THE

POWER OF GOD,

DEDUCED FROM THE

Computable Instantaneous Productions of it

IN THE

SOLAR SYSTEM.

By SAMUEL HORSLEY, F.R.S.

Rector of St. Mary Newington, *in* Surry.

Sæpe hæc cogitanti mihi, in mentem venit, tantum in primis numerorum exordiis calculos omnes noſtros verſari.

HUGEN. COSMOTHEOR. LIB. 2.

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TO

THE RIGHT HONOURABLE

THOMAS VILLIERS,

BARON HYDE, OF HILLDON,

ONE OF

HIS MAJESTY'S

MOST HONORABLE PRIVY COUNCIL,

A DISTINGUISHED FRIEND

TO SCIENCE AND TO VIRTUE,

THESE PAPERS ARE,

WITH ALL RESPECT,

INSCRIBED BY

HIS LORDSHIP'S

MOST OBLIG'D,

MOST DEVOTED,

AND MOST OBEDIENT SERVANT,

SAMUEL HORSLEY.

TO THE

READER.

The Story of *Kepler's Experiment*, related in Page Twenty-three, is to be found in his Piece *De Stellâ Novâ in Pede Serpentarii.*

ERRATA.

Page 2, L. 1, for *ſo* read *ſuch*.---Page 8, L. 10, for *ſemidiameter* read *ſemidiameters*.---Page 19, L. 12, dele *it it*---Page 23, L. 6, for *ſun's* read *ſuns*---Page 25, L. 16, for *have thrown* read *throw*---Page 28, L. 23, for *millionths* read *millionth*---Page 36, L. 7, for *millionths* read *a millionth*---Page 40, L. 15, for *that is leſs*, read *that is, it is leſs*.

ERRATA in the NOTES.

Page 31, L. 1, for *equalateral* read *equilateral*---Page 32, L. 2, for *third equal, to each*, read *third, equal to each*.

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WHILE I was engaged in conſidering the foregoing intereſting problem, I fell into a very ſingular, and perhaps a whimſical, ſpeculation. It occur'd to me that the determination of the ☉'s diſtance wou'd not only ſettle the whole extent and dimenſions of the ſolar ſyſtem, but wou'd likewiſe enable us to compute the quantity of new moving force that is every inſtant produced therein by the mutual gravitations of the bodies that compoſe it, which may fairly be conſidered as the inſtantaneous efficiency

(in one article) of that mighty Cauſe, whoſe power produced, and whoſe inceſſant activity maintains, this great and beauteous fabric: the inveſtigation of this ſeemed a curious enquiry, and I thought it might be uſeful, as it might afford a new evidence, of the power of the Firſt Cauſe, of a very ſtriking kind. I therefore determined to ſet about the computation, ſuppoſing the ☉'s diſtance to be no greater than we may ſafely conclude it to be from obſervation. Indeed it is not right to adopt the concluſions of theory till verified by obſervation, when ſuch verification can be attained. The ☉'s parallax therefore I reckon 8″, and the computation is as follows.

	I. Apparent semidiameters of the Planets seen from the Sun at their respective mean distances.	II. Apparent semidiameters of the Planets seen from the Sun at the mean distance of the Earth.	III. Diameters of the Planets.	IV. Solidity of the Planets.	V. Densities of the Planets.	VI. Matter of the Planets.	VII. Accelarating gravities of the Planets to the Sun at their respective mean distances.	VIII. Gravitating forces of the Planets to the Sun at their respective mean distances.
n ♄	8″	1′..16″,303	9,5379	867,69	0,16464	142,84	0,010992	1,5702
er ♃	18″,625	1′..36″,87	12,1088	1775,4	0,23806	422,67	0,036965	15,624
♂	6″	0′..9,″141	1,1427	1,492	0,73	1,089	0,43072	0,469
Earth	8″	0′..8″	1	1	1	1	1	1
s ♀	15″	0′..10″,85	1,3562	2,494	1,27	3,1681	1,9113	6,055
ury ☿	10″½	0..4″,0644	0,5080	0,131	2,04	0,267	6,6735	1,786
Sun ☉			120,18	173584 1	0,25456	441876		

Sum of gravitating force 26,504

In the above table, on a line with the name of each planet, is placed, in column 1, the quantity of its apparent ſemidiameter to an obſerver in the ⊙; in column 2, the angle under which the ſemidiameter of each would appear, at the mean diſtance of the earth from the Sun; in column 3, the numbers expreſſing the diameters of each, in ſuch parts as the diameter of the earth is 1; in column 4, the number expreſſing the ſolid contents of each, in ſuch parts as the ſolidity of the earth is 1; in column 5, the denſity of each, in ſuch parts as the earth's denſity is 1; in column 6, the quantity of matter in each, in ſuch parts as the quantity of matter in the earth is 1; in column 7, the accelerating gravity of each, in ſuch parts as that of the earth is 1; and, in column 8, the gravitating force of each, in ſuch parts as that of the earth is 1.

The numbers in column 1 and 2, are deduced from the obſervations of aſtronomers, and the proportions between the mean diſtances of the planets, and that of the earth, from the Sun. The numbers in column 3, are proportional to the collateral numbers

of column 2, and arise from the division of the latter by 8. The numbers of column 4, are the cubes of the collateral numbers in column 3. The densities of ☿, ♃ and ☉ in column 5, are according to computations of my own, formed on the third corollary of the eighth proposition of the third book of the Principia. Those of ♂, ♀ and ☿, are taken from De la Lande. The numbers of the sixth column arise from the multiplication of the collateral numbers of column 5, into those of column 4; the numbers of column 7, are in the inverse proportion of the squares of the mean distances, and the numbers of column 8 are produced by the multiplication of the collateral numbers of columns 6 and 7.

Upon summing up the numbers of column 8, it appears that the whole gravitation towards the Sun (excluding the gravities of the secondary planets, and the comets) makes up a moving force $26\frac{1}{2}$ times the gravitating force in the earth alone toward the ☉; and the gravity of the ☉ toward each planet being equal to the gravity of that planet toward the ☉, the sum of the gravitating force exerted between the Sun and all the planets, will

be

be to the gravitating force exerted between the earth and ⊙ alone, as 26,504 to 1. The moving force produced by the gravitations of the planets to each other, I ſhall not conſider, as it bears but a mighty ſmall proportion to the ſum of force produced by the gravitations of the planets and the ſun *.

Now the mean ſemidiameter of the earth, according to the French meaſurements of it, reduced to our ſtandard, contains 6983550 London yards. Hence, if the mean denſity of the earth be that of common water, the quantity of matter in the whole earth is to the quantity of matter in a ſphere of water, whoſe diameter is one yard, as 272470310000000000000000 to 1; the denſity of water is to that of iron, as 1 to 7,645. Therefore

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* The greateſt alteration the gravitations of the planets to each other can make in the whole ſum of the ſeveral inſtantaneous productions of motion, is, when all the other planets are heliocentrically oppoſed to Jupiter. The inſtantaneous production will then be increaſed, by the gravity exerted between each planet and Jupiter. But the effect of theſe gravitations will not all amount to ,0015 of the gravity between the earth and ſun.

fore the quantity of matter in the whole earth, is to the quantity of matter in a ball of iron, of 1 yard diameter, as 35640325000000000000 to 1. Again, by the proportion of the ſemidiameter of the ☉ to the ſemidiameter of the earth, and that of the denſity of the ☉ to the denſity of the earth, as above ſtated, and by the 72d propoſition of the firſt book of the Principia, the weight of a heavy body on the ſurface of the earth, of a ball of iron, for inſtance, 1 yard diameter, is to the weight of the ſame body on the ſurface of the ☉, as 1 to 30,593. The weight on the ☉'s ſurface is to the weight to the ☉ at the earth's mean diſtance as 30,593 to 0,00066470.

And the weight of a ball of iron, 1 yard diameter, to the ☉, at the earth's mean diſtance from the ☉, is to the earth's weight to the ſun at the ſame diſtance, as the matter in the ball to the matter in the earth; that is, as 0,00066470 to 23690180000000000000. Hence the weight of a ball of iron, 1 yard diameter, towards the earth on the earth's ſurface, is to the earth's gravity towards

 the

the ☉, at her mean diſtance from the ☉, as 1 to 23690180000000000; and the whole gravitating force, exerted between earth and ☉, is to the weight of the iron ball, as twice the foregoing number to 1, that is as 47380360000000000000 to 1. And the ſum of the gravitating forces, exerted between the ſun and all the planets, will be to the weight of the iron ball, as this laſt number multiplied by 26,504 to 1. That is as 1255769060000000000000 to 1. The weight of an iron ball, whoſe diameter is one London yard, on the ſurface of the earth, if no part of it were deſtroyed by the reſiſtance of the atmoſphere, wou'd be in the latitude of London 2741,1912lb. Troy. Hence the weight in vacuo in the latitude of 45°, I find by computation to be 2739,846lb. Troy. But in the latitude of 45° the centrifugal force deſtroys ſo much of the whole weight of the ball as amounts (as I find by computation) to 4,753lb. Troy. Hence the whole weight of the ball in latitude 45°, if gravity had its full effect undiminiſhed by a reſiſting atmoſphere, and a centrifugal force, would be 2744,599lb. Troy. Hence, and from the fore-

going computation, a force of motion is every inſtant produced a-freſh in the ſolar ſyſtem, exceeding 3446582000000000000000lb. Troy, or 25526040000000000000 hundred weight Averdupoize.

I have taken ſome pains to accommodate this enormous number to my own conception. The reader would perhaps be ſurpriſed, ſhou'd I only tell him that if he wou'd attempt to count this number of hundred weights, and would ſpend ten hours at it every day, and were to count 100 in every minute, he could not hope to finiſh it it within the compaſs of his life. But, perhaps, he will hardly credit me, when I aſſure him that were the work tranſmitted from father to ſon, it would employ many millions of generations; as at the rate I have ſuppoſed (which is exceſſive) it cou'd not be brought within the compaſs of

1164770000000000000 Julian years.——Such, at the loweſt eſtimation, is the inſtantaneous production of moving force, ſuch has been the production of every ſucceſſive inſtant ever ſince the heavens and the hoſt of them were finiſhed; and ſuch muſt be the inceſſant production of every

inſtant to come, ſo long as they ſhall ſubſiſt in their preſent form. Forces of the like kind muſt every moment be produced in each of thoſe innumerable ſyſtems, which are only known to the tenants of this ſmall globe, by the glimmerings of their diſtant ſun's. The whole inſtantaneous production, therefore, in this ſyſtem, can be but a ſmall, an inſenſible part, of the whole force that is produced every inſtant in the boundleſs univerſe. Sir Iſaac Newton, in the Scholium with which he cloſes his immortal work, the mathematical principles of natural philoſophy, concludes from what he had diſcover'd of the ſtructure of the world, and ſome of the plaineſt metaphyſical axioms, the intelligence, the wiſdom, the eternity, the ubiquity, the unity, and the dominion of the Firſt Cauſe—I know nothing that ſo forcibly evinces the infinitude of his power, as the demonſtrable exertions of it in this ſingle article. For what can that Power be leſs than infinite to whoſe inſtantaneous production (in that ſingle inſtance the production of motion) the vaſt computable effect in this ſyſtem bears but the proportion of finite to infinitely great?

It

It were to be wiſhed that thoſe who apply to the ſtudy of nature, would take more pains than they generally ſeem to do, to conſider what may ſafely be concluded concerning the Firſt Cauſe, from the knowledge that we have gained of his works; and, every ſtep that we advance in ſcience, conſider whether it opens any thing new with reſpect to him. If this method were taken, the partizans of fate or chance, or of any but an intelligent Principle, would ſoon find that they have a deſperate cauſe in hand. God has not left himſelf without witneſs——The words are in the Bible, but the aſſertion is Newton's. In what we already know of nature, we have ſo many infallible marks of deſign and wiſdom, that I cannot believe that any man, well verſed in philoſophical ſtudies, can, ſeriouſly, and in the ſimplicity of his heart, eſpouſe the atheiſtical ſide of the queſtion. If there were *many* different ways, in which the principal phænomena of nature might be produced, chance might be allowed ſome ſhare, in the making and preſerving of the world; but if there be only *one* way of producing them, if things could not *be* as they *are*,

but

but by a certain force inceſſantly exerted by one unvaried law, this has but little the appearance of an accident—That each of the primary planets moves in an ellipſis round the ſun placed in the focus, and that the area terminated by that focus and any two points in the circumference of the orbit is always proportional to the time which the planet takes in moving from one of theſe points to another, is an inconteſtable truth, concluded from the ſucceſſive obſervations of many thouſand years. The ſecondary planets move in the ſame manner round their primaries, and this motion can no otherwiſe be produced, can no otherwiſe ſubſiſt, but by a force conſtantly urging the planet to the ſun, or the ſecondary to the primary, and remitted or increaſed in proportion, as the ſquare of the diſtance from the ſun, or from the primary, increaſes or diminiſhes. A ſmall deviation from this proportion in the force impreſs'd, wou'd ſoon produce ſuch alterations as wou'd amount to a demolition of the ſyſtem. This force muſt likewiſe be duly adjuſted to the velocity wherewith the planet is moving in its orbit; or, if the force impreſs'd be too weak,

the orbit will be changed from an ellipſis into another curve. Theſe are things which, of all others, mathematicians believe with the moſt full aſſent and conviction of their reaſon, becauſe they know them to be of all things the beſt evidenced, deducible from the moſt ſimple laws of motion, confirmed by long experience, and from the uncontrovertible principles of geometry. And if theſe things are ſo, do they not neceſſarily infer an intelligent Cauſe, an inceſſant Providence, an entire dependance and a moſt abſolute ſubjection, of all created things? If any man can ſeriouſly believe that chance may have conducted things with all this regularity for ſo many ages, he would do well to repeat honeſt Kepler's experiment. John Kepler was a plain man, of good natural underſtanding, and the beſt acquainted with the ſtructure of the univerſe of any of his day. He was very unwilling to believe that chance had built it, though chance had then many zealous advocates, who loudly contended that the whole honour of the work belonged to that blind divinity. To give the queſtion a fair diſcuſſion, he reſolved to try whether chance could

do

do a much more ſimple thing; whether with the letters that compoſe John Kepler's name in Greek, ſhe could make out the words Σειρηνων καπηλος. He wrote theſe fifteen letters upon fifteen ſlips of paper: theſe he rolled carefully up, huſtled them in his hat, and then drew them out one by one, to ſee whether, in many repeated trials, they would come out in the required order. He continued his experiment till he was quite tired, without ſucceſs. Indeed, according to the beſt computations I can make, chance was not likely to do right above one time in 16345929600o. The fortuitous concourſe of atoms has had many a more ſerious anſwer, but never had a better one.

If ever there ſhould be virtue and vigour enough among the ſons of men, to proſecute that noble plan of enquiry, which the great Newton has traced out in ſome of the laſt pages of his Optics, we might then reaſonably hope not only for further evidence of thoſe things which we already know of God, but for a much clearer inſight into the nature of that great Being, and a better underſtanding of the relation that *we* bear to him. And though the

faith

faith of miracles is of no ſmall uſe, and indeed neceſſary to the bulk of mankind (becauſe they can have little other) yet, with the higheſt ſenſe of the value of that great and general bleſſing, I ſhall not ſcruple to pronounce that the *faith of philoſophy*, as far as it goes, and where it can be obtained, is far ſuperior to it, as it approaches many degrees nearer to knowledge. And for that rea on it is much to be wiſhed that *one reſpectable order* of men, would conſider theſe enquiries as ſome part of *their* proper buſineſs. A little induſtry beſtowed in ſearching out the *works* of the Moſt High, and in ſearching *him* out from *them*, would turn to much better account, bring more improvement to themſelves, and more profit to mankind, than all the time and pains that ſo many have thrown away in the cultivation of the barren *priori* argument, and ſometimes on things of leſs ſignificance, and leſs harmleſs. Their labours in this way might ſurvive and do them honour with poſterity, when the lumber of chimerical metaphyſics, and the odious filth of rancourous controverſy ſhall "*roll down the gutter of time*" forgotten and neglected.

When I took the foregoing enquiry in hand, I had ſome ſuſpicion that the force of motion produced by the gravitations of the ſun and planets, might be but a ſmall part of the whole inſtantaneous production in this ſyſtem; for I conſidered that we ſhould add to it the forces produced every inſtant by the emiſſion of light from the ſun, by the reflections, refractions, and inflections of that light by other bodies; by the agitations of the conſtituent particles of bodies by heat, and the cauſes of fermentation and putrefaction, by the circulation of the blood and juices in the veins and veſſels of animals and vegetables. Now, though the bodies on which theſe forces are exerted are extremely minute, yet, conſidering the great velocity, and the vaſt number of the corpuſcles, I conceived that they might make up a prodigious ſum of motion; but I afterwards found reaſon to change my opinion, and to think the amount of theſe motions ſo very inconſiderable, as to bear hardly any ſenſible proportion to the inſtantaneous productions of gravity; ſo that the latter may fairly be conſidered as the whole production of every inſtant.

inſtant. In order to form ſome probable judgment in this matter, I endeavoured to make ſome eſtimate, what might be the greateſt poſſible amount of the moving force produced every inſtant by the emiſſion of light from the ſun. I found it almoſt nothing. The following is a brief account of my enquires on this difficult ſubject.

The light of the ☉ traverſes the ſemidiameter of the orbis magnus in 7′ nearly †. The earth's mean motion in 1″ is 2‴-27⁗-50ᵛ or 2‴,463888. The verſed ſine of this arc (the radius being 1) is 0000000000019818. Hence the velocity of light is to the earth's perpendicular acceleration toward the ☉, at her mean diſtance, as 236196,9 to 0,0000019659972 or as 120141000000 (log. 11. 0796912) to 1. The thickneſs of the particles of glaſs that reflect the white light of the 1ſt order, is, according to Sir Iſaac Newton, $3\frac{2}{5}$ millionths of an inch; and, if I miſtake not, he reckons that

† This is the velocity wherewith the reflected light of the ſun returns from jupiter. I think it is not improbable that in its firſt propagation from the ſun it may travel much faſter.

the particles of metallic ſubſtances reflecting the ſame light, are leſs thick than thoſe of glaſs in the ratio of 2 to 7. The thickneſs therefore of theſe will be in decimal parts of one millionth of an inch 0,97144. Let us ſuppoſe them to be ſpherules of this diameter, and that they are ranged in the cloſeſt manner poſſible. It will eaſily be admitted that the particles of light muſt be ſmall enough to enter in great abundance into the pores of theſe ſubſtances, and even into thoſe of their component ſpherules, and to find room to move freely about in them. It will be ſhewn hereafter, that when a body is compoſed of equal ſpherules ranged in the cloſeſt manner poſſible, the diameter of the greateſt ſpherule that can poſſibly enter into the pores of ſuch a body, is little more than $\frac{3}{20}$ of the diameter of any one of the ſpherules that compoſe it. The ſpherules of light therefore to enter into the pores of metallic ſubſtances cannot much exceed 0,145716 decimal parts of one millionth of an inch. They might enter in ſwarms and have room to move about, if we make their diameter $\frac{1}{100}$th part of this, or 0,00145716 decimal parts of one millionths of an inch. But ſince they enter in ſwarms into the much ſmaller

pores of the tranſparent particles, and have room to paſs freely through them, we will ſuppoſe their diameters not quite $\frac{1}{1000}$th part of the laſt magnitude, and ſay that they do not exceed a millionth of a millionth of an inch.

The denſity of the particles of the ſun's light, I ſhould imagine muſt be very great. The ſpiſſitude of his rays, when they fall upon our organs, is probably infinitely leſs than that of rays iſſuing from a candle or lamp, or thoſe emitted from a bar of red hot iron; and yet a good eye will look ſteadily for ſome time, not only at a candle, or a lamp, but at the hotteſt iron held at a ſmall diſtance. Whereas the ſtrongeſt human organs can hardly, for a moment, ſuſtain the direct aſpect of the ſun. I imagine therefore, that the *hardneſs* and *ſolidity* of the particles of the ☉'s light is ſuch as much more than compenſates for their want of ſpiſſitude, and enables a ſmall number of them to move the organs much more forcibly, than a great number of leſs ſolid corpuſcles, and conſequently that they are infinitely more denſe than the particles of light emitted from red hot iron. In the preſent enquiry we ſhould be

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more miſled by making their denſity too ſmall then by over-rating it. Suppoſe we reckon it therefore juſt three times that of iron (which will be ſome-what greater then the denſity of gold) then the quantity of matter in each ſpherule of light, of one millionth of one millionth of an inch diameter, will be to the matter in an iron ball of one yard diameter, as 1 to 15552XXX.VI.* Hence the force of the ball's weight to the ⊙, at the earth's mean diſtance, will be to the force of motion in each ſuch particle of light, as 129447XXiV to 1, and the earth's weight to the ſun is to the moving force of every ſuch particle, as 4613566XLIII to 1, and about 4613566XLIII ſuch particles go to make up a moving force, equal to that of the earth's weight to the ſun.

Now let us conſider what is the greateſt number of ſuch particles that can poſſibly fly off from the ſurface of the ſun every inſtant.

The

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* The numeral letters placed after the Indian characters denote the number of cyphers that are wanting to complete the integral places.——

* The cloſeſt manner in which a parcel of equal circles can be ranged, is, when every one is touched by ſix others, every adjacent pair of which touch one another. Seven circles, thus diſpoſed, have ſix interſtitial areas: namely, the ſix curvelinear triangles. ABC,CLV,VNO,OKQ,KRS,STA. And by every circle that is added to the 7, one new interſtitial triangle is formed. So that the number of interſtices is only one leſs then the number of circles, provided the number of circles be not leſs then 7. Therefore when the number of circles is ſo great, that 1 bears no ſenſible proportion to it, the number of circular areas, may be conſidered as equal to the number of interſtitial areas. And the whole ſpace covered by the circles, will be to the whole interſtitial ſpace, as the area of one circle to the area of one interſtice; that is (as may appear by computing the area of the interſtitial triangle ACB) as 9,741114 to 1 (Log. 0,9886087.)† ——

Let

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* See fig. 3.

† ABC is an equalateral triangle. AD perpendicular to one ſide. The area ABC, is to the ſquare of BC, as $\frac{1}{2}$ AD to BC, that is, as $\frac{1}{2}$ the ſine of 60° to the radius, or, as 1 to 2,3094.

Two

Let it be ſuppoſed that the ſpherules of light iſſue from the ⊙, in this moſt compact arrangement; ſo that when their centers are in the ſurface of the ⊙, the great circle of each ſpherule, formed by the ⊙'s ſurface cutting it, is touched by the great circles of ſix others, formed by the like interſection with the ⊙'s ſurface, and that every adjacent pair of theſe ſix do alſo touch one another.

The

Two equal circles touch in the point A, and are touched by a third equal, to each, in B and C. The curvilinear area, ABC is required. Join the three centers D, E, F. D F E, is an equilateral triangle, each of its ſides being equal to 2 DA, that is equal to the diameter of either circle. Each of the circular ſectors BDA, BEC, CFA is $\frac{1}{6}$ of the circle to which it belongs; and the circles being equal, the 3 ſectors are $\frac{3}{6}$ or $\frac{1}{2}$ of the area of either circle; $\frac{1}{2}$ the area of the circle D is to the ſquare of the diameter DE, as 0,392699081 69 to 1. The ſquare of DE is to the area of the triangle DFE, as 2,3094 to 1. By equality, $\frac{1}{2}$ the area of either circle, that is the ſum of the three ſectors ADB, AFC, CEB, is to the area of the triangle, D F E as 0,392699081 69 × 2,3094 to 1. By inverſion, the area of the triangle DFE is to the ſum of the 3 ſectors, as 1 to 0,392699081 69 × 2,3094.

By

The ſemicircumference of the earth, ſuppoſing it a ſphere, according to the French meaſurements, is about 65818440 Engliſh feet.

The

By converſion the area of the triangle DFE : the area ABC= 1 : 1—0,392699&c. × 2,3094. And by diviſion the 3 ſectors, or $\frac{1}{2}$ area of the circle is to the area, ABC as 0,3926990816 9 × 2,3094 to 1--0,3926, &c. × 2,3094 that is as 9,741114 to 1.

From hence I conclude that the greateſt poſſible denſity of a body, compoſed of equal ſpherules, is ſuch, that the ſpace occupied by all the matter, is to the ſpace of all the pores, as 6,494076 to 4,247038, or, as 1,529083 to 1. This I deduce thus. I imagine a parcel of equal ſpherules, placed on a baſe of circles, ranged in the manner above deſcribed; each ſpherule is to touch the baſe, in the centre of a circle, and the circles of the baſe, are to be equal to the great circles of the ſpherules. Now, if inſtead of every ſpherule, a cylinder were erected on the ſame baſe, the altitude of which ſhould be equal to the diameter of the baſe, the ſolid contents of all the cylinders, would be to the ſolid contents of all the pores, as the ſuperficial contents of all the circles of the baſe, to the ſuperficial contents of all the interſtitial triangles. But the ſolid contents of all the ſpherules, is but $\frac{2}{3}$ of the ſolid contents of

The ſemidiameter 20950652, + Engliſh feet. Hence the number of ſquare feet that compoſe the area of a great circle of the earth is that of which the logarithm is 15,1395451.

Therefore

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of theſe cylinders, and the $\frac{1}{3}$ of the ſolid content, that is taken from the ſpace occupied by the matter, in reducing the cylinder to ſpherules, is to be added to the ſolid content of all the pores.

Again, from what has been demonſtrated, it follows, that the diameter of a ſpherule which is ſmall enough to paſs through the pores of a body, compoſed of equal ſpherules, in the cloſeſt arrangement, is to the diameter of any one of the ſpherules of which the body is compoſed, as the exceſs whereby the ſecant of 30° degrees exceeds the radius, to the radius.

Let three equal circles ABG, BCH, ACK, touch in the points A, B, C. Theſe may repreſent the ſections of three contiguous ſpherules, compoſing a body of the greateſt denſity, whoſe centers lye in one and the ſame plain. Join AB, BC, AC. From D and E, the centers of the circles ABG, BCH, draw DL, EM perpendicular to BA, BC; let DL meet the arc AB in n, let EM meet the arc BC in o, and let DL, EM, meet each other in P. Join PF, let PF meet the circle ACH in r. Now it is manifeſt (by the conſtruction) that the angle EDP is $\frac{1}{2}$ the angle ADB, and that the angle DEP is $\frac{1}{2}$ the angle BEC. But the angles ADB, BEC, are equal (becauſe the triangle DFE is equilateral). Therefore

the.

Therefore the logarithm of ſquare feet in the earth's ſurface is 15,74160 51.

In

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the angles EDP, DEP are equal. Therefore the right lines DP, EP, are equal. But Dn = Eo. Therefore Pn = Po. Again, in the two triangles DFP, EFP, becauſe FD = FE, and FP is common, and DP = PE, therefore the angle PFD, is equal to the angle PFE. Therefore PFD is $\frac{1}{2}$ the angle DFE, and PDF is $\frac{1}{2}$ the angle ADB. But the angles ADB, DFE are equal. Therefore the angles PDF, PFD are equal. Therefore PD = PF. But Dn = Fr. Therefore Pn = Pr. Therefore the three right lines Pn, Po, Pr are equal. Therefore a circle deſcribed upon the centre P with the interval Pn, will paſs through the points o and r, and will touch the arc AB, in n; AC, in o; and BC in r. It is manifeſt that this is the greateſt circle that can be placed in the ſpace ABC, and conſequently the ſpherule of which this is a great circle, is the greateſt that can paſs through the pores of the ſuppoſed body. Join PA, becauſe in the two triangles DAP, EAP, DP = PE, and AP is common, and DA = AE, therefore the angles PAD, PAE, are equal. Therefore each is right. Therefore PA is the tangent of the arc An, and DP is its ſecant; and Pn, the ſemidiameter of the ſpherule, is the exceſs of the ſecant above the radius. But the arc AB being 60° and An being $\frac{1}{2}$ AB, An is 30° whence the thing affirmed is manifeſt.

The

In the ſun's ſurface, 19,9012785.

Therefore the logarithm of ſquare inches in the ſun's ſurface is 22,0596410.

And that of ſquare millionths of a millionth of an inch 46,0596410.

And the logarithm of the ſquare millionths of millionths of an inch in the ſpace occupied by the particles of light, iſſuing from all parts of the ⊙'s ſurface, in the moſt compact arrangement poſſible, is 46,0172006. And the number of circles of one millionth of one millionth of an inch diameter, that go to compoſe this area, is that of which the logarithm is 46,1221107. And ſo great would be the number of ſpherules iſſuing every inſtant from the ⊙'s ſurface, ſuppoſing them to iſſue in the thickeſt poſſible arrangement. And this is not quite $\frac{1}{3\,4\,8^{2}}$ of the number that compoſe a force of motion equal to the earth's weight to the ⊙ at its mean diſtance.

It

The exceſs whereby the ſecant of 30° exceeds the radius, is to the radius as 0,1547 to 1. That is the exceſs of the ſecant is ſomewhat more than $\frac{1}{1}\frac{5}{0}$ or $\frac{3}{2\,0}$ of the radius.

It is not meant by the foregoing computations to determine the moving force, which is every inſtant produced, by the emiſſion of light from the body of the ⊙, but only to enquire whether it is likely to bear any ſenſible proportion to that ſum of force which is produced every inſtant in the ſyſtem by the mutual gravitations of the ſun and planets. I think it may ſafely be concluded, that its proportion is mighty ſmall. In the foregoing computations it is certainly much over-rated; for if the particles of light iſſued from the ⊙, in that cloſe arrangement, which has been ſuppoſed, and with the denſity that has been aſſigned to them, they muſt form a ſort of cruſt upon the ſun's ſurface, at leaſt 48 times more denſe than the ⊙ itſelf, which ſeems highly improbable. I apprehend that the error has rather been in over-rating the diameters of the ſpherules of light, and the cloſeneſs of their arrangement, than their denſity. For if they fly off from the ⊙'s ſurface in the cloſeſt poſſible arrangement, and fly off in right lines perpendicular to its ſurface, the interval between the ſurfaces of every two globules, when they

they reach the earth, will be above 213 times the diameter of each globule, and a very great denſity of the ſeparate globules muſt be neceſſary with ſo ſmall a ſpiſſitude, and a ſtill greater denſity neceſſary with a ſpiſſitude yet ſmaller, that they may move the ſenſory with the force, which experience proves they do: the denſity therefore has not been over-rated, but the ſpiſſitude and magnitude probably have.

From an experiment of Mr. Boyle's, it appears, that the ſmoke of $\frac{1}{2}$ a grain of gunpowder, occupied at leaſt 500000 times the ſpace of the unfired powder. Now the light of heated bodies may poſſibly be an emanation from their ſmoaks, which may be as much rarer than the ſmoke, as the ſmoke is rarer than the unheated ſubſtance of the ſmoaking body. At this rate the denſity of the light of heated bodies, will be at moſt, but $\frac{1}{25000000000}$ of the denſity of the bodies themſelves. Suppoſe this to be the caſe with the ⊙'s light, in its firſt emiſſion from the ſun's ſurface, then its denſity in its firſt emiſſion will be $\frac{1}{100000000000}$ of the denſity of water. The ſpace occupied by the matter

matter of water, is to the whole ſpace occupied by matter and pore, but as $\frac{1}{40}$th to 1, at the utmoſt probable eſtimation. Therefore the ſpace occupied by the matter of the ⊙'s light, is to the ſpace occupied by matter and pore (in its firſt emanation) but as $\frac{1}{400000000000000}$ to 1. The ſpace occupied by the matter of each globule has been ſuppoſed to be to the ſpace of the whole globule, as 1 to 2, or thereabouts. Therefore the ſpace occupied by any very great number of theſe globules is to the ſpace occupied by them, and the interſtitial ſolids, as $\frac{1}{2000000000000000}$ to 1, or as 1 to 2000000000000000. Hence the ſpace occupied by the globules, is to the ſpace occupied by their interſtices, as 1 to 1999999999999. Imagine a number of globules arranged with this quantity of ſolid interſtice, to have their centers in one and the ſame plane. The ſpace occupied in that plane, by the great circles of the globules, muſt be to the whole ſpace occupied by their interſtitial areas, as $1\frac{1}{2}$ to $1999999999999\frac{1}{2}$; or, as 3 to 3999999999999,5; that is as, 3 to 4000000000000000 very nearly (by the reverſe of the computation deſcribed page 33 and 34., &c.) Hence the

the ſpace occupied by the great circles, is to the whole area of the ſection of the ſolid on the plane, as 3 to 400000000000000 very nearly: and this muſt be the conſtant ſpiſſitude of the great circles of the particles of light on the ⊙'s ſurface, if the number iſſuing from it, every inſtant, be what it was found when the diameter of each ſpherule was ſuppoſed one millionth of one millonth of an inch. That is, *that* number iſſuing in *this* ſpiſſitude will compoſe a body of *that* denſity, which ſeems to be the greateſt that can with probability be aſcribed to the ⊙'s light in its firſt emanation. The area therefore occupied by the ſpherules of light, iſſuing from the ſun, on the ſun's ſurface, is not more than $\frac{3}{400000000000000}$th of the whole, that is leſs than that number of ſquare millionths of a millionth of an inch, whoſe logarithm is 33,5367623; and ſince the number of circles that go to compoſe this area, is that whoſe logarithm is 46,1221107, the area of each is in ſquare millionths of a millionth of an inch $\overline{1}$3,4146516. Hence the diameter of each, is ,00000040669 ($\overline{7}$,7597806) millionths of a millionth of an inch. Each ſpherule of this diameter is leſs than

Pl.

Fig. 1

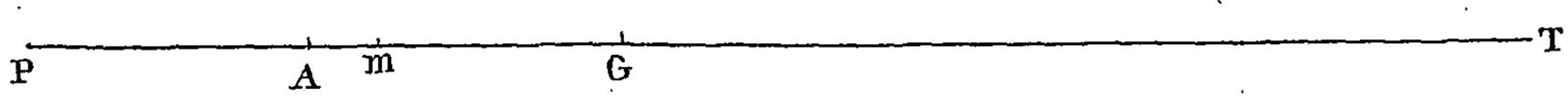


Fig. 2

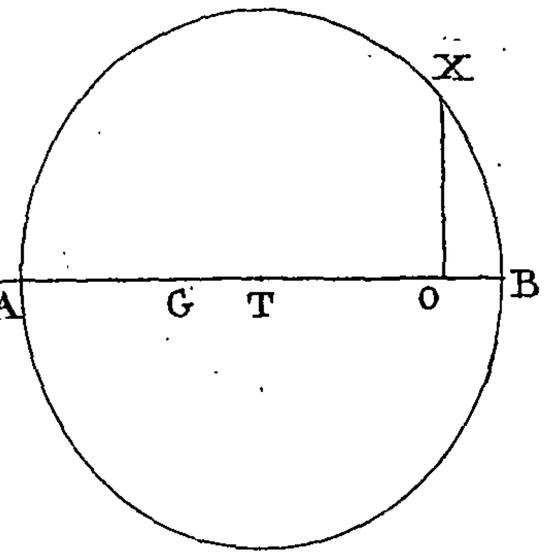


Fig. 3

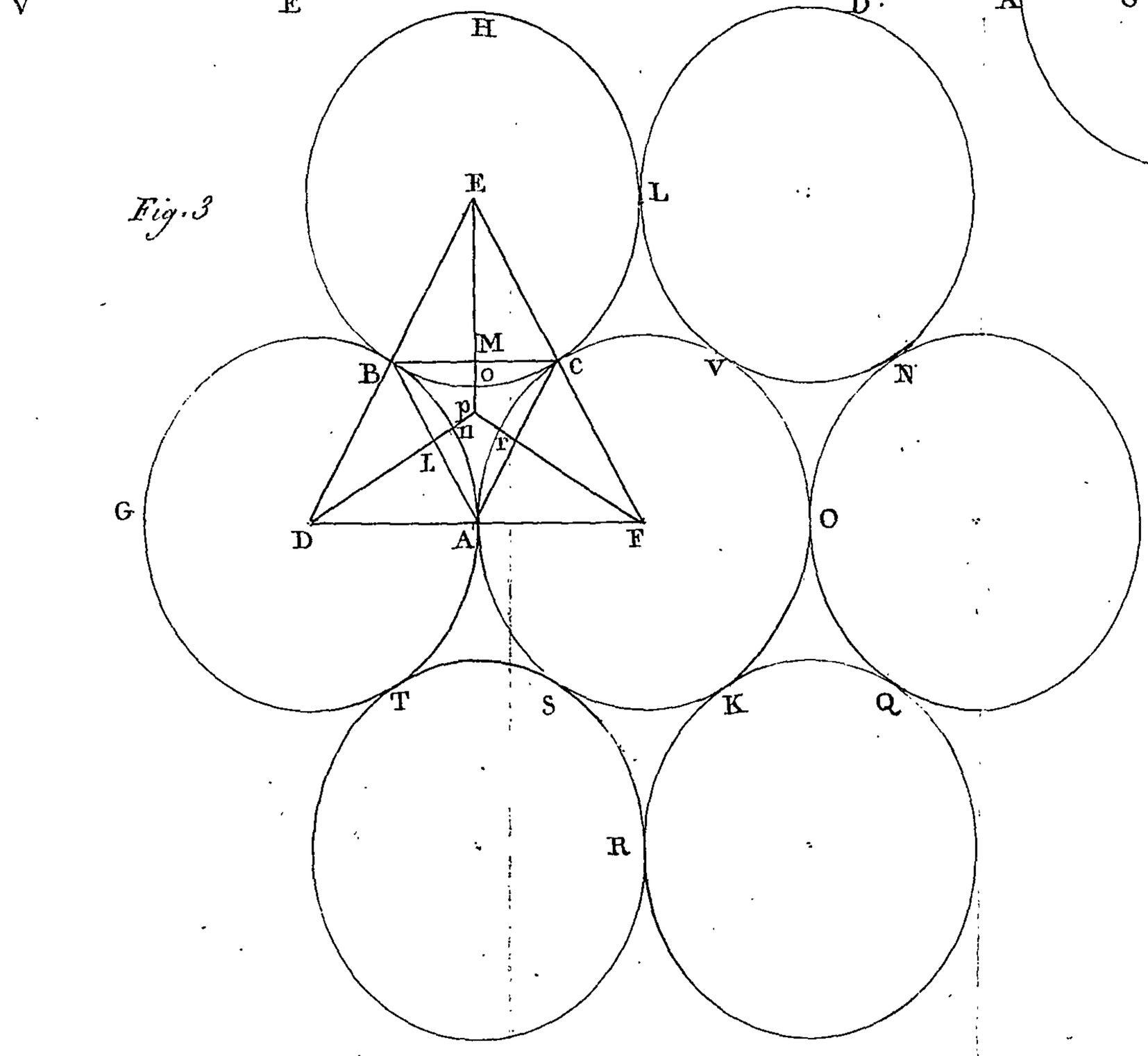
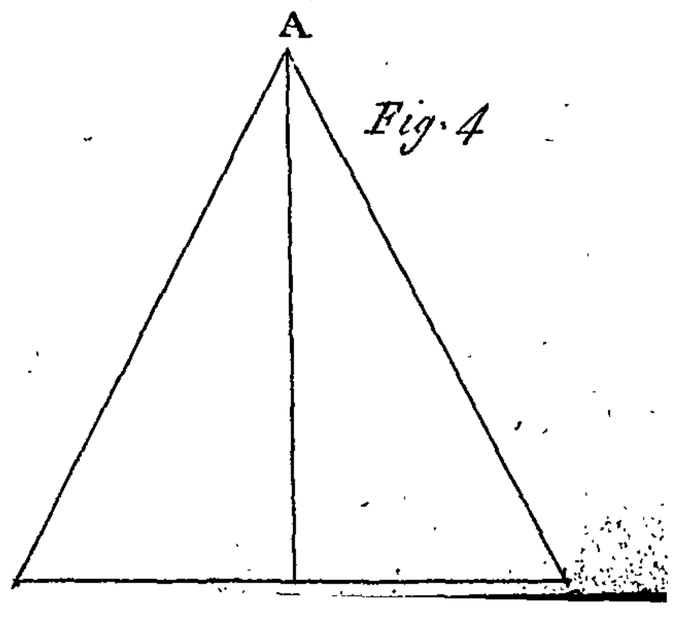


Fig. 4



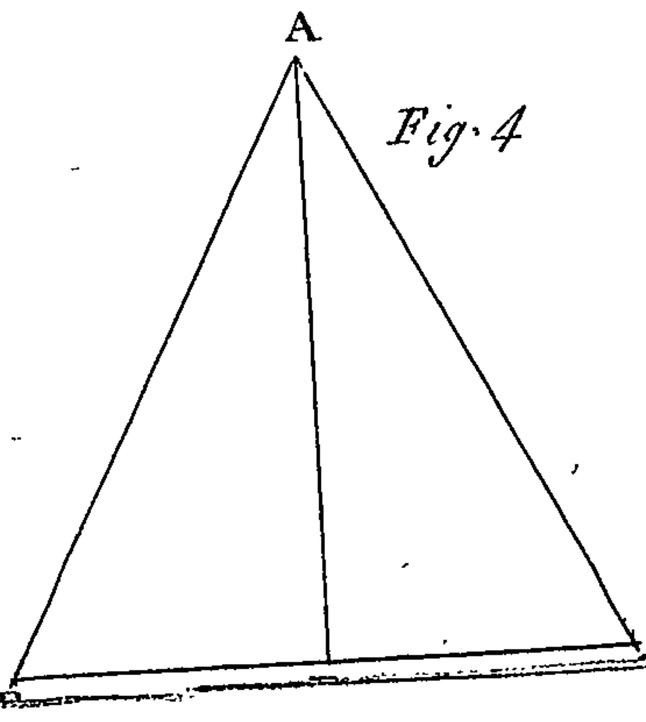


Fig. 4

then 0000000000000000019025 ($\overline{19}$,279341 8) of a ſpherule of the ſize firſt aſſumed. So that 5256XV of theſe ſcarce make up one of the former, and the force of motion produced by the inſtantaneous emiſſion of light, at this reckoning, will be leſs than $\frac{1}{18301392000000000000000}$th of the earth's mean weight to the ſun.

If the ſun's parallax be 6″-52‴, the proportion of all the primary planets to the ⊙, remaining the ſame as before, that of the earth excepted, increaſe the ſolid contents of each planet, its quantity of matter, and its gravitating force, as before determined by $\frac{5}{8}$, and we ſhall have the true ſolidity matter and gravity of each very nearly.

Solidities.	Matters.	Gravitating forces.
♄ 1409,99	232,11	2,5515
♃ 2891,2	686,83	25,389
♂ 2,424	3,394	0,762
Earth 1	1	1
♀ 4,052	5,148	9,84
☿ 0,213	0,433	2,902
☉ 2736718,8		

Sum of Gravitations 42,444.

And the whole instantaneous production of moving force will be 4087780000000000000000 hundred weight Avoirdupoize.

F I N I S.