of four ſides of ſtrong well-ſeaſoned planks cloſely jointed, and may be held together either by iron hoops or ſcrewed bolts, ſo that they may be eaſily ſeparated when required, in order, if thought neceſſary, to pack in ſmaller compaſs when carried from one place to another. AB, The body of the pump. CC, The ſucking tube that goes into its under end; and on the top of this ſucking tube is fixed the open frame D, upon which are placed the valves 5, 6, 7, 8, that will open or ſhut according as they are preſſed from above or below. There is alſo a moveable piſton or bucket E fixed to the lower end of the iron rod F, connected by a bolt with the ſhorter arm of the lever GG. This piſton is ſo fitted to the ſides of the pump AB that no air or water can paſs between them; and upon it are placed the valves 1, 2, 3, 4, which open and ſhut as the piſton is moved up or down in the hollow of the tube or pump. H, a

crofs bar on the top of the tube, having in it a hole, in which the rod F moves up and down to keep it in the centre of the pump, while its upper end yields on a pin at F as it is raifed and depreffed. Fig. 12. The open frame of the pifton or bucket, on which the valves are to be placed; and round its fides is to be nailed a collar of leather, to prevent either air or water from paffing between it and the fides of the tube. The principal advantage of thefe fquare pumps is, that they may be made of a very large fize at a fmall expence; and the piftons and valves being conftructed with long narrow flaps, they open eafily and fhut inftantaneoufly without lofing any advantage of the ftroke, as would be the cafe in a common pifton or valve of a large fize: and having fo wide a tube, they will raife a great quantity of water at every ftroke, even though the ftroke fhould be but fhort; and by making the long arm of the lever of confiderable length, a fmall power applied will in a fhort time raife a large quantity of water; and as it may fometimes happen that it would be much eafier and more convenient to apply a fhort ftroke than a long one; in which cafe thefe pumps would be very convenient; for if only eighteen inches fquare they would raife as much water with one fix-inch ftroke as a pump fix inches fquare would do at nine fuch ftrokes, or at four and a half twelve inch ftrokes, or three ftrokes of eighteen inches.

Fig. 7.—AC, CN, Are two fucking pumps placed near each other, the piftons of which are moved by the wheel fixed on the iron axle K, having teeth that act upon the teeth in the rods E and F; on the lower ends of which are fixed the moveable piftons DD, having valves or *clacks* P and R, which open or fhut as the piftons are moved up or down in their tubes. Upon the iron axle K is alfo faftened the iron rod M, and on its under end is fixed the weight I of lead or caft-iron, made thin one way that it may meet with fmall refiftance from the air when pufhed forward or backward to move the wheel GG, and of courfe raife and deprefs the piftons DD alternately, fo that the one going down affifts in raifing the other. O and S are likewife valves placed in the fucking pipes that open and fhut according as the preffure is from above or below. When the moving piftons are raifed up, the lower valves are opened by the water below rifing in the tube; and when the piftons are moved downwards, the greater preffure being above fhuts the under valves, and prevents the water fo raifed from returning to the well. BB, The fucking pipes placed in the well or ciftern of water HH; and on the under end of the pipes are drainers to keep back any refufe that might choak the pumps. TT, The frames that carry the wheel GG and pendulum KI, by which the piftons are moved. LL, Are friction rollers moving on their axes in the frames to prevent the rods E and F from going off the *grip* or hold of the wheel GG when moving up and down.

Fig. 8.—A fucking pump of caft-iron, which is commonly made ufe of to work in hot liquor. AB, The barrel of the pump, having a flench at B, by which it is fixed with fcrew bolts to a flench on the fucking pipe ST. In the cavity of the barrel is the moveable pifton D, fixed on the rod F, which may be moved by a lever or fome other contrivance. The pifton D is fo fitted to the tube as to move eafily up and down, having a valve or *clack* R of caft-iron fixed on a fmall iron rod that moves up and down in its frame with the valve R upon it, which is fo fitted to the hole in the pifton, that when fhut no water can pafs between. There is alfo placed in the barrel at C a valve G of caft-iron, fixed on a rod of iron, and having freedom to move up and down in its frame when the valve G is either raifed or depreffed; which valve muft be fo fitted to the opening, that when fhut neither air nor water can efcape. When the pifton D is moved upwards, the valve G is raifed up by the liquor preffing into the barrel; and when the pifton D is moved downwards, the valve G is fhut by its preffure, and the valve R opened by the water fo raifed above the valve G. When the pifton is again moved upwards, the valve R is then fhut by the weight of water; above which, as the pifton rifes, the water iffues from the fpout at A, while a frefh fupply is raifing into the barrel below to fupply the place of what was carried off by the moving bucket.

Fig. 9. *A Forcing Pump of Caft-iron.*—AB, The forcing barrel; being a hollow tube, with its infide made perfectly ftraight and fmooth. E, The forcer, which muft be fitted to the tube fo as to move eafily up and down in it; being fixed on the lower end of the forcing rod F, which rod fhould be ftraight and well polifhed, that neither air nor water may be allowed to pafs be-

tween the forcer and barrel. The forcing rod F goes through two collars of leather, which are ſcrewed between three rings of metal, fixed on the upper flench of the barrel: The middle ring is of braſs, and ſerves for a guide to the forcer, being of a leſſer bore than the other two, which are of iron, that neither the upper leather nor the lower leather (one whereof is turned upwards and the other downwards) may ſlip between the forcing rod and the middle braſs ring. This barrel has a curve-branching pipe LL, coming out of it juſt above the ſucking valve G; and the pipe has a flench at LM, to carry the forcing valve K, which plays in the tube MM. The ſucking pipe CC, that goes down into the well or ciſtern D, has a flench, by which it is fixed to the forcing barrel; and upon this flench the under valve G is placed, which opens when the forcer E is lifted up, and allows the water to riſe as the atmoſphere preſſes it up from the well to fill the ſpace left empty by the forcer; the forcing valve K being ſhut all this while. Then as the forcer is moved down again, it preſſes a quantity of water equal to its bulk through the opening of the forcing valve K up the pipe PN; the ſucking valve G being ſhut at this time: And ſo on at every ſtroke of the forcer till the water is driven up through the pipe PN, and iſſues out at the pipe R, which is made of any height to which the water is to be raiſed or forced up.

FIG. 10. *The Chain Pump*, commonly made from 12 to 24 feet long. It conſiſts of a ſquare barrel AB, and a chain of piſtons of the ſame form, fixed at proper diſtances thereon. The chain is moved round a coarſe kind of wheel-work, as CC, fixed on the upper end of the barrel; and DD, on the under end. The teeth are made ſo as to receive one half of the flat piſtons, and let them fold in; and they take hold of the links as they riſe in the barrel. This machine is wrought either by turning one handle, as E; or two, according to the labour required; depending on the ſize of the barrel and the height to which the water is to be raiſed. The piſtons muſt be made ſo as to go a little free of the ſides of the barrel; yet do they, in the ordinary way of working, as it is pretty briſk, commonly bring up a full bore of water in the pump. The chain is made ſo, that by the continual folding in of the piſtons, as they move round, ſmall ſtones, ſand, or looſe earth, and whatever of that kind happens to come in the way, are cleared away; and therefore it is generally made uſe of to drain ponds, to empty ſewers, and remove foul water, in which no other pump could work. GG, a ſquare box placed on the pump, open at one ſide, at which the water, when raiſed by the piſtons, runs out.

FIG. 11. *A Hair Pump*, or a machine to raiſe water by means of one or more hair ropes, according to the quantity of water intended to be raiſed.—AB is a hair rope paſſing over the pulleys DE, which turn on their axles. The pulley D is immerſed in water, and is kept therein by a weight ſuſpended from its frame. The pulleys are made ſo as a ſmall part bears on the rope. Theſe pulleys are turned round pretty quick by turning the crank handle C, fixed on an iron axle; on which is faſtened the wheel F, having on it a band or rope L, paſſing round the ſheeve G, fixed on the axle of the pulley E, which being turned quickly round the hair rope, revolves alſo with rapidity; and the aſcending rope carries up a conſiderable quantity of water which it diſcharges with violence into the reſervoir M, from whence it is conveyed into any convenient place by a pipe, as N. If there are more than one rope they ſhould not be placed above one inch aſunder. HH, the frame that carries the pulleys. This kind of machine will bring water from a great depth; and if the upper ſheeve be placed high, will ſend it to a conſiderable height. In the beginning of the motion, the column of water adhering to the rope is always leſs than when it has been worked for ſome time.

FINIS.

D. Willison, printer,
Edinburgh.