Philosophical Transactions

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A Letter from the Learned and Ingenious Maurice VVheeler *M. A. and Rector of* Sibbertoft *in* Northamptonſhire, *to the* Publiſher *of theſe* Tracts, *concerning a* Movement *that meaſures time after a peculiar manner, with an Account of the Reaſons of the ſaid Motion*

Hon. SIR,

THE Relation which I have, and the great Reſpect that I bear to the lately erected *Philoſophical Society* in *Oxford*, will ever oblige me to ſerve it in the meaneſt offices, if thereby I may contribute the ſmalleſt Advancement towards that noble Deſign they are in purſuit of. Wherein, foraſmuch as an Attempt is vigorouſly (and in the iſſue I hope ſucceſsfully) carried on, by the communicated Obſervations and united Counſels of ingenious and learned Perſons in this and other Nations, to improve the knowledge of things to the real uſe, or (at leaſt) the ſober delights of mankind by your encouragement; I have herewith (and as my firſt tribute,) preſented to the conſideration of our Society, the Scheme and Contrivance of a *Movement*, which meaſures time indeed by *Number*, *Weight* and *Meaſure*; but after a manner ſo peculiar, and in ſeveral of its properties ſo ſurprizing, and of a ſtructure ſo unexampl'd; as you your ſelf (if the invention be worth the owning) can vouch me to be the ſole Author of. For altho the late *Lord Marquis* of *Worceſter* is ſaid to have contriv'd a Watch that ſhould move upon a declivity, as this (hereafter deſcrib'd) is intended to do, and Monſieur de *Gennes* in the *Philoſoph. Tranſact. Numb.* 140. has given ſome account of a *Clock* aſcendent on a *Plain* inclin'd. yet neither of them, nor any like them, was ever ſeen by me, and for ought I could ever learn, the *Reaſon* of their *Motions* remains

to this hour as great a Secret, as if they had never been.

Now whether I have diſcover'd this or no, will appear from the Account I am now about to give thereof; which I ſhall deliver with all the clearneſs I can in this method following. 1. By propoſing the State of the *Ploblem*, or declaring what is to be done. 2. By offering at a Solution thereof, and ſhewing from allow'd Maxims in *Statics*, and other Principles proper to the Queſtion in hand, the Reaſons how, and the Cauſes whereby it may be effected.

1. The ſtate of the *Problem*, may be compriz'd in theſe four particulars; by deſcribing 1. The *Movement* as to its exterior ſtructure 2. The manner of its motion, as it appears to the Eye. 3. The uſe thereof in the meaſuring of time. 4. The way of adjuſting this Motion to the exact diviſions of an hour. All which forementionʼd particulars (were the *Movement* actually made,) would be obvious to the apprehenſions of any Spectator, who perhaps might never be able to comprehend the Reaſons of the Motion it ſelf.

1. For the exterior ſtructure of the *Movement*, be pleas'd to ſee *Fig*, 3. which repreſents a circular body of 3 inches ½ diameter, conſiſting of 2 plates meaſur'd by the ſame *Radius*, and fixt in a parallel poſition to each other by the hoop, (*h*.) the bredth of which is about an inch. This hoop and the 2 Plates form the Caſe of the *Movement*; of which, that which appears in the front, is towards the verge thereof inſcrib'd with a horary circle, the diviſions whereof anſwer the hours of a natural day. The deep ſhades within this circle are intended to repreſent a Concave, of near half an inch deep; and the prominence (*g*.) in the middle of this Concave, is a hemiſphere of Braſs or Silver, riding looſly on a pin, which lies hid, and is the *Axis* of the *Movement*. The upper half of this hemiſphere is hollow, but the nether fill'd with Lead; and the ſmall Gentleman that ſits thereon, does with an erected finger perform the office of an *Index*. The Reaſon why this

plate

plate is concave, is grounded upon no neceſſity; but ſince the ſtructure of the internal parts will very wel admit of ſuch a figure, and it comported pleaſingly with a fancy I had of rendering the front of the *Movement* more beautiful, therefore *currente rota* (as the Poet ſpeaks,) I gave liberty to my penſil to deſcribe it in this manner. But if the hemiſphere with the figure thereon, ſhall ſeem a piece of work too elaborate for the end it ſerves unto; and for the ſake of which the Dial-plate is form'd into that ſhape: I have (*Fig. 4.*) drawn a plain *Index*, which you may ſubſtitute in he room thereof, or any other, (as it ſhall pleaſe the Painter) provided that the *Axis* whereon 'tis ſupported, move freely in the hole (*H*); and the lower part thereof *H. I.* may ſo far preponderate to *H. P.* as always to keep the *Index* pendulous, with its point to the vertical hour.

2. For the manner of its motion, as far forth as it appears outwardly, it is thus; *S. E. Fig. 3.* repreſents a board or ſhelf, of a ſtrait and even ſurface, about 6 foot long, and ſo thick as not to be apt to caſt with change of weather; nor to grow *Camber* under a ſmall weight; on this is the *Movement* plac'd and here to perform its courſe, and therefore I call it the *Stage* of the *Movement*. This *Stage* is rais'd at the end *S.* about 10 degr. above the Horizon or line of level *H. E*; but the Angle of its declivity *D. E. H.* is variable, as will hereafter appear; and although it happens in the Scheme to be 10 degrees, yet I would have it underſtood to be indefinite at preſent, till I come to ſhew the cauſes that will determine its quantity. The 2 plates which form the Caſe of the *Movement*, are to be extant all round without the hoop (*b.*) ⅛ of an inch, and the edges of 'm lightly indented; that while the *Movement* deſcends upon the *Stage* it may turn only, and not ſlide.

3. The uſe thereof in meaſuring time, is as follows. The *Movement* being plac'd as high as it may, near the point (*S.*) ſhall move downward towards *E.* with that

ſlownes, as to finiſh one entire Revolution in 24 hours; and while it does ſo, the diviſions on the horary circle (or Dial-plate) ſucceſſively culminating over the point of the *Index*, will ſhow the hours of the day and night. For in this Movement (contrary to what is uſual in others) the hour is diſcover'd by the acceſs of the numbers to the *Index*; which (as was ſaid *Par ic.* 1.) is always to keep the ſame Poſition. Now when by ſeveral repeated Revolutions it has meaſur'd out the length of its ſtage, it is to be replac'd at *S.* as before; which may be done in leſs than half the time you are winding up a Watch; and if the ſtage be but 6 foot long, no oft'ner then once in a whole week.

4. The way of adjuſting this Motion to the exact meaſure of an hour, and rectifying its errors; comes in the laſt place to be provided for. No Movement could ever yet be found, that would keep pace with the Sun; and the Reaſon of this, beſides the alteration of weather, and other common accidents to which the moſt curious Movements are liable; is becauſe the Sun it ſelf does not always keep the ſame pace, nor is the preciſe duration of a ſolar hour in any one day ſo exactly aſſignable, as to ſerve indifferently for the whole Year round. But leaving that *Aſtronomical Enquiry* to ſuch as have better helps and opportunities for Celeſtial Obſervations; I ſhall crave leave to think, that if no greater objection can be rationally made to this Movement, then the neceſſity of its being ſometimes adjuſted and rectify'd; even this will appear a very inconſiderable one, ſince the manner of doing it, is ſo very obvious and eaſie. To explain this, 'tis to be conſider'd that there are two Errors which every Movement is ſubject to, and indeed ſcarce ever entirely free from, tho when the aberration is ſo ſmall as not to be diſcernable, it paſſes for truth. The firſt of theſe is, when a Movement gives you a wrong meaſure of an hour, by going remarkably too faſt or too ſlow; and this is an error in the whole train of the Movement from the beginning to the end. The ſecond Error is,

when

when the *Index* points to a wrong time; and this happens either 1. By conſent, when it follows the Error of the Train; for while the Movement goes too faſt, or too ſlow, the *Index* can never be right Or 2 It is a *Solitary* Error in the *Index* only, when the motion of the Train being duly adjuſted, the *Index* it ſelf is not ſet exactly to the (τὸ νῦν or) preſent inſtant of time on the Dial-plate.

1. Therefore, to remedy the former error which lies in the whole Train; we nic our Watches up or down (as the caſe requires) by turning the endleſs skrew, or by removing (either forward or backward) the *Retinaculum* or Brace of the ſpiral ſpring; and in *Pendulums*, by gi ing the Boſs a turn or two upwards or downwards: but in this Movement (if ſo be it ſhall happen to prove one,) the adjuſtment is readily perform d without ever tampering with the Movement it ſelf; for by a skrew inſerted in the *Stage* at (*S.*) with the turning of which the *Stage* may be elevated or depreſs'd, I affirm that the Movement will go faſter or ſlower: faſter, if raiſed up; and ſlower, if let down.

2. The motion of the Train being thus adjuſted (as near as may be) to the true meaſure of an hour, the error of the *Index* will be rectifi'd thus I ſaid before, that the *Index* is always to hang in the ſame poſition, and therefore cannot be turn'd to the time, but the time muſt be brought to it; which is readily done by making the *Horary Circle* movable, and inſerting ſeveral ſmall boſſes or buttons here and there upon the verge thereof whereby (with an eaſy touch of the finger) it may be ſtirr'd to the right or left, as there ſhall be occaſion.

AND thus Sr. you have the *Problem* propos'd, and nothing material omitted in the deſcription of the intended Movement, either as to its external ſtructure, or the manner how it moves in the meaſuring of time, or the way how it is to be adjuſted and rectifi'd: You have heard both what it will do of it ſelf, and what is to be done with it; in all which I affirm it will fully anſwer your expectations and mine, for proof whereof I haſten to the remaining part of my diſcourſe, which contains,

II. THE SOLUTION of the *Problem* propos'd; wherein I ſhall endeavour to ſhow from allow'd Maxims in *Statics*, and other Principles proper to the Queſtion in hand both the Reaſons how, and the Cauſes whereby this may be accompliſh'd.

1. Then, becauſe it may ſeem at firſt view a little ſurprizing, that a circular body ſhould reſt (or which in the preſent caſe is all one, move ſo imperceptibly ſlow) upon a deſcending plain, having no viſible impediment either to ſtop or retard

tard the *impetus* of its own weight: therefore to explain this, be pleas'd to see *Fig.* 2. where first. Let the circle (*L. O. D. N.*) represent any circular body whose centers both of gravity and magnitude are coincident at *M.* Let this circular body be plac'd upon some level plain *G G.* and then 'tis evident that the Angle of its contact with that plain at (*a*) will also be the point of its Libration, and consequently it must needs rest there; *Quia momentum & amplius momentum sunt æqualia.*

2. Let *D E.* represent a descending plain, making an Angle of contact with this circular body at (*a.*) and here, 'tis manifest it cannot rest; because the *Line of Direction* (*ra.*) which (while it insisted on a level) divided the circular body by the centers of magnitude and gravity into parts æquiponderate, is now remov'd to *L D*; which line *L D* falling without or beside the center *M.* evidently destroys the æquipoise of its parts, and therefore must leave it to tumble down towards *E.* for here *Momentum impedimento majus.* The reason therefore of its descent now, being the overballance of the parts *L N D.* to the remaining Section *L D O.* it must necessarily follow.

3. That if some weight equal to the excess of L N D. above L O D. were affixt to the limb of the Quadrant (*O, a.*) as at *P*; then the circular body would rest as quietly at (*b,*) as it did before at (*a.*) The supposition cannot be denied, and the consequence is unavoidable, because L *D O* + *P*=L *N D*, *i. e. Impedimentum æquatur Momento.* Nay I affirm that this circular body shall now resist a greater force, and maintain its point of libration (*b*) more pertinaciously on the declivity *D E*, then it could before, when it rested on the poynt (*a*) in the level *G G.* The reason of which, is evidently this; because by the addition of the counterpoise *P* to the Quadrant *O a*, the center of gravity falls lower in the line of Direction L *D*, and is remov'd from *M* to *C*, *i. e.* nearer to the poynt of libration (*b*): and consequently will keep the circular body more steady in its present Position. From whence if it be remov'd about 7 or 8 degrees of the Quadrant from the poynt of Libration (*b*) either upwards or downwards by a motion of volutation, it will vibrate briskly till it recover its poynt of quiescence: whereas any globular body having the same centers of Magnitude, and Gravity, and insisting on a level; as it is turn'd with a very light impulse, so as soon as its circular motion ceases, it never undulates one jot, but rests immediately.

THUS it appears evidently (as to me it seems) how such a circular Body as is describ'd *Fig.* 3. may be made to rest upon the descent *S E*: which if I have prov'd, more than half the difficulty of the *Problem* is solv'd; for what I have already

dy offer'd towards it ſolution, has been but as it were the winding up of the Movement in order to make it go; and it will appear from what follows, *That the ſame principle, which hitherto has bin the cauſe of its* REST, *ſhall from henceforth be the cauſe of its* MOTION. To this purpoſe, be pleas'd to obſerve *Fig.* 1. where the ſame Movement, which was ſciagraphically deſcrib'd *Fig.* 3. is for the better diſcerning its internal ſtructure, and explicating the reaſon of its motion, repreſented in naked lines. Here then, let the numbers 1, 2, 3, 4. repreſent a train of wheel-work, wherein there is no material difference from what is found in a common Watch; only the numbers of the teeth on the wheels and pinions are to be ſo calculated, that the motion of the whole train may correſpond to the aſſign'd Revolution of the body of the Movement, which is to be once in 24 hours. It would be expedient alſo, that a ſpiral ſpring were applyed to its Ballance, as in the latter Movement is uſual; but of a *Fuſe* here's no need, for the turns of the body of the Movement as it deſcends upon the Stage, anſwer all the intentions of a ſtring or chain; and the contranitence of the weight *P* to the exceſs of L E D above L Q D, ſerves inſtead of a perpetual ſpring; and the Movement wants only a perpetual deſcent, to make its motion ſo. And whereas the great wheel in ordinary Movements, is plac'd as near the edge of the framing plate (*ff*) as it may be; here it muſt (with its *Axis* or *Arbor M*) poſſeſs the center of the Movement: becauſe this wheel is to carry the weighr or power *P* by the *Vectis M P*, and that weight *P* muſt always keep an equidiſtance from the center of the Movement, that while the body thereof (*i. e.* of the Movement) performs its Revolutions; the ſaid weight P and the great wheel (to which it is affixt,) may without any conſiderable variation, continue in or near the ſame Poſition, wherein they now are. Now for a while, be pleas'd to ſuppoſe this weight P with its *Vectis* M P, to be taken quite out of the Movement, and laid aſide: and and then conceive the body of the Movement to be plac'd on a Horizontal plain *H H*, its point of contact in that plain where it ſhould, but cannot reſt, is *T*; becauſe the weight of that part of the Train mark'd with the numbers 2, 3, 4. removes the center of Gravity from *M*, and therefore on the oppoſite part of the Movement as about *C Q*, the inſide of the hoop which forms the Caſe is to be loaded with a thin lining of lead, which may be a counterpoiſe to that part of the train; that ſo the whole body of the Movement, together with all its furniture within and without (excepting only, that *P* with its *Vectis* is as yet laid aſide;) may on that Horizontal

rizontal plain, or while it rides upon its own *Axis*, reſt indifferently in any poynt. This reducing of the Movement to an equilibration of all its parts in the center M, muſt be perform'd *tentando*, *i. e.* by raſping the lead at C Q, as much and in ſuch places as is needful; which to an Artificer of ordinary ſagacity, will not be at all difficult.

THE center of gravity being thus reduc'd to M, the next thing that follows, is the replacing of the weight P; which, for the better repreſenting its ſhape, is drawn according to the dimenſions of its ſolidity as *Fig.* 5. and by the hole *H*, is to be ſet on the *Arbor* of the central wheel M. Now let the body of the Movement be plac'd on the Declivity D E, and ſuppoſing (as was ſhow'd above *numb.* 3.) $P + L\,Q\,D = L\,D\,E$. then the body muſt needs reſt there: but becauſe the weight P is not now (as in *Fig.* 2.) fixt to any part of the Quadrant Q D, but hangs upon the train of wheel-work 1, 2, 3, 4. it evidently follows that if the power thereof be ſuperior to the reſiſtance of the train, then the whole body of the Movement muſt needs deſcend towards E in *Fig.* 3. By this you ſee there are 2 offices aſſign'd to the weight or power repreſented by P in *Fig.* 1, or *Fig.* 5. which if I can make evident it will perform, I conceive this will be a complete Solution of the *Problem*. The

1. Is, to be a counterpoiſe to the exceſs of the weight of L E D, above L Q D; which that it may be, upon the reaſons given in the explication of *Fig.* 3. I now crave leave to take for granted. The

2. Is, that it be of force ſufficient to put the train into a motion ſo adjuſted, as may exactly comport with the time aſſign'd for the revolution of the whole body. So that if there be any difficulty remaining, it conſiſts in ſuch an exact ſtating of the weight and power of P, that it may adequately ſerve both theſe intentions. Now how very eaſy this is, will be manifeſt from theſe Propoſitions following.

1. That whatever the intrinſick weight of P ſhall be, (as ſuppoſe it 4 ounces Troy;) yet the power of that weight will be augmented or diminiſh'd according to the different degrees of its elevation in the Quadrant T Q. Thus conſidering P M as a Vectis, its *Hypomochlium* (for want of an Engliſh word) is M, the point where it exerts its power on the train, is at V, I ſay then, that whatever power it has upon the poynt V in its preſent elevation of 45 degrees; it will acquire a greater by being rais'd to 50, 55. *&c.* and the greateſt of all in 90 degrees at Q: and on the contrary, let it ſink to 40. 35, *&c.* its power upon the point V will ſtill be diminiſh'd, in ſo much that in T it will be utterly extinguiſh'd

and

and in reſpect to any influence upon the train, 'tis in that poſition (as the Poet ſpeaks) *Nec quicquam niſi pondus iners*. I need not ſpend time to demonſtrate this Propoſition, conſidering to whom I write; and therefore upon the pr ſum'd conceſſion thereof, this conſequence muſt be allow'd: that if P be of a competent weight (*i. e.* not utterly too light) to move the train at all, it will certainly move it in ſome degree of Elevation or other in the Quadrant Q T.

2. If the weight P be conſider'd as to its office of being a counterpoiſe to the body of the movement; as I need not prove, that it will perform this no leſs while it hangs by upon the *Vectis* M P, then if it were faſt rivetted in the ſame place to the caſe of the Movement: ſo I affirm, that in what poynt of the Quadrant ſoever it will move the train, it may be alſo a counterpoiſe to the Body of the Movement. This propoſition is not altogether ſo evident, but moſt certainly true, as I hope in what follows clearly to demonſtrate. Be pleas'd therefore, to obſerve

1. That at what poynt ſoever of the Circle L E T Q *Fig.* 1. the line of Declivity D E makes an Angle of contact; on the ſame poynt will the Diameter S D fall at right angles with D E.

2 That the line of direction L D will ever fall upon the poynt of Contact D, making an Angle with the Diameter, as S D L. Theſe 2 propoſitions need no proof.

3. That the Angle S D L will be always equal to D E H in *Fig.* 3. *i. e.* As great as is the elevation of the line of Declivity D E above the Horizontal E H *Fig*, 3: ſo great will the Angle of diſtance be between the Diameter S D and the line of direction L D *Fig*, 1. To prove this ſee *Fig.* 2. where let E H repreſent the Horizon, E D line of declivity; to E H draw parallel *e h*, and to E D parallel *b d*. therefore Angle *d M h* is equ. to D E H, and *e M b* equ. to *d M h*; and becauſe S M *b* and *r M e* are right angles, therefore is *S M r* equal to *e M b*, and *r a* being parallel to L D, the Angle S D L muſt be equal to (S M r,=e M b,=d M h, *i. e.* =to) D E H. and from hence it follows.

4. That the greater the Angle of declivity is in *Fig.* 3. the leſs will the Section L Q D be in *Fig.* 1. and ſo on the contrary, the leſs that Angle is, the greater the Section. And therefore,

5. The exceſs of the weight of L E D above L Q D muſt be alſo greater, by raiſing up the ſtage with the ſcrew at S: and that exceſs leſs, by ſcrewing it down.

6. The lighter that part of the body is, which is repreſented by the Section L Q D; the more heavy ought the

counterpoiſe P to be, and that either in its owne intrinſick weight (in Ounces and parts of Ounces) or elſe in its potential weight, by being rais'd higher in the Quadrant Q T.

7. The ſkrewing up the Stage of the Movement at S *Fig.* 3. will raiſe the Counterpoiſe higher in the Quadrant Q T. by *Prop.* 3 and therefore potentially heavier. And from hence appears (I take it moſt clearly) both the reaſon of the due adjuſtment of the motion of the Train to the exact meaſure of an hour, and what weight is to be aſſign'd to P, that moves it; and that we are not confind to ſcruples and grains, but are allow'd ſuch a conſiderable latitude, as it is not eaſy to erre therein. I ſhall give a word or two for direction in that Particular and conclude. Therefore having ſet the Stage (by the help of the arched Skrew) at the elevation of about 10 degrees; place the Movement thereon, and try what weight hanging at the end of the *Vectis* M P while ſtir the Train, meanwhile holding the Movement with the hand in ſuch a poſition, as the *Vectis* may make an Angle of about 30 degrees with the perpendicular M T: then let the Movement looſe to undulate upon the Stage; and when the vibration ceaſes, obſerve to what degree of the Quadrant the *Vectis* poynts, and at the ſame time mind the pulſes of the Ballance. If at this Obſervation, the weight lies low (as for inſtance between 25 and 35 degrees of the Quadrant) and the beats of the Ballance are gueſs'd to be not much different from their due time; the weight P is well enough proportion'd; for herein (as I ſaid) there is a conſiderable latitude, and if it chance to be much heavier then is abſolutely needful, that exceſs will be moderated by skrewing down the Stage; and if it be not abſolutely too light, its defect will be compenſated, by skrewing the Stage higher. Therefore of theſe two extremes, chooſe the former; for the fewer degrees that P ariſes in the Quadrant beyond what is abſolutely neceſſary, it will (for reaſons very obvious) be ſo much the better.

And thus Sir, if I have not err'd in my apprehenſions; you have preſented to you the Scheme of ſuch a Movement, together with the demonſtration of it's Motion, as will fully anſwer the Problem propos'd. Upon the careful review of what has bin ſaid, tho I find ſome defects in poynt of method, and not alwaies ſo natural a Syntax in the periods as might have bin: Yet I thing neither of that conſequence, as to render my meaning any where unintelligible, or my reaſons leſs concluſive; tho both of them I acknowledg to be ſuch faults, as not to deſerve your pardon without a juſt excuſe. I have drawn conſequences from ſome aſſertions not

prov'd,

prov'd, becauſe I judg'd them unqueſtionable to any that know the undoubted principles upon which they are founded: and it would have bin an unpardonable trifling with your patience, upon every occaſion to demonſtrate 2 + 3 = 5 with the formality of an ὅπερ ἔδει δεῖξαι. Notwithſtanding which I confeſs I am too long,, and that for want of more time: and yet perhaps had I ſtaid longer, I might have ſhortned this diſcourſe as to its preſent ſubject; but added much more by the way of improvement of it to other purpoſes. For tho I ſhall not raſhly anticipate the Εὕρηκα, before the triumph be legally decreed by the Philoſophical Senate, at whoſe feet I humbly lay this performance: yet I perſwade my ſelf, that if what I have ſaid concerning the Structure and motion of this Automaton, holds true; it may be made (upon the ſame principles and in a more capacious fabrick,) one of the Nobleſt Machines of Wheel work, that is yet known; ſo as to repreſent the entire Syſteme of the Heavens, and that by a more natural imitation, and with fewer uncertainties in the motion, and with much leſs trouble in the keeping, then any movement that I (in this obſcure place) have yet hard of. But it will be time enough to conſider that, when I ſhall find how far the ſociety approves of this: whoſe bare judgment ſhall be to me under all my preſent confidence, of farre greater moment then ten thouſand reaſons of my own. 'Tis indeed only a domeſtic Time-keeper (if that be any objection againſt it) intended for a ſteady regular motion at home, and not for wandring abroad: accommodated to the ready ſervice of the induſtrious Student, and a fit companion for Books, among which it may poſſeſs a Shelf; and by it's Myſtick Frontiſpiece teach the ſober Spectator more true wiſdom (namely, that of knowing how to Number and ſpend his daies;) then great maſſy volumes that contain nothing but Ink and Paper: I am very ſorry, that I am not where I might have provided the Movement my ſelfe, and without the help of a Carrier, or the trouble of a journey, have preſented it to you with my own hands inſtead of the Scheme and Notion; which would have been a conviction beyond all other demonſtrations: But and if in my preſent circumſtances I have attempted my utmoſt to obey your commands; I hope it will be no leſs to your acceptance, then it has been to the ſatisfaction of

Your moſt affectionate Friend and Servant

Sibbertoft
May. 22. 84.

M. WHEELER.

Fig. 5.

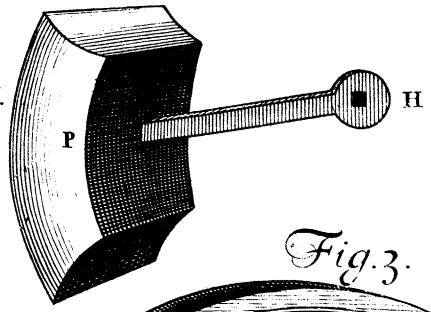


Fig. 4.

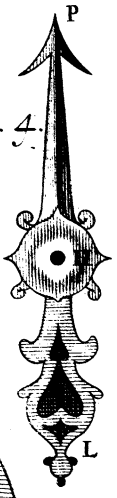


Fig. 2.

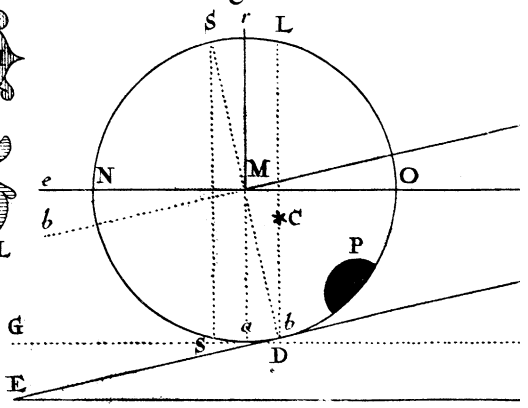
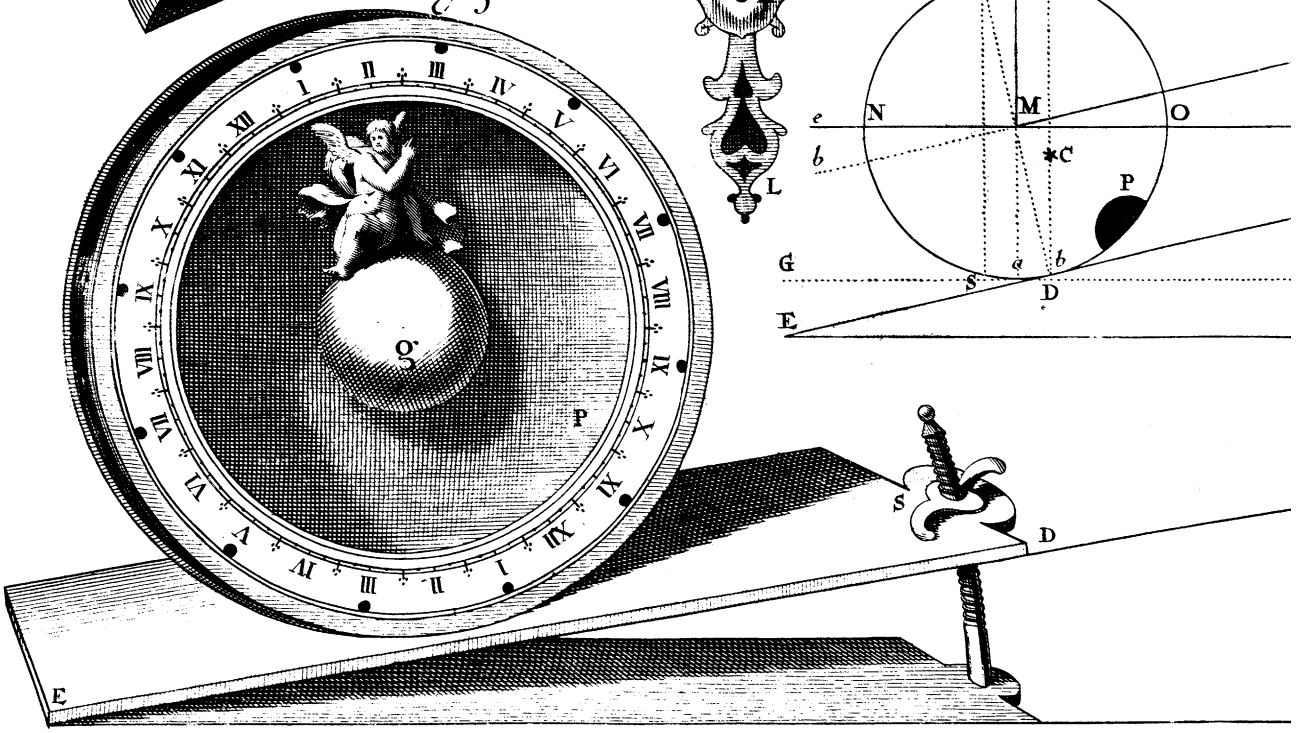
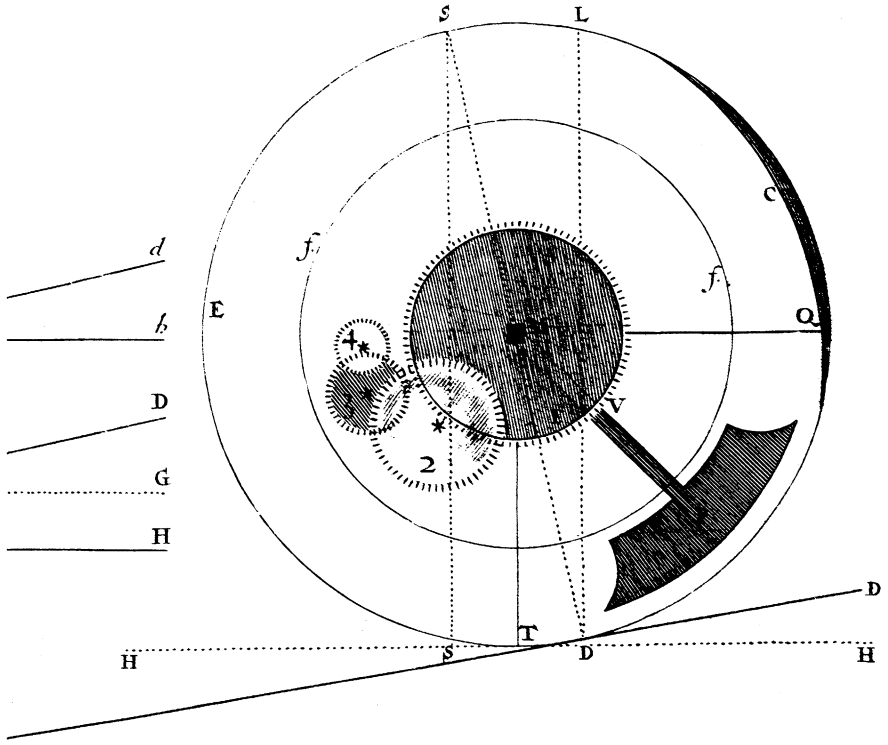


Fig. 3.



1;161.

Fig. 1.



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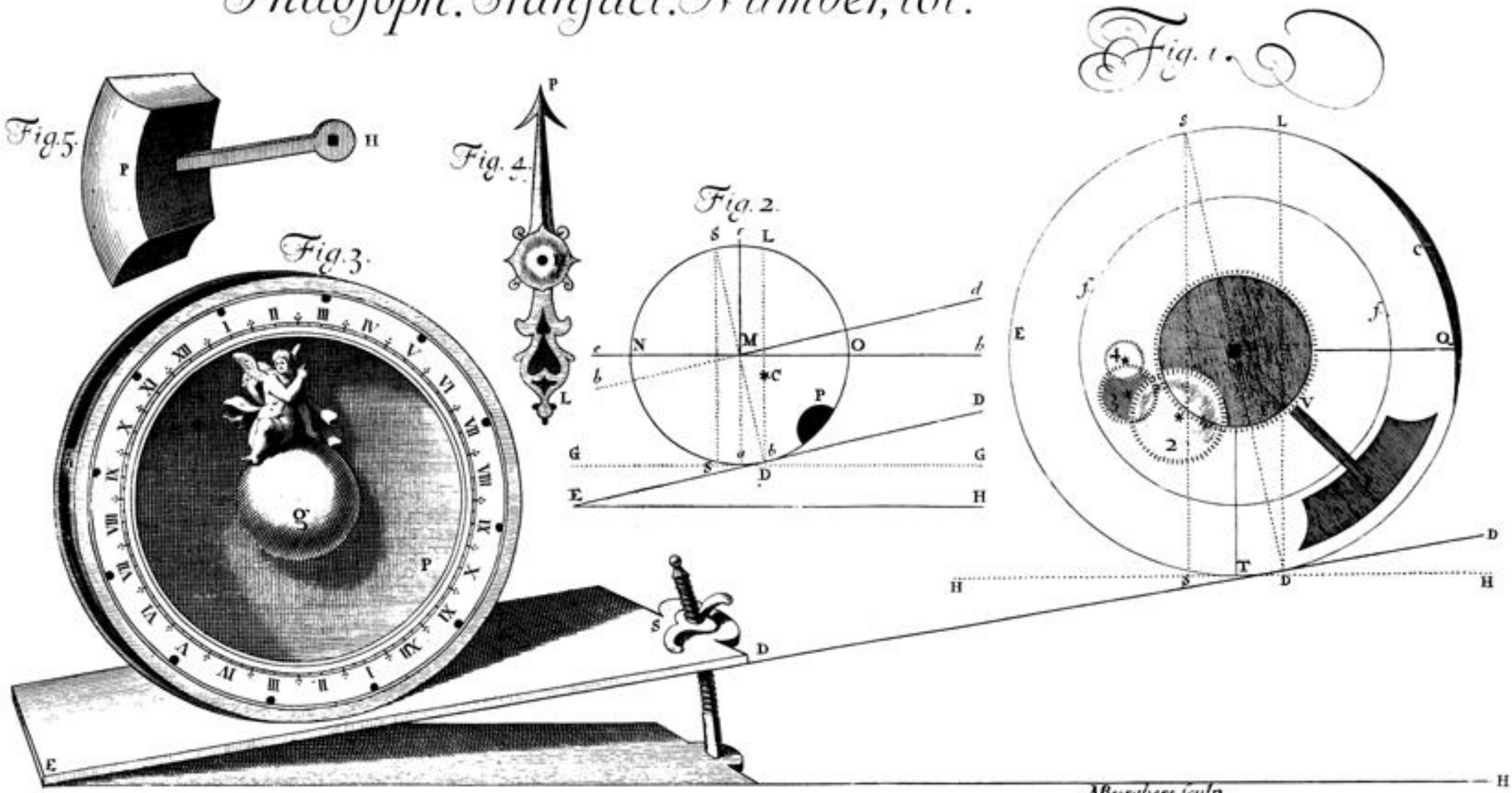
Philosoph. Transact. Number; 161.