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– Essays –
– on –
– Mechanics –
– and other –
Usefull Knowledge
– – – – – –

– Ja^{s}. Lamb –
– Anno Domini –
– 1796 –
– S^{t}. Vincent –

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– Mechanics –

DEFIN^{N}. Ist. Mechanics, is a science, which treats of the forces, motions, velocitys, & in general, of y^{e}. actions of bodies upon one another; it leaches how to move any given weight with any given power; how to contrive engines to raise great weights, or to perform any kind of Motion. –

IInd. Body, is the mass or quantity of matter; density, is the proportion of quantity of matter in any body, to y^{e}. quy^{t}. of matter in another body of the same dimentions. –

IIIrd. Velocity, is property of motion, by w^{h}. a body passes over a certain space in a certain time; & is greater or less, as it passes over a greater or less space in a certain time. –

IVth. Motion, if y^{e}. body moves equaly, it is called equable or uniform motion; if it increases or decreases, it is called accelerated or retarded motion

Vth. Direction of motion, is the course, or line it moves in. –

VIth. Quantity of motion, is y^{e}. motion of a body, considered both in regard to its velocity & quantity of matter; y^{s}. is called y^{e}. momentum of a body. –

VIIth. Gravity, is y^{t}. force where with a body endeavou^rs to fall downwards. –

VIIIth. Specific Gravity, is y^{e}. prot^{tn}. between y^{e}. weights of bodies of y^{e}. same magnitude. –

IXth. Center of Gravity, is a certain point of a body; upon w^{h}. y^{e}. body, w^{n}. Suspended, will rest in any position. –

Xth. Center of motion, is a fixed round about w^{r}. a body moves; & y^{e}. axis of motion is a fixed line it moves about. –

XIth. Equilibrium, is y^{e}. balance of two or more forces, so as to remain at rest. –

XIIth. Machine or Engine, is any instrument to move bodies, made of levers, wheels, pullies, &c. –

XIIIth. Friction, is ye resitance w^{h}. a machine suffers by y^{e}. part rubbing agst. one another. –

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– Axioms –

Ist. Every body endeavours to remain in its present state, whether it be at rest, or moving uniformly in a straight line. –

IInd. The alteration of motion by any external force is allways proportional to that force, & in y^{e}. dierection of y^{e}. right line in w^{h}. y^{e}. force acts. –

IIIrd. Action & re-action, between any two bodies, are equal & contrary. –

IVth. The motion of any body is made of y^{e}. sum of y^{e}. motions of all y^{e}. parts. –

Vth. The viscnertia of any body, is proportional to the quantity of matter. –

VIth. Two equal forces acting agst. one another in contrary dierections, destroy one anothers effect; & unequal forces act oney with the diff. of them. –

VIIth. If a body be acted on by any power in a given Direction; it is all one in w^{d}. point of that line of dierection y^{s}. Power is applied. –

– Of the Mechanic Power –

Which may be reduced to these 6 viz. **Ist.** y^{e}. leaver –
IInd. y^{e}.axis in PereTrochio
IIIrd. y^{e}. pully –
IVth. y^{e}. wedge & inclined plain
Vth. The screw –

These may be comprehended under the Leaver & Wedge,viz the axis in peretrochio depend entirely on y^{e}. same principles w^{d}. e^{e}. lever, in like manner the screw may be explaned from the wedge – – – Of the level. The most simple of all y^{e}. mechanic powers is the level an engine cheifly used in raising great weights from small heights. The lever is a bar of iron or wood, one part one part of which being supported by a prop, all y^{e}. other parts turn about that prop as a center of motion: and y^{e}. velocity of every part or point is dierectly as its distance from the prop. There w^{n}. The weight to be raised at one end, is to the power applied at the other end to raise it, as the dist: of the power

Ist. The common sort, where ye prop is placed between the weight & the power. **IInd.** When the prop is at one end of y^{e}. lever, the power at the other, & the weight between them. **III.** When the prop is at one end, the weight at the other, & the power in y^{e}. middle. –

IV. ~~When~~ The bended lever, w^{h}. differs only in form, & not in property from the ~~other~~ first sort. – The proportion for the **Ist.,IInd., & IVth.** is the same as already mentioned; for the **IIIrd.**, that there may be a balance between the power & the weight, the intensity of the power must exceed the intensity of the weight, just as much as the distance of y^{e}. weight from the prop exceeds, the dist: of the power from the prop –

IIIrd. That there may be a balance between the power & the weight, the intensity of the power must exceed the intensity of the weight, from the prop is to the dist: of the weight from y^{e}. prop, y power & weight will exactly balance each other: & as a common lever has next to no friction on its prop a very little weight added to it will serve to raise it. Exe. Suppose y^{e}. lever divided into 13 parts, & the prop placed at one of thes parts from the end y^{e}. W being placed at that end wh is distant only one part from the prop, & the power at the other which is distant 12 parts from the prop; now a W of 12 pounds will be supported by 1 pound hanging ~~hang~~ at ~~then~~ end w^{h}. is distant 12 parts from the prop. – There are four Kinds of levers,

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just as much as the distance of y^{e}. weight from the prop exceeds, the dist: of the power from the prop –

IInd. Mechanical Power is the wheel & axle, in w^{h}. the power is applied to the circumference of the wheel, & the weight is raised by a rope which coils round the axle as the wheel turns. Here it is plain that the velocity of the power must be to that of the weight, as the circumference of the wheel is to that of the axle: & consequently, the power & weight will ballance each other, w^{n}. the intensity of the power is to that of the weight as the circumference of the axle is to that of the wheel. –

IIIrd. Mechanical Power or engine is the pully, which consists either of one moveable pully, or a system of pullys; some in a block or case w^{h}. is fixed, & others in

in a block which is moveable, & raises with the weight. A single pully which ~~moves~~ turns in its axis & moves not out of its place, may serve to change the dierection of the power but can be of no mechanical advantage; but is only as a beam of a balance, whose arms are of equal length & weight. The advantage gaind by a single moveable pully or any system of moveable pullies; will allways be equal to twice the number of moveable pullies in the undermost block. So that when the uper or fixd block contains two pullies, w^{h}. only turn on their axis, & the lower or moveable block contains two pullies, w^{h}. not only turn upon their axis, but also rise with the weight; the advantage gained by this is as [I] to to the working power. –

The [velsatys] are reciprocaly as the power & weight. – Another combination of moveable pullies, which differ from the former in not having one single rope rceved through all the pullies both in the moveable, & the unmoveable pullies. In this each moveable pullie has a distinct rope ~~fastned to an~~ one end of e^{h}. is fastned to an unmoveable block; & the other end hooked to the lower most end of the block next above it. The power

first will be = 2, the power of the second = 4, the power of the third = 8. – This combination of pullies is called running pullies; when one of them is applied to a system of moveable pullies; it is called a runer, & i~~ncrease~~ it doubles the whole force of the moveable pullies to which it is applied. – –

The **IVth.** Mechanical power is the Wedge & inclined plain. The inclined plain, the advantage gained by which, is as great as its length exceeds it perpendicular height. The force where with a rolling body decends upon an inclined plain, is to the force of its absolute gravity, by which it would descend in a free space as the height of the plain to its length. A weight may be rolled up an inclined plain if with one fourth of its weight, if the length of the plain exceeds its perpendicular height [4] times – The proportion the power must be to the weight as the height of the plain to its length. – –

Of the Wedge: which may be considered as two inclined plains Join & to gether at their bases – When the wood does not cleave at any distance

is in a series of these numbers as 2,4,8,16,&c. –
Eom: suppose three moveable pullies the power of

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before the wedge, there will be an equilibrium
between the impelling power & the resistance
of the wood acting ags^{t}. The two sides of the wedge, when

– Axioms –

the power is to the resistance, as half the thickness of the wedge at its back is to the length of either of the sides; because y^{e}. resistance then acts perpendicular to the sides of the wedge. But, when the resistance on each side acts parallel to the back, the power that ballances the resistances on both sides will be as the length of the whole back of the wedge is to double its perpendicular height. When the wood cleaves at any distance before the wedge (as it generaly does) the power impelling the wedge will be to the resistance, as half the length of ~~either of its sides~~ the back of the wedge is to the length of either of the sides; or w^{h}. am~~m~~ounts to the same thing, as the whole length of the back is to the length of both the sides –
The wedge is a very great mechanical power, since not only wood but even rocks may be split by it; which would be impossible to effect by the Leaver, wheel & axle, or pully: for the force of the blow, or stroke, shakes the cohering parts, & there by mekes them seperate more easily. – –

The **V.**, & last Mechanical power is the screw; which cannot properly be called a simple machine because it is never used without the application of the leaver, or winch, to assist in turning it:

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& then it becomes a machine of great force either in ~~placing~~ pressing the parts of bodies together, or in raising great weights to small heights. It may be conceived by cuttin a piece of paper into the form of an inclined plain, & then wrapping it round a cylinder. Here it is evident that the winch must move once round before the weight of resistance can be moved from one spiral winding to another: therefore as much as the circumference of the handle (or the circumference of the circle in which it turns) is greater than the interval or distance between the spirals, so much is the force of the screw. Exa. Supposing the distance between the spirals to be equal to one half inch, & the length of the winch 12 inches, the circle which it describes viz the handle, will be 76 ins nearly, or about 152 half inches, & consequently 152 times as great as the distance between it spirals: & therefore a power whose intensity at the handle, is equal no more than a single pound, will ballance 152 pounds acting upon the screw; the velocity of the power will be to that of the weight as 152 to 1. Hence it appears that y^{e}. longer the winch is, & the nearer the spirals are to one another, so much the greater is the force of the screw. – – –

– The Method foe setting out a Spur Wheel & Wallower.

Fig 8
Plate 1st

Draw the pitch lines **A1, B1, A2, B2**; y^{n}. Divide y^{m}. into y^{e}. number of teeth or coggs required as **abc**. Divide one of those Distances, as **bc**

compasses in y^{e}. dot **3**, of the cog **a**, & strike the line **d, e**; y^{n}. remove the point of the compasses to y^{e}. point **d**, & strike the curve line **3f**, w^{h}. They account near enough the truth for practice – –

into seven equal parts, **1, 2, 3, 4, 5, 6, 7**; thence of these parts allow for y^e. thickness of the cogs, as **1, 2, 3**, in the cog **a**, & four for the thickness of y^e. stave, of the Wallower (one reason for allowing 3 parts for the cog, & **4** for the stave, is, the wallower is in general of less diameter than the wheel, therefore more subject to wear in proportion to the number of cogs, to the number of staves; but if there is the same number of staves as cogs, they may be made of equal thickness) as **1, 2, 3, 4**, in the stave **m**, Fig **9** plate **I**; the height of the cog is equal to four parts, then divide the height into five equal parts, as **1, 2, 3, 4, 5**, in the cog **c**; allow three for the bottom to the pitch line of the cog; the other two parts for the Epicycloid, so as to fit & bear on the stave equaly The Millwrights in general put the point of y^e.

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Fig. 9 Plate 1st. The method for a face wheel is thus; divide the pitch line **A B** into any number of cogs intended, as **abc**; divide y^e. distance **bc**, into seven equal parts; three of those parts allow for the thickness of the cogs, as **1, 2, 3**, in the cog **a**, four for the height, & four for the width as **de**, & four for the thickness of the stave **m**; draw a line through y^e. center of y^e. cog, as y^e. line **A1**, at **S**, & on y^e. point **b**, describe y^e. line **de**; remove y^e. compasses to y^e. point **A**, & draw the line **fg**, w^h. forms the shape of y^e. cog; y^n. Shape the cog on y^e. sides to a cycloid, as **defg**, **Fig. 8th. Plate 1st**. – But this method of setting out the shape of a cog is variable, according to the cycloid in the different diametrs of wheels. –

Fig. 10th. Plate 1st. In common spur nut, divide y^e. pitch line **A**, into twice as many equal parts as you intended teeth, as **a, b, c, d, e**; with a pair

of compasses open to half the distance of any of those divisions, from the points **a1, c3, e5**, draw y^e. Semicircles **a, c**, & **e** w^h. Will form the ends of y^e. teeth From the points **2, 4**, & **6**, draw the semicircles **ghi**, w^h. will form the hollow curves for the spaces; but if the ends of the teeth were epicycloids, instead of circles they would act much better. – –

Definition of y^e. Pitch line in a Wheel

– The pitch line, is that line which when the height of the teeth or cog, is divided into 5 equal parts; then a line drawen (if a spur wheel from y^e. center of the wheel) at y^e. distance of three of those parts from y^e. outward edge of the Rim, is that line; if a contrat wheel it must be three of those parts from the flat of the Rim, for the pitch line

The Princpals of Bevel Geer –

Consists in two cones, rolling on the surface of each other, as **A** & **B** revolving on their centers **ab**, **ac**; & if y^e. cones were fluted, or had teeth cut in them, diverging from the center **a**, to y^e. bases **dc**, **ef**, they would y^n. become bevel geer. – The teeth at the point of the cone may be cut off, as being of little use; as may be seen by **figure 2. PLATE I.**, where the up right shaft, **ab**, w^d. y^e. bevel wheel, **cd**, turns the bevel wheel, **ep**, w^t. its shaft **bg**, & y^t. Teeth work freely into each other. The teeth may be made to any dimention, according to y^t. Strength required; & y^s. Method will enable y^m. to overcome a much greater resistance, & work smoother than a face wheel & wallower of y^e. common form possibly can do; besides, it is of greater use to convey motion in any direction, or to any part of a building with the least trouble & friction. – –

Fig. IIIrd. Plate 1st., The method of conveying motion in on the cog. – – –

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any direction is as follows, with proportioning or shaping the wheels there to; let the line **ab**, represent

A shft coming from a wheel, draw y^{e}. line **cd**, to intersect the line **ab** in y^{e}. dierection, y^{t}. y^{e}. motion to be conveyed is intended, w^{h}. will now represent the shaft to the intended motion. – –

Again, suppose the shaft **cd**, is to revolve three times, whilst the shaft **ab** revolves once, draw the parellel line **ii**, at any distance not too great, suppose one foot by the scale y^{n}. draw the parallel line **kk**. at 3 feet distance, after which, draw the dotted line **WX**, through the intersection of the shafts **ab**, & **cd**, & likwise through the intersections of y^{e}. parallel lines **ii** & **kk**, in the points **X** & **Y**; w^{h}. will be the pitch line of the two bevel wheels, or y^{e}. line where the teeth of y^{e}. two wheels act on each other, as may be seen from **Fig. IV. Plate Ist**. Where the motion may be conveyed in any direction – –

Fig. V. Plate Ist. Represents y^{t}. Universal joint w^{h}. May be applied to comunicat motion instead of Bevel Gear. Where the velocity is to be continued y^{e}. same, & where

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y^{e}. Angle does not exceed 30 or 40 degrees, & the equaety of motion is not regarded, for as it receeds from a right line, its motion becomes more irregular. – –

This joint may be constructed by a cross, represented <at right angles> in the figure; or w^{d}. fowr pins fastned ^ to the circumference of a hoop or ^<solid. Ball, it is of great use in cotton mills where the tumbling shafts are continued at a great distance from the moving power; But by applying this joint, the shafts may be cut to convenient lengths, by which it will be enabled to overcome greater resistance

To describe y^{e}. Cycloid & Epicycloid, of great use in shapings the Teeth or Coggs in wheels –

Fig. VI Plate 1st. If a point or pencil **a**, on the circumference of the circle **B**, proceeds along the plan **ac**, in a right line, & at the same time revolves round its center, it will describe a Cycloid. –

Fig. VII Plate 1st., And, if y^{e}. generating circle **D**, moves along the circumference of another circle **E**, & at y^{e}. same time turn

Turns round its center, the point **O** will describe an Epicycloid. – –

To Divide y^{e}. circumference of a circle into any given number of equal parts, whether even or odd. – –

There is no odd number, but from w^{h}., if a certain number be subtracted, there will remain an even number, easy to be subdivided: thus, supposing y^{e}. given number of equal divisions to be 69; subtract 9 & there will remain 60. – –

will be divided into 69 equal parts, as was req^{d}.

Supposing y^{e}. distance between y^{e}. centers of two Wheels, one w^{h}. Is to turn y^{e}. other, be given; that y^{e}. numb; of teeth in one of these wheels is different from the numb: of teeth in y^{e}. other, & it is req^{d}. to make y^{e}. Diameters of these wheels in such prop: to one another as their numb^{s}. of teeth are, so that the teeth in both wheels may be of equal size & y^{e}. spaces between them equal, that either of them may turn the other easily

Every circle is supposed to contain 360 degrees: therefore say, as y^{e}. given number of parts in the circle, which is 69, is to 360 deg^{s}., so is 9 parts to y^{e}. coresponding are of the circle that would contain them: w^{h}. Are by the rule of three, will be found to be 4695 – 100. Therefore by the line of chords on a common scale, or rather on a sector, sett off 4695 – 100 (or 469 – 10) degrees with your compasses, in the periphery of a circle, & divide that arc or portion of y^{e}. circle in to 60; & the whole

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that either of them may turn the other easily & freely: it is req^{d}. to find their diameters. – –

Here it is plain, that the distance between the center of the wheels is equal to the sum of the radii of both the working parts of the teeth. Therefore, as the numb^{r}. of teeth in both wheels, taken in is to the distance between their centers, taken in any kind of measure, as feet, inches, or parts of an inch; so in the numb^{r}. of teeth in either of the wheels to the Radius or semidiameter of that wheel, taken in like measure from its center to the working part of any one of its teeth. – –

Thus, suppose the two wheels must be of such sizes as to have their distances between their centers 5 inches; that one wheel is to have 75 teeth, & the other to have 33, & that sizes of the teeth in both wheels are equal, so that either of them may turn the other. – The sum of y^{e}. teeth in both wheels is 108; therefore say, as 108, teeth is 5 inches, so is 75 teeth to three inches & 47 hundred parts of an inch; & 100: is to 5, so is 33 to 1 inch & 35 hundred parts of an inch. So that, from the center of the wheel of 75 teeth to the working part of any tooth in it, is 3 inches & 47 hundred parts of an inch, & from the center of the wheel of 33 teeth to the working part either of its teeth, is 1 inch & 35 hundred parts of an inch.

To find y^{e}. diameter of the wheel; when y^{e}. number of teeth, & space between them are given

Divide the number of your cogs, or teeth, by the space between
<~~xxxxxxxxxxxxxx~~>
their centers ^ , taken in Ten Inches, and parts of an inch for any other measure which the Mechanic thinks best

addapted to his purpose), & the quotient y will give y^{e}. length of the Radius or half Diam. of that circle; at will contain the number of teeth or cogs required. – –

For as the Radius of the circle divides it into 6 parts, twice that Radius, made the Radius of another circle in a Twelve of ~~of~~ these parts will be contained &ca. – –

N.B. If y^{e}. wheel be large & the number of cogs considerable; the Mechanic will better lay down the req^{d}. circle at large, as as directed, upon some convenient place; then take the distance between the centers of your teeth, or cogs, & with that extent of your compasses go round the circle; exemining when you come to the last, whether the space between the centers of the two last cogs to be greater or too small; if y^{e}. former you can diminish, or if the latter you can increase the Radius, of your circle; which will be very little either way, if the foregoing directions are attended to. – –

To find the Diam: or circumference of a Circle

The common method which is erroneous, but may serve in common purposes wher exactnes is not required
Say as 7 : 22 so is y^{e}. diam: to y^{e}. circumference
Say as 22 : 7, s is y^{e}. circumference to y^{e}. Diameter
– – Another Way nerer the Truth

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Say as 1 : 3.141592 :: 10 is the diam. to y^{e}. circumference
Say as 3.141592 : 1 :: so is y^{e}. circum: to ye Diam.

– To find y^{e}. area of a Circle –

Multiply the circumference by ¼ of the Diameter, & the product will be the area. or half the circumference by ½ the Diam: will produce the Area. – –

A small Wheel or Nut, being given with a certain number of teeth, or cogs; To make a large Wheel, viz a spur, & Contrat wheel to turn it, with a certain number of Teeth Cogs. – –

Rule if you call the length of your line between the cert^{r}. of the two contigous cogs,6; w^{h}. observe in every proportion, what ever number of inches or parts of an inch there be in it. Then divide the numb: of your cogs by 6 & y^{e}. quotent will give the answer in so many times the length of your line viz y^{e}. distance between y^{e}. center of y^{e}. two contigous cogs; which you must make Radius. But if you cannot get ~~the distance (which allways in every case call 6~~), 6 without a remainder; then divide the length of your line of distance in to 6 equal parts (then if the remainder which suppose 5 cogs); take 5 of these equal parts & lay it on the Radius of your circle; extending from the circumference of your circle w^{h}. Answered for the even number of [Jutt], or cogs. – –

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– Of Friction –

There are few compound engines, but w^{t}., upon account of y^{e}. friction of y^{e}. parts agst. one another, will require a third part more of y^{e}. power to work y^{m}. w^{n}. Loaded than w^{t}. is sufficient to constitute a balance between the power & the weight. – – –

In y^{e}. lever, y^{e}. friction is nothing. In y^{e}. wheel & axle, it is as y^{e}. small diam. of y^{e}. gudgeons (added to y^{e}. power req^{d}. to bend y^{e}. Rope) is less than y^{e}. Diam. of y^{e}. wheel; but it increases according to y^{e}. weight with w^{h}. y^{e}. axle is charged.

The like might be said of y^{e}. pullies, if they did not rub agst. y^{e}. sides of y^{e}. mortices in y^{e}. block in w^{h}. They are placed.

A new rope of 1 inch Diam., going over a pully 3 inches ~~diam~~ diam, & pulled w^{t}. a force = to 5 pounds, requires a force of 1 pound or upwards to bend it; & a rope of 2 inches diam requires 4 times as much force. – –

Wood greased, or metal oiled, have nearly y^{e}. same friction; & the smoother they are, their friction is y^{e}. Less. Yet ~~metals may be~~ so highly polished, as to have their friction increased by the cohesion of their parts. – – –

Wood slides easier on y^{e}. ground in wet weather than in dry; & easier than an = weight of Iron in dry weather: but Iron slides easier in wet weather than wood. Iron or steel running in [bras] has y^{e}. least friction of any. Lead makes a great deal of resistance. In wood, acting upon wood, grease makes

the ought to be made of y^{e}. fewest & simple parts. –
The diameters of y^{e}. wheels & pullies ought to be larg as possible & the gudgeons of y^{e}. axles as small as is consider^{d}. w^{d}. The strength req^{d}. The sides of the pullies ought to have a small riseing y^{e}. middle ~~po~~ to prevent their rubbing against the sides of their mortises, at

y^e. motion at least twice as easy. Wheel naves greased or tarred, go 4 times as easy as when wet. Smooth soft wood, moving upon smooth soft wood, has a friction equal to about a third part of y^e. weight. In rough wood wood, y^e. friction is equal almost to one half y^e. weight.

In soft wood upon hard, or hard wood upon soft, the friction is = to about one fifth part of y^e. weight. –

In polished steel, moving upon polished steel or pewter, y^e. friction is about a fourth part of of y^e. weight; on copper, a fifth part, & on brass, a sixth part of the weight. Metals of the same sort have more friction than different sorts. – –

In general, y^e. friction increases in y^e. same prop^n as the weight. The friction is also greater with a greater velocity; but not so great in proportion as y^e. increase of y^e. velocity. – –

To have y^e. friction of machines as little as possible,

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a dist from their axles. All chord & ropes ought to be as pliant as possible: & for that end greased. The teeth of the wheels ought just to fit & fill ~~each other~~ the openings, so as not to be squeesed therein All y^e. part w^h. work into, or upon one another, ought to be smooth, the gudgeons ought just to fit their holes, & the working parts must be greased. The rounds or staves of y^e. [t]rundles may be mad to turn about upon iron exels, fixed in the round end boards, w^h. will take of a great deal of the friction. – –

Let the strength of all the parts be in proportion to the stress they are to bear, so they may last equally well. He is by no means a perfect mech^<anic> who only adjusts the strength to the stress, if he does not contrive all y^e. parts to last so as y^t. one shall not fail before another – – –

When any motion is to be long continued, contr[ ] y^e. Machine so, as that y^e. working power may always move to act one way, if it can be done: for this is better & easier performed, than w^n. the motion is interrupted by the powers being forced to move first one way then the another: because every new change of motion requires a new additional force to effect it; & a body in motion cannot receive a contrary motion without great violence, & danger in tearing of y^e. machine to pieces. But w^n. the natur of the thing requires that a motion should suddenly be communicated to a body, or suddenly stopt; let the force act ags^t. some spring, to prevent The machines being injured by a sudden jolt –

When a machine is moved by two handles, or winches, on y^e. ends of an axle, y^e. handles are so placed as that when y^e. one is up the other is down; w^h. is the worst way possible of placing them, save

much backward as he pushes the winch forward; & y^e. handle of y^e. winch is down, ~~the~~ directly below the axle, he loses half his force; because y^e. winch pulls him as much forward tit as he pulls it towards him: and, therefore, y^e. greatest effect this force has upon the machine is w^n. He either pulls the winch upward, on the side of the axle next toward him, or pushes it downward on the side farthest from him. Yet even in these cases the pulling force is stronger than the pulling. –

In order to remedy this defect as much as possible, the handle should be so placed as to stand at ~~right~~ right angles to one another; & then, w^n. There is a man at each handle, y^e. effect of the one mans force will be greatest w^n. the effect of y^e. other man’s is the least upon the machine, whereas, in y^e. common way of placing the handles, w^n. the effect of the one mans force is the greatest the other’s is so too;

y^t. of their being both up or both down together. –

For w^n. a man raises a weight by means of turning a winch, he loses half his force w^n. the winch is upward; because he pushes himself as

& w^n. the effect of that mans force is the least, so also is the others; which is working at y^e. greatest disadvantage possible. – –

It has been found by experiment that a body of wood, brass &c. laid on a plain surface will

drawen along by a weight, nearly equal to $^1/_3$ of its weight if the surfaces be hard & polished; it will be less than one third, best if the parts be soft or rugged, it will be much greater. – Thus a cylinder of wood if polished very smooth & laid on two very smooth supports, having been first well oiled & greased, & then charged with a weight of 2 pounds in two equal balls, it will require an additional weight equal to $^1/_3$ of 2 pounds, to be able to overcome the friction of the said cylinder. –

Now this additional weight, as it causes a greater pressure of the cylinder, will likewise increase, & therefore require an additional weight, equal to $^1/_3$ of its own weight; this other weight will also require another equal to $^1/_3$ its part, & so on adinfinitum

Hence upon a supposition y^e. friction is exactly equal to $^1/_3$ its own weight, the first weight with all the additional ones viz. 2, $^2/_3$, $^2/_{29}$, $^2/_{27}$ & will be a series of numbers in a geometrical progression decreasing. Now the sum of all the infinite numbers of additional weight is found to be equal to one pound. So that if the

so that if the weight of y^e. cylinder be in considerable, the way to over come the friction is to double the power at once. But if the weight of the cylinder be so great as not to be neglected in the calculation, it will be necessary to add besides this weight to the, a weight equal to $^1/_3 + {}^1/_9 + {}^1/_{27}$ &c. that is to one half the weight of the cylinder. – –

N.B. In either oiling or greasing of Machines we may exceed; for if there is too much oil or grease rubbed on the working parts of a machine, it will clog & retard the motion; care must be taken that before fresh oil or grease be laid on the working parts of y^e. machine, that the old & clotted, be carefuly wiped off, as it would hinder the effect of the other & would both conspire to stop the motion. – –

When too high a polish is given, the attraction of cohesion takes place in this case & retards their motion more than the friction, which was intended to be removed; as was experienced by some, who wanted to give watches so high a polish, that they would never stand in need of oil, which as formerly observed retard y^e. motion. – –

Friction does not follow the Ratio of the rubbing surface, as

as is ignorantly supposed by many, but universally follows y^e. ratio of the weight body; for a brick will be d[raiden] a long upon a plain surface as easily on its flat side as on its edge. – –

would strike against any [obstace] are equal to each other. – For 40 multiplied by 2 gives 80, the force of the body **A** & 20 multiplied by 4 gives 80, the force of the body **B**. – –

The foundation of All Mecanics. –

If we consider ~~them~~ ^<bodies> in motion, we may compare them to gather, either with respect to their velocities, or the quantity of matter they contain. – The heavier any body is, y^{e}. greater is the power either to move, or to stop its motion: & again the swifter it moves, the greater its force. So that y^{e}. whole momentum of a body is the result of its quantity of mater multiplies by the velocity with w^{h}.it is move. – –

When the products arising from the multiplication of the two> bodies, by their respective velocities, & quantities of mater are equal; their momenta; or entire forces are so. – Thus, suppose a body, which we call **A**, to weigh 40 pounds, & to move at the rate of two miles in a minute; and another body, which we call **B**, to weigh 4 pounds, & to move at the Rate of 20 miles a minute; y^{e}. entire forces with w^{h}. these two bodies

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If the perpendicular ascent of one body mult: into its weight, be equal to the perpendicular decent of another body mult: into its weight, those bodies, however unequal in weight, will balance one another in every situation. – Upon this easy principle depends the whole of Mechanics: for the power of any Mechanical engine whatever (whether simple or compound), may be computed; it is only finding how much swifter the power moves than the weight (i.e.) how much further in the same time; just so much is the power gained by the engine. – –

Whatever is gained in power is lost in time; for by increasing power we may be enabled to [p]remove great weights, or perform whatever is req^{d}. from hence it may be im~~m~~agined that no bounds can be set to strength of Machines, since we can increase the velocity of the moving power as

as much as we please; but in this as in all other human things there is a Neplus Ultra, beyond which we cannot pass. – That therefore we may not promise for ourselves greater effects from the theory of any Machine, than can possibly be produced; there are some necessary directions to be attended to; a few of w^{h}. Are as follows. –

The exelencey of any machine consists in her performing, the end intended; with the least expence of the moving powers possible; in order to obtain these ~~things~~ ^<ends>, the following things must be attended to. – –

Ist. The strength of a machine must be able to bear the weight, or stress put upon it. A small ballance should never be applied in weighing great weights; for this would disorder its structure, & render it unfit for the use intended for at first. The strength

next to the weight, ought to be the strongest; & on the other hand those next to the power the weakest; & as the parts come nearer to the one, or the other, they should respectively stronger or weaker. – –

IInd. An engine ought to be as little complicated as possible; indeed in some Machines it is necessary for a complex structure; as such where a regular motion is req^{d}.; as watches, orreries &c. But in engines for raising weights, it would be highly rediculous, to apply such a complicated structures; as in clocks; as a number of parts increase the friction, as well as the expence of the Machine. – –

IIInd. The power must be so far increased above what is necessary to make it in equilibrio with the weight; as to over come all the

of a machine, however ought to be made
greater, than is necessary for bearing the stress;
as this increase of weight, & with it the friction:
consequently it requires a greater expence of the
moveing power than necessary. – –

Hence it is evident that the parts of a machine

friction, & resistances arising from the
engine or other wise & then the power will
be able to raise the weight. – –

In order to find what must be added

to the power on this account it will be necess^{ry}.
to calculate the friction of the Machine; –

The way to find the friction of the several
rubbing parts (you will see by the rules on
friction all ready laid down) & the sum
of these ~~rubbing parts~~ resistancess will
give the whole friction of the engine. –

Likewise for this purpose it will be necessary
to know the fraction of the several mechanic
powers; which is as follows. – –

The single lever makes little, or no ristance
from friction. – –

In the wheel & axle the friction is equal
to $^{1}/_{3}$ of the weight; this however is diminished
in proportion as the diameter of the wheel
exceeds that of the axle. – –

The friction of the pully, especialy when
a great number of them are combined
together, is often very considerable: to remedy
w^{h}., they should be made as large as possible;
it also in all blocks of pullies there ought
to be at the end of the ~~two~~ axis two convex

pieces of brass, y^{n}. by jutting out beyond the
flatside of the pully would prevent it from
rubbing against the block. – –

– In the wedge, the friction is at least equal
to the power: as when it is driven into any
situation, it retains that setution by friction.

– In the screw there is a great deal of friction,
those of sharp threads have more of this than
those with square; in the endless screw there
is more than either – In a common screw
the friction is so great, that it will retain the
situation in any position given when the
power is taken off, & therefore it is at least
equal to the power; hence the power must
lie to the weight, as the distance between
two contigous threads, is to the periphery
described by the power. – –

Besides this resistance arising from friction,
there is another, which arises from the
bending off ropes. This resistance differs
in degree according to y^{e}. temperature of the
weather & other causes but (cateris paribus)

the force necessary to bend a rope, is as the
square of its dierectly, as its Tension
Dierectly, & as the diameter of the cylinder
about which it is bent Inversely. –

will carry 100 to 250 pounds according
to their different strengths. – It is said the Turkish
porters will carry 500 to 900 pounds; what
would be enough to break a horses back. –

IVth. The size of a Machine should be as possi[ble]; as the larger it is, the less effect will the errors be, & in accuracies unavoidable in all machines made by human hands.
The powers applied to work a machine, are commonly divided into thre kinds –

Ist. A living power: as the force of men or horses –
IInd. A natural power, as wind, water, &ca –
IIInd. An artificial power, as a spring, weight &c.

Also the effect it matters not what kind of power is made to act, for the same quantity of force will produce the same effect; & by a skillfull Mechanic different powers may be applied in a variety of ways, so as to produce very astonishing effect. – A mans force may be applied to many different purposes; & it is various in different ways of applying it. – The porters ~~in Turky~~

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In pulling a boat along a canal, the heavier a man is the better he will draw; the addition of a weight on the mans shoulders will also make him draw a long with a greater force. –

A horse will carry 260 or 270 lbs; in a cart he is commonly recorded to exert a force equal to 5 men, & will draw 1000lbs. – Carying burthens up a hill is a bad way for a horse to exert his strength, his body being very ill addapted for that purpose. – In Turning round a beam, he requires a walk of 40 feet in diameter; & in this he will exert a force,[ ] is perform a work equal to five men. –

A horse may exert his strength very conveniently in drawing any thing out of a well, over a pully – A spring is a very convenient power but never acts equaly, being stronger, or weather, as it is more or less bent. – The natural powers, wind & water &ca; cost nothing & require

no winding up; wind is very inconstant & not to be depended on; Water is more certain & therefore of greater value in turning a machine; & is allway used in preference to all other powers when it is convenient & can be had. –

The different simple engines may be combined together so as to form compound ones. –

The leaver may be combined with the axis in [perctrochio], or with the screw; but not with thew edge, or pullies. – The axis in [perctrochio] is combined with pullies to a great advantage; & the perpetual screw with the wheel & axle; but not with pullies – The Wedge cannot be combined with any other of the mechanic powers, as it performs its work by percussion; but this percussion may be increased by the help

line, by means of the teeth of a wheel acting on the teeth of the Ruler. – –

A Pump may be made to raise water, in an uniform, or uniformly accelerated motion as follows. – – – – – –

Fig. **Ist.** Let **AB**. (as in the figure following) be a lever moveable about **C**, as a center, & whose end **B**, raises the piston of a pump at **E**; & lett the wheel, which acts on the end of the lever at **A**, be teethed only half round. & the teeth shaped in the manner which will be described; it is plain from the inspection of the figure that this must alternately raise & depress the piston, with an uniform or uniffor^<mly> accelerated motion, acording to the figure of y^{e}. teeth.

Fig The method of determining the shape of the teeth,

of engines. – –
Motion may be communicated from one
part of a machine to another, by ropes, levers,
teethed wheels &ca. – Combinations of levers,
serve to communicate motion in different
dierections. – A straight ruler may be made
to move backwards & forwards in a straight

II

which shall produce an uniform motion as follows. –
In the circumference of y^{e}. wheel **ABCD**, take **AB** equal to
y^{e}. space occupied by one tooth, w^{h}. Divide into 4 = parts, as
Aa,**ad**,**de**,**deb**, & draw the straight lines **eh**, **dh**,**ag**,
& **Af** in a proportion of 1, 2, 3, & 4, the line which joins
their extremitys will give the proper figure
for the tooth Required. – –

For an uniformly accelerated Motion. –
Divide the space occupied by one tooth as before
into 4 equal parts, through which draw straight
lines through the center as before; but make those
straight lines from the circumference of the wheel
in the proportion of 1, 2, 4, & 8, & the line DC, joining
their extremitys will give the proper shape for y^{e}. tooth.
That a level of this kind may act dierectly;
arm the end of it with an arch of a circle, whose
center is of motion. – –
If a machine has too little force, the moving
power will not be able to put it on motion; & if
it is too ~~[be]~~ much it will act slowly, therefore
a medium is to be observed; & it is found by experience,
that it performs most work in the same time, when
it is loaded with four nineths of it is weight, which
would serve to keep the moving power in equilibrio;
but if allowance be made for friction the
proportion will be defferent. – – <tion, >
A Hetrodromus Lever changes y^{e}. motion into a contrary dierec^
& if it be crooked, or bent, it will change the dierection of a
motion, into one, which will form an angle with the
former. The dierection of motion may be changed, with
wheels with teeth, whose axles are perpendicular to
one another, or inclined to any angle, moving each other
by lanthotns inclined at y^{e}. same angle. By means of fixed
pullies motion may be changed into any dierection req^{d}.

Here I shall mention a proportion “In similar
“bodies of the same Texture, the force that tends to break
“them increases in a greater proportion than that, which
“tends to keep them together entire; the one increasing
“in a quadruplicate, & the other in a triplicate Ratio of
“the length of the bodies. – – Let **DCHG** &
dchg, be two similar cylinders, whose extremities
are fixed in a wall. – Now the force that tends to
breake them may be considered ^<as> their weight, that
as their quaintity of matter; which being as their
cubes of their diameters; forces must also be in
that proportion; but as the whole weight of each of
the bodies, may be considered as collected in their
centers of gravity; the force tending to break the
greater body acts at a distance from the wall,
which may be looked on as the center of motion;
greater than that, which tend to break the lesser
body in the proportion of the diameter of the larger
cylinder to that of the less. – Therefore taking
both these considerations into account, the force
tending to break the two cylinders, or Tear them
from the wall; are in the quadruplicate Ratio
of the diameters of the cylinders. – On the other
hand the forces tend to keep the bodies together,
may be looked on as consisting in the number
of fibres of which the bodies are composed, that is

as the bases **DC** & de, which are as the squares of the diameters. – But as the center of motion may be considered as being **c** & **c**, & as the forces which tend to keep the Bodies together act at distances from their respective centers of motion as the diameters of their bases; therefor the preserving forces in the two cylinders are in the triplicate Ratio of their diameters. – – Hence we that if buildings, or machines of any kind, or animal bodies &ca were to be made much grater, but in such a manner as to have the same texture, as well as to have proportion of the parts, as at present; they might be increased to such a size as to fall to pieces by their own weight – – –

Hence the larger animals become useless relative strength they have (ie) the less weight they can bear in proportion to their size. – The lesser animals are likewise more active, & less liable to accidents, than the greater. – – –

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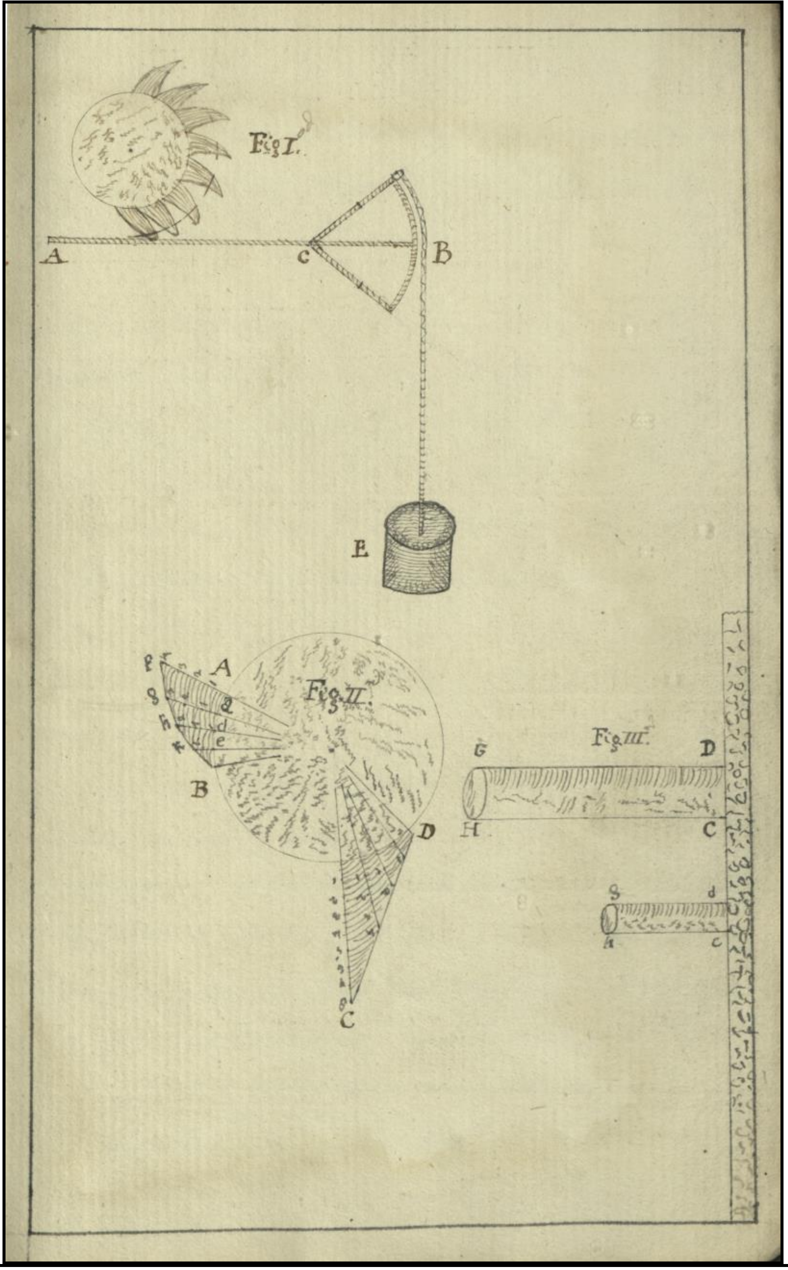
[Plate I. Diagrams of Figs. **I**, **II**, **III**]



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Description of a Pump invented by M. de la Hire, w^{h}. Raises water equaly quick by y^{e}. descent as by y^{e}. assent of y^{e}. Piston in the Pump Barrel. – – –

Plate IInd. Fig 3rd. **AA** is a well in w^{h}. The lower ends of y^{e}. Pipes **B** & **C** are placed. **D** is y^{e}. pump barrel, into y^{e}. lower most end of w^{h}. y^{e}. top of of y^{e}. open pipe **B** is soldered, w^{h}. opens into y^{e}. barrel, & y^{e}. top of y^{e}. Pipe **C** is soldered into y^{e}. piece. – Each of y^{es}. Pipes has a valve on it's top, & so have the crooked Pipes **E** & **F**, whose lower ends are open into y^{e}. pump barrel, & their uper ends into y^{e}. box **G**. – – –

H is y^{e}. pump handle, its center of motion is a **I**; & as it is moved up & down, it moves y^{e}. solid plunger up & down in y^{e}. Barrel, by y^{e}. straight rod or spear **L**, w^{h}. Moves air tight in along collar of leather in y^{e}. neck of **M**; & y^{e}. plunger never goes higher y^{n}. **K**, & not lower than **D**, so y^{t}. from **K** to **D** is y^{e}. length of y^{e}. stroke. – – –

As the plunger rises from **D** to **R**, y^{e}. atmosphere (pressing on the surface of y^{e}. ^<water in y^{e}.> well **AA**) forces y^{e}. water up y^{e}. Pipe **B**, & fills y^{e}. pumps barrel with water up to y^{e}. plung; & during this time, y^{e}. valves e & **S** lie close and air tight on the tops of y^{e}. Pipes **E** & **C**. – When y^{e}. plunger is up to its greatest height **a' k**, it stops there for an

instant, & in y^{e}. instant the valve b falls, & stops the pipe **B** at top. – Then, as y^{e}. plunger goes down, it cannot force the water between **K** & **D** back through y^{e}. close valve **b**, but forces all y^{t}. water up through y^{e}. crooked pipe **E** through y^{e}. valve **e**, w^{h}. y^{n}. Opens upward by the force of y^{e}. water, & this water, after having filled the box **G**, rises into the pipe **N**, & runs off by y^{e}. spout at **O**. –

And thus as y^{e}. plunger descends, it forces the water below it up the pipe **E**; & as it ascends, it forces the water above it up the pipe **F**, y^{e}. pressure of y^{e}. atmosphere filling y^{e}. pump barrel below y^{e}. plunger through y^{e}. Pipe **B** while y^{e}. plunger ascends, & filling y^{e}. barrel w^{t}. Water above y^{e}. plunger, through y^{e}. pipe **C**, as the plunger goes down. – – –

During y^{e}. decent of y^{e}. plunger **K**, y^{e}. valve **f** falls down, & covers y^{e}. top of y^{e}. crooked pipe **F**; & pressure of y^{e}. atmosp^{here} on y^{e}. well **AA** forces the water up y^{e}. pipe **C**, through y^{e}. valve **S**, w^{h}. y^{n}. opens upwards by y^{e}. force of y^{e}. ascending water; & this water runs from **S** into y^{e}. pump barrel, & fill all y^{e}. space in it above y^{e}. plunger. –

When y^{e}. plunger is down at **D** its lowest decent, & stops there for an instant, in y^{t}. instant y^{e}. valve **S** falls down, & shuts y^{e}. top of y^{e}. pipe **C**: & y^{n}., as y^{e}. plunger is raised, it cannot force y^{e}. water above it, back through the valve **S**, but drives all that water up through y^{e}. crooked pipe **F**, through the valve **f**, w^{h}. opens upwards by the force of y^{e}. ascending water, which water after filling y^{e}. box **G**, is forced up from thence in to the pipe **N**, & runs off by the spout at **O**. – – –

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And thus there is as much water forced up the pipe **N** to y^{e}. spout **O** by y^{e}. decent of y^{e}. plunger, as by its ascent; and, in each case, as much water discharged at **O** ~~falls~~ as fills that part of y^{e}. pump barrel as y^{e}. plunger moves up & down in. – – –

On y^{e}. top of y^{e}. pipe **O** there is a close air vessel **P**. When y^{e}. water is forced up above y^{e}. spout **O** it compre^<sses> the air in y^{e}. vessel **P**; & this air, by the force of its' spring acting on y^{e}. water, causes the water to run off by y^{e}. spout **O** in a constant & (very nearly) equal stream. – – –

When ever y^{e}. height of y^{e}. spout **O** be above y^{e}. surface of y^{e}. well, y^{e}. top **S** of the pipe **C** must not be 32 feet above that surface; because if that pipe could be entirely exhausted of air, y^{e}. pressure of the atmosphere in y^{e}. well would not force y^{e}. water up the pipe to a greater height than 32 feet. And if **S** be within 24 feet of y^{e}. surface of y^{e}. well, y^{e}. pump will be so much y^{e}. better. – – –

As the collar of leather within y^{e}. ~~me~~ neck **M** is apl[ ] to dry & shrink when the pump is not used, & consequently to let air get into y^{e}. pump barrel, w^{h}. would stop the operation of the atmosphere in the pump be pipe **C**; I think collars of old hats might be used instead of leathers, as they would not be liable to that inconvenience

It matters little what size y^{e}. pipe **N** be, through w^{h}. The water is force up to the spout **O**: but a great deal depends on y^{e}. size of the pump barrel, & according to the height of the spout **O** above the surface of y^{e}. well the diameter of of y^{e}. bore of the barrel should be as follows. – – –

For 10 feet y^{e}. bore should be 6.9 inches; for 15 feet 5.6; for 20 feet 4.9; for 25 feet 4.4; for 30 feet 4.0; for 35 feet 3.1; for 35 feet 3.7; for 40 feet 3.~~5~~7; for 40 feet 3.5; for 45 feet 3.3; for 50 feet 3.1;

In this pump y^{e}. pipes seem to be rather too small, which will cause y^{e}. water rising in them to have a great deal of friction from y^{e}. quickness of its motion: who ever makes such a pump, will find it very difficult to make the leathers in the neck **M** Water tight, so as y^{t}. no water shall be forced out that way when y^{e}. piston is drawn up. – – –

Another Pump on a more simple construction, Invented by M. Noble – –

This pump deserves notice, as it keeps a continual stream; being composed only of one straight pipe, or tube, & two Pistons, having each a bucket & a valve; it raises as much water with the same power & in the same time as two barrels with four valves will do; & being simple in its princip^<les>, for 55 feet 2.9; for 60 feet 2.8; for 65 feet 2.7; for 70 feet 2.6; for 75 feet 2.5; for 80 feet 2.5 will do; for 85 feet 2.4, for 90 feet 2.~~2~~3; for 95 feet 2.2; and for 100 feet y^e. diameter of y^e. bore should not exceed 2.1 or 2.2 inches at most. If these proportions are attended to, a man of comon strength may raise water 100 high by one pump as easy as he could raise it 10 feet high by another. –

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may be constructed reasonable, compared with M. de la Hires's pump. – – –

A is a straight tube, or barrel, in w^h. two buckets work; y^e. bucket **B**, is worked by y^e. rod **C** & y^e. bucket **D** is worked by y^e. rod **E**; which goes through a hole in y^e. bucket **B** & is moved up & down by two circular pieces of wood **F**, fixed to[two] handles **g**,**g**, w^h. Causes one bucket to ascend w^t.is & load & so Visa versa.

– Common Steam Engine –

There is y^e. Boiler. y^e. Cylinder, the injection cock. y^e. steam cock, or regu-lator. y^e. snifting clack. The eduction, or sinking pipe. y^e. eduction valve. y^e. Safety valve. y^e. piston, y^e. lever beam. Weights to counterpois y^e. piston & to press y^e. forcer down y^e. pump barrel, to drive the water up y^e. pipe or sp[out] a cistern to hold y^e. injection water. & an air vessel to keep y^e. pipe from bursting, & to ^<preserve>a regular stream. The boiler is a copper vessel partly filled water, which being set over a fire to boil, will fill y^e. uper part with a vastly elastic vapour, y^e. sufficient strength whereof is f[ ] by its forcing open the safety valve: y^e. heated ^<elastic> steam is, by turning a cock let in to the barrel [sohere] by its elastic force it raises the piston w^h. drives the air above it through a proper clack at the top. After this, y^e. y^e. piston may by its weight decent, a little cold water is lett in from y^e. injection cistern at y^e. bottom, by turning y^e. inj^t. cock, w^h., in form of a jet, condenses the [hd]steam in y^e. barrel, into 13000 times less space than it took up before. w^h. makes a sufficient vacuum for y^e. piston to decend in. The piston & lever being, thus put in motion, do according raised depress the piston in y^e. barrel of y^e. forcing pump, on the other side; w^h. by a pipe, draws y^e. water from y^e. req^d. depth, & forces to rise & spout through a tube (as in y^e. ~~forci~~ common forcing pump) continued to any height at pleasure. This is used to draw water from the bottom of coal pits & other mines. – – –

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– Watts improved Steam Engine –

M^r. Watts improvement is founded upon these, & some other collateral observations. He preserves an uniform heat in y^e. cylinder of his engines, by suffering no cold water to touch it, & by protecting it from the

air & other cold bodies, by a surrounding case filled w^t. the steam, or w^t. Hot air or water, & by coating it over with substances that transmit heat slowly. – –

His makes his vacuum to approach nearly to that of y^e. barometer, by condensing y^e. steam in a separate vessel, called y^e. condenser, which may be cooled at pleasure without it cooling y^e. cylinder, either by an injection of cold water, or by surrounding the condenser with it, & generaly both. He extracts the injection water & detached air, from the cylinder or y^e. conderser, by pumps which are wrought by the engine itself, or he blows it out by steam. As the enteran^<ce> of air into y^e. cylinder would stop the operation of y^e. engines, & as it is hardly to be expected that such enormous pistons, as those of steam engines, can move up & down & yet be absolutely air tight in the common engines; a stream of water, is keept allways running upon the piston, w^{h}. prevents y^{e}. entry of air, but this mode of securing the piston, through though not hurt full in the common ones, would be highly prejudicial in the new ones. Their piston is therefore made more accurately; & y^{e}. outward cylinder having a lid w^{h}. covers it, the steam is introduced above the piston; & when a vacuum is produced under it, acts upon its elasticity, as the atmosphere does upon common engines by its gravity. This way of working effectualy exclud[es] y^{e}. air from the inner cylinder, & gives y^{e}. advantage of adding to the power, by increasing the elasticity of the steam. – – –

Fig 1st. Plate <u>IInd.</u>

A y^{e}. Boiler. By y^{e}. safety Valve. **C** y^{e}. pipe w^{h}. conveys the steam to outer cylinder – **D** y^{e}. outer Cylinder. **E** y^{e}. inner Cylinder – **F** y^{e}. piston. **G** y^{e}. valve that admits y^{e}. steam from y^{e}. outer cylinder into the inner Cylinder, called y^{e}. steam valve. H y^{e}. valve that admits the steam from the inner cylinder into y^{e}. condenser, called y^{e}.

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condensing valve. – **I** y^{e}. Condenser. **K** y^{e}. injection valve y^{t}. admits a jet of cold water into y^{e}. condenser to condense the steam. **L** y^{e}. Air pumps that exhausts the condenser both of the air & the injection water that is let in every stroke; & is fixed under water in y^{e}. condensing back **M**. – **N** y^{e}. lever beam. – **O** y^{e}. great warter pump for cleaning the mines or raising water for other uses through the pipe **P**. – – –

The Clinder is smaller than usual in prop: to the load, & is very accurately bored. In the most compleat engines, it is surrouded at a small dist: w^{t}. Another cylinder, furnished with a bottom & lid. The interstice between y^{e}. Cylinders, communicates With the Boiler by a large pipe, open at both ends, so that it is always filled w^{t}. steam, & thereby maintains y^{e}. inner cylinder always at the same heat w^{t}. The steam, & prevents any condenstion within it, w^{h}. would be more detrimental than an equal condensation in y^{e}. outer one. – The inner Cylinder has a bottom & piston as usual, & as it does not reach up quite to the lid of the outer cylinder, the steam in the interstice has all ways free access to the uper side of y^{e}. Piston. The lid of the outer

cylinder has a hole in its middle; & the piston rod, which is made truly cylindrical, moves up & down through that hole, which is keept tight by a collar of oakum screwed down upon it. – at y^{e}. bottom of y^{e}. inner cylinder, there are two regulating valves, one of w^{h}. admits the steam to pass from the interstice into y^{e}. inner cylinder below the piston, or shuts it out at pleasure; the other opens or shuts the end of a pipe, w^{h}. Leads to the condenser. The conderser consists of one or more pumps furnished with claks & bucket (nearly

conveniency may require. The Condenser being exhausted of air by blowing, & both cylinders being filled with steam, y^{e}. regulating valve w^{h}. admis y^{e}. steam into the inner Cylinder is shut, & the other regulator w^{h}. communicates with the condenser is opened, & y^{e}. steam rushes into y^{e}. vacuum of the condenser with violence; but there it comes into contact into contact with the cold sides of the pipe & pumps, & meets jet of cold water w^{h}. was opened at the same time with the exhaustion regulator, these instantly deprive it of its heat, & deduces it to water; & the vacuum remain^<g>

the sa[m]e as common pumps) which are wrought
by chains fastened to the great working beam
of the engine. The pipe, w^{h}. comes from y^{e}. cylinder,
is joined to y^{e}. bottom of these pumps. & y^{e}. whole
condenser stands immersed in a cistern of cold
water supplied by the engine. The place of the cistern
is either within the house ~~or~~ under the floor, between
y^{e}. cylinder & the lever wall; or without the house,
between that wall and the engine shaft, as

perfect, more steam continues to rush in, & be condensed
untill the inner cylinder is exhausted. Then the
steam w^{h}. is above the piston, ceasing to be counteracted by that w^{h}. was below it, acts upon the piston
with its whole elasticty, & forces it to descend to the
bottom of of the cylinder, & so raises the buckets of the
pump which are fasted to the other end of the beam
The exhaustion regulator is now shut, & the steam
one opened again, which by letting in the steam,
allows the piston to be pulled up by y^{e}. superior weight of y^{e}. rods;

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and so the engine is ready for another stroke
The working of the engines are more regularly
steady than in y^{e}. common ones, & from what
has been said, their other advantages are very
considerable; but to say how much they exell
common engines, is difficult, as common engine
differ much among them selves. I am told, that
the savings amount at least to two thirds of the
fewel, w^{h}. Is a very considerable object where fuel
is expensive – – –

In the Common Steam Engine when
water is thrown into the cylinder (being
first filled with hot steam) it condenses the
steam into 13000 times less space than
it took up fore which makes a sufficent
vacuum to desend. – – – – – –

[**Plate II** from the document appears to be missing]

[Bud-143]