R. North
Works Vol. XIX
Natural Philosophy
BL Add MS 32544[1]

UPDATED/REVIEWED April 2015

"& if this be not enough to say upon y^e^ subject, I shall freely own
that I cannot, & believe that few (if any) can to y^e^ purpose say more.
And that if I have not proved that every thing in these papers is true
(excuse y^e^ braggadochio) I shall most willingly go a great way to meet any one
who shall prove any of them false"

[1] Bound volume; external measurement, 200x220mm; made up of sheets 320x404, folded hoizontally to make pairs of folios 320x202, and folded vertically to produce eight sides or pages 160x202mm, then cut. All the sheets are of the same high quality paper, and each pair of sheets is [now] stitched. See also further comments on appearance and condition throughout the footnotes, below. The whole is written in Montague North's hand.

[colophon i]
(inner of board cover)
<in pencil:
m
388.a>

[colophon ii]
(binders' paper)
<stamped: ADD. MS. 32,544>

[colophon iii]
(binder's paper)
<page blank>

<unnumbered page>
<stamped: 32,544.>

<unnumbered blank page>

1r[2]

Physica (1) 1[4]

Discourses Introductory

1

Of percepti= on & union of y^e^ mind & body[3]

In life y^e^ first notion is of self existence, w^ch^ (as I take it) Cartesius means by cogita= tion. But this seems not intuitive, as An= gells may be supposed to know themselves; but from an attachment to materiallity; whereof y^e^ perpetual changes prove to be y^e^ objects of our continuall percepti= on from y^e^ first to y^e^ last moment of life. If y^e^ condition of y^e^ materiall of our bodys continued always in y^e^ same state, without change, It is hard to say that any perception cou'd be; And then y^e^ creature, if at all, must know it self by other means. as I hinted of angells. This perception by materiall changes Cartesius calls imagination; & so distinguisheth it from cogitation, but I must needs think they are one, & y^e^ same; for if y^e^ creature perceives at all, it is by means of imagination. But now considering these two, y^e^ Ani= mall & it's ~~s~~Shell[5] (y^e^ Materiall part) joyned

[2] The front page is darkened by exposure to dust, and has suffered some damage, and a degree of polish, by rubbing.

[3] The marginalia thoughout the *Physica* appear to have been added after the main body of the text, but usually in the same pen and ink that has been used for the main text.

[4] Every page in the Physica has been numbered by MN, nearly all of them in the right order, and nearly all of them have the number written, as here, in brackets. The recto pages have been renumbered in pencil by the BM/BL curators. I use that numbering (e.g., fol. 45r, fol. 58v) as the reference numbering throughout.

[5] Although the handwriting in the Physica is generally neat and well finished, MN frequently makes minor alterations as he goes - as here, changing a lower-case 's' for a large one by over-writing, or as in other cases changing a letter by the same means. Where I see this, I note it in this way.

(2) Physica.

/joyned together, one to observe, & ye other\
(both being organized for ye purpose) to be
observed, an united intelligent being Re=
sults; wch In ye course of life, having a be=
ginning in utmost simplicity, paSseth thro'
innumerable varietys of change, untill
ye organization diSsolves, & then ye union
ceaseth, & one part goeth into ye comm/o\n
mixture of things, & ye other into a state
solute from all materiallity, & (as wee
Respecting our selves religiously believe)
continues to exist in a different order
or state of sensible living. That these
two, ye mind & ye body are plainely di=
verse one from ye other, however they
<red BM stamp> come to be united in life may hereafter
be demonstrated; but at present we
are too early; I am sure it is Expedi=
ent sooner or later to endeavour it,
Considering ye turne it will take in ye
overthrow of all Atheism, & Irreligi=
on.[7]

2 Here finding our selves capable of obser=
Brutes[6] vation experiment & discourse, wee
not spe= launch into speculations of ye whole
culative state of humanity, & to that we con=
fine our selves; And it concerns us not
here to determine, whither Brutes have
sense & Conclude, as we do, for wee
cannot

[6] MN has begun writing the looped upright of the letter 'B' twice to the left of the eventual letter 'B'.

[7] I have inserted a line break at every paragraph break in order (in my opinion!) to help legibility.

cannot know them as (by means of speech)
we know one another; It is enough for
us to conclude of them as we wou'd of
a silent man, that is from a paralell
behaviour; It is hard to say what is y^e^
difference between dumb animalls &
speechleSs savages. But y^e^ subject is
become problematiq, & some prime phi=
losophers take advantage to maintain
either partie, as y^e^ Cartesians for instance
argue that Brutes are meer automata,
without sense or thinking, that their
actions are but similitudinary, & pro=
ceed Not of thought or Memory: And
for reason Alledge that none can be
made speak or answer questions. And
I am satisfyed that untill Brutes do
speak, this Captious opinion, as others
of subjects altogether in y^e^ dark, will
not be formally Confuted. But in
y^e^ mean time, all indifferent Coniseu/rs\.
as well as almost y^e^ whole race of man=
kind will attribute sensation, thought
& memory to Brutes; however it appears
in various

in various measures & distinctions; & that
there is not such reason to allow them
Science or abstract thinking; but sen=
sation of things, & of y^e^ consequences
of good or evil to themselves, & in y^e^
end certainly perish. But more of
this elsewhere.

3
The man=
ner of sen/ce\
& self re=
flexion

I shall here move all Inquiry Into y^e^
secrets of this union of mind & body
with y^e^ m~~i~~ysterys of generation, Nutri=
tion, Instinct, & diSsolution: & at present
be satisfyed with having gained a hu=
mane person, (by a common course
of life & vegetation) arived to a degree
of strength, & Capable by y^e^ use of his
facultys, to know as much of y^e^ sensible
world, as he happens to be concerned
with; w^ch^ faculties are (directly) sen=
sation, & (Reflexly) Memory. From
~~y~~these he advanceth to opinion, & so to ex=
periment, by w^ch^ means only opinions are
regulated according to truth. The sence
that is y^e^ knowledge of exterior beings,
Cannot be had otherw/w\ise[8] than by touch
of

[8] It often happens that MN's pen *accidently* blots out a letter or part of a word as he writes, he corrects this accidental blotting by adding a correction, as transcribed here.

of (or from) them upon some parts of y^e^
animall body or frame: by w^ch^ y^e^ parts
affected are more or leSs disturbed, &
that (disturbance) or differences (compa=
ratively) y^e^ united soul cannot but ob=
serve: Then supposing an apathy of y^e^
mind, or y^e^ body wholly unaltered, yet
when a restoration happens, there emer=
geth a connexion & comparison of y^e^
two states, that before, & that after y^e^
[C~~i~~eSsation?][9] as if no time had intervened, for
what is a series of time but a negation
of all intermiSsion or termes that im=
ply it; but to return to y^e^ sensible state,
w^ch^ may be adumbrated by a spider in
his seat of observation upon his webb
extended largely to all parts about a
room; Nothing can touch y^e^ finest
thread of this texture in any part, but
y^e^ creature shall instantly perceive it,
& prepare for action accordingly. So
our bodies are as y^e^ webb Continually
Elastick, over w^ch^ y^e^ mind or soul [~~..~~?]/pre\
sides. And as without some impreSsion
derived

[9] Where I am not sure of my reading of a word I have used square brackets and a question mark [?] - thus you will find it where the text becomes illegible (to me). Rather than repeatedly insert '*sic*' I have also used [?] to indicate a form, or spelling, that puzzled me, even where I could read it, but thought it might have been a slip of MN's pen. I make as few comments of this kind as possible when I am confident that I have read the MS correctly, and where it seems clear that the reader can make (mine, or their own) sense of even a mis-written word.

derived from exterior action, y^e^ Mind wou'd
Gather or Know nothing of y^e^ world abroad,
& perhaps not of its own existence, so y^e^
perpetuall agita/[c?]\tion of y^e^. contiguous
matter variously imreSsing y^e^ surfaces
of y^e^ body externally or internally y^e^
mind is imbued with a continuall sence
of it self, & that instills y^e^ notion of life
& time, y^e^ during such ceSsation as above
wou'd not be had.

How sen=
sation is
distingui=
shed

Hence it is concluded, that all sensation
is no other than materiall pulses upon
y^e^ (webb or) exterior surfaces or some
internal receSses of our bodys. But
such is y^e^ diversity of [~~...~~?]/the\^se^ pulses, & also
of y^e^ parts of our bodys impelled, that
y^e^ mind shall be affected with conti=
nuall variety Corresponding those im=
preSsions; And y^e^ more violent pulses
that fall with distinguishable inter=
valls (whilst y^e^ fainter are unreguar=
ded) will be more eminently perceived,
than y^e^ leSs violent. And so when di=
verse fall upon y^e^ several members,
or parts

or parts of our bodys, distingu/~~isht~~\isht
by experiment or use one from
another: they tun into ClaSses in Infi-
nitum. As what falls upon y^e^ optick
nerve, gives y^e^ sensation called light &
thereby vision, very different from what
falls upon y^e^ tympanum of y^e^ Ear, Cal=
led Hearing. In y^e^ sensation of light there
are numberleSs varietys, whereof y^e^ chief
are called colours, w^ch^ are only pulses
differently modifyed: And under hea=
ring arrive y^e^ variety of sounds, y^e^ most
egregious of w^ch^ are called Harmony,
& act by pulses in known proportion
tho not sensibly distinct, & it's pitty
those of light & colours are not (as of
sounds) so clearly discovered. What is
say'd of these two Energys extends ana=
logically to all other branches of sen=
sation, as tast, feeling &c. therefore it
will be superfluous to instance in
more. And of these in another place
{_}[10] where it is purposed to discourse more /fully.{__}\.

Here

[10] *See* note on fol. 7v, below.

(~~8~~)(9)[11] Physica

5. Of Ideas, attention & Memory

Here is all that can concern us ab extra,[12] that is touch or motive im= pulse upon ye materiall of our bodys, And whoever will pretend other means of influencing our perception must be pleased to demonstrate ye what & ye how, or else meer nothing is held forth. And now it is to be inquired how ye knowledge arrives, whereby we determine ye nature of those things wch so affect us; & for this wee must inspect ye inferiora, and there wee find first an image in ye mind, or sence of a difference or change com= paratively wch is called an Idea, pecu= liar to each varia/e\ty of touch, whither from ye materiall, as hard, soft, moist, dry &c. or from ye different parts of ye body as ye Eye, Ear, Arm, Legg &c. And next, that these Ideas do not vanish upon ceasing of ye influence whereby ye parts, as springs, Resulting take again ye former posiTure, but as Lead or wax Retain ye impreSsion, till by many following attaques the impreSsion

w[13]

[11] MN has written '(8)', which he has blotted when correcting to '9', and then (it would seem, later) he has written '(9)' next to it. This is page 8, but the numbering from here on proceeds as if this were page 9.

[12] i.e., 'from outside'.

[13] At the foot of the page, in the middle, the letter 'w' has been written so close to the bottom edge that the previous page has been marked with ink. The following two pages were simultaneously marked with the top of the letter.

5r



impreSsion is gradually defaced, & often
worn quite out; as y^e^ presiding mind
(by like means [.....?]whereby it was[14] at first
affected) knows things by their differen=
ces; So also it hath an affection from
y^e^ differences of these remaining impreS=
sions, w^ch^ faculty we call memory: By
means whereof Ideas of things past &
present are compared: And by a won=
derfull power y^e^ mind paSseth arbitrari-
ly to & from among these impreSsions, & dwells
or departs according to contingent Fan=
cy or determination. The continuance of
of this agency upon certein subjects, is
called attention, And that is ever at work
but in sleep, w^ch^ is little else but a surren=
der of all power of attention for a time,
& then y^e^ mind (Dreaming) roves about
its Magazition of impreSsions, without
stopp or order of time, till y^e^ attention
(by waking) Resumes y^e^ reines, & then y^e^
mind proceeds orderly again, as y^e^ will/ll[15]
or such

[14] 'whereby it was' is written over some washed out text (outline text, as here, is used throughout to represent washed out text).

[15] Rather than being blotted, the two 'l's appear to have washed out or brushed away by accident, MN has re-written them.

or such Incidents as then happen to Incline
it, Invites; This is a copious subject, & admi/tts\
a world of reflexon, but is only touch'd
upon here, to shew ho[~~r~~?]w thinking is de=
rived upon materiall influences ab
Extra.

6
Ideas of sence in y^e^ mind only & not in y^e^ exte= rior cause

But however those influences fall, y^e^
Ideas in y^e^ mind occasioned by them, are
found only there, & not in anything that
gives y^e^ occasion, all w^ch^ is but touch, &
nothing else; As when when y^e^ Ideas are of
colour, sound or (to instance in y^e^ most
observable) of pleasure or pain, w^ch^ are
extant only in y^e^ imagination, & of such
none subsist in y^e^ object; Who ever
thought that y^e^ Idea of pain subsis=
ted in y^e^ sword that made y^e^ wound?
or that Harmony was to be found a=
mong y^e^ fiddle-strings, tho' y^e^ Idea of
it is excited or occasioned by them, &
that only by means of pulsation in
ordinate, (but indistinguishable) times?

Therefore

6r



Therefore it is Concluded that all y^e^
ideas of sence are Interior arising
& Resident in y^e^ mind only, & not in
any object or matter without us. And
whoever doth not take & digest this
Notion clearly, can never think Phi=
losophically, or overtake any natu=
rall truths of Externall things, Res
alias agat.[16]

7
Whence
errors of
Judgment,
& Preju=
dice

From hence it appears how y^e^ common
method of knowledge is eCorrupted, &
with what difficulty (if at all) mens
minds may be set right. For among
y^e^ community, who is there that as soon
as they know what is y^e^ Cause of any
Idea, do not translate that very Idea
from their minds to y^e^ thing that cau=
seth it?- As when they see y^e^ colour
blew, or yellow, w^ch^ proceeds from a
certain confusion or Mixture of
(indistinguishable) touches, they instant/ly\
- say

[16] i.e., 'let him do something else'.

say that colour is in y^e^ object, or comes
from it. So of heat, that it is in y^e^
fire, & Cold in y^e^ ayre, all w^ch^ Ideas
are but modes of sensation, Et prae=
terea nihil.[17] How therefore should
truth ever be known, So as for us
to be able to judge of what is with=
out us? at present wee are got no
further than opinion, w^ch^ is acciden=
tall, & for y^e^ most part false. And
when such devious opinions prove
hard to be corrected, <u>they are called
prejudices</u>, w^ch^ are /y^e^\ main obstacles ag:^st^
all right understanding. And y^e^ worst
is men commonly add obstinacy & paSsi=
on to Prejudice. A new born child
admires y^e^ light, & judgeth it to be in
y^e^ candle just as it is in its Idea, So
as men grow up, they continue y^e^
same way of erroneous thinking, &
strive against all conviction.

But

[17] i.e., 'and otherwise nothing'.

7r



8

Know-
ledge not
by meer
sence but
by expe=
riment

But notwithstanding all this, wee have
no other means of knowing truly any
thing but sensation. And ~~th~~/th\at know=
ledge is brought about, not directly,
or by pure perception, but by ex=
periment; w^ch^ is made by applicati=
on of sence in divers manners (or
rather divers sences) to one & y^e^ same
Object, & that will best be explained
by some ordinary practises. As if a
guilt Ball is presented, that affords
y^e^ same Idea as gold it self, but being
handled is found to be wood; & if it
proves still heavy, a rasure upon y^e^
superfices, discovers it to be lead, & y^e^
covering only gold. A child in a coach
thinks y^e^ trees move, y^e^ Idea being y^e^
same as if they did so; But a fore=
knowledge of y^e^ condition of trees,
Convinces an adult person, that it
is only y^e^ parallactick change of y^e^
position

(15) Physica

Position w^ch makes them seem to move,
Distances of things are not determi=
ned by view, for a Landscape is to
sence (like a picture) a meer flatt,
but y^e experience of magnitudes & [vi=
sive?] distinctions by various. distances
{_} makes y^e discovery{,_}& even y^e picture
seem hollow. All w^ch knowledge, where=
of infinite Instances may be given,
is obtained not by direct sence, but
by accumulation of experiments,
w^ch in such extent is called common
experience. And this grows up in men
chiefly out of y^e ordinary transactions
of life; Whereby they gain y^e proofs of
most objects that commonly occurr,
& with w^ch they have frequent concern.
And y^e collection of these truths
may be called also commion sense;
but when things are not obviously
experimentable, & Impart nothing

Materiall

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[18] Across the page opening 7v-8r there appear to be six horizontal dashes marked in a very soft-leaded pencil - one in each of the four margins, and one in the middle of each block of text, apparently suggesting a correction to be made. Such marks recurr throughout this volume. I indicate them here and elsewhere in the margins by {_} or (where it is a word or comment) {word}. Sometimes, in the text, there is a dart suggesting the insertion of a word{/insert\}, sometimes a word is crossed-out {~~crossed out~~}, in each case I have indicated the 'correction' by the same curly brackets and underlining. On a few occasions in the Physica the marks are vertical lines, which I have indicated by {|}. Sometimes there is *only* a pencil mark in the text (also indicated by curly brackets and underlining). MN's *own* underlinings in ink are indicated by underlined text without any brackets. The marks are editorial which, if not immediately apparent, becomes clear later in the MS where specific underlinings of words and phrases, and marginal comments or clarifications of badly written words appear, usually in alignement with pencilled dashes like these (see, for example, page opening f. 75v-f. 76r). The BM curators have used pencil throughout to change the page/folio number on each recto as has shown on each page from the beginning, but the 'editorial' marks we are here discussing are in a much softer graphite. They are most likely by RN himself (see other clues concerning dating, for example that offered by the reference to the 'theory of Sounds' on fol. 191v, below). The marks and writing is very shaky indicating an elderly hand. There *appear* to be six marks on this page opening but in fact the marks on one side are the result of the transfer of this very soft graphite from the one to the other (this happens throughout the volume). So, across this opening, the outer mark on f. 7v is 'reflected' on f. 8r, and the inner margin mark on f. 8r is 'reflected' on f. 7v. Here and elsewhere I have only indicated the 'positive' marks.

8r



Materiall to life, as whither colour
or sound exist within or without us,
wee are not Concerned to apply either
thoughts or experiments abo/u\~~ut~~ them;
but in opinion such ordinary Ideas
paSs for y^e^ very truth of those matters;
And here lyes y^e^ case of philosophicall
speculations, w^ch^ also lean{_}upon expe=
{_} riences; Some in y^e^ way of vulgar
practise, others of deeper research,
by w^ch^ after due reflection it is dis=
covered, that Ideas of sence are
not in y^e^ object; And that y^e^ mag=
nitude, distances, & motions of y^e^ ce=
lestiall luminarys are not as they
seem. And that y^e^ matter of y^e^ world
hath no property inherent, but on=
ly filling place & impenetrability;
And that all other phaenomena are
but sensitive Ideas; with many other
like topicks of naturall science. Wee
are not

are not to let it paSs that ye meer
sence of matters obvious & common=
ly experimented will instruct any use=
full practices, for Ideots & brutes have
all ye same sensations. But it is an
application of thought & memory
working comparatively, that raiseth
veritable notions, & of these even ye
vulgar, as well as phylosophicall per=
sons have the/e\ir share, according to
their several engagements; And a
common mechanick shall interpret
a diversifyed view of numerous ob=
jects,{_}as philosopher, tho there is no
{_} truth in ye Ideas of magnitude, Co=
lour or proportion yet it is acquired
(as all knowledge Results) from ex=
perience; And Indeed supposing a due
application of thought upon ye most
ordinary occurrents observable in ye
course of human practises, there will
be little

9r



be little need of exotick experiments, for
those others will serve ye turn, & Cartesius
himself used mostly ye like.

Of Natural Principle

Body the
only Prin=
ciple to be
Relyed on

The tendency of these discourses is (if it may
be) to adjust ye notion of what things are
really existent in ye universe, abstracting
all sense, & as if all sensitive beings were
annihilated, & what are non existent but
in our sense only. As yet wee are advan-
ced no further than ye discovery of one on=
ly genus or principle, upon wch in ye science
of naturall things we can surely rely. And
that is matter extended, mensurable & im=
penetrable, Influencing by meer touch. And
whatever notions can be showed neceSsarily
Resulting from what we know of such mat=
ter, & its apparent modes, may be set down
for truths inviolable, & that such solutions
of naturall phaenomena, as are founded,
or derived thereupon, & None else may be re=
lyed on: And diverse have for that end used
this

(19) Physica.

This Hypothesis, w^ch^ is called y^e^ Corpuscular, but few or rather none with that justice, & Retention as ought to be; that is to carry it on so far as a just reasoning will warrant, & no further; & as for y^e^ rest to sit down contented w^ch^ is better than to spoil all with doubtfull gueSsing & there|upon p~~osi~~/osi\ tively to affirm non Entitys; for in naturall philosophy Nothing should be affirmed pre= cisely w^ch^ in thing or manner any one can with reasoning or countenance deny. So here Prest securely upon this one Principle, un= derstood by y^e^ word, body or matter; whether wee shall find, or rather have occasion for more y^e^ sequell will discover.

False Hy= potheses E= picurean Aristote= {_}lian, Car= tesian, New tonian; & Chymicall

The most celebrated naturalists in y^e^ seve= rall ages of literature, Instead of things, have taken y^e^ phaenomena of them for principles; or {~~l~~r}ather, joined y^e^ one with y^e^ other & accordingly framed their Hypotheses, & a= dorned them with such suppositious Ener= gys as they judged woud be most easily admitted. First y^e^ Atomists ledd by Demo= critus who sent his insecables[20] to stray, &

take

[19] Ther are a number of large splashes of spilt ink on this page opening which have not been pressed onto each other.

[20] Democritus called the building blocks of matter 'insecables' (i.e. 'indivisibles').

{_} {th}eir chance by gravitating in vacuo in=
finito, & this seeming not clutter enough,
Epicurus sent in a party that shoud move
croSs y^e^ stream of y^e^ others obliquely, th~~at~~/at\
chance might have means to operate.
This being but shew'd is Eo Nomine[21] Con=
futed, for what is it else but a preca=
rious Imagination? Aristotle bid defy=
ance to these & all other y^e^ Physici in
generall, &. set up a science of meer words,
by w^ch^ he cou'd dispute or resolve any thing,
whereas y^e^ others (faculties failing) were
at a stand; Hence Matter, Form, Privation
Qualities & substantiall forms &c. & his
physis or nature like a Deity presiding
over all. That w^ch^ is most wonderfull
is that this pretended philosophy shou'd
ride admirall in all y^e^ schools of lear=
ning for many hundred years, till Bacon,
Ramus, GaSsendus, &c Insulted y^e^ frothy Co=
loSsus; & at length y^e^ Cartesians overthrew
it, Never to rise again. And that (Cartesian)
sect however coming neerest truth in general/libus\,[22]
[libus]yet

[21] i.e., 'under that name', i.r., 'explicitly'.

[22] i.e., 'generalities', 'in general'.

yet in y^e^ formed Hypothesis have aSsumed
for principles certain stated formes & fi=
gures, as well as motions of imperceptible
matter, w^ch^ are so open to a prompt denyall
as makes all y^e^ usefull inventions of Des=
Cartes of leSs authority.[23] And y^e^ underminers
that come after, take advantage thereby
(Most Candidly) to deride y^e^ greatest, & (for
{_} it's time) most succeSsfull work{_}that hath
been known. These latter beyond all that
have gone before are authors of suppo=
sitious principles, as (to instance in some)
Universall vacuity, & Coattraction of body,
Materia rara & densa,[24] Centripetal, Centri=
fugall, & Inertiall powers, of w^ch^ more else=
where. Nothing leSs than indubitable ex=
periment will sustain universall prin=
ciples. I must not omitt y^e^ vain hypo=
thesis of y^e^ Chymists, who claim Salt, Sul=
phur, & Mercury for principles of all
things, Each of w^ch^ needs an Analysis, as
much as any other Compounds, & more
especiall y^e^ Salino-nerio-nitro Sulphu=
reo particles of M^r^ Mayo w^ch^ in phi=
losophy

[23] RN laments here, as elsewhere in the MSS, that Descartes expressed his ideas and circulated them when they were not yet fully worked out, and therefore not quite correctly expressed. Descartes urgency to publish (much of which was not *to* a public, but by means of private letters to friends - letters which were then published after his death) meant that Descartes' insights and understandings were sometimes betrayed by his informality and expression - one example of this, for RN, was the notion of 'conatus', a concept inherently 'aristotelian', implying as it does a 'quality', which was nevertheless used by Descartes to describe the capacity for movement.

[24] i.e., 'matter rare and dense'.

losophy are Ignota per [mueto?] Ignotiora.[25]

11
Nothing depends on or flows from y^e^ intrin= sick na= ture of body.

Now to clear y^e^ way for what is to come aft= ter, wee must prepare our selves to aS= sume [..........?] y^e^ one universall & indubitable principle, profered before & instead of depriving its simplicity & incumbring it with propertys or quallitys beyond its reall ESsence, wee must depose all power of prejudice & Imagination, & lay aside all y^e^ Ideas of sensation, & speculatively lean only upon y^e^ notion of ESence im= penetrable that is Body, y^e^ has no de= pendence on our thinking, & is understood or known by no means /but\ ~~of~~ contact. But here wee meet an objection, w^ch^ is that we take no notice of y^e^ intrinsick nature of body, w^ch^ many say m~~ust~~ay have effects Consistent with impenetrability, & extend certain powers without or beyond y^e^ sur= faces; And so occasion in us a sence of di= vers variations of things without impeach/ing\ their form & substances; And it is accounted an Insuperable charge upon y^e^ philosophers to Resolve

[25] i.e.'the unknown by the unknown'; I have not been able to identify or trace this specific version of what is a widely-used latin tag. The general reference is to John Mayow (1640-79), chemist, experimenter and associate of Robert Boyle. He was actually much better than MN/RN allows here, anticipating the discovery of oxygen in his studies of respiration and combustion. The text referred to here seems to be Mayow's *Tractatus quinque medico-physici, quorum primus agit de sal-nitro et spiritu nitro- aereo* ..., Oxford, 1674.

to resolve y^e^ intrinsick nature of body,
& y^e^ Chymists labour hard for propertys,
ESsential besides pure extension; to this
it may be answered first, that if y^e^ cor=
puscular hypothesis will not solve all
y^e^ phaenomena of nature, yet it will
go far enough, to shew there is no evi=
dence of any thing intrinsick, to aSsist
y^e^ exterior effects; But if there be such
influences they must be Corporeall or
not; If not, they cou'd not affect body;
And if flowing from y^e^ superficies, they
are but effluvia, w^ch^ are admitted to part
from solids, as odors, or y^e^ like; If from
within, being body (as it must be to act
upon body) how shoud they penetrate
forth? As for unintelligible powers &
quallities; Let those take them that
love ~~them~~/such\ misterys, therefore we lay all
that Commentitious fancy of y^e^ intrinsick
nature of body aside, & adhere to y^e^ sin=
gle & incomplex notion of impenetrabil=
lity, & (of body) Ne plus Ultra.[26]

12 Every thing that is known to exist, must
The seve= be perceived
rall modes

[26] i.e., 'go no further'.

12r



of body understood

be perceive

be perceived under certein modes or cir=
cumstances, w^ch^ modes may change infinite=
ly, & y^e^ thing in it self be in no sort al=
tered. And body is never so much as
thought of without regard to certein
of its modes. First as to separation, where=
by it appears distinct from all others; 2.
as to magnitude w^ch^ is comparison, & is
styled great or little accordingly. 3. as to
figure w^ch^ is y^e^ position of y^e^ parts res=
pecting each other. 4. distance, or space
interposing between one body & another
5. Aspects, as y^e^ parts may be obverted
or averted to or from any other. These
modes & all distances Continuing in y^e^
same state are called Rest. 6. Those dis=
tances or aspects changing is called mo=
tion. And both fall under y^e^ same con
sideration, that is distance Respecting y^e^
Totum, & aspects Respecting y^e^ parts. All
these modes are referred to extension or
Measure of space, & Nothing else, & y^e^ body
intrinsically

intrinsically is not in any respect afec=
ted thereby, but Remaines ye same in all
respects, however ye modes that are found
only in ye exteriora, alter or vary ye mea=
sures in which they consist. Therefore of
these modes None require further Con=
sideration here except ye two last, that
is change of distance & aspects, or conti=
nuance of ye same, wch under ye charac=
ters of motion & rest have occasioned
much puzling among ye philosophers;
how ye Same existed, or were to be defined;
Scarce agreeing in any thing. Therefore
I shall take up ye matter, as fitt to be
handled with clearneSs & distinction.

Of motion what & how.

Motion derived from col= lision of body else Nothing

It will be neceSsary here to discourse of
bodys in a method of singleneSs, & to sus=
pend all regard to ye fullneSs & frequen=
cy of things in ye world; & (complying
with ye fancy of many) seem as if ye trans=
actions were in a perfect vacuity, Re=
serving our application to reallitys in

pleno

Pleno[27] till wee come to proper places for it,
And first as to y^e^ common distances of
things, [.....?]Suppose (for instance) 2 bodys
A & B in vacuo, y^e^ intervening space be=
longs to neither but indifferently to both,
for if it be imputed to A as distant
from B I return y^e^ same from B to A
& if y^e^ distance happens to change, it
is equally in both and Not in either, for
y^e^ summ is only that y^e^ distance becomes
leSs, or more; And y^e^ same is inferred u=
pon change of Aspects, w^ch^ quoad[28] y^e^ bo=
dys under our regard is nothing at all.
But this will neceSsarily require us to
shew y^e^ Consequences of distances chan=
ging. What was y^e^ occasion of any change
of distance at first is not at present
materiall. But will appear to have
no influence on our Theory w^ch^ will
hold y^e^ same in all states whatever,
all antecedents being in this regard

meer

[27] 'In pleno', literally 'in the fullness' (as he states it earlier in the same sentence), this is what is later discussed as the 'corpuscular theory' (*see* fol. 134v, below). The plenum or corpuscular theory proposes that the universe is made up not of a vacuum in which objects move according the attractive force of gravity, but that it is rather filled with an infinitely fine 'aether' within which the stars and their planets are suspended, and by which they are moved around in vortices. This is the principle assumption of MN/RN's cosmography.

[28] i.e., 'as regards'.

meer nullitys. Therefore we must con=
esider, that when distances continue chan=
ging as between A & B they will either
come to touch, or not; If ye latter ye bo=
dys are unconcerned, for so nothing hap=
pens to Induce any other alteration
than hath been described, that is distance.
But is ye bodys touch, then there is
cause of further & other alteration, for
Impenetrability most irresistiably inhibits
that course ~~to~~ to continue, & Induceth
a neceSsity for ye bodys to separate. And
this fatall inconsistency is alike in both
bodys ~~but~~& not found in one only. So that
if ye Contact inclines B to separate frō
A, ye same inclines A to separate from
B. Therefore ye consequence must be
that ye two bodys from a course of
acceSsion must face into a course of
separation, & that separation cannot
be charged upon one or other, but both
are participant as well of ye effect as
they

they are of y^e^ cause (a truth ever to be
remembred).So that it will be a rule
universall, that all bodys w^ch^ advan=
cong come to a contact will separate
in one & y^e^ same moment, but for what
reason it falls out, that we ascribe
more or leSs of y^e^ cause, & of y^e^ effect,
& in certain proportions one way or
other shall [~~.~~?]be ℂConsidered afterwards.
I have often taken offence at a pre=
judice w^ch^ hath poSsest most of our phi=
losophers; w^ch^ is that motion [..........?](I must be=
gin to use the language) is somewhat
reall, subsisting in body, distinct from
y^e^ Adamantine nature of it; & that
upon Contacts w^ch^ are called impulses,
it paSseth from one to another, as if
what was not transferred was left be=
hind. Cartesius himself who was a great
reformer in these matters yet was not
free from this prejudice, but made mo=
tion a sort of principle; And hence

14
Motion
no reall
ESsence but
a mode of
bodys con
sidered to=
gether

come

come y^e ordinary termes of paSsing, im=
parting & communicating of motion from
one body to another. And so a sort of
seemingneSs creates in people notions
of somewhat reall, very vain & wide
from truth, y^e fallacy of w^ch upon a
fair attention to things existent or not
must appear. Therefore I shall proceed
to consider some of y^e varietys of modes
attendant upon this action of bodys Res=
15 pecting one another, w^ch by degrees
Velocity. may elucidate y^e subject entirely.
& compa=
rison of
Spaces

And first in y^e Idea of Velocity; And
that ariseth from comparison of ex=
tension or spaces. For when y^e distan=
ces of two bodys from a third are y^e
same, & in approach y^e one arrives at
contact before y^e other is arrived neerer
than at half y^e distance, y^e velocity of
y^e former is accounted double of y^e lat=
ter; & so in all proportions, w^ch are found
Exactly in y^e measures of y^e spaces com/pared\

And

seeing that y^e^ direct effects of all im=
pulses, appear in y^e^ succeeding velo=
citys one way or other. And that
wherever measure is found in causes,
y^e^ like will fall out in y^e^ effects.
(A common Axiom) In this case of a
duple proportion, whatever y^e^ celerity
of y^e^ separation would have been upon
an impulse with a single velocity, shall
upon an impulse with double, be also
dupled. And hence comes one charac=
ter of force, w^ch^ is y^e^ celerity of y^e^ ac=
ceSs & separation (ceteris paribus),[29] & so
it is ascribed to velocity in /y^e^\ general,
as when we say by swiftneSs force is
encreast.

16
Determi=
nation of
motion
Reall

Another mode to be considered in mo=
tive cases, w^ch^ will have considerable
consequences, is y^e^ direction or deter
mination of y^e^ acceSs or separation;
For that is always reall & not dependa/nt\
on any relation, It is not y^e^ same
thing

[29] i.e., 'all other things being equal'.

thing, when ye direction is to ye north or East
but ye one from ye other is distinguished,
as diverse spaces are; what these conse=
quences may be in many respects, shall
be reserved to ye place of mechanicall
powers; but at present for ye sake of
clearneSs I shall suppose ye acceSs, & sepa=
tion upon every impulse to be upon
ye same line: And then I am bold to
affirm, that whither ye quantities of
ye bodys are equall or unequall wch
(quantities are ye other ingredient or
<red BM stamp> character of force, ye Resilition shall
be with a velocity equall to that of ye
acceSs, as if it were but a continua=
tion of it, one case only excepted, wch
is when ye direction of both bodys
after ye collision, shall fall out to
be pointed towards ye same quarter,
for then ye greater body will always
follow ye leSser, & ye velocity of ye se=
paration must diminish as ye quan=
tity exceeds. These are but Hints in or/der\
to a

to a Resolution of Mechanicall pow=
ers under w^ch^ topick these points must
be resumed, & better explained, & at pre=
sent this physicall account may suf
fice.

14. Motion consists wholly in rela-tion.

But I must take a step further, in order
to explain y^e^ subject of motion, & to
diSsolve y^e^ prejudices, & false GloSses that
have been put upon it. Therefore set=
ting aside what follows consequentially
upon contact, (Referred to y^e^ Mecha=
nicks) I do insist that all y^e^ varietys w^ch^
are commonly observed, & predicated
of motion, & are understood by y^e^ com=
mon expreSsions of Moving, Resting, fast,
slow, or y^e^ like characters, are meerly
relative (Except position as I shall
shew) & have no existence in y^e^ nature
of things. And (among y^e^ infinity of bo=
dys, may be arbitrarily presumed, where=
by Every motive alteration, May be one
or other kind of motion. Nay in so

many

many respects, as there are various rela-
tions made, & at ye same time (perhaps) be
no motion at all but (as may be repu=
ted) Meer rest. This supplants ye question
whither ye earth of heavens move, wch some
say is not demonstrable, for it is but al=
ledging that it is all one, or yt neither moves,
& it is not motion (a word misused) but
change of position & aspects, wch is equally
applicable to both, ye occasion of ye mis=
take is a mentall Supposition of some
original cause applyed, wch is not extant
nor any thing to ye purpose. But now
for clearing of these paradoxes, wee
must consider, that in all judgement
of motion, we appeal to something wch
is supposed stationary or at Rest, & by
ye scituation of that ye motion is judged.
But if that Critical object in truth (or
Relatively) does not rest, )but is carryed
one way or other, ye Judgment is false,
& perhaps that that was presumed to
rest,

17r



rest (collated with other things) was y^e^ true
movent. There are so many instances of this
deception & so obvious that it is fastidious
to shew them; but this science is so important
as to y^e^ knowledge of truths concerning
our own & other bodys in motion collated,
that I shall further explain y^e^ Nature
of these relations.

18.
How such relations are judged

Motive relations are made either to sin=
gle objects, or to compounds, or systems
of bodys; when singles we commonly
plant our selves in y^e^ place of rest,
to arbitrate y^e^ movements of every thing
else; & accordingly some paSs here & some
there; And such as hold y^e^ same position
respecting us, we say are at perfect rest.
But if we call in another relation, as
from y^e^ terrene to y^e^ celestial objects,
Neither our own or any other bodys are
at rest, but move in different manners
from what was presumed. A shipp ag:^st^
a current

a current shall Rusle as sailing hard,
& so it doth, Referred to ye water, but
touch ye ground, & ye Relation to that
shews it does not move at all. So Re=
ferences may be to ye systems of bodys as
to ye parts of a shipp. If a man walks
from stem to stern as fast as ye shipp
sails, Respecting ye mast & Rigging he
moves fast, but Respecting ye Soyle he
stands still, & if lying at anchor he
walks as fast as ye diurnall motion (is
easterly) westward, ye sun seems to stand
still, but [yeet?] respecting ye annuall course,
ye ship & all that is in it partake of that
unleSs a current carryed ye ship East=
wards as fast, & ye then ye annuall course
is at ye rest, & (as ordinarily) ye diurnall
takes place. If ye Astronomers had not
ye systeme of fixt starrs to referr all
their planetary courses too; their art
wou'd be at a loSs, how to account for
any

any of them. So if you please to respect
y^e^ moon, Jupiter with his Satellits or any
other Systeme of bodys in y^e^ whole uni=
verse, y^e^ Aspects & distances changing
give a character of motion or rest
to be, or not to be; & in infinite ways,
at y^e^ same time (as was observed) as well
concurrent, contrarient, & (seeming) incon=
sistent. Hence ~~y^e^~~we derive y^e^ stations & Re=
trogradations of y^e^ planets. And I chal=
lenge all y^e^ virtuosi to shew me any
thing subsisting in body's understood to
move or rest, More than an exterior
Relation by distances or aspects Reci=
19. procally changing or continuing y^e^ same,
Against y^e^ according as References are made.
distinction
of Motus
verus & re=
lativus[30]

All this is designed in opposition to a
new-fangled ditinction lately introdu=
ced of motus verus & Relativus, first by
Borellus[31] & then inforced by S^r^ I. Newton.
They

[30] i.e., 'true' (that is, absolute) and 'relative' motion.

[31] Giovanni Alfonso Borelli (1608-79), an Italian natural philosopher who experimented in and published on a wide range of topics from physiology to astronomy.

They cou'd not all motion of relation,
because ye case is so manifestly obser=
vable. But then to alledge a motus
verus als[ɵ]/o\ subsisting, in nation so dif=
ferent as something is from nothing with=
out shewing what it is, wherein exis=
ting, or how to be known, is a procee=
ding in philosophy so legislative, & ar=
bitrary as useth not to be yielded to.
Borellus makes a motion under-deck
in a ship to be Relative viz: to ye ribbs
and beams of ye veSsell, but above-board
it is motus verus. Who sees not ye variety
of this distinction? for without & with=
in all relations are ye same as, if ye
ship was transparent, wou'd be mani=
fest. Principles of nature, as Motus Verus
(if any such there be) Cannot be dis=
tinguisht upon; as to say that motus is
sometimes a principle; & sometimes not a
principle

principle, but so like it as one can scarce
be known from y^e^ other. Or as if I
shoud say that that there is corpus ve=
rum & corpus relativum,[32] it wou'd
soun'd odly. And so will y^e^ making
any distinction upon a reall existence,
w^ch^ must be simply as it is, or nothing.
Therefore I conclude all motion to be
alike, as that w^ch^ shews it plainly in
being meer relation & nothing else.
And I must observe that however
we take relations obviously, & without
much reflexion, yet in truth there
is no body or System of bodys in y^e^
whole universe, w^ch^ being (arbitrarily)
supposed stationary, but may be made
a standard for y^e^ designation of any
movement whatever; So that in this
Respect, all y^e^ beings in y^e^ universe are
Correlative, & so long as one thing may
be said

[32] i.e, 'true' body and 'relative' body.

be said to move; Nothing in nature can
be said to be at rest, & in a just estima=
tion there is no such thing as Rest in
y^e^ world, & if there were any, it woud
be an existence as reall ~~i~~as motion is
pretended to be. How many vain puzle=
ments about motion doth this specu=
lation diSsolve? as of y^e^ old Astronomers
about one motion contrary to another;
of Cartesisus that rest only is contrary
to motion, & of GaSsendus about mo=
tion natural & violent, Motus verus
& Relativus of Newton & some others,
as I shall observe. All w^ch^ are most fas=
tidiously accumulated in most philo=
sophick discourses of our time.

20. The pre= judice oc= casioned by abuse of language

The occasion of this prejudice against
motion's being only a mode of body,
is given by a mistaken sence of y^e^
word motion, w^ch^ i~~s~~n common speech
~~is used subs~~ is used

is used substantively whereas it is an abstract
word, w$^{ch}$ without a substance signifies no=
thing; take y$^{e}$ word instead of motion (in
truth y$^{e}$ same) MovingneSs & all is set
right; whoever said that falling was
by a fallingneSs, or rising by a rising=
neSs, or motive alterations by a moving=
neSs? & is not that all one as by motion.
But before we leave this subject, right
must be done to S$^{r}$ I. Newton for he
hath found out that y$^{e}$ constant re=
ceSs & conatus of bodys from y$^{e}$ center
of all compaSs movements is motus
verus. And yet y$^{e}$ questions returns
why, or whence is it derived? but of
that afterwards & now to answer y$^{e}$
pretense it will be shewed among y$^{e}$
mechanicks, that bodys are actuated
in that circumstance, that is turning,
by y$^{e}$ same measures as take place upon
all collision of bodys whatsoever. S$^{r}$
I Newton

(41) Physica.

I. Newton had need of such a principle
to poise his planetary orbs (to be con=
sidered afterwards) w$^{ch}$, as he will have
it, are conserved by two forces opposed,
one is y$^{e}$ centripetall & y$^{e}$ other direct
by tangents, y$^{e}$ latter producing y$^{e}$ Motus
verus by ReceSs, & if y$^{e}$ former shou'd be
a reall principle, & as y$^{e}$ latter only a
meer relation (that is nothing at all)
there woud rise an objection as of
something & nothing acting counter.
But why others, Especially y$^{e}$ Mecha=
nicall gentlemen, shou'd espouse y$^{e}$
fond notion, of w$^{ch}$ it will be shewed
there is no need, I can by no means
understand. If we are to define mo=
tion according to what we know of
it, there can be no distinction, but
we must allow that it is as we per=
ceive of it, & not any thing else that
cannot be perceived, & who ever cou'd
perceive y$^{e}$ verus distinct from Rela/tivus\.

Here/Of\

## Of Plenitude & Vacuity

21. Against yᵉ supposition of vacuity.

Here I find my self pusht upon another matter of controversy, wᶜʰ hath exercised yᵉ naturalists in all ~~g~~ages, & that is if ~~y~~ᵉthere is or may be in yᵉ world a pure vacuum, or space absolutely void of body; I shall not collect all yᵉ chiccane that is to be found about this dispute, but only touch some principall matters, & having exprest what I think of yᵉ question give yᵉ reasons as clearly as I can. What yᵉ ancients thought comes to nothing, for their argument against vacuity from suction is diSsolved by yᵉ Torrecellian experiment,[33] wᶜʰ hath discovered yᵉ cause of that effect to proceed from yᵉ weight of yᵉ Atmosphear, & not from fuga vacui;[34] & further that Suction working beyond yᵉ power of such preSsure

[33] Evangelista Torricelli (1608–1647), Italian physicist and mathematician, student of Galileo, and inventor of the barometer. The barometer is in fact 'the experiment'; for us the barometer measures air pressure, when invented (in 1643) it demonstrated that the atmosphere actually had weight. The vacuum is formed between the mercury and the sealed end of the glass tube.

[34] i.e., 'flight from vacuum', i.e., that nature abhors a vacuum. Torricelli's barometer demonstrated that it was not some 'tendency' in nature, but simply the weight, or pressure of the atmosphere, which caused air to rush in and fill a vacuum.

preSsure, when vacuity seems to appear
as in ye mercuriall space derelicted, &
all long tubes. It is not purely such, but
Repleat with more minute parts, to wch
ye veSsel or tube is permeable; So ye dis=
pute falls between ye Cartesians & New=
tonians; Cartes thought that vacuity was
impoSsible, for body & space were one &
ye same thing, Because we had ye like
Idea of both, that is extension, & no o=
ther, & more of, either we know not. The
Newtonians, who seem instituted in [...?]af
[..?]fected opposition to ye Newtoni/Cartesi\ans, al=
ledg that there is no cogency in that ar=
gument, for consistent with extension,
there may be other propertys[;?] And they
[..?] hold that empty space not only may
be but actually is ye case of ye great
hollow of ye universe, wch is pure & pute
vacuity, Except a few clodds swimming
in it called starrs or planets. But this
seems

seems a very violent supposition; for how
shoud Light & heat be communicated
through vacuity? And it hath great
similitude with y^e^ Aristotelian princi=
ple of privation;[35] however it is hard to
admitt vacuity for a principle of w^ch^
~~th~~in such large extent, there neither
is, or can be any proof, & our senses
make no discovery but of plenum.

2.2.
Plenitude
{_}demons-
trated

Des Cartes says that if nothing{ be}tween
y^e^ {two} sides of a veSsel, they must touch.
The Newtonians ~~say~~ /deride\ that, and say there is
empty space between; This lett's me in to
shew y^e^ side I take, & that will be with
y^e^ cartesians, so farr as to think that bo=
dy is space, & space body, & equally impe=
netrable, w^ch^ admitted there can be no ab=
solute vacuity. They say that empty space
may be between y^e^ two sides of a veSsel,
so that they shall not touch, Then it is
granted that such space is something &
not

[35] Aristotle srets up his theory of change near the beginning of Book I of The Physics, in part 7. Privation is the absence of form, or matter, and is therefore a lack of either, offering the possibility of becoming either.

not merum nihil,[36] for then ye Cartesian
{_} inference wo{ud} be too hard for them,
since touching & having nothing between
is all one. Then if space be something,
it hath an existence as other beings
{_} have, so that of the two spaces{ on}e is not ye
same as ye other, but both are beings
subsistent apart from each other, &
{_} cannot be m/m\{a}de one; as ye space of
Trin: College Library is one, & that of
ye College Hall another, as distinct as
{_} ye Library {&} Hall are twain, & to say
that one may be moved & put into ye
other, is to speak against ye common no=
tion of things, & may be said of body as
well as of space. And ye case will be ye
same if any one space be devided
into parts as Cubick feet, one part is
not ye same, & cannot be made ye same
{_} as any other part, w{here}by two spaces
of each one [~~....~~?]foot shall become one Space
& be no

[36] i.e., 'mere nothing'.

& be no more extended: And what is this
{_} but impenetrability? {th}ere y^e^ space & y^e^ mat=
ter contained in it are one & y^e^ same &
constitute y^e^ same substance we call body
It was noted That some expect a discovery
what is y^e^ intrinsick nature of body, is
it not as proper to ask what is y^e^ intrin=
sick nature of vacuity or /empty\ space? The witt
of man can find nothing to answer but
that w^ch^ equally & alike exists, or Resides
in both, as being all that is knowable
of either. viz. Extension.

23.
Whence this pre=judice for vacuum.

But all this while we fight against
a prejudice almost invincible, w^ch^ ari=
seth from y^e^ common notice of veSsels,
that contain matter not directly sen=
sible, & therefore are stiled empty. No=
thing can eradicate this Idea of em=
{_} ptyneSs, for whatever is alledg{e} a sup=
posall will remove it, as that y^e^ veSsell
is full of water, then suppose y^e^ water
taken out, t is full of air, They'l

further

{_} further say{_}take out y^e^ air,& so by a
perpetuall negatioon, y^e^ same Idea will
be susteined, & for fail, recurr to an al=
mighty power to evacuate a veSsel of
all kind of body; & say suppose it so,
y^e^ answer must be as that of a gunner
who upon a supposall was urged by
a great Lord to say, how far a gun
five miles long wou'd carry, his an=
swer was that by G...d he would not
suppose it. Wee are not to argue from
our Ideas, w^ch^ are for y^e^ most part, as
to y^e^ nature of things, that have no con=
nexion or to do with them, very de=
ceiptfull. Nor may we accuse provi=
dence, for permitting such Ideas to
seem clear & yet (as above) be false, y^e^
same say they as deluding us; w^ch^ is not
so; for y^e^ Ides are certein~~ly~~ /&\ true as they
seem, but our judgement & inferences
are untrue, & so we decieve our selves;
as for y^e^ most part we do when we

have

have nothing better to alledge than that
wee can or cannot conceive it. As for
y^e^ conceipts that without vacuity there
coud be no fluidity, motion & ~~þ~~light, or
sound in y^e^ world, y^e^ vanity of them
will be exposed when we come a=
mongst y^e^ mechanicks, & in other pla=
ces where such matters may properly
be Canvased.

Of Time.

24
Like dis=
tinction
of time
absolute
& relative

The same shop out of which came y^e^
distinction of motus verus, & Relativus
hath sent out another in company, not
unlike, that is of tempus absolutum,
& tempus Relativum. The latter is
meant of our common accounts of
time by Revolutions & Horloges, w^ch^
(its said) are Inequable, incertein, &
not commensurable. But time it self
or absolute time flows (as they say) e=
quably for ever, & such as must be

admitted

admitted to exist, altho $y^e$ whole universe
were annihilated, Styling it fore, & af=
ter, Duration, and $y^e$ like Synonimes, that
all signifie $y^e$ same thing, as doth $y^e$
single nominative, time. And so it seems
$y^e$ thought is, that time (& I suppose $y^e$
like is affirmed of infinite space) is a
being independent ~~e~~in $y^e$ world, & all its
materialls, & phaenomena; & never having
had a beginning, will have no end,
but must exist Deo volente vell no=
lente.[37] If I mistake $y^e$ sence, or Conse=
quence of this distinction, I beg par=
don, but hope when I have done with
$y^e$ subject, some colour for these in=
ferences may appear, therefore I pro=
ceed to expose my notions of time.

25.
Whence $y^e$ Idea of conti= nuation or time.

It must be considered either according
to $y^e$ Idea or sence we have of it, or
else as it is to found in $y^e$ world, If
all thinking beings were annihilated;
as if there never had been such. The

former

[37] i.e., 'whether God wills it nor not'

former I call y^e^ Interior Idea of time,
w^ch^ consists of sensations & reflections with
varietys following so fast, that distinction
failing, all run together & make y^e^ Idea of
{_} a continuation. And {&} of that y^e^ modes are
so variable, & uncertain, that without a
reference to exterior Cronometers, there
wou'd be scarce a sence of time, but it
woud be drowned, in y^e^ Ease, disease, or a
meer perception of our existence. For
appealing to y^e^ Cronometers, we find that
attention, study (w^ch^ are almost in y^e^ pow
we of y^e^ will) Ease & pleasure make y^e^
time seem short; Whence M^r^ Fairfax[38] in=
ferred that a being perfectly happy cou'd
not be sensible of time. And on y^e^ other
side pain, y^e^ absence or expectation of
good things, makes y^e^ time seem long;
And in sleep or trance it is nothing at
all. So that time, of w^ch^ we have inter/nally\
no

[38] Nathaniel Fairfax (1637-1690), author of *A Treatise of the Bulk and Selvedge of the World; Wherein the Greatness, Littleness, and Lastingness of Bodies are Freely Handled*, etc, London, 1674.

{_} {n}o Criterium, is a meer chimera, & per=
takes of no existence, or principle of
naturall things, more than our other
Cogitations or Imaginations. And our Re=
{_} {f}erence t{o t}hings without us for y^e^ charac=
{t}er of t{hing}s without us for y^e^ character
of times is arbitrarious, & may or may not
be regarded, & within our selves there is no=
thing that time shou'd relate to.

26.
Time is a compa=rison of velocitys

Now abstracting all animall sensation,
as if none such were, or ever had been in
y^e^ universe, what do we find there but
body & y^e^ various shapes, mutations of posi=
tions, & y^e^ proper velocitys, all w^ch^ are com=
parable, but that only by measures of
extensions? I shoud be glad to be adver=
tised of any other ESsence, or principle
coordinate with these; Animall sensati=
{_} on {(}of which I have given an account
only excepted?{)}, w^ch^ was before withdrawn,
that

that y^e^ Idea of time at large in y^e^ world
might be more incomplex & limpid. But
now to abstract further this whole state
of body & its modes & velocitys, What Re=
mains then? they will say time, & what
is that? a thing that flows equably? So
flowing equably is y^e^ thing that flows
{_} equably. B{u}t then there is faster &
slower, & what is y^e^ standard, with w^ch^
a comparison may be made? Motion hath
{_} some station supposed, but{,}station hath
time? By this one may perceive that
this Idea of tempus absolutum, volens
nolens,[39] hath reference to y^e^ matter of y^e^
world w^ch^ imagination will affix to it;
Therefore this stubborn notion is Groun=
ded upon nothing else but upon our Idea
of time w^ch^ they call relative, both
Ideas Relative & absolute /in us\ being ~~y^e^~~one
& y^e^ same, & y^e^ inequallity & incommen/surability\
of

[39] i.e., 'will you won't you'.

of velocitys, is all one as of magnitudes,
of w^ch all proportions are poSsible. And
as those are defined only by compa=
rison so as each part is a standard of
all y^e rest, as y^e parts happen to deno=
minate each other to be great, small,
or equall, so time that is no more e=
quiable than magnitude, can be in
measure defined no otherwise than as
noted periods of moving matter make
a distinction. So that Equabillity of
time abstractedly{,} seems a meer Chi=
mera.

27.
Vacuity of body hath sensible representations but non time none.

The only argument (after these abstrac=
tions) insisted on, is that we cannot con=
ceive it should be poSsible for time to
cease, as if our imaginations were a
certain criterium of truth, touching y^e
ESsence of things out of all reach
of sence, or experiment, & whereof no
connexion

connexion can be made appear. This on
like occasion was answered before. And
now to conclude. I have often reflected
upon a disparity in y^e^ way of some mens
thinking, viz: that an absolute vacuity
shou'd not only be conjectured as in na=
ture poSsible, but affrmed by whole-
sale & made a principle in a spacious
hypothesis of nature; And then if one
ventures to suppose that a vacation of
time in case all y^e^ materiall world was
{_} annihilated wou'd b{e,} then: The same
persons Reluct, & say this tempus abso=
lutum is of neceSsary existence, & cannot
be abstracted or annihilated. It seem y^e^
inducement to this unequall thinking,
is because there are images of vacuity
by means of veSsels called empty: These
are continually occurrent to sense, Where=
of y^e^ Ideas without violent Abstraction,
cannot

{_} cannot be del{e}ted. But there neither is
nor can be any sensible image of non
time; And during sleep or trance when
{_} as to all knowledge y^e^ time paSsing {is }
nothing, upon Revivall there is (in a
way of history) a recourse to externall
Revolutions & Horologes for making good
y^e^ account; therefore it is no wonder that
{_} y^e^ mind having no previous example {~~or~~}
or impreSsion, hath no power to conceive
that time shall be no more. The pre=
judice ariseth from deferring too much
to ~~our~~ imagination, y^e^ is but a copy of
things, & what things are not copyable
as y^e^ true principles of nature, we must
come at them by means of reiterated
sensations, & Rationall conclusions there=
upon; beyond w^ch^ all that imagination
can pretend too, will be ranked under
no other claSsis but that of Dreams.

of

Of Force.

There is another Idea imbibed from
ordinary recurrences in y^e^ world, w^ch^ ac=
cording to y^e^ truth of things is seldom
justly understood, and this is called force of
w^ch^ y^e^ true esteem or measure is compound
of quantity moving, & swiftneSs of acceSs,
of w^ch^ more elsewhere; At present we
only reflect upon certain prejudices
& y^e^ useleSs applications of that word;
we are sensible of our own wills, & there=
under of a power to compell, or (when
{_} Subject{}) to be compelled, & also of y^e^
niceneSs of our senses, & tenderneSs of
our bodys; And from ~~an~~thence are fear=
full of attaques, as may bring pain, &
destruction. These sentiments induce an
Imaginative Idea of force, supposing
it to include somewhat like y^e^ efficacy
of our

of our members when we are disposed
to use them for offence, or defence, per=
suant to the determination of our wills,
without any regard to mechanicks, but
as a consequence of active life. All wch
imaginations differr much from a true
notion of force in inanimate things.
And in our late poeticall philosophy,
ye word force or in Latin ~~v~~Vis, is used in
ye same manner & like signification as
among ye ancients ye word quallity, &
bating ye charm of a learned language,
(but rendered) power or force woud not do
neer so well. As for example we can
rellish ye words, vis Attractiva, Centripe=
ta, Centrifugo, Resistentiae, Inertiae &
some others, & swallow them for princi=
ples affording clever solutions of diverse
capitall phaenomena. But these in
plain English wou'd sound odly & not

be so

{_} be so readily admitted as /.?\[42] a force to draw,
to centreseek, to centerfly, to Resist or
to be quasi dull, or lazy & ye like; all
wch may serve even as /well as\ ye others, to barr
further enquirys. But ye vain amusement
[.?][41] of ye [vires]definitions by ye vires will be fur=
ther exposed afterwards: We allow no
natural force but what falls out u=
pon collision of bodys, & Renounce all
{_} those ColoSsian structures [hicht upon?]wch are erec=
ted upon ye vires, & such (however ye
matter is minced) are no better than
(in English) quallitys long since seclu=
ded out of ye philosophick schools.
I believe he that said, that altho ye phae=
nomena of nature were caused by
attraction, pulsion or any /other\ unknown
cause, his demonstrations grounded upon
ye vires wou'd hold, was pleased with ye
subterfuge

[41] An editorial mark or symbol looking like a 'y', with a short tail to the right.

[42] A small, pencil-drawn shape above the word.

subterfuge, altho few will think y^e^ con=
clusion undenyable, or y^e^ premises be=
ing unknown better than Gratis dicta.[43]

[43] A statement freely, or voluntarily given, but meaning also 'so he says'.

(61.) Physica

29. Ordina= ry terms referring to impul= {_} ses to be used.

## Rules of impulses.

In order to proceed further in y^e^ theory of impulsive motion, for want of more artificiall terms apt for y^e^ purpose: I must{_}y^e^ forms of common speech, & o{r_} dinary words such as force, violence, strength, weakneSs, advance, accede, de= part, follow, or y^e^ like, but allways with a reserve upon occasion for redu= cing y^e^ ~~m~~Notions to y^e^ standard of motion already declared. And in this inquest I propose to touch upon all y^e^ modes of percuSsive force, Mechanicall pow= ers & some more complicate Energys; And not to be incumbred with objec= tions too soon. I shall at present, as before, waive plenitude, & borrow a portion of y^e^ supposed vacuity, & abstract all mediall

all mediall resistances, till I shall have
opportunity to shew that motion by im=
pulse in fluido will be subject to y^e^
same rules as in vacuo; & then we may
hope to bring y^e^ various modes of per=
cuSsion with y^e^ antecedents & consequen=
ces under some rule with competent per=
spicuity. But with precaution, that how=
ever our dealing is formall, by proposi=
tions as Mathematicians use, y^e^ discourse
will be physicall, not pretending to
strickt demonstration, all w^ch^ is left
to y^e^ profeSsors.

29[2]. account of some terms.

We are now in view of a campane repleat
with variety of modes under w^ch^ y^e^ many
sorts of impulses are to be considered,
& that will require y^e^ using some terms,
perhaps not common & if those are not
a little

a little explained, y^e^ campane may turn
to a wilderneSs; therefore I shall pre=
mise somewhat of that kind, w^ch^ I think
may aSsist y^e^ following propositions.

Impulse is y^e^ occurse or contact of bodys
moving.

The direction of a moving body is y^e^
path of its center.

The line of acceSs is y^e^ direction before
y^e^ impulse, & y^e^ line of separation or
departure is that after y^e^ impulse, &
may be understood of y^e^ one or other
of y^e^ collisors, or both.

A Regular or direct impulse is when
y^e^ directions of both bodys fall upon
y^e^ same line as of globes. A, & B. y^e^
line a, b. being y^e^ direction of both
as well after y^e^ acceSs a~~S~~s before.

An obliq impulse of such regulars, is
when

when it falls otherwise as from E &
ye angle C, A, D. is ye angle of obliqui=
ty.

If both are movent in severall directi=
ons there is obliquity in both as of A.
by ye direction CA, ye angle of obli=
quity bAC. & of B by ye direction
EB ye angle of obliquity is DBE.
Plus minus.

A body regular impelled upon a dia
{_} meter or a point having {ind}ifferent
or uniform respect to all ye parts, is a
direct impulse, otherwise obliq, viz:
(a) Direct. (b) oblique.

Contingent impulses of irregular bo=
dys of wch ye common matter of ye world
consists are mostly on both sides obliq
as at c.

For wch reason in calculating ye events
of impulses, Substances, form, & direction,
with

32r



with some other circumstances must
be given, y$^{ch}$ is y$^{e}$ art Statick, whereof y$^{e}$
principles will be found in y$^{e}$ follow=
ing propositions. But going off from
Regulars, that is to contingent impul=
ses, y$^{e}$ events are so perplext that few,
Even y$^{e}$ great Geometer himself hath
declined to enter into y$^{e}$ consideration
of them. What is meant by Equallity
or indifference of respects, is to come
from y$^{e}$ Mechanicks.

30.
Impulses
by points

1 All cases of impulses will be com
be comprised under y$^{e}$ consideration of t
of two bodys only viz A impell=
lent & B impelled.

For all contact is understood to be by
points, if superficies convex or plano
convex occurr y$^{e}$ touch is by a point
If flat or any paralell superficies con/curr\
then

then $y^e$ center point of such contingent superficies, as to all efficacy, is $y^e$ point of $y^e$ contact, for every way $y^e$ effect is ba= lanced, & if two or more ⊖Contacts hap= pen at $y^e$ same instant, $y^e$ medium point of all is $y^e$ point of contact, & $y^e$ consequence is ruled accordingly.

31. Recipro= call Re= lation

2. All relations in $y^e$ universe, as to $y^e$ motions of A & B Except of each to $y^e$ other (or as p next) are to be layd aside, as if none such were.

For Distances, aspects, & directions, are jud= ged £by $y^e$ bodys respected, & not otherwise.

32. Station fixed as resting.

3. In order to fix a state of im= pulses, it is neceSsary that some= what shou'd be supposed immove= able, & that commonly falls out to be $y^e$ station of $y^e$ observer.

For if regard is had to other bodys or systems of $y^e$ world that may appear

as

as moving, y^e^ rule & cnaracters of y^e^ mo=
tion Respected will be confounded. And
it cannot be determined, whether A or
B moves or how. Therefore when we
referr to y^e^ station or (for reasons as
will be given) to y^e^ point or place of
contact, of w^ch^ either is supposed to
be fixed & determined, y^e^ motion is de=
clared.

33.
No conti=
nuance
in y^e^ con=
tact

4. A & B cannot continue in y^e^
Contact but eo instante[44] must
separate.

This is not according to y^e^ late cant,
vis resistendi but (if vis must be in y^e^
case) impenetrabilitatis; And in truth
it is not in A nor in B but in both,
Each alike (by y^e^ inconsistency) forced
from y^e^ other, for as to that purpose
each is impellent & impelled, w^ch^ con=
sidered there is no need to differr about
y^e^

[44] i.e., 'at the same moment'.

yᵉ modes of expreSsion.

34. Separations direct & not curve

5 When A or B move from yᵉ con= tact, it shall be direct by strait lines, & not by any curve what= soever.

For infinite curves may be co-tangent at one & yᵉ same point, as in yᵉ figure, & nothing is found by way of cause to determine wᶜʰ shall be taken, therefore yᵉ direction shall be indifferent, that is strait. If a body be diverted from that towards a curve, it must by me/ans\ of further impulse, & then yᵉ same con= sequence returns, & so continually till it is free, & then at that instant, it takes a strait course, & yᵉ moment of parting is an impulse, & What of course follows. A further reason may be, that in all curvity yᵉ exterior surface move faster than yᵉ interior or concave; wᶜʰ in a momentary action will not succeed; And in such case all yᵉ

parts

parts of y^e^ body being close united, will affect each other quasi by impulse, till by inciting & retarding they will paSs equally; what may be y^e^ case upon turning will be considered afterwards.

35. Modes not change without some ef= ficient cause

6 The modes of bodys (no more than y^e^ substances) will not alter with= out a cause efficient.

This is common notion & grounded on exp= rience constant & universall; Hence it is concluded that a state of approach or departure must cont~~v~~/in\ue till some competent power effects a change w^ch^ can be no other than y^e^ occurse of bo= dy, with wit~~h~~/^ch^\ a continuance is incom= patible; this is y^e^ only cause why a bo= dy moves after y^e^ moving force with= drawn.

36 Motion de= termined by some fixt place

7. Motion & rest are allwa~~i~~ys referred to some fixt place else y^e^ relation is to

is to all things ad libitum & vagum[45] &
all that belongs to motion speci=
fically stands; undetermined.
v.[46] before N°. 3.

When A & B approach or separate, who
can say whither one, other, or both
move, but by reference to something
of w^ch^ y^e^ place is supposed to be fixt?
& that depriving y^e^ arbitrary relation
to other things in y^e^ world, gives an
Idea of y^e^ locallity of moving bodys.
And such as make no change at all
with this fixation are said to rest, o=
therwise to be in motion; & perhaps
that very fixation (as may be presumed)
changeth in other respects & then all
is loose again.

37.
point of
contact
fixt &
also some
station

8 All space is reall & depends on no
relation, & upon collision, y^e^ point
of contact being momentary is
fixed, & y^e^ states antecedent & con=
sequent may be referred to that,
& delineated accordingly: & we may
term

[45] i.e., 'optional and undefined'.

[46] i.e., '*vide*' - i.e., 'see above, No. 3'.

35r



term it $y^e$ contact, or station promi=
cuously both in effect meaning $y^e$ same
thing.

As for example two shipps in $y^e$ wide
sea fall foul, The motions of them
more undefined & accountable by re=
lation to $y^e$ heaven's, $y^e$ sea, or $y^e$ soyl, or
otherwise at pleasure; but $y^e$ place of
$y^e$ touch is momentaneous, & fixed
with respect to $y^e$ whole world. And
is to be taken as a center /to &\ from $w^{ch}$ all
impulsive directions are describable,
& so taken as a station of an observer
(or any other place fixed with respect
to that.) projects a certeinty of any mo=
tion & all its modes. Motion is Relative
but Impulse is not.

$37^2$.
Velocity
of acceSs
& separa=
tion equall
except &c.

9 If after an Impulse $y^e$ bodys sepa=
rate upon $y^e$ smae line contrarily,
or one rests & $y^e$ other moves $y^e$ se=
paration shall be always with
velocity

velocity
velocity equall to that of $y^e$ acceSs.

As when B is equall to, or exceeds A.
The velocitys cannot be more, for that
is to create what is not, it cannot be
leSs, for that sinks past into nothing.
This rule holds in all cases whatever
but only when A. is greater than B
& then B will take $y^e$ full velocity, $w^{ch}$
is $y^e$ utmost any impulse can give. And
A. following upon $y^e$ same line, $y^e$ ve=
locity of that must be subducted from
$y^e$ other, according to $y^e$ proportion of $y^e$
quantitys. v. $y^e$ next.

37.
~~37~~
Equalls change states

10. A. = B. shall stop in $y^e$ place of
B. & that shall move with $y^e$ same
velocity.

This is $y^e$ case of a leSs body falling upon
one equall to it & is just as if $y^e$ two
bodys chaged states, & $y^e$ velocity or mo=
tion [changed states]seemed continued as $y^e$ same with/out\
interruption

interruption at y^e^ contact; And in rea=
son & experiment y^e^ consequence is veri=
fyed. There is equall reason of change
in both, therefore y^e^ change in both
must be equall; & one resting, & y^e^ other
moving from rest to y^e^ same velocity, is
equall change. A certain philosopher
Dr Clerk with his usuall opiniatrete[48] says A
in trans:[47] shall [refelct?] with 1/2 & y^e^ other move
1/2 y^e^ velocity, not ~~to~~ considering that
to stopp & reflect A, is much greater
change than to move B into 1/2 y^e^ velo=
city. The game called shuffleboard
proves this event, & billiards wou'd do
y^e^ same, but for rolling. Many equalls
(sans Friction) neer in y^e^ same line, y^e^
first impelled shall send the impulse
through all y^e^ rest, w^ch^ accounts for y^e^
equabillity of watery waves dilating.
A leSs

[47] Jean le Clerc (1657-1736), a Swiss theologian and scholar, published his *Physica, sive de rebus corporeis libri quinque* in Amsterdam in 1696. Le Clerc had been in London during the most turbulent months of the Exclusion Crisis in 1682, moving to Amsterdam where he became a close associate of John Locke (he was later his biographer). He would therefore be considered by the Norths to be neither a theological, philosophical nor political friend.

[48] i.e., 'opiniatreté', i.e., stubborness

39. Velocitys of greater & leSs as quantitys.

11. A. leSs than B. they shall divide at ye contact & move in oppo= site directions, & ye velocity be distributed as ye quantitys, in proportion the greater having ye leSs share.

{_}

{~~Stet.~~} A shall reflect, to a contrary di rection, with 1/2 velocity & B shall pro= ceed with ye other half. So A = 4B shall reflect with 3/4 & B proceed with 1/4 of ye velocity. And so quantity & space rule ye effects of all impulses.[6] [49]

These cases require ye bodys to be Ada= mantine & not yielding or springy in ye least, for that is an operation of compound matter, & in all degrees uncertain. The french author in his

{_}

choq du Corps[50] ascribes ~~e~~Elasticity, {(}as a principle

[49] '6' here in superscript might refer us back to note/rule 6 above on fol. 34r. (i.e., 'The modes of bodys (no more than ye substances) will not alter without a cause efficient.').

[50] L'abbé Edmé Mariotte, (1620-84) physician and botanist, his *Traité de la percussion ou choc des corps ...*, was published in Paris in 1673.

principle,{)} to all body whatsoever &
thereby, pretends to solve all y^e^ effects
of percuSsion; but allows that bodys
may be springs infinitely strong [~~in=~~
{_} ~~finitely strong~~], & what is that but Ada=
mantine, w^ch^ falls into our rules, & /[.. ..?]\ {those} /[...?]\[52]
{_} springineSs disturbes? By y^e^ proposition
here of A more than B & y^e^ velocity
parted as y^e^ disproportion inverted.
It appears that y^e^ result of a leSs
body from a greater, w^t^ever y^e^ dis=
proportion is, cannot be with y^e^ full
velocity absolutely.

Observat= Hence it follows that y^e^ least thing with
{_}tions par= y^e^ l{east} velocity, moves y^e^ greatest in
part 20.[51] some measure, & however small it is
somewhat, for of time, or velocity there
is not found a minimum, no more
than of body or space; And we are
not to start when it is affirmed that
y^e^ fall

[51] Here, and over leaf ('par: 22') MN?RN seem to be referring to Newton's *Principia* - although I have yet to satisfy myself exactly where. The *obvious* reference here is to the *Principia*, Definitiones III: '*Materiæ vis insita est potentia resistendi, etc.*'.

[52] Word 'those' crossed out, and illegible comments inserted, in pencil.

yᵉ fall of a Tennis ball moves yᵉ whole
terraqueous globe; & this immensity of
disproportion I shall afterwards have
occasion to call an infinite resistance.
v. par: 22 We find in Sʳ Is: Newtons principia
a definition of body by a vis insita
resistendi; & why not vis impellendi[53] /wᶜʰ is\ as
real as yᵉ other? These definitions by
yᵉ vires are but affirmations, wᶜʰ, ha=
ting yᵉ Logicalia,[54] are better [expresse]known
by a common way of expreSsion. As, is
it not as intelligible to say impene=
trabilis, as vis impenetrabilitatis?[55] In
another place we find - Quantum in
se est, as if yᵉ thing were alive &
strove to prevail; if yᵉ sence is is quan=
tum substantiae,[56] we are agreed. In phy=
sicks yᵉ definitions shou'd be ex natura
rei,[57] & not, as in Mathematicks, circum/scriptive\
only

[53] i.e., 'an innate force of resistance' and 'an impelled force'.

[54] i.e., the volumes of scholastic Logic, existing in many editions from the thirteenth century onwards, usually known as the 'parva logicalia'.

[55] i.e., 'the impenetrable force', and 'the force of impenetrability'.

[56] i.e., 'in and of itself', and 'amount of substance'.

[57] i.e., 'things actually existing', 'reality'.

{_} only. Vis is a physicall term & {(}abstrac=
ted;{)} of universal signification, w^ch^
wants to be defined or naturally ex=
plained, as much as any other, & with
out such intelligences y^e^ science of
naturall philosophy failes.

There is also a specious axiom - Ubi
percuSsio ibi repercuSsio,[58] whereof y^e^
matter in effect is true, but is is Ae=
nigmatically exprest, as if it were
intended to offuscate rather than to
proffer any clear notion, for Re=
percuSsio seems to imply activity as
of a spring, & in that sence y^e^ axiom
is not true; the just signification is
of [body]y^e^ common inconsistency of bodys
meeting in y^e^ ins~~y^e^~~tant of contact, w^ch^
produceth a separation, not by per=
cuSsio, or repercuSsio but by ConcuSsio

whereof

[58] i.e., 'where there is percussion there is repercussion'.

whereof y^e^ effect is not divided, but
is one only resulting from an united
neceSsity, acting ad modum Substantia=
rum.[59]

The like is to be observed of y^e^ chimeriq
conceipt of Vis Inertiae,[60] w^ch^ is an insen=
sible expreSion; & it is not true of any
body to say it is iners, for besides y^e^ re=
ference to active life, w^ch^ is by no means
{lazy=} proper (for what is y^e^ Idea of {laz}i=
neSs to y^e^ mechanick effects) All bodys
are more adequately reputed active.
And y^e^ larger more so, than y^e^ leSs,
& on either side y^e^ conforming to ne=
ceSsity is paSs/i\o,[61] but not inertia, w^ch^ sup=
poseth an aversion to comply, of w^ch^
body is not guilty. But vis is a favou=
rite term, & stands in y^e^ formality of
a definition of anything not understood
or when

[59] i.e., 'in the manner of substances'.

[60] i.e., 'force of interia'; *iners*/*inertia* also means lazy, reluctant or idle, in latin.

[61] i.e., 'a passion', i.e., a positive force.

or when y^e^ notions are concealed, &
yet somewhat must be speciously
held forth, tho' it is but Verba dare;[62]
Here i~~s~~s but a touch upon this sub=
ject, perhaps, more may come after=
wards, but now we proceed to some
further rules of impulse.

41.
Greater upon leSs follows with leSs velocity {w^ch^}

12 When a greater body impells
on leSs, y^e^ velocity of y^e^ sepa=
ration shall be to that of
y^e^ acceSs as y^e^ leSs body is to y^e^
greater {as} respec{t t}o y^e^. contact
or station will declare.

As A = 1/2 B shall give B y^e^ full ve=
locity of y^e^ acceSs, w^ch^ is all that any
impulse can give. for if B had mo=
ved with such speed all contact had
been avoided. And now A shall not

rest

[62] i.e., 'a word given', i.e., a trick.

next at y^e^ contact, as an equall wou'd, but
it shall follow with a veocity propor=
tionall with y^e^ exceSs of substance, that
is 1/2 & that substracted leavs [2/1]1/2 to y^e^
separation, & y^e^ like will hold in eve=
ry other proportion, as y^e^ expert may cal=
culate. This rule woud be sensible
in y^e^ greatest as well as y^e^ least dis=
proportions, but y^e^ mediall resistance
getting y^e^ better of y^e^ leSs, y^e^ greatest
seems to carry it away before it in
contiguity; This & diverse of y^e^ follow=
ing propositions may be groSsly ex=
perimented of w^ch^ afterwards, And in
{_} y^e^ mean time let it be considered {~~that~~}
that all these actions & paSsions of bo=
dy, as well regarding substance as ve=
locity, will be found as was said, Re=
gulated by measure of space & dimensions.

13. All

40r



42. Like magni= tudes like ef= fects

13. All magnitudes in like proportion have like proportion whatever y^e^ ve= locities, & however y^e^ impulses happen.

As A = 2, 4, 6 or 8, /&c\ And B = ~~2~~4, 8, 12~~2~~, ~~or~~ or 16. &c. impelling with any velocity shall separate with y^e^ same respec= tively, & not varying on acco:^t^ of y^e^ dif= ferent magnitudes, for all that may be alledged of A = 2 B will be true of 2A = 4B of y^e^ rest.

43 Meeting adds ve= locity

14 Any 2 bodys meeting with divers velocitys is all one as if y^e^ 2 velocitys were conjoy= ned, & either rested. Saving only y^e^ direction w^ch^ as well after as before will referr to y^e^ station or contact, whereby all directions are declared.

This

(83.) Physica.

This means as to measure of force, w^ch^
is y^e^ celerity of y^e^ congreSs, whither
y^e^ motion is aSsigned upon one, other,
or both y^e^ bodys. But then y^e^ mode
of y^e^ acceSs, being referred to y^e^ sta=
tion, that of y^e^ separation will be
so too; And as y^e^ directions of y^e^ for=
mer may be various, those of y^e^ lat=
ter derived of them will vary accor=
dingly. As more at large in y^e^ next.

44.
distances & aspects without contact nothing

15. The direction of y^e^ impellent is
referred to y^e^ station, before &
after y^e^ impulse, & untill im=
pulse happens, The variation of
distances & aspects, quoad y^e^ bo=
dys is merum nihil.[63]

This is self evident, for bodys that do
not touch, are to each other as non
entitys

[63] i.e. 'as regards y^e^ bodys is merely nothing'.

entitys. The ESsence of body (impenetr=
ble) consists in tangibility, w$^{ch}$ deprived,
body is no more; this setts aside y$^{e}$ ima=
ginary attraction, w$^{ch}$ is both contrary to
y$^{e}$ experimented existence of body, &
not provable by any reall experim:$^{t}$
of w$^{ch}$ elsewhere.

45.
velocity
referred
to y$^{e}$ sta
tion.
23.

16 The velocity as well as y$^{e}$ direc=
tion of moving bodys stands
also referred to y$^{e}$ point of
contact or station; accordingly
to w$^{ch}$ all circumstances are de=
clared.

For laying aside y$^{e}$ station, or place
of y$^{e}$ contact, y$^{e}$ motion in y$^{e}$ wide wor/ld\
capapbale of infinite relations is wholly
undefined, & may be accounted as di=
versly; But an impulse makes a fixa=
tion, according to w$^{ch}$ all circumstances
of y$^{e}$

of y^e bodys concerned are determined
& may be described that is by lines eve=
ry way as well to as from a center.

46. Direction of y^e im= pelled from all directions of y^e im= pellent y^e same.

17 A Globe D.G. impelled at any point D from what region so= ever y^e impulse comes directed, whether from C or from E shall move from y^e contact all in one and y^e same direction D, F, y^e same will hold of y^e cube H. I. parallelipipedon K. L. Ellipse M, N, or other regular body, so as y^e impulse feels on y^e extremity of a just diameter as in y^e figure D.G.

<space for diagram?>

Here we begin with obliq impulses; & first that of y^e acceSs; where= upon we hold as in y^e proposition, & y^e reason is, that y^e contact is un/derstood\ to be

to be a single & individual point, w^ch^
admitts no difference, from whence y^e^
impellent comes; Nothing is significant
but y^e^ inconsistency at y^e^ contact w^ch^
being of moving bodys requires an im=
mediate separation; And that after y^e^
impulse will be in such a manner as
y^e^ state of y^e^ impelled shall require.
So that upon every impulse there will
be a mode of acceSs, & of y^e^ separation,
according to circumstances always re=
gular & constant in y^e^ effects.

18 All obliquitys of y^e^ impulse
inferr a diminution of y^e^ force

47. obliquity is always a diminu= tion of force

For a better gage of y^e^ obliquity, Sup=
pose a plane AB <u>tangent at y^e^ con=
tact</u>, (y^e^ plane represents y^e^ contact
point as to all poSsible obliquities as
if it were extended in infinitum, or

were

were $y^e$ diameter of an hemisphear)
& $y^e$ several angles made with that
plane, shew if $y^e$ impulse be direct,
or obliq, & in what degree. Coming
at right angles C.D. is direct, & other=
wise, as frome E it is obliq. And $y^e$
same force from E is weaker than it
is from C as $y^e$ space ED is more than
$y^e$ space C.D. for let $y^e$ impelent from
C & from E be $y^e$ same as to quantity
& velocity, C. will arrive at D sooner
than E therefore quoad $y^e$ impulse it
moves swifter & so hath more force.
And further if parting at $y^e$ same time
from C & E. If $y^e$ latter, E, is to arrive
at D together with C at $y^e$ same in=
stant, then E must have more velo=
city as $y^e$ space E.D. is more than C.D.
& by that (caeteris paribus{}) $y^e$ forces will
be equall

be equall; all w$^{ch}$ is apparent upon in=
spection of y$^{e}$ diagram. Whereby it ap=
pears that velocity at large & velocity
of approach are different & not calcu=
48 lated by y$^{e}$ same measure.

Velocity (in acco$^{t}$ of force) {_}is equal- lable by quantity & e con= tra.

19 What in velocity of approach is
lost by obliquity of y$^{e}$ acceSs, may
{by} supplyed by quantity added in
y$^{e}$ same proportion as before.

As for example. If E was greater than
C as E.D, is more in length ~~a~~than [E?].D.
& y$^{e}$ velocitys y$^{e}$ same, y$^{e}$ effect of y$^{e}$ im=
pulses wou'd be y$^{e}$ same. For velocity &
quantity compensate each other. So
that what ever a single substance will
do wi[~~..~~?]th ~~sing~~/doub\le velocity, a double sub=
stance will do with single velocity.
And when y$^{e}$ velocity of y$^{e}$ acceSs is
reduced by obliquity (for E with like

velocity

velocity as [b.?] approacheth y^e^ tangent plane
AB. slower than C.) a due quantity ad=
ded makes an equation of y^e^ force.

The di=
rection
of y^e^ im=
pelled y^e^
same
from all
velocitys

20. The direction of y^e^ impelled from
y^e^ contact will be y^e^ same with
whatsoever force y^e^ impellent
strikes.

For y^e^ contact is a point, upon w^ch^ all im=
pulses as to y^e^ direction of y^e^ impelled, ad=
mitts no variation, but whether y^e^ force
comes one way or other, y^e^ impelled will
take y^e^ same direction. And more or
leSs in y^e^ degree of y^e^ force will not, there
being no cause to vary it; but y^e^ direc=
tion of y^e^ impelled will be ruled by cir=
50 cumstances proper to itself.

Direction
by a line
from y^e^
{_} contact
thro y^e^ cen=
ter of y^e^ im=
pelled.

21. Every impulse direct, or (on y^e^
part of y^e^ impellent) obliq
shall cause y^e^ impell{ent} to
move in a direction by a line
from y^e^ contact to its center.

Here

Here note a distinction of obliquity on y^e^
part of y^e^ impellent & on y^e^ part of y^e^
impelled w^ch^ will be of much importance
afterwards. At present, y^e^ impulse is sup=
posed to fall indifferently; that is, upon
a diameter of a regular body impelled,
as a Globe for instance, w^ch^ however
touched shall paSs away by this rule as
y^e^ gamesters at billiards well know.
For y^e^ impellent influencing nothing,
one way or other, y^e^ substance of y^e^ im=
pelled must decide, & that will be in
a direction w^ch^ is indifferent to all y^e^
parts; y^e^ force requires a separation,
not of one or other part but of y^e^ whole
from y^e^ contact, & how ~~t~~should that be
but by a line that paSseth both con=
tact, & y^e^ proper center?

So also

51. Like tho yᵉ impulse be obliq upon yᵉ impelled.

22 So also if yᵉ impulse happens to fall Besides yᵉ extremitys of yᵉ diameters. The[64] Rectilinear di= rection direction shall be by a line thro yᵉ just center of yᵉ impelled from yᵉ contact.

This is yᵉ case of all irregular & ir= regularly impelled bodys, & it is easily imagined into what variety yᵉ specu= lation will runn, & how hard it will be to gather into heaps any measure of conformitys, as may make it appear that any certain rule governs them all. But I hope I may distinguish enough to shew, that measures of Quantum & space, shall be that very aforesaid stated rule by wᶜʰ all mechanick ac= tion in yᵉ word is governed. And here we find that upon all these oblique

impulses

[64] There is some marking with the soft-leaded pencil here - it is not clear what is meant, it might be accidental marking, it might be related to the repetition of the word 'direction' in this and the following line.

impulses, respecting y^e^ quantity & direc=
tion, there will be two effects, that is
progreSsion & gyration; & before we
apply to this proposition, we must ad=
just some particular cases concerning
that.

52.
Bodys tur=
ning move
on y^e^ pro=
{_} per center
or axis

23 When any body turns round
(being {free}) it shall turn
upon a center or axis. And
not with uncertainty, or
shifting from one point or
axis to another whatever y^e^
form of it is.

This proposition is not easily proved by
argumentation, because our principles
are not so sensibly exposed, as to ground
a firm demonstration upon. And it is
scarce poSsible to make any experiment
that shal clearly inferr it, or y^e^ contrary.
And so

And so long as ~~whe~~ have a liberty to
opine in such matters, & to sustain our
opinion by discourse. I shall venture upon
this point w$^{ch}$ perhaps may be rendred
more clear in what follows.

As upon impulses we take y$^{e}$ point of
contact, quoad y$^{e}$ position, to be at that
time fixed & determined with respect
to all y$^{e}$ world. So also we take all y$^{e}$
points in that body to be in like man=
ner as to position fixed & determined.
And as y$^{e}$ impulse at y$^{e}$ contact exter=
nally affects y$^{e}$ whole by measure of
substance & velocity; So also each
~~other~~ /part\ internally affects each other lying
in continuall contact. And in Regard
y$^{e}$ substance of those parts as all mo=
menta must be understood to be equal,
such affection must appear only in y$^{e}$
velocity. Now in all turning, Some part
must

move in larger arches, that is swifter,
& some slower than others, but from y^e
{_} contact non{e t}han y^e acceSs. Therefore
at y^e commencement of every turning
movement, y^e parts moving quicker or
slower by continuall impulse inter=
nally working to accelerate, & to re=
tard, must affect each other, so that
all shall fall into equallity or bal=
lance as was proposed. suppose y^e body

AB. to turn in y^e order AEB.
F. not upon y^e center or axis C.
<space for diagram?> w^ch equally or rather uniformly
respects y^e whole, but upon a
center or axis at D. ther~~e~~n y^e
parts at A move swifter than
those at B. & those at B slower.
Nothing seems more obvious than
that y^e former shall be a means to

accelerate

accelerate, & y^e latter to retard, till y^e forces of all y^e parts ballance in equality, by transferring y^e center or axis of y^e motion to y^e most indifferent point C. And that perhaps may be determined in y^e very instant of y^e contact.

The force of bodys turning

24. The force of a turning body is y^e summ of y^e force of all its parts. w^ch will be calculated by y^e obliquity of impulses that excite it.

For a body equall to y^e whole impelling at a[65] directly, shall excite a velocity equall to that of y^e impulse, but at y^e extream obliquity b. a leSs body will excite an equall velocity, that is, of that part turning; & then as y^e force of y^e whole body directly impelled is to y^e same, with y^e diminution (by y^e velocity diminishing

[65] Geometrical points are referred to in lower-case letters throughout the following section (up to fol. 51r.).

diminishing towards y^e^ center) substrac=
ted; So is y^e^ force of y^e^ impellent apply=
ed at y^e^ diameter a. in all quantitys,
to y^e^ force of y^e^ same applyed at y^e^
extream obliquity b. So that suppo=
sing y^e^ force of a body turning stated
by velocity at y^e^ extream parts, to
be leSs than that of y^e^ same velo=
city as one to two then if any im=
pulse at y^e^ extream b. by one of Subs=
stance will excite there one of velo=
city; it will require at y^e^ diameter
a, two of substance to excite 1. ve=
locity of y^e^ whole directly. or in some
other certain proportion this being
certum pro incerto.[66]

The following diagramm may partly
explain this ~~diagram~~ proposition.

Let.

[66] i.e., 'certainty by incertainty'.

Let $y^e$ circle a, e, d, f, be a solid body
c $y^e$ center, a,c, $y^e$ semidiameter diS=
sected equally in b. & a.g. equall to
$y^e$ periphery aedf, & its half e h,
equall to $y^e$ periphery b.i. let $y^e$
whole turn in $y^e$ order a f d, & a
small body applyed so as to be im=
pelled at a & in a certain time driven
to g, that is $y^e$ whole compaSs of $y^e$
revolve at, a And then let $y^e$ same
body by applyed at e. that on $y^e$ same
account shall be driven but to h
half $y^e$ length, & so in every other
point of $y^e$ semidiameter propor=
tionally: whereby $y^e$ velocitys from
every point of $y^e$ semidiameter a c,
thus expreSsed will be exposed by lines
from $y^e$ respective points determining
in $y^e$ hypothenuse c g, & so $y^e$ velocitys

or force

or force of y^e^ body moving, from y^e^ grea=
test a.g. diminish & dye in y^e^ center c.
But further, lett some body, of magni=
tude but just sufficient to stop y^e^ turning,
be applyed against a. to cease y^e^ motion.
It will require double y^e^ magnitude to
stop it, if applyed at b. & so increasing to=
wards c. to infinite. And if a will repell
y^e^ appositious body to g in a certain time,
& y^e^ like, proceeding towards ℂc. y^e^ velocity
will come to nothing in that center, this
will concern mechanicall powers w^ch^ I
will not anticipate here.

54.
turning
& progreSsi=
on together

25 Between y^e^ extreams of direct
& obliq, there is a double effect
(viz viz (of y^e^ whole) turning & (of
y^e^ center) a progreSsion.

An impulse upon a diameter is direct
& y^e^.

& y^e effect single, that is progreSsion, for
y^e force is indifferent towards all y^e parts,
but declining from that is obliquity,
w^ch makes y^e impelled separate unequally
that is, some parts with more celerity than
others, for leSs will yield faster than more,
but yet, y^e whole opposing more or leSs, every
part partakes in y^e separation, & y^e diffe=
rence succeeding of more or leSs swiftneSs
of y^e parts y^e body must both turn & pro=
ceed; But if y^e impulse deviate from y^e
direct, & come to y^e extream obliquity, y^e
body shall turn, & not proceed, or but very
little. As here y^e body struck at b is di=
rect, but at y^e impulse is obliq. And in
in y^e separation (respecting y^e diameter b
c) more substa/a\nce lys towards f than to=
wards e or (w^ch amounts to y^e same) more
remote

remote, therefore e must paSs swifter, but
y^e^ part a f, must also separate; That is by
y^e^ center, w^ch^ induceth y^e^ double effect of
turning & progreSsion. But if y^e^ impulse
be at y^e^ extream obliquity as at e, y^e^ whole
effect must be (as I said) by turning with=
out any progreSsion (ferè).[67] Here y^e^ obli=
quity depends wholly upon y^e^ scituation
of y^e^ parts respecting y^e^ ~~p~~impulse, y^e^ momen=
of w^ch^ (parts) may be imagined, or supposed,
but in y^e^ irregularity of things, cannot
be accounted for, yet there are experi=
ments w^ch^ shew these effects in groSs, as in
y^e^ strokes upon a Kitt-catt w^ch^ everyone
observes. Curvity in y^e^ paSsage of y^e^ cen=
ter upon these obliq impulses cannot be
alledged, because y^e^ reasons afore given for
rectilinearity of all free motions will
disprove

[67] i.e., 'almost, or nearly'

disprove it, for whatever may be said
to draw one way, hath its like to draw
equally ye other way, so being undeter=
mined to wch, its must go strait: nor can
ye old whimsey of various motions not
subsisting together in one & ye same bo=
dy, concern us: for it hath been shewed
that as many motions as their may be
relations had, will subsist; & indeed every
thing that can be conceived of body not
inconsistent with impenetrability, tho
of infinite variety of motions may be
affirmed.

55

The obliq angle in= creaseth & ye pro= greSsion weaker

26 With ye obliquity ye angle of ye departure of ye progreSsion, from ye direct increaseth, & ye velocity of it declines.

The progreSsion of ye direct is h, [b?]. & of ye obliq is h d, & ye angle of ye departure is

is i h d, w^ch by more obliquity, opens thro
all degrees of y^e ri~~h~~ght angle i h f as y^e
momenta of y^e substance incline towards
y^e extream obliquity, in w^ch all progreSsi=
on is lost; And that y^e velocity of y^e pro=
greSsion shoud pari paSsu[68] decline, must
so happen, because of y^e whole effect
w^ch an impulse if direct woud have,
that is all progreSsion by hc. what part
goes to y^e turning, must be detracted
from y^e progreSsive, & at y^e extremity e
all will be turning as I say'd & no pro=
greSsion left, for y^e effect cannot fall
wholly upon either. So that y^e turning
& angle of departure increase, & y^e ve
locity of y^e progreSs decrease pari paSsu
together.

The least.

[68] i.e. 'in step', or 'step by step'.

(103)[69]

56. least ob= liquity diverts

**The least** 27 The least obliq force in y^e^ way of a moving body, in some degree diverts y^e^ direc= tion of y^e^ movement, making an angle.

This being little may be called refraction & if much, reflexion as per y^e^ next.

57. Ang: of incidence = y^e^ ang: of reflexi= on.

[6?] 28 if y^e^ resistance of such force or impediment to an obliq mo= ving body, be infinitely strong, as y^e^ globe of earth is to be accounted, y^e^ angle of reflexi= on is equall (nearly) to y^e^ an= gle of incidence.

For judging this angle, we must resume y^e^ tangent plane before described, & is no other than y^e^ common planes upon or about y^e^ earths surface, w^ch^ supposed,

y^e^

[69] MN has forgotten to write the header 'Physica', for once.

yᵉ event is here described as follows. Let
yᵉ body of A B C.[70] be as yᵉ globe of earth,
an infinite resistance H.K, yᵉ tangent
plane, E, a body moving to yᵉ contact at
D; I say that E shall reflect from D to
F so as yᵉ angle EDK = FDH, & not to L
{_} or M. {(}H A{)} being yᵉ tangent of yᵉ im=
pulse, extended to infinite. It must be
always understood, that
<space for diagram?> a body approaching
another of infinite re=
sistance, must sepa=
rate from it with
yᵉ full velocity of
aceSs, for yᵉ im=
pelled not giving any
way, yᵉ change must
appear on yᵉ part of yᵉ impellent. In ob=
liq cases, yᵉ velocity of yᵉ approach is Gaged
by yᵉ

[70] MN here returns to using capital letters for geometrical points.

by y^e tangent plane, as by y^e normall I
K, then a separation by like degrees,
must be by y^e normal GH. If y^e body
DB, gives way, then y^e reflexion will be
by a leSser angle as towards L but if
it continues to resist as before, y^e re=
flexion will not ever be towards M.
Gaged at y^e tangent by MH, for so it
will depart from it faster than it
acceeded, y^e velocity being y^e same if
DB yeild much y^e direction may be
towards A w^ch being below y^e tangent
may be called refraction.

Hitherto of impulses either direct, Res=
pecting both bodys, or obliq by incli=
ning y^e acceSs, & also by disposition of y^e
substance of y^e impelled. Now it re=
maines to be considered, that obliquity
by y^e disposition of substance may
fall

fall on y^e^ part of y^e^ impellent as of y^e^
impelled, y^e^ impulse acting indifferently
on both, w^ch^ in y^e^ varietys of action pro=
miscuously in y^e^ world, will have like
effects, & coming to thse by degrees I
lay down this proposition.

58. Obliquity of y^e^ im= pellent,

29 If y^e^ impellent toucheth with
obliquity of its substance, there
will befall to it, Turning, dimi=
nution of force, & diversion of
y^e^ separating line, Exactly alike
as hath been shown of y^e^ impelled.

As y^e^ body A meeting an immense ob=
stacle at C in an obliq course from D
shall turn in y^e^ order AFC. & also pro=
ceed by its center (perhaps) towards E
or as y^e^ substance prevails. And if at c
y^e^ body

ye body cB, is irregular also ye like will happen on that side, ye track & course of these are hardly to be ac= counted for but in hypothesi, for no= thing is more sure than that ye dispo= sition of ye substances governe ye mode of ye separation, & who shall adjust ye momenta of them? This shews what various effects promiscuous motion in ye world hath.

59. Direction contrary to ye impulse

<space for diagram?>

30. If two bodys impell with obli= quitys in both they may be so ordered that ye impeled shall depart in a line near opposite to ye line of ye acceSs of ye im= pellent.

As here Let CD be a body of wch D is

D is taken to be y^e^ center, & let an im=
pulse come from A upon B & from that
contact (besides turning) Let B. E. thro'
y^e^ center D be y^e^ progreSsive direction.
That will be neer an opposition to y^e^
course of y^e^ acceSs AB. But if E F were
an immense obstacle, & y^e^ side of y^e^ body
C[F?] infinitely slippery, such an impulse
at B wou'd drive y^e^ whole body almost
back towrds E ~~y~~by DE. y^e^ reason of
that shall be given, but in y^e^ mean
time observe here y^e^ foundation of
those wonderfull effects of windmill
sails & of shipps going against y^e^ wind,
{_} as they call it.,{/\} all w^ch^ depend upon this
case of obliq impulses, w^ch^ may be obvi=
ously applyed.

If y^e^

60. Direction will be in any degree from ye force

31. If ye substance of ye impell/d\ be confined by an immense obstacle, but so as it may move in some degree towwrds ye proper sepa= ration, & ye force of ye impulse is more than superior to ye fric= tion, ye impelled shall move. will celerity accordingly.

The example is in ye former proposition, For ye impediment by {ye confi}nement is not to ye whole separation, but to part of it, therefore ye Rest shall take place, but very weakly: Upon ye reason of this proposition depend diverse surpri= zing incidents in wedge work, as when ye wedge driven with a mallet, Instead of working into ye cleft, shall spring

spring out of it in a manner not very
safe to y^e^ by standers. For when y^e^ cleft
is too stubborn, y^e^ pinch of y^e^ materiall
against y^e^ slope sides of y^e^ wedge hard
driven amount to an impulse, in a
manner repercuSsive, w^ch^ makes it start
out. And so a round thing nippt be=
{_} tween{_f}inger & thumb, is mad{e_}fly
a considerable distance. And so a
ferry boat is made to steer it self
by a rope croSs a river, & no instance
is more egregious than y^e^ rudder of a
shipp, w^ch^ having y^e^ impulse of y^e^ water
violent upon its slope, runns back (as
I may say) with y^e^ efficacy of all that
force so that it draws y^e^ stern of a
mighty shipp with it, & of this sort y^e^
instances

{_} instances {~~of this sort~~} by windmills & shipp=
sailes & others are innumerable.

Force impreSst by an impulse
upon any part of an uniform
fluid, disperseth an influence
quaquaversum ad infinitum.[71]

And this, whether ye parts are Regular,
irregular or mixt, such as we have pre=
sumed most fluids in ye world more or
leSs to consist of, as air water spiritts
oyles &c. for Letting ye imagination paSs
to & fro from contact to contact thro
ye center, besides turning; ye spreading
effect here proposed will appear ne=
ceSsary; & as for ye infinity, what ever
our capacity of sence is, there is no mi=
nimum of force more than of Quantity.

In such fluids ye tendency of ye
force

[71] i.e., 'in all directions, to infinity'.

force will be by (quasi) strait lines from
y^e^ impulse as a center from all
y^e^ parts.

For accidents working one way will be set
right by another, as many accidents are
esteemed to produce a certainty; this re=
flexion will be of use when we come
to consider y^e^ case of luminarys, whereof
y^e^ emanations are strait upon this account
& no other.

If y^e^ tendency of force in fluido
is found to paSs either by pa=
ralell or converging lines; a
solid immerst of leSs force
than y^e^ fluid, shall be detru=
ded against y^e^ course of it,
if more, protruded with it,
& in equallity be stationary.

This suits y^e^ case of gravity & levity [~~...~~?] w^ch^
with

with y^e^ medium imbued with y^e^ force is comparative, for nothing can discend or ascend unleSs a quatum of y^e^ me= dium either way conformes; & neither can properly be termed the positive.

Gravity hath y^e^ property of a perpetual impulse upon y^e^ whole substance of y^e^ me= dium, with a direction in perpendiculo, & force stated.

This, & y^e^ rest that follow, are by com= mon experiment found true, & what= ever disputes may be about y^e^ cau= ses of gravity whither interior attrac= tion (as it is canted) or exterior pul= sion, w^ch^ is endeavoured in these pa= pers to be demonstrated, y^e^ consequen= ces will be alike, & y^e^ subject stands referred to its proper place.

A body

A body moving in fluido perse=
veres with force as y^e substance,
& y^e resistance is upon y^e whole
obverted superficies.

Therefore if abobody covered under such
part of y^e superficies, hath its substance
unequally disposed, it shall in paSsing
turn, & y^e GroSser part having more per
severance, preceed & y^e rest in course fol=
low, & settle in a posture so as y^e whole
substance shall be alike resisted by
y^e matter opposed at y^e superficies; & that
will be when y^e center of gravity of
y^e body & y^e center of y^e obverted su=
perficies are in one & y^e same perpen=
dicular line.

As let ABC, be y^e course in w^ch y^e body

A is propelled; of w$^{ch}$ y$^{e}$ center of gravi=
ty is a, & y$^{e}$ center of y$^{e}$ obverted su=
ficies b. untill those two points fall
in y$^{e}$ same perpendicular, that is at
B & y$^{e}$ points c & d fall in y$^{e}$ line Bc, y$^{e}$
body will not rest but turn, & settle
there.

> If a body in y$^{e}$ course is resis=
> ted by an infinite & immoveable
> force, ~~y$^{e}$~~the body not, [poised?][72] at
> y$^{e}$ contact as before, shall
> turn upon y$^{e}$ point of y$^{e}$ con=
> tact as upon a center.

This makes a confinement, so
that no other superficiall cen=
ter is to be looked for, & in me=
chanicks is called y$^{e}$ fulchrum,
& according as y$^{e}$ center of gra=
vity falls in or at distance fr$^{m}$.

that

[72] Or: 'raised'.

that, y^e^ opposite powers of y^e^ matter are
estimated as to more or leSs prevalent,
as here at A & B,. a is y^e^ center & b y^e^
immoveable obstacle or fulcrum.

How y^e^ mechanicall ballance & lever are
derived; appears by view of this diagrā,
wherein we may suppose y^e^ substance
wholly deprived, & scheme reduced to a
meer line, & y^e^ forces oppositions as at
A w^ch^ is a ballance & B a lever. w^ch^ lat=
ter is y^e^ soul of all mechanicall pow=
ers y^e^ view of which in draught only
explaines y^e^ Archimedean aenigma
Datum pondus cum data potentia.[73]

The expreSsions here suppose gravity
to be y^e^ active principle, but all y^e^ ef=
fects of y^e^ lever, & other mechanicall de=
vices

[73] i.e., 'the greatest conceivable weight with the least conceivable power'. The quotation is likely taken from the book rerferred to on the following page, John Wilkins' *Mathematical Magick, or, The wonders that may by performed by mechanichal geometry: in two books, etc.*, London, 1648, p. 79; the first volume was devoted to an account and explication of Archimedes (*see* note on fol. 114v, below).

vices, will fall under y^e^ same produc=
tion, be y^e^ force that of animalls, or
any other contingent disposition or ap=
plication; & y^e^ particularitys of such con=
trivances are so well known, & that by
their proper names & descriptions, as
not to need a speciall declaration or
delineation here, but (no dispraise to
y^e^ later authors) none hath perfor=
med better than D^r^ Wilkins.

61. Mecha= nicall powers.

32 In all mechanicall dispos=
tions of matter, wherein bodys
in action are opposed, y^e^ ad=
vantages result from y^e^ seve=
rall velocitys compared, uni=
versally.

This refers to engine-work, & is a co=/rollary\
drawn

drawn from y^e^ common theory of force,=
w^ch^ ~~y^e^~~is compound of quantity, & time, that
is velocity of matter. And may be in=
creased by multiplication of either ad in=
finitum. But y^e^ proposition above is
taken in here as a <u>test of all mecha=
nicall powers</u>. & dispositions whatsoe=
ver; for be y^e^ contrivance what it
will, whither, y^e^ common as y^e^ lever,
pulley, screw, or otherwise more out
of y^e^ way, take an account of y^e^ space
in w^ch^ y^e^ weight (to ~~y~~use that for instance)
moves, & that in which y^e^ force moves
in y^e^ same time (allowing for fric=
tion) & those two spaces compared,
~~gi~~/gi\ves y^e^ proportion of y^e^ one power ag^st^
y^e^ other obtained by y^e^ engine. As to
instance

instance, by a screw y^e^ weight shall rise
one foot, y^e^ hand that turnes it, shall
paSs y^e^ space of ten feet, w^ch^ gives y^e^ me=
chanicall advantage of ten to one.
And so of pulleys, measure y^e^ space
shortened by y^e^ weight rising, & y^e^ length
of rope that paSseth. y^e^ hand in y^e^ same
time, & those compared give y^e^ proper=
tion; so of a wedge, as the length of
y^e^ wedge, to y^e^ cleft opened by y^e^ paS=
sing of it, so y^e^ proportion; therefore
a sharp wedge hath most force; by
those & other devices machines are com=
pounded to exceed y^e^ power of materiall,
to resist, whereof y^e^ art lyes chiefly
in y^e^ application of them. Cartesius
wou'd not allow time in y^e^ cause of

mechanicall

mechanicall powers tho it allways fell
out so, for congruences are not causes.
But he mistakes y^e^ case, for y^e^ ques=
tion is not of causes but y^e^ demensions,
that is of velocity as well as quan=
tity.

61.2.
Body
moved in
circulo,
not tend
but

33. A body detained in a circular
motion, & set free, shall depart
as by impulse at y^e^ last con=
tact, whither it be a tangent
to y^e^ gyration, or not; as was
hinted before.

This is by way[74] of demonstration
ag^st^ those who lodge motus verus[75]
<space for diagram?> of body in a compaSs movement,
for, say thay, it always tends
to depart in a tangent, w^ch^ pro=
duceth a reseSs of all matter

so

[74] There is a circular mark, in ink, above the 'a' in 'way'.

[75] i.e., 'true movement', not a new term, but here used to invoke Newton who referred to '*motus verus et absolutus*' (ie., 'true and absolute movement'), that is the movement of an object not determined in relation to other objects, but as an absolute movement in absolute space (both of which concepts were anathema to Cartesians such as RN).

so moved from y^e centr, so farr, is true,
that matter set free, shall so depart,
because it will be by straight lines,
w^ch in course must at length leave y^e
cpmpass & its center. But that it will
be in a tangent I deny, unleSs y^e rules
of impulses require it, & every depar=
ture shall be according to those rules.
It was insisted that in y^e compaSs mo=
{_} tions, y^e last touch {~~or~~}, or instant of
freedom is an impulse. Then let y^e
table [c?] turn round horizontally
in y^e order ABD, & let three bodys
be deteined as in y^e figure; & then
apply a desperate stop at F. & y^e
bodys shall fly away as by lines
from y^e contact through their centers.
w^ch here is described, whereof only A
shall paSs in a tangent, but B outwa/rds\
& D

& D. inwards. So let sand be strowed upon
y^e^ table as at C, when y^e^ stopp comes,
those shall not go off in tangents,
but shall flirt about every way,
as y^e^ impulses ~~[shoul~~?]occasion to di=
rect them. Here is neither conatus
nor tendency[76] more than in other bo=
dys under a continuall impulse, &
for setting up a motus verus distin=
guisht from all other motions, some
other device must be sought, for this
will not do. It may happen that ge=
nerally these departures may appear
in tangents, but it is because y^e^
manner of detension, & y^e^ impulses,
by y^e^ universall rules require it. I
state this instance as at a stopp at
F.

[76] 'Conatus' is a Aristotelian term. The Latin word 'conatus' ('trying' or 'endeavouring') was a translation of the Greek word ὁρμή. Conatus, or ὁρμή, suggests a desire or will on the part of an object to behave in a certain way, it suggests an anthropomorphism. The word is ubiquitous in early-modern physics, as well as other sciences. Descartes adopted the term and sought to employ it in a purely materialistic sense, meaning the tendency of an object to move when struck by another object. RN did not approve of Descartes' use of the word and he criticised it in a number of places in the MSS (as does MN below, at f. 61v, where he declares that he uses the term for 'conformity of speech'), however he nevertheless continued to use it - although as we see here, he might seek to qualify it with a 'mechanistic' English translation, 'tendency'.

F, but it had been all one, it had
been stated so as y^e^ table & y^e^ bodys
contiguous, in those postures, [head?] all
rested together, &, instead of a stopp,
an impulse had fell at F y^e^ depar=
ure had been y^e^ very same, for a stopp
& an impulse are in truth in all
respects alike, so that no more reality
can be argued of y^e^ turning, than might
be inferred from y^e^ common impulsive
force, & y^e^ motus verus appears no more
in y^e^ one case than in y^e^ other, both
being alike relative.

631.[3]
~~n~~No cona=
tus ad mo
tum

34. No tendency or conatus ad motum
in any case whatever.

It is easy to shew what is true in those
cases in w^ch^ conatus or tendency are re/puted\
to take

to take place, but it is not easy to di=
vell y^e^ prejudice of such notions, out
of mens minds, being grounded upon
a vulgar Idea of reallity in motion,
& some phenomena intirely mistaken;
as when they say, omne Grave tendit
deorsum,[77] & y^e^ like. The truth of all
those cases is no more but this; There
is a continuance or rather continu=
all repetition of impulses upon a bo=
dy, w^ch^ cannot evidently answer them
by moving, by reason of some impe=
diment, but still y^e^ imulses continue,
& when y^e^ impediment is removed, then
y^e^ body evidently moves persuant to
y^e^ last of those impulses, & it is said that
in y^e^ mean time it rested under a cona=/tus\
ad motum

[77] i.e., 'everything heavy tends to decend'

ad motum. Therefore whenever, for confor=
mity of speech, one is tempted to use
y^e^ word tendency or conatus, it must
suppose a motive cause, but effectleSs
by reason of impediments, or at least
whatever y^e^ effect is, it doth not ap=
pear to us. And I cannot but wonder
that our capitall philosophers,[78] have
made conatus almost a principle,
or at least are not explained as to y^e^
truth of it.

61.[3].
No compound\ or mixt motions.

35. Motion is always single & never
mixt nor compounded.

If a notion is derived from divers pul=
ses succeSsive, & is so reputed of a nature
commixt, all y^e^ motions in y^e^ world are
mixt & none single, Such are y^e^ infinite
various

[78] A list of these would obviously include Descartes, and also include Hobbes, Spinoza and Leibnitz, all of whom elaborated fruitfully, although diversely, from the concept of conatus.

various agitations of y^e^ mundane fluids.
Therefore y^e^ question is not of such, but
of impulse separately considered, such
(& in truth there are no other) cannot
be compounded because in y^e^ effect they
are instantaneous. If a body be struck
by two or more points in y^e^ same instant,
y^e^ case is y^e^ same as of an impulse upon
y^e^ medium or center of all, as was ob=
served before. The ordinary insta/a\nce gi=
ven is by y^e^ production of a diagonal.

<space for diagram?>

As let a body move upon y^e^ side
of a quadratesquare from A to B, &
in y^e^ same time let it be born
down from A to C & y^e^ path of
its motion will be y^e^ diagonall
AD. Nor this is not two motions,
but [...?] y^e^ same two relations applyed to
one &

one & ye same /prescribed\ motions. For suppose ye body
not moved out of ye line AB, but ye qua=
drate or frame AD, by itelf, (being
loose from AB) mounted (in ye time)
up to GH, without touch or concern
with ye body of A, wch from a simple im=
pulse persues its course (in time) to B.
Is not ye diagonal AH as well pictured
as by ye suppositious mixture of motion
<red BM stamp> in A? so here are two relations, one
to ye station direct, from A to B, ye other
imaginary of a quadrate from A to G.
these two relations have nothing to do
each other, but a consequence is derived
of both. Therefore this is a Mathema=
ticall & not a physicall case; those ar=
tists supposing such motive paths, gene=
rate (as they style it) many various forms,
of wch

of w^ch^ nothing is true, but imaginary re=
lations, w^ch^ are arbitrary, that is, to be
or not to be any thing or nothing, as
was at first observed. If in a shipp un=
der sail, an arrow is sent right up, &
then collate y^e^ shipps way, y^e^ sun, starrs,
y^e^ soil, ~~wy~~^e^ water, with y^e^ line y^e^ arrow
makes, what a perplexure is y^e^ path
of that arrow, & how many relations
must conspire in y^e^ describing it? But
this proceSs of y^e^ mathematicians is not
here accused, as for any absurdity in
supposing lines created in this manner,
because all things poSsible, w^ch^ include
no contradiction, may be supposed, where=
by to gain a proof of certain measures,
& propositions. But when they come to
physicall matters, & pretend to demonstrate
reall

reall truths, from no better data than
such suppositions, we abrenounce them.
Des Cartes in his Dioptrica, pretended to
demonstrate y^e^ equiangularity of reflexi=
on, by supposing a mixt motion; And
a latter author[79] borrows that conceipt,
& carrys it a great way further & pre=
tends to demonstrate thereby all y^e^
known mechanicall powers; And to
both it is answer enough that there is
no mixt motion, & that they can never
prove any, so down-falls y^e^ demonstration,
If naturall aSsertions are to be proved, it
must be done by reall & experimented
truths, & founded upon universall axi=
oms; not by subtile [contrivancis?] & ar=
tifices of imagination. And therein lyes
y^e^ infirmity of all our physico-mathemati/call\
undertakers

[79] i.e., Isaac Newton.

64r



undertakers in naturall philosophy, as
I have elsewehere observed, & with some far=
ther explanation of my thoughts upon
that subject. And here, I may repeat
that whenever we shall leave y^e^ tracts
of reall truths in naturall philosophy,
& take in with y^e^ mathematicians, we
exchange knowledge for suppositions.
Now for reconciling action in fluido
take these two propositions & what
follows.

61[4]
Motive
influences
infinite

36 A body continguous to another,
is impelled, that shall impell
y^e^ other according to rule &
that others as far as contigu=
ity happ~~en~~/en\s in y^e^ directions

I might expreSs this proposition with much
variety

varivariety of forms & those irregu=
lar, but this here of a few
regulars shew ye course as well.
For imagination armed with ye
rules of impulses will repre=
sent any instance that can be
proposed. Here ye globe A im=
pelled at E impells B. & that C & so
D, all in ye same instant. And ye di=
rections falling as here at a, b, c, d,
ye last will fall directly pointed con=
trary to ye first. Hence may be con=
ceived ye infinte tendencys among ir=
regulars, especially fluids, & that an
uniformity of action results (as I ob=
served of rectilinearity) to us sensible
wch in ye elements is imperceivable, &
therefore

<space for diagram?>

therefore turns into hypotheses; /And\ ~~t~~thereby
we may be entertained with a poSsi=
bility ~~of~~that influences may be so won=
derfully conveyed as we observe of
them, & extending quaquaversum even
as infinitum, w^ch^ considering that mo=
tion consists in relation only is not very
paradoxical.

61.5.
Resistance

37. Bodys devided resist leSs than
y^e^ same united

As y^e^ bodys B & C. impelled y^e^ A with
diverse directions, Resist leSs than E &
F impelled by D al in one direction
This is considerable with respect to y^e^
transit of bodys in fluido as per next.

61.[6]
Fluids re=
sist less
than pow=
ders

38 Bodys conglomerate in solido,
are leSs resisted by fluids, of
w^ch^ y^e^ parts are in perpetuall
motion

motion, than if resting tho'
loose as powders.

For $y^e$ parts moving are a force per=
petually in ballance; so that to de=
termine their courses, one way or o=
ther, requires little motive force, &
that last sufficient to turn $y^e$ scales.
It hath been pretended that equall
substance resists, & therefore without
vacuity, there can be no motion at all.
Now as to fluids, $y^e$ case is $y^e$ same as
of scales, put $100^{ll}$[80] weight in each, $w^{ch}$
shall rest in ballance, add to one a sin=
gle ounce & $y^e$ whole $200^{ll}$ shall move,
this is not by $y^e$ force of $y^e$ ounce, for
what is that $ag^{st}$ $200^{ll}$? but it is effec=
tuall by means of $y^e$ equilibrity deter=
mined; so a fluid is in a state of per=
petuall but uniforme preSsure of all
$y^e$ parts

[80] i.e. '££', 'lbs', or 'pounds'.

$y^e$ parts equilibrated against each other,
& $y^e$ least force serves to determine $y^e$
action wherever there is a capacity
for it to move. Therefore a solid im=
pelled, is not resisted with equall
quantity, as if it were collected into
one maSs in opposition. But acts by
opening & closing as scales by rising
& falling & $y^e$ fluid parts by their
proper motion conforming. If a body
shou'd detrude $y^e$ matter before, & leave
a void behind, $y^e$ opposition wou'd be
totall, but $y^e$ void behind receives
in course $y^e$ matter from before fal=
ling in as when one weight sinks $y^e$
other riseth; This disperseth $y^e$ mist
raised against plenitude by a preten=
ded inconsistency of motion in fluido.

A

617
Bodys
in fluido
moves
wedge=
wise

39. A solid in fluido moves wedge
wise, either by ye form of it, or
by ye fluid collected both be=
fore & behind, & born along
with ye solid.

If ye superficies in front be a flat, ye
water about ye middle of ye front
cannot be at ye edge in a moment
therefore that (& so likewise more & more,
till near ye edge it may paSs sliding by)
is carryed with ye body in its motion;
& ye like if ye superficies behind be a
flatt, for always some of ye fluid will
remain there by way of edge or shel=
ter. As here ye body a moving in flu=
ido towards /b.\ be, carrys a part of ye fluid
b fibefore it, of a figure nearly pyra=/midall
& so

& so in like manner y^e^ eddy behind it
as at c. And it must be remembred
that a swift motion carrys more of y^e^
medium & in sharper pyramid than
a slower, because leSs time is allowed
to shift out of y^e^ way, & for that
reason a very violent course (as of
a cannon bullet) seems to rend y^e^ air
[~~&~~ &?] make a noise accordingly, for y^e^
driven air by alternate compreSsions
& relaxations breaks away at times,
& as may happen like disorder behind.
but a slow motion allows y^e^ fluid ac=
tion time according to y^e^ density to ac=
commodate, & then y^e^ paSsage is tran=
quill. And this will also depend much
upon y^e^ constitution of y^e^ medium, for
if it

if it be very dense & not without te=
nacity, as melted pitch, some oyles, or
mercury, ye impediments will be grea=
ter & these gatherings more; so that ye
different circumstances of moving bo=
dys, wch are very many, are always to
be considered. And however such a=
gencys, of /wch\ ye elements being impercep=
tible, are in our Ideas of them con=
fused, yet we must consider that they
acto by solid parts, wch are bodys govern'd
by mechanick rules, no leSs than a con=
geries of millstones so actuate woud
be, but of fluids more afterwards.

61:8
Substance added from ye fluid.

40 The quantity of ye fluid born a=
long with a body moving, is to
be accounted as so much of sub/stance\
added

added to it.

All y^e^ vertuosi are disposed to put their
cases of motion in vacuo, & I have com=
plyed with it, to fend off a shower of
objectins Ready to fall if I stated y^e^
matter otherwise, for most of them make
y^e^ rules in one state & y^e^ other, toto caelo
different;[82] as I might instance in many,
one is of Pardie's, who holds that in vacuo,
y^e^ least body moved y^e^ greatest with e=
quall velocity, & why? because a body
was indifferent to move or to rest, & any
thing that determined y^e^ indifference
prevailes, but he considered not that
there was more & leSs in y^e^ cause, & y^e^
indifference went only to y^e^ thing but
not to y^e^ ~~cause~~ /degrees\. But I must maintain
that all

[81] MN's own page numbering (crossed out in pencil by the BM curators) goes a little haywire over the following pages. This number appears to be 188 corrected to 138.

[82] i.e., 'the whole of the heavens' different, i.e., completely different.

that all y^e^ rules supposed to take place
in vacuo, are of like force in pleno,
for y^e^ adhering medium is but so much
added to y^e^ quantity of y^e^ body im=
pelled, ~~&~~ /&\ it is not materiall how it
may vary in y^e^ course of proceeding,
for y^e^ impulse is a meer moment, in
w^ch^ it is determined what y^e^ quantity is,
& y^e^ inception of y^e^ separation is ac=
cordingly & so also is y^e^ resistance when
a body in fluido is impelled by another.
The propositions of single impulses,
on w^ch^ y^e^ whole hypothesis of force
depends, may seem too abstract or
speculative to demaund an aSsent
with such authority as if mathema=
tically & in form demonstrated £For
altho'.

61.[9]
Cases of motion not to be demon= strated mathe= matical= ly.

altho quantities of substance, velocitys & positions may be postulated, with as much certainty as figures & dimensi= ons are in mathematicks, yet y^e^ con= clusions are not alike. For y^e^ latter determine of certain & permanent quantitys (consequentially) but these here conclude in event, & it is impoSsi= ble speculatively to exclude y^e^ im= perious (may be). It is probable a mathema= tician adept; may adjust these propositions with more art & exactneSs, than here is doen, & obviate y^e^ jealousy w^ch^ many may, & I must, have of errors & mistakes. But after all y^e^ aforesaid (may be) will in= terpose, & any one may say to any of them

them, perhaps it may fall out otherwise.
Therefore there is no strikt relyance upon
consequences, by any indication, but that
of experiment; And what applications
in that way, & with what aSsurance
such may be made is to be considered
next.

61.10
How to
experi=
ment im=
pulses.

First no experiment of these cases can
be made precise or without y$^{e}$ adjunct
of a (nearly) or (a little more or leSs)
because substances cannot actually be
adjusted (as mathematicks aSsume) in
any reall proportions exactly. Nor can
y$^{e}$ same be done as to figures & shapes,
& least of all velocitys, w$^{ch}$ must be sta=
ted at y$^{e}$ instant of y$^{e}$ contact, w$^{ch}$ cannot
be done

be done with tollerable satisfaction; for
y^e^ mediall resistances perpetually influ
ence to diminish them. But in y^e^ GroSs,
& at y^e^ chief periods of y^e^ computations,
Experiments may declare y^e^ events of
impulses so nearly as may amount to
y^e^ higest degree of probability. In order
to w^ch^ I propose to take in hand solid
lumps of mettall, such as y^e^ heads of
iron hammers, w^ch^ have y^e^ least spring
and are most obdurate. Choose of these
y^e^ fittest for y^e^ purpose, & have a near
gueSs at y^e^ weight, whereby to aSsign
y^e^ measures of y^e^ substances to be im=
pellent or impelled in proportion. Lett
these swing at y^e^ arms end, hanging per=
pendicularly, & moving freely, & so lett
them clash face /to\ ~~to~~ face & observe as
one may

one may quasi feel.

First an equall shall drive its equall
with y^e^ same speed, & nearly stop in its
place, & if they meet equally swift, they
shall part several ways in like man=
ner, And if unequally swift y^e^ parting
will be with commuted velocity. This
of equalls upon equalls is almost a
standard case. The next is that a leSs
body against a greater shall reflect
nearly as y^e^ difference. And a greater
upon a leSs, shall follow. And upon
an oblong with obliquity of substance
shall make it turn as well as de=
part, & y^e^ leSs obliq leSs turning, & with
more, more. So also of y^e^ progreSsion,
y^e^ more obliq y^e^ slower. And of irre=
gulars somewhat may be observed by
theise

this means & a great deal from y^e^ ordi=
nary & contingent clashings of bodys,
that happen among operators. One
might invent, & dispose matters for ex=
periment of these cases more [cleaverly?],
as by Granado shells filled more or leSs
with leaden shott, or having y^e^ weights
adjusted by melted lead powered in, &
suspended at long radius's. These suffered
to clash, being weighty, will move slow
& shew y^e^ events, so as they may be near=
ly judged by y^e^ bare eye. But somewhat
must be allowed to y^e^ spring of such
bodys, tho even that may be corrected
by filling y^e^ shells with water (if le/e\ad
be not used) w^ch^ hath no spring. If y^e^
discovery of these events make @appear
that a measure of substance & velocity
decide these groSs consequences, it will be
thought

thought probable that ye like govern ex=
quisitely in all cases of impulses whatever,
& if ye momenta of each might be pre=
cisely known or stated, ye conclusions
wou'd be nearly mathematical; And ye
same hath been attemptd in some mea=
sure, but not with an universall view,
{__ cernd} that I know of. I have been more co{n=}
{th}at this subject of mechanicall force
shou'd be carefully apprehended, because
some physicall conclusions depend upon
it. For whatever of motion is true in
cases of groSs bodys, is true of all like
forms & proportions tho never so small.
And neither immensity nor exility of ye
proportion of events, & where we cannot
prove by actuall experiment, we must
grant upon ye analogy of causes & effects.

Eadem

Of impul=
ses trac=
tive

Eadem ratio eadem lex.[83]

It may be recollected that before prop:
28 for better judging inclinatory cases,
or obliq impulses, I have spread y^e^ point
of contact into an universal (imaginary)
plane, naming it y^e^ tangent, of w^ch^ some
further use is to be made. In y^e^ mean
time I wou'd not have it thought a meer
chimaera, for a point is indivisible, &
cannot be touched or touch by any di=
rections expanded or inclined beyond y^e^
compaSs of an hemisphear according to
Euclid who allows no quantity to y^e^ an=
gle of contact therefore every point
acceSsible is quasi y^e^ tangent point of a
{_} circle, & that becoming an indefinite plane
determines t{o h}emisphears of w^ch^ y^e^ supe=/rior\
may be

[83] i.e., 'the same reason the same law' (more properly '*ubi eadem ratio, ibi eadem lex*').

may be called $y^e$ hemisphear of $y^e$ force, &
$y^e$ inferior $y^e$ hemisphear of $y^e$ departure,
for as $y^e$ impulse cannot come from any
point without $y^e$ sweep of $y^e$ former, so
$y^e$ departure of $y^e$ impelled cannot be to=
wards any point without $y^e$ latter, all
$w^{ch}$ $y^e$ view of $y^e$ diagram to pro 28 will
demonstrate.

This extends to all cases universally,
where $y^e$ tangent plane does not in=
tersect $y^e$ body impelled or any part of it.
But it may happen that some, if not
$y^e$ greatest part of it may (by such
intersection) fall within $y^e$ hemisphear
of $y^e$ force, & perhaps $y^e$ departure of such
part if not of $y^e$ center of $y^e$ impelled
may tend into $y^e$ same hemisphear.

Therefore

Therefore I must make a distinction between
forces pulsive & tractive so that $y^e$ depar=
ture of so much of $y^e$ impelled as falls
beneath $y^e$ tangent plane is from a force
pulsive, & as to so much as falls above $y^e$
tangent is from a force tractive; $w^{ch}$ I
observe because I may not seem to have
{_} done half my work. But {$y^e$ doc}trine
will by plain analogy govern both
cases alike, & there cannot be an impulse
contrived so interior as to leave great
part of $y^e$ impelled
in $y^e$ hemisphear
of $y^e$ force, but with=
<space for diagram?> all a point may be
found in $y^e$ exterior
superficies on $w^{ch}$ a
force falling im=
pulsively will not
cause $y^e$ very same
departure, of $w^{ch}$ be
this a diagram

{_} {(}a{)} Contact point. b~~e~~ center of $y^e$ impelled.
a.c. impulsive tractive. ~~b~~Ed, im{pulse}
{_} pulsive, bd common departure. f g,
tangent plane. And thus every force
whether pulsive or tractive falls un=
der $y^e$ like rules of impulses $w^{ch}$ are for=
med upon $y^e$ velocity of $y^e$ action & quan=
tity of substance universally as hath
been before particularly declared, &
are $y^e$ law of all mechanicks.

## Extent of our Facult~~i~~eys

62.
Difference between perception & know= ledge

Thus farr in generall, concerning $y^e$ princi=
ples from whence all our knowledge of
nature is derived; And in $y^e$ next place
wee advance, by some applications to $y^e$
state of $y^e$ universe as it is represented
to our minds by means of sensation;
And under this we must distinguish
between perception & knowledge; for we
often

often have strong perceptions, but we
know not of what, but only that we
perceive, as when men say they are
uneasy, or that they ail somewhat,
but know no more. This is a true but
not a usefull sensation, w^ch^ (latter)
comes only by knowledge. And when
we have not power to perceive y^e^
constituent parts of any object, we
may admire, but without some as=
cititious instruction, we remain igno=
rant in y^e^ midst of sensation. And
out of this ignorance flows certain
adventitious but false Ideas of some=
what, w^ch^ in truth are as nothing, as
(for example) continuation, for all
things in y^e^ world small & great, are
alike distinct one from y^e^ other, how=
ever we may perceive aggregates, as

being

being singulars, w^ch^ is a false perception;
as of y^e^ Galaxy, Harmony, Heat, & even
time itself, w^ch^ are all by distinct touches
yet to our minds represent a continu=
ation. As for space or corporeal ex=
tension it is, y^e^ only thing in y^e^ world
w^ch^ may be understood continuando.[84] But
yet it comes to our notice only by pul=
ses distinct for all materiall things
in y^e^ world w^ch^ transact them are dis=
63.. tributed per partes.[85]

The ex=
tent of
our fa=
culties.

It becomes therefore very materiall to
be well informed whence this defect, &
y^e^ consequent errors proceed; & it seems
y^e^ cause lys not in any default in our
perception, for that is perfect, but
in y^e^ power of our members to act
{_} {w^ch^} according/g\ to their frame & magnitude
is limited & respects other substances,
comparatively

[84] i.e., 'to be continuous'.

[85] i.e., 'from each individually', the point being that we apprehend the continuity of the world around us from a host of individual instances of (or in) that world.

comparatively, w^ch^ is mechanick. For
if we cannot mark y^e^ diversity of
things by some action of our mem=
bers, as nodding, pointing, or y^e^ like,
such things appear, not diverse, but
continued; as in y^e^ instances above.
And it is obvious to conceive that diverse
pusille animalls, as flys &c w^ch^ move
their wings with notable celerity, may
perceive very minute things distinctly
as y^e^ ingredients of colours &c w^ch^ to
us seem continued; & if we retire to
y^e^ seat of imagination & see what is
doing there; we shall find that nothing
in that sphear will have place, but
what[,?] is or may be corpor/e\ally transacted
Any one may prove this by his power
of interior reflection. For let him on=
ly imagine numbers of any thing paSsing
by

by, & in ye Idea of counting he must
conceive himself acting, & if ye fancy
carry them so fast, as in truth ye ac=
tion could not have distinguished, ye
Imagination wou'd not do it but
fall into a conceipt of continuance,
as in fact ye sence it self in like case
had done. And this extends to spaces,
for altho we may move a finger
an inch, we cannot do it an hair's
breadth; therefore small dimensions
are inconceivable, & ye mind in ye
act of attention to various things is
limited; for there can be no atten=
tion to such as ye members can by
no means distinguish; & therefore
free will wch commands ye attention
fails of its power, for if one hath an
utmost desire to distinguish & applys
to it

{_} to it with all y^e^ powers of {<u>its</u>} will, unleSs
he hath his instruments where-with to act
corporally or at least fancy so he cannot
attain his desire, therefore it is concluded
that indistinction argues no imperfection
in y^e^ mind, or apprehension of things,
but that all defect proceeds from y^e^
magnitude or power of y^e^ bodily engine;
And that must be intended when we
say, any thing is in or out of y^e^ reach
of our faculties.

64.
Difference between distingiuish=ables & indistin=guishables

Hence flows a distinction very mate=
riall in all naturall science, & that
is between things distinguishable &
indistinguishable; this distinction is not
founded in y^e^ nature of things, but in
y^e^ power of our facultys. For, as I sayd

all

all corporeall powers great & small are
ruled by like measures, & those are ye e=
vents of impulses; as hath been at large
dilated in ye aforegoing propositions. And
in ye promiscuous state of things moving
in ye world, ye actions & events of bodys
that are distinguishable, are ye proper
objects of sence, & being experimentable
by diverse /modes of\ applications afford us just
appearances, & we need not fall under
any mistakes concerning them; And within
these limits are comprisꝛzed all things that
our sences can take any precise account of
circumscribe, or terminate, with ye proper
powers & symptomes of their natures, wch
ordinary practise, or more diligent expe
rience have more or leSs discovered to
us; &

us & I need not add instances of things so well known; y^e^ single one of a golden ball, toucht upon before interprets all the rest.[86]

65. Naturall history im= proved.

And I may summ up all by referring to na= turall history, of w^ch^ every man that lives, & breaths, gathers his share, & some, with most laudable industry have collected much more; w^ch^ (in history) have been & are d~~ai~~/ai\ly communicated for y^e^ benefit of human kind. And y^e^ great patrons of discoverys, by art & mechanick con= trivances, have brought to light & ma= nifest distinction, such exillitys as nude perception by many parasangs cou'd ne= ver have reached; such as y^e^ animaculae, & circulation (as it is called) of y^e^ blood most evidently seen in fishes,[87] & on y^e^ other side, of

[86] *See* f. 7, above.

[87] MN/RN here refers, of course, to the microscope and the telescope. The demonstration of the circulation of the blood by means of viewing the tail-fin of a fish through a microscope (against a bright light) is famously associated with Anthony van Leeuwenhoek (1632-1723).

side, of amazing immensitys whereby $y^e$
cosmography of $y^e$ universe is in great
measure regulated, all $w^{ch}$ with $y^e$ leSser
operations of $y^e$ virtuosi accumulate
experiences, but yet do not develope $y^e$
crypticks of nature, that reside in mi=
nuteneSses indistinguishable & so utterly
inscrutable. And what is to be $y^e$ phi=
losophick behaviour as to those mat=
ters, must come under consideration,
66. next.

Indistin=
guishables As to $y^e$ condition of $y^e$ universe, while
[exteemed?] we have no sence or experiment of va=
by analo= cuity, there is no reason to presume ag=/st\
gy with dis= absolute plenitude of impenetrables,
tinguishables according as was insisted before. And
that in all fluids there is a manifest
{_} de{£vi}sion of $y^e$ matter into minute parts
or bodys

or bodys, w^ch^ are in perpetuall motion &
counter change of places, is discovered,
by y^e^ dispersion of powders, smoak & o=
dours, w^ch^ are most sensible, & cou'd not o=
therwise happen. And y^e^ like is made
apparent by y^e^ paSsage of groSs sub=
stances, with little or no disorder, thro'
them. And seeing that about us we
find all distinguishable substances,
unequall, variously figured, & without
any kind of regularity, we have rea=
son a similitudine to conjecture, that
y^e^ rest of y^e^ divided matter of y^e^ world
(in those respects) must be in a like
condition, that is difforme & irregularr.
And we find also that not only ~~y~~^e^the
common lumps of matter both great
& small, as stones, sand & y^e^ like (of w^ch^
we

we can take any account) but all other
solids conglomerated of those, or other
species are difforme & unequall, as also
y^e^ ingredients of all compositions, when
by solution, they can be examined; from
whence (as above) we argue to y^e^ state
of things universally, but with this re=
serve, that there may be such simi=
larity, aptitude, or other contingent cir=
cumstances, w^ch^ in promiscuous action
may be a means that bodys of certain
formes & dimensions may gather toge=
ther, & be distinguisht in groSs fluids
or solids of various dispositions, as when
{_} things are severed by cri{~~p~~br}ation, or
by y^e^ tormenting furnaces of chymists
whence are produced salts, sulphur, &
diverse magisterys & corrosives w^ch^

disperst

dispers't in y^e^ common fluids, or mixt
with other conglomerate substances, are
absconded, but y^e^et retaining y^e^ very I=
dentick substances, & minute formes,
& capable by like mens to be brought
together again & be denominated as
before.

67.
Elementa=
ry matter
not disco=
verable

Before I drop this universall specula=
tion if reall substances in y^e^ world, some
matters must e considered; As frst
that all things palpably known & dexa=
minable, are found to consist of parts
seemingly united together (y^e^ manner is
reserved to its place) but yet discerpable,
& further, that all y^e^ frusta[88] that to us
appear as parts, consist of minor parts,
& by chymistry those are also found parta=
ble & sic (for ought can be made appear)
ad

[88] i.e., 'pieces'

ad infinitum; but so farr is certain
that neither /by\ chymistry or other means,
can we discover any bodys, or parts
w$^{ch}$ are indiscerpable; Whence we may
be aSsured that y$^{e}$ Elementary state
of things of w$^{ch}$ y$^{e}$ universe consists,
lyes absconded in inconceivable minute=
neSs; And that all discourses leaning
upon any presupposed formes, & actions
of elementary matter, such as y$^{e}$ Car=
tesian &c. are unphilosophicall & vain;
& all that can be conjected in that
sphear, must fall in generalls, as may
be vouched by a conformity with things
palpable, & not in any subparticula=
ritys whatever.

## Of Motion in fluido

68
Motion in pleno vindica= ted.

It is now expedient that a poSsibility of motion in pleno should be further vin= dicated, for ye vacuists fiercely deny it. I need only, with the old philosopher, to prove it, rise up & walk;[89] for if any thing of a complex action be manifest, to scence; it is ye ceSsion of fluids to con= globate bodys. moving in them; ye manner of wch hath been partly described in ano= ther place; at present it is enough~~t~~ to reconcile ye inconsistences urged against it, by shewing that if there were a ge= nerall, or intersperst vacuity yet things being crowded together as they are, it woud not help ye case of motion, but it wou'd be (nearly) ye same as if all our fluids

[89] Diogenes (*c.*412-*c.*323 BC) when asked what motion was stood up and left.

fluids were (as we take them to be) plena=
nary. And to instance in water; It is pro=
ved that y^e^ parts are contiguous, & that
y^e^ body is not further compreSsible by any
force, & it is shewed also that it lyes un=
der such perpetall compreSsure, not
only by y^e^ weight of its own body, of
w^ch^ y^e^ superior parts perpetually preSs y^e^
inferior, but also by y^e^ weight of y^e^ bo=
dy of y^e^ air that lyes upon it, w^ch^ by
Torricellian experiment appears to be no
trifle. And bodys sinkin~~k~~g & fishes swim=
ming in water, must in some manner
remove y^e^ substance of it, as ~~y~~^e^they paSs.
All w^ch^ is done by a force much inferi=
or to that of y^e^ preSsure, w^ch^ brings y^e^
case to y^e^ same difficulty, as some ob=/ject\
in pleno

in pleno; for if there was not an easy
ceSsion of y^e^ matter, as is most observable,
opening before, & closing behind, things
cou'd move no more (as fluids now are)
than if y^e^ vacuitys were granted, because
y^e^ weaker (action) cou'd not prevail ag/st\
y^e^ stronger (compreSsion) when y^e^ oppo=
sition is so disproportionate; If y^e^ fluid
were to be moved quantity for quan=
tity & in like time, I grant motion
thro it were impoSsible. But it is
not so, for y^e^ fluid stands upon a bal=
lance of all its parts w^ch^ are in conti=
{_} nuall motion (uniformly/{)}\ & a small
force determing them (gradation) one
{_} way or other. {A} equall weights in
scales, were it 100~~11~~ in each, will turn
with a single ounce, & such is y^e^ case of
motion in fluido, w^ch^ matter hath been

in part

in part already noted, & will be further
considered afterwards. But I must not
omitt to answer a common but Idle
allegation, that nothing can move till
was is made by ceSsion of other matter,
& (in fullneSs) that (as they say) cannot
be; ye answer is that ye impulse & ceSsion
{_} {are eadem instante} are eadem instante,[90]
{_} & (in fluidity) {it is} in circulo[91] as engins in
turning all ye parts move & remove in
ye same instant, & it is ye same case of an
arrow, ye head advanceth & ye feathers
{_} follow altogether, & is /{_}\ that enough to
answer so vain a scruple? if not con=
69. sider that no part of ye fluid is carry=
great bodys ed on, but all is left in its proper place.*[92]
leSs resisted It being cleared that compound or large
by fluids bodys will paSs thro fluids, it must be
than small considered that it never is without

some

[90] i.e., 'at the same time', or 'simultaneously'.

[91] i.e., 'in a circle'. It is not clear what is meant here, perhaps MN is saying that engines continue to turn even when they are moved.

[92] The cross/asterisk refers to a note in the LH margin of the next page.

some (tho not a totall resistance of $y^e$
fluid against $y^e$ force with $w^{ch}$ they paSs
whereby $y^e$ speed is continually abated;
as in all cases when smaller bodys lye
in $y^e$ way of greater bodys, & Gradually
deprive all their velocity. And this
resistance hath respect not only to
$y^e$ condition of $y^e$ fluid, but also to
$y^e$ magnitude of $y^e$ body that paSseth;
I make no account of figure here,
but suppose all to be alike as globes,
(for instance); And then as to $y^e$ fluids,
they are of diverse consistencys, &, as
was observed, resist accordingly; as
pitch melted resists more than water,
& that more than air, & that (perhaps)
more than either.[93] And then, whatever
$y^e$ fluid is, $y^e$ resistance is leSs effectuall
against

* for chipps and stra/ws\ paSs by, and are left behind in $y^e$ same order (nearly) as they lay be= fore, & $y^e$ action is not a protru= sion, but a se= paration of $y^e$ fluid mat= ter, & what impediment that will be, will be consi= dered next.

[93] It would make more sense here if we read 'ether' (or 'aether') for 'either'.

against great, than it is against small
bodys according as $y^e$ substances hold
proportion with $y^e$ superficies. The force
of a moving body is gaged by $y^e$ sub=
stance, & $y^e$ resistance by $y^e$ superficies.
And $y^e$ increase of force is triplicate
as $y^e$ cubes of $y^e$ diameter, but of $y^e$
as squares of it, $w^{ch}$ is but duplicate;
& $y^e$ like of decrease reverst, $y^e$ greater
body diminishing looseth force as cubes
but $y^e$ superficies looseth by squares
only, & (one woud think) may hold
out longer than $y^e$ substance, of $w^{ch}$
notion some use may be made af=
terwards. In $y^e$ mean time, we are sure
that $y^e$ course of small (coagulated)
bodys thro' fluids are more resisted.
{_} (substance considered/{}\ than greater &
a body

{_} a body in respect to y^e^ minute parts of a fluid {<u>must</u>} be so groSs that y^e^ re= sistance of y^e^ fluid against them shall be inconsiderable. All great things being leSs resistable & more pervicaci= ous in paSsing than small ones, where= of y^e^ reason was touched before. W^ch^ notion will resolve diverse phaenome= na of nature, as shall be shewed else= where.

70. SwiftneSs belongs to small & not to great things

As to y^e^ intestine movement of fluid mat= ter, we can form no other Idea of it, than with analogy to things distin= guisht, & experimentable; because y^e^ minuteneSs of matter flys all manner of sensible discovery. Therefore we must first imagine, that as sensible

things

{_} things reall{ɾ} consist only of impene=
trable matter, & that in every instance
of contact, change of aspects & dis=
tances, that is motions are governed by
rules of dimension impulsive. ~~w~~We
have reason to conclude that y^e^ least
things (however indistinguishable)
being impenetrable, & figurate are
lyable to y^e^ like consequences (in pro=
portion) as are deducible from every
contact, according to y^e^ rules before
declared, w^ch^ afford this difference that
being minute they are more mobile,
& so are y^e^ more minute (continually)
than greater things because they re=
sist leSs. And it is observable in y^e^
world, that y^e^ swiftest agitations are
among

among ye smallest, & ye slower with ye lar=
ger bodys, wch ye actions of animalls great &
small plainly demonstrate. And that dif=
ference (mentally) translated to ye elementa=
ry parts of common fluids, argues an in=
conceivable swiftneSs, as well as minute=
neSs of them. And in all that extream
abceSs of matter, no one part moving e=
ver toucheth another; but ye effects of mu=
tuall impulse succeed. And considering
ye plenitude, ye whole divided materiall
of ye world reciprocally acts & is actua=
ted circuatim[94] indefinitely. And there is
nothing can be called rest, but only when
two parts join & do not separate, (if any
such happen) or if ye parts of ye same body,
{_} {wch} always hold ye same aspects & contigui=
ty together. And we are not to be discou=/raged\
in these

[94] i.e., 'around it'.

in these speculations, because we do not
(among sensibles) find anything conside=
rably like to fluidity, for stones, sand, dust
& impalpable powders lye quiet; But ye
imagination may help, as supposing in a
heap of stones, other stones, in ye intervalls
shou'd fall into a rapid & shallking motion,
such heap woud like water, fall into a
levell, & by no means stand accumulated.
But we have an experiment of solids,
as I may call ye powder of Alabaster,
ye consists of small stones, becoming, as it
were, fluid, for that powder ofver ye fire
will appear almost to boil.

71. Motion acco= modated by interstitiall matter.

Now to enter deeper into ye these poSsible,
if not probable constitutions of ye com=
mon fluids of ye world; They must consist
of matter in parts of all variety of shapes
and

& (imperceptible) magnitudes, w^ch^ are inter=
mixt, & being together with matter it self
(w^ch^ must be postulated), once, as at y^e^
beginning of y^e^ world, put into agitati=
on, there will succeed a promiscuous ac=
tion & paSsion, y^e^ parts perpetually striking
& being striken, & so rolling & interchan=
ging all manner of ways; And it is
impoSsible y^e^ universall agitation shou'd
cease wholly, tho' perhaps there may not
be y^e^ same modes or degrees in all places,
but as y^e^ matters & agitations vary, y^e^
state there abouts may also be influ=
enced. But is is not considerable to
reflect on y^e^ [genius?] of y^e^ in[~~.~~?]terstitiall
matter. That there is such & in all pla=
ces of y^e^ fluid world, may be concluded,
because y^e^ matter is made up of irregular

or perhaps

or perhaps some near to regular figures,
w^ch^ will require interstitial spaces to be
frequent amongst them; And those must
be filled with matter, of w^ch^ y^e^ like is still
affirmed, & in y^e^ same manner, of one
order within another, as infinitum of
minuteneSs; as I am about to shew, w^ch^
accomodates all promiscuous action, it
being scarce poSsible any place or space
shou'd happen, & matter not be at hand to
fill it. But in y^e^ mean time I must note
that here I use y^e^ style of y^e^ vacuists,
but according to our hypothesis, y^e^ presu=
med spaces are reall body & neither want
nor admitt any other filling, w^ch^ sup=
plants all objections of this nature, &
so I go on.

72.
Actuall infinity

Here waving y^e^ dispute of divisibility

86r
of minute=
neSs of
matter



of minute=
neSs of
matter

ad infinitum, w^ch^ is now universally allow=
ed, I insist further, & (upon like probabi=
lity) affirm/;\ that there is actuall infi=
nity of ~~matter~~ /small\ things; & as immensity of
space, is without limit, so exility of di=
vided space or (if you please) matter is
also unlimited; both w^ch^ cases y^e^ mathe=
maticians describe, by quovis dato major
aut minor,[95] So that if any case is objec=
ted of matter put into difficulty to move
for want of acceSsion to accommodate,
I can say as before that there may be smal=
ler & smaller almost everywhere for
supply, w^ch^ cannot be denyed, for actuall
infinity includes no contradiction: And
every state that can be invented or con=
ceived for body, whether of form, action
or mag=/nitude\

[95] i.e., 'larger or smaller than any given'.

or magnitude, is poSsible penetration on=
ly excepted. Whither parts may cohere or
divide will be considered next; At pre=
sent it is presumed that $y^e$ matter of $y^e$
world, as well at large, as in $y^e$ intersti=
tialls of conglomerates, consists of minutes,
diversifyed, divided, unequall & actually
more & more minuted, indefinitely &
perpetually interspersing & moving with
inconceivable agillity, & allways accor=
ding to $y^e$ rules of impulses. And it is
not discovered that any composition can=
confine or exclude $y^e$ subtile matter in
all places intersperst, but on $y^e$ other
side that it actually permeates $y^e$ clo=
sest veSsels men can form any famili=
ar Idea of, as to instance of air paSsing
thro walls

87r



thro walls of straw. And when quanti=
tys seem to be confined, as in y^e ~~p~~hneu=
matick experiments whither exsucking
or compreSsing, it is by way of vibration,
when y^e groSser substances only are
detained, & y^e more subtile paSs in or
out freely. And what phaenomena may
depend on y^e contingent separations &
various dispositions of y^e subtile mat=
ter of y^e world, may summarily be
presumed afterwards. In y^e mean
time, without violence to thought
we may presume that (excuse a bold
expreSsion) y^e universall world is com=
pounded of infinitys unequall, diSsi=
milar, & of incommensurate parti=
cularitys.

72.[2] Continuity of matter

The naturallists have been at a loSs how to

a dark subject.

how to resolve y^e^ continuity of matter, or compounds of many parts; Cartesius said by rest, but that answers not y^e^ why or y^e^ how. The atomists have said by Hamositys, but what holds y^e^ parts of those hooks together, & sic ad infi= nitum? This made Le Clerk say that y^e^ question is irresolvable because it ever returnes, but there is a better reason, w^ch^ is that y^e^ cause is hid in extream minuteneSs. The Newtonians

25[96]

say by <u>attraction</u> w^ch^ is ultimately strong in y^e^ contact, & so things hold together by a quality of holding together. It is certein that no experiment of this effect can be made in sensibles, & to work by analogys & poSsibiltys is but an infirm proceSs, & here y^e^ subject is uncomfortable

[96] This is clearly a reference - but, to what?

uncomfortable, Audendum tamen.[98] The question is pregnant of another, w^ch^ is se= paration; It being no leSs abstruse to know how matter, being one, may be bro= ken, or divided into two, or more, than it is to discover what cement holds y^e^ parts together.

22.[3] of union & y^e^ means {there several?}[97]

And first of union, that{_}is an oneneSs of{_} materiall parts must be taken as a principle included in y^e^ eSsence of bo= dy; for that is continuall, and hath no distinction but what results from mo= tion, w^ch^ is eo nomine[99] a separation, & that only affords y^e^ distinction of one thing from another. But it doth not follow that parts once devided, & coming toge= ther again, or diverse parts in contact must

[97] (What I read as) 'there several', in pencil, in the margin, to the left of the section heading. It would seem that the words are to be entered into the text at the places marked by underlining. This pencilled-in writing, here and elsewhere, employs a distinctive greek 'e', leading us to ask whether, if the main text is in MN's hand, these comments might not be in another.

[98] i.e., 'yet be bold'. *See* Quintilian *Institutione Oratoria*, Book 1, chapter 5, section 72; the phrase had been previously and famously used by Horace in Epistles I, 2.40. *See* also BL Add. MS 32546, f. 153r; also BL Add. MS 32545 29r and 202r, also note 38 in the biography page on this website, at http://www.ucl.ac.uk/north/bio.

[99] i.e., 'by that name', i.e, 'by definition'.

must neceSsarily unite, & become one,
tho' it is hard to shew a difference, be=
tween such union, & y^e^ coherence of
{undevided} matter originally {undeivided}. If y^e^ con=
tact be by points there can be no co=
hesion, for how Shou'd any thing lay
hold cujus pars est nulla?[100] therefore y^e^
contact must be by superficies, & those
may be either flatt, or curve; if flatt,
we have a resemblance by flatt po=
lished marbles, w^ch^ are found to cohere, so
that in paral/e\lelism it is very hard to part
them. The preSsure of y^e^ Atmosphe~~r~~ear
(by a neceSsity of some Torricellian va=
cuity in y^e^ middle) hath been e~~x~~stee=
med y^e^ cause, but that hath been re=
moved in y^e^ exhausted receiver, & yet
some

[100] i.e., 'no part of which exists'.

some cohesion remains. This cannot be
by attraction, for in any other manner
than paralell, y^e^ peices will freely sepa=
rate as either angular~~ity~~ly, or (friction
considered) by sliding. But pure pleni=
tude without preSsure will hold flatts
in that manner together, for matter
cannot succe/e\d in y^e^ middle at y^e^ same
instant as at y^e^ edges. Thus farr con=
tact may joyn matter, so that it may
not readily b~~y~~e divided, & if we sup=
pose a compage of flatt bodys tou=
ching by superficies, & constituting a
pyle of thousands, it is not conceiva=
ble that these shoud part by any
means or force but what is exter=
nally & minutatim applyed,[101] & for
ought I know May be y^e^ case of metta=/lls
& stones

[101] i.e., 'applyed bit by bit'.

& stones, w^ch magisterys will corrode, but
force groSsly applyed, will not diSsolve;
but there is a further inducement
to think that plenitude hath a great
share in cohersion, for if y^e superfici=
es are curve so as not to slide one way
or other, or scarce be made to open an=
gularly, y^e bodys must cohere. And y^e
superficiall parts will not readily
separate because of some preSsure
from y^e medium, & those must depart
before y^e rest can remove.

73.
Of polished
marbles
& touch.

I do not mention this case of polished
marbles as a clear instance of cohesi=
on, but in gradu only,[102] for we know
that what seems tous us a perfect flatt,
is not truly so, but [rugged?] &, probably,
touching more by points then by super=/ficies\
& y^e

[102] i.e., 'by degrees'.

& y^e^ subtiler matter that permeates all
is in y^e^ way to impede much y^e^ nett
contact, & facilitate y^e^ separation, but
if y^e^ flatt were perfectly cotangent in
all its parts, I cannot say /if any,\ what force
{_} (in a paralell state{}) woud part them;
for it is not reasonable to distinguish
between such touch & y^e^ consistence
of pure matter; It is some reason for
cohesion of parts, that there is no spe=
cificke gravity effectuall, betwe~~en~~/en\
y^e^ component parts of a body & y^e^ me=
dium, w^ch^ shoud cause such bodys that
consist of parts supposed to be loose,
to fall in pieces; Collections of groSs
bodys in a pile of brick lifted up
woud scatter, because y^e^ parts are much
heavier, & wou'd fall thro y^e^ air; but
if they

if they were as small as smoak they
wou'd not separate by force of gravi=
ty, so that ye image of falling in pie=
ces is derived. of large and heavy bodys,
& ought not to be transferred upon ye
minute, that wou'd swim in the air as
parts of steel do in a fluid menstru=
[qu][103] um[104] of{ wch} ye compounds must diSsolve
gradually, and by apt means & not all
at once, even Ice it self will not diSsolve
but by superficiall operation Gra=
dually.

74. Of con= glomera= tion by friction

Another cause of conglomerates is friction
tion, for when parts are interwoven,
as bricks & stones in masonry, admit=
ting there were no principle of cohe=
sin, a body so composed coud not be
broken without a mutuall fricture
of ye

[103] RN uses this abbreviation (a lower-case 'q' with an indeterminable superscript letter, which I read as 'u') a number of times throughout the MSS. I read '$q^u$' (here, and elsewhere in the MSS) in agreement with Jamie C. Kassler (*Seeking Truth. Roger North's Notes on Newton and Correspondence with Samuel Clarke c. 1704-1713*, Ashgate Publishing Limited, Farnham, 2014, p. 10) as an abbreviation of '*qaere*' meaning 'enquire', or as we might say 'to be checked out'.

[104] i.e., 'solvent'.

of y^e parts in y^e separation, w^ch demands
some force to conquer, & this seems to
be y^e case when a barr of iron is to
be broken. This brings to my mind what
hath been already advanced concerning
y^e fluidity of y^e world at large, & y^e
matter collected about y^e centers of
y^e vortexes w^ch is of y^e smallest sort,
& also such as one of expanded shapes,
y^e former are most apt for fire, &
y^e others by reason of difform shapes
most apt to impede each others mo=
tion & so to coagulate; but there is
no coagulum so strong compact but
fire will get y^e better & flux it, &
when y^e fire that agitated y^e matter
abates; y^e part fall together & close in
a coagulation, as may be perceived

by y^e

by $y^e$ naked eye, when mettalls are
melted, & by degrees cool again. There=
fore considering $y^e$ wonderful exility
of divided matter, & $y^e$ infinite variety
of shapes & dimensions, in our [regions?]
, as I may say deformed, & of these com=
positions upon compositions, & sub com=
positions indefinitely, we need not
launch beyondnd $y^e$ commond mecha=
nick rules of corporeall impulses,
or invent powers or quallitys, to de=
rive a poSsibillity of minute bodys
coagulating into such lumps, & so va=
riously, as we are in common life
concerned with.

75.
The cases of disunion more ob= tuse

I ha[..?]/ve\ touched upon bodys joyning by
planes & so continuing, sto become
as perfectly united as parts are that
never

never were divided. This I take to be a
coalition rather than a conjunction,
& now whether such bodys, either simple
or united, may by any force be broken
or separated, is a question much har=
der to resolve than y^e^ former of uni=
ting. It is certain that y^e^ conceipt of
Cartesius that y^e^ Globuli or Aether be=
come round by motion wearing away
y^e^ unevenneSs, is vain for so all y^e^ whole
matter must become (greater or smaller)
Globules w^ch^ is contrary to his own scheme.
But there is no experiment, not so much
as in Idea, whence to inferr a deter=
mination of this question; only thus
much must be affirmed that if matter

were not

were not hard, that is not partable without some force, there cou'd not be y^e^ like in compounds. And then if any force will divide matter, What hinders that every force may not do it, for we find nothing to determine any degrees? This hath inclined many to Conclude that origi=

75.(2) Materi= all parts not indis= cerpable

nall matter is indiscerpable by any force. I cannot altogether come into this, for it is hard to say y^t^ matter may unite but by no means divide, I believe it may well be thought that no direct, or nearly direct impulse will break an intire substance, because y^e^ force is by yielding complyed with. But when obliquity is considered, y^e^ extreams may be such as no person can suppose a

resistance

resistance sufficient to sustein an im=
pulse without a fracture. As if A were
a part of y^e^ earth globe, such as
a common obdurate rock is, & at y^e^ sum=
mit a spike C of originall matter were
fixed & a shot B, from a cannon come a=
gainst it at BC. It is not in our power to
imagine that y^e^ ball shou'd reflect, & y^e^
spike at c not break, or to carry y^e^
point further, altho y^e^ spike were ex=
treamly leSsend. ~~t~~These considerations
compell us to opine that matter is dis=
cerpable provided a sufficient force falls
mechanically upon it, tending to sepa=
rate one part from another, & he that
ascertains those requisites erit mihi
magnus Apollo.[105] But as a opinion
only, I say that there is not & never was
or will

[105] i.e., 'he shall be my great Apollo', referring to Virgil's *Bucolica/Eclogue* III, 104 (properly 'eris mihi magnus Apollo', as the source is in the second person)

or will be any part of matter so cir=
cumstanced that any impulse or force
that can happen to fall upon it
shall discerp any part of it. For if ye
forms are compact, & not wiredrawn
out, as may not be supposed, ye yeilding
{_} of ye impuls{ers} one way and other, will
prevent fracture. And in ye breaking
of compounds ye divisions are most like=
ly to fall between ye compound (ra=
ther than upon ye originall) parts. And
ye wonderfull tenacity of threads & wires
&c shews that there is a principle in ye
matter that small forces such as our
imaginary attraction will not work
upon: But we seldom or never reflect,
that all character or judgement of hu=
man force, (& thereby of other powers) is
comparative

comparative; we attribute all to our
selves, as when a weight is great, it is
{_} as true, tha{t p}ower is little, but we
choose y^e^ former estimation, w^ch^ is de=
rived upon a partiallity or flattery of
our selves, & hence most of our won=
derments proceed, as all our great,
mighty, & other superlatives, are of
things wch {out} contrarily to be of our
{also} selves as {/\} if we said small, weak, & other
diminutives, w^ch^ I think more acco=
ding to nature than y^e^ other, & tend
to a better judgement of union & se=
paration of matter, especially {y^e^ latter,
{_} that is} tenacity wch is (by no means)(
(attraction,) or otherwise resolvable, &
if this be not enough to say upon y^e^
subject, I shall freely own that I cannot,
& believe

& believe that few (if any) can to y^e^
purpose say more. And that if I have
not proved that every thing in these pa=
pers is true (excuse y^e^ braggadochio) I
shall most willingly go a great way
to meet any one who shall prove any
of them false._____[106]

The Stellary world.

76.
The Ideas of immen= sity

Hitherto of matters introductory viz:
principles, mechanicalls & some gene=
rall considerations of body, without
meddling without sensi~~ble~~/tive\ Ideas, or com=
mon fantasmes, residing not in things,
but in y^e^ imagination only w^ch^ kindle,
subsist & dye with animall life; as
sound, colours, tast, smell, soft, rugged,
& y^e^ like, with y^e^ operations occasionall
of such

[106] MN/RN here introduce a flourishing, wavey line.

of such Ideas; as fire, rarefaction [~~levity~~?] ~~con=~~ con=
densation, gravity, levity, fluidity, me=
teors, & other complex phaenomena; All=
w^ch^ depending upon minuteneSs might
be aptly called upon here; But I pro=
pose (rather than seem over hasty)
to discontinue y^e^ present course, & set
on again at y^e^ other extream immen=
sity, comprising y^e^ utmost extent of our
discoverys. And in y^e^ discSsing of those
matters, some usefull opportunitys may
occurr for resolving physically, as well
y^e^ near as also y^e^ /more\ remote objects, by y^e^
analogys w^ch^ may appear in y^e^ works of
nature universally; & then y^e^ stage
will be clear for exposing some ab=
strusitys in particulars w^ch^, not without
reason we [requi~~t~~red?] insoluble. And now
we

we must invest y^e^ course of our ima=
gination, w^ch^ before tended to advance
imperceptibles into a state examina=
{now} ble, by magnifying: And {/\} y^e^ same pre=
rogative must be imployed to reduce
y^e^ incomprehensibles into a sensible
compaSs, by diminishing them; & who=
ever hath not a command of all
Ideas of dimension (saving proportions)
& a power to schematise them in his
mind, as representations are usually
drawn upon paper, can never have
either a just notion of y^e^ naturall
world, nor pleasure in y^e^ speculation
of it, & ought to imploy his thoughts
upon other matters.

77 The intire extent of y^e^ mundane space
The mun= is most reasonably supposed to be infinite;
dane space what
infinite

what y^e^ ancients thought to be limits,
that is, solid orbs, are found to be null;
some carryed their thoughts further,
& fell into y^e^ conceipt of an empyre=
um, w^ch^ must of course be unlimited.
And now y^e^ moderns having confounded
y^e^ solid orbs, with all y^e^ vain adjunct
of epicycles, there seems to be an u=
niversall agreement to open y^e^ scene
of infinite space quaquaversum,[107] un=
leSs we may exempt y^e^ Idiotae, as y^e^ un=
learned have been styled. And why shoud
any one dream of limitt/s\ when no kind
or symptom thereof appears. Actuall
infinitys immense & minute include no
contradiction. And then what is more
consonant to religion, than that y^e^ works
of y^e^ almighty shoud be deemed infinite?

The sensible

[107] i.e., 'in all directions'.

78.
Of y^e fixed starrs & y^e sun.

The sensible Idea of this infinite space, is as of an hemisphear upon y^e plane of y^e horizon, in y^e center of w^ch we seem to stand; & where sight fails to distinguish, men fancy limits: for distances are judged by comparison, & that requires somewhat presupposed, or known. The most eminent object that this immense space presents to our senses is y^e sun; & y^e Epicureans judging, as of a picture, by meer view, decla= red y^e sun to be no larger than as it seemed to be. But astronomic expe= riment have shewed y^e immensity of it by perspectives & discovered to to be above 12000 semidiameters of y^e earths globe distant from it.[108] In y^e absence of y^e sun as in y^e night, there appear to us other originall luminarys called starrs of various

[108] An example of the best knowledge available in the early eighteenth century is the estimate provided by the Italian astronomer Giovanni Cassini (1525-1712) from 1650 Professor at Bologna, and from 1659 Director of the Paris Observatory. He used trigonometry to estimate a distance of 140,000,000 km. This distance is nowadays extimated at 149,597,870,700 kms. Using MN's terms and our own measure of the earth's radius we get 6378.1 km x 12000 = 76,537,200 kms. This is only half of Cassini's figure, suggesting that perhaps MN meant to say a *diameter*, rather than a semidiameter of the earth.

of various (apparent) magnitudes, sprin=
kled about in a manner contingent, &
without any order or regular disposi=
tion, & w^ch never alter their mutuall as
pects & distances, no more than their res=
pective magnitudes, Saving only some
comets, & some few starrs growing & de=
caying of w^ch more when we come to
y^e celestiall systeme. The like experi=
ments have demonstrated that this or=
der of luminarys are from us posited
{_} at {~~an~~} unconceivable dist{an}ce{s}, with
respect to w^ch y^e sun, its distance & all
that belongs to it, are almost of no di=
mension. So that there is no means to
discover whither y^e apparent magnitudes
are so unequall by means of more or
leSs quantity, ir by distance, but proba=
bly both, altho we cannot but gueSs by
y^e view that distance is y^e chief cause of
y^e diminution

ye diminution, & that it goes on till
many are but just discernable, & ma=
ny not at all (singly) but in nebulae,
as ye galaxies &c The secrets of wch are
discovered by telescopes, & as ye ordinary
course of imagination, is to reiterate
distances indefinitely, so here now we may
conceive an ultraneous proceSs of lumi=
narys, that wou'd, like landscapes rising
one b~~y~~eyond another (in case we might
travell farr enough) appear to us: And
it is judged that ye sunn resident in
this common immensity is like one of
those starrs; And at like distance from
any of them, as those are from each
other, woud appear as a starr & any
other near enough as a sun.

79.
Of planets
& their
courses

This I take to be ye most reasonable Idea
of ye wide world. I mean as to so much
of it as appears to us fixed, or never
interchanging

interchanging either distances or aspects,
altho $y^e$ objects discernable are magnifyed
somewhat by $y^e$ help of Telescopes; but
that cannot be much because $y^e$ vi=
suall angle of $y^e$ magnitudes at such
immane distances, run almost into a
strait line, & so are near lost. But a=
mongst these fixt luminarys (seeming=
ly) there are a few others called planets
or wanderers,[109] that judging by relation to
$y^e$ former appear to us perpetually
changing place, except at some short
stationary times; These are all found
to be solid & globular, & seen, not by
originall light as $y^e$ fixed starrs but,
only by $y^e$ sunns light reflecting from
them, to $w^{ch}$ they are comparatively near.
And their wandrings are also found to
be nearly regular in orbits amost cir=
cular, having $y^e$ sun near to $y^e$ center
of their

[109] The word 'planet' derives from the Greek πλανης (plánēs) meaning 'wanderer'. It was given to the planets because they appeared to wander against the background of fixed stars. Their movement was only finally explained by the Copernican model of a heliocentric solar system (... or rather: in seeking to explain the movement of the planets Copernicus ..., etc.).

of their courses, & more stricktly observed
appear to be short ellipticks, & y^e^ sun
to be in or near y^e^ focall points. And these
formes are not so mathematicall as most
astronomers presume, but being subject
to y^e^ common law of irregularity, ne=
ceSsarily attendant upon all naturall
principles, do admitt of a fere or quam
proxime ~~to~~ /in\ all y^e^ calculates that be=
long to them.[110] And of these, y^e^ orbits more
remote from y^e^ sun turn slower than
those nearer, & therefore shew leSs irre=
gularity, & y^e^ nature of these planets
is best known by analogy with y^e^
earth, upon w^ch^ we live, for that is
found to be globular also, & to make
one in y^e^ coursing (like y^e^ other planets
about y^e^ sun. And this earth of ours, be=
sides such course, w^ch^ is called annuall,
as we observe its relation to y^e^ fixed starrs,
in that

[110] 'fere' means 'almost'; 'quam proxime' means 'nearly'.

in that period makes about 365 revo=
lutions from y^e^ west eastwards, upon a
proper axis, obliq to y^e^ plane of the/e\
annuall about 23°; these are days in
each year, w^ch^ subdevided into [˳˳˳˳?]24
x 60 x 60 &c are y^e^ hours, minutes,
{_} seconds &c. These period{s} being of our
continuall acquaintance, are used for
y^e^ common measures of all y^e^ other
planetary revolutions, altho nothing
commensurate is found amongst them.
The order of those beginning with y^e^
nearest to y^e^ sun is (1) Mercury w^ch^ re=
volves in 3 months, (2) Venus in 8 months.
(3) y^e^ earth in 12 months or one year
(4) Mars in 2 years (5) Jupiter in 12
years & (6) Saturn in 30 years, all
from west, eastwards. The orbit of
y^e^ earth (to sence) is y^e^ path of y^e^ sun
& called y^e^ ecliptick, thos of y^e^ planets

swerve

swerve, but not much, from that, &
ye croSsings are called ye nodes, of all
wch courses ye whole sweep is called ye
Zodiack. The bodys of these planets
with their forms & distinctions appear
to us in telescopes plain enough, altho
to our bare sight they are but as starrs,
not much exceeding those of ye prime
magnitudes. And by ye apparent mag=
nitudes, & ye times of revolution, ye pla=
netary distances from ye sun, & ye mu=
tuall aspects of them, are (not much
{_} out of ye way)) {~~gueSst~~} gueSsed at. But as
{nor distances} to ye fixed starrs neither magnitu{des/\} are
accounted for, because their [vissive?] an=
gle even in telescopes, becomes (as I said)
tantum non[111] a strait line, & discover
scarce any dimension. But it is pre=
{that} sumed{ /\} from ye nearest of ye fixt starrs,
ye whole solar systeme woud seem, but as
one of

[111] i.e., 'no more than'.

one of them seems to us, a meer speck of
light, & it is most rationally conjectured
that ye fixt starrs are all sunns, & proba=
bly circumstipated with planets: These
contemplations are apt to stir up admi=
{Immensity in ye Idea} ration at ye immensity of ye world {wch /\}ra=
ther belongs to ye exility of human kind.
for magnitudes saving proportion are all
alike.

80.
Of ye same & subpla=nets

But to return, we have yet reflected only
upon ye primary planets attendant upon
ye sun, there remains to account for ye
state of each of them in particular,
wch will introduce ye severall orders of
subplanets, such as ye moon coursing about
ye earth, ye 4 satellites or moons about
Jupiter, & 5 at ye least about Saturn.
None being yet discovered to attend either
mars, Venus, or Mercury. And somewhat is
is observable

observable of each of these. But first
of ye sun, ye substance of wch is most ra=
tionally by all symptomes, concluded to
be a body of pure fire, for ye maculae
(apparently) paSsing upon ye surface,
or not far from it, argue smoak, &
ye faculae,[112] continuall eruptions of fresh
fire, as we see in furnaces upon ye ac=
ceSsion of fresh fuel, or like Aetna &
vesuvio &at times, when ye fire rages,
& there is like reason to conceive that
ye whole luminary may consist of in=
numerable & perpetuall fiery eruptions
all over it, & if there be any intersperst
darkneSses, they are absorpt by ye surroun=
ding light, so that ye whole, at ye immense
distance from ye earth cannot appear
otherwaise than as an even light, like
that of melted glaSs or iron, Wch near

(If we

[112] i.e., the (respectively) dark and bright spots apparently on the sun's surface.

(If we may give scope to fancy) wou'd ap=
pear as mountains & seas perpetually eruc=
ting fire & exploding with tremendous
noises of infinite horror. When barely
reflected on. But ye more certain conclu=
sion, is that ye body of ye sun rolls about
an axis, as ye planets from west towards
east /in\ about seven days. For ye paSsing
of ye maculae plainly demonstrate it,
as also that ye body of ye sun ~~it~~s round,
because ye perspective rule takes place in
ye form & spaces of their paSsage, as spotts
upon any turning globe ar discerned, or
as if they are pictured upon a projecti=
on of it.

81.
Of venus &
mercury

There is little to be remarked of ye planets
Mercury or venus, only that their orbitts
being leSs than that of ye earth, they are
never seen far from ye sun, not at
any time

any time to surround y^e^ body of y^e^ earth,
as Mars, Jupiter, & Saturn, (by reason their
orbitts are larger than that of y^e^ earth)
allways do. Venus is more observable than
Mercury, w^ch^ for y^e^ most part is hid under
y^e^ light of y^e^ sun; And y^e^ phase of ~~v~~Venus
often appears falcated & Gibbous, as y^e^
luminated part is more or leSs obverted
towards us. But it is very remarkable
of ~~v~~Venus, that y^e^ phase is as smooth &
lucid as GlaSs whereas y^e^ more remote
planets upon ~~&~~their phases have various
pbscuritys. Some think that Venus is en=
veloped in a perpetuall c~~o~~loud; & y^e^ fi=
nallists[113] say it is a provision to keep y^e^
planet cool, & thereby habitable, w^ch^ so
near y^e^ sun without a screen cou'd not
be. I have not found that ~~without~~ /altho y^e^\ ter=
minations of light & shade upon y^e^ body
of Venus

[113] 'Finalism', definition 2: "The doctrine that natural processes (e.g. evolutionary changes) are directed towards some end or goal." (OED online, accessed March 20, 2015).

of ~~v~~Venus, are by y^e^ telescopes plainly dis=
covered; yet that any ruggedneSs in y^e^ junc=
ture, by w^ch^ a mountanous state, as of
y^e^ moon, is arguable, ever appeared, I
have not heard, w^ch^ favours y^e^ former
opinion. The planet Mars y^e^ nearest
to us, hath an obscure cingulum, (&(so
Jupiter divers) & that neer y^e^ plan of y^e^
Zodiack. And Mars compaSsing both
earth & sun, is sometimes very near to us,
& as often very farr off, even beyond y^e^
sun; And thereby y^e^ anomala or disor=
ders of his course seen from y^e^ earth,
are more egregiously observable than
those of y^e^ other more remote planets.
And it may be presumed that he doth
not turn because he hath no visible
satellites therefore prob~~l~~ably none at
all, nor any other sign of rotation.

The earth

[~~2~~?]82
Of y^e^ earth
& its alte=
rations

The earth is best known to us b~~y~~ecause we
live upon it, & being manifestly in y^e^ or=
der of planets that surround y^e^ sun, is
sample by w^ch^ we judge ~~y~~the state of y^e^ rest.
That w^ch^ is most observable of it is first
y^e^ annuall course, or circle about y^e^ sun,
w^ch^ we call y^e^ ecliptick, & y^e^ return of it
to y^e^ same point, & is, in time, a year.
But more is required to show y^e^ difference
of seasons, as summer & winter, & that
is derived of 2 concurrents one is y^e^ li=
bration, where by y^e^ polar parts allways
respect y^e^ same point of y^e^ heavens, & y^e^
other is y^e^ rotation, that is upon an axis
from pole to pole; of w^ch^ (rotations) there
are 365 in one annuall w^ch^ are our
days & nights, & y^e^ axis of this rotation
being obliq, to y^e^ plane of y^e^ annuall,
y^e^ poles of y^e^ earth are inlightened half
yearly, & y^e^ adjacent parts of y^e^ earth are
light

light & dark succeSsively every revolve;
$y^e$ obliquity is to an angle of (about)
23 degrees. Hence it follows as I said
that each extremity of $y^e$ axis, called
$y^e$ poles, enjoy $y^e$ light, & are as to $y^e$ sunns
presence dark half $y^e$ year alternately,
& in generall $y^e$ nights & days become
unequall, & are equall only half-year=
ly, when $y^e$ luminary in $y^e$ ecliptick
paSseth (seemingly) $y^e$ middle circle of
$y^e$ globe, $w^{ch}$ is at equall distance from
both $y^e$ poles, & is called $y^e$ equinoctiall.
The two circles paralell to this at $y^e$ ex=
tremitys of of $y^e$ declination of $y^e$ ec=
liptick are called $y^e$ tropicks, & by $y^e$ 2
contact points, called $y^e$ solstitialls, $y^e$ sun
in appearance marks out $y^e$ longest
& shortest days alternately; & $y^e$ sun is ne=
ver verticall to any point of $y^e$ globe
but between $y^e$ 2 tropicks. Nor at $y^e$ poles
ever higher

ever higher than 23 degrees above y^e
horizon. The diurnall rotation yields y^e
same phaenomenon as wou'd be if y^e earth
stood still, & y^e heavens moved, w^ch makes
our common speech between both am=
biguous & some importune people, fond
of y^e latter, say that it cannot be de=
monstrated that y^e same is not true. But
that is not y^e point, y^e motion in our sence
is a non ers,[114] and nothing is true but relation,
w^ch is in one, other or neither; And it is
nonsence to affirm more than that as=
pects change. But if y^e maSs of infinity
be let in, & an originall cause respected,
I presume y^e motive impulse when y^e
same was first inflicted, wou'd not be
supposed to have fallen upon y^e infinity
but upon y^e petit parcell w^ch compara=
tively is next to nothing

Of y^e poles/The earths present\

[114] i.e., 'it does not exist'.

83
Of y^e^ poles
of y^e^ world
& universall
magnetisme

The earths present state with regard to y^e^
sun, is secured by one wonderfull pro=
perty, w^ch^ I termed y^e^ libration, & is that y^e^
diurnall axis (almost) always respects
a certain place or point in y^e^ heavens
(seemingly) at an infinite distance;
whereby y^e^ axis, how ever obiq to y^e^ plane
of y^e^ ecliptick, in all y^e^ annuall course,
maintains a perpetuall paralellism
with it self (quam proxime)[115] as if a
magnetiq needle were set to swim u=
pon a rolling surface of ~~m~~water, y^e^
length of it woud alway continue in
paralellism. This made M^r^ Gilbert[116] con=
clude that y^e^ globe of earth was but
one great magnett, & respected y^e^ north
& south poles with its axis, by y^e^ same
means as rules y^e^ needle, & every leSser
magnett

[115] i.e., 'or near enough'.

[116] William Gilbert (1544-1603), physician, mathematician and astronomer, author of *De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure,* London, 1600.

magnett. And ye behaviour of ye needle
when free shews ye conformity, for in
sailing farr towards ye north, ye compaSs=
fly dipps (as they calle it) & from thence
a hint was taken to mak ye inclinatory
needles, wch tho not steddy, incline enough
to shew that ye magnett point not
in regular order, nor to ye horizon on=
ly. But under ye poles wou'd stand with
ye axis upwright. This polarity seems to
be universall, in ye region of ye sun at
least, & argues some principle no leSs
spacious, wch acts upon ye [calibeats?] in & about
ye planets, & is not, & its feared never
will be ~~well~~ /clearly\ understood, nor known
how farr it extends. But as to ye aecono=
my of ye magnett respecting ye earths
globe it is a spacious subject & ye pro=
per authors are to be consulted.

64. It is now time to take notice of ye earth's
of ye moon subplanet

subplanet y^e^ moon; this is much leSs than
y^e^ body of y^e^ earth &c. but y^e^ nearneSs makes
it seem much larger than y^e^ other pla=
nets; y^e^ apparent magnitude is almost
as that of y^e^ sun, by y^e^ light of w^ch^ re=
flected it is seen; & by vertue of that is
so conspicuous as to be accounted y^e^ 2^d^ lu=
minary of y^e^ heavens. The Telescopes have
given so precise an account of it, that
no person doubts of its being a globous
maSs, such as we live upon, with y^e^ like
or rather greater asperitys upon y^e^ surface.
It compaSseth y^e^ earth in about 28 days
& being without any rotation, allways
shews y^e^ same phase to us, & y^e^ same
aspects towards y^e^ north, w^ch^ is enough
to perswade us that both polarity, & gra=
vity take place there. The description of
its phase is in Hevelius's Selenography,
& y^e^ astronomy of it in Keplers's Volva,[117]
who

[117] Johannes Hevelius (1611-87), Polish politician, administrator and astronomer. His *Selenographia, sive Lunae descriptio*, Dantzig, 1647, was illustrated with his own engravings. It represented four years of study made from his own observatory in Dantzig. Many of Hevelius's names and characterisations of lunar features are still employed. Like Hooke's *Micrographia* which gives an account of the microscope used, Hevelius's text also gives an account of the design and use of his instruments and telescopes. Johannes Kepler (1571-1630), was a German mathematician, astrologer and astronomer living in Prague and Linz. His *Somium* (or *Dream*), was first circulated in manuscript and combined a fantasy, told as a dialogue, describing a voyage to the moon. It contained a section of not so fantastical, non-geocentric observations describing the solar system according to the Copernican account, but imagined as being made from the moon. In the text the moon is called 'Levania' and the Earth 'Volva', hence MN's reference. The *Somnium* was eventually published in a much transformed version in 1634 by Kepler's son. Before entrusting it to the world at large, Kepler senior had thought it wise to add footnotes to explain that it was an allegory and not a record of witchcraft.

who explaine y^e^ appearances of y^e^ heavens
there, & that is as y^e^ body of y^e^ moon shews
to us, so y^e^ earth shews to y^e^ moon, but
(as a clock) rotatile[118] and very much larger.
The course of that planet & of y^e^ earths
rotation, being nearly y^e^ same way, & as
all y^e^ other planets move from west east=
wards, tho not in y^e^ same track but within
y^e^ compaSs of y^e^ Zodiack, (altho y^e^ earth
rolling deviates /even\ from that considerably)
argue some common influence, that ab
origine[119] hath determined, & holds them
in their severall courses, as I shall shew
after~~w~~/w\ards. But in y^e^ mean time, as to
y^e^ rotation of y^e^ earth, w^ch^ is of all y^e^ most
declined from y^e^ ecliptick, I must ascribe
that greater declination to y^e^ common
magnetism; for it is impoSsible y^e^ earth
shou'd roll upon any other axis than that
wch y^e^ polarity lays hold on & keeps almost
fast to

[118] i.e., 'rotating'.

[119] i.e., 'since the beginning'.

fast to y^e^ station. If y^e^ polarity shoud vary,
y^e^ axis must follow, & perhaps cause grea=
ter irregularitys in y^e^ moons course, than
any altho enough are known at present.

85.
Of Jupiter
y^e^ Sattell=
ites & ro=
tations

The next step is over Mars (mentioned before)
to Jupiter, w^ch^ is y^e^ fairest & largest of
all y^e^ planets, Immensely larger than y^e^
earth, & instead of one, y^e^ earths portion,
hath four moons but discernable by us
only with telescopes. Those are called y^e^
Satellites, or, for flattery of y^e^ Tuscan
family, y^e^ Mediceans. The phase of y^e^
planet appears large, ~~The phase of y^e^~~ /& distinguished\
[◦◦◦◦◦◦?] by some thinn obscuritys or cingulums;[120]
& y^e^ Mediceans very observable in their
motions, w^ch^ as all other planets, tend from
y^e^ west eastwards. And so regularly,
as to constitute a circumJoviall, as so=
lemn as y^e^ circumsolar astronomy, with
Ephemerides, Eclipses, occultations transitive.
And if

[120] i.e., 'belts' - the visible surface of Jupiter's upper atmosphere is characterised by banded patterns.

And if there might be a constant & steddy
recourse to this planet, without ye Helia=
call settings, cloudy nights, toSsings at sea &c
wch impede ye observations, there needed
no other help for rectifying, if not for
finding ye true longitudes ~~of~~ /in all\ places upon
earth, for ye eclipses being a privation
of light are momentaneous, & ye same
to all places, & however ye horary account
may vary, do [.?]mark an universall;[121] Now.
The vertuosi are pleased by like means,
to compute ye time of lights paSsing from
Jupiter to us. For ye eclipse or emession,
happening, as they say it doth a few
minutes beside ye prediction, that inter=
vall is ye time, wch being allowed their
calculations will fall ~~f~~just (fère).[122] To
this I shall say only at present that
ye time & distance being compared, ye
former may justly stand for nothing
at all

[121] i.e., were it always observable, Jupiter could be used as a clock to tell the time wherever you were on Earth, enabling voyagers to compute their longitude. John Harrison (1693-1776) invented a chronometer reliable enough for measuring longitude soon after this was written, in 1737.

[122] i.e., 'thereabouts, nearly'.

at all; but more at this when we fall
upon y^e^ subject of light. The Zodiack
of these subplanets lys near to a pa=
ralellism with y^e^ plane of our eclip=
tick; And that gives great suspicion
that y^e^ planet turns upon an axis, if
not at right angles, yet not much
declining, & that subject to y^e^ common
law of magnetism, whereof y^e^ condition
of our earth is a notorious example.
And I do not see why y^e^ cingulum of
Mars, being always in y^e^ same position,
or near it, may not be an argument
that y^e^ planett, is held in its positure
by y^e^ same universall influence: And
altho it is reasonable to opine that it
turns round, if y^e^ desolation of y^e^ back
side, w^ch^ otherwise never or very rarely
sees y^e^ sun (& y^e^ like as to Saturn, Venus,
& Mercury,) may be an argument (a

finali

finali)[123] to rescue one half of each of those worlds from eternall or most tedious nights. But these considerations are more speculation than (as we pro= feSs) physicall, but it is hoped at such distances somewhat ultra may be in= dulged.

Of Saturn y^e^ annulis & Satellites

The next & last of y^e^ planets is Saturn w^ch^ lyes without all y^e^ rest at an immense distance beyond Jupiter; y^e^ true state of it was a discovery of this last cen= tury, & not before; when it was looked upon only as a common wandring starr, a tricorporeall as was thought. Now it is found that y^e^ Globe of it is invironed by a solid substantiall ring, leaving a space between that & y^e^ body, of about 1/3 of y^e^ diameter of y^e^ latter, & containing more quan= tity than y^e^ planet it self contains. The plane

[123] i.e. 'conclusive'.

plane of y^e^ ring doth not decline much
from y^e^ plane of our equinoctiall. And
there is an order of subplanets, of 5, some
say more, these move near y^e^ plane of y^e^
ring as y^e^ satellites of Jupiter, but at greater
distances; & y^e^ observation of them being much
more rare & scrupulous than of y^e^ others,
y^e^ like use cannot be made of them.
The condition of this planet is so rare &
singular, as may tempt us to fancy more
varietys among y^e^ celestial incognita
than have been imagined; for who cou'd
have dream't of such an annulus in y^e^
heavens, before y^e^ telescopes plainly dis=
covered it? & even now it is a matter of y^e^
greatest irregularity & wonder; some fi=
nallists have conceipted, that as at Venus,
clouds for refrigeration, so at Saturn, y^e^
ring for calefaction, were purposely ordai/ned\.
But a~~s~~t

But at ~~if~~y^e^ latter if y^e^ reflection helps one
way, perhaps one y^e^ other, y^e^ shade may
hinder. Yet however that may happen,
y^e^ annuall course, together with y^e^ tur=
ning of y^e^ planet (most probably to
be presumed) will give all parts a su=
ceSsive share of y^e^ better & worse. What
is most fully instructive of all thats
known, & I believe knowable of this
planet, may be found in Mons^r^: Hugens's
Systema Saturni, & his Cosmotheoreos.[124] I
shall not encourage such an abySs of
speculation as y^e^ ultra Saturnian world
must afford, supposing as some do that
viewing from a fixt starr y^e^ sun to
appear no better, or all y^e^ planets invi=
sible, & that turning y^e^ other way, every
fixt starr as a sun, & probably circumsti=
pated with an order of planets, & subplanets
& sic in

[124] Christiaan Huyghens (1629-95) wrote a general account of cosmography, *Cosmotheoros ...*, The Hague, 1698. Although completed by Huyghens before his death, it was published posthumously. It was translated into English (from Latin) as *The Celestial Words Discovered ...,* (London, 1698) even before a Dutch translation.

& sic in infinitum. We have enough to do
at home, where we inhabit our planet,
& so must know y^e^ nature & constitution
of it by that & observations, are in=
structed in y^e^ constitution of our subpla=
net y^e^ moon. And being aided by y^e^ ~~op~~di=
optick means, discerne y^e^ others, & conclude
analogically y^e^ same ~~with~~ /of\ them. And
that y^e^ negative fancy, if any such be,
that those great bodys are not, like
y^e^ earth, inhabited, & planted, is most
unreasonable.

87.
Astronomy waived & of y^e^ incer= tainty of it

I have here treated y^e^ mundane scheme,
not as an astronomer, to instruct that
exquisite science, but as a naturallist
discoursing (as it were ex paSsant)[125] of y^e^
world, to inform so much of it as an or=
dinary curious person may be desirous
& contented to know; without insisting
upon nice account & calculates, w^ch^ cou'd
not

[125] i.e., pausing briefly from that role (and not, therefore, making the observation 'en passant').

not be persued without making at
least a compendium of astronomy; &
transcribing out of authors what every
one may come at; I must own that
of all ye sciences astronomy is ye most
magnificent; But I have no faith in
ye precise regularity of form & mea=
sure; wch by ye profeSsors are aSsigned to
ye observables in ye boundleSs universe
no more thatn what is found in ye mi=
nor elements, of wch ye whole is composed,
of all wch nothing is so securely predicated
as irregularity, and it wou'd be wonderfull
indeed, if rude ingredients coming toge=
ther without expreSs art or design, shoud
make an artfull & polite composition.
It is a mean reflexion that cannot tran=
scend our exillitys, but esteems immensi=
tys (of wch ye least observable differences
are in truth vast Hiatus's) according to
our

our diminitive capacitys. Who ever in
nature found any thing truly, round,
square, cubick or Globular? And how
comes y^e planetary bodys & their formes
or courses to be so qualifyed, or otherwise
than as common things of w^ch we can on=
ly say, inclining to one or other? as when
we say y^e earth & y^e rest of y^e planets
are globular, we mean in y^e main on=
ly, as discernable at a distance, where
y^e asperitys of of y^e surfaces cannot ap=
pear, & when we speak of orbits circu=
lar or elliptick we mean inclining
most to such figures, but perpetually
more or leSs varying, as incident irre=
gularity may intervene to influence
them. Nor may this be accounted any
imperfection, for all quantitys of 3
dimensions, longum, latum, & profundum[126]
are equally

[126] i.e., 'length, breadth and depth'.

are equally perfect & precise dispositi=
ons belong to art & not to nature.

88
against
ye philo=
sophy of
ye vires[127]

And for this cause in these enquirys
I relye upon physicall principles on=
ly, wch I am sure are universally true,
& by ye help of these I expect, as I have be
gun, to go on, & physically to resolve ye
aeconomy of ye planets, as ye analogys of
sensible things in our observation in=
struct us. And it is hoped this may be
warrantably done without appealing
to any ascititious principles, wch are no
leSs readily denyed than demanded. As
for instance, ye common law of attrac=
tion, wch supposes all bodys indued with
a power to attract each other according
to substance & distance. Now besides that
this is not proved true by any, but to be
false by many experiments of subluna/ry\
things

[127] i.e., 'forces'.

things; it is an unphilosophical way of
proceeding, because it always [Leavs?] y^e^
same Nescience that is designed to be
removed by it. As when two things come
together, it is asked why? we answer
by reason of some impulse. But they
~~say~~answer, by attraction; & what is that?
a quallity or (w^ch^ is the same thing) pow=
er ~~to~~ inherent in a body to attract.
And so of every other quallity, w^ch^
they are pleased to call powers; of
w^ch^ there are many supposed to draw
or drive body severall ways; And
are but so many stopps to inquiry,
without any science of naturall things;
Is it not better (so farr as may be) to
reduce all action & force to impulse,
w^ch^ by y^e^ very nature of body must
yeild y^e^ effect? But this doth not
what attraction pretends to, plaister

every

plaister every sore, as when questions
are asked concerning blood, bones, nou=
rishment & y^e^ like? answer y^e^ parts at=
tract one another. And so every
one that gets by heart y^e^ cant is a
philosopher. As what question can
be unanswerable, when y^e^ particulae
attractivae are ready to be called in?
And in short, in all our late philoso=
phicall wrightings, we are so dinned
with y^e^ word attraction, that it is be=
come perfectly fastidious.[128] As for y^e^
trite answer commonly given to ob=
jectors, against y^e^ use of these pre=
carious powers in [pholosophising?], that
most phaenomena are not resolvable
without them. I answer, nor any tru=
ly with them, as was noted, in y^e^ fore=
going discourse of indistinguishables, such
as may be gueSsed, but cannot be known

And who

[128] This is one of the many dark, punning jokes available to readers: for someone with school Latin, 'fastidious' means the opposite of attractive, so attraction has become repulsive.

And who set us a Cock-horse to know every
thing? that we may & do know something
of y^e^ world is true; but that we can, or
do know everything is false. And want
of science, is no scandall; but to pretend
it, where in truth there is none, is deceipt=
full. And if that is found in any philo=
sophicall sect, it is where, in y^e^ room of
causes, quallitys or vires, and are held forth,
& so there may be found as many kind
of quallitys, as of querys. But to finish at
once y^e^ question of attraction, acc~~or~~/or\ding
as it is stated of every thing, if we per=
sist in in y^e^ opinion of universall ple=
nitude, it vanisheth, for in fullneSs
all drawing & none drawing, is y^e^ same
thing. And it was partly for that thing
y^e^ cosmicall vacuity was set up, for with=
out that, y^e^ whole hypothesis in many respe/cts\
failed

failed. I know there are many experiments
from w$^{ch}$, vacuity, density, & rarity of so=
lids are said to be inferred, but untill
y$^{e}$ elementary composition of things can
be exposed, none of these inferences will
lay hold of any aSsent to principles, that
have but a presumptive existence. And
many for shelter alledge that they are
not bound to give any reasons for y$^{e}$
vires; it's enough that there are such, & thro
them as, from phaenomena to come to y$^{e}$
generall cause, true; for principles are
to be argued, but discovered, as. body im=
penetrable, is a principle known to be u=
niversally & without exception true, &
none asks a reason for it. And when
attraction comes with that character
89. we will subscribe, and not demand any
The plane= reasons.
tary scheme
proposed as It may be expected here that having laid
to y$^{e}$ causes down
of it

down y^e^ scheme of y^e^ planetary world, I
should proceed to give some physicall ac=
count of y^e^ severall revolves & y^e^ medium
in w^ch^ they are made, as y^e^ late grandees
in philosophy have attempted. But fore=
seeing that this will draw on a compa=
rison of y^e^ two late famous hypotheses
of y^e^ heavens, y^e^ one of attraction in va=
cuo, & y^e^ other of common motion in ple=
no; And that besides y^e^ comparative
magnitudes & courses of y^e^ planets w^ch^
y^e^ late /optick\ discoverys have cleared, nothing
further of y^e^ whole subject is or can be
conjectured but (as I hinted from analogy,
& those respecting ~~of~~our common notices of
~~things~~ objects about us, w^ch^ may be nearly
observed & experimented; I have thought
fitt to postpone y^e^ physicall resolution
of y^e^ solar system a short space, & here
directly fall upon y^e^ principall terres=
trian phaenomena, & to resolve them as
farr as

farr as by ye means of our sensitive fa=
cultys & reasonable imaginations may
be warranted & in that course beginn
with fluidity.

Of ye Air & Hemisphear.

90.
of fluidi=
ty

The difference between ye states of solid
& fluid bodys, is obviously perceived, being
only that ye former consists of parts res=
ting in continuo,[129] & ye other of parts al=
way in agitation, as hath been already
noted. And to this I add that all ye mat=
ter of ye world, is either fluid, or by ye
operation of fire may be fluidized.
And in generall it is to be affirmed, that
ye matter of fluids agitated. And in generall
it is to be affirmed, that ye matter of
fluids agitated, is more subtile than even
imagination can reach,[130] therefore ye Idea
of it is confused, that is indistinct, & no
poSsible means can discover ye texture, &
minute

[129] i.e., 'staying in the same place with regard to each other'.

[130] There are numerous repetitions of words and phrases in the MS; some have been identified in the process of writing and corrected by MN, some have been struck out by the editorial graphite pencil, some have been missed, as here - the rest are the fruit of my incompetence.

action of any fluid. And it is to be re=
membred that celeritys properly belong to
small things, & motions discernable unto
greater, & we must not carry our notions
of palpable objects, & y^e^ distinct effects
of force, referring to our practises, by
mentall comparison down into y^e^ re=
gions of minuteneSs; for y^e^ phaenomena
will be very different, as no artfull means
whatever can by application to bodys
distinguishable, produce an effect
paralell with fluidity. but excepting
y^e^ single effects of impulses w^ch^ are alike
in all instances of great & small what=
soever; there is in fluidity an intertex=
ture of y^e^ motive effects ~~of~~ in per,
& trans[131] all manner of ways, whereby
every part is influenced by every part,
& in all directions promiscuously, w^ch^
produceth various effects in common,
& is y^e^

[131] i.e., 'in, by and through'.

& is y^e foundation of a peculiar science
of fluids preSsing or gravitating, of w^ch
Archimedes hath left us a tract, w^ch is
like Euclids elements to y^e matters of hy=
drostaticks,[132] & (presuming upon a liberty
of repeating a little of what hath past)
of them let us borrow but one image, w^ch
is a tun of water with a foramen at y^e
bottom, whence iSsues a current with
a force as y^e perpendicular height of y^e
inferior water requires. Now every part
within, by y^e influences of its impulses, con=
tributes to y^e force of y^e water iSsuing,
but in no sort directly, but consequently,
being conducted thro innumerable ambages,
therefore by way of summ y^e mecha=
nicks ~~e~~tsteem y^e common influence to
paSs by strait lines from every part to
y^e foramen. As by means of gravity
all parts of a fluid have a tendency one
way

[132] i.e., Archimedes' *De insidentibus humido* (i.e., '*On floating bodies*'), and Euclid's *Elements;* both texts date from c. 300 BCE.

way, but under confinement or preSsure, there will be a direction of y^e^ forces by strait lines every way, in y^e^ least yielding, as may be afterwards obser= ved, & partly already explained.

91. porositys & intersti= ces ad in= finitum

As to those collections of matter w^ch^ compose our common fluids, as water, oyle, Mercury, spirits, &c. their compo= nent parts must be (in all respects some fluidity only) looked upon as solids, he= terogene, & consisting of a consimilar matter up~~on~~/on\ mutuall touch apt to combine; but how, and wherein y^e^ diffe= rences consist, neither y^e^ exterior phae= nomena, nor interior conjecture will inlighten, but all such matters must be ablegated to y^e^ regions of y^e^ in= cognoscibillia.[133] But in one respect both fluids & solids have a common capacity, w^ch^ is to be permeable to some parts

[133] i.e., (!) 'unknowable'.

parts of y^e universall fluidity, w^ch I
have called y^e interstitiall, & may add
y^e subinterstitiall matter & so on ad
infinitum. And it may be made a ques=
tion whither there is an intire part of
matter in y^e world, not porous or wholly
impermeable, by some other (more mi=
nutely) interstitiall ~~matter~~. We are sure
we have no experiment of any com=
pound so quallifyed, wittneSs y^e transit
of odors, y^e magnetick operations, & y^e
effects of fire. According to this scheme
I shall presume that y^e generall mat=
ter of y^e whole world, consisting of
difforme & unequall parts is (quasi)
one universall fluid, of w^ch each part
hath an influentiall communication
with all y^e rest, as water in a veSsell
within its limits hath. And as to y^e extent
of influences, none can say that they are
not as

not as matter it self is infinite, for en=
titys comparative do not determine in any
degree of exility. This boundleSs fluid is,
not $y^e$ leSs intirely one, for having some
solids, as $y^e$ planets, casually natant in
it; so a pool of water, or $y^e$ sea is one,
tho some spongeous substances grow up
or swim in it. And upon this method
of imagination I have founded $y^e$ notion
of actuall infinity of minuteneSs in
all $y^e$ world, of $w^{ch}$ further use will be
made, when we come to deal with ex=
plosions, & some other Crypta of nature.

93,
Of water
& air only

I intend here to have no more to do with
any kind of fluids saving only air &
water. The rest are of so many sorts, &
have such variety of effects, that nothing
singularly can be affirmed concerning
$y^e$ composition of them. The vertuosi,

especially

Especially chymists may afford us some
naturall history of ye symptomes, but
nothing phisycall concerning them, as to in=
stance, what is ye reall difference, between
Mercury, Rectifyed spiritss, oyle & fair
water, about wch matters ye philosophers
have a ready cant of attraction, & I
know not what, but nothing substan=
tiall or satisfactory? And we living
perpetually, as it were, in ye midst of
air, & water, can observe & know more
of them than of all other fluids in ye
world; And if we can make any disco=
very out of these, there is a liberty
by analogy, or otherwise a may be
thought fitt, to apply them to other
instances of fluidity.

Of ye Atmos
phear &
elastici=
ty

Speaking of air we mean not in a sence
universall, but that wch we breath, & by
pneumatick

pneumatick experiements is found to
envelope y^e^ globe we live upon, with
a thickneSs of about 50 miles high e=
very where more or leSs compreSst, &
called y^e^ atmosphear, And that it is
further compreSsible, or may be con=
tracted by cold, or by any force artifi=
cially applyed, whereby it will seem
to take up leSs room than before. And
on y^e^ other side by relieving y^e^ preSsure
or applying heat, it will reexpand, &
being in such cases [.....?] confined, it will al=
ways (in appearance) crowd to gain more
room. And y^e^ body of it being of it
self ponderous, there succeeds a con=
tinuall preSsure of y^e^ superiour parts
upon y^e^ inferior, y^e^ whole tending
always to expand with a force dimi=
nishing upwards, in y^e^ proportion (as I
take it)

take it) of squares, And that every solid
immerst in it, as well as $y^e$ earths sur=
face, bears $y^e$ force of this expansion,
according as it is placed higher or lower
in $y^e$ perpendicular. And this is called
$y^e$ spring or $y^e$ elasticity of $y^e$ air; And
whatever is $y^e$ cause of this tendency
to expand, is by analogy $y^e$ cause of all
springyneSs (even in solids) as will be
shewed, therefore $y^e$ word elasticity, is
very properly applyed to signify all
such tendencys of what kind or man=
er soever. I must here observe that
what we understand by $y^e$ words ra=
refaction & condensation belongs wholly
to air & $y^e$ interstitialls of one sort or
other, & to no other substance what=
soever. I account not $y^e$ expansion &
contraction of oyls & spirits among these,

The

The severall diSsipations of matter
effected by force, or fire, have other de=
nominations, as explosions, consumings,
& y^e^ like, w^ch^ will have their places.

94.
Of water becoming air

Now y^e^ case of common water is to be
considered, & first that (directly) it is
neither condensible, nor extendible; for
taking a quantity apart, no force will
either compreSs, or make it swell, so
as to require more or leSs space. This
shews y^e^ parts obdurate, but what
porositys may be, nothing can discover,
no more than what are y^e^ forms or com=
parative magnitudes of y^e^ parts. It is found
that water will seem to decay, or
dry up; And that heat is y^e^ cause of
it; I am not yet ready to persue y^e^ ex=
tream effects of fire, but at present
attend only to y^e^ manner of this wasting
of humidity; w^ch^ every degree of heat

more or

more or leSs produceth. And in ye main
I must affirm, that all substance wch
ye water departs from, its maSs will be
found in ye air. It is certain that ye preSsure
of ye air upon ye watery surface is very
great, & those conterminous superficies
being on either side (however they appear
to us) rugged & interfering, & ye superfi=
ciall parts also in continuall agita=
tion, those of ye water are struck or
fly into ye air, & there aSsimilate &
are as it were lost. This operation
may be visible to ye eye for if ye
water is set over a fire to warm, ye
waving of ye air upon ye surface of ye
water apparently licks ye steams from
it, & this ye learned call vapour, &
suppose it to exist in its proper form
heterogeneous to ye air, & upon contin=
gent causes, to return to water again.

But I

But I must suppose that this steam be=
comes perfect air as any we breath,
& (as I take it) water will be found
y^e^ chief ingredient in y^e^ air. But that
it is such from y^e^ moment of its
parting, is demonstrated by y^e^ Aeolipile,
b~~y~~ut more eminently by y^e^ pneumatick
fire-engine.[134] For, (there) y^e^ steam of a
copper, is directed into a braSs veSsell
(al~~l~~most) full of water & makes room
for it self by crowding y^e^ water out
by a conduct to a vent at any height
required. And then y^e^ steams filling
y^e^ voided veSsell, is as perfect air with
all its propertys. Especially y^e^ constant
quallity of elasticity, as any air we
breath; as for this air returning back
to water, I shall observe it afterwards.
In y^e^ mean time, I cannot Joyn with
those

[134] An aeolipile (literally 'wind-ball' in Greek) is a steam-driven engine described first by Vitruvius (c.75-15 BCE). Water was heated in a vessel suspended on a spindle sealed except for two jets; when steam formed its escape would would cause the ball to spin. The 'Fire Engine' was patented in 1698 by Thomas Savery (1650-1715). Water heated in a closed vessel was allowed to escape as steam, this created a partial vacuum which, by the manipulation of taps, allowed water to be drawn into the vessel which could, in its turn, be heated and released - allowing more water to be drawn in. The Fire Engine was designed for the draining of mines. Savery's engine was demonstrated to the Royal Society in 1699 (*see* the *Phil. Trans.* 1 January 1699 vol. 21 no. 248-259 (http://rstl.royalsocietypublishing.org/content/ 21/248-259/228.full.pdf+html). Savery's Fire Engine inaugurated the mechanical application of Boyle's law for productive purposes. *See* also BL Add MS 32545, note on fol. 316r.

those that distinguish vapour from air,
& fancy that air consists of globules
hollow, & filled with vacuity w^ch^ gives
way to compreSsure, & by a vis elastica,[135]
of y^e^ materiall of y^e^ globules, dilate
again. Of all w^ch^, so much as signifys
any thing is begging, w^ch^ allways returns
upon them. But philosophick presump=
tion, or rather ignorance will always
deal precariously, & never advance
science.

Atmos=
phear, or
air is but
water e=
vaporated
& of va
pours

{_}

But now we are to remark in generall,
that y^e^ surface of the earths globe is
most sheer water, & much of y^e^ rest
humid, & scarce any part absolutely
dry; And all apt {(}with a moderate
warmth,{)} to part with their moisture,
whereby if there were no atmosphear
at all y^e^ suns heat wou'd soon, from y^e^
humiditys of y^e^ earth, raise one. And
then

[135] i.e., 'elastic power'.

then y^e^ whole body of y^e^ air wou'd con=
sist of meer water evapourated. But
as it is, supposing that y^e^ atmosphear (what
ever y^e^ substance of it is) hath been ori-
ginally raised (& is continued) by y^e^ vertue
of heat, from y^e^ earths surface; It is cer=
tain that great part consists of matter
adust, & untill received into y^e^ body of
y^e^ air, not properly fluid; but of that
kind, w^ch^ by strong culinary fires is rai=
sed in smoak, & y^e^ groaSs substances, as
wood &c are discerped & dispersed, & only
an ashy [fecae?][136] left. But still, all cir=
cumstances considered, there is so little
of this, compared with y^e^ steams from
moisture, that, denominando a majori,[137]
I may inferr that y^e^ Atmosphear con=
sists of evapourated water. I know that
it is

[136] i.e., feces, waste.

[137] i.e., 'in large part, the most of it'.

it is a mode at present,, to reject this
{or heterogen} notion, & to give $y^e$ air a specifi{ck } body,
$w^{ch}$ is to serve as a vehicle for $y^e$ watery
parts raised by heat, & to bear them a=
bout till causes intervene to return
them to water again; & hence is formed
a science of vapours; sometimes they
are high, & sometimes low, then heavy,
now light. And serving here & there in
$y^e$ composition of unusuall phaenome=
na, as if they were Jupiters militia
in $y^e$ government of $y^e$ air. And nothing
meteorall can be spoke of or proposed,
but strait regiments of vapours are
raised for $y^e$ service, & in all those in=
stances, as $y^e$ Aurorae Boreales, par=
heliae, Halos, Hurricans &c, $y^e$ unknown
trade of vapours is so inculcated, as
to become a fierce insult upon pati=/ence,\
being

being for y^e^ most part ignotum per ig=
notius;[138] And some being enamoured on
new principles, y^e^ air is adopted for
one, tho containing nothing but what
is common to y^e^ terraqueous globe: The
atmosphear, considering y^e^ magnitude of
its basis, can be no strange thing; since
it is thought every animall, & even plants
& seeds have their proper effluvia, w^ch^
to them are in y^e^ state (gravitation
excepted) as our atmosphear is to y^e^
earth.

96.
circulati~~on~~/on\ of air waters

But to take a larger view of y^e^ course
of air & waters, some have estimated
that y^e^ sun draws up from y^e^ medi=
terranean sea, more waters, than all
y^e^ rivers that run into it, & rains to boot
can supply; & for that reason it always
runns in at y^e^ fretums.[139] What then is
raised from y^e^ oceans? Enough one
wou'd

[138] i.e., 'unknown to the ignorant'. RN could be included in that regiment of vapourous theorisers, *see* BL Add MS 32546, fols 124r-140r.

[139] i.e., 'straits', such as connect the Mediterranean to the Atlantic and to the Black Sea.

wou'd think that without a restitu=
tion, shou'd dry up ye seas, & make
ye Atmosphear, as it were, run over.
This grand exhaustion is made in ye
tropick regions, & ye restitution about
ye articks, where in rain, snow's, & Dews,
{_} {~~almost~~} continuall & great increase
of waters is made, wch devolve in rivers
& currents to recruit ye ocean; so that
upon ye face of the earth, between ye
polar & & ye equinictiall regions, there
is a perpetuall circulation of air, & wa=
ters, for ye atmosphear settles towards
ye poles, & ye seas by various unaccoun=
table currents from ye poles towards
ye equator, & so make a ballance of
rotundity of ye whole.

97. We see how water comes to be sub=
Water limed into air, it is next to be exa=
drawn from mined how ye restitution is made by ye
air by cold precipitation

precipitation of air into water, & that
seems to be done by a reverst proceSs.
For as heat raised y^e^ water into air,
so cold letts it fall again; for it is
never known that y^e^ quallitys of heat
& cold meet in or about y^e^ air, but
betwixt them moisture is generated;
all y^e^ humid meteors, as clouds, mists
& rain, so also all our practiq dis=
tillations, depend upon this Crisis, when
it rains, y^e^ drops fall, as from a still.
There is not such a thing as a cool
place dry, & even y^e^ springs of water,
especially from rocky & cavernous hills,
{<u>as will be shewed</u>} are perennall by y^e^ same m{<u>eans. Th</u>}ere
are some that pretend to defecate air
from all humidable matter. It is
hard to pronounce a certainty, in
sny such experiment, for who can tell
when y^e^ air is perfectly defecate? and
what

what of that kind is done is by means
of cold, & y^e^ power of that is limited,
& cannot be, as fire, carryed to any great
extremity. But thus farr seems true,
that air immediately raised falls back
into water, quicker than after it
hath been long intermixt with y^e^ com=
mon air. this appears by y^e^ fire engine,
where y^e^ hot vapour, w^ch^ aSsuredly is
nothing but a steam of water is im=
mediately cooled into humidity, but
where such artful circumstances
do not meet, y^e^ proceSs is slower. And
poSsibly, when a hot new raised steam
is diSsipated in y^e^ air, y^e^ parts may divide
& perhaps clasp with adust particles,
& acquire a degree of siccity, as when
water is put upon lime, it petrifys
& perhaps never returns to water again
But as to y^e^ effects of cold producing
humidity

123r



humidity, y^e^ experiments are so constant
& universall, as leave no doubt of y^e^
manner of y^e^ operation, that is, by im=
peding y^e^ agitation of y^e^ parts, w^ch^
permitts them (that by motion were
kept asunder) to coalesce, & so to ap=
pear in dropps. Cool wine /in a\ glaSs, A coach
glaSs after y^e^ sun hath shined upon y^e^
door; an empty glaSs bottle in a win=
dow where y^e^ sun comes, & infinite
other instances shew this effect; & y^e^
saying that vapours are in y^e^ air in
all these places, is a chiccane, that
can never be answered. To confirm
all: humidity in y^e^ air prevails in
y^e^ conterminations of hot & cold, as
between summer & winter, between
y^e^ warm soil, & y^e^ middle region, where
clouds are generated, between North
& south winds interfering, between night
& day

& day, & between ye hot climates & ye
cold; so that when ever ye contrarietys
appear, either naturally, or by means
of art, ye air is never wanting to cor=
respond in moisture.

98.
Of rare=
faction &
conden=
sation

Of all our obvious phaenomena, None
is so misterious, as that of rarefaction
& condensation; ye principles of Carte=
sius led him neerer to a solution than
any have come either before or since.
for his making body impenetrable, &
ye like of extension or space, did not
consist with any compreSsure, or dila=
tion of ye same matter; but made ye
ceSsion & acceSsion of parts to be a ne=
ceSsary resolution. But when he con=
discended to aSsign praecise forms, &
flexibillity to his watery parts, he
exceeded ye power of human sense, &
also contradicted himself; for if parts

may not

may not be compreSsed, how shou'd they bend?
The latter philosophers are so gone with
y^e^ doctrine of powers, as to resolve every
thing by them, so here y^e^ account they
give, (as I think was hinted before) is that
rarefactio est partium ses mutuo fugi=
entium, & condensatio est partium sese
mutuo appetentium.[140] If this was intended
a definition only, it is very ill worded,
for it aSsigns living quallitys ~~to~~of detes=
tation & appetition to inanimato matter:
but finding no other resolution from
them we must take this for one, or at
least for a figurate description only.
As~~t~~ to one thing both agree, w^ch^ is that
matter is not compreSsible, not exten=
dible so as to make more leSs, & leSs more.
But y^e^ former supposeth only an ex=
clusion, & acceSsion of matter in y^e^ opera/tions\
to make

[140] i.e., 'rarefaction is the mutual flight of parts, condensation their mutually approaching each other'; I have not traced this as a quotation, it is possibly paraphrased freely from Newton's *Principia*.

to make room & withall to conserve plenitude;
according to y^e occasion. but y^e latter are
so fond of vacuity, as to make that serve
either way. First to make y^e room for
condensing, & then as for rarefying, y^e
intersperst vacuitys are to be encreased;
but this is hard to be conceived, considering
how matter about us is ever crowded, suf=
ficient to keep it close enough together.
But I believe that upon this notion of
intersperst vacuity, y^e fancy of dense &
rare is founded; And they seem to make
those to be different characters of body,
rather as specificke principles, than as
consequences of operation. Density &
rarity supposing them to be no other=
wise conceived are confused Ideas; but
there is an usefull latitude by arbitra=
ry degrees or plus & minus of them w^ch
some

some make use of in their method to re=
concile divers hard cases; but no more of
these.

99.
Both de=
pend on
confine=
ment

Now since we have not facultys to inspect
these operations, by means of any but con=
fused experiments; we must follow them
a well as we may by conjectures; & that
according to analogy with known things,
whereby to discover (if not clear & dis=
tinct truths yet) fair probabillitys. It
is certain that y^e^ whole phaenomenon
of rarefaction & condensation depends
upon confinement, without w^ch^ we should
discerne or know nothing of it; & what
we do know is by veSsells of common
materiall, as wood, leather, earth, glaSs,
&c. w^ch^ being filled with y^e^ materiall
we call air, are impervious to some
part of it, & to other part are meer sives,
{_} like our basketts that {<u>that</u>} let water or
sand

sand paSs freely, but retain all manner
of grain. Let a blown bladder be of that
sort, & held in its state under a cont=
nuall distention or compreSsure. If
y^e^ sides became as a spunge or wool,
pervious to y^e^ whole materiall contai=
ned, they woud soon come together; but
since they yield to compreSsure but in
some degree, & that enforced, it appears
that of y^e^ whole content, only some
part is extruded, & y^e^ rest remains, &
thus farr upon account of impenetra=
billity is true. But what is it that holds
y^e^ bladder extended, & that but to a
certain degree, thereby resisting y^e^ out=
ward compreSsure, w^ch^ being removed, an
expansion results accordingly? I answer
that it must be y^e^ force of y^e^ interior
parts, w^ch^ by fluidizing activity of y^e^
whole strike against y^e^ sides of y^e^ bladder;
& it is

And it is not enough to reply that such
strokes are pusille & weak, for number
always makes an equivalent to measure.
But then what susteins this impelling
force in y^e^ air, w^ch^ being included & preSst,
one woud gueSs shoud like as other agencys
in like circumstances, sink by degrees
& come to nothing? I must answer that
it is not only y^e^ impulse of y^e^ matter in=
closed, that of it self works this effect,
but of y^e^ exterior matter of y^e^ world (for
I know not where to confine it) that from
all regions round about, by means of y^e^
interstitiall matter acts upon y^e^ subtile
matter within, & that upon y^e^ groSser
air, & that upon y^e^ sides of y^e^ bladder,
& so by a series of activity from abroad
y^e^ expansion is invigorated. Here is a fund
of force sufficient, if duly ~~applyed~~ /collected\, &
employed to blow up a mountain & is
termed

termed rarefaction, & so with ordinary
means to stand against a common com=
preSsure.

100.
The force of
compreSsure
gradually
wasts

But ye matter is yet not a little dark,
for one cannot well imagine that when
ye included air is [...?]compreSst into a small
compaSs, ye parts shou'd not cling toge=
ther & take a form more quiescent as
of dust or water. I answer that it doth
so, but in time; for nothing can on a
sudden drive such an effect against
ye force of all parts abroad, so as to make
an extream condensation all at once,
but gradually ye strength of a com=
preSsure wasts; As a bladder blown
turgid will become flaccid, a wind gun
charged & let stand, will contract
a moisture, & loose its force. We have
many instances of things that being o=
ver violently urged will burst; & so it is
when

when a compreSsure is over exasperated,
as lett a man jump upon a bladder,
y^e^ sides will burts rather than on a sud=
den yeild to extremity. ~~f~~For y^e^ action is
opposed by y^e^ exterior matter, & in such
greater extent as y^e^ force is more ra=
pid. Now that cold ~~ha~~& warmth have y^e^
same effects upon inclosed matter, as
compreSsure & relaxation have, will be
allowed, when it is considered, that heat
by agitation increasing y^e^ interior force,
produceth more distension, & cold abating
y^e^ action, is equivalent to compreSsure.
And how farr these causes may be aug
mented so as to produce very violent
effects, may be considered afterwards.
In y^e^ mean time y^e^ question must be an=
swered, how it happens that these effects
shou'd be y^e^ same in y^e^ open air, where
(it may be said) there is no such inclosure
as I have

as I have all along supposed, & it is done
by shewing, that ye weight of ye air
in tanto[141] makes an inclosure; for as
hath been observed, that holds ye air
itself under a stated compreSsure,
according to altitude in ye perpendicular.

101.
Of elasti=
city distinct
from im=
pulsory se=
paration

I mentioned common elasticity, supposing
it resolvable upon ye like principles of
rarefaction, & now ye busineSs is to make
good ye paralell. And I must first pre=
caution that in this discourse I shall
referr only to bodys that being deflec=
ted shall result, & vibrate, & not to
cases of impulse, as when one hard bo=
dy is forced against another, it is sayd
to reflect. For that is not spring but
an instantaneous separation, & ad=
mitts no degrees; there is often a com=
mixture, as when a pellet of marble
is dropt upon a marble floor, both cau/ses\
may

[141] i.e., 'meanwhile, at the same time'.

may operate, as hardneSs chiefly & spring
partly, whereof y^e^ effect is confused, & not
wholly derived of either; & y^e^ computation
can scarce be made, for soft bodys re=
flect most by spring, as Tennis-balls, that
are made of hair, & y^e^ obdurate, most
by mechanick law, as Marbles. For even
those are not without some spring. But
y^e^ mediall resistance considered, y^e^ most
perfect resilition, or neerest to y^e^ force
of y^e^ acceSs, is y^e^ adamantine.

102

Contracti~~on~~/on\ of cavitys y^e^ cause of springs

But to avoid these suspicions of a difference,
I shall as I said take a pure vibrating
spring, such as y^e^ lath of a croSs bow, un=
nealed wire, or y^e^ like, be it of wood, glaSs,
or any compound w^ch^ will result & vibrate.
In these there are cavitys of all forms,
& most frequent, so that one may re=
pute them intirely either vascular, or ca=/vernous\
& however

& however Microscopes may shew it in
some measure, especially in wood, there
is reason to presume much more. These
cavitys contain air, or else a fluid, mat=
ter finer than air, but yet distinguisht
into more or leSs fine; y^e^ latter of w^ch^ is
enclosed, & cannot paSs; y^e^ other may paSs,
& communicate with y^e^ externall fluids,
& receives activity from them. Now when
any of these bodys are bent, y^e^ cavitys are
contracted, & y^e^ spring of y^e^ included matter
operates to reinforce y^e^ former capacity,
as so many bladders of air compreSst; But
y^e^ most elastick of any are those bodys
w^ch^ consist of tubes, or whose cavitys runn
out at length; & such are all vegeta=
tion, & bodys formed by a proceSs of exten=
ding, as wire. And some have their ex=
terior superficies closed, as harden'd mettalls
watch-

watch-springs, & some others, as if a single
hair be paSsed against a thumb nail, it
becomes more springy, & curles up. Sometimes
meer hammer hardening will cause e=
lasticity, & in all those cases, y^e^ loosening
y^e^ parts of y^e^ body by fire, w^ch^ opens y^e^ cavi=
tys, & is called nealing (y^e^ practise of silver-
smiths) disables y^e^ spring, w^ch^ by hamme=
ring again is restored.

103.
The state
of glaSs
dropps

But y^e^ most wonderfull of all springs is
y^e^ glaSs dropps; those hot from y^e^ furnace
are dropt in cold water, & such as do
not burst have a wonderfull hardneSs,
& if y^e^ tails be deflected to a fracture, w^ch^
is not easily done, y^e^ crack runns through
y^e^ whole substance, & y^e^ included sprin=
gy fluid works in diSsipating all y^e^ ma=
teriall in dust, as an explosion. And
if y^e^ tail be put in a candle, so much
of it as takes an heat broke off without
any such

any such consequence. For that opens
ye cavitys, so as ye included matter may
vent, while ye unnealed part is left as it
was constringed by sudden applications
/of ye extreams of\ of heat & cold at ye superficies to a
great closeneSs without discharge. It is
commonly observable, that glaSs from a
point where ye force is applyed, cracks
as ye grain leads. Now in a drop ye grain
is not linear but quaquaversum, direc=
ted every way, & runns per & trans thro'
ye whole maSs all at time, so as every
point is a center or concourse of
springy effects, & so blows like a [....?]
{_} spr{ing}. This seems to verifie ye analogy
between elasticity & rarefaction. If ye
exility of force in ye particulars is
objected, I answer as before, that num=
ber is equivalent to quantity. And it
will be found in ye course of nature,
that ye

that y^e^ greatest & most wonderfull effects
are produced by y^e^ cooperation of most
minute & indistinguishable materialls,
& in that respect such may justly be
styled element.

104
The New=
tonian
system
of y^e^
heavens

Common Cosmography.

I shoud now undertake those two vulgar
(its true) but stupendious phaenomena
of light, & fire, but I find that y^e^ so=
lution of them will depend so much
upon y^e^ aeconomy of y^e^ world at large,
that I think it best to deal with that
first, whereby its hoped we may gather
also a tolerable solution of gravita=
tion, & then I think little will remain
of physicall science, to be looked after
& all y^e^ rest that may be styled natu=
rall philosophy, will become pure na=
turall history. To proceed therefore, y^e^
modern

modern rationale of y^e^ heavens suppo=
seth first y^e^ whole aetheriall space to
be pure & pute vacuity,[142] wherein no
manner of impediment or resistance
is given to any thing that moves to & fro'
in it. 2. that y^e^ sun is a body of light &
fire, w^ch^ holds its place immoveable 3.
That y^e^ planets are like y^e^ earth solid lumps
that move about y^e^ sun in orbits as hath
been declared, & that these receiving y^e^
light of y^e^ sun reflect it every way,
& thereby we discern their aspects, &
movements. 4. That these bodys being
once originally placed & put in mo=
tion (for all things that change are
thought to have had a beginning)
by y^e^ law that all things will continue
their state till till something causeth
an alteration; will move to eternity
by strait lines, unleSs diverted by some
cause

[142] i.e., 'pure and unmixed'.

cause. And that there was & is a sufficient
cause to divert ye rectilinear courses, & de=
tain ye planets in ye present order & cir=
cuition, & so to continue indefinitely.

(105)
ye postu=
lata on
wch it is
founded

All wch is pretended to be mathemati=
cally demonstrated; & in order to that
It is postulated that all bodys in ye
world great and small, farr and neer, are
indued with a power of mutuall attrac=
tion ad modum densitatis & distantiae,[143] where=
by all have a tendency accordingly to
move, and wou'd come together, if there were
not sufficient causes that operate to
impede them; And that wou'd be ye case
of ye planets wch tend to run all,together
and into ye sun, of wch as being much ye
greatest body, ye attraction is strongest;
& this attractive power of ye sun is ter=
med centripetall, & operates upon all
ye planets. Now that wch staves off this
consequence

[143] i.e., 'in proportion to their density and distance'.

consequence, is another power w^ch^ draws
another way, & that is y^e^ motion in direc=
tum,[144] for all motion not influenced
otherwise will be in directum, w^ch^ (as
they say) in all gyrations, will be a tan
gent to y^e^ orb. But as to y^e^ planets y^e^
y^e^ centripetall power of y^e^ sun checks
this direct course, & perpetually ben=
ding, it somewhat to sunward, y^e^ orbit's
must prove ℭElliptick with y^e^ sun
in y^e^ focall point. So all y^e^ courses
are compound of two motions, y^e^ direct
& centripetall; But all this wou'd
little agree with y^e^ phaenomena of
y^e^ heavens, because of y^e^ anomala,
or very great deviations from this
order, w^ch^ marks y^e^ calculations of y^e^
planetary aspects very troublesome,
& not to be made out without great
allowances. And for that reason all
those

[144] i.e., 'straight'.

those irregularitys are changed upon col=
laterall attractions of y^e^ planets among
themselves, & those are accounted for by
bringing y^e^ distances & solidity of y^e^ pla=
netary bodies to a due estimate, adjusted
by astronomicall observations, & judicious
conclusions; & these furnish such data as
help out y^e^ predictions, & enable y^e^ demon=
strations. And upon these schemes, y^e^ science
& practice of modern astronomy are re=
lyed; & in good truth there is a wonder=
full congruity between them, & y^e^ course
of y^e^ heavens, so that if truth needed
no other witneSs than congruity, this hy=
pothesis might paSs for demonstration in
earnest. But some philosophers have
held that diverse hypotheses may con=
gruere,[145] but there can be but one truth.
And if any be accepted upon that account,
it must

[145] i.e., 'agree'.

it must be founded, not upon concinnitys,
106. but upon reall & undenyable principles.

Diverse fatall objections to it

Now to this hypothesis, not withstanding $y^e$ great Eclat & generall acceptance of it, there may be some objections made. As first, that if $y^e$ universall vacuity be, (as it is) positively denyed, down falls $y^e$ fabrick; And if it is said that congruity proves, it, then $y^e$ truth & $y^e$ congruity prove one an/d\other, $w^{ch}$ is no proof at all; & if its said $y^e$ courses of $y^e$ planets are impoSsible & cannot continue without it, that will be seen afterwards. Next, $y^e$ universall attraction is precarious, $y^e$ proofs by experiment are against it. For (magneticks & Electricks excepted) no 2 bodys can be (directly) so placed /in a levell\ as to come together. If 2 millstones or large Granado shells are suspended at long radius's,

they

they will rest tantum non[146] touching. If
they say that y^e^ attraction of y^e^ earth
overcomes all other attractions, I answer,
that operates only in y^e^ perpendicular, & not
laterally, & so neer y^e^ perpendicular y^e^ weights
swinging do not rise (scarce) at all. If
gravitation is alledged for proof, I answer
that as well that, as magnetism & electri=
city are particular & y^e^ consequences of
complex motions, & no proof of a power
universall; what is pretended from y^e^ ma=
rine tydes will be considered afterwards.
Then upon y^e^ whole, it is an ingenious
contrivance (I confeSs) to bring things to
bear so near, but withall a piece of
machinery, fitter to come from a clock=
maker, than from y^e^ author of nature,
whose works are simple & uncomplex.
Here are 2 forces set on work to tugg
against

[146] i.e., 'just about, very nearly'.

against each other for producing a
mixt effect, as if ye creator needed two
strings to his bow where one woud not
serve, wch without a revelation can scarce
be believed. But what if ye motus in
directum[147] be nothing at all reall, but
only a relation, how should that have a
reall effect, in opposition to ye centri=
petall? wch must be reall or nothing;
~~so that a planet being poised, & as qui=
escent in ye rolling aether, & (as they say)
influenced centripetally, hath no ten=
dency in directum but for restitution
only, & ye contention is not between cen=
tripetall & direct (per tangentes)[148] but
between attraction & restitution, that is
to & from ye center, weh utterly ruines
ye attractive scheme of ye planetary
orbs~~. It was therefore well contrived to
set up

[147] i.e., 'direct, or straight movement' (i.e., gravitational pull).

[148] i.e., 'by means of a tangent'.

set up a motus verus contra distinct from
y^e^ motus relativus,[149] in order to find a
match for y^e^ centripetall, w^ch^ is a positive
agent (as was observed before). And what
becomes of all y^e^ fine spun demonstra=
tions to y^e^ wast of so much good geo=
metry, when y^e^ principles w^ch^ ought to be
incontestable are precarious, & what is
worse, denyed, & by no earthly means to be
proved? And in Mathematiques, w^ch^ are y^e^
vain pretense of this hypothesis, y^e^ least
tripp of a principle, or datum, overturns
y^e^ whole cargo. But now admitting all y^e^
magnitudes, soliditys, & distances of y^e^ pla=
netary bodys from y^e^ sun to be as they
are esteemed, or for y^e^ purpose contrived
or gueSst at; yet y^e^ aspects & places are
not (as I sayd) exactly correspondent, there=
fore y^e^ collaterall attractions of y^e^ planets
respecting

[149] i.e., 'true (or absolute) motion against, as distinct from a relative motion'.

respecting each other reciprocally are in=
troduced to set all right, (as I have above
remarqued). And if any unaccountable
deviations are found, as of Mars, & ye moon,
then it is allegdged that such are caused
by some unknown attraction not yet
discovered. And in a word, ye truth of
attraction proves ye courses & aspects of
ye planets, & those prove ye truth of
attraction, so Idem per Idem,[150] summs
up ye evidence.

107,
The corpus=
cular scheme
of ye hea=
vens ex=
plained

After this, I am to declare ye corpuscular
hypothesis of ye heavens & ye probabili=
tys of it. I go no further, not thinking it
mends ye matter to cry out principia
Mathematica, & demonstration. First upon
what hath been alledged, it is presumed
that all space is body, & ye whole world
is perfectly fill'd with matter impenetrable.
And next

[150] i.e., 'the same for the same', i.e., the argument is circular.

And next that this matter is devided into
parts inconceivably small, & smaller yet,
& smaller ad infinitum, & such devisions
signalized by a perpetuall motion or a=
gitation of them, rendring ye whole to
be one universall fluid, That ye sun is
a vast luminous maSs of fire; & a portion
of ye Aether (as I must call ye universall
fluid) comprehending ye planetary regi=
ons, & further perhaps, as (for instance)
half way between Saturn & ye fixed
starrs perpetually, after ye manner of
a vortex, Rolls about ye sun /but slower as more remote from ye center\.[151]
The mi=
nute parts of this vortex, like ye casuall
concourse of body's as stones, sand &c are
of various forms, & magnitudes, Except where
accident hath bro/u\ght similar parts toge=
ther, or such as are apt to unite in moti=
on, & not to diSsipate into ye common maSs.
Of these ye largest, & most compact figures
have

[151] This correction added (in ink) by a different hand - using the greek 'e' characteristic of the hand responsible for the pencilled-in corrections elsewhere.

have more force & perhaps perseverance in
motion, than ye smaller & more spread, of
ye difference an accot: hath been given.
It hath been also shewed, that all bodys
impelled must move from ye contact by
strait lines unleSs diverted by some re=
sistance, & in a fluid action ye parts pro=
miscuously impell & resist, & consequently
ye stronger parts have more force to move
in strait lines than ye weaker; therefore
when ye motion of ye whole is about
a center, & withall ye parts continually
agitated with reciprocall impulses; ye
common result is, that ye strongest will
most persevere in ye rectilinear direc=
tion, & that must produce a partiall
reseSs & aceSs to & from ye center, a con=
sequence of such prevailing force. This
is mentioned comparatively, for all ye
matter of ye vortex, (being free) for

like

like reason, draws from y^e^ center w^ch^ produceth
{_} a generall receSs & in{test}inally a distinction to
& from y^e^ center, all y^e^ circumstances have
been already stated, & may be further explai=
ned.

108
The dis=
tribution
of matter
in rolling
about y^e^
sun

So then taking y^e^ impulses comparatively, as I
said, there must follow a sort of fermentation
in y^e^ whole maSs, w^ch^ will devide y^e^ leSsmore from
y^e^ leSs powerfull matter. For y^e^ former
gaining outwards, y^e^ latter must of neceSsi=
ty (notwithstanding y^e^ common tendency) yield
& gather inwards, & croud about y^e^ center,
& y^e^ weakest woud be at, or nearest to it,
that is, y^e^ largest & most compact forms
woud be about y^e^ circumference, & y^e^ minor
& most irregular, & dilated matter about
y^e^ center. And this must take place in
all degrees from y^e^ center outwards, unleSs
it may so happen that there is sphears of
similar matter, of w^ch^ y^e^ parts little exceed
each other

each other in strength, & these may have
no such cribration amongst them. But
it is manifest, that if a parcell of circum=
ferentiall matter is brought down, & near
ye center lett loose, it wou'd not cease to
work upwards, till it recovered its due
place, & there to rest from that action;
& on the other side if a parcell of ye cen=
trall matter were removed up, & freed among
ye superior, it wou'd be driven downwards,
till it found its ballance near ye center, or
met with obstructions, & thence gravitation.
And ye consequences woud be ye same, if ye
matter were coagulated, as if, fluid or loose;
for being pervious as all coagulum are, to
ye generall minuter matter, ye force is convey=
ed to all ye component parths, so that such
as belong to an higher sphear will work
upwards, & such as appertain to a lower
sphear, will work to that. This being ye state
of ye

of y^e^ great Solar fluid, & y^e^ consequences,
by mechanick laws, neceSsary, we have a
prospect of a fair re~~v~~solution of y^e^ posi=
tions & orbits of y^e^ planets.

109. No regu= lar pro= greSsion of power from y^e^ center outwards.

Those who deal by attractions suppose their
centripetal power to extend every way
deminishing in a certain proportion regular=
ly proceeding from y^e^ center, & by means of
that supposition, & some others of like arbi=
triment, etermine of y^e^ states of y^e^ planets;
but we must remove ~~y^e^ state of~~ that sup=
postion, & conclude that y^e^ condition of
y^e^ aether from y^e^ center outwards is not
stated in any regular progreSsion, but
is subject to contingents; & all that can be
determined is, that y^e^ sphears, or (to use an
apter word) y^e^ orbs w^ch^ contain y^e^ stronger
matter will be outermost, but (as I sayd)
there may be orbs of similar matter, or
such as have not such different powers to
cause

cause any separation, but continue uni
form, or some more or leSs so than others,
so as to deprive that regularity of pro=
greSsion from ye center, as they suppose;
{_} And this I mention because the{ir c}on
futation of ye present hypothesis de=
pends upon such supposall; So that we
esteem ye Aetheriall powers to be as ye
parts are powerfull in whatever dis=
tant orbs they happen to fall.

110
Of ye motion & libration of ye planets

Then it must be required that ye planets
by an almighty power were at first
placed in ye aether; whither neer or
farr from ye sun (in this inquest) is
not materiall. I say here will be two
consequences 1. ye motion, 2 ye libration.
1. as to ye motion, ye current of ye aether
will bear against ye body of each pla=
net, untill all impulse of ye fluid upon
it shall cease, & it shall move, conformly
in ye

in y^e^ current as if it were a part of it;
And this is y^e^ present state of each pla=
net, w^ch^ relating to y^e^ fluid wherein it
is immerst, is at rest, & no motion, co=
natus or tendency[152] can be ascribed to it,
but having relation to y^e^ fixt starrs, y^e^
sun, or to each other, a motion is accor
dingly defined. And this manner of paSsing
about y^e^ sun, without any hurry, violence
or new invented principles, but in a tran=
quill manner, as bodys immerst in fluids
are observed every day to move, or rather
paSs is most plausible, for how shou'd we
judge of those mighty revolves, but by a
conformity with leSser, w^ch^ we may close=
ly observe, since nature hath but one law,
that governes both y^e^ greatest & y^e^ least Sys=
tems of matter? & it is not true to say
this body (or planet) hath a tendency
in direction, & so fromwards y^e^ center, more
than y^e^

[152] '*Conatus*' was an Aristotelian/scholastic term explaining movement as the result of a tendency to move, suggesting, therefore, a quality inherent in an object. The word confers an anthropomorphic will, or inclination, to the object. Although the notion of such a cause of movement (the object *willing* ...) would have been anathema to him, the word is one that Descartes himself used. RN also used it, although he frequently apologises for doing so, and he also apologises on behalf of Descartes for his employment of the term. Attraction would be a kind of 'conatus', and RN ubiquitously criticises this notion of an Aristotelian quality or tendency at the heart of the Newtonian system.

{_} than $y^e$, {~~more than $y^e$~~} rest of $y^e$ fluid in $w^{ch}$ it /now\ swimms, & being (as I suppose) equall, then it is ballanced, & amounts in effect to nothing. But it was poSsible that $y^e$ planets might have been put in places not so ballanced, or that they shoud deviate and then

111

The mea= sures of force to recede from $y^e$ center

2. I say that $y^e$ power of $y^e$ fluid parts to move in directum, is either equall, more, or leSs than that of $y^e$ parts that com pose any one planet Residing in it. If more, then $y^e$ action will detrude $y^e$ pla= net down to a place, where it will ballance, & so if leSs. $y^e$ planet will prevail, & rise till it meets with $y^e$ like, & then paS away with $y^e$ fluid tacitely in a perpetuall orb, as we see they all do, & this is properly a mo= tion of libration. There have been great mistakes in this matter, for Cartesius de termined $y^e$ ballance by $y^e$ solidity of $y^e$ planet

planet compared with y^e^ content of y^e^
Aether, y^e^ place of w^ch^ it filled. And that
indeed is y^e^ rule of bodys observable in
fluido, because our common account
of solidity, [◦◦◦◦◦◦◦?] is taken by weight, w^ch^ here
is not y^e^ question, therefore it is not y^e^
solidity, or content of y^e^ planet, but y^e^
condition of y^e^ minute parts. For bodys
may have equall quantity, & yet une=
quall force to persevere according as
in figure y^e^ component parts are more
or leSs compact or spread. The other par=
ty take advantage of this, & fall to pro=
ving y^e^ planets to be more or leSs solid
than y^e^ Aether where they reside, whereas
(if that cou'd be proved) it is not measure
of substance, but y^e^ forms of y^e^ minute
parts, that make y^e^ question. As a sponge
or whisp of straw under water, hath not
force by y^e^ Exterior shew, but by y^e^ intrin=/sick\
condition

condition of y^e^ matter, therefore all
their demonstrations upon those calcu=
lates must fail. And surely nothing
can prove a ballance surer than
just scales; & y^e^ very Aether, & planets
ballancing in orbs so constantly one
against y^e^ other as they do, have y^e^ pro=
perty of y^e^ truest scales.

112.
The au=
thority of
congruen=
cy.

There are many matters that ly ready
to be discourst of concerning these 2
hypotheses, some for, & some against
either, w^ch^ if I shou'd spin out as long
as y^e^ subject woud bear, I shou'd be not
only tiresome but tired; But I think
in y^e^ stating a few objections & answ/ers\
I may say as much or more than will
be thought to y^e^ purpose. For y^e^ attrac=
tive scheme, they say all y^e^ courses
& aspects answer so precisely, that it
cannot but be true. To that I answer
(allowing

(allowing y^e^ congruency to be very egregi=
ous) that it is a congruency at y^e^ wrong end.
That is, a congruency of y^e^ effects, but without
any congruence of /y^e^\ causes; y^e^ former is of
much leSs regard than y^e^ latter, for effects=
may be congruent to divers causes pro=
posed, when but one cause can be true.
But when a cause is congruent ~~to~~ /with\ y^e^
whole course of nature, tho y^e^ effects
do not in all circumstances (as we may
opine) answer precisely, yet that may
be with reason judged to be y^e^ true cause.
For w^ch^ take for instance Copernicus,
who from a wonderfull congruency
of his new scheme of y^e^ planets, con=
cluded it to be true, altho all y^e^ phae=
nomena did not agree, for y^e^ visible
magnitudes of y^e^ planets, being nearly
y^e^ same, in y^e^ Apogee & perigee, was al=/most\
a con=

a confutation; but he chose to be=
lieve some future discoverys wou'd
answer that objection, rather than [quite?]
such a flaming probabillity in uni=
versallibus[153] as his scheme carryed; & so
it fell out, for afterwards, telescopes,
shewing ye magnitudes in true perspec=
tive, not known in his time, made
good his prophesy. So here I diferr
more to ye congruity of ye cause, that
is one universall flowing of ye whole
solar fluid, with ~~h~~h ye planets silently
carryed along, some faster, others slow=
er, in order (nearly) of distance from
ye sun, in one intire maSs. Whither
all ye appearances to our thinking an=
swer punctually or not; than to a more
scrupulous account of some particulars
tho derived upon a well contrived scheme
of wch

[153] i.e., 'in universals', i.e., 'as a general rule'.

of w^ch^ no part hath its fellow in y^e^ ordi=
nary course of nature.

113
Of y^e^ de=
crease in
y^e^ time
of y^e^ pla=
netary re=
volves.

Another thing alle/d\g'd@ against y^e^ corpus=
cular hypothesis is y^e^ eternall continu=
ance of y^e^ planetary courses without
wasting, w^ch^ doth not happen to any
bodys whatsoever, moving (as we suppose)
in pleno. It must be yielded that if
y^e^ planets were hurryed thro' y^e^ Aether,
as common bodys moving thro' y^e^ air, it
cou'd not continue without considera=
ble loSs of speed. But y^e^ case is not so;
for in y^e^ orbs y^e^ planets have no vis
impreSsa,[154] but are (quasi) at perfect
rest. If any power supervening shou'd
either impell, or retard y^e^ planet, then
a motive effect (as in other like cir=
cumstances) wou'd appear & not other=
wise, but what say we to y^e^ Grand
course of y^e^ whole Aether, must not that
loose

[154] i.e., 'inertia, or impressed force or velocity'.

loose of its speed in proceSs of time?
I answer not sensible in 100,000 myriads
or more of years; Even y^e^ globe of earth
revolving diurnally, upon y^e^ measures of
force & resistance before shewed, colla=
{_} ted with y^e^ gyrations of a childs {jigg}.
coud not in many hundred thousand
years shew any perceptible decrease.
for if y^e^ Gigg will make ten turns in
a second carry on y^e^ proportion of so=
{_} lidity or perseverance triplicate, & {.?}[155]
superficies or resistance duplicate
up to y^e^ magnitude of y^e^ earth, & y^e^ re=
sistance w^ch^ is by y^e^ superficies, wou'd
be found next to nothing compara=
tively. Here I cannot but wonder at
y^e^ vain industry of those who are plea=
sed with computations of y^e^ enorm ce=
lerity of y^e^ planetary motions, as they
take them to be, all w^ch^ are but mag/nitudes\
that

[155] An unidentified (by me, so far) editorial mark in pencil in the RH margin.

that admitt all proportions; ye motions
{_} being nothing pr{ae}ten[156] relations, & are
no cause of wonderment, however some
folks are apt to admire at such no=
things. But to return.

The ori= It is alledged against ye attractive scheme
ginall that no account is given why all ye
settlemt. planets shoud, as they do, keep close to
of ye pla ye Zodiack & not deviate much
nets frm ye great circle of ye ecliptick.
Nor why all ye celestiall transitts, even
ye praeceSsion of ye Aequinox as by com=
on consent, shoud tend Eastwards. They
might as well have moved from N. to
S. or in any other rhumb or great cir=
cle; & in a word, some one way, & some
another, with out any apparent impe=
diment, or contradiction on account
of attraction, tending to reduce them
to ye present order, but rather to make
or increase confusion; for altho ye sun's
attraction

[156] i.e., 'delicate'.

attraction is Common, Each planet at=
tracts for it self, & there are as many
severall agents at work, as there are
planets. But in ye other scheme, ye move=
ment being directed all ye same way,
argues one common influence that
rules them all, & that is ye universall
vortex, & ye planets are independant
& uninfluentiall with regard to each
other; & if it be said that ye almighty
placed them, I answer, very true, for
<red BM stamp> ye world was created at once & not left
to shufle it self into order. But it
cannot be denyed that some things
might be left, under a generall law,
to second causes; & it may be that ye
settlement of ye planets may be among
them; for as preponderation might
reduce, so equilibration may keep them
in their places. And it is observable that
ye Zodiack is about ye ecliptick, wch
is ye

is y^e^ equator of y^e^ solar orb, & at y^e^
greatest distance from y^e^ two poles
{to} of it, {~~to~~} w^ch^ (equator) all bodys im=
{q^u^}[157] merst in a turning fluid, as well
(59) from about y^e^ poles as elsewhere, must
tend. Attraction can be no cause of
such conformitys as these. & therefore
claims no preference against a com
mon course of things observed in y^e^
world. I take no notice of a late whim
that distinguisheth between celestiall
& terrestrial attraction, as ruled by
different measures, because like li=
berty will introduce aeriall,aqueous,
metalline, & as many various attractions
as ignorance shall have occasion for.

115
Of y^e^ Sub= There is little said here of y^e^ subpla=
planets & nets & y^e^ con~~sequ~~e/veya\nces of them; as of
their libra= y^e^ moon about y^e^ earth, & y^e^ Satellites
tions about Jupiter & Saturn, because those
matters are included in y^e^ consideration
of y^e^

[157] An editor's mark (q^u^? *see* note on fol. 90v, above) is entered here. Is this querying what appears to be a reference to section 59 (which would be to fol 52v above)? If so, that query seems approriate as the reference is not ... helpful.

of y^e^ Grand vortex, & have been touched
before. For y^e^ supposall is only that
there is an Epicyclar or minor vortex
belonging to each of those tribes of pla=
nets. And that such imply no contradic=
tion. nor inconsistency, may be proved
by y^e^ experiment upon any watery sur=
{_} face Made to{t} turn, in w^ch^ minor tur=
nings may be excited, w^ch^ shall without
any disorder be carryed about in y^e^
great one. The proof of this is y^e^ paSsage
of y^e^ Satellites about y^e^ grand planets,
as that of those about y^e^ sun. But ha=
ving a neerer observation of y^e^ moon,
we discern plainly a gravity (that
is unequall power of receSs from y^e^
center in y^e^ parts of y^e^ moon) because
y^e^ same phase is always obverted to=
wards y^e^ earth, w^ch^ must be by libra=
tion, as when a body is immerst in
fluido y^e^ heavyest side (if there be such
difference

difference) will always be downwards.
There is a conceipt that ye moon turns on a
center but just so fast as in its orb shall
{concordance} always shew ye same face to ye earth, if {any } of faster & slower so to agree were poSsi=
ble, ye effect might be argued; but as
it is, ye moon, say they, shews to ye sun
all its parts succeSsively as a thing that
turns, wch I allow must be so to all things
without (as to ye sun) but to none within
its orbit, as to ye earth. And it is proba=
ble that ye satellites of ye other planets
shew ye same, for (no turning being
supposed) one side by common accident
will be heavyer than ye other. And ye
vertue of attraction cannot be introdu=
ced here otherwise than in ye /cases of\ common
gravitation of bodys among us, of wch
as also of ye Lunar influences upon ye
marine

marine tydes, I shall imploy a few para=
graphs apart, hoping to find some clea=
ner solutions, than every one is aware
of. And in $y^e$ mean time I shall take up
{comets} $y^e$ subject of fire. As concerning {/\} vide
80. $y^e$ notes 80.[158]

## Of Fire.

Of fire, accension & extinction

There is as much concern to know what
fire is not{,} as what it is. For it is an
object almost perpetually before our
eyes, & being compound altogether of
materiall parts indistinguishable, ap=
pears in confused Ideas, & so becomes sub=
ject to chimeriq & false notions. First
it is not an elementary or specifick
matter, distinct from all other terrene
eSsences; for every thing we know is
obnoxious, ~~to~~by due means to become fire.
And that

[158] *see* above, fol. 100r.

And that makes me very attentive when I
find among y^e^ naturall philosophers, a men=
tion made of parts of fire, or fiery parti=
cles, when I cannot but think they talk of
they know not what. We are aSsured that
no fire is to be had but by y^e^ ministra=
tin of some compound materiall, nor can
it be continued without a continuall sup=
ply of y^e^ same, w^ch^ is called fewel. What
y^e^ nature of it is may in some mea=
sure be obtained byy y^e^ commom means,
& that is a very violent motion, w^ch^ seldom
& if violent enough, never fails to cause
an accension. And of these means y^e^ most
remarkable is y^e^ /use of\ steel & flint; y^e^ old con=
ceipt was that fire was lodged in y^e^
flint, but it is now found that y^e^ sparks
are pieces of steel fluxed by y^e^ violence
of y^e^ percuSsion. And as fire is bred, so it
acts, by force [divelling?] y^e^ parts of y^e^ fewell,
& sen=

& sending most of it into y^e^ air in vo=
lumes of smoak, & other vapours leSs vi=
sibe. And water not being accendible
but evapo/u\rable, it sends it into y^e^ air
in steam, & by affusion of water, fire
is extinguished, that is y^e^ rapid agitati=
on of y^e^ fiery action cohibited. But no=
thing is more remarkable of fire, than
that it will not subsist without a
strong compreSsion of air upon it. For
in y^e^ pneumatick receiver, upon relax=
ing y^e^ spring of y^e^ air, it immediately
goes out. And not only such compreSsi=
on of air is neceSsary to fire, but it must
have space allowed, that y^e^ air in circu=
lating may ventilate; for upon any
clausure it goes out.; therefore y^e^ storys
~~plusquam aniles~~ /of sepulchrall lamps\ are fables plusquam
aniles.[159] And I may here obiter[160] observe,
that life & fire have y^e^ same friends &
enemies

[159] i.e., 'old wives tales'.

[160] i.e., 'by the way'.

enemys, for where fire will not con=
117. tinue, life will not subsist.

The common
fires of y^e
world
{_}

The accumulating observations of y^e
course & efficacy of fire may inlarge
y^e naturall history, but conduce {little}
little towards explaining y^e phisicall
state of it. But for that we must go a
great way off, & interest y^e sun, & regi=
on of y^e planets, in order to a tollera=
ble resolution. It will be remembred
{_} that {that} y^e vortex of y^e sun being in
perpetuall rotation, y^e materiall by a
kind of fermentation, becomes sorted, &
y^e most powerfull parts working out=
wards y^e leSs powerfull are detruded
down towards y^e center, & there, as
I say, constitute y^e body of y^e sun; w^ch
consists of y^e minute & spread matter;
And those are apt to exhibite two kinds
of effects one bey reason of smallneSs, of

fire

fire; & ye other by reason of shapes to
coagulate, but being so minute, apt
as well to diSsolve or melt, as to coagu=
late, & so one & other contingently. Now
for ye moving part we must remember
ye interstitiall matter, wch is disperst all
over ye universe, as well circumference as
center. And being one as ~~y~~ewe suppose at
ye creation, with other things, after their
manner, put into a way of moving
ye same by mutuall & continuall im=
pulses, must continue indefinitely. And
wherever coagulums happen obnoxious
to be discerped by this subtile action, ye
effect is discerend as in common fermen=
tations.

118
The sun
a body
of fire &
its influ=
ence

And admitting these premises, ye sun
will be concluded to be a body of fire
for it must consist of interstitial mat=
ter chiefly, but withall sub-interstitiall

also

also, for matter is of all magnitudes di=
minish~~able~~/ing\ ~~in~~ad infinitum, [still?] y^e^ finer de=
truded towards y^e^ very center, where
resides y^e^ ultimate perfection of fire;
but towards y^e^ circumference of y^e^
sun y^e^ groSser of that subtile matter re=
sides, w^ch^ by reason of forms, as well as
magnitudes, may be leSs combustible, &
apt to make some coagulums, & those
to break up again, as fires increase &
diminish accidentally, w^ch^ appear by y^e^
maculae & faeculae observed to paSs upon
or near y^e^ body of y^e^ sun. And it is
not unlikely that y^e^ sun hath an At=
mosphear of pure fire such as our
purest flames, with some smoak perhaps
that extend to a great distance round it,
& thus y^e^ sun being a residence of y^e^ Sub=
tilest matter, moving with greatest rapidity,
hath

hath, influence more or leSs to agitate more remote subtile matter, & there= by to excite warmth (according to our sence) where ye like subtile matter occurs; & if any of that be susceptible to accend, it must so accend as we find in many instances, particularly. ye phos= phorous wax, wch, hot from ye still, will in ye open air, become fire.[161]

119. The cir= culation of fire at ye sun

I say'd that fire cou'd not subsist without a compreSsion, & there is enough of that at ye place of ye sun, for ye combusti= ble matter., doth as it were gravitate into it; & without such compreSsure all fire must diSsipate, as (concerning our culinary fires) will be shewed. But it will be asked whence is ye aliment that conserves ye suns fire alive, for we find a supply of fewell, as neceSsary to fire, as food

[161] RN explains and illustrates his (relatively early) acquaintance with phosphorus (first isolated in 1669) in BL Add MS 32546, fol. 168r ff.

as food to animalls? The answer to that
is obvious, for granting that ye fury of
ye sun disperseth vast quantitys of mat=
ter in fire & smoak, ye same cause that
brought it there at first, will return
it back again combustible, as soot
will burn as well as ye very fewell
that made it; & so there is at ye sun, a
perpetuall circulation of combusti=
ble matter, being smoak or vapour,
& fire alternately; & thus ye sun wor=
king by perpetuall diSsipations, coa=
gulations & fluxions of ye same matter
going & returning, is ye only perpetu=
all motion, if there be such a thing,
in ye world. However I think here is
given a familiar resolution of ye na=
ture & cause of ye suns fire. And now
it is time to retire to ye planets, where
we reside, & to observe ye analogy of

particular

particular fires with y^e^ common fire
at y^e^ sun.

It was not an ill thought of Cartesius,
that (ever supposing y^e^ world was made
in perfection at once) there was a poSsi=
bility that coagulums might get y^e^ better
of y^e^ suns fire & so choak it, & that other
suns (or fixed starrs some of w^ch^ are ob=
served to /have\ vanished, & then to have re=
vived, & some never to be seen more)
may have been so served: & who can
answer what alterations of that Kind
have been in y^e^ Nebulae & Galaxy?
And any of those minor starrs of in=
finite numbers from fluid fire, beco=
ming continued solids., may change their
ballance, & go astray till finding a
ballance in other vortexes, become
planets, & for fail, comets perpetually
errant; & y^e^ proper vortexes be absorpt
w^ch^ first

149r



w^ch^ first happening might be y^e^ cause of
y^e^ rest; & some c~~ar~~/ar\rying their weakened
vortexes & [. . . . . ?] subplanets with them, ob=
tain such settlements as y^e^ earth, Jupiter,
& Saturn are seen to have. But he was
mistaken in one chief article of his scheme
of y^e^ heavens, w^ch^ was that y^e^ motion
of y^e^ sun continued y^e^ motion of y^e^ vor=
tex, & that failing y^e^ vortex was expo=
sed to be absorped by its neighbours,
for y^e^ gyration of y^e^ planets on their axes
rather depends on their revolving of
their vortexes than these on them. But
these are fancys of no import to us; it
is certain that their is a vortex in w^ch^
y^e^ earth swimms, & all y^e^ consequences
of a vortex, w^ch^ are y^e^ crowding y^e^ sub=
tiler matter toward y^e^ center. And
altho y^e^ earth is covered with coagu=
lums, yet there is a warmth about it,
& much

& much of ye materiall, as sulphur
very accendible, & for ought we know
to ye contrary pure fire at ye center,
but be that as it will: wee are sure
there is a maSs of terrene fluid matter
in a form we call ye Atmosphear,
{_} {lying}, lying continually upon ye surface
of ye earth with a gret weight, & what
influence this hath upon fire is to be
129 considered

The in=
terstitiall I have often mentioned ye subtile inters=
matter titiall matter wch is no where excluded,
ye ~~a~~true but is continued all ye world away over, &
anima is very influentiall in most of our ter=
mundi restriall phaenomena, & may justly be
esteemd ye true anima mundi. It is
100[162] efficacious in nothing more than in ye
operations of fire where of ye force is
not so much derived from ye fewell
as from ye subtile matter. The power of
that

[162] (presumably) *see* above fol. 113v.

that is not confined to any compaSs,
but hath a communication more or
leSs with all y^e^ circumaƀmbient space
indefinitely. This subtile matter in=
tersperst among y^e^ parts of fewell
however combustibe, altho always in
swift agitation, hath not power to
excite (ordinarily) an accension; for
minuter parts separatim have little
power over greater. But when y^e^
Ice is broke (as they say) & a little ac=
tuall fire is applyed, y^e^ accension shall
take & consume or diSsipate y^e^ whole
maSs. The reason of this is that parts
once actually set on fire have power
to agitate y^e^ adjacent parts of y^e^ few=
ell; & then y^e^ subtile matter rushes
in, & Joyning y^e^ motions with greater
swiftneSses; increase, dilate, & continue.
for smaller bodys by their adjunct will
not

not only sustein $y^e$ motions of greater,
but also augment them. As of swing
pendulums, & raising a steeple bell.
It is no wonder therefore that fire
begun by a slight touch shall run
thro a maSs of proper fewell, when
upon $y^e$ first overture $y^e$ subtile matter
enters & cooperates in $y^e$ action. And
(however $y^e$ fuell by diSsipation may
be wasted) $y^e$ force of $y^e$ subtile matter
rather increaseth /by $y^e$ heat\ round about.

122.
Fire dis
tinguish't,
& air (preS=
sing) ne=
ceSsary

In $y^e$ buisneSs of fire, we may make 4
partitions, or rather gradations. 1. Heat,
2. Burning, 3 Flame. 4. Explosion.
1. Heat shews $y^e$ first inceptiones of fire,
of $w^{ch}$ (besides our sense of touch) $y^e$
symptomes are $y^e$ rising of steams, &
smoak. 2. Burning is $y^e$ state of a coal,
as that of a charcoal kindled. 3. Flame
is a st/r\eam or flux of fire, & 4. Explo/sion\
is when

is when y^e^ whole effect of fire & suc=
ceeds all at once, or appears so to us.
In all these instances y^e^ subtile matter
is y^e^ principall agent, for y^e^ fewell is
sluggish, & what shoud move it, but
that w^ch^ is mixt amongst it? But
that w^ch^ preserves fire in a body, &
makes it a object of our observa
tion, is y^e^ air by y^e^ urgency of its preS=
sure: 1. In heat, y^e^ air is intermixt
{ rising} with y^e^ {/\ fewel}l, & all y^e^ matter raised
& diSsipated is taken into y^e^ body of
y^e^ air, & contributes to y^e^ common mix=
ture, as when we see steam & smoak
rise & disperse every way till it is va=
nished, & so becomes common air. The
preSsure hath no part in this action,
but only to receive & aSsimilate what
riseth. But 2. when a coal is kindled
y^e^ air, by preSsing, keeps close y^e^ accension
as in a case that contains y^e^ fewell from
dispersing

dispersing; For ye fire is always urgent
against this preSsure, tending to diSsi=
{_} pate, or as they say evapourate, & {/yt\}
succeeds, not all at once, but gradieually
as ye parts intermix with ye ambient
air. And when ye force of that exha=
ling matter is sufficient to beat back
ye air, so that it doth not intermix
{kindled coal} with ye {fewell} /accension\,[163] one superficies clas=
ping close to ye other, ye coal continues
to burn, but if ye exhalation grows
languid, & ye preSsure of ye air gets ground,
& as it were unites with heated matter
ye fire goes out, & so also when by suc=
tion, as in ye air pump, ye preSsure is
relieved; ye action of ye subtile matter,
together with ye parts of fewell actu=
ated by it, disperse all at once, & ye fire
ceaseth. So that ye air is a confinement
that keeps ye matter of ye fire together,
& also by ye agitation of ye adjacent
parts

[163] The word 'accension' inserted in ink in a different hand, the word 'fewell' struck out in ink; the word 'fewell' is underlined in pencil and the words in the margin are in pencil.

parts, contributes to y^e^ accension of y^e^ few=
wll, w^ch^ is proved by applying a current of
air to y^e^ coal, for that, by friction exas=
perates y^e^ fire exceedingly; And without
some Lambent transition of y^e^ air upon
y^e^ face of this sort of fire, it will hard=
ly live, such effect hath friction to sus=
tein as well as to excite or kindle fire.
But y^e^ chief remarque here is, that when
y^e^ action is strong enough to repell y^e^ air,
so that y^e^ fewell & y^e^ air have distinct
superficies, without interfering totally,
then it is fire, or else, not, as I may fur=
ther elucidate afterwards.

123
The diffe=
rence be=
tween
smoak &
flame

The next state of fire is inflamation;
It is certein that all fire whatever e=
vapourates, & ~~red~~thereby reduceth y^e^ com=
bustibles to a faese. But y^e^ composition of
fewell

fewell is of Matter, as to that Energy,
very different, for some parts separate
with much leSs violence than others; as
at y^e^ beginning of a combustion, there
is a plentifull separation that appears
in y^e^ form of smoak; & at y^e^ conclusion
also, a meer coal still evapourates,
but not so groSsly to be made visible
as smoak is, of w^ch^ (smoak) I take y^e^
materiall to consist of combustible
parts, w^ch^ were separated, but not
kindled. Whereas y^e^ steam from a coal
is matter w^ch^ hath undergone a combus=
tion, & after that, exhales in y^e^ form
of ashes dispersing. Now when smoak
riseth, y^e^ air is intermixt with it, as
well as conjoyned to y^e^ fewell from
whence it is derived, & y^e^ parts continu=
ally separate [untill] in y^e^ air untill it is
consi=

consimilated, & lost in it. Now y^e^ heat
urging continually more & more, at
length y^e^ parts of smoak take fire, &
are kindled, y^e^ eCrisis of w^ch^ transit of y^e^
form, from smoak to fire & contra,
is y^e^ repelling y^e^ air from all intermix=
ture with it, or not; for when y^e^ agita=
tion of y^e^ fumose matter is so power=
full, as to resist y^e^ preSsure of y^e^ At=
{broader} mospheare, then it is f{lam}e & not smoak,
& when y^e^ Atmosphear gets ground,
& intermixeth, y^e^ flame goes out, & y^e^
stream becomes smoak, & in this tran=
sit there are no degrees, but either
way all is done at once. So that Flame
is nothing but smoak kindled, & during
{_} y^e^ burning, {~~Flame~~} as to air is a Tor=
icellian vacuity. This proved by a
common boys experiment: as make a

pure

pure flame in a pitcher & suddently
invert y^e^ mouth into a bason of wa=
ter y^e^ flame in that instant goes
out, & y^e^ pitcher sucks y^e^ water out of
124. y^e^ bason, in great fury & in large
A lu= quantity.
men at=

tends There are divers things to be taken no=
smoak tice of relating to flame. As that y^e^
{_} parts of ~~fire~~Smoak set on fire, {(}separate=
ly considered{)} are but of a moments
continuance in that form. But flame
w^ch^ is but a succeSsion of minute ac=
centions seems a continued substance;
& as to that, I must say that altho a
particle, as to sence, is (quasi) nothing,
many together make a sensible appea=
rance. As one lighted candle at distance,
may not be seen, & 40 together will be
very visible, all which are but of

candle

candle strength. The flame of a can=
dle it self consists of minor flames, of
y^e^ pabulum as specks of fire paSsing
us in a current. So one straw makes
an inconsiderable fire, but a quantity
of y^e^ same will raise a pyramid as high
as an house, & y^e^ whole is made up of y^e^
fire of single straws, & even that, as I
may say, of single sparks. The like is
true of y^e^ Galaxy, & six hundred other
instances; & of all manner of Energys
where many small things cooperate;
As I shall observe when I come to y^e^
subject of light; But of this matter
I shall ~~but~~ here /but\ only hint, that y^e^
Metamorphosis of smoak into flame
& e contra, is, to our sight, done in a
moment; & so is perceived by light &
opacity

opacity. For till y^e^ light appears, y^e^ profluvia are amoak, but then it be= comes flame; For nothing leSs than actull combustion hath strength to beat off y^e^ Atmosphear, & that force, & not leSs, procures y^e^ sensations of com= mon light.

125. No fire without a current of air that tends to y^e^ upright. notes 19. 44.[164]

It is notorious that whenever there is smoak, flame, or any exhalation, there is a stream upwards. As first, that there must be a current is necessary, for y^e^ fewell discharged being rarifyed will expand some way; & that will proove to be in y^e^ upright, & not Laterally, unleSs some force from y^e^ air, as in a wind, diverts it. And this determination our vertuosi ascribe to y^e^ lighneSs of y^e^ vapour; for if y^e^ air is heavier, that

(vapour)

[164] It is not entirely clear how these references help - 79: fol. 217v; 44: fol. 40v.

(vapour) must needs mount. And one of
them fancyed that by his microscopes
he discerned y^e^ waters stream to consist
of small bubbles, w^ch^ he concluded were
filled with some refined matter, as
fire; & by that means y^e^ air became re=
pleat with these vapours, w^ch^, breaking,
became clouds, & rain; & when y^e^ air
had fewer vapours, or they kept aloft,
there was fair weather, but more of
this, if I shall happen to talk of me=
teors. Nowe y^e^ vapours from fire, whether
steam, smoak, or flame, with respect
to y^e^ air, are neither light nor heavy,
but being of y^e^ same nature with it,
& intermixt, do ballance, & conform to
all y^e^ motions, or waivings of y^e^ air
w^ch^ way soever it goes. But y^e^ preSsure
of y^e^ Atmosphear diminishing upwards,
y^e^ resis=

yᵉ resistance is leSs that way, than any,
other, & on that accoᵗ yᵉ current, wᶜʰ flows,
from all fire, will go upwards, & when
there is no more combustion, then as other
smoak (but in yᵉ form of ashes) becomes
air. All this is egregiously experienced
by yᵉ flame of a candle, or lamp, wᶜʰ
circulates yᵉ air, & yᵉ preSsure drives yᵉ
pabulum up yᵉ [weak?], as way is (by yᵉ
{_} bu{rn}ing{)} made for it. And yᵉ flame re
sisting{)} yᵉ airs preSsure most at first is
rounder, & then grows weaker, & thereby
together with yᵉ flowing current of
yᵉ matter becomes pyramidall, & what
doth not expire in yᵉ paSsage, deter
mines in a dry Ashy smoak. Without
these efficient causes, yᵉ flame, as other
unconfined fluids in yᵉ air, must be per=
fectly round. And by these and all other
instances

instances, it appears that about us y^e^
weight of y^e^ Atmosphear is y^e^ causa
sine qua non[165] of all fire & flames &
that except it be about y^e^ center of a
vortex, or in some Elastick Atmos=
phear, there neither is, nor can be
such a thing as fire in y^e^ world. And
what heat subsists in y^e^ aether at large,
where is no Sulphur or other pabu=
lum of fire, None of us can know,
nor confidently pronounce it to in=
crease from our common heat by proxi=
mity to y^e^ sun, in such immane pro=
portion as y^e^ moderns are pleased to
calculate, more to excite wonder than
126. to increase knowledge.
The opera=
tions of I have considered that our known com=
fire not to pound materialls are differently qua=
be minute= lifyed as to fire, some for smoak & flame,=
ly accoun= some to exhale without flame, some to
ted for Liquefy

[165] i.e., 'cause without any equal'.

liquefy or vitrity only, & some to all
these one after another, & so readyer
or slower to accend, & some to explode,
& by reason, of y^e^ exillity of y^e^ energe=
tick particles, these matters are im=
poSsible to be crittically accounted for
by any observations we can make. I
shall persue no further varietys, & de=
clare only y^e^ GroSs effects, with y^e^ poSsi=
bilitys conceivable to be y^e^ cause of
them. But I must except one article
of y^e^ most stupendious consequence, &
that is explosion, w^ch^ I shall endeavour
to look more narrowly into.

127
of explo=
sions &
how

In order to come at this subject, it is
expedient to take up some one egregi=
ous example of explosion, & that, if it
may be understood, will give a light
to all y^e^ rest, & I think none more pro=
per than our common gunpowder, w^ch^

takes

takes fire from a small spark, & at
one heave doth wonders. The materialls
are Sulphur y^e^ readyest of any thing
to take fire, Nitre, that burns pervica=
riously, & charcoal as a sort of Tinder
to kindle & communicate y^e^ fire; these
inflamables, all pulverized well to=
gether, & granulated are ready for
use. I shall beginn with a particle
of y^e^ impalpable dust, before it is
granulated; & in that we find all y^e^
ingredients, w^ch^ (by means of y^e^ coal) be=
ing fired, must emitt a small flame;
for y^e^ whole substance, as smoak, is in=
flammable, y^e^ Sulphur & Nitre, w^ch^ a=
part are slow burners, breaking each
others body by y^e^ mixture, diSsipate all
together, & become a flammulae,[166] in w^ch^,
besides y^e^ materiall (y^e^ extant, as in all
rarefactions being multiply dilated)
nothing

[166] i.e., 'fires'.

nothing but $y^e$ subtile matter is contained,
& that with a common force, derived from
all parts without, agitates & forceth $y^e$
inflamed matter against $y^e$ air, that preS=
seth against it, till at last it is absorpt,
& becomes air it self. This wou'd not happen
if $y^e$ body were not first lifted or broke
by $y^e$ application of externall fire, but
then, as I sayd before, $y^e$ subtile matter
agitates $y^e$ parts into a rarefaction, $w^{ch}$
is flame; & that is best understood by
$y^e$ effect of a single pulviscule, of $w^{ch}$
$y^e$ force to expand against $y^e$ preSsure
of $y^e$ air, belonging to all flame, little
& great whatsoever, is not in propor=
tion inconsiderable.

128.
The proceSs
& increase
of explosive
powers

Now supposing another pulviscule con=
tiguous, that must be fired from this, &
then there is two flames joyned, $w^{ch}$ require
double space, & so more till a granule
is fired

is fired, of w^ch^ y^e^ flame is (nearly) instanta=
neous, & how much dilated in manifest to
y^e^ eye; And y^e^ reason of granulating is
that thro y^e^ interstices, w^ch^ are large, y^e^
fire of one granule may have convey=
ance or acceSs so as to kindle many at
or near y^e^ same time, for if y^e^ pulviscu=
lae are compact close together, w^ch^ they
call wild fire, they kindle succeSsively
one after another, & so burn in time, &
have not an explosive effect, w^ch^ de=
pends wholly of qualitys almost instan=
taneously rarefyed into flame. I propose
this image w^ch^ I have all ~~l~~ready made use of;
take a single straw & fire it, w^ch^ will pro=
duce a small flame, add another &
then y^e^ flame is double, & so accumula=
ting more, y^e^ flame by such addittion, will
inlarge, till it becomes as large as an
house with a larger pyramid. This fire
being

being graduall, shews no manner of ex
plosion; but supposing all that flame
to be generated (almost) at once, one
cannot but conceive y^e manner of ex=
plosions. And y^e mighty power of them
is not derived from y^e parts of y^e few=
ell, w^ch are paSsive, & a mean whereby
y^e unlimited power of y^e subtile matter
(y^e soul of all rarefication) acts. When
y^e materiall is agitated whereby y^e sub=
tile matter, that is much quicker, &
backt from without; lays hold, & y^e
materiall also reacting upon that,
there is a combined force to rarefy, w^ch
is seen & practised every day in y^e use of
explosive powers.

129.
Instantane=
ous accen=
sions ex=
plode

Hereby it appears that y^e whole work
of every explosion consists in y^e difference,
when y^e fewell takes fire gradually, &
when all at once. For whatever y^e mate/riall\
is, if

{_} is, ~~it~~f ~~eait~~n can be so kindled {~~as~~}, it hath
y^e^ effect of gunpowder. Aurum ful=
minans,[167] & even GlaSs pulveri~~s~~zed (as in
brazing of iron) will explode, & with
no small force; but not being handy
as they say, nor kindleable without a
very strong fire, & requiring time, they
cannot be applyed to use. Bodys that
do not flux without y^e^ utmost force
of fire, as some meta~~t~~talls, stones, earth,
& such things as turn to vitrification,
or emitt little vapour, & none accen=
dible, make no explosion; bodys apt
to evapourate all, as water, if put in
a furnace, so strong as to throw it into
vapour all at once; furnace house &
all go for't. So many are y^e^ varietys of
combustibles, w^ch^ are exercised by fire; &
produce divers effects, that most are not
to be accounted for but by chimists, whose
work

[167] lit: 'exploding gold'. Aurum fulminans was discovered by alchemists in the later sixteenth century. Gold dissolved in Aqua Regis (nitro hydrochloric acid) precipitated a powder which proved sensitive not only to heat, but also vibration. It was the first high explosive.

work it is to persue them. It is remar=
kable that y^e^ [.....?] of a burning glaSs[168]
will melt but not move gunpowder
to an explosion because it is y^e^ ac=
tion of a subtiler matter, & common
flame will scarce do it. And it must
be a culinary for that purpose, as y^e^
sparks fro~~form~~ a steel & flint, w^ch^ are
melted mettall or some groSs fewell,
that will fire gunpowder. It seems
that parts of some magnitude & force
must be applyed to make a rupture
& raise a fiery action in y^e^ materiall
of Gunpowder. The subtile matter or
athereall parts will not do it alone,
but after they are lett in, & commixt,
work effectually.

130
Of mettalls heated & ig= nis lambens

The heat preceeding diSsolution by fire,
must be an actuall agitation of y^e^
matter, w^ch^ y^e^ touch discovers, especially
in terrene

[168] i.e., a magnifying glass focusing the sun's rays.

in terrene or mettaline bodys, for those
[~~,~~?] without changing y^e^ exterior form, will
rend & tear most things. But in these ca=
ses y^e^ subtile matter hath y^e^ greatest share,
& y^e^ solid, without separation, bears a
concuSsion of y^e^ groSser parts, & in some
sort a dislocation, w^ch^ is proved by y^e^ nea=
ling of mettalls, altho in y^e^ groSs they do
not, or very slowly, diSsolve, or flux, &
then y^e^ heat abating coagulate again;
y^e^ secrets of w^ch^ effects will not be known;
All hitherto of y^e^ ignis ardens, as for y^e^
ignis lambens,[169] it hath nothing common
with y^e^ other, but y^e^ name & a faint
lumen, & more properly belongs to y^e^
subject of light, whereto it stands
referred.

[169] i.e., 'burning fire' and 'kindling fire' (*see* BL Add MS 32545, fol. 215r). *Ignis lambens* literally translated is 'licking fire'. Here MN uses the term to refer to the cold 'fire' of phosphorescence.

Of light & Colours

(131)
Of y^e won=
derfull
paSsage
of light &

The action w^ch causeth our sence of light is extant in y^e whole luminated space, & at one & y^e same time, or rather at all times, by instantaneous influence trajects all manner of ways, extror= sum, retrorsum, decuSsation, continu= atim,[170] without reciprocall impediment or disorder; altho y^e same medium is per= petually concerned in y^e conveyance. All w^ch may be perceived by any person that looks about him abroad or within doors, where any light shines; for all points in a lighted room are seen by strait lines alternatively to, at & from all points of y^e confines; so that every point of y^e medium hath all y^e others croS= sing thro' it by infinite intersections.

All w^ch

[170] i.e., 'outward, backward, crossed, continuous'.

All w^ch speculation is so repleat /with\ mistery,
that y^e whole world of physicall phi=
losophy hath not yet gained a tolerable
analysis, whence to hope for a resolu=
tion. The Epicureans supposed certain
refined species to flow perpetually from
luminous bodys to y^e visuall organ, w^ch
is a fancy so senceleSs, & precarious, & with=
all full of absurditys that it is imper=
tinent to note them. But with a view
of somewhat of like nature to be ob=
served afterwrds, I shall here note
that how thinn soever these species are
supposed to be, they are somewhat, & that
materiall, y^e perpetuall flowing of
them (by night & by day) directly & trans=
versly infinities, croSs & thro each other
without interruption or confusion,
all over y^e atomicall world,[171] is such
a maSs of impoSsibillitys, as cannot for
a moment a moment

[171] The Epicureans also proposed an atomical theory of matter.

a moment be endured.

132.
Of ye Cartesian attempt & of rays

There is nothing in ye antiq philosophy of this subject worthy to be mentio=ned, till we come to Cartesius, whose dis=courses are most explicite, &, as I think, border upon truth more sensible, than any others have done, but yet leave us in doubt, what is light? He hath used ye image of a vintage table, to shew ye poSsibillity that a promiscuous ac=tion may have effect by right lines qua=quaversum; And every fluid & solid con=sidered by its parts, doth ye same; but what is this to ye force of light? As to that he hath a most nice distin=ction, between motus & actio. He will not say that actio is motus but that it is propensio ad motum, & what that is Quaere?[172] I have shewed already that there is no medium between moving &

not moving

[172] i.e., 'He will not say that action is motion, but that it is a propensity, or tendency to motion, and what is that I ask?' - the answer in Descartes' own words would be 'conatus', see note on fol. 138r, above.

not moving, & that conatus, tendency,
& propensio ~~a~~drem but analogys, & really
nothing at all. But unde[173] that actio
in a luminary w^ch excites th~~is~~at propen=
sio? an account of this is chiefly wan=
ted, & for want of it we are as far
from knowing what is light, as if no=
thing at all were say'd of of it. The
account of rays given by him, is in=
genious, & it is that they are no other
but y^e right lines of y^e tendency or pro=
pension, & if y^e tendency be nullity what
are y^e rays? I believe never poor word
was so bandyed thro. voluminous scien=
ces of y^e opticks, as that (of rays) taking
up y^e whole matter of y^e argumenta=
tion, & withall so little understood.

133.
The New=
tonian
Hypthe=
sis & pro=
greSsion

Wee come now to y^e last attempt in
order to render y^e theory of light & co=
lours compleat to be found in y^e justly
admired

[173] i.e., 'where is'.

admired optica of S^r^ Isaak Newton;
but here we must stand & look about
us, to see that no danger is near, for me
are entring into y^e^ sanctum sanctorum,
& to contravert any thing held forth by
that great author, must needs be pia cu=
lar;[174] therefore I shall use this cautelous
distinction. Wch is between y^e^ cause of
light, & y^e^ naturall history of light &
colours. As for y^e^ latter, & y^e^ optick con=
sequences, Nothing that I can say can
come near y^e^ value of that work;
for w^ch^ reason, & because I am not mas=
ter of y^e^ experiments, I adventure not
amongst them, or meddle with y^e^ in=
ferences. But as to y^e^ cause of light, w^ch^
is my proper undertaking, I shall do
no great harm, for y^e^ great author
declines all that is physicall in that
subject, & referrs wholly to matters of
fact &

[174] *sanctum sactorum*, i.e.,` the holy of holies; perhaps '*pia culpa*'? an error in faith, a heresy.

163r



fact & experiment. But for y^e^ clearer
conduct of those he hath contrived
an hypothesis. And from y^e^ many con=
gruitys of that, his followers argue to
y^e^ reall truth of it; The hypothesis is
this. That light is a collection of rays,
that is, Heterogene strings variously colou=
red, that move in time (but inconceiva=
bly swift) from y^e^ luminary to all pla=
ces quaquaversum by strait lines; that
these rays at ~~ee~~/ce\rtain paSses reflect, & refract
from y^e^ direct course. That some coloured
rays refract to a greater angle than
{_} others, & altho {<u>are</u>} differently coloured
yet all are comprisd in & shew as com=
mon light; & when refractions happen,
y^e^ unequall refrangibillitys of y^e^ coloured
rays lays them all apart, Redds, blues,
yellows, purples &c by themselvs as in y^e^
rainbow, & common prismall inspections

And there

And these influences falling upon y^e^ or=
gn of sight are y^e^ cause of our sence
of light & colour. I might here as well
say reflectible as ref~~l~~rangible, in diffe=
rent angles. If y^e^ one follows y^e^ laws of
motion, why not y^e^ other? & so equally
produce colours, w^ch^ we find not conse=
quent; but speculums give us y^e^ whole
nature of reflections.

134.
Light not progreSsive nor sub=stantiall

Now without any altercation upon this
hypothesis, I shall apply to y^e^ root; y^e^
only thing affirmed at y^e^ entrance of
y^e^ ~~book~~ /work\ is that light is somewhat, that
moves locally through y^e^ medium, w^ch^ is pro=
ved by shewing that an opack body
interposing stopps y^e^ course of light, &
y^e^ removall of it letts it paSs.. This by
no means inferrs a locall progreSsion
of y^e^ light, tho it intercepts y^e^ effect of
y^e^ agitation that is y^e^ means of light,
of w^ch^ more afterwards, as also of time

in y^e^

in y^e^ paSsage. In y^e^ mean while observe
this gradient light affects our sence, w^ch^
must be by touch, & that of body. Then
observe what innumerable impoSsibilli=
tys occurr here[ass?]. y^e^ stream of this cor=
poreall light, from y^e^ sun (at least) is
perpetuall, & from all luminous & lu=
minated bodys continuall. And in y^e^ eter=
nity of time must surely fill up all y^e^
vacant space in y^e^ universe, & leave no
{more} room for {inane}, & what a deluge of in=
cinsistencys must gappen from ~~m~~hence,
w^ch^ I hinted at y^e^ beginning? 2 All y^e^
experiments in our power to try shew=
light to be instantaneous; but wa/i\ve
y^e^ rigor; & if any time paSs it is so little
we cannot observe it, as by y^e^ fire of
cannon at two or three miles distance;
How can such swift progreSsion be
made thro' a compreSs Atmospher?

3.

3, but then without reflecting y^e^ light it
self must in time fill y^e^ world, they tell
us of vacuitys; there cannot be much in
compreSst air, & light being a body is
but a slight one & subject to yield to
all resistance. Then we are sent out into
y^e^ world, & there (in fullneSs of light) is
all vacuity & no resistance; & it is com=
puted that seven minutes is taken up
in light paSsing from y^e^ sun to us. PaSs
all y^e^ dubia about y^e^ computation;
what is seven minutes of time to that
space? it may be answered, as to esteem
or value, just nothing at all. The neceSsa=
ry disorders of things, wou'd in such dis
proportion, infringe even mathematical
rules reduced to practise, so I must acco^t^
this a lean pretence. Then 4. What prin=
ciple of force can reside in y^e^ lumina=
ry, that shou'd dart these strings called rays,
so Hetero=

so heterogene, as they say they are, as
to colours i continued streams of tac=
tile substances, with such incredible
swiftneSs as from y^e^ sune to us in 7 mi=
nutes, & all this with out ceasing, & withall
a continuall exhaustion of such matter?
And y^e^ Satellites of Jupiter whose light
at greater distance have not so large
an allowance of time. And what then
of Saturn in his Apogee (however we
forget y^e^ fixt starrs). If any persons are
inclined to credit such flights, May their
joy never forsake them, while they are
pleased to allow others a freedom of an=
intire diSsent.

135,
Rays &
pencills of
rays not
solid

It is plain that y^e^ great author deferred
more to y^e^ concinnity of his hypothesis,
than to y^e^ reallity of any principle, for
he no where affirms that rays of light
are solid or corporeall emanations from
y^e^ luminary, but only insinuates as much
saying

saying that they move quasi corpus,[175] &
ye like, wch so farr must be granted, for
light & fluids are found to flux in like
manner, as will appear afterwards;
but ~~this~~ his followers affirm downright
ye perpetuall and universall emanation,
so that ye matter wch toucheth our eye,
& excites ye Idea of light, was actually
in ye sun about 7 minutes agone; & they
have endeavoured to solve ye matter
by pretending that ye corpuscles being
small ad infinitum, such thredds, or pen=
cills of rays (as they love to speak) poSseSs
but small part of ye space, & may paSs
to & from without much interruption, & if
any of ye matter justles, so much falls
to ye ground, & is Lost, & yet enough always
to supply our groSs sence. And this mate=
tiall of light is so subtile that ye con=
tent of what is in ye solar sphear col=
lected wou'd be contained in ye space of
a cubick

[175] i.e., 'similar to body, or matter'.

a cubick inch. This is all that I have
met with to palliate y^e^ monstrous o=
pinion of solid rays of light; And it sa=
vours strongly of y^e^ Epicurean system
w^ch^ rests upon y^e^ like subterfuge of mi=
nuteneSs, And for y^e^ sake of a compa=
rison I mentioned that before. If it is
alledged; as y^e^ mode of some is, that it
is impoSsible light shoud be solved any
other way, I answer first, that no argu=
ments flow from ignorance; Next, that
as it seems, a fair solution of light
may be given, consonant to y^e^ energy
of body, & y^e^ state of y^e^ universe; And
I am about to make y^e^ same appear, &
have touched this last scheme of y^e^ mo=
dernes, to remove a prejudice; for y^e^
prepoSseSsion in favour of it, derived
from y^e^ transcendant abillitys of y^e^ author
(In Geometry at least) is so violent that
nothing

nothing of a different genius must ap=
pear till that be removed; And whither
I succeed or not, ye very attempt to ad=
vance a naturall knowledge is not illau=
dible. I wish that our moderns wou'd con=
{_} sider better ye nature of principles {~~than~~}
than to talk of particles of light, par=
ticles of fire, & particles attractive,
of wch ye summa totalis is, Nihil,[176] & why
not particles of sound, particles of pain,
particles of pleasure, Justice, & summum
bonum,[177] or any other metaphysicall en=
titys; & all with ye same measure of
science.

136.
Of medi=
ums ye
more sub=
tile of
light & ye
more groSs
of sound.

There is some resemblance between ye
conveyances of sound & light, from re=
mote objects to ye organs of our sence,
both are advanced by ye interposition
of ye same common medium, ye air;
light appears to be in instante,[178] but sound
in time

[176] i.e., 'the sum total of which is nothing'.

[177] i.e., 'the highest good'.

[178] i.e., 'immediate'.

in time, considerably slow. And both these
influences never affect y^e^ same organ,
for light is perceived by a materiall
touch of a force wonderfully subtile
w^ch^ paSseth thro y^e^ tunicks of y^e^ eye,[179] & no
leSs wonderfully affects only y^e^ pointed
extremitys of y^e^ optick nerve, in a man=
ner augmented by refractions, as will ap=
pear. And y^e^ same matter, if y^e^ artifice
of y^e^ eye were away, woud penetrate
all y^e^ ordinary flesh & membranes of
y^e^ body, without exciting any sensati=
on; But sound penetrates or paSseth
through no part of y^e^ body, but is eve=
ry where stopp~~t~~ed, & if violent is per=
ceived by a sort of heave, as when a
cannon is fired: And preSsing thro y^e^
tube of y^e^ ear meets woth a membrane.
the tuggs of w^ch^ excites a sence of sound,
& hath no effect at all upon y^e^ interior
organ of sight; from whence I conclude
That y^e^

[179] The eye was described as having three '*tunica*' or tunics - the external, 'fibrous tunic' (cornea, etc.), the middle, 'vascular tunic' (iris, etc.) and the internal 'nervous tunic" (the retina). In the tradition following Galen (especially in the Arabic tradition), the eye (and indeed the human body) came to be described with a complex and an evocative poetry of metaphors, still available to anyone who is bothered to look up, say, the etymology of 'retina' or 'iris'.

that y^e^ proper medium of sound is y^e^
groSs air w^ch^ we breath, & will be con
sidered elsewhere, but y^e^ medium of
light is some order or measure of y^e^
subtile interstitiall matter w^ch^ is found
to permeate all our compound solids,
& is every where intermixt with y^e^ air.
And considering that (air) is a compreSst
fluid & confined to y^e^ limits of y^e^ Atmos=
phear, there is reason to think ~~that~~ /y^e^\
matter at large in y^e^ world to be of
y^e^ more subtile sort, at least that
by w^ch^ light is conveyed, is so, & w^ch^ every
where permeates y^e^ interstitia of it.

137.
A groSs
image re=
presenting
y^e^ united
cause of
sound &
light.

But it is found that as well in y^e^ paS=
sage of sound as of light, y^e^ influence,
however multiplyed & directed, paSs
croSs each other all manner of ways
without disorder or confusion; w^ch^ wou'd
be more admired, if y^e^ circlings upon
water did not shew y^e^ like distinctly, but
that

that reconciles y^e^ common experience we
have in cases analogous, but leSs distinctly
as by y^e^ ordinary use of our senses. How
this makes it neceSsary to distinguish y^e^
actions of light & sound, y^e^ latter is to be
dropt, & y^e^ present speculation confined
to y^e^ former. And this is not to be done
but in y^e^ Cartesian method ny contriving
some ordinary image to referr to. And
that here shall be a large pool of wa=
ter; let y^e^ labourer come with his spade
flatt, & strike a smart stroke with it
upon y^e^ surface of y^e^ water. Here are
2 influences of very different effects,
one of circling waves spreading gra=
dually upon y^e^ surface, w^ch^ represent sound;
y^e^ other of an impulse eodem instante[180]
upon y^e^ whole body of y^e^ water, w^ch^ wou'd
be perceived accordingly by animalls having
senses sufficiently subtile for it. And this
resembles

[180] i.e., 'at the very same moment'.

rese/e\mbles y^e^ action of light. How these strokes
may be reiterated, broken, multiplyed
& diversifyed, & y^e^ animalls affected there=
with; will be considered & referred to after=
wards. But at present we have here an
Image of y^e^ action & our sence of light,
w^ch^ is like y^e^ animalls perception of those
strokes; & y^e^ minuteneSs of such impul=
ses, will appear to be no objection, so
long as they are any thing; & y^e^ consequen=
ces of all motive impulses are infinite,
as our theory of motion hath demonstra=
ted. It is to be added here that y^e^ percep=
tion of these animalls is not of a pro=
pension, but of a reall loco-motion, to
w^ch^ y^e^ organick substance of their bo=
dys yields, & a quick iteration of y^e^
strokes amounts to a continuation, as
light seems continued by an interrup=
ted succeSsion of pulses upon y^e^ optic nerve.

Now

pulses of
$y^e$ sun's
fiery parts
$y^e$ cause
of light

Now we must consider $y^e$ luminarys, &
collate them with $y^e$ foregoing scheme,
& for this purpose I shall select $y^e$ most
worthy $w^{ch}$ is $y^e$ sun. We presume that to
be planted in $y^e$ center of a large At=
mosphear consisting of groSser matter,
as that about $y^e$ earth, $w^{ch}$ by a (solar)
gravity continually preSseth upon its
surface. And $y^e$ body of $y^e$ sun being
apparently a body of fire, $y^e$ parts of
$w^{ch}$ are always in a violent agitation,
& those at $y^e$ surface, continually strike
against $y^e$ adjoyning Atmosphear, $w^{ch}$
affect $y^e$ contiguous parts, & those others,
& so by $y^e$ plenitude of $y^e$ world, or per=
petuall contiguity of matter, Each
particular pulse extends an influence
to all distance; even as farr as wou'd re=
duce $y^e$ suns apparent magnitude down
to that of a fixt starr. And I must also

affirm

affirm that all those pulses ac=
tually move $y^e$ infinity of matter in $y^e$
world, & being combined is that action
that inspirits $y^e$ universe with a tremo=
lous agitation, $w^{ch}$ resented at our op=
ticks, excites in our minds, $y^e$ glorious
Idea of an universall light. I know
that here I run a risq of being accoun=
ted madd, what; $y^e$ pulse of an imper=
cetible particle at $y^e$ surface of $y^e$ sun
inspire a perceptible action in $y^e$ whole
universe? therefore, as they say, I desire to
be heard, not doubting to shew that, all
things considered, what I advance is $y^e$
very truth of $y^e$ matter.

139
The subtilety of sence & power of minute a= gents with instances

First I observe, ~~that~~ /but\ not with much re=
lyance, that, sence, as action, amy be sub=
tile ad infinitum, & $y^e$ capacity of sight
(as $y^e$ exillity of matter & motion) is unlimi=
ted. And in favour of it, $y^e$ organ is guarded
& con-

& conserved in perpetuall humidity, so
that we have no means of perceiving
so nice as by sight. But this compared
with y^e^ magnitudes abroad is but a pe=
tite circumstance. Next I respect conjun=
ction of forces.It is plain that many mi=
nute agents of w^ch^ y^e^ powers act in y^e^ same
tendency, unite in Grand effects, w^ch^ is de=
monstrated by a common instance in me=
chanicks, as when 2. bodys of equall force
Impell a greater third; that shall receive
a stronger impreSsion than singly either
of them wou'd have given. So (to use y^e^
former instance) y^e^ light of a candle being
stated to be just seen at a certain dis=
tance; if another like candle is sett near
it, y^e^ light will be visibly magnifyed, & so
more like, to a great augmentation, of w^ch^
{_} y^e^ strength is but as that of a single {straw},
but y^e^ conjunction of many acting upon y^e^
same

same substance augments y^e force. where=
by out of weak causes combined, vio=
lent effects proceed. And since such out
of-y^e-way truths as we have in hand
must be persued thro' more familiar
Images, before we can come at a direct
credit, I shall produce a few more to
y^e same purpose. Take a single straw
(as was before instanced) & light it,
it will burn with a flame an inch
long; but if you light a large heap of
straw, when y^e whole hath taken fire,
it shall mount in a pyramidall flame
as high as an house, & all this consists
but of single straws inflamed. All
kinds of explosions may be instances of
this phaenomenon, but I will select one
w^ch is more ad rem.[181] We know that y^e sunns
light upon a small particle or misty
drop of water is but a speck of light, &
scarce

[181] i.e., 'relevant, to the point'.

scarce, or rather not perceivable at all. Yet a maSsy cloud that after a storm is exposed to ye sun consisting only of such misty dropps, severally insensible, yet in union shall shine as strong as (almost) sun it self; after this flagrant instance, I think I need produce no more to shew that extream exillity of force in parti= culars, by multitudes cooperating are magnifyed in ye effect to any degree. And if on ye one side ye progreSsion decreaseth towards infinite exillity, on ye other give we an arbitrary increase of numbers oppo= sed ye result shall surmount ad libitum, datum eum dato.[182]

140. The notion explained & ye appli= cation.

After this it cannot seem strange that ye light of ye sun altho consisting only of a continuall tremulation of ye whole Aether caused by ye impulses of ye subtile matter of fire upon it, shou'd be so fierce. Because taking

[182] i.e., 'freely, according to the given circumstances'.

taking ye diameter of it to exceed that
of ye earth as they compute 100,000
times, & ye fire more violent than (perhapps)
we can conceive. ⸗In this account ye num=
ber of /ye\ minute pulses shall overballance
ye exility of ye particulars, & inspirit ye
whole Aether, & signally at our distance,
So that having apt organs of sight, we
are in admiration at ye light of ye sun,
& may not wonder that ye barbarians
thought it ye God of ye world. We have
now to consider how this notion agrees
with ye phaenomenon; & first, here being
a reall tho tremolous motion of ye whole
Aether, derived from every point of ye
sunn's Surface, to every point in ye Aether,
making impreSsion upon tender things:
The effects must be regulated in ye
same manner, as if ye Aether moved not
tremolous, but currently. And ye seeming
proceSs,

proceSs of light will conform to y^e^ common
rules of fluid streams, w^ch^ is proved by y^e^
consequences in reflexction, Refraction
&c. as will be further observed. There is
but one law w^ch^ rules all impulsive ac=
tion of atter, whither progreSsive or
Tremolous. As in y^e^ instance of y^e^ spade.
If y^e^ water were quiet & unconfined, then
as y^e^ substance of it being free wou'd
{by right lines} actually have moved from y^e^ [stroke?]stroke {__}
every way; so y^e^ influence of y^e^ stroke,
is to be accounted. And it is really y^e^
same thing; for where way is made,
or things, (as y^e^ Organs of animalls) take
impreSsion, so actuall motion succeeds,
& not otherwise. And this is t be aesti=
{_} mated as at y^e^ first {sta/r?\te} of y^e^ motion,
as supposing an obstacle immerst in
w^ch^ there was a foramen, y^e^ influence of
y^e^ spade

ye spade, wch paSseth by direct lines, woud
not turn about ye obj~~ect~~stacle, wch covers
ye fluid according to its extent, but
it woud paSs /directly\ thro ye foramen to ye ut=
most extent. What is it else, when ye
sun shines, & a screne interposeth ha=
ving an hole in it; ye light is shaded
except against that hole, thro wch ye
influence (that is ye tremolous light)
paSseth in directum, & it is observable
that when a fluid is strongly urged, to
paSs against a foraminated obstacle,
altho ye direction is strait, ye edges by rea=
son of ye common irregularity of mi=
nute parts will be ragged, & intermix
or swerve a little; so ye light falling
upon an opposite plane will shew ye
{_} like, for angles will appear rou{nded},
& triangles & squares circular or ovall,
& no

& no edges justly terminated. And when y^e^
influence is tremolous, that is by conti=
nual starts, all y^e^ rules of impulse &
action take place, therefore it is justly
affirmed that altho light is not com=
posed of heterogene substances, yet
all its results are according to y^e^ laws
of substance. Nor doth it inferr that
light is really progreSsive, because
it hath some analogous effects, for
those attend indifferently as well a
tremolous action, as a progreSsive, for
the~~r~~ey are quasi y^e^ same, & y^e^ argument
{at first} from y^e^ skre{en in} y^e^ optica[183] hath nor fo/r\ce
to y^e^ contrary.

141.
Light is meer touch, {_ are} & colours y^e^ modifi= cations, in y^e^ eye not in y^e^ object

Now as to our sense of light, it is induced
by y^e^ like means as all other sensations
whatsoeve{r &} that is pure touch, where=
by y^e^ parts of y^e^ organ are more or
leSs, or in one manner or other actu=/ally\
moved

[183] This refers to Newton's description in the *Opticks* of light, having passed through a hole of whatever shape in a screen, when projected onto a surface, tends to be rounded which Newton used to argue for his particle theory of light (*see* p. 216 in 1718 edition)

{w^ch touches?}

moved. And y^e Ideas are not in y^e ma=
teriall {tangent}, but in our imagi=
nations only. To instance (in com=
mon apprehension) pain is not in y^e
sword, saw, or fire that torments, but
in y^e mind or imagination, of y^e ani=
mall tormented. Therefore it is vain
to say that light, is in y^e sun or any
luminary, or that (in form) it proceeds
from thence, for any manner of touch
upon y^e optick nerve, gives y^e sence of
light, & some diversifications of it,
colours; As a finger touching one cor=
ner of y^e eye, excites a lumen (seemingly)
at y^e opposite; So a rude fist of one
clown upon y^e visage of another, (as
they say) makes fire fly out of their
eyes, & so hard vomitings, & y^e like. Where
are here to be found y^e adventitious
rays & pencills of rays of Heterogene
substances

substances commixt in y^e^ body of light,
as y^e^ Newtonian hypothesis presumes.
Now as to y^e^ varietys of colours in gene=
rall, there is no more to be sayd, but
that y^e^ modes of pulsation upon y^e^ eye
may be as copiously diversfyed as any
changes we can perceive by means of
light. And why not blew, redd, or green,
be as well derived from various tremo=
lous touches upon y^e^ eye, as unisons, thirds
& fifths, from y^e^ various vibrations of
musicall instruments? But I must ob=
serve that no reason is to be asked or
given for specifick sensations; but each
is in y^e^ mind, as form or shape is pecu=
liar to bodys. None can ask ~~y^e^~~why y^e^ sence
called y^e^ head ache, is not y^e^ same as that
called y^e^ heart ache or y^e^ contra. So no
one can say why y^e^ sence of one action
shoud represent to y^e^ sight blew & not
redd

redd. This puzzled Cartesius, who thought
he knew & cou'd resolve every thing, &
at last he was forc't to referr it to ye
Almighty's will that it shou'd be so,
that is that ye cause that exhibites
redd, shou'd not be efficient as well
for blew, or any other colour. But
here it is enough, whether blew, redd, or
green, neither one or other is found in ye
object, but is a creature of imagina=
tion; wch so understood as I take ye meer
truth to be, diSsolves ye whole scheme
of ye optica as to ye physicall part, wch
ye Newtonians of late do most furi=
ously hold forth.

As to other propertys of light, a word
or two further; first, that objectively
it is rectilinear, & never Arcuate (Ex=
cepting as afterwards), & that rectili=
nearity must terminate in ye luminous
or luminated

or luminated body, & thereby y^e^ artifice
of y^e^ eye directs y^e^ sight, & this action
for y^e^ porpose in hand may resemble
gravity w^ch^ is always estimated by right
{for thro .. yniforme &c?} lines directed from y^e^ center, differing
chiefly in to & from{/\}. Next, y^e^ action of
light, tho' from infinite resources,
croSsing & recroSsing continually, cre=
ate no confusion, & are not reciprocal=
ly obstructive, but with this exception
only, that, as to sence, y^e^ greater absorp
y^e^ leSser, as greater magnitudes cover
leSser, or as y^e^ gliSsening of y^e^ sky hinders
y^e^ sight of starrs by day light. This ir=
reluctable perseverance of light paS=
sing from & to all places, & in all direc=
tions is a stupendious property & y^e^ whole
use of light in y^e^ world depends upon it.
And it is so much more to be admired,
as it is considered, that y^e^ action it self,
commu=

communicates no distinct images of any
thing; for a simple organ capable of
exciting a sence by y^e^ touch of light,
is displayed & deprived of its artifices,
that is y^e^ refractions, wou'd communicate
no shapes or distinctions of any thing, &
so light is in y^e^ world at large, a con=
fused action, Like that of gravitation
of a fluid. In w^ch^ an animall may per=
ceive a preSsure from a ship under
<red BM stamp> sail, but no form of y^e^ veSsell: And
consequently y^e^ world hath not that or=
nament by light as commonly is con=
ceived: For that wonderfull consequence
of refractions thro angular/ar\ or arcu=
ated forms of glaSs, w^ch^ latter reduce y^e^
action to a distinct base (as it is termed)
is y^e^ only instructor of y^e^ forms, & termi=
nations of all visibles, & y^e^ humours
or membranes of y^e^ eye are as those glaSses,
without

without w^ch all lumen wou'd be as a mist, & y^e
luminary it self without shape as when folks
look against y^e sun with their eyes shut; this
is a profound truth, tho' little considered, when
men lookk about them & admire y^e glory of
y^e universe; I do not say a wonderfull lustre
of things! but a wonderfull operations of
sence; that from y^e agitations of meer matter,
conducted by y^e single but universall law
of mechanicks, shall derive those illus=
trious, usefull, & delightfull Ideas, as we
enjoy by vision. Some may think that I
here supplant one of y^e chief philoso=
phick proofs of a deity, that is y^e beauty
& order of y^e world; but it seems to me
rather exalted; we allow y^e order to y^e
world, but what wee call y^e image & beau=
ty of it is referred wholly to y^e mind of
man. Then consider what incompre=
hensible wisdom is eclatant in this dis=
position? I may perhaps undertake thereby
to prove

to prove not only spirituallity, but ye De=
ity it self with more force than hath been
done by any philosophick argument yet;
143.) But of this in another design.

Difform
mediums
deprive or
refract ye
rectitude
of light.

Now to return to our subject ye naturall
operation, & effect of light; ye curiousity of
it is such; that I cannot part without some
further altercation, tending to clarify it
to our ordinary understandings, or at least,
make my notion as limpid, as ye principles
in these discourses presumed, will bear. And
this I shall attempt by examining weht may,
or rather must be incidentall upon this
supposed action of light. If I shall call it
a tremor, or perhaps (conforming with ye
usuall language) Rays, ye thing, as I under=
stand it, will be ye same, & that is to be al=
ways reserved. It was observed that ye tremor
is derived from impulses upon ye subtile mat=
ter, such as we take ye common Aether of ye
world to be; wch maintains a contiguity thro
ye whole

y^e^ whole open universe; & being of an uni=
form mixture, y^e^ action must disperse eve=
ry way in y^e^ manner of strait lines, for
how shou'd it swerve when there is nothing
unequall to incline it one way or other.
The groSser matter of y^e^ fluid world, as (for
instance) y^e^ common air we breath is influ=
enced ~~y^e^~~by y^e^ tremor only secondarily. But
while y^e^ composition of that, as also of o=
ther transparent fluids or solid substances
is uniform, y^e^ tremor in paSsing thro' will
maintain y^e^ like rectilinearity; but if y^e^
composition be of groSs, difform, or uncom=
pliant parts, & compact so ~~as~~ /that\ y^e^ tremor is
interrupted, as this is more or leSs, so such
bodys tend to opacity. But it is made a
question whither there is made a place in y^e^
whole universe perfectly dark, for y^e^ sub=
tile matter w^ch^ runs thro all, will convey
y^e^ tremor in some degree. For w^ch^ reason
opacity is referred to y^e^ tone of our sensitive
facultys

facultys, w$^{ch}$ in y$^{e}$ presence of great are e=
nervated as to small things, as y$^{e}$ starrs in
y$^{e}$ suns light, or glissening of y$^{e}$ air, become
imperceptible.

144.
In y$^{e}$ con=
fines of
difform me=
diums
light both
reflects &
refracts.

But in every case where y$^{e}$ tremor is con=
tinued thro compositions of different tex=
ture, there is some interruption, & in con=
sequence a division of y$^{e}$ tremor, so that
as ~~is~~much as is resisted (in a way of opaci=
ty) reflects, for w$^{ch}$ reason every superficies
of y$^{e}$ most transparent body reflects
some of y$^{e}$ light, & only y$^{e}$ rest so excised
paSseth thro'; & in this conflict, y$^{e}$ dir~~ee~~/ec\tion
of y$^{e}$ tremor, w$^{ch}$ ~~we~~they call rays, falling
in any obliquity [upone?] y$^{e}$ plane of y$^{e}$
direction angular to y$^{e}$ former from y$^{e}$
point of y$^{e}$ transit, & this is called refrac=
tion, & y$^{e}$ like happens & every exit &
introit of light from & into transparent
bodys of different composition; while in
y$^{e}$ paSsage

y^e^ paSsage thro each substance (uniform=
ly composed,) between y^e^ superficies, y^e^
rays are strait. But this of an excep=
tion w^ch^ falls out to be when y^e^ mediums
are not parted by an abrupt superficies,
but gradually changing, as we suppose
to be between y^e^ Aether & y^e^ Atmosphear,
because y^e^ latter gradually condenseth
from Aetheriall purity to y^e^ density of
y^e^ common air we breath, therefore y^e^
light of any celestiall luminary, falling
obliquely upon y^e^ Atmosphear, doth not
refract angularly, but arcuatim,[184] as y^e^
Astronomers well know & declare.

148.
Of refrac=
tion, con=
vergences,
& universall
indistinction
in light.

Now to postpone y^e^ consequences of reflec=
tion, we will first consider y^e^ events of
that lumen w^ch^ paSseth refracted. The angle
of y^e^ refraction, made by figurated GlaSses
is managed so artificially that y^e^ light
shall converge or diverge almost ad
libitum[185]

[184] i.e., 'in the form of a bow or arch'.

[185] i.e., 'in any way whatever (or: in whatever way you like)'.

libitum. And considering that light from
any luminous point spreads everyway,
A glaSs they call a lens convex hath such
effect, that all ye rays from any point,
paSsing ~~as~~so as to cover or fill ye whole sur=
face of ye glaSs, shall by refraction con=
verge & centrate in some one point upon
a plane they call ~~a~~ye distinct base, & upon
that mark out or represent ye place of
that point; & then taking ye whole space
without, to be or to consist of luminous
points radiating every way ye place of
each is ma~~r~~/r\ked upon ye distinct base, & by
this means ye shapes of all things Resi=
dent in ye space before ye glaSs, with every
circumstance of colour, motion, & pro=
portion and described by touch upon this
plain & distinct base, wch is demonstrated
by ye experiment of ye camera obscura.
And as this is done by ye means of human
sagacity

sagacity, y^e^ like is providentially settled in y^e^
eyes of men & animalls, w^ch^ consist of fluids
transparent, & so conformed, that y^e^ light
from every thing without, point by point,
converging, touch y^e^ optick nerve or sen=
sible point called y^e^ retina, & so (as upon
a distinct base.) describe y^e^ images of all
things externally objected, & thereby vision
(as all other modes of perception) appears
plainly to be an effect of pure materi=
all touch, & not otherwise. And it appears
also that besides these precise convergen=
ces, & topicall projection of objects in
finitely croSsing, & in y^e^ proceSs each point
filling (as it were) y^e^ whole foramen
of y^e^ eye, & reduced to points again,
whereby y^e^ forms of things without,
are mapped in proportion upon y^e^ retina
or (as in y^e^ camera obscura) there is no
flowing distinction of forms, termina
tions & dimensions of any thing abroad

in y^e^

in y^e^ whole universe, but whatever influen=
ces proceed by way of lumen, they are all
blended & confounded together. As for exam=
ple, if a cartoon is presented afore y^e^ sun
or any maSs of luminous objects, y^e^ effi=
cacy of y^e^ light will fall upon it, but
it is upon all parts alike. And nothing de
termines y^e^ form of y^e^ sun, or resembles
any thing from whence y^e^ influence ar=
rives. And while it is a common notion
in opticks touched upon before, that each
luminous point influenceth (for so it is
seen) every way, y^e^ lumen from all points
perpetually croSseth, so that y^e^ whole (as
I sayd) must be a confusion, & what is
most wonderfull is to consider, that y^e^
lumen from every point of an exteri=
or view at y^e^ same time fills (as I may
say) y^e^ whole formamen of y^e^ eye, before
it is segregated again & reduced to ana=
log~~ary~~/ous\ points upon y^e^ retina, by conver/ging\
as was

as was expreSsed. And this, I think, is demon=
stration enough, that rays cannot be ma=
teriall, or transient emanations. I cannot
therefore sufficiently expreSs y^e^ inconsis=
tency, I might say contradiction wrapt
in y^e^ proposition, that light contains really
any thing, besides y^e^ substance of y^e^ medium,
y^e^ modes of w^ch^ only as of sound, affect our
senses with such known varietys.

146,
Refrac=
tions shew
colours, but
not singly,
& all but
modes of
touch

I must precaution here, that y^e^ first prin=
ciples of y^e^ optick science are no secrets,
else, it is scarce poSsible in these matters
to discourse so as to be understood; And al=
tho my aim is wholly physicall, I must ne=
ceSsarily trench upon arts, to reduce y^e^ subject
to terms of certainty, but a small advance
will be sufficient. Now we come to other
consequences of refraction, besides configu=
ration or order, & those are y^e^ various brillant
colorations, w^ch^ are found to be produced thereby:

& are

& are become ye subject of much criti=
cism. I paSs, ye hypothesis, /&\ experiments in
ye optica, having touched upon them al
ready; & again affirm that colours, like
all other Ideas of our perception, are in
ye imagination, & not in ye object. The ma=
teriall as it is applyed may occasion va=
rious Ideas, & so materiall rays (if any such
were) by way of contact might occasion
Ideas of colour, but not be in themselves
coloured. But ye sence or Idea of colour
proceeds from ye modes of ye touch inflic=
ted upon ye organ by ye action or tremor
called light, & may be diversifyed as our
sence represents varietys, especially in ye
transition of light between mediums of
different compositions. This I think will
not be doubted, & first of a refraction
by one plane superficies, as when ye light
paSeth obliq thro level water; I have

not

not observed colours at y^e^ bottom, so an oar
or staff refracted doth not shew colours,
no more than a piece of mony thro y^e^ water
in a bason; but if y^e^ surface of y^e^ water
{_} be arcuated as by {waves} then colours plen=
ty are seen from y^e^ bottom. All w^ch^ shew
that such transits as most [◦◦◦◦◦◦◦?] disturb y^e^ course
of light Exhibite most colours. If y^e^ doc=
trine of gradually refrangibillity hold,
how comes it that common objects seen
thro y^e^ many refractions in y^e^ eye, are not
colour'd? And so divers other instances may
be given of like consequence; we find no
colours attend y^e^ celestiall luminarys, as y^e^
sun, moon, & starrs tho their light falls
obliq, upon y^e^ atmosphear; And that not
{Repeated} single but re{flect}ed, w^ch^ bends them not by
an angle, but by an arch, as y^e^ astronomers
declare; we find tha most colour proceeds
from subjects of greatest disturbance of
y^e^ strait course of light as thro divers arcuate
superfices

superficies, or thorough severall inclining
planes, such as prismes, of w^ch^ forms are
accomodated to shew y^e^ perfection of refrac=
ted colours. And I shou'd prosecute divers in=
ferences from them, were not y^e^ subject
almost exhaust in y^e^ optica. But this
farr I may presume, advising y^e^ curious
to take up a prism, & turn it afore their
eyes against a light window [shaSsed?], &
then to observe what is obvious. And that
will be, that y^e^ colorations are but symp=
tomes, not of any regular order, as fillets
of colours one by another, but of con= *X*[186]
fusion & disorder. For y^e^ colours are at
y^e^ edges of y^e^ opaques, & not only of y^e^
{trans-} {trans}verses, but of y^e^ uprights as full &
strongly, w^ch^ coud not be if y^e^ refran=
gibillitys run one way. And each opaq
is seen almost merged in colour, if one
side is ~~bules~~/blues\, y^e^ other side is redds perpe=
tually, those two not coming any where
near

[186] *See* note on following page.

near together so as to intermix, w^ch^ is a
wonderfull mistery; & as to y^e^ fundamen=
tall observation that a refracted colour,
will not vary upon any further refrac=
tion, y^e^ inference is but ignorance; we
know not why, Ergo Rays & refrangibil=
litys. But to leave these matter to y^e^
curious, we affirm only that colours
proceed from divers & not single refracti=
ons. And such is y^e^ case of y^e^ rain bow, &
y^e^ morning dew. Des Cartes shews how y^e^
lumen both enters y^e^ drop, & exit with
*X** refraction, but between both, reflects
from y^e^ interior superficies & so altoge=
ther colour strongly, w^ch^ I must ascribe
to y^e^ curvity of y^e^ superficies every way
disturbing y^e^ lumen. And to conclude,
some transparent bodys colour much
more than others, as Diamants more than
crystall, of w^ch^ y^e^ cause, till we have ultra
Lincean

[187] In the gutter, in pencil, a star-like image formed in the fold by a horizontal line, with two 45° lines, one above and one below the horizontal, as if describing the angle of incidence and reflection on a reflective surface. The image is very small, hardly an illustration or diagram, more likely a doodle related to the discussion of Descartes description of the light refracted in the rain/dew drop.

Lyncean[188] facultys will never be made
appear to our understandings.

147.
Specular
reflexions
do not alter
but from
rough
superfices
all colour
& distinc=
tion.

Hitherto of light transient, next, of
light reflected, of w^ch^ it is observed first
that however y^e^ light is affected or colou=
red, it suffers no alteration by pure re=
flexion, but a clear or coloured lumen
so reflected is still y^e^ same. And whatever
succeeds upon refraction, so much of y^e^
lumen as will be reflected (w^ch^ is not a
small share) is y^e^ same as it was at y^e^
touch. I said a just reflection, that is
from a plain superficies, w^ch^ diverts
all y^e^ light in y^e^ same order & manner
as it came, & is y^e^ case of polisht mettalls
& looking glaSses, for so, it is but as other
materiall reflexions, a continuation of
y^e^ prior action in all y^e^ modes, saving
only y^e^ direction. Originall light it self
may be tincted, as when we say corusca/tions\
are

[188] i.e., eyes 'like a Lynx', or 'like Lynceus'. Lynceus was a companion of Jason on the Argos, reputed to have the ability to see through solid objects. His name is derived from the Greek word for 'sight', as is the name of the Lynx. The title page of Hooke's *Micrographia* bore a quotation from Horace's first epistle that would have been familiar to contemporaries: 'Non possis oculo quantum contendere Linceus, Non tamen idcirco contemnas Lippus inungi' ('Your eyes will never see like Lynceus'; still//You rub them with an ointment when they're ill.' trans. John Conington MA (1869), Corpus Professor of Latin in the University of Oxford. Project Gutenberg. Retrieved 10 August, 2013.) Eyesight is is the most privileged tool of early-modern science and is celebrated and referred to repeatedly during this period, from the choice of the name of the Roman Accademia dei Lincei in 1603, to Hooke's dictum: "with a sincere hand and a faithful eye".

are' redd, or a candle burns blew, w^ch^ is
from y^e^ various modes of y^e^ luminous
action, or when y^e^ medium is such, as
shall affect y^e^ action of light, so that
being clear, yet thro coloured glaSs shall
become blue or redd. I do but touch upon
these instances to lay them aside, for all
such varietys will be accounted for
under y^e^ common consideration of co=
loured objects, w^ch^ are continually ob=
servable. And of these we have nothing
to do; but with y^e^ superficies, & those
differ from specular surfaces, by con=
sisting of parts of irregular forms &
positions, so that light reflecting from
them is confused & so sent every way.
The speculars are seen only in y^e^ course,
or angle of y^e^ reflection, but these are
seen from all positions. This whole
matter is so obvious to our imagination
as needs

as needs no exaggeration; And it is no
leSs familiar to conceive; And it is no leSs
familiar to conceive, that light from su=
perficies of contingent or irregular posi=
tions, or shapes, must differ one from y^e^
other & those differences by w^ch^ we distin=
guish things, we call colour; An{d /y^e^\ use of}
{_} such differences, whereby y^e^ various ob
jects of y^e^ universe, falling in view, are
terminated, Experimented, & known, & all
by y^e^ means of those petite convergencys
in y^e^ eye, while confusion takes place
without, is admirable, & a demonstrati=
on of a wisdom superior to y^e^ materiall
world. It may be expected I shoud take
notice of a conceipt that reflected angles
are curves & not rectilinear angles, but
finding no ground for such a fancy, I
leave it intire for those that delight in
such raritys.

149. ~~Phy~~/hy\sica (~~421~~) 184

Light in=
creased, di
minisht,
or distur=
bed & of
burning

Light may be increased or diminished, y^e^
former only by convergencys, either
from convex or concave bodys, nicely
polished. It is no wonder that y^e^ action
of a larger space brought to bear in
one more contracted, shou'd urge more
violently. As water forced into a tunnell
shaped pipe, must move swifter & with
more force in y^e^ smaller than in y^e^
wider space. And y^e^ groSs air being ob=
noxious to y^e^ insults of y^e^ subtile matter
by w^ch^ y^e^ suns light acts, when it is
much contracted a culinary fire is
excited by y^e^ violence of y^e^ agitation,
all y^e^ is but y^e^ ~~agitation~~ /effect of\ multipli=
cation, & when y^e^ spaces from whence
y^e^ action is derived, as from y^e^ whole ex
tent of y^e^ concave, to y^e^ space of 1/4 inch,
are calculated & compared, y^e^ effect of
~~y^e^~~that combustion collated with y^e^ ordinary
heat

heat of y^e^ sun will not be thought ex=
ceSsive. Setting these convergencys aside,
light can have no increase, but may
be diminish't by many ways, & one is with=
out change of condition or colour, by
debillity of reflexion, as when a tennis
ball is struck against a matt, y^e^
reflection is little. And so it is upon
a privation of light, w^ch^ we call black,
And is most found in things macera=
ted or honycombed by fire, as charcoal,
or y^e^ like, But this privation is never
perfect, for light in some measure is
allways reflected, w^ch^ painters are a=
ware of. Light is strongest from bo=
dys called white, & that consists of
parts that reflect pure light; & black
substances w^ch^ at certein views shine,
being broken into powder become white
because a speck of pure light is reflec/ted\
from

from each granule & on that account
snow, & all sorts of froth, are milk white,
That w^ch^ we call shining is only a degree,
as of y^e^ luminary, Especially y^e^ chief,
but common objects, tho white or co=
loured, are not said to shine but when
seen out of darkneSs as some clouds, y^e^
moon, or a steeple shined upon in y^e^ e=
vening. Light upon common coloured
objects allways looseth a portion, & that
more or leSs is an ingredient in y^e^ colou
ration; but that (colouration) is mostly
derived from y^e^ confused mode of y^e^ re=
flexion of y^e^ surfaces, w^ch^ being alike are
called of y^e^ same colour of w^ch^ there are
always degrees, & those in order are cal=
led shades, & what ever y^e^ shades of colours
are they terminate in y^e^ same extreams
of black & white. And even those as
well

well as intermediates have dependance
on y^e^ mode of y^e^ reflexion, for there
is a lively black, & also a faint white
w^ch^ are of y^e^ same hew whither y^e^ light
be strong or weak.

149
The dis=
tinction of
originall
& compound
colours
vain.

Of y^e^ intermediates, y^e^ author of y^e^ opti=
ca hath advanced a distinction that
is of originall colours, supposed to be
simple ~~or~~or unmixed, & those that are
compound of y^e^ former; as there is an
originall blew, & a blew made by
black, yellow & green powders ground
together & y^e^ eye cannot tell w^ch^ is w^ch^,
but yet a micro~~s~~/s\cope will distinguish
y^e^ several granules in their proper co=
lours; And I say that if we had mi=
croscopes of centuple y^e^ capacity of
magnifying, we might discern y^e^ mi
nute composition of originall blew

& also

& also all y^e^ severall modes of superfi=
cies that produce y^e^ images of colours
in our sence. It is certain that minutes
in mixture, (as when sence cannot
distinguish) produce Ideas that are
not in y^e^ object; as Harmony from
pure pulsation, & so colours from mix't
& confused reflexions; & y^e^ great author
was aware of this when he fancyed
there might be some alliance between
colours & Harmony; but his reason I
think was extraordinary, for he fan=
cyed that colours were disposed by inter=
valls as y^e^ fretts of a base violl. But
now to take leave of this subject of
colours whither from mixt reflections,
or different refrangibillity of rays as
they seemed ranged by a prism; I shall
only observe that light (from a shopwin/dow\)
colours

colours so as by a sort of spreading they co=
ver ye opac; wch cou'd not be if laid side
against side by refrangibillity.

150.
Distur=
bance &
obstruction
ingender
colours

I shall close this tumultuous eSsay of
light & colours with observing, that
conterminations or junctures of diffe=
rent substances are allways ragged or
disordered & never as by a strait joint,
but perplexly interfering or indentated;
wch may be observed in liquors of diffe=
rent weight & colours wch (as they say)
shade into one and other, without
commixing intirely. And an instance
no leSs familiar is that of an half=roast'd
apple, wch cutt thro, shall shew in ye con=
fines of ye hot & cold parts a circule
quasi coloured, wch must put one in
mind of a rain bow, Halo or ye cir=
clings about ye parhelia. Considering
therefore that colours from refraction

always

always cleave close to y^e^ contermination
or y^e^ opaques where y^e^ course of y^e^ lu=
minous action is first disordered, & that
in no case y^e^ whole space is coloured, it
seems sufficient to persuade one that
colour is but y^e^ effect of disorder
in paSsing from one medium into
another, as y^e^ raggs & indents of all such
junctures, w^ch^ create in us images we
call colour. I know that y^e^ author of
y^e^ optica most ingeniously ~~des~~/as\cribes
y^e^ recovery of y^e^ pure light, to y^e^ re=
dintegration of y^e^ mixture or con=
fusion of all y^e^ colours w^ch^ turns to
y^e^ image of common light, w^ch^ as he
{Ag^t^} says (cautelously) whitish. At{g^t^} w^ch^ Hy=
pothesis I have to say only, that y^e^ strength
of white is manifestly greater than
tha of y^e^ colours separated; & all y^e^
refracted colours collated with y^e^ plain
light

light compounded of all is a sort of
opacity, as in ye image from ye diamant
cutt of a coach glaSs. The coloured
{_ a}[189] part {/shewing\} at ye edge, to a careleSs eye or at
a distance appears like a seam or
dark border, & how then shoud ye mix=
ture of those colours; wch they say is
resumed in ye next light, & all from
ye same source, obtein such increase
of strength, as ye comparison of ye
clear light, & ye coloured part plain=
ly shews. And in like manner ye sun's
light into a dark room thro a prism
is obscurity compared with ye same
light thro a plain glaSs. And both
are derived from ye same originall,
therefore ye difference is made by ob=
struction, & not propriety.

151.
some in= The very great copia of nice matter
stances in in ye optica wou'd afford endleSs subject
ye optica of alter
considered

[189] In the margin a dash, followed by a reversed 's' shape.

altercation touching rays & y^e^ union &
separation of them, & by resolving y^e^
authors inferences from his experi~~men~~/men\ts,
weaken his hypothesis; But I shall not
undertake so, immense a task, but on=
ly touch upon one or two of his instan=
ces; as first of prismall colours cast u=
pon a paper, If a common horn comb
is interposed, y^e^ colours will appear
cleaving to y^e^ shades of y^e^ teeth. There
is a plain separation & distinction of
them. But if y^e^ comb be paSsed to & fro
so as y^e^ shaddows of y^e^ teeth are not dis=
tinctly discerned, then all are in confu=
sion. & y^e^ image becomes not coloured
but white, whence he argues colours
mixed make a white or pure light,
but non sequitur.[190] For there is no confu=
sion in y^e^ thing but in our facultys, y^t^
have no true Idea of objects pa~~Ssin~~/Ssing\
before

[190] i.e., 'it does not follow'.

quick before us, as a coal moving shines
an image of a redd ribbon, & ye like,
but ye ~~th~~ruth hath no such continua=
tion, & ye colours in distinct places ~~are~~/re\
ye same whither ye comb paSseth or
not, but our sence cannot keep pace
with or attend them, whereby they
seem to vanish. Another instance is
of a barbers bason, wch at a distin=
guishing distance shews colours upon
all ye froth, but at a greater distance
{_} (as all froth whatever) {~~is~~/)\]} shews white,
that is because ye colours all intermix
in ye view & so become white. This is
answered as ye former, & it is not fair
to argue from our sence to ye nature
of things, for ye colours do not inter=
mix but maintain their distinction
however our facultys cannot attend
them. But here is more, & that is, every
bubble

bubble of y^e^ froth sends a speck of pure
light, & (when y^e^ view is neer) those re=
flexions are distinct from y^e^ colours,
but at distance they run together, &
appear as a luminous white. For com=
mon daylight is always white, tho
reflected from y^e^ blackest substances
as from pitch; & all powders whatso
ever will shew whiteneSs, tho y^e^ gra=
nules are all of one sort coloured: &
if y^e^ specks of light from each con
vex bubble w^ch^ joyn at y^e^ eye, being
stronger & spread into ~~one &~~ /each\ other of=
fuscate y^e^ distinction of y^e^ weaker
colorations, & shew perfect white, it is
no wonder. To all this it may be an=
swered, that whither y^e^ mixture of co
lours be reall or sensible only, y^e^
consequence is y^e^ same, for 2 colours
mixt will produce a 3^d^ & yet remain

truly

truly distinct; but no mixture of
colours will produce a vivid white.
And as to ye specks of light, wch makes
ye coloured froth seem white, they will
say that white so reflected contains all
colours, wch is petitio ejusdem rei cujus
petitur diSsolutio.[191] And this is surely
enough upon this subject of light & co=
lours.

## Of Sound, ye Manner & ye Effect

1532
Of sound
& ye diffe=
rence from
light.

Having produced all my poor stock of thoughts
concerning ye misterious subject of light, wch
have been partly collected from ye hints
of others, & partly added, or ingrafted out
of my own nursery; I shall proceed & give
a short account of that generall energy
wch toucheth ye sence of all animall, (Es=
pecially human) kind, that lives & breaths
ye common

[191] A legal term, usually expressed 'e*xceptio ejus rei cujus petitiur dissolutio nulla est*', i.e., 'there can be no plea of that thing of which the dissolution is sought' - i.e., 'you cannot have it both ways'.

190r



y^e^ common air of our world; & in gene=
rall is understood by y^e^ word sound. This
comes aptly after light, being born thro
y^e^ same mediall conveyance y^e^ common
fluid; And in one respect both agree, w^ch^
is that y^e^ paSsage of either to & from all
parts, continually croSsing & recroSsing
as (concerning light) hath been demonstr=
ted, is also of sound perpetually experi=
enced; And both these act in & thro y^e^
same fluid without any disorder or im=
{_} pediment to each other, {/and\} if anything can,
{_rather} must excite our admiration, or {/\} adora=
tion of y^e^ author of nature, that out
of such singleneSs of principle, as pure
space, connected with human sensation,
hath establisht such sublimity of [~~...~~?]won=
der, as words cannot expreSs; but to for=
bear flights & to proceed; in many respects
sound & light differ. One is that y^e^ same
organ

organ or part of y^e^ body is not affec=
ted by both, but each hath its cha=
racter apart; for no cause of sound
will affect y^e^ eye, nor lumen y^e^ ear,
but what ever impreSseth those organs
(& by whatsoever means) produceth y^e^
proper & respective Ideas of light &
sound, & never both. This argues y^e^ dis=
tinction of y^e^ medium touched before,
w^ch^ is that y^e^ conveyance of light is by
y^e^ subtile matter to w^ch^ y^e^ tunicks & hu=
mours of y^e^ eye are permeable, & y^e^
GroSser air cannot penetrate; but that
(groSs air) impreSseth y^e^ organ of hea=
ring, w^ch^ y^e^ subtile matter of light paSseth,
without any impreSsion at all. Another
difference is, that light is rectilinear
& doth not lapp round about obstacles,
as sound doth. And that argues a fur=
ther difference, w^ch^ is that light is in
instante, but sound is progreSsive, & in
time

time, as when both proceed from y^e^ same
motive cause, viz^t^: from a gun dis=
charged, y^e^ light is seen at a distance
long before y^e^ sound arrives. To conclude,
in one thing they agree, w^ch^ is reflexion
for both do that, & in a like equian=
gular manner, so here we dropp y^e^
matter of light (sufficiently canvas't
already) & fall upon that of sound,
considered by it self.

153.
The affec=
tions of
watery
waves cir=
cling

The common image by w^ch^ y^e^ generation, &
proceSs of sound is represented to our i=
maginations, is that of y^e^ circling waves
upon y^e^ surface of calm water, into
w^ch^ a stone is toSsed; those & all other wa=
vings of water are analogous to y^e^ ac=
tions of springs, or pendulums; that is
by vibrating equably, y^e^ nature of w^ch^ is
not to be entered upon here, being al=
ready crittically touched in a small
tract,

tract, tituled y^e^ theory of Sounds,[192] treating
of harmony, & discord, without appea=
{_c} ling to any particula consonant{/c\}es &
diSsonant{/c\}es, or other immechanicall
suppositions, so for nicetys we are re=
ferred to that. And here we shall pre=
sume ~~w~~that all waiving of water is
quasi pendulous, & as such Isochronous,
& therefore y^e^ circles open from y^e^ center
every way equably, that is by equall
radius's in equall times, unleSs a par=
tiall stiffneSs of y^e^ fluid varys y^e^ sur=
face, & then upon y^e^ stiffer part y^e^ waves
will proceed slower, & if leSs stiff, faster,
& y^e^ figures of y^e^ circlings will alter
accordingly. But ordinarily as y^e^ waves
expand & affect larger surfaces, y^e^ force
becomes leSs effectuall, & rise leSs but
but spread broader,. But if y^e^ course is
confined from y^e^ surface of open water
to a

[192] The first MS of the 'theory of Sounds' was produced by 1726 (*see*: Chan, M, *Roger North's The musicall grammarian and Theory of sounds : digests of the manuscripts by Mary Chan and Jamie C. Kassler; with an analytical index of 1726 and 1728 Theory of sounds by Janet D. Hine*, Kensington, NSW, 1988.) Below, on fol. 195v, MN referrs to the same work as very recent - 'a tract express'. *See* fol. 7v, above, for other clues to dating this MS.

192r



to a channell, y^e^ waves will proceed with
much leSs alteration of form, & vigor, & con=
tinue apparently longer. And then against
obstacles that impede y^e^ course, it shall con=
tinue by reflexion; & also as y^e^ circlings upon
water turn round about all that is in its
way, & follow [∘∘∘∘?]y^e^ surface wherever it
leads, Either Laterall or reverst; so shall
it appear that no place is sheltered from
sounds. And y^e^ most remarkable circum=
stance of this phaenomenon is that every
order of circling, be they never so many
shall croSs & recroSs each other, & hold eve=
ry one y^e^ proper relation to its center
without any disturbance, or, as one wou'd
expect, utter confusion{|.}[193] I shall further
154. reflect upon this state of watery surfaces,
Of sound & y^e^ when I come to consider of y^e^ marine tydes.
compreSt
wave According to this image we are to respect
y^e^ action

[193] A curved line, in pencil, has been inserted her. It may be intended to be read as calling for a paragraph break.

ye action from whence we have ye Ideas of
all sounds, for those proceed from ye im=
pulses of ye groSs air upon ye sensitive mem=
brane in ye ear called ye drum. And as all
kind of touch wch affects ye optick nerve, ex=
cites in us an Idea of lumen, so all tou=
ches that affect this membrane (& no=
thing else) gives us ye sence of sound. That ye
immediate instrument of this [....?]perception
is ordinarily, ye groSs air, is not questioned,
so we have only to consider ye manner
how ye air is put into, & conveys such ac=
tion as causeth sound. And that appears
to be by some sort of percuSsion of one
obdurate body upon another, or violence
falling [.....?]otherwise upon ye air directly,
but chiefly by percuSsion. And as to that
ye nature of ye air is to be considered, &
chiefly that it is elastick, & if by any
trusion it is crowded together, & instantly
set free

set free; The compreSsure made by that force
as by a spring is disperst every way, &
becomes gradient in ye air, but continually
spreading & ye force languefying, in man=
ner as ye circling waves upon ye watery
surface proceed. Only instead of acting
as ye water in plano, it acts spherically in
orbe,[194] & carrying that difference, those ~~2~~ ac=
tions are almost in all respects parallell,
of ye eye part upon ye water plainly, & of
ye means of hearing intellectually, & that
I shall call ye compreSt wave.

155.
What force may excite sound

{doe-}
{_}

By what is past it appears that ye comprest
wave gradient in orbe enters all cavitys
& tubes in ye way of it, & ye hollow duct
of every ear receives it, & answers in ye
sence of sound; How [/\] we inquire by what
means these waves are ex{/|\ci}ted, & that de=
pends wholly upon celerity, for ye air by
ceSsion gradually makes way to ye transit
of slow

[194] i.e., 'on a flat surface ... on a round object'.

of slow motions, tho of mighty force, as
$y^e$ falling of a tower, till it meets $y^e$ ground
& a stream of $y^e$ whole body of $y^e$ air, as
in winds, do not enter $y^e$ tube of $y^e$ ear,
or (directy) cause sound; but it must be
/from\ some action excited in $y^e$ air, swift be=
yond ~~$y^e$~~ poSsibillity of means, by ceSsion of
$y^e$ matter to continue, & then follows a
compreSsure, of $w^{ch}$ $y^e$ wave disperseth qua=
quaversum.

156.

{2} Most sounds are by percuSsion

There are {2} manners, for this porpose,
of forcing $y^e$ air, one I have called trusi=
on, & other percuSsion. Ast to $y^e$ former
$y^e$ instances are great, but leSs frequent, &
will fall under $y^e$ character of explosions,
as thunder, Guns, & aurum fulminans,
there are others of leSs account, as $y^e$ flying
of ravens, sound of switches, & $y^e$ like, but in
consequence all will come to $y^e$ same,
as from percuSsion, $w^{ch}$ is in continuall obser/vation\
& that

& that is by exciting compreSst waves in y^e^ air.
It is observable of percuSsion, that 2 bodys
{_} of common magnitude, {/moving\} can scarce ever
meet, swift or slow, without a consequence
of sound, y^e^ reason of this is, that upon touch
y^e^ separation is instantaneous, & that cannot
but excite a wave, but further in y^e^ acceSs
y^e^ air is put into a course conforming
with y^e^ action, & being stopt in an in=
stant, crowds together, & in y^e^ resilition,
Joynes with y^e^ impellent, to make a com=
preSsure. And if there be no separation
by reflection, as when y^e^ hatchet sticks
in y^e^ wood, yet y^e^ very crowding of y^e^ air
at y^e^ stop, will excite a wave, so that
from y^e^ frequency we may almost af=
firm that sound is derived of percuSsion.

157.
How sound continued

There are so many circumstances of va=
riety that belong to percuSsion, that we are
not to wonder at y^e^ vriety of sounds /w^ch^\ from
experience

experience informes us of y^e^ nature of things
distant, No leSs important to our state, than
even what comes by vision. If a body im=
pelled gives way, as lead, or wool. y^e^ per=
cuSsion failes of its force, & y^e^ sound (such
as it is) speaks y^e^ subject. If it be obdurate
& have a spring, y^e^ resilition is so strong,
that it is distinguished by y^e^ appellation of
ringing, such as from bells, Iron barrs, an=
viles, or any thing that results upon a
spring, w^ch^ more or leSs is y^e^ property of al=
most every thing. But y^e^ most remarka=
ble phaenomenon of sound is continuance,
& that is derived wholly from springs.
If y^e^ pulses from percuSsion come suc=
ceSsively so fast, that we have not y^e^
{_} faculty {~~by y^e^ action~~} by y^e^ action of any
of our members, or (w^ch^ is y^e^ same) thing)
imagination to attend them; then y^e^ sound
is to us continued; for all such are derived
of distinct

of distinct percuSsions, & it is y^e^ indistin=
guishable succeSsion of y^e^ pulses that gives
them a sensible continuance. Now springy
bodys that after one stroke continue y^e^
sound, or ring, without more, till by a
graduall wasting all sence of it ceaseth,
are in themselves y^e^ percuSsors; for every
return in y^e^ vibration is a pulse upon y^e^
air, till all is spent, or not perceivable.

158
Whence mu=
sicall
sounds

It is y^e^ nature of springs to vibrate Iso=
chronically, & that effect is pleasing to
our minds, & by y^e^ musitians is called a
tone; but if y^e^ pulses are irregular or
contingent, as scraping of china or cutting
[~~.~~?] /&\ y^e^ like, y^e^ sound is offensive to a degree
of quarreling with y^e^ offenders that make
it. And there are also musicall conso
nancys, w^ch^ are when 2 continuing
sounds are carryed on together; if one
move quicker than y^e^ other they term it

sharper

sharper, & y^e^ slower more flatt, or base.
And by this means y^e^ sounds going off
from their synchronism, w^ch^ is called uni=
son, into flatter or sharper are by no
means gratefull unleSs y^e^ [~~...~~?]pulses fall
in some proportion; 2/3 3/4 4/5 5/6 &c w^ch^
ar termed, fifths, 4^ths^ 3^ds^, ^6^3^s^ &c. w^ch^ are
y^e^ ingredients of harmony in musick,
& whereof y^e^ conduct, Joyned y^e^ skill of
knowing opertors of sounds, is y^e^ so=
lemn undertaking of y^e^ profeSsors of
that angelicall science, & art of musick
w^ch^ subject here wou'd admitt a deeper
penetration, had it not been exhausted
already in a tract expreSs.

159.
Some ob=
servations
of sounds

But now to conclude with some obser=
vations of sounds in generall; y^e^ virtu=
osi del cimento[195] have made divers expe=
riments, as in their beautifull collection
may be seen; but one conclusion of theirs
I do not

[195] The *Saggi di naturali esperienze fatte nell'Academia del Cimento ...*, first published in 1666, was a manual for laboratory procedure. The Accademia del Cimento ran in Florence for ten years, from 1657-67. Its members included students of Galileo, with others, under the protection of Prince Leopoldo De Medici and Grand Duke Ferdinando de' Medici. RN's brother Dudley had met the Grand Duke in 1661 (on his journey from London, via Archangel to Turkey). The Accademia was typical of the many scientific academies and societies springing up in the middle of the century for its emphasis on experiment and empirical methodology.

I do not agree to, w^ch^ is, that sounds paSs
y^e^ same space in y^e^ same time for, or
against y^e^ wind, y^e^ cannot be true; for
taking y^e^ resemblance of water, & in
a silent current excite an order of waves,
that (center & all) shall paSs along in
y^e^ current, so that y^e^ wave cou'd not
reach any place up stream, so soon
as it wou'd, if y^e^ center, & its circles
were not born away, but it is likely
y^e^ space of y^e^ experiment was not enough
for proof, upon so swift a transit, &
nicety of time. It is to be observed that
y^e^ dispersing of sound is not in true cir=
{-way} cles {any/\} upward or downward but in
y^e^ horizontall only, for there y^e^ air is
equally preSst & of like density; But
lower where it is more preSt, & consequent=
ly denser, y^e^ waves will retard, & not spread
so fast. So upward, in greater rarity, y^e^
sound

sound starts quicker, & spreads it self
more, & so to ye summit if ye Amos=
phear, where it comes to nothing at all,
And ye form of ye wves, in ye groSs is
{-proved} accordingly. this may be in pa{rt/\} by ye
experiment of an high tower, for if
persons below speak, those above can
scarce be made to hear; but if ye
persons above talk but ordinarily loud,
those below are amazed. For ye wave to
them is not so dispersed as it is aloft,
when ye proceeding is from below. When
an ordinance is discharged & heard 3
miles off; ye sound is not as when near,
a bounce, but a roar. That is because
{_} ye wave ~~upon~~/in\ spreading {(}as upon water{)}
grows broader, & further than that,
upon a single discharge 2 sounds shall
be heard; & ye latter loudest; of wch ye rea=
son is, that ye trusion by ye fire from ye
gun is one sound, & ye return of ye air
into

into y^e^ gun (w^ch^ y^e^ fire had made a Torri=
cellian void) with y^e^ weight of y^e^ atmos
phear driving upon it, meets a sudden stop
at y^e^ bottom, & consequently a strong com
preSsure is made there w^ch^ starting from
y^e^ mouth of y^e^ gun is y^e^ second sound; w^ch^
M^r^ Derham[196] wou'd have to be an eccho,
but how shoud that be stronger than y^e^ ori=
ginall force? Thus it appears that y^e^ spring
of y^e^ air bent by its weight is y^e^ causa
sine qua non[197] of sound. And y^e^ pneumatick
engin[198] shews how it is debillitated by y^e^
exhaustion of most of y^e^ air. Therefore we
conclude that beyond y^e^ atmosphear, or
without those sphears of compreSsure
that may in like manner belong to y^e^ sun
or other planets, but in y^e^ Aether at large,
there is no such thing as sound, as if it
were bestowed wholly upon y^e^ planetary
inhabitants for y^e^ uses of life. Thus sound is
propa

[196] William Derham, 1657-1735, a clergyman, theologian and natural philosopher; among many other things, he was the editor of Robert Hooke's *Posthumous Works*, in 1705, and *Philosphical Experiments*, in 1726. He estimated the speed of sound by observing a gunshot from several distances. He viewed the flash of the shot with a telescope from the tower of his church (St Laurence, Upminster, Essex), while at the same time listening for the sound of the explosion. (*see* Phil. Trans. 1708 26 2-35, online at http://rstl.royalsocietypublishing.org/content/26/313-324.toc; note, when you download the page, that 'Soni Motu' is not a loud and moving author, but part of the title transferred in error ...)

[197] i.e., 'cause without which there would be nothing'.

[198] i.e., the 'air pump'.

propagated by an elasticity, but light by
a perpetuall contact of ye medium all
ye world over, so that light flows co=
piously from ye celestiall luminarys,
but they afford us no musick, as hath
been childishly pretended. I say'd sound
is spent upwards, & descending augmen=
ted; this answers ye question of travellers,
who living above ye tempestuous clouds
hear no sound of thunder, (wch terrifys ye
inhabitants below) when they ask ye rea=
son why it is so.

160
The sym=
pathy of
{_} sounds

There are two matters yet concerning ye
genius of sound ye require to be touched
{~~upon~~}, one is sympathy, & ye other augmen
tation. The common vibration of one mu
sicall string when another sounds in uni=
son to it, is called sympathy, & vulgarly
esteemed to carry somewhat metphysicall
in it, & it serves among ye topicks of flou=/rish\
upon

upon naturall congruitys. But it is pure=
ly mechanicall, & tho trans-acted in mi=
nuteneSs indistinguishable, yet being well
attended to may be understood as well as
some things more distinctly perceptible.
And all depends upon y^e^ tone of y^e^ vibra=
ting s~~t~~prings; w^ch^ being so constituted as to
vibrate in like time, if one sounds, y^e^
other must move, & sound in company;
for y^e^ compreSst waves; w^ch^ more or leSs
move every thing in their way, move this
quiet string into action equall timed, &
then are no stop /to\ but continually favour
y^e^ vibrations of each other whereby they
continue & become apparent, whereas
other springs not so quallifyed however
moved, are by y^e^ succeSsive pulses stopt
from continuing to vibrate; & if it happens
that at first between two sounds there is
not this exact conformity of pulses, y^e^ action
instantly

instantly brings them together, not by
any operations of $y^e$ compreSt waves re=
ciprocally upon each other in $y^e$ air,
but by working upon each others spring
to accellerate or retard till they agree.
And for this reason strings or pipes will
in some measure tune one another;
but bells will not, for $y^e$ rigiddity of
$y^e$ mettall will not permitt any alte=
ration of $y^e$ proper vibrations, & for that
reason in consort, bells hardly ever
sound in tune.

162i,
~~$y^e$~~The aug=
mentation
tation of
sounds

Then next $y^e$ augmentation of sounds
affords matter of considerable specula=
tion, for what is $y^e$ reason that in most
flatile instruments there seems to be no
warrantable proportion between $y^e$ in=
spiring force & $y^e$ magnitude of $y^e$
sound; as in a common organ pipe, $y^e$
air at $y^e$ mouth, if $y^e$ pipe happens not
to speak, is a trifle but upon speaking $y^t$
trifle

trifle roars out so that one may wonder
whence that force of sound comes:, so in
a Trumpet $y^e$ eruptions at $y^e$ lipps without
$y^e$ instrument, are scare heard, but with
$y^e$ tube are heard at a wonderfull dis=
tance, & in $y^e$ open air. The reason at
this (, Joyning $y^e$ proper formation of $y^e$
tubes, accounted for elsewehere) is $y^e$ ur=
ging, of $y^e$ uniform pulses in $y^e$ paSsing
one upon another with a vis impreSsa
of all, whereby they spread into each
other, & so conglomerate into one uni=
ted force; And so $y^e$ ingredients, small
of themselves, combining in this manner
prove great; & nothing is more common,
than that small forces by iterations shall
produce much superior effects; $w^{ch}$ will
best be explained by instances, as in com=
mon clocks what keeps in motion $y^e$ weigh=
ty pendulum, but $y^e$ aiding its vis impreSsa
by a slight

by a slight touch /at every\ return? And how comes
a weak mortall to mount a bell of
am immense weight till it is sett with
y^e^ mouth upwards, but a small addition
(comparatively) being properly applyed
to y^e^ vis impreSsa of y^e^ swing? & if such
an ascititious force cou'd be had gratis, y^e^
perpetuall motion woud be so~~und~~/on\ found
out. And so it is in all cases of continuing
or vibratory sounds, for y^e^ compreSst waves
accumulate & enforce each other. I shewed
y^e^ like consequences in y^e^ cases of light &
flame. For light is composed of single
pulses, of themselves next to nothing,
but innumerables acting together in y^e^
same direction [.....?]combine [.....?]& become [.....?]thereby
[.....?]great, & what is y^e^ flame of a single
straw, yet when many burn together,
those little uniting in one direction can
pose a pyramid of flame. So y^e^ minute
pulses

pulses of a continuing sound by a sort of co=
alescence make such surprizing vocifera=
tions, as must every day be observed.

## Of ye Marine tydes

In ye main seas tydes not current but lifting

Nothing that belongs to ye terraqueous Globe is more exposed to common obser= vation than ye ordinary flux & reflux of ye sea. It is no wonder that we can= not trace ye powers that cause such al= ternations of ye waters up to ye originall source of them, considering that ye im= mensity of ye terraqueous globe, colla= ted with our pus~~il~~/il\lity, interdicts our having a tollerable naturall history of them. And altho we navigate almost all ye world over yet we know little how ye tydes are in ye main ocean. It is certain they are not the~~y~~re as in our ri= vers current to & fro, nor so as to continue a perpe

a perpetuall stream of ye whole main
sea round ye globe in one grand wave,
because ye saylors fancy ye navigation ea=
syer one way than ye other, for if ye tydes
were current, they might as other currents
prove them. But by all symptomes of
ye action, it appears that ye motion is like
that of common waves heaving & subsi=
ding alternatim,[199] & when pinched at
shoars & strait channells take a course
of ebbing & flowing, ye like of wch any
one that stands by ye sea side may ob
serve even of ye common waves, wch are
lifting but not gradient till ye shoals
& narrowneSses constrain them; & so
they come & retire in near equall times
but not exactly, wch hath made some
fancy ye tenth wave most remarkable.

Tydes reflect ye moons course but not ex= actly

As to ye tydes in generall, ye great & al=
most insolvable mistery is, that in all
ye alternations of them, respect is had to
ye moons

[199] i.e., 'in alternation'.

y^e moons course so that folks may thereby
prognosticate y^e high & low waters, toge=
ther with y^e springs & neaps that almost
of course happen; But we must take
along that however there is symptome e=
nough in y^e phaenomena to demonstrate
some correlation of cause between y^e
moons course, & y^e tydes, yet it is not so ma=
thematicall as to point out an imme=
diate influence of one upon y^e other, like
that of y^e magnet upon iron, but there
appears much incerteinty & notable vari=
ations in y^e times; for sometimes y^e tydes
shall fall very wide of y^e lunar times,
& not only hours, but days, 3, or 4, one
way or [~~y^e~~?] other, & seldome or never exact=
ly consonant with y^e moons transits; w^ch
seems to shew that y^e tydes are not im=
mediately, but consequentially confor=
mable thereto. As when fire is applyed
to fewell, y^e conflagration follows, or a mi/nute\
touch

touch continues $y^e$ motion of a large
swing pendulum; That is, somewhat
else effective conspires with $y^e$ moons in=
fluence to continue $y^e$ action of $y^e$ waters,
& that they are not agitated to flow &
reflow by that alone, $y^e$ matter I shall
endeavour to clear afterwards.

The Car=
tesian solu=
tion incom=
petent.

The ancients scarce ever dreamt of fin=
ding out a resolution of tydes, but
when $y^e$ earths motion was agreed, some
fancyed an inequallity in that to be $y^e$
cause, but this cou'd not be without a
discovery in our account of time. Carte=
sius was $y^e$ first who hit upon a tolle=
rable resolution, $w^{ch}$ was that $y^e$ strait
between $y^e$ moon (En paSsant) & $y^e$ earth
made a compreSsure that affected $y^e$ wa=
ters, & considered $y^e$ globe as being all sea,
& that $y^e$ compreSsure had like effect on $y^e$
opposite, $w^{ch}$ caused $y^e$ air & waters to turn
ovall, with $y^e$ shortest diameter always
attendant

attendant upon y^e^ moon, & y^e^ springs & neaps were changed upon proximity or distance of that planet. This tho' seeming plausi= ble, doth not come up to a solution, for besides it doth not answer all y^e^ circum= stances, as latter authors have shewed, y^e^ preSsure under y^e^ moon, tho it is somewhat, yet may not be allowed sufficient to move their waters from y^e^ rotundity of their surface, by an immediate force, & much leSs on y^e^ opposite hemisphear; & such a compreSsure must remove y^e^ whole {waters} globe, as well as y^e^ {wa}ters, unleSs somewhat on y^e^ other side stood y^e^ thrust; & such dislocation of y^e^ center wou'd be discove= red in other phaenomena.

The Newto= nian solu= tion by at= traction not suffi= cient

The last solution is that of S^r^ Is: Newton w^ch^ carrys it full cry omniomodo[200] per= fect. He alters y^e^ state of y^e^ fact, & suppo= seth y^e^ waters lifted & not compreSsed under y^e^ moon; this may be affirmed, but hardly proved

[200] i.e, 'in every way, completely'.

proved, for at rivers & creeks no account
is to be taken, & what shou'd plumb y^e^
main sea; Either may produce y^e^ effect,
w^ch^ makes me fancy it is neither constant=
ly but as shall happen, of w^ch^ more after=
wards. Now supposing y^e^ rising, it is ascri=
bed to y^e^ power of universall attraction,
whereby all bodys co=attract according
to y^e^ substance & distance. And according=
ly when y^e^ moon is verticall, y^e^ waters
of y^e^ sea are by attraction lifted, & as
y^e^ moon paSseth, demitted, w^ch^ makes y^e^
12, hours tyde, six flowing & as much
ebbing. And to solve y^e^ neaps & springs, y^e^
sun is introduced, but with a minor attrac=
tion, & barring some anomala caused by
y^e^ winds &ca, all y^e^ dubia[201] about y^e^ ma=
rine tydes, by these two attractive powers
are resolved. There may be divers objec=
tions to this common with y^e^ former,
as that an opperation on y^e^ one side of y^e^
globe

[201] i.e., 'doubts'.

globe cannot affect y^e^ other, & that y^e^
great variations of y^e^ tydes in severall
parts of y^e^ world cannot fall under
this, or any [rulle?] yet known, But a~~t~~s to
y^e^ principle, ⟪Attraction,⟫ ever alledged
but never proved, I shall take a rounder
course, & (for argument sake admitting
y^e^ hypothesis) endeavour to shew that it
is utterly incompetent for y^e^ present
porpose wherein it is used.

Fatall objection to y^e^ attrac= tive scheme

Here for singleneSs of argument, I shall
referr wholly to y^e^ moon, whereof y^e^ attrac=
tion is allowed to be more considerable,
& by that; frame an answer to y^e^ whole,
So taking y^e^ attraction as it is delivered to
us, it works not supeficially as elec=
tricks, tat lift what is next, but upon
y^e^ whole solid substance of y^e^ body ex=
posed to it, for its force, as they say, is ac=
cording to density; therefore y^e^ moons at=
traction affects y^e^ whole terrestriall globe,
& not

& not any one part more than another,
that is to say, not ye waters of ye sea more
more than ye solid earth & stone. And this
being so, ye attraction shall not only work
upon ye waters tending to lift them, but
draw ye whole globe along, whereby there
succeeds no partiall lifting at all. If to
this it be said that ye waters are a yielding
{comply wth} body, & will {yield to} ye force readyer, or
more than ye solid, I answer that such
wou'd be ye consequence, if any means
held back ye earth, as by some chain
from a stated part of ye skys & affixt
to the earths center, but ye whole is e=
qually free to comply with ye attrac=
tion that seiseth all alike; & no rea=
son can be given why any part (as ye
waters) shou'd out run ye rest as ye lifting
by attraction supposeth.

Confirmed by instances parallell

It is hard to answer why ye power that lifts
ye waters shou'd not separate & carry them
clean

clean away, for by that action y^e^ gravity is
weaker to hold back, & y^e^ attraction sytron=
ger to lift up, such is y^e^ consequence of
distance. But, say they, y^e^ waters are a te=
nacious body & will not readily separate,
w^ch^ is true, but then what parts happen
to devide, must go for it, as also y^e^ sands
of Arabia when under y^e^ moon raised
by y^e^ winds & follow y^e^ moon. I know a
ballance is aSsigned between y^e^ force of
sinking by means of gravity, & y^e^ rising
by means of attraction, & such equi=
librity determines y^e^ height of y^e^ tides.
But here we forget that y^e^ very center
is drawn as well as y^e^ waters, & there
is nothing to hold that back, to raise
such a [conterntion?], but all go pari paSsu[202]
together. Let me give a familiar & in=
telligible example; conceive a ligno aque=/ous\
ball[203]

[202] i.e., 'in step'.

[203] i.e., 'a ball of wood and water' - MN is suggesting an experimental apparatus.

ball, resembling ye terraqueous globe,
affixt in ye air. The force of gravity
(wch is esteemed a proper attraction)
shall draw away ye water, either to
swell downward, or to dropp away
leaving ye woody part behind; but if
at ye first instance, ye whole together
is freed in ye air, ye water shall not out=
run ye wood (supposing that ye heavyest)
nor swell at all upon ye surface of
it, but both alike obey ye force of at=
traction, by falling in statu quo[204] toge=
ther. but if that force were in any de=
gree sudden, so as to give ye substance
a greater celerity or jogg, ye watry or
looser part, woud rather hang back than
advance; & (supposing, (as ye truth is) that
ye solids of ye globe, are more weighty,
that is more exposed to ye force of attraction,
than ye

[204] i.e., 'as they are'.

than y^e^ waters, w^ch^ are lighter, there is rea=
son to argue that attraction shou'd ra=
ther depreSs than raise y^e^ waters; as if
y^e^ ball afore-mentioned were auria=
queous,[205] & let fall, y^e^ waters wou'd reluct
& not outrun y^e^ gold. In short, untill
some principle in nature is found out
that shall attack y^e^ earths center, qua
center, & hold it back from complying
with y^e^ lunar attraction, leaving y^e^ cir=
cumambient matter free to contend, &
come to one equilibrium between y^e^ two
powers; it will become impoSsible to re=
solve y^e^ flux & reflux of y^e^ sea, by y^e^
Hypothesis of attraction. It will be in
vain to appeal unto centripetation, mo=
tus in directum, or any imaginary pow=
er whatever, to cast any influence upon
our globe, favouring y^e^ notion of tydes by
attraction for they must affect y^e^ earth
as a

[205] i.e., 'a ball of gold and water'

as a totum, & not by parts, since all
parts are equally subject. I must con=
feSs I am here an adventurer, &, I may
say, against wind & tyde, attaquing y^e
Palladium of y^e modern philosophy,
of w^ch y^e author Idolized, as having by
his attractive scheme, untyed y^e Gordian
knot of nature, a work (as some pro=
fanely say) plusquam humane.[206] But
as a [sectator?] of truth, I deferr only to
y^e evidences of it as they appear to me,
abstracting all personall considerations
or prejudices whatsoever.

Use to be made of y^e lunar com= preSsion, ~~bu~~ but in part only

Objections raised against any received
opinion are seldom fairly enterteined
without a retribution of somewhat
better in y^e room, Els there remains
a suspicion of ill nature, or malevo=
lence; w^ch is not purged without a com=
petent rectification. For what profit is
there

[206] The Palladium was a small ancient wooden figure of Pallas maintained as a sacred relic in Troy and later carried to Rome by Aeneas. The Gordian Knot was a knot (or riddle) that none could undo (or solve) until Alexander simply cut through it with a sweep of his sword. '*Plusquam humane*' means 'super human'.

there in overturning a scientifick struc=
ture, without erecting a better. Therefore
it concerns me that have oppugned y^e^ 2
grand Analyses of y^e^ marine tydes, es=
pecially y^e^ latter, of w^ch^ y^e^ Eureka is al=
most universally ecchoed, to start another,
w^ch^ if not competent to stop all further
inquiry, may yet afford some matter
of fresh consideration, & thereby perhaps
obtain a clearer resolution of y^e^ sub=
ject than hath yet appeared. And in
order to that I observe that y^e^ supposed
power of attraction, not only for y^e^ in
competency already declared, but for non=
{_} entity also (since{, /y^e^\] whole scheme of that
Energy is utterly denyed) ceaseth; there
remains no conceivable possibillity of
any influence of y^e^ moon upon y^e^ earths
surface, but by means of y^e^ compreSsion

before

before touched upon, & however as to y^e^
groSs effects, that must be laid aside
also, & we must find some other mo=
tive principle to sustein such violent
agitations as appear i y^e^ flux & re=
flux of y^e^ seas, for w^ch^ in toto y^e^ com=
preSsure cannot but be insufficient,
yet we must make some use of it, as
effectuall, not of direct force, but for
regulation only in y^e^ manner I am ~~a~~
about to shew.

A new
scheme of
y^e^ tydes by
proper un=
dulations

My scheme is founded upon y^e^ constant
& known propertys of all watery sur=
faces small & great universally observa=
ble; & that is after y^e^ powers that
disturbed them ceased to undulate from
{heavings}
{__}
{__}
leSser to more spread{~~ings~~}, Isochronically
& very rarely, {/And\} that in small waters on=
ly appear wholly to cease, & if fresh
disturbances happen, y^e^ effect will
be seen

be seen upon, & conssistent with y^e^ former,
in small upon greater, & all in course
tending to a coalescence, & at last cea=
sing (If they ever cease) in a true level;
But this happens only to small waters,
for y^e^ greater are subject to such per=
petuall disturbances, that they never
stand in a true level, but however
seeming flatt, there will be heavings,
of w^ch^ boats & shipps are for y^e^ most
part sensible. And for beteter clearing
y^e^ condition of immense actions, it is
usefull to aSsume y^e^ ordinary images
of leSser matters more comprehensible;
As here, a large pool of water; w^ch^ ei=
ther rippled with minor waves, or not,
is scarce ever without groSs heavings of
y^e^ water in equable times as may be per=
ceived at y^e^ shores, or straits, where y^e^
liftings by coarctation bycome currents
for w^ch^

for y^e take this experiment, draw a
small trench from y^e water upon y^e
shoar a little rising, & (even) in a calm
one may observe y^e water run up that
trench & so back again Equably at
certain times, but much more sensibly
when y^e water is under a disturbance of
wavs, & these itions & reditions shall be
by larger intervalls at y^e brink of lar=
ger than of smaller waters because y^e
expanse of y^e heave is greater.

The sea heaves in great waves & tydes wou'd be if no moon, but irregular.

It is obvious to transferr this Image of
a minor water to y^e great sea of w^ch no
part is long without disturbance of waves,
w^ch coalescent one under another produce
vast heavings in y^e main, w^ch at shoars
& creaks shew themselves in currents, y^e
certain consequences of rising waters
contracted. And this consequence of y^e
marine swellings, I must presume to
call

call y^e^ tydes, w^ch^ work equably up & down
mechanically, according to common hydrolo=
gy, without any need of conjuring up any
spirits of attraction or compreSsion to excite
y^e^ common flux & reflux of y^e^ sea waters; so
that I must conclude that if there were no
moon, nor ever had been any, yet there wou'd
be marine tydes, & nearly at equall intervalls,
{_} but whither 12, 13, 14, {/hours\} or any other periods of
time may not in such case be determined;
because y^e^ magnitude or expanse of y^e^ heaves
must in those measures by y^e^ regulator. Nor
can it be declared what, or how many heavs
may fall out in any part of y^e^ sea, as be=
tween y^e^ lands end & y^e^ cours of America
w^ch^ cannot be surveyed by us, but one may
safely opine that it is not y^e^ whole body of
y^e^ sea that riseth & subsides at every high &
low tydes (as all y^e^ modern schemes suppose)
Such a

such a body of water being to great (com=
paratively) to dance up & down so fast, but
$y^e$ action is restrained to competently expan=
ded waves, or heavings so as $y^e$ measures may
be conform to $y^e$ times. And it is to be observed
of $y^e$ common wves of $y^e$ sea, that they spread
according to circumstances of breadth & depth
of $y^e$ waters, as in $y^e$ bay of Biscay more than
in st Georges channell, & in minor waters,
$y^e$ largest break into many waves or heaves,
but ever those of $y^e$ leSser work faster than
$y^e$ othere. But now $y^e$ labor & opus is to shew
$y^e$ moons influence upon $y^e$ working of $y^e$
waters, & by what means they are reduced
& confined to 12 hour heaves, not without
some inequallitys at certein times, I shall
not concern my self to know whither $y^e$
moon is, or is not always verticall to either
$y^e$ liftings or depreSsions of $y^e$ surface, but con=
ceive that it is indifferent & contingent, & that
either

The moon re
gulates $y^e$
tydes to 12
hour heaves

either way y^e^ consequences as to y^e^ heaves will
be y^e^ same, that is, in about 12 hour periods, w^ch^
will answer y^e^ relation to y^e^ moon; And I do
not find y^e^ contrary of this made out, altho y^e^
authors are pleased to suppose it in their own
way, nor doth y^e^ rule of y^e^ tydes hold so certainly
to hours, to justify them in either. But I conceive
that whither by originall appointment, or y^e^
result of continuall agitation, y^e^ heaves of y^e^
sea, whither many or few, are reduced to such
expanse as by water-law shall keep time near
ly with y^e^ moons course. That it is not y^e^
moon it self paSsing by or any virtue from
it, that directly raiseth or depreSseth y^e^ ma=
rine surface; but y^e^ proper undulations of y^e^
moving waters, to w^ch^ all y^e^ waters in y^e^ world
are alike subject; & if y^e^ moon were anni=
hilated y^e^ tydes wou'd continue nearly y^e^ same
for many years if not ages to come, & ask
as many to be restored again.

The sweep at y^e^ moons paSsing regu= lates y^e^ tyde hours

But we must attribute somewhat influentiall
upon y^e^ surface of y^e^ sea, by reason of y^e^ coarcta/tion\
of y^e^

of y^e^ medium between y^e^ planet & y^e^ earth;
w^ch^ hath been called compreSsure, but wou'd be
more properly termed pulsion, operating by dri=
ving, in manner as a sweep or as y^e^ winds lift
& lett fall y^e^ waves, rather than by crowding
from above w^ch^ I have argued aready to be in=
sufficient. But this influence hath no force,
either by pulsion as a wind or otherwise to make
any impreSsion or raise y^e^ least wave upon y^e^
surface, such is y^e^ exillity of it; but it may
be allowed y^e^ effect of a slight spring, near
y^e^ center or fulchrum of a weighty & long
{_} pendulum, w^ch^ in a state of rest {so?} is not put
in action by such a force in that manner
applyed altho multiplyed 100 times over, but
yet small as it is it shall suffice to continue
y^e^ pendulous movement indefinitely. And
y^e^ force of y^e^ swing is not derived of y^e^ small
spring, but from y^e^ ~~wat~~/eight\ of y^e^ pendulum it
self; but yet much adminiculum[207] serves to
keep y^e^ action going, w^ch^ of it self woud not ex=
cite a scruple of it. Do if we conceive y^e^ surface
of y^e^

[207] i.e., 'supporting, or continuing force'.

of y^e^ sea to be a perfect flatt without any
heavings at all, it is not 20 moons paSsing
by, either by traction or pulsion wou'd raise
any, or be y^e^ cause of y^e^ least tyde. But y^e^
waters always acting by pendulum law, be=
ing once excited to wave in a certein proporti=
on, that pusill difference of y^e^ medium
about y^e^ moon paSsing, may serve to con=
tinue y^e^ wavings in y^e^ same manner, as
well when y^e^ moon is absent as when pre=
sent.

The man=
ner by brea=
king y^e^ heaves
so as to con=
form

But there is a slighter imployment for y^e^
moon than to contribute much, if any
thing, towards y^e^ exciting or continuing y^e^
tyde waves upon y^e^ surface, w^ch^ hath al=
ready been consigned upon y^e^ ordinary dis=
turbances by y^e^ winds, & that is only y^e^ com=
partition of y^e^ waves that they might fall
in such magnitudes ballancing each other,
as might correspond y^e^ going & returning of
y^e^ moon, that is by near 12 hour heaves, w^ch^
by partly resisting, & partly promoting, will
after many turns bring each other to a con/formity\;
there

there are diverse operations that may serve
to explicate this effect, as musicall vibra=
tions that yielding unison sounds, when set=
ting out at different & contingent times, w$^{ch}$
[continuing?] wou'd prove discord, yet acting
against each other soon fall into harmo=
ny of motion & sound. So funipendulums
with weights at different lengths set ago=
ing after a few croSs tuggs shall fall in=
to accord in y$^{e}$ easyest & best manner that
may be. Why then shoud it seem strange
that y$^{e}$ moon by 12 hour returns, shou'd
after many ages bring y$^{e}$ great ocean's un=
dulating surface, to such a conformity of
motion, as may answer y$^{e}$ flux & reflux of
our tyde shoars & rivers? I seek not here
to resolve particularly y$^{e}$ various phaeno=
mena & anomala observed of y$^{e}$ tydes, I
shoud indeed wonder if they shou'd be exact=
ly regular, seeing no Energys in y$^{e}$ world
are so. But conidering y$^{e}$ moon's proximi=
ty & distance, Islands, promontorys, tempes=
tuous times & y$^{e}$ like, we need not be ama~~z~~=/zed\
to hear

to hear of half tydes, 3 quarter tydes, &
{litle or} sometimes (as at St Helena) {/\} no tydes at all,
& y^e^ meer view of a fictitious globe will
plainly shew reason enough for greater
irregularitys of tydes than we are yet
acquainted with.

171. Of Meteors.

Difficulty about me= teors

I have had thoughts of entering into y^e^ a=
bySs of natural philosophy so deep as to offer
at some account of meteors, w^ch^ are y^e^ appea=
rances in y^e^ air. Against w^ch^ design it occurrs,
that not a little of those matters have been
touched already, that is y^e^ genesis & state of y^e^
air, y^e^ atmosphear with its propertys, & y^e^
vain science of vapours. And what remains
may be seen', tis true, but not, as they say
felt, being [inconsct?] in mmmensity or mi=
nuteneSs where our facultys will not reach,
{clear} & {cle}ar solutions, such are desired, will
not be given, & y^e^ most that can be said
will amount but to naturll history. Of
this sort

this sort are y^e^ rainbow, y^e^ parhelia,
{-Ja-?} parselenes, Halos, Auroras, Ignis {jocu}lan=
tes,[208] lumens, or coruscations, winds, clouds,
snow, storm, thunder, lightning, Hurri=
cane, whirlwinds, mists & rain. It is a sort
of audacity to meddle too much with these,
& if I do touch it must be, as they say,
with a pair of tongs, timorously; But as
to what relates to y^e^ air, its spring, & known
propertys, w^ch^ of late by means of y^e^ Baero=
meter, serve to prognosticate weather I
shall ,respecting y^e^ usefull part, be more
diffused.

172 The chief mistery of y^e^ rain-bow belongs
The rain= to y^e^ optick sciences, where y^e^ subject of
bow & par= colours, in that as clearly, as in any thing
helia. else, is elucidatd. The colours are y^e^ very
same as appear in y^e^ dropps of dew to a
traveller when y^e^ sun shines, & y^e^ like in
a due position from any w[~~.~~?]atery sprink=
lings whatever. And such is y^e^ rain, when
y^e^ sun

[208] i.e., 'playful fires', presumably/possibly a natural phenomenon such as will-o-the-whisp.

ye sun shines upon it. But ye exterior re=
flexions from ye dropps, cast only a faint
lumen, opposite to ye sun; as for ye arcuate
colourations ye regularity of ye phaenome=
non, permitts a scrutiny of all that's Ge=
metricall belonging to it. For when ye
paSsage of ye ye light from ye sun thro a sin=
gle drop ℔ comes to ye eye, it hath past thro'
2 refractions & one interior reflexion, &
by ye rules of refraction must shew colours.
And supposing a line from ye sun thro your
eye extended, an angle of ..... degrees
by a line from your eye, & so turned round
ye former, making a sort of cone, ye coloured
light will come according to that angle, &
{arch of a} shew a perfect {/\cir}cle. The colours are equally
dispersed every way, & every spectator hath
only those that come in such an angle,
& as he moves ye colours are different, & this
is all that is known of ye rainbow, & is lucu/lently\
described

described by Cartesius & others since him.
The parhelian circles are of like nature,
but ye rule, as of ye rainbow, is not known,
it is enough that ye colours come regular=
ly by some kinds of refractions in humid
dropps, & when ye circles croSs each other,
ye light & colours & ye intersections are much
more vivid, & strong, & those are ye parhe=
lia, or as they call them mock suns. And
these appear sometimes intire & sometimes
by pieces, & so more or leSs vivid accor=
ding to circumstances. I know that in all
these cases, vapours are lett in to ye pre=
{are -} rogative of ruling, wch {~~is~~/\} by humid dropps
& nothing else; for where there is not
173. somewhat of cloud or mystineSs in ye air,
Coloured no parhelia or other such meteors appear.
Eclipse &
Halos

In ye late totall eclipse of ye sun,[209] at ye
moons edge upon ye emersion appeared
ye most vivid colours that ever were seen.
From

[209] This could refer to the eclipses of either May 3, 1715 or May 22, 1724, most likely the 1724 event; both were more or less complete, and both were visible all across England, both were also very well observed and recorded. There were no further significant (let alone total) eclipses in England until the twentieth century.

From whence an atmosphear about y^e^
moon is gueSsed at; & must be judged from
analogy with y^e^ production of colours
here below, altho y^e^ specifick ingredi=
ents are not known. As for y^e^ Halos
w^ch^ are most common, they are always
in a misty air uniform & not broken
by clouds; thay shew little colour, &
that very dusky, but obscurity in a cir=
cle makes y^e^ figure, having y^e^ lumina=
ry in its center. It is observed that when
light is collected into one place, other pla=
ces, deprived of their light, shew dark, as
we see by burning glaSses, & y^e^ lights of
that genus, sometimes used in London streets.
This occasions me to think, that in Halos
y^e^ light by reflection from y^e^ humid
dropps being at a certain angle toSs't
inwards, a darkeneSs takes place, & makes
an intire circle; w^ch^ is but a slight

acc^t^

account, tho all that I know can be said
of ye matter.

174.
Aurora Borealis & coruscations

The Aurora Borealis commonly appears
when ye year is declining towards win=
ter when ye coolneSs increasing ye air is
full of frequent humiditys, & probably
very high in ye Atmosphear;[210] wch may
be argued from ye very rarity or thinneSs
of ye clouds at such times. And ye great
luminary lying on ye north side, projects
light upon ye humid air, as when it is
lofty may be imagined, & then ye wind
gently fanning ye humidity to & fro
sometimes opening & sometimes closing,
ye light after many reflections gives
very odd appearances, but never in any
regular or steddy form. As for ye coru=
cations, as falling starrs &c that seem
to shoot various ways, they are a train
of an ignis-lambent[211] matter, wch being ac-/cended\
follows

[210] RN developed a very complete account of the nature and causes of the Aurora following the great display of March 1716, *see* BL Add MS 32546, fol. 124r ff.

[211] *See* note, fol. 160r, above.

follows as if somewhat moved, like a
train of gunpowder fired, w^ch^ seems to
run along as y^e^ matter leads it. And of
this sort may be y^e^ evening coruscations,
for what in one place may be a falling
starr, at a distance, will appear a co=
ruscation, for they are always seen near
y^e^ Horizon, & very often between layers
of clouds w^ch^ by reflexion increase y^e^
coruscation, but cannot be seen by
those underneath; very often Thunder
storms, w^ch^ have caused great disorders
in y^e^ air, & left spirituous matter not
apt for fire, (but to shine only) & deter=
mine, leaving y^e^ succeeding night subject
to coruscations. And we are not to pre=
sume these appearances to be pure night
work, but rather more spread by day,
as I have seen some egregious lumens of
incomparabl beauty so long as they lasted.

As to

175 (482) Physica

Couds & rain

As to clouds there is no distinction be=
tween them, & common mists, only y^e for=
mer are either bredd in y^e air high, or when
generated, taken up by winds, & consisting
of dropps of water or Ice, interceps y^e
sun's light, as dust, smoak, or any such
solids concumulated in y^e air below,
will do. These dropps, as hath been tou=
ched, are bredd by a very familliar a=
gency called distillation; w^ch happens al=
most universally when cold & warmth
meet anywhere, & particularly in y^e air,
for water in y^e air (mostly) raised by
heat, returns to water by cold; & begins
by imperceptible dropps, & when those in=
crease & by coalescence become large
Enough, they appear in clouds, & fall
down in rain. It was observed that
of small body's, y^e superficies (by w^ch
y^e resistance is applyed) is accordingly
in pro=

in proportion to y^e^ substance (by w^ch^
y^e^ impetus is gaged) much more than
in greater bodys; therefore y^e^ resistance
of y^e^ air that holds up small things,
letts great ones fall, as y^e^ steel suspen=
ded in menstruums demonstrate, tho
much specifically heavyer than y^e^ li=
quor, as water is also than air, there=
for y^e^ suspension of clouds in y^e^ air,
notwithstanding their bigg looks, is
not to be wondered at. But yet y^e^ dropps
that compose y^e^ cloud, of w^ch^ no one can
fall, yet together with y^e^ interfering
air, w^ch^ is in part, confine/e\d amongst
them, make one body & may gravitate,
tho not according to a solid of that
bulk. As if a faggot or spunge were
specifically heavyer than water, it
wou'd sink & carry all y^e^ interstitiall
water with it, as one intire lump.

This gives

176. causes of yᵉ winds



This gives me an handle to think, that yᵉ preSsing of clouds in a body upon yᵉ air may be one cause of winds, for one may discern a great content of maSsy clouds like mighty rocks with yᵉ sun shining upon them, but underneath as flatt as a trencher, & level as water, wᶜʰ shews that yᵉ air bears yᵉ weight of them, & altho they may preSs out some air, they cannot sink much in that manner, & generally speaking it is yᵉ fanning of yᵉ air that lifts & partly holds up some heaps of clouds from sinking. But now having mentioned one cause, wᶜʰ I cannot say is yᵉ chief, but only (as I said) condu= cing to winds it is seasonable to look out for yᵉ head quarters, yᵉ is a subject that hath tormented yᵉ naturalists as much as any. And for that I have 2 conside= rations, first, yᵉ originall cause that excites

excites such a flowing of y^e^ air, & next, y^e^
cause of so much violence as we style
storm & tempest, for y^e^ first, it is enough
that y^e^ air is a rarefyable & condensible
body, as heat & cold contingently falls
upon it, & such changes must needs be
observed; then upon heat swelling y^e^ air
it must dilate, & that will be towards
such parts, where are least impediment
by mountains & clouds. And y^e^ body of air
once put in motion, hath a vis impreSsa,
by w^ch^ it perseveres, till some noncurrent
powers obstruct or divert it. Here is enough
without more to answer y^e^ question, whence
y^e^ winds? to w^ch^ I may add y^e^ trades, w^ch^ y^e^
{_} {/1/2\} diurnall course of y^e^ suns heat excites &
drives westward, as y^e^ Indian voyagers
well know.

177.
Of tempes=
tuous winds

But y^e^ great enforcements of y^e^ common
winds whereby they shoot into tempest,
is a matter more perplext, & after a compe/tent\
knowledge

knowledge of what accidents of temper
& coarctations may happen to ye air,
it must be left to imagination to form
sn Idea of ye various consequence of
winds that may happen. For if 2 winds
concurr in an acute angle & so become
one, that one must accelerate; or if a
wind be urgent, & fall into constraint
either by clouds, shores, or other winds, by
ye rules of hydrology, that wind must exas=
perate, & who shall limitt ye degrees;
Thus there can be no tempest so violent
but, considering ye force of so great a
body in motion, all ye extreams we
know of storms may be reconciled to
poSsibillity.

178.)
Of aeriall
earthquakes

But I think it reasonable to make a
distinction between ye powers of a bo=
dy of air in motion. For there is one
sort, that goes beyond all that may be
called wind, & that is an aeriall earthquake;
I use

Physica (~~4857~~)

I use that term to distinguish those, from
y^e^ true earthquakes of y^e^ land itself.
I heard a Smirna merchant[212] say, he was
upon a house & by y^e^ rattling of y^e^ tyles
heard an earthquake coming, & observed
it rattle y^e^ tyles all along as it came,
& so to y^e^ place where he stood, & there
he was sensible of a great rufling di=
sorder, & so it went ratling away & left
y^e^ town. And upon inquiry they were
informed that other towns in y^e^ dint
felt y^e^ same. He sayd y^e^ shipps in y^e^
Bay felt exactly y^e^ same, by w^ch^ it
appears this sort of earthquakes are
gradient. These throw down houses more
effectually than storms of wind tho very
violent. And y^e^ difference will be best
shewed by a type, that is between a
fierce stream & y^e^ waves of y^e^ sea, y^e^ for=
mer had never thrown down Winstanelys
light house upon y^e^ Eddistone rock.[213] For
y^e^ storm

[212] RN's brother Dudley had been a merchant both at Smyrna and Constantinople. This part of the Physica follows quite closely (without the biographical and contextual material) a similarly subtitled episode in the *Life of the Honourable Sir Dudley North, Knt, etc.*, London, 1744 p. 36 ff.

[213] Henry Winstanley (1644-1703), a polymath and entrepreneur and, among other things, proprietor of Mathematical Water Theatre in Piccadilly, designed and built the first lighthouse on the Eddystone Rocks (a reef twelve miles south of the Plymouth Sound in the Channel Approaches). He had himself lost two cargoes in wrecks on the Eddystone. The lighthouse was built in wood in 1696-7, and having suffered damage from storms, was enlarged and refurbished with stone in the following year. The whole of the lighthouse, Winstanley included, for he was visiting it at the time, was swept away by the Great Storm of 1703.

ye storm or current is steddy one way
but ye waves do not onely suck & draw
backwards & forwards, but lift at
ye same time, & such is ye action of an
earthquake; but as to ye cause & de=
rivation, Latent in tenebris.[214]

179.
Of whirl=
winds

And our common turbo's or whirlewinds
are all mistery; they (as ye earthquakes)
happen in calms, & of these ye action
is turbinated but not in ye others wch
seem to paSs direct. I was once rufled
in one, & saw it cutt like a knife into
a watring place of a river, & then, at
ye deep, paSsed silently over, & appeared
to go on from ye otherside twisting up
ye heaves, as it came, so it went, & ye
time of ye latent paSsage seemed to
agree with its speed afore & after. A
vertuoso in ye transactions,[215] mentions his
seing a whirlwind come from ye clouds
if such observation cou'd be well secon/ded\
it wou'd

[214] i.e., 'remains obscure'.

[215] I have been able to find nothing in the Transactions searching on these words.

it wou'd open a stately inquiry into y^e^ cause;
But a present we have no Glimps of an
efficiency by any conformity's in nature,
to furnish out so much as a gueSs at y^e^
reason of these phaenomena.

180.
Of spouts in y^e^ medi= terrane

The alliance of y^e^ subject invites me here
to give an account of what hath come
to my knowledge concerning y^e^ spouts
at sea, frequently observed, in y^e^ medi=
terane. They appear at distance like
a column of solid water rising from y^e^
sea, & determining in cloud; & it is y^e^
common opinion, that it is really so, w^ch^
is strange, because nature hath not done
y^e^ ~~same~~ /like\ in any instance; & what shou'd
lift a ponderose maSs in y^e^ perpendicu
lar right up S^r^ H. Shears,[216] who had been
Engineer at Tangier told me that he
went in a veSsell out to sea on purpose
to observe them, & made y^e^ veSsel go-di~~r~~=
rectly into one, & by y^e^ symptomes ~~it~~ it
appeared

[216] Sir Henry Sheres, 1641-1710, naval engineer (he built the mole at Tangiers harbour), member of the Royal Society, friend of Samuel Pepys and, after 1690, suspected Jacobite; author of *A Discourse Touching Tangier*, London, 1680, and *A discourse on the Mediterranean Sea and the Streights of Gibraltar*, London, 1703. I have not yet tried to trace the source of this story. Sheres edited two volumes of Sir Walter Raleigh's works and may have been the source for RN's obscure reference to Raleigh's advice on infantry assault in 'of y^e^ English Militia', *see* BL Add MS 32526, fol. 78r.

appeared to him to be only a great whirle=
wind; for ye ruffle was unaccountable; &
he cou'd see a ripple as unaccountable
upon ye surface of ye sea, from wch flakes
of water were continuously taken up,
whirled & twisted about & broken, so that
ye folks were as wett as if they were
dipt, & ye sailes flowed water upon ye
deck as much as ye scuppers cou'd well
carry off, & so it proceeded, The flaky
dropps growing smaller, & by rising in
that manner were broke into mist & went
away in a cloud. But whence this turbi=
nous action came he cou'd not imagine.
This is one instance to shew, that in phi=
losophy as well as policy, ye truth of fact
is ye limit & content of knowledge.

181.
State of ye air with respect to wett & dry

But returning to ye winds, considering
that ye different temperatures of cold &
warmth (than wch nothing is more con=
tingent) meeting & intermixing in ye air
by ye law

by y^e^ law of distillation must produce
wett; It is no great strain to y^e^ imagina=
tion to represent how these changes may
happen, for wind of one temper may be
aloft, & another below, & laterally, such
confining will Eddy & vorticate one into
another, & so meeting & interfering
all manner of ways, may happen to
produce wett, when clear & single
winds are allways dry. And it must
be taken for granted that whenever
in y^e^ air a condensation happens by
cold, it will subside & make a valley
in y^e^ Atmosphear, & contrarily heat
puffe it up in a protruberance, so
that in y^e^ main, y^e^ Atmosphear, in y^e^
regions where these changes happen,
is never prefectly levell but, more or
leSs, allways rising or falling, Except
at some stationary times, as wh~~en~~/en\ we have
steddy weather. So that in y^e^ generalls
condensations

condensations are productive of wett, &
rarefactions of dry ~~weather~~. And there
are folks that by much observation of
symptomes, & consequences in y^e^ air, have
acquired a skill of gueSsing at future
weather, & sometimes, tho farr from allways,
and indeed not very often succeed. And many
contrivances, as Thermometers, Hydrascopes,
Salt strings, & y^e^ like have been used to
discover humidity in y^e^ air, w^ch^ I cannot
say are, in foretelling changes of weather,
much to y^e^ purpose, for many saylors,
shepherds & other persons imployed mostly
abroad by a sort of habit in gueSsing,
wou'd, till lately) have farr out gone
y^e^ philosophers & all their machinerys.

182.
Of y^e^ Tor=
ricallian
experim^t^
& y^e^ baro=
meter.

Of the Barometer.

But now by an application of y^e^ Torri=
cellian experiment, a surer prognostick
of weather is obtained, than ever was
dreamt of in y^e^ world before. And this
is y^e^

is y^e^ Mercuriall Barometer; an instrum^t^:
that from being a curiosity in y^e^ philoso=
phick schools, is become, like clocks, a
furniture ~~for~~ /in\ most mens houses. The ma=
teriall & fabrick is so well known, that
I need not stay to describe it, nor be con=
cerned into how many forms artists have
disposed it, for all amounts to y^e^ same;
w^ch^ is only that a column of Mercury,
in a long tube inverted in Mercury,
without any air escaping into it, will
fall untill y^e^ crowding of y^e^ air upon
y^e^ mettall in y^e^ cisterne below, tending
to drive it up into y^e^ tube, is ballanced
by y^e^ weight of y^e^ mettall that is in it,
tending to discent into y^e^ cisterne. So here
is force against weight, w^ch^ will not rest
but in a ballance of equallity. There=
fore y^e^ immediate indication is, that if
y^e^ mercury in y^e^ tube riseth, y^e^ crowding
upon y^e^ stagnum (as it is called) in y^e^ cis~~t~~=/terne\
becomes

becomes stronger, & if that in y^e^ tube
sinks, it argues a diminution of y^e^
preSsure upon y^e^ stagnum below.
Therefore it remaines only to consider
y^e^ state & condition of this compreSsure
that operates upon y^e^ stagnum, & there=
by lifts, & supplys y^e^ mercury in y^e^ tube.
As for y^e^ history & experiments relating
to this discovery, they are a large,
field, & not to be taken into this de
sign w^ch^ is to follow y^e^ pure facts, &
prognostication of weather expected
from it.

183.
Of y^e^ ~~ee~~ co=
lumn & y^t^
rules y^e^
weight of
y^e^ air

The measure of this preSsure is styled
y^e^ superimpending column, but impro=
perly, for y^e^ force is derived from all
parts, as well laterall as upwright,
but in regard y^e^ whole Atmosphear
is incumbent upon y^e^ whole face of
y^e^ earth, Each part bears his share, w^ch^
is equall to y^e^ column, as a proportion

& not

& not a precise weight. It was observed
y^e^ weight of y^e^ air diminisheth upwards,
because y^e^ quantity preSsing is leSs, in y^e^
proportion of squares: And accordingly
raising y^e^ instrument locally in perpen=
diculo, detracts from y^e^ length & /so\ also
{_} from y^e^ weight o{f y^e^ /aeriall\} column, {& l}etts y^e^
Mercury in y^e^ tube sink, & a lowering
y^e^ instrument raiseth it; by w^ch^ means
some have pretended to calculate nearly
y^e^ perpendicular height of mountains.
The magnitude of y^e^ tube hath no son=
sequence, for one as wide as a barrell
works y^e^ same as one 1/4 inch wide. for
it is a rule in hydrostaticks, that y^e^
force of fluids preSsing is as y^e^ apperture,
& here is but one apperture w^ch^ is com=
mon to both, w^ch^ makes y^e^ forces always
{_} alike, & {/to\} increase & diminish together.

184.
Of y^e^ weight of y^e^ air wett & dry

It is usuall in y^e^ printed discourses of ma=
ny of y^e^ vertuosi, Especially of y^e^ medicall
faculty

faculty to meet it observed, that ye air
was at certain times heavy or light.
But such expreSsion is insensible; for
if they mean a power to raise ye Mer=
cury, & suppose it to proceed from hu=
midity intermixt with ye air, it is er=
roneous, for it is lowest,(generally) in
{_} mo/i\st air, & higest in dry, when {~~too~~} ye
air is thought to be lightest. If they
woud note when ye air preSseth most
or least, or (wch is ye same thing) let them
say when ye air is strongest or weakest,
& then make ye best of their remarques.
But I know ye common opinion is that
moist air, by vertue of ye water that
is in it, is specifically heavyer, than
when it is dry; yet our chief virtuosi
affirm theres is no difference of such
specifick weight by any experiment
they have made to be discovered. However
ye matter imports not, for ye spring of ye
air

air is actuated by other means than wett & dry, altho those conditions may happen in consequence of what will affect ye spring.

185. Raising or de= preSsing ye Atmos= phear only af= fects ye column

It is next to be considered, what is ye true efficient cause of ye increase or abate= ment of ye preSsure or spring of ye air, referred to any thing in a fixt place. And as to this matter, I do insist that ye cause is wholly by a coacerva= tion & concavation of ye superior At= mosphear, & nothing else; That is when by any means ye summit of it is lifted up, as a rising country above ye common levell, then (by force of addition) ye preS= sure is increas't, & on ye other side when a valley is excavated below ye same le= vell, then (by ye substraction of so much) ye preSsure is relieved; for by Hydrostatick philosophy, it is determined that fluids

preSs

preSs & have force according to ye per=
pendicular gage, as all experiments
have approved. If it be said, that above
where ye matter thus accumulated
or excavated may be of a sort of more
rare & not so ponderous as ye rest; I
{_} answer that {~~that~~} ye account will be
ye same; for ye Atmosphear is a body
like water, [~~(~~&?] (perhaps) as much distin=
guished from Aether, as that as is from
air, & all ye matter in its limits whi=
ther interstitiall or other, make good
ye fullneSs, & preSs upon ye base, but
grant that a parcell of ye lower air
tra~~n~~/n\Slated (as in a bladder) to ye sum=
mitt of ye Atmosphear, woud weight
& incline to fall more than ye rest that
is there; yet ye addition or diminution
of air tho most rarefyed may signify
leSs, yet it will have some, but (perh~~aps~~/aps\)
not so

not so much effect upon y^e^ mercury be=
low but according to y^e^ proper force of it.

186 This fluctuation at y^e^ surface of y^e^ At=
How y^e^ mosphear can be caused by nothing but
Atmosphear bu condensation & rarefaction, & those can
is raised happen only by means of adventitious
or depreSsed cold, or heat; & those quallitys can by no
means arrive, but by y^e^ winds, y^e^ contin=
gency of w^ch^, whereupon all the rest de=
pend, is well known. It is certain that
if a cold air interferes with a warmer,
either above, below, laterallyor other=
wise, y^e^ latter must undergo condensa=
tion, & consequently shrink into leSs
room, & so lett down a valley in y^e^ At=
mosphear; & contrarily, if a warm air
fall among cold, that must rarefy, &
puff up y^e^ Atmosphear. But these
states are not of long continuance, un=
leSs y^e^ causes continue, but y^e^ extravagants
immediately tend towards a resettlement

in y^e^

in y^e^ proper levell. Now it is a capitall
inquiry, how y^e^ winds as to cold & heat
Acquire such different tempers, & what
means shou'd produce such various & im=
portune marches fiercer & milder as we
have experience of them; of all w^ch^
we may gather somewhat of observa=
tion in generall; but as to particulars,
we are left to work by imagination &
reflection, w^ch^ go not further than than poSsi=
billitys, or perhaps probabillitys.

184.
The state of y^e^ globe as to heat & cold

And as to these researches, we must look
into y^e^ wide world, & there we find that
all heats about y^e^ globe come from y^e^
sun, & that very unequally both as to
place & time. As first y^e^ alternations of
heat & cold between night & day, but
those follow so fast one upon another,
that y^e^ consequences are slight; Then y^e^
middle Latitudes upon w^ch^ y^e^ sun never
shines directly, have leS heat, than y^e^
tropicalls,

tropicalls, & y^e^ Articks home to y^e^ poles
have least of all, but on y^e^ contrary in=
tense cold. And /to\ these, add that all parts are
warmer & colder viciSsim.[217] And from
these conditions we inferr that /all\ travell~~e~~ring
a~~n~~ir carrys with it y^e^ temper of y^e^ place,
from whence, after some stay, it came.
And waiving nice distinctions in these dis=
courses for all cold winds I shall use y^e^
term north, & for warm, south, leaving
y^e^ intermediate points to supposition. And
accordingly I conclude that no ~~n~~North
wind can be warm, Nor south, cold. But
in regard we find by experience, that
some cold winds will come, as our wea=
ther cocks shew, directly from y^e^ south,
& warmth often from y^e^ North, I gather
that those are not genuine or true winds,
but such as are incidentally diverted from
their proper course; And those I shall call
reflex

[217] i.e., 'in turn'.

reflex winds, whereof ye propertys shall
be touched afterwards.

188,
Winds in=
dicated
by ye Ba=
rometer

We are to consider next that ye northern air
is allways more condensed than ye southern,
& that in measure as ye difference of ye
tempers, & on ye other side ye Southern by
rarefaction is more dilated th~~an~~/an\ that of
ye North, therefore whenever ye air of ye
North is by ye winds brought Southward,
it swell's & makes ye Atmosphear Gibbous,
& when ye Southern air is conveyed into
colder regions, that is, more Northwards,
it shrinks, & makes a valley in ye At=
mosphear, & these consequences are most
manifestly by ye rising & falling of ye
Mercury in ye Brometrick tube, wch is a
direct experiment to declare it. Therefore
whenever ye Mercury riseth much, it
may be concluded that ye air of ye regi=
on is Northern, & so persevering, however ye
weather

weather cock stands, it will soon be where
y^e^ instrument stands. And y^e^ falling of
an high Mercury with perseverence, y^e^
wind standing North, is a certain sign
that it is then coming about to y^e^ South.
And this is y^e^ grand & immediate indica=
tion we have by y^e^ Mercury, & most to
be depended on. And a noble discovery
it is, when by a petit utensill in y^e^ cor=
ner of a cabanet, y^e^ immense changes
of y^e^ tone of y^e^ aire over whole regions,
& nations upon y^e^ earth, with y^e^ prevai=
ling winds, or like to succeed, by y^e^ ri=
sing & falling of y^e^ Mercury in y^e^ space
of about two or three inches, are vis=
bly marked. And in consequence of this
very same experiment, we come to know
y^e^ condition of y^e^ air we breathe, y^e^
Atmosphear, & more naturall philosophy
than y^e^ Greeks ever dreamt of.

But

189,
Wett &
dry affect
ye Baro=
meter

(4504) Physica

But we must not stop at ye winds for
ye greatest expectation is ~~is~~ of a prog=
nostick of weather, as to wett & dry, be=
cause that is of use wch may turn to pro=
fit. And seeing ye Barometer by its be=
haviour in those respects rising & falling
hath given occasion sufficient to inti=
tule it Κατ'ζξοχη'ν, The Weather GlaSs:[218]
I must enter upon ye spatious field; I
mean to give an account of ye various
succeSses of that sort, & as they have hap=
pened to credit or discredit ye instrument.
And herein, I shall be forced to step /much\ in
ye dark, because ye indications are se=
condary & not primary; & consequently
more vacillatory or inconstant. There=
fore as a staff to aid ye stepping, [I?]
must use ye naked observations abroad,
that Joyned with ye movement of ye
Mercury wch are but simply up & dø/o\wn.
And so

[218] Following his Moderns *versus* Ancients comment at the foot of the previous page, MN exercises his Greek language skills (and tests ours).

And so perhaps gain a tollerable pre=
diction of ye weather. And I must be
excused for using ye foregoing hypo=
thesis thro'out. For in such obscurity
we can never find a way to any cer=
tainty of principle, wch makes it ne=
ceSsary to move by analogys, wch pro=
ving conformable in ye chief, may
be trusted in ye inferior instances. I
think our best Method will be, to set
down ye rules of ye Barometer, by
way of aphorism, & then for confir=
mation add such commentations as
shall seem proper.

190,
Aphorismes
of ye Ba=
rometer

1. The rising of ye Mercury is a sign
of dry weather, & ye falling of ye contrary.
This is ye most generall rule of ye instru=
ment, & for ye most part holds well, for
condensation of ye air, wch is always
brought about by cold, fills it with
humid dropps, wch coalescent, as must
follow

follow if y^e condensation proceeds, or
continues, will fall in rain, or at least
become misty, or cloudy, w^ch without more,
corresponds y^e symptome, for humidity
in y^e air may not allways turn to rain,
Nor be determined to more or leSs certein=
ty, but according to circumstances.

2. In both rising & falling of y^e Mer=
cury, y^e quickneSs or dullneSs of y^e mo=
tion, is of more signification, than y^e
space moved.
It is to be found by experience that very
quick motions seldom, or, in some mea=
sure at least, never fail of a confor=
mable succeSs, for it shews y^e cause,
whatever it is, acts powerfully.

3. In settled weather & y^e Mercury
standing long in a place, no change
of weather can come without a con=
siderable notice beforehand by some
movement.

For here is no croSs working of causes
one over another w^ch^ must create
incerteinty, but a single cause that
must precede some time before y^e^
effect can follow, for be it ag^st^
rain, y^e^ valley will be formed, be=
fore y^e^ dropps coalesce so as to be sen=
sible.

4. In such case, if y^e^ motion stopps
suddenly, & then returns towards y^e^
same station, it is a sign y^e^ same
weather will continue.
For towards rain as before, in y^e^
time between y^e^ /valley &\ coalescence of y^e^
{_} dropps {~~i~~}y^e^ latter is prevented by a
restitution of y^e^ former state.

5. If y^e^ alteration stands long &
be considerable, there is certainly an
effect somewhere.
This is y^e^ greatest infelicity of y^e^ instrum/^t^\
for

for effects are not always extended
as y^e^ cause is; for that shall be y^e^ same
all over England, giving signs of
wett weather, & no effect locally
appear, but it shall be known by
report that in remote countrys, there
had been great rains or snows, But
this happens not often, & for y^e^ most
part, y^e^ effects answer y^e^ symptomes
every where; however this use may
be made, that when y^e^ signes are e=
gregious there is reason to conclude
there are great effects somewhere, &
it is probable that all places, in time
will partake of ~~y~~^e^them.

6. When y^e^ signs are not answered,
it is a sign that y^e^ same weather
will continue, & that y^e^ Mercury
will return to its post, but still sub=
ject to effects in places remote.

This

This coincides with y^e^ former, & y^e^ like
is observed of y^e^ naked sympromes abroad,
for when y^e^ clouds threaten in a dry
time, as if rain were coming, & none
follows, it is a token that y^e^ drought
will continue, Especially if y^e^ Mer=
cury, hangs back, & makes little or
no steps towards a change.

7. High Mercury & North winds, & low
with Southwinds are naturall, but y^e^
alternate, Low Mercury with North & high
Mercury with Southwinds I term non naturall.
It was observed before that y^e^ cold air coming
from y^e^ Northern regions, towards y^e^ Southern,
accumulated, & y^e^ alternate depreSsed y^e^
Atmosphear. W^ch^ appears manifestly in y^e^
Barometer, for that constantly riseth & falls
with y^e^ winds, [.....?] w^ch^ I take {/stet\} y^e^ alledged to be
y^e^ sole cause [....?],[219] I mean rarefaction & conden=
sation: Dr Halley who allows y^e^ alterations
of y^e^

[219] The text between the two bracketed trails of dots has been washed-out and overwritten. It is not absolutely clear that it was then *subseguently* crossed out, the pencilled-in 'stet' might indicate that RN, or whoever it was annotating the text, read the marks left by the washing-out and overwritting as a crossing-out!

of y^e^ Atmosphear to be hydrostatick, &
yet aSigns y^e^ cause upon y^e^ winds, w^ch^
meeting raise, & deviding depreSs y^e^ surface.
But I do not agree with him in that, for
y^e^ air is so open, & unconfined, that if
contrary currents meet, that will divert
laterally easyer then accumulate, for
that can happen only in a channel.
And then this accumulation or devision,
if any such happened in an even tem=
pered air had no effect upon y^e^ weather;
but ~~t~~when it comes by condensation &
rarefaction it toucheth y^e^ weather &
y^e^ Barometer at y^e^ same time & unites
y^e^ symptomes with y^e^ effect.

8. The naturall produceth fair, & y^e^ non
naturall foul weather.
As for examples; If y^e^ wind be North
& y^e^ Mercury low, it is a most sure sign
of moist weather, unleSs y^e^ Mercury riseth
swift. So if y^e^ wind be South & y^e^ Mercury
high

high, it may be dry, but always (if not wett)
it is either cloudy, windy, or both, & never
holds in quiet weather. But ye other non na=
turall is more humid, because ye whole
operation is condensing, & this hath some
share of rarefaction.

9 Winds North & high Mercury, if shifting
tho' in ye Northerly points, ye air will be
wett or cloudy.
The instrument is defamed because some=
times it contradicts it self, as in this case,
therefore to do right, ye state of ye air
abroad shou'd always, be considered toge=
ther with ye Mercury, for in some states
of ye winds & ye non naturall cases, expec=
tations built upon ye general rule, will
fail. And thse shiftings as from North
to N~~or~~/or\th West, & so to North east, East, or
North again, are not without commixtures
of differently tempered air. If none comes
over

(512). Physica

over from warmer points, & not discerned,
w^ch^ produce wett tho y^e^ Mercury is in y^e^ up=
per storys.[220]

[220] The rest of this page and the following twelve pages have been left blank - except for MN's numbering and header. The BM curators have not given the sheets folio numbers.

Physica (515),

(520) Physica

(522) Physica

191. Of Thunder & Lightning

Of Thun=
der storms

Of all y^e^ phaenomena of nature none is
so exposed to common sense & observation,
& withall none so tremendous to all; &
fatall to some, & yet leSs understood, or
honoured with a tollerable solution by
any of our philosophers, thn y^e^ ordina=
ry thunder & lightning. That of Carte=
sius, by strata of clouds, falling upon
each other, is redicolous. The latter ora=
cle[221] says nothing of y^e^ matter; D^r^. Wallis
in y^e^ transactions[222] say's only that somewhat
like gunpowder, as Nitre, sulphur, &c come
together, & with help of a little moisture,
accend & explode. That such materialls
are in y^e^ air, who doubts? But hath any
one shewed what brings them together at
certein times, & in such consistencys, as
shall have such outrageous effects,
as are

[221] i.e., Isaac Newton.

[222] John Wallis, 1616-1703 was a mathematician and held the Savilian Chair of Geometry at Oxford from 1649 until his death. 'A Letter of Dr. Wallis to Dr. Sloane, Concerning the Generation of Hail, and of Thunder and Lightning, and the Effects Thereof', Phil. Trans. 1695-1697, 19, 653-8, esp. p. 655 (*see*: http://rstl.royalsocietypublishing.org/content/19/215-235/653.full.pdf+html?sid=34ad6a77-81de-462b-aecf-271f6d7089b8)

as are notorious? I knew y^e^ body of a great
timber oak torn to chipps & filaments
& y^e^ head dropt with out a leaf toucht,
w^ch^ for ought that hath been discovered
yet, must seem (as it were) impoSsible;
Historicall relations supply innumerable
instances of unaccountable effects in
such storms, of w^ch^, y^e^ ~~y^e^~profusion of rain,
& hail stones of surprising magnitudes,
as it were shott against y^e^ ground,
are not y^e^ most amazing. And slighter
effects than these are sufficient to require
of all y^e^ courtiers of physicall know=
ledge, to make continuall & severe in=
spections into such flaming misterys;
whereby (perhaps) some persons may be
eased of their exceSsive, concern w^ch^ upon
these occasions torments them, by shewing
that y^e^ forces are naturall, & hurt very
few. And from y^e^ influences no defence
can be ~~had~~found or had above ground.

I intend

I intend to venture forth a thought or
two, w^ch^ together with what will be es=
teemd more common, may come neerer
a solution than is yet known.

192.
The gene=
rall cause
by conden=
sation

The genes[~~..~~?]is of thunderstorms are most
in calmes (next y^e^ soyle) & made by oppo=
sition & commixture of divers winds aloft
of a very contrarient temperature.
Some extream warm, & others cold in
like extremity, wherein respect is had
to y^e^ ordinary tempers in common weather;
& these quallitys are contingent as y^e^
winds, of w^ch^ there may be a concurrence
of many to exasperate y^e^ disorder. The
heat is for y^e^ most part felt below,
as when we say it is sultry, & expect a
storm, & y^e^ cold is above, verifyed by y^e^
quantitys of ice ingendered there. And
that in such conjunct~~ions~~ures there must
be very great condensations (w^ch^ increase
as y^e^ suns heat is deprived by accumula/tions\
of them

of them) is neceSsary from such opposi=
tions, but ye very view declares as much
for it is usually seen how ye clouds in=
crease, & roll about, as driven with di=
verse winds. And if we cou'd discern more
of ye clouds than ye inferior parts, & pe=
netrate into ye volumes above, we shod
have better information of ye state
there, than we can have below, where
we can only gueSs at ye rest.

193.
Of ye man=
ner, & how
thunder

And if we may be allowed to launch
out in that track, we must conceive
that ye cloudy collection is immensly
extended every way. If I say'd some miles
long, broad & deep, it wou'd not be much
out of ye way, And this not all in a
lump as one common mist, such as we
often have a view of Laterally, when ye
storm is over; But continually moving
& toSsing in heaps one way & other, &
full of ducts & cavitys, wch are always, by

closing

closing & opening in change, & where y^e
{_} clouds {were} preSst together by winds,
they may open & make a cavity, & that
turn to a duct & close again. And y^e air
in y^e cavity may be cold or hot, & in y^e
ducts, diriven with impetuous force,
& perhaps meet, w^ch must create as was
said extraordinary condensations, & dis=
tillations of water, w^ch prove frozen,
or mixt, some wett, some Ice w^ch begins
with snow, & that hurryed with winds
become hail, w^ch in such state increase
& are not permitted to discend, till (quan=
tity (increast) will endure it no longer,
and then it comes down alltogether in sheets
of hail, & those not derived from y^e low=
er, but perhaps y^e highest orders of clouds,
{_} & falling thro all, are in y^e paSsage {ever
viol}enced, & gather continually. Now
conidering these extreams, It is obvious
to imagine that when either y^e weighty

bodys

bodys of clouds are by contrary winds
compreSst together, or by any accensi=
ons happening in ye cavitys, ye air com=
preSst within (for tho clouds are made up
of distinct dropps, yet they, with ye in=
terstitiall air, make one body, & mostly
come & go together) will produce Erup=
{_} tions; And {(}when these are with ~~vio~~/io\lence{)}
to cause accension or lightning, There
will succeed a fragor that receiving
augmentation below, is terrible to all
creatures. And first, ye sound is increas't
by coming from high, or thinner air,
down to an air more dense as it is at
ye earth, & then ye Ecchos not only from
among ye clouds, & against ye strata or
heaps of them, but between ye clouds
& ye earth perpetually rebounding to &
fro till ye force of it is wasted; & this
makes ye sound, ye is but ye strokes from
ye Eruptions, continuing & seeming to roll
from

from one place to another & ceasing by
degrees~~,~~ not unlike a meer Eccho.

194.
Of light=
night & its
forces

But y^e^ more transcendent inquiry is of
y^e^ lightning & its forces, & manner of stri=
king. The configuration of it appea=
rance is to be observed, some may think
that y^e^ darting to & fro is as a train
fired, w^ch^ seems to run as a progreSsive [~~....~~?]fire,
but upon consideration, I think this is not
so, for y^e^ going & returning, as it doth
often by long stretches, seems too swift
for that course, w^ch^ wou'd take more time
to paSs, & repaSs such lengths, as we see
in starrs shooting & falling. Therefore
I repute y^e^ lightning to be pure & pute
eruption. And not altogether of y^e^ form
as it appears by y^e^ acute-angle returns,
for however y^e^ returns too & from are, y^e^
perspective view of y^e^ under parts of y^e^
clouds will make them seem acute-angled,
& sometimes

& sometimes $y^e$ whole eruption angular=
ly figured, shall appear, as in $y^e$ same
instant, & how farr it is from us or
how near, tis impoSsible, for want of
comparatives, for us to judge.

I once saw a kind of light column,
distinct, distinct from $y^e$ other lightning
reching from $y^e$ cloud to $y^e$ ground, $w^{ch}$
might be a blast, wherever it fell,
such as melts mettalls or does worse mis
chief; But that $w^{ch}$ rends trees seems to
be not $y^e$ lightning or any emanation
from it, but a formed consistence of
spirituous explosive matter, $w^{ch}$ in $y^e$
violence of $y^e$ eruptions, (being as I
suppose formed in $y^e$ cavitys of $y^e$ clouds,
& so strays about till it meets of a con=
juncture to give fire to it, as $y^e$ styptick
sap of an oak is like to do) hath a
gunpowder effect as was noted. And it
is not

is not unlikely that many accendible
coagulums, may paSs about unseen, & not mee=
ting with such opposition, or other means to
fire them, fail of that event, & as Ice, diSsolve,
& come to air again as they were before.
As for y^e^ storys of melting a sword & not
hurting y^e^ scabbard /& y^e^ like\ y^e^ /there wants som vi=\ [.....?]there
wants a sen=[223]
sible proof to perswade they can be so, for
y^e^ melted mettall woud soon consume y^e^
scabbard.

195.
How y^e^ ac=
cendible spi=
rits collected
{ operations}

But yet y^e^ principall secret remains un=
disclosed, & that is y^e^ collection, & accension
of y^e^ inflammable spirits among y^e^ clouds,
where y^e^ {greatest} are to distill water, w^ch^ doth
not well consist with fiery accensions. My
conceipt of y^e^ matter is this; It is well known
that together with y^e^ abundance of water
raised up into y^e^ common are by heat, there
is mixed with it not a little of adust parts
of y^e^ spirituous kind, as a suphur, Nitre, &c such
as come

[223] Two possible versions have been left - and both are written over an earlier washed-out version.

as come by smoak, & culinary, as well as
other exhalations. Amidst ye tempestuous
clouds, there is not only vast compreSsion
but mighty condensations, wch latter draw
from ye air as well interstitiall, as in ye
cavitys of ye cloud, mightys quantitys
of humid matter producing those orages
of rain & hail that seem in short tempes=
tuous gatherings to fall from them. The
watery parts by coalesccence increase &
fall, leaving ye spirituous part, wch will
not, like water, coalesce so as to fall.
And hereby ye intercloudy air becomes
mostly spirituous & accendible, & in that
is like to vapours, as they are called, in
mines, & subterraneous cavitys, where ye
sulphureous habitus of ye earth fills ye
air of those places; it being all one whi=
ther ye spirits are copiously, (as in ye damps)
infused into ye air, or ye air (as in ye clouds)
be by

be by distillation discharged of great part
of water leaving ye spirit; both ye one
& ye other for parallell cause become in=
flammable. And in ye mines it is common
for ye damps to kindle at a stroke of ye hack
against a stone, or by fire designedly
applyed, & not seldom by other unknown
accidents. And why shoud not ye ~~h~~same
happen in like manner by accident a=
mong ye tempestuous clouds; This is enough
to shew that it is no wonder that tempes=
tuary air shou'd take fire, & appear to
us by lightning. And to bring ye matter to
a nearer familiarity, how often do we
complain of stinking mists? No water is
sweeter than that from ye clouds. The rea=
son of such stenches is that such air;
however it c~~omes~~/omes\ to us, hath much of ye
aqueous parts distilled into dropps, & much
perhaps fallen to ye earth, & ye rest that
is left consists partly of sulphur &c wch stinks
wherever

wherever it comes) mixt with ye remaining
air. And if ye experiment coud be tryed; &
a large extebt of sulphureous air in a
common stinking mist be hard pent,, &
let go at narrow crevises, I shoud be loath
to stand ye fire for ye very quick motion
& friction woud kindle it.

196,
How ye mat=
ter of light=
ning is ac=
cended

Here is a reason enough to satisfy one, how
ye air among tempestuous clouds may be
accendible, but how it is actually kin=
dled, is matter of further consideration.
Some have thought of spirits opposite
in nature, wch put together will grow hot
& kindle, & some salts with ye addition of
a little water, & so lime readily burns;
The Phosphorus (new) will kindle in meer
air; & other like accensions are (on these
occasions) mentioned. I must allow them
all & more that are unknown to be poSsi=
bilitys, & cannot say negatively that any
of them are excluded from being concerned
in ye operation

in y^e^ operation of lightning. but my senti=
ment is that y^e^ common, & most frequent &
effectual cause is, friction. If y^e^we ima=
gine that in a cavity of y^e^ clouds com=
preSst, y^e^ air by any of y^e^ aforesaid acci=
dents shall take fire, there is no doubt
but there will be an eruption, w^ch^ to us
will be as lightning, & how often it may
happen so, I cannot pronounce. But if
from such compreSsure there followeth an
eruption of sulphureous air, then without
any other means of accension but by meer
swiftneSs & snatching of y^e^ current against
y^e^ stated & unmoved air of y^e^ clou'd, it will
take fire, & y^e^ manner of its shooting to
& fro, seems to argue for this explication.
There is nothig further as Icknow to pro=
voke our conjectures, but y^e^ nature of
those transparent bodys they call fire
balls, w^ch^ are supposed to paSs harmleSs un=
till some accident fires them & then they
blow

blow thro all. Gunpowder is too groSs to
aSsist an Idea of them; It is not certain
they enter thro walls, but it is more pro=
bable, that such encounters might fire
them. Therefore it is adviseable to stand
clear of paSsages. Harmes often happen
in ye fields wch I take to be jaculation
from ye clouds upon ye eruptions, rather
than any matter that takes fire near them.
And the fire balls, as they are called, seem
to be collected & composed in ye cloudy
regions and blown towards ye earth, rather
than gathered so low. Some think that
lightning is transient as in a train, but
it seems that ye appearance is more in di=
vers parts instantaneous than suits that
resolve, but rather agrees with Eruption,
altho even that, as a rent, may shew ye
appearance of a transit, wch is too nimble
for ~~shew~~/uch\ exceeding swift darting & such
lengths as are observed.

{Ante}[224]

[224] The pencilled annotation, marking a section with a verticle line and annoted 'Ante' suggests that it should be inserted earlier in the chapter.

## Of Curuscations.

197.
Of corus=
cations &
how dis=
tinguish't

I mentioned elsewhere that thunder storms
often concluded in harmleSs coruscations;
And now springs a temptation to examine
a little more scrupulously into y^e^ causes
of such effects; I mean y^e^ various sorts
of Lumens, w^ch^ stike our sense, but without
fire or sensible warmth. The vertuosi
have observed severall of them, but
without so much as proffering to resolve
their efficients; & I am not a little piqued
upon y^e^ subject~~s~~, because y^e^ scheme of
li~~t~~ght & colours, w^ch^ I have proposed, will
be very imperfect, without a supplemen=
tary explanation of these sub lumina.
In order to w^ch^ I must remember that y^e^
former supposed that y^e^ action of y^e^ sun,
& leSser fires impreSst y^e^ whole intermediate
fluid, as well y^e^ groSs, as y^e^ more minute
interstitiall

interstitiall matter, but ye latter only
found its way to ye optick nerves, & so ex=
cited our Idea of of light, but ye GroSs af=
fected only ye exterior parts of our bodys,
& raised no other Ideas, but those of heat
or burning, in caSe ye action pointed with
force sufficient, as by lent glaSses, or con=
cave mettalls. Now here ye segregation of
these powers are made at ye eye, wch letts
in ye one & that is conveyed by ye subtile
matter, & excludes ye othr wch tends to fire
rather than light. Therefore if there be
an action wch works (almost) wholly upon
ye subtile matter of ye medium, & not (much)
upon ye groSs, tht will affect ye sence
with ye Idea of light without any con=
sequence of heat, wch had little or no share
in ye cause & wch arose not from any ac=
cension, but from a more retired princi=
ple. So that common light comes attended
with a principle of fire, but coruscation
by an action intromitted to ye sence, without
any ten=

any tendency to fire, & originated upon ye sub=
tile matter only.

198,
Of ye diverse sorts of faint lights

If it be said that however ye action is excited,
it must affect ye whole medium both
groSs & subtile, I answer, true, but with
effect so slight, that as to ye groSs it sig=
nifyes next to nothing, when ye action ori=
ginally falls upon ye groSs, that by mecha=
nick law must propell ye finer with full
velocity, but if ye originall cause falls
upon ye subtile matter, that hath not
power to propell ye groSser, but slightly,
& with little (or(comparatively) no velocity.
Now these coruscations are observed to appear
in ye air by accidentall production, or
upon ye earth by corruptions, fermenta=
tions & ye like.

199
Of ye accen= dible mix= tures in ye air.

First as to ye air, we have considered that
some part of it is not water, but spirits,
as sulphur, & salts of various denominations
for those

for those readily take wing, & will spring
{_} {/from $y^e$ Earth\} into $y^e$ air by common heat, but most
by $y^e$ intense heat of $y^e$ sun, or from cu=
linary fires; but little or none of $y^e$
ashy kind of matter riseth, but all
that, remaines behind, $y^e$ fire having
pickt out all that is spirituous from
it, & joyned it with $y^e$ watery part
of $y^e$ air in one common fluid, This flu=
id being perfectly transparent, we do not
discenre $y^e$ differences of $y^e$ matter where=
of it is composed in manner as we see
$y^e$ sorts of earth, as stones, sand, or water;
therefore think it to be a particular u=
niform substance, & wonder at any thing
that appears otherwise in it. But if we
consider it, as variously composed of hete=
rogene parts, & with analogy to things
sensible, as water & earth; we must opine
that there are in it, composed at $y^e$ spiri=
tuous parts, coagulums, vegetation, & perhaps
animalls

animalls, as there is in standing water cor=
ruptions, insects, & vegetables, & so in y^e^ earth
{_} veines plants & animalls{. Wh}en any of
y^e^ slighter veines of spiritous matter
in y^e^ air, accend, they run on in trains, &
shew a faint lumen, of w^ch^ there is great
{_} variety, {we} call{/d\} coruscation, & have no
violent effects, because their beginning
& continuance, is in such subtile matter
as propells only its like, without affec=
ting y^e^ groSs air. And this doth not impeach,
but coincides with what hath been said
of tempestuous lightning; for that w^ch^ is
fiery in it, proceeds in coagulums bredd
in compreSsure, most of y^e^ aqueous mat=
ter being distilled from it, for these are
GroSs, compact, & dry, & capable of explosion
with direfull effects. W^ch^ never happen,
but in such outrageous circumstances,
as appear by y^e^ [postliminious?] coruscations
after a storm, w^ch^ are innocent, as many other

contingent

contingent (tho very observable) lumens
in ye air have been.

200
Coruscations about ye earths surface very weak

Hitherto of coruscations in ye air; of wch
I must observe, as of all this kind of (~~cold~~)/cold\
lumens that they are very weak, & scarce
or not at all perceivable but in ye night,
when ye power of daylight is gone. Now we
come to those coruscations, wch are found about
ye earth; & these are either from animalls,
or from fermentation or corruption of ani=
malls, ye Glow-worm or fly is ye most consi=
derable; whose body & skin are transparent,
& ye action of life in ye creature at certain
times is such as gives a faint impulse upon
ye finer matter of ye air, without any (dis=
cernable) effect upon ye more groSs parts, so
is seen tho no heat is to be felt. If it be asked
why in some fly's not in all, & why in
some evenings & not in all? I answer from
like cause as produceth flys, some with
4 leggs & some with six, some blew & some
redd

redd. It is enough to shew that where such
lights are, It follow[~~.~~?]s not that there must
needs be fire in any degree (except what
is common to all animall life) because y^e^
powerfull part of y^e^ air, is not concer=
ned in y^e^ originall cause of such lumen
w^ch^ is derived from & led by a subtile mat=
ter only.

201.
Of ignis fatuus or will in y^e^ wisp

But to persue these trifling matters a little
further; we have a phaenomenon, w^ch^ is fre=
quently seen, & not only admired, but
made y^e^ subject of many fabulositys. It
is called will in y^e^ wisp & never seen but in
y^e^ night, & then moving desultorily, up &
down, & in places low, & seeming at con=
siderable distan~~t~~ce, & if any person goes
towards it, y^e^ appearance will go from him,
& perhaps lead him in to a bogg, about w^ch^
places it i~~n~~s most often seen; & if y^e^ person
retires it comes towards him. And all this
is ama=

is amazing to y^e^ common people; y^e^ whole
secret of this matter is that y^e^ lumen is
wholly from aSsemblages of flyes, w^ch^
we may observe to sport afore us in a
summers evening in columns; & those may
be observed to use y^e^ very practiqs of Will
in y^e^ wisp, that is, if you go towards one,
y^e^ column falls back, & if you retire, it
follows, & sometimes it will be on one
side & sometimes on y^e^ other. But when
it is dark, & y^e^ distinct bodys of these flys
cannot be discerned, what part of them
falls below y^e^ plane of y^e^ horison (for
above there will be, even in a dark night,
too much light for this purpose) as from
rising ground towards a valley will be
seen, but higher, that is, above y^e^ horizon=
tall plane, no such lumen for y^e^ rea=
son before hinted will appear. When
men travell in open countrys, without any
light, but in extremity of darkneSs, there
will

241r



will be a fancy that y^e^ paSsage is between
two walls; w^ch^ proceeds from a distinction
of y^e^ horizon what[225] is above & what
beneath it, for no darkneSs will deprive
that distinction w^ch^ is by means of some
degree of light w^ch^ will make such diffe=
re/e\nce. Now in viewing this dancing lumen
there is nothing comparative to judge of
this [.....?]distance by, therefore when y^e^ flyes are
not two yards from your eyes, they will
be judged to be at y^e^ remotest distance.
W^ch^ must be so, for y^e^ desultory motion
cou'd not appear so swift, nor wou'd y^e^
angles open as ~~u~~they seem unleSs y^e^ ob=
ject were near. And by these deceptions
folks are amazed, & none cou'd ever by
following find y^e^ specter out.

202.
Of y^e^ sea
burning, &
y^e^ colours

But now to come to those things that are
solid & palpable; first y^e^ sea burning (as
it is called) is remarkable, y^e^ phaenomenon
is when oars strike y^e^ water; A strong
lumen

[225] Above the 'w' in the word 'what', MN has drawn a small circle.

lumen attends, as it were struck out of
ye body of ye water. So when ye surges
rage & froth, ye whole sea seems to burn,
& it is hard to perswade a mariner
that it doth not. This proceeds from
that light wch is in ye air tho it be very
little, for no time is absolutely dark.
But ye surface of water will be exqui=
sitely opack, especially if it be smooth
for that can send no light to ye eye, wch
must be of common observation; But
when ye oar breaks ye surface of ye wa=
ter, & turns it into numberleSs forms
such as they call frosting, or like froth,
then ye light, wch is in ye sky, is thrown
from such broken surface, & upon ye
smooth, that is ye dark surface, appears
quasi a light extraordinary. And ye
like is ye case of ye waves, for when those
curl & froth & ye topps, ye little light from
ye sky upon them appears more vivid to
ye eye

y^e^ eye than from y^e^ common water of y^e^
sea. Another phaenomenon of y^e^ sea is when
it appears of deep blue, or strong green, y^e^
water it self is always y^e^ same, limpid &
transparent. The reason is, y^e^ Azure sky
reflecting from y^e^ disturbed water shews it
blew, & if y^e^ sky is cloudy with some azure
it is green, & if all cloudy, it is grey or
muddy; all by reflexion.

203;
Of rotten
wood shi=
ning

Other noted instances of y^e^ faint shinings
in y^e^ dark, are either such as from y^e^ con=
stitution of y^e^ parts (as y^e^ sea burning) seem
to shine, or else have a positive lumen
attending them; y^e^ former are chiefly rot=
ten wood, & things w^ch^ carry a lively white
colour; for y^e^ lyittle light in y^e^ air re=
flecting from such in a place accounted
very dark, shews them distinguisht from
those things, w^ch^ reflect no light at all. It
is

is common for travellers in a dismall dark
night, to put ye white horse before, for
he will be distinguished when no under=
colour can be discerned; & of this sort
rotten wood, such as we call touchwood
seems to shine in ye dark, ye rather be=
cause ye superficies is broken, upon wch
ye little light sparkles; & all is by vertue
of its whiteneSs, & not by means of any
lambent fire; that it is corrupted is certain,
but it is a dry finished corruption, & con=
duceth only by a severence of ye parts;
There is wood full as rotten but of a dark
colour, wch never affords any shew of lumen.
And I believe a very white paper, or rather
snow wou'd shew as much as any touchwood.

204.
Of shinings about ani= mall sub= stances

Of those things that shew a positive lumen;
Besides ye flyes touched before, are jellys abt
oyster shells, moisture in ye hair of dog or
catt

catt, in an humid evening, that when stro=
ked back will shew a light; & ye like from
human bodys, as when ye lady was frighted,
that letting her shift fall from her, it
flasht as all on fire. So ye heads of fish
begun to corrupt, & flesh also, witneSs
Mr Boyle's lucid loyn of veal.[226] All wch
imply a kind of fermentation residing
in ye receSses of ye most subtile matter, wch
can be sensible by no touch, but that
of ye eye, & that so weak, that in ye utmost
darkneSs, it is but just discerned; & we must
not pretend to know more of them; & I had
not pretended to say so much, but for
speculation of our sensitive powers, wch,
as ye propertys of sensible things have no
termination. In ye absence of ye greater,
we perceive ye leSs, & I doubt not but one
long confined in ye deepest dungeon, woud
come to perceive all parts of his mansion
plain enough; for wch reason Dr Halley
thought

[226] Robert Boyle, 'Some Observations about Shining Flesh, Made by the Honourable Robert Boyle; Febr. 15. 1671/72 and by Way of Letter Addressed to the Publisher, and Presented to the R. Society', Phil. Trans. January 1, 1672 7 5108-5116. (*see*: http://rstl.royalsocietypublishing.org/content/7/81-91/5108.full.pdf+html)

{_} thought his four interior worlds, {to /tho\} no sun, had light enough to supply ye inhabi= tants.[227]

Of Divers Phaenomena.

205. How heat & fire is excited by action upon mettalls.

The physicall cause of fire struck out between a steel & flint, hath been much mistaken, when ye flint hath been sup= posed a secret repository of fire. Whereas fire as such is lodged in neither of them, but created by a rending from ye steel very small slivers of ye mettall, in such a violent motion as makes a fusion of it; & every spark is a piece of melted steel, & many be seen with a microscope upon a paper, over wch fire hath been struck, in all ye little burnt specks as small shot like that wch flys about a smiths forge when he ham= mers upon a flame heat. And ye very likeneSs of this may be seen by file dust of iron thin dropt over ye flame of a candle, for each

[227] Edmond Halley (1656-1742) proposed his 'hollow earth' theory in 1692 while attempting to explain magnetic variation: 'An Account of the cause of the Change of the Variation of the Magnetic Needle; with an Hypothesis of the Structure of the Internal Parts of the Earth', Phil. Trans. 1686 16 563-578 (*see*: http://rstl.royalsocietypublishing.org/content/16/179-191/563.full.pdf+html). Halley imagined the earth being made of a number of concentric globes (sized proportionately to Mars, Venus and Mercury) each with different magnetic polarities. From p. 572 onwards he speculates more broadly about other features of such an imagined globe, including the flow of water between them, the different forms of life possible owing the absence of sunlight, and going so far as to make literary allusions to classical hells.

each particle will melt & fall in vivid
sparks as from flint [&?] steel. This shews
in what proportion great things resist
more than small, for it must be fur=
nace or forge to flux great lumps, when
a candle or strokes will melt y^e^ pul=
viscula.[228] And it is very remarkable that
drawing or extending mettalls conduceth
much more to raise a heat in them than
any other kind of force. It is common
for smiths to hammer a piece of iron, till
it is hote enough to kindle a match, &
so they do not visit neighbours, as they say,
to fetch fire. But this must be tough &
ductile iron, & not such ⟨as(cold) will
burst rather than draw, & ~~y^e^~~they hamer usu=
ally upon y^e^ edge of y^e^ anvill, to drive it
whereby it soon becomes hot, & y^e^ like may
be observed, of wire-drawing, or watch-
spring-making. In all w^ch^ actions, y^e^ friction
of y^e^ parts, however slow y^e^ motion is, being
generall

[228] i.e., 'dust'.

generall, Excites heat more than down=
right blowes; & as nothing under y^e^ sun is
hotter than melted iron, so y^e^ very sparks
de[£?]rived from y^e^ fluxed shivers of y^e^ steel,
for y^e^ quantity are as fierce as any fire
whatever.

206.
The At=
mosphear
preSsing
least up
wards di=
rects fire &
plants that
way.

It was an old dotardism to conceipt that
fire rose up[w]right to joyn with its pro=
per sphear regnant above y^e^ air, The mo=
dern cosmography hath dismist all those
Ptolemaick fancys, but yet it is worth
our enquiry to know, by what agency, that
mounting property is wrought. And in
order to that, we must consider that in
all fire, there a dispersion of rarefyed mat=
ter w^ch^ requires much more room than it
{_} had in y^e^ fewell. As for instance {/A candle\} throws
off round about it y^e^ tallow rarefyed. This
must make a current or stream from it,
& w^ch^ way shou'd that take; I answer it shall
take that course where it may paSs with
least

least impediment, & that is up[w]right, be
cause ye preSsure of ye air in perpendi=
culo is continually leSs, & consequently
resists leSs. This I mentioned before, & touch
it again now because of a conformity
with another phaenomenon leSs under=
stood, & that is ye frowth of plants, wch
if ye stems have strength to carry them, al=
ways shoot upwards. And ye reason of
this is no other than as before, for ye air
resists ye shooting forth of ye sapp, & ac=
cordingly it must tend that way where
it meets with least resistance, w/c\h is in ye
due upright.

Of Water Springs & fountains.

It is not amiSs among ye abstruse phaeno=
mea of ye world, to bring under conside=
ration that of ye effusions of water, fre=
quently iSsuing from earth in most parts
of ye world, called springs. The benefit of
wch to

w^ch to all /y^e\ animall kind is incomparable;
but common as they are, y^e originall cause
of them, seems to ly absconded in subter=
ranean darkneSs & out of y^e reach of hu=
man sagacity to resolv e. And all not for
want of [◦◦◦◦◦◦?] applications & industry, for y^e
philologers in every age have inquisited,
& in their works indeavoured to explain
them: But with so much infelicity, that
I cannot say I have yet met with a tol=
lerable account {⸗}[229] By what means such
quantitys of water are collected in y^e
bowells of y^e earth & thrown out, as main=
tain all y^e small & great rivers w^ch irrigate
y^e face of y^e earth; there hath been no
want of conjectures & imaginations, by
way of attempt to resolve y^e difficulty,
& altho put forth with aSsurance enough;
but most of them so farr from giving
satisfaction, that I do not care to enume=
rate them, as done in imitation of Plutarchs
placita

[229] A full stop is here struck out by a vertical line in pencil.

placit philosophorum,[230] therefore I shall
take notice of but one solution, w^ch^ is y^e^
last, & I think y^e^ best, & owing (as I take it)
to our proto-naturalist D^r^ Halley, & ha=
ving shewed wherein that failes, endea=
vour to demonstrate how y^e^ defects may
be supplyed.

It is supposed that by secrets ducts & cre=
vices, y^e^ waters of y^e^ sea find ways to pe=
netrate into y^e^ hollow caverns of y^e^ earth,
w^ch^ are to be found in most regions more
or leSs, Especially under mountaines, &
likewise what with fires dispers't about
near these waters, & what with various
salts intermixt w^ch^ ingenders heat, as y^e^
liquors are impregnant & mixt, mighty
vapours are raised, & those always ascend,
till, coming near y^e^ surface, where y^e^ cool
air occurrs, & condenseth y^e^ vapours into
water & fills not only y^e^ soil abo/u\t y^e^
surface, but subsides into y^e^ clefts of y^e^ rocks,
& by

[230] The *Placita Philosophorum* (i.e., the 'Doctrines of the Philosophers') is a lost work now attributed to Aetius (1st or 2nd century BCE). The surviving text (an abridgment of the earlier work by Aetius) was/is attributed to 'Pseudo-Plutarch' (now any one of a number of authors from the 3rd and 4th century CE) to whom certain works are or have been attributed. Together these works added substantially to Plutarch's prestige as an author. Sir Thomas North, a relative of RN and MN, was the translator of Plutarch's *Parallel Lives* into English (from Jacques Amyot's French edition) in 1579.

& by settling downwards, find crevises
& channels, & thereat iSsue in springs, w^ch
collecting make rivers. And what share
percolation of rainmay have in this
discharge of waters by springs w^ch can=
not but be very considerable, shall
be considered afterwards, & it being pre=
sumed that y^e supposalls here are just,
y^e consequences will answer effectually
y^e question proposed.

In y^e course of naturall philosophy, doubts
are to be resolved by means that admitt
of no doubt, or at least leSs doubtfull
than y^e matter in question: Now here
we doubt what is y^e cause of water-
springs, & are told that y^e sea finds paSsa=
ges thro y^e earth to y^e hills, & so in quantity
all about, where vapouring breeds hu=
midity, that, being condensed, flows out;
To this, say we, there is no such inletts, &
subterranean pools of sea water, nor fires
to raise

to raise steams, nor places near y^e^ surface, col=
der than in greater depths, to condense
them; & who can shew us y^e^ contrary? there
are some particular places where underground
fires are observed, & some bituminous ex=
halations, as at Aetna &c. but springs are
all y^e^ world over, & most frequent where
is least suspicion of fire; & as to hot springs,
if no heat cou'd be derived but from culi=
nary fires, y^e^ argument foerr them wou'd
be strong, but it is well known that wa=
ters by various mixtures wil calefy & almost
accend, so that for such purpose there is
no need of actuall fires. Nor is it found
that in y^e^ regions of such eruptions, wa=
ters come forth more frequently, or war=
mer than in y^e^ most inland places, where
y^e^ sea is least suspected to make any un=
derground visits, or fires to kindle so near as
to raise any steam from them.

(560) Physica

Another cause of springs, as I remember
hath been touched upon ~~y^e~~by y^e same au=
{_} thor,[231] or some of his {/sequel\ seques}, & that is, filtra=
tion. And that operation is, when a fluid
gathers into, & wetts loose substances, as
linnen, spunge, brick, sand, mould & y^e like,
& climbs in capillary tubes, & rising above
its surface, even against y^e power of gravi=
tation. Here it is supposed that y^e subter=
ranean waters, derived from y^e sea, wett y^e
soil, & climb up in small cavitys, & from
thence collect & iSsue in springs. Now filtra=
tion be/e\ing only y^e action of y^e fluid parts
laying hold of y^e parts of a solid (in
{ parts} parts[/s\] immersed, tending always to a com=
mixture, never riseth so as to make a dis=
charge, syphon wise, unleSs y^e body moistned
returnes & ends lower than y^e superficies
of y^e water that wetts. As when a towell
is put into a bason, & part is in y^e water
but y^e greater part hangs over, & lower than
y^e surface

[231] i.e., Edmund Halley, *see* note on fol. 551v, above.

y^e^ surface of y^e^ water in y^e^ bason. The towell
shall by degrees gather water, & at y^e^ low=
est part dropp, till y^e^ bason is empty. In this
posture y^e^ towell is (quasi) a spring, but y^e^
fountain springs cannot be wrought in that
manner, because y^e^ discharge cannot be
so low as y^e^ sea water from whence y^e^
great quantity is drawn. But when y^e^ bo=
dy is satiated, were it a spunge, or any
other[,?] y^e^ filtration ceaseth & y^e^ moisture
hangs as suspended, & dropps nothing. And
this is y^e^ summ of y^e^ experiments of fil=
tration w^ch^ cannot be applyed as any cause
of water springs.

Another cause of water springs, w^ch^ must
be allowed to be considerable, but not
to a degree as some have supposed, is per=
colation, w^ch^ is of y^e^ ordinary rains &
melted snows, w^ch^ settle thro y^e^ sand, or
mould neer y^e^ surface of y^e^ earth, & at
a certain depth collect & find vent, &
iSsue

iSsue in ye valleys, whence rivers have their
beginning & increase. Some of these are
taken to be perennall, being seldom, others
wch they call Land springs are frequently
dry. These are supplyed chiefly, but not on=
ly, by rain & snow water, of wch no small
quantity falls upon ye surface of ye earth,
but a good part must be allowed to eva=
porate by ye suns heat, & to solidize in
plants & foSsills, but there is enough, as
ye nature of all fluids is to settle lower
& lower, & still ye lowest earth has most mois=
ture, so that at certain depths, if wells
or mines are sunk ye water (wch they call
ye springs) flow to ye great nuisance of ye
miners, who are forced to evacuate their pitt
with engines, & yet to be soon drowned out
again; & sometimes at ye stroak of an hack
a vein shall be touched, & a bagg of wa=
ter break, to ye oSs of ye work & perhaps some
mens lives. Now it is obvious to consider, that
if a

if a vent were found or coud be made in
some valley below these watery depths,
a copious spring must be y^e^ consequence;
Such as are every where found without
help of y^e^ sea to flow to flow out in valleys where
rivers commonly run; But not without
some considerable additament, as I
shall shew.

The work of finding fault, I know, is ea=
syer than to mend, but every one shou'd
not be foreward, to do y^e^ one, without a
disposition to do something /in\ y^e^ other way;
& for that reason I shall endeavour to
obtain a probable, if not a certain re-
{_} solution of y^e^ cry{/p\}tick cause of common
fountain springs, designing it to be short
& clear. And therefore in few words I af=
firm that all y^e^ water springs in y^e^
world proceed wholly & soley from y^e^
air, & y^e^ waters drawn from it by one
ordinary operation, called distillation.

How

How humiditys are raised from water is
matter of continuall & notorious experi=
ence, & that of steam, w^ch I /might\ call mist or
vapour, raised by fire, or in leSser degree,
meer warmth, & condensed again into wa=
ter by cold, & accordingly in every degree
of coolneSs; & having elsewhere maintain=
ed that air, denominando a majori,[232] is
made up of water evapourated, & redu=
cible (as afore was alledged) to water a=
gain by colder applications. I need only
add, that cold never fails to extract
humidity out of warm air, & according=
ly it is found that no cool place in y^e
world is dry; & as y^e contrariety is exas=
perated, so y^e fluor of water from y^e air
is increas't, w^ch is a doctrine well known
to all distillers.

Now taking an account of a vast moun=
tain it will be found to consist most of
rock, & that not continued intire but splitt
& cracked infinite ways, in all w^ch clefts
air is

[232] i.e., 'for the most part'.

air is resident, not stationary, but ventilating
as rarefactions & condensations from abroad
& within, happen to urge. What is more ap=
parent than that water, as upon common
marble, must engender in the clefts of
cold stone, & run down as we see perpetually
happening, when cold gaines upon warmth,
as infinte experiments, w^ch^ might be set forth,
if such were not obvious to anyone's notice,
woud demonstrate. And not only condensa=
tions within, w^ch^ make room, & winds urging
from without, draw fresh air condensible
into y^e^ cavitys, w^ch^ supplys a perpetuall dis=
charge of water, w^ch^ settles, a~~d~~s ducts hap=
pen, to certain vents, & so makes perennall
fountaines; that these partake of per=
colated water water from rain & dews
is not denyed, but y^e^ springs upon y^e^ sides
of stony hills & neer y^e^ topps must be chiefly,
if no wholly, acribed to y^e^ cavernous & cra/c\key
productions, because such shew little or
no change

no change upon any difference of weather,
aswett or dry, as springs in earthy coun=
trys do.

But there well appear yet further effects
of condensation in producing flows of
water, besides those from ye ordinary fiSsures
among rocks; that is from cavitys in ye
meer earth; for we see in clay countrys
clefts of great wideneSs & depth, wch are
within as cold as stone itself, & consequent=
ly must derive moisture from ye inclu=
ded air. Nay I will not exempt common
earth from doing ye same, for altho that
consists of small bodys, yet they are de=
vided & have their interstitia, in wch, air
tho in thin quantitys, paSseth or resides
& produceth moisture, for underground is
always humid, & siccity is not found, but
at ye exterior surface of ye earth, where
ye sun & winds come. Now it being a con=
stant course of waters commixt with
earth,

earth, [◦◦◦◦◦◦?] to settle downwards, it is always
found that by sinking wells /or mines\ y^e^ waters
shew themselves more & more till they come
almost into a lake or flow of so much
water, as crys go no further; And this hap=
pens to be at such a depth as falls neer
a levell in those parts, & where y^e^ usuall
springs do not extend to drein. But surely
all these many sources of humidity are
sufficient to supply water to answer all
y^e^ discharges, & to solve y^e^ phaenomena
of springs all y^e^ world over, without
calling in y^e^ seas & subterranian fires, or
any precarious energys, but by y^e^ strength
only of such means as we know to be
true & effectuall agents in all other
instances experimented; w^ch^ I think is y^e^
true & only method of physicall science.

[233] The next five pages are given numbers and headers, but no content.

207. Body in statu in= finito im= p[~~l~~?]ollible by spirit.

## Of spirituallity

At y^e^ entrance of these papers, I toucht upon a shaddow of reason as might be given for y^e^ mind having power to move y^e^ body; w^ch^ however a meer conceipt I shall now produce it. And observe forst that it is in Mathematiques agreed, that superficies increase as squares, & solids as cubes of y^e^ root; whereby circles or sphears are as y^e^ squares, & globes as cubes of y^e^ diameter in figures thus.

| Roots | Squares | cubes or solids | faces or superficies | As |
|---|---|---|---|---|
| 1 | 1 | 1. | 6 | 6 to 1 |
| 2 | 4 | 8 | 2~~5~~4 | 3 to 1 |
| 3 | 9 | 27 | 54 | 2 to 1 |

And y^e^ reverse of this, w^ch^ I have most to do with, proceeds in y^e^ like proportion y^e^ solidity decreasing, y^e^ superficies (~~b~~in pro/portion\ decla

declared) increaseth. Now consider that all
bodys, w$^{ch}$ move, are more or leSs resisted, w$^{ch}$
is y$^{e}$ case of y$^{e}$ motion in pleno, & ~~y$^{e}$~~then y$^{e}$
power of any body to perseverre in motion
is according to y$^{e}$ solidity, but y$^{e}$ resistance
is according to y$^{e}$ superficies; that is, y$^{e}$
action of a body is by y$^{e}$ solidity, & y$^{e}$
paSsion by y$^{e}$ superficies; And these de=
creasing, but y$^{e}$ active faster than y$^{e}$
paSsive principle, to an infinity, y$^{e}$ action
must expire first, & then it may be said
y$^{e}$ body is become infinitely paSsive.

What I say here of body at y$^{e}$ expiring
is obnoxious to every, almost infinitely
weak force, to move it absolutely, may
be turned into y$^{e}$ alternate, & be said of
spirit by way of increase of power, as
in some degre approaching to y$^{e}$ nature
{_} of body. And then these extreams mee=
ting, of body & spirit [~~.....~~?][234] {/in a state of\} in a state of matter

[234] 'in a state of matter' has been written over another, apparently similiar phrase and then the words 'in a state of' has been inserted later, in pencil, to clarify (!) the reading.

[~~.....~~?]Matter adapted for y^e^ porpose, why
shoud not y^e^ one work upon y^e^ other, in
their severall functions; y^e^ body by be=
ing moved, & y^e^ mind by influencing of
{_} it to move? & so long {~~as~~} they conjoin; &
when y^e^ former is disjointd, as a broken
clock, it can perform no longer, & that
is death.

208.
Some ob=
jections
considered. I know there are many gaping objections
against this novell imagination, w^ch^ I
am sure cannot clearly be answered,
but yet I shall make y^e^ best of my way
towards y^e^ mark, whether I think it may
be reached or not. They may say that
body while it is quantum, tho never
so small, hath all its proertys, as to be
impenetrable, active, resistable &c. as
truly & integrally as y^e^ greatest. And then
it may be added, that in all degrees of
diminution

diminution, being among y^e^ like dimi=
nished matter, all proportions of force
& resistance take place, as in all other
instances of bodily commixtures. I can=
not pretend to y^e^ contrary, but body
while such, is like other sorts. But still
who can answer for things in a state
of infinity? we judge by what we
feel & know, & cannot depart from
those images, as in y^e^ cases of vacuity
& time; But all will not amount
to a demonstration of a negative. We
aSsume y^e^ nature of body [~~by~~?]from our
experience of it; but when y^e^ questi=
on falls beyond & without all expe=
rience & tryall, y^e^ generall rule may
not hold, & some influences may[, nay?]
have effect of w^ch^ we can give no man=
ner of account. And there is this reason
to conceive that somewhat of this kind

lyes

lyes absconded in infinity, for no Anato=
mick searches or sagacity can discover a
commune sensorium;[235] It is probably in ye
brain, & that is a willderneSs; It is also
reasonable to suppose it to be in some
point, but where is it to be found? I
therefore conclude that wherever it
{_} is, ye seat is in infinite ([。。。。。。?]I must {/I must]\} use ye
29.9 word) minuteneSs.

Immense
effects from That ye mind, wch certainly is not body,
petite ~~causes~~ is ye cause of most of our corporeall agi=
causes tations; no one without a conscious {/lye\} lye, will
{_} pretend. For ask any one, can you rise or
sitt still as you will? Can any honest
{_} man say no, or ingenio[/.?\]us man say that
your words have compelled me to /sitt\ still,
& this by a mechanicall deduction?
There is so much undenyably to be said for
free will, & that, apart from body, that I
shall

[235] That there was an actual part of the brain given over to the '*commune sensorum*' ('common sense') had long been assumed. It was imagined to be part set aside for assimilating all sensory data from all the 'five senses' (it being the sixth, in many accounts). Common sense, therefore formed the site of sensory *identity*.

shall not exaggerate y^e^ matter but pro=
ceed to answer an /other\ objection, w^ch^ is that
such sufficient force will not flow
from a point, next to indivisible, to move
such immense machines as our bodys
are. I answer, that, as in other cases, so
here we must distinguish between y^e^
cause & y^e^ occasion; it is not y^e^ spark of
fire that lifts a bastion, Nor a grain or
two that directly causeth y^e^ motion of
200~~ll~~ weight in a ballance. ~~w~~We know
that our bodys are a compage of springs,
w^ch^ continually draw one again another.
And it is also plain that when we spon=
taneously move any part, it is a ballan~~ce/ee~~\/ce\
determined that doth it. For a muscle
is always upon stretch or tension, &
when y^e^ force of y^e^ antagonist muscle
fails, that draws, & so alternatim, &
when y^e^ alternate doth not give way,
it is a

it is painfull cramp. And there cannot
be a greater disporoportion in practise, be=
tween y^e^ sensorium, how small soever y^e^ force
springing from thence may be conceived to
be, than there is between y^e^ force of a spark
& y^e^ weight of y^e^ bastion. In all those cases
y^e^ pilots force determines greater powers,
elsewhere provided for his porpose, so y^e^
mind operating by y^e^ sensorium determines
y^e^ chief powers of y^e^ body organized for
spontaneous action. I say'd y^e^ sensorium was
certainly a point. But what if such points
may be, many, & resident not only in y^e^
brain, but in other parts of y^e^ body? of
this some short mention about muscular
motion.

But waiving further notice of muscular
action at present, a subject reserved to a=
nother place;[236] & having hinted a conceipt
of body & non body or eSsence incorporeall
being

[236] Here is another hint at further volumes devoted to particular parts of North's natural philosophy.

being united in infinite minutneSs, I shall
persue a little further to see how farr that
thought may lead towards a solution of
those profound misterys of generation & ve=
getation; & first as to inanimates (as common
vegetables are reputed) they are propagated
of branches, & each budd is a branche & every
seed is a budd; w^ch^ they call plantula, & in
some, as in y^e^ seeds of tulips, are discovered
subplantulae; & by like proceSs, if art might
advance y^e^ discovery further, we shoud discern
y^e^ like proceSs of such seminals, one beyond
another, indefinitely. This shews that plants
are originated in minuteneSs inconceivable,
{_} I do not call it infinite, but most {/<u>certinly</u>\} that no
means will instruct a vegetable, of w^ch^
there is not any one w^ch^ is not derived from
ga germen of y^e^ like kind. But whither, or
where any such beginning resides, or whither
any thing incorporeall (I dare not say spirituall)
is adjoy

is adjoyned to y^e^ substance, or negatively that
there is none, I may not positively determine.
But so farr I am certain, that no valid solu=
tion of vegetation by any mechanicall
agents hath yet fallen in my way; y^e^ con=
ceipt of Borellus, that it is produced by force
of compreSsure will not be sufficient for
plants in a veSsel, where compreSsure is as
strong as abroad, without a free air, will
not grow. Nor is it in y^e^ power of art to make
a plant, of any sort whatever, old or new,
without a seminall, w^ch^ argues that there is
somewhat in vegetation more than purely
mechanicall. If we shoud say there is in
plants a motion analogous to what in
animalls is called peristaltick (for both
plants & animalls) are all vascular) we sh'd
be at a loSs to find y^e^ muscular power as
well in y^e^ one, as in y^e^ other, that actuates it.
But in some plants y^e^ plastick vertue seems
to reside in all parts or in every fibre as in
elms

elms y^e severed from y^e earth will derive
numberleSs shoots, that transplanted may
become trees, but from what origin doth
not appear.

211.
All ani=
malls in ori=
gine ver=
micular.

As for animalls & their origination, I think
that now after all y^e inspecting & experi
ments that have been made, it is conclu=
ded that it is universally vermicular, &
that y^e distension & form of all creatures
proceeds from nutrition. The vermicule
whether in ovo or in utero; was once a
part of y^e animall of w^ch it was genera=
ted; & (to use y^e analogy) such a part of
y^e parent, as a seed is of a plant, & that
is (dimension excepted) alter Idem.[237] And
whatever spirit of substance incorporeall,
is in infinite minuteneSs. And whatever
spirit or substance incorporeall, is in in=
finite minuteneSs adjoyned to y^e parent it
it/s\ taken derivatively by y^e creature in its
first formation & separation, & so by means
of nutrition

[237] i.e., 'a second self'.

of nutrition y^e^ animall is produced, & after
its full increase, & similar propagation, when
y^e^ vegetation & operation of y^e^ vitall in=
struments fail, y^e^ compage diSsolves, & whate=
ver of it was incorporeall ceaseth, & y^e^
whole substance falls under y^e^ laws
purely mechanicall, without being in=
fluenced by volition, w^ch^ cannot be mate=
riall.

212.
Of y^e^ im=
mortallity
of y^e^ soul

I might here expatiate & largely enough
upon y^e^ subject of analogy between
plants & animalls, respecting nutrition as
well as origination; since that is b~~t~~y roots
& branches, only in animalls they act in=
ternally, & in plants from without; but I
am called away to a matter of greater
importance. And that is y^e^ immortallity
of y^e^ soul. For it will be alledged that
this scheme supposeth it impoSsible; &
that every solution of y^e^ substance de=
termines y^e^ unity. All w^ch^ I grant, Except
only in y^e^ case of human kind. The philo/sophers\
have

have strove by their metaphysicall dis=
courses, to prove human souls immortall;
but all in vain, for mankind has no
principles in nature whereupon to derive
such a dogma. And ye transmigrations
& other conceipts of ye ancients are meer
dreams. But we have a more sure word
that setts us at ease & reconciles ye whole
matter, & that is Revelation, where upon
we rest our holy religion & faith.
And other reasoning than from thence
ye subject will not bear. Thereby we
are told that all men as well ye wicked
as ye just shall rise with their bodys,
& be judged according to demerit; And what
is this, but that ye union between ye souls
& bodys of men shall not determine
by death, but whatever becomes of ye
GroSser members, wch St Paul calls ye naturall
body, another body shall remain consis=
ting of spirit, & substance, capable of sense,
memory, happyneSs or ye contrary; to appear at
ye generall

generall resurrection. And this immor=
tallity of y^e^ soul, is not a naturall con=
sequence, but a Devine gift bestowed
upon human kind, whereby their natures
are exalted above y^e^ rest of y^e^ animall
world; it being declared that beasts shall
perish, that is (Dying) cease to be, & never
revive.

213,
But not
of [~~y~~^e^?] Brutes

There may be diverse objections to what
is here advanced; as that either spirit
must grow & be nourished, as animall
substances are, or it is inconceivable
that spirit united to such pusille matter
as y^e^ inchoamenta[238] of animalls are sup=
posed to be, shou'd increase with y^e^ matter
so as to influence it in y^e^ ordinary opera=
tions of life. To this I answer that accor=
ding to our notion of spirit, w^ch^ goeth no
further than a negation of body, we
must conceive, that it admitts not of
more or leSs, but is y^e^ same in y^e^ vermicle
as in y^e^

[238] i.e., 'basic constituents'.

as in ye man. And for extent of power,
it lyes not in quantity but in nature,
& what that is, but by some obscure
effects, we know not, & scarce can gueSs.
Buyt this scheme of our immortallity
we get ridd of certain dangerous pre=
judices. For while some argue, that ye
soul wch subsists in thinking, & is distinct
from body , wch (body) cannot think, (&
so is independent) & is not extinguisht
by ye diSsolution of ye body{s?}. Others (oppo=
sing) will inferr that ye souls of brutes
are immortall: for bating speech, & science.
(wch flows from it,) there is no more ev/i\dence
of reason in men than in brutes, & an im=
partiall judge that stands by & observes
must so determine; for wch reason, say
they, ye souls of brutes are alike immor=
tall. All wch pretension is diSsolved by ye
reference of immortallity to ye Divine
bounty with respect to human kind,

whose

souls otherwise wou'd sink in mortallity
as those of y^e^ brutal kind do.

Of The Almighty.

214.
The scep=ticism of y^e^ ancient Atheists.

It is no new observation that among y^e^ an=cient philosophers, y^e^ question, an sint Dij,[239] was matter rather of contention than of conviction. For they had not y^e^ uncontestible evidence of miracles, as y^e^

{_} Jews had, & under them, with undubitable {/certeinty\}
and confirmation, y^e^ eChristians. But when y^e^ Orthodox philosophers alledged y^e^ popular arguments of y^e^ order & beauty of y^e^ universe, y^e^ cou'd not be without a wise & powerfull disposer, no more than a Vergilian verse be found descri=bed upon y^e^ sea-sand by meer chance;

{_} W^ch^ arguments, tho to a reasonable creature {/are\}
convincing enough, yet did not prevail, be=cause they were not of that sort as must
stop

[239] i.e., 'whether there is a God'.

stopp y^e^ mouths of importune & captious
Atheists, who denyed all consequences, & called
for demonstration even of y^e^ first prin=
ciples & affirmed y^e^ world to have been
from eternity, & all things to follow e=
ternally in a series of neceSsary causes.
And our modern unbelievers to avoid y^e^
consequence, that when anything is per=
ceived, there must be a perceiver, or thin=
king being, that is not y^e^ thing perceived
or thought of, go further, & say that
matter it self, organized for y^e^ porpose,
as common automata, or rather than fail,
without so much pu~~z~~/z\le may think & per=
ceive; So for y^e^ work of perception no need
of any incorporeall powers, nor to rule
/any part of\ y^e^ universe; & in this manner perception
is made a quallity, inherent in matter,
w^ch^ is monstrous absurd.

215. Danger of y^e^ at= tractive scheme

And as to my thinking, this shou'd alarm y^e^ gentlem~~en~~/en\ of y^e^ attractive sect, shewing how dangerous their proceeding is, in affixing quallitys to matter, as attrahent, propellent, centripetal, & y^e^ like, least it be said, that it is from thought (in matter) that such quallitys proceed, & so deliver up y^e^ cause of all incorporeall agen~~ts~~/~~cys~~\/cys\, & powers. What else can be y^e^ consequence when all y^e^ symp= tomes of appetite peculiar to living animalls, are turned into materiall quallitys? And if y^e^ latter had /had y^e^\ titles of appetites & aversions given them, there had been a plain con=

216, The mode or argu= ing de Deo[240] ana= lytick or Synthetick {_}

sequence.

But now having touched upon this circum= stance, I must need observe that y^e^ great author of those principles, seems as ear= est in persuit of Theologicall evidences, as any before him, but because y^e^ ordina ry proceeding, w^ch^ , he says, ought to [。。。。。?] be anali/{/anali\}tick\ and not

[240] i.e., 'out of, or from God'.

& not Synthetick, that is, not to go from
principles (meaning I suppose some hy=
pothesis) to ye phaenomena, but from ye
phaenomena to principles, as ye likelyest
course to come at a certain proof of a
Deity, And so we must stay or wait
for phaenomena whence to conduct ye
analysis. It may be I do not perfectly
understand ye tendency of this distinction;
but I am very sure that no physiologer
will pretend to discover any principles,
but what he deduces, or pretends to de=
duce from experience of ye phaenome=
na. And it wou'd be inconvenient to
stay for our proof of ye Deity, till ye phi=
losphers have collected phaenomena enough
to fulfill ye demonstration, of wch we think
we are poSseSed already; And that will
happen when ye R. Society have made
a collection of experiments whereby to
compose

compose a compleat hypothesis, & leave no
phaenomena unresolved, & till then nullius
in verba.[241] But herein y^e^ great author
217. contradicts himself.
The po=
puar
argum:^ts^
to be im=
proved

But now to resume y^e^ consideration, of
y^e^ popular arguments, I touched upon at
first, w^ch^ have been insisted on by y^e^ best
philosophers, & chief advocates for y^e^
christian religion, as a full proof of
y^e^ Deity & providence: I mean y^e^ notori=
ous & admirable disposition of y^e^ worlds
aeconomy, w^ch^ cou'd not have been so by chance,
or otherwise than by almighty wisdom
& power. I fear y^e^ subject hath not been
urged to y^e^ best advantage, but that
in another manner more might be made
of it, so as to bring it home to a demon=
stration. Therefore I shall presume to
new mould it, & if I seem to derogate on
y^e^ one side/e\, I hope to make full amends
on y^e^

[241] i.e., 'words mean nothing' - with reference to the motto of the Royal Society.

on y^e^ other, And first, building upon
what hath been held forth in these pa=
{_} pers, I d{i/e\v}est y^e^ materiall world of all
of all order, regularity & beauty. And
considering no£ further than naturall
means, y^e^ rotations of y^e^ Aethereall mat=
ter with y^e^ planets conveyed in it, might
have fallen into this way, or any else,
as we see ordinary vortications of fluids
happen; But in this instance I must re=
serve y^e^ consequences of y^e^ following dis=
course.

218
Regularity & beauty not in na= ture but art

Next I have ascribed all these Ideas of
sence, y^e^ are ordinarily attributed to y^e^
objects that cause such sensations (as
subsisting in them) unto our internall
facultys, whereby we perceive light, co=
lours, audibles, & all y^e^ varietys of touch.
So that if all sensitive animalls wer an=
nihilated, None of those things (in Idea per/ceived\)
wou'd

woud have any existence. And as to re=
gularity, that belongs to art, & not to na=
ture, for it cannot be made appear that
among all y^e^ individualls, there is an equal=
lity or precise form to be found, but all
things are as we term it irregular, in=
commensurable & unequall. And there is
not a naturall beauty in any thing,
but all of that sort is referred to ima=
gination & usefullneSs, & y^e^ perfection of
body consists in y^e^ 3 dimensions, w^ch^ grant=
{_} ed, all bodys, {(}whatever y^e^ shapes are,{)} are
{_} equally perfect. This, w^ch^ must be owned
to be {/a\} true state (since specifick quallitys
are, or soon will be laid aside) demonstrates
that y^e^ sensible eSsence, w^ch^ is called y^e^ soul,
is different or distinct from y^e^ materiall
part.

219
The space of y^e^ uni= verse in= finite

And by means of y^e^ union of these 2 ESse=
ces, mentall & materiall; there ariseth an
Idea of power, & particularly of y^e^ mind

over

over y^e^ body, to move it, as in y^e^ practisce of
muscular motion is demonstrated; & every
one (not lying to himself) must own it. And
this power being quallifyed or confined gives
an Idea of more & leSs, & a clear notion of
a poSsibility of a power greater than our
own, which may influence matter in grea=
ter degrees than we can do, altho aSsisted
by mechanism, as hath been shewn. Now by
our attention to body, we gain an Idea
{space} of [....?]space. But we cannot comprehend it
in larger extent than as our practise of ex=
perience, & reasonable deductions from thence
enables us. And from thence we argue
(tho we do not comprehend) great distan=
ces, & so by mental repetition, we conclude
even to infinity. Now space having degrees
of more or leSs, we are as well satisfyed
in our minds of an infinity of space, as
of any thing whatever that may be artifi=
cially demonstrated; & no person whatever
of y^e^ least philosophicall sence, will pretend
to opine

to opine that space is not infinite, & if any such appear, they must be turned up for scepticall impertinents not to be discours=ed with.

220. The al=mighty power de=monstra=ted

Now to consider mankind, that is a creature arose in weakneSs, & want of most things desired; but having abillity in some mea=sure to serve it self, as to ~~wa~~hat it wants, & continually more, as practise or experi=ence inlargeth; in that proceSs finds y^e^ ex=tent of its power, w^ch^ consists in a sponta=neous agitation of certain parts of his body, one way or other as there is occasion: And in that exercise it will soon appear that y^e^ power is very defective, & that y^e^ mind or volition cannot in many respects be cor=responded by consentaneous actions. And y^e^ Idea of this defect, that is, of a limited power, by continuall (addition (as before of space so here of abillity) we are led to con=ceive that w^ch^ is called infinity. And in this way of thinking to derive a firm opinion & belief of it

of it, w^ch^ no abstraction or power of y^e^ mind
whatever, will obviate or restrain, as for
instance in y^e^ case of space, Is there a
speculative person in y^e^ world, that doth
not really opine, that space whither ple=
num or vacuum is extended in infinitum?
It is a neceSsary conclusion w^ch^ is comprised in y^e^
Idea of every reall eSsence w^ch^ in y^e^ abstract
admitts of augmentation, & diminution,
& accordingly y^e^ mathematicians define
{_} their quantum. How th{en it/f\} no m{ore/an\} doubts
of y^e^ infinity of space, can any one doubt of
an infinity of power? There is a certain
Idea of space as also of power, both limi=
ted, but equally capable of increase; & y^e^
same Idea of infinity attends both. And
a man may as well doubt [.....?]whither there
[.....?]is any space existent ultra y^e^ limits of
things sensible; as whither there is any
power greater than what he feels in him=
self, or observes in others. If space hath
no limits

no limits, what shou'd limit power? There=
fore there is invincible reason for men
to believe, & consequently to put their
trust in an infinite & eternall power,
w^ch^ is y^e^ almighty. And this tends not to
set up a parity of power in matter. For
matter hath a being but not power,
but what is obnoxious to that of y^e^ imma=
teriall infinity. For our immateriall part
(our will) controuls it in tanto, & so y^e^ di=
vine eSsence controuls it in toto. For y^e^
power is conceived as opposed to matter, &
in a state of infinity is absolute, to order,
create, or destroy it: And nothing can resist
an absolute power.

221.
Diverse ca=
vills an=
swered

If clara & distincta perceptio[242] be (as y^e^ phi=
losophers now say) y^e^ utmost criterium of
truth, this existence of an almighty power
is fully proved, & in a strikt sence demon=
strated. But since importune people will
always resort to cavills, w^ch^ they will call
objections

[242] i.e., 'clear and distinct perceptions'; for Descartes 'omnis clara et distincta perceptio procul dubio est aliquid' i.e., 'everything perceived clearly and distinctly is something incontrovertible'; 'ideoque procul dubio est vera', i.e., 'that which is incontrovertible is true'. Descartes, Meditation VII, 62).

objections; I woud examine what may
be moved against this truth. And 1. if
they say, that infinity is ultra captum,[243]
& no proposition can be built upon it.
I answer, true, when infinity hath been
taken as a substance determinately, much
puzzle hath followed, & nothing conclu=
ded; but when taken as a proceSs only,
as when y^e^ mathematicians say, quo vis
dato major vel minor,[244] it stands fairly
in a proposition, & in a proper subject
may take y^e^ place of a datum; as when
it is said y^e^ hyperbole & asymptote meet
in a point at an infinite distance.[245]
2. If they say, we may affirm as to power,
but not to volition & knowledge, & some
other attribute; I answer, that all those
are comprised in y^e^ Idea of infinite pow=
er, w^ch^ cannot be without y^e^ attributes. Body
in motion hath power by contact reci=
procally as to some modes of it, but no
knowledge

[243] i.e., 'beyond comprehension'.

[244] i.e., 'where the given force is greater or less'.

[245] These two terms are discussed below on fol. 267r ff.

knowledge or will. Therefore infinite
power, w^ch^ controuls body, & is of that kind,
as is adumbrated by y^e^ mind of man, can=
not exist without an infinite measure
{_} of all that in man is finite that is know=
ledge, will &c. If 3, they say{/,\} true, space
in poSsibillity may/y\ be infinite, but whe=
ther it is actually so, is another question,
so power, &c. I answer that this includes
a contradiction; for y^e^ limitation it self
must be extended & so continually. And
as to power that, if at all, must be li=
mited by some other power, w^ch^ is infinite.
4. If they say that incorporeall power
to move body may be found in animalls,
but no where else. This is Gratis dictum,[246]
& cannot be answered but by fact, w^ch^ is
miracles of w^ch^ there is incontestable evi=
dence. Yet who can say that vegetables,
of w^ch^ no mechanicall account hath been,
or, as I opine, can be given, may not (in suo
genere[247]

[246] i.e., 'stated voluntarily', or 'stated for free'.

[247] i.e., 'by its nature, or kind'.

genere) partake; if they say, powers in=
corporeall may not cease by death, & so
brutes be immortall. I answer, quoad ye
specifick substance of ye animall (Except
of human kind by speciall providence)
they do cease, but not quoad ye univer=
sallity of power; & it is ye union only, &
neither ye substance, nor power that can
indefinitely be said to cease. As a bottle
of fresh water immerst in ye sea, & then
broke, there is no annihilation of what
was contained, but ye form determined,
so as it may be truly said of ye bottle of fresh
water is no more.

222.
The attrac=
tive schema
considered
& conclusion

And lastly it may be said that here we
have confirmed ye attractive scheme, by
allowing that ye world is actuated by pow=
ers (inherent in, that is) united by efficacy
with body. I answer that ye question is not
of pure poSsibillity, for ye Almighty (so
pleased) might have made matter to be
attrahent

attrahent, impellent, d~~epellent~~/pellent\, centripe=
tall, or otherwise as may be invented, or
imagined. And so destroy all naturall know=
ledge & turn all changes, & events to a mi=
racle. But by ultimate exerience it
is found, or from paralell reason inferred
that (animall powers apart) there are no
naturall effects, but what are derived
from a single principle, & by consequence
absolutely neceSsary, as extension, & there=
by impenetrabillity, w$^{ch}$ hath been y$^{e}$ sub=
jest of y$^{e}$ foregoing discourses. & main=
t~~ain~~/ain\'d by reference to fact in all exa=
minable instances, from thence con=
cluding by parity to instances in groSs,
but not of elements distinguishable. And
if y$^{e}$ disposition of y$^{e}$ world upon one single
& manifet principle, with y$^{e}$ adjunct of
animalls so (as it were by art) consituted,
there shall emerge y$^{e}$ sence of celestiall glo=
ry, & harmony, & all that is called wonderfull
& great

& great, in every one severally & yet all de=
rived out of y^e^ same common principle; be
a symptome of infinite wisdom & power,
here it stares us in y^e^ face, & will not in
any conscientious measure, be contrave=
ned. And as to y^e^ consequences, with regard
to human concerns, & expectations of good &
will, or what is understood by y^e^ word pro=
vidence, they are y^e^ subject of greater un=
dertakings, & may be found in y^e^ wrightings
of diverse Christian authors; Here it is pro=
posed to discourse; only of naturall means,
& to leave all that is supernaturall, or di=
vine to y^e^ profeSsors of those misterys, or
rather to y^e^ consciences of common men,
who seldom want knowledge/e\ enough
to secure them a happy eternity of soul
& y^e^ best sensuall life of y^e^ body, w^ch^ latter
is by common experience found not to sub=
sist out of a religious obedience, & y^e^ ordi=
nary exercise of virtue.

223.
Of y^e^ a=
symptotes
& hyper=
bole

Some Mathematical
Mysterys

It may be observed that some topics of
y^e^ genus Mathematicum carry a face Ae=
nigmatiq, & y^e^ artists are content, if not
affecting, that they shou'd be so, altho'
capable ~~to~~ to be developed, & made fa=
miliar to common understanding, & I
know but one author who hath been
so kind to be explicite in such matters
as fell in his way to discourse of, &
that is y^e^ incomparable D^r^ Barrow,
whose generall lectures,[248] are a specimen
of what of this kind is desirable. And
there he toucheth upon y^e^ most abstruse
matters, even to y^e^ squaring y^e^ circle, (so
farr as it may be carryed) in a manner
plain, significant, & even by y^e^ tyrones
most intelligible. As for instance y^e^
hyperbole

[248] Isaac Barrow, 1630-77, was at various times (and with interruptions) Regius Professor of Greek at Cambridge, Gresham Professor of Geometry and fellow of the Royal Society in London, and (the first) holder of the Lucasian Chair in Mathematics at Cambridge which he resigned in 1669, to be succeeded by Isaac Newton. He was Master of Trinity College, Cambridge, previous to RN's brother, John North. RN, who knew him well, only ever mentions him with respect and affection. The 'generall lectures' referred to were his *Lectiones Mathematicae xxiii; In quibus Principia Matheseôs generalia exponuntur: Habitae Cantabrigiae A.D. 1664, 1665, 1666. etc.*, London, 1684, (later translated as: *The Usefulness of Mathematical Learning explained and demonstrated: Being Mathematical Lectures Read in the Public Schools at the University of Cambridge. etc.*. Translated by the Revd. Mr. John Kirkby of Egremond in Cumberland, London, Stephen Austen, 1734).

hyperbole & its aSsymptotes; y^e^ property
of y^e^ is that those lines continued together
/come nearer,\ but extended in infinitum, shall not
touch. This is not well apprehended
without entering deep into y^e^ conicks,
but is made plain thus. A cone standing
{_} upon its base, & cut right down by a pl{ain }
paralell to its axis, y^e^ outline of that sec
tion is that curve form w^ch^ is called an
hyperbole, & y^e^ same cone cut right down
thro its axis, shews a rectilinear triangle
including y^e^ same, & every other hyperbo=
licall section (as before paralell) & y^e^
lines of that triangle, are y^e^ Asymptotes;
w^ch^ running on to infinite, never meet, or
as some please to say, meet in a point
at an infinite ḡdistance, w^ch^ is y^e^ same
thing in other words. Here y^e^ figure D.
RF. is y^e^ hyperbole, & ABC, its asymptote.
Whereof y^e^ lines AB, & DE, & BC, & EF,
tho continually approaching shall never
meet

<space for diagram>

meet; & what is all this,
but a cone of infinite ex=
tent? For carry out ye cone
ABD. as farr as you will,
ye section & plane hyper
bolick goes along with it,
& can never coincide with
ye axis or a (supposed) sec=
tion thro' it; This is made a proof of ye di=
visibillity of matter or space in infini=
tum, for if ye 2 sections were within a hairs
breadth of each other or infinitely leSs,
ye consequence were ye same. And if pa=
ralells exterior to ye asymptote were drawn
wider ad infinitum, it doth but shew ye
hyperbolick section to be made so much
further from ye plane of ye axis.

224,
Ellipses
circles
corrupted

The Ellipse is a figure described by a sec=
tion obliquely thro' both sides & axis of a
cylinder

cylinder or cone, & is termed ovall; it is ge=
nerated also by y^e perspective view of a
circle, or by y^e shaddow of an upwright
wheen projected obliquely upon a level
plane, & divers other ways mechanically,
but however it is generated, it is but a
corruption of a circle, w^ch in such case
always becomes ovall. And propertys of
a circle will be found in y^e correspon=
ding ovalls, & there by work is made for
y^e analytick Geometers to demonstrate; as
for instance that y^e radius of an ellips sweeps
equall spaces in equall times. This must
be true when y^e figure turns ypon y^e um=
bilicus or center, w^ch answers y^e center of
~~a~~y^e circle. As here there is not
<space for diagram> a point in y^e circle ABCD,
w^ch hath not its correspondent
point in y^e ovall abcd, & not
for y^e circumference only but in y^e whole
area. And if in equable rolling of y^e circle
y^e spaces

$y^e$ spaces of $y^e$ ovall in times shall be une=
quall, $y^e$ spaces from $y^e$ center extend, & those
nearer $y^e$ center contract accordingly; &
what appears more or leSs in $y^e$ times, as
every one may see that observes $y^e$ shaddow
from $y^e$ sun of a coach-wheel upon $y^e$ ground.
This is not strange. But they say $y^e$ orbs of
$y^e$ planets are ellipticall & $y^e$ sun about
$w^{ch}$ $y^e$ planet rolls is in a focus. I know that
$y^e$ foci of $y^e$ orbs are so neer $y^e$ umbilici,
that $y^e$ differrence may not be much; but take
an ellipse formed mechanically or by pro=
jection with foci very distant, & it seems $y^e$
proposition cannot be true. For let $y^e$ ovall
a.bcd. turn upon $y^e$ focus e & than $y^e$ part
c cannot paSs round by d to a & in time so
much swifter than from a by b to c, as
$y^e$ space acd. is larger than $y^e$ area or space
abc. And whoever observes $y^e$ shaddow I
mentioned shall find that $y^e$ parts at d shall
move

move with ye same celerity as ye parts at
b, & so ye rest as they are opposites to each
other. This ovall figure is of vast use in
Astronomy, for by ye propertys of it they can,
from past observed, calculate ye whole fi=
gure, & when ye planet shall arrive at any
part. And thereby ye unequall course of ye
sun is demonstrated, & tables of equation
made, wch are most usefull to compare with
clocks & watches. But as to ye Newtonian
Ellips consult ye demonstration.

225,
Chimera's
about ye
angle of
contact

The misterious disputes about ye angle of
contact between a strait line tangent & a
circle, is merry, as any dispute where no=
thing is ye subject must needs be. Some say
it is an infinity of approach diminutively;
& then prove that one infinity may be
greater than another, & so fall into pro=
portions, & ye infinity may be increast to infi=
nite. As AB. tangent, Ac, ye circle, AD
a leSs circle, tangent at ye same point. the
angle

angle CAB is no quantity, no more than
DAB, being both infinites diminutively,
& yet y^e^ infinite DAB is greater than y^e^
infinite CAB. And if y^e^ tangent be of a
plane to a sphear, y^e^ infinites are augmen=
ted to infinite. Now in account of rectili=
near angles, CAD, is nothing, because CA,
is not a right line, but an arch, & y^e^ rules
of rectilinears will not hold of curves, or
curves & right lines mixt; as between y^e^
hyperbole & asymptote, & of sphericall
{_} triangles, for such have more {/degrees\} than two
right angles. Therefore Euclid determines
right that y^e^ angle of contact is no angle
or no quantum. But in curvity it is an
angle, & comparative, as DAB, is greater
than CAB, & so foth, & y^e^ semicurve solid
angle between y^e^ plane & y^e^ sphear will
be as y^e^ sphears, wherein is no mystery as y^e^
jargon of terms often makes in mathema=
ticall as well as in other sciences.

When

226. Of incom= mensura= billitys

When a Geometer affirms, that there may be & often are quantitys, bewteen wch no number in ye whole stock of Arithmatick integer or fraction, can be a common mea= sure; his doscurse is commonly taken to be Aenigmatick, or ye case very wonderfull; for so long as there is a liberty of subdividing, it must at last (surely) come to a scantling apt to both. For if upon a (supposed) tryall it shou'd fail, then divide on, in wch proceSs there is no end. Now in truth ye wonder wou'd ly on ye other side, if it cou'd be shewed that any two things in ye whole universe were either equall alike, or commensura= ble; for nature it self is compound of ir= regularitys, & whatever is otherwise, is not of nature, but of art, & a creature of meer supposition grounded upon poSsibillity, for artfull purposes & not otherwise, as all Mathematicall objects are. The cause of this misapprehension that increase & di= minution of numbers & quantitys proceed alike

& correspond

& correspond each other (cujus contrarium
verum est) is,[249] for that in arithmetick
y^e^ progreSsion is by units or aliquots,[250] so as
y^e^ parts always measure y^e^ whole, w^ch^ parts
are distinct & determinate; But in geo=
metry y^e^ progreSion is not by parts deter=
minate, as by stepps, but continuall, and
major or minor than quo vis dato,[251] whereby
no number can be so multiplyed or sub=
divided as to measure every geometrick
quantity; let y^e^ minutes be small to y^e^
utmost of imagination, yet while it is
[a?] quantum, & pars extra partem,[252] we may
proffer a dimension a little more or leSs,
& sic ad infinitum, By this it appears
that there may be quantitys between w^ch^,
arithmetick, out of all its stores, cannot
furnish a common measure, & those are
incommensurables.

227,
The demon=
stration.

It appearing here that such may be, it re=
maines to shew that y^e^ same in diverse instan=/ces\
have

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[249] i.e., 'the opposite is true'.

[250] i.e., 'several' (i.e., any number greater than one).

[251] i.e., 'the given force'.

[252] i.e, 'a value', and 'part outside parts' (i.e., 'side-by-side').

have been by ye mathematicians paSsim
demonstrated. And this they have derived
upon ye notion of a quadrate wch is a num=
ber, or (wch is always understood) a substance
generated by number multiplyed into it
self. The product is ye square, & ye multi=
plyer is ye root, wch (root) whither expreSsi=
ble or not,is always a mean proportio=
nall between ye unite & ye square. Some
numbers are termed square numbers, as
4, 9, 16 &c because these are numbers as 2x2=4,
[2x3=9?], And 4x4=16, will produce
them, whereby ye proportions are 1:2::2:4,
1:3::3:9. & 1:4::4:16. But if ye numbers
are not square numbers (so as these may
not be any numbers self multiplyed that
will produce them) as 2, 5, & 7, &c. then sup=
posing quantitys, equall to them, ye roots
of those quantitys, (that is mean propor=
tonalls between ye unite & those numbers)
cannot

cannot be expreSsed by any other num=
bers, however subdivided: but they are no=
ted by a mark of radicallity, as they call
it, thus √ w^ch always signifies a mean
proportionall. Now seeing that y^e number
2 is no square number, & y^e mean propor=
tion between 1 & 2 inexpreSsible by num=
bers, it follows that all quantity's w^ch are
to each other as 1 to 2. are incommensura=
ble. or without a poSsibillity of any mea=
sure common to both, as mean propor=
tionallity requires. And this holds of all
y^e equimultiples as infinitum. Therefore
in every geometrick square, y^e square of
y^e diagonall being equall to y^e square of
y^e two sides. That is as 1 to 2 whereof y^e
roots are inexpreSsible, it follows, that y^e
diagonall, & y^e sides of every quadrate are
incommensurable.

Now if I may be allowed further to touch
y^e mathematicall point with a physicall
or rather

or rather vulgar style, waiving ye me=
thods of expreSsion, & demonstration or=
dinarily affected in those cases. I shall
now take into consideration ye (hitherto)
insuperable probleme of squaring ye
circle, wch is to prove that a content of
any circle is equall to ye area of any
quadrate or right-lined figure. It is
well known that this was undertaken
by Archimedes, & hath been persued by
most geometers ever since. The incompa=
rable Dr Barrow spent, as he said, more
time upon proving one single approach
to it, wch was to find a strait line equall
to an arch of a circle, than many men
have done in acquiring ye skill of some
gainfull profeSsions, & all he got for
his pains, was a demonstration, as he
thought that it was impoSsible to be done.
About ye same time Mr Hobbs published
his Eureka,[253] & was by ye virtuosi so exposed
that

[253] i.e., in his *Elementorum Philosophiae Sectio Prima de Corpore* of 1655. This prompted Wallis' *Elenchus geometriae Hobbianae* of the same year. An appendix to the English edition of 1656 (which was known as *De corpore*) Hobbes responded to Wallis with his 'Six Lessons to the Professors of Mathematics'. For a fascinating overview of the dispute between Hobbes and Wallis *see* Jesseph, G M, *Squaring the Circle. The War between Hobbes and Wallis*, Chicago University Press, Chicago, 1999.

that his positiveneSs was pleased to say, that either he was madd, or all y^e^ world was madd.[254]

The method of Archimedes was that w^ch^ they call of exhaustions & approximations, w^ch^ at every instance comes neerer, but never closeth. As suppose a circle to be divided into equall isosceles triangles, having y^e^ cusps at y^e^ center, & y^e^ basea angles touching y^e^ circles, then there will be a segment subtended by each base. Then multiply these triangles, & y^e^ segments will diminish, untill y^e^ bases & y^e^ periphery come to a coa= lescence, that is to say never: for y^e^ proceSs is infinite. As in dividing a strait line, first by half, then by half of y^e^ residue, & so on to infinite, w^ch^ can never be, because after every division, there will still re= main a part to be divided. This bredd a sophism, as proving that one body cou'd not by motion ever come to a contact with another

[254] 'ANIMADVERSIONS *Of* Dr Wallis, *upon* Mr Hobs's *late Book*, De Principiis & Ratiocinatione Geometrarum. These were communicated by way of Letter, written in *Oxford*, July 24. 1666. to an Acquaintance of the *Author*, as follows: Since I saw you last I have read over Mr. *Hobs's* book *Contra Geometras* (or *De Principiis et Ratiocinatione Geometrarum*) which you then shewed me. A *New* Book of *Old* matter: Containing but a *Repetition* of what he had before told us, more than once; and which hath been Answered long agoe. In which, though there be Faults enough to offer ample matter for a large Confutation: yet I am scarce inclined to believe that any will bestow so much pains upon it. For, if that be true, which (in his *Preface*) he saith of himself, A*ut solus insanio Ego, aut solus non insanio:* it would either be *Needless*, or *to no Purpose*. For, by his own confession, *All others*, if they be not mad themselves, ought to think *Him* so: And therefore, as to *Them*, a Confutation would be be *needless*; who, its like, are well enough satisfied already: at least out of danger of being seduced. And as to himself, it would be *to no purpose*. For, if *He* be the Mad man, it is not to be hoped that he will be convinced by Reason: or, if *All We* be so; we are in no capacity to attempt it." *Phil. Trans.* 1665 vol. 1 no. 1-22 289-294, p 289-90 (*see* http://rstl.royalsocietypublishing.org/content/1/1-22/289.full.pdf+html).

another, because it must paSs by perpet=
tuall halves, as before;[255] but y^e^ solution
was that every stated time was divisible
in infinitum as well as every limited
space. But to return to y^e^ circle; The tri=
angles by their laws may describe a mul=
tisi+/i\ded figure in y^e^ circle inscribed, & more
numerous than quovis dato, but yet seg=
ments will remain, w^ch^ destroy y^e^ equation,
So that altho y^e^ triangles may be reduced
to a square, y^e^ whole circle can never
be squared. But yet this approximation,
as to all practick uses serves as well as if it
were so.

This case of squaring a circle hath in y^e^
nature of it a great resemblance with
those of surd roots, & in commensurabilli=
tys. For y^e^ infinity of materiall divisibilli=
ty declares that no limited quantum, as
every thing that is to measure another must
be, can fall into a precise equallity with
any

[255] MN/RN refers here to Zeno's Paradox, or the Paradox of the Tortoise and Achilles.

any incommensurab~~ility~~/~~bes~~\/les\. Else subdivision
might be continued till it arrives at a
common measure, w^ch^ in such cases cannot
be; & no one breaks his braines to find a
communis mensura[256] between y^e^ diagonall
& side of a quadrate; but all are sa=
tisfyed; & by means of y^e^ radicall marks,
make such use of y^e^ (supposed) proportion
as may be allowed. So in case of y^e^ circle;
a right-lined particelle can never be drawn
so fine, to be adapt to a segment of a circle;
nor a strait line so small as to become part
of an arch; from whence there ariseth
a plain incommensurabillity between
every strait line, & circular arches whatever
w^ch^ puts an end to y^e^ tetragonism for ever.[257]
<flourish underline>

[256] i.e., 'common measure', i.e., 'standard proportion'.

[257] i.e., the squaring of a circle; a tetragonist was one who sought to square the circle. The OED gives the earliest use of the term (in English print) to Robert Boyle *The Excellency of Theology, Compar'd with Natural Philosophy. (as both are Objects of Men's Study.) Discours'd of In a Letter to a Friend... To which are annex'd Some Occasional Thoughts about the Excellency and Grounds Of the Mechanical Hypothesis*, London, 1674. In this book Boyle cautioned an enthusiatic natural philosopher not to forget the divine providence behind all phenomena in the world. Perhaps not an intended resonance, but a fitting one, in this last and paradoxial chapter of the *Physica*.

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