XIX. *A Defence of* Mercator's *Chart against the Censure of the late Mr.* West *of* Exeter : *In a Letter to* Charles Morton, *M. D. Secret. R. S. from Mr.* William Mountaine, *F. R. S.*

To Doctor Morton, *Secretary to the Royal Society.*

Dear Sir,

I Received your favour with Mr. Samuel Dunn's letter, touching Mr. West's method of constructing a nautical planisphere, referred to me by the Royal Society, which I now beg leave to return with the following account.

As this island is situate by nature, not only for coasting trade, but foreign commerce, so every real improvement in the art of navigation has always met with the approbation and encouragement of the ingenious and sensible part of these kingdoms.

The greatest single advantage that this important business ever received, was from the invention of the mariner's compass; and next to this, the projection of a true nautic practical chart claims place; — this last was performed by that great improver of navigation, Mr. Edward Wright, as appears by his book intitled " certain errors in navigation detected and corrected", published about the year 1599.

In chapter 2d, of said book, he tells us, " that " the errors in the plain chart had been complained

" of

" of by divers, as namely by Martin Cortefe, Petrus
" Nonius, and even Gerardus Mercator feemeth to
" have corrected them, in his Univerfal Map of the
" World; yet none of them had taught any certain
" way how to amend fuch grofs faults:" And, in
his Preface, he declares, " that, by occafion of Mer-
" cator's map, he firft thought of correcting fo many
" and great abfurdities in the common Sea Chart, but
" the way how this was by him done, he neither
" learnt of Mercator, nor of any man elfe."

Wright's method (erroneoufly called Mercator's)
was at this time then adopted, has continued ever
fince in ufe, and has been improved by fome of the
greateft mathematicians who have flourifhed fince
that time, and although fometimes attacked, yet it has
been found impregnable.

The firft perfon (that I am aware of) who charged
Mr. Wright with errors in his tables of rhumbs, is
Simon Stevins, in his large volume of mathematical
remembrances, which Wright himfelf plainly con-
futes in a fubfequent edition of his book: now, Ste-
vins does not condemn the principles, but only afferts
that his tables have fome faults in them, and endeavours
to prove that the fourth rhumb at 78 deg. of longitude
ought to have $61^d. 26^m.$ of latitude, whereas Wright
makes it only $61^d. 14^m.$ Hence, the great difference
is no more than 12 minutes; and what inconvenience
can arife hereby to the mariner in fuch a run, was this
the fact? But it turns out otherwife, for this difference
is reduced to lefs than one minute (even according
to Stevins own way) as evidently appears from Wright's
anfwer in page 214.

If

If every rhumb is then found to poſſeſs its true latitude in this chart at every degree and minute of longitude, without any ſenſible or explicable error (to make uſe of our author's own words) it follows, that the degrees of latitude are duly encreaſed, or that the table of meridional parts are true.

The great Doctor Halley has given us a curious method of dividing the nautical meridian, and of performing the problems in ſailing according to the true chart, in Philoſophical Tranſactions, Nº. 219. by a method different from Mr. Wright's, but ſo nearly correſponding in practice, that this alone is a ſufficient teſtimony in favour of my author.

Our worthy brother Mr. John Robertſon, in his excellent Elements of navigation, vol. II. page 358, expreſſes himſelf thus: " Now although a table thus
" made (Wright's table of meridional parts con-
" ſtructed to minutes) be abundantly ſufficient for
" all nautical purpoſes, yet had the ſecants of ſmaller
" parts than minutes been taken, the table would
" have been more correct; and therefore Mr. Ought-
" red, Sir Jonas Moore, Doctor Wallis, Doctor
" Halley, and others, have been induced to find me-
" thods of conſtructing thoſe tables with more ac-
" curacy than by the addition of ſecants to every
" minute.

" But a table of meridional parts, conſtructed by
" the moſt accurate method, only ſhews that Mr.
" Wright's tables do no where exceed the true me-
" ridional parts by half a minute, and this only near
" the pole; for in latitudes as far as navigation is
" practicable the difference is ſcarce ſenſible".—

About

About the year 1720, a curvilinear fea chart made its appearance, faid to be done by Henry Wilfon, the publifhers whereof reprefented Wright's chart as puzzling, difficult, and falfe.

But thefe groundlefs affertions were rationally anfwered by Mr. Thomas Hafelden, afterwards mafter of the Royal Academy at Portfmouth, in a letter and pamphlet addreffed to Dr. Halley about the year 1722.

In the year 1755 was publifhed a book intitled, " The art of failing upon the Sea", by W. E. which initial letters are fufficient to point out the ingenious author.—In page 74 he faies, " It is demon-" ftrable (by the method of fluxions) that the length " of the part of the meridian line in Mercator's " chart, which reprefents the difference of latitude " of two places upon the globe, is equal to the dif-" ference of the log. tangents of half the compli-" ments of the two latitudes, multiplied into the " number 2,30258509, and that product into the " radius of the fphere".

And in Scholium to his Fundamental principles, page 75. " In the few foregoing propofitions, I " have demonftrated the truth of the chief methods " of failing now in ufe; and deduced them from their " genuine principles, and fixt them upon their pro-" per foundations: By which the reader will be en-" abled to fee that this theory is not founded upon " falfe principles; but upon fuch as are folid and " true; and confequently that all calculations built " hereon may be depended on as exact".

Notwithftanding thefe, Wright's method is charged with great imperfection by the late Mr. Weft of Exeter, in his pofthumous work, referred unto by

2   Mr.

Mr. Dunn.—Mr. Weſt therein declares that " the er-
" rors of the plain chart are correćted, in a great mea-
" ſure, by Mercator's or Wright's chart; tho' the lat-
" ter is not a true projećtion of the ſphere in any ſhape;
" nor indeed is it pretended to be ſuch by Mr.
" Wright, one of its inventors". — The firſt part
of this paragraph ſurely contains a contradićtion; for
how can the errors in the plain chart be in a great
meaſure correćted by a projećtion that is not true in
any ſhape? And in anſwer to the latter part, — Mr.
Wright has no where made ſuch conceſſions that I
know of;—and further Mr. Weſt blends Wright and
Mercator together, when at the ſame time it does not
appear that the latter ever publiſhed any principles
of this kind of projećtion to the world.

In the 20th article of the beforementioned book,
Mr. Weſt has laid down a method of conſtrućting a
nautical chart, which he aſſerts to be " the firſt re-
" preſentation of the terraqueous globe ever yet in-
" vented, in which the meridians, parallels and
" rhumbs, are juſtly and truly projećted in *right*
" *lines*, for the latter cannot be *ſo* projećted in Mer-
" cator."—If they cannot be *ſo* projećted in Wright's,
they cannot in *his*; for in both, the meridians are ſaid
to be right lines and parallel, and therefore the rhumbs
muſt be right lines alſo, or how can they interſećt
the meridians ſo ſituate at equal angles?

He alſo ſaies in his ſcholium, that " It does not
" appear that Mercator or Wright ever thought of
" this projećtion; for the meridian line here is mani-
" feſtly a line of tangents; whereas in their projec-
" tion, it is a collećtion of ſecants."

What Mercator's thoughts were upon this matter when he formed his univerfal map, I know not, as he has left us no account thereof; but what Wright's were, he has very plainly told us in his aforefaid book; and whether his primary conceptions, and preparative modulus, do not only take in the whole, but alfo the very manner, of Mr. Weſt's conftruction, will better appear upon a due comparifon of their refpective methods, which I fhall beg leave here to introduce in their own words.

Mr. WEST's PROPOSITION.

" If a rectangular piece of paper be turned into
" the form of a right cylindrical tube, and a fphere
" be infcribed therein, fo as that the axes of the
" fphere and cylinder do coincide, or that the equa-
" tor be the line of contact between the faid tube
" and fphere, and all the points of the fpheric fur-
" face be projected or transferred to the concave fur-
" face of the tube, by right lines proceeding from
" the center of the fphere, and terminating in the
" faid concave furface of the tube: And then, if
" the paper be opened, and ftretched upon a plane,
" it will prefent a chart, in which the meridians,
" parallels of latitude, and rhumbs are all truly and
" geometrically projected in *right* lines".

In Wright's Correction of errors, reprinted by Mox-
on in 1657, not having the original edition by me,
in Chap. 2. we have the following account —
" Whereas the fpaces betwixt the parallels fhould in-
" creafe

" creafe more and more as you go from the equinoc-
" tial toward either of the poles, which Martin Cor-
" tefe alfo noteth in his third book and fecond chap-
" ter of the art of navigation; But he omitted *that*
" wherein all the difficulty lyeth; that is, how much,
" or in what proportion thofe fpaces fhould increafe:
" Which that it may the better be perceived, I think
" it not unmeet firft to fhew by what kind of pro-
" jection (or extenfion rather) the nautical planifphere
" may not unfitly be conceived to be geometrically
" made, after this manner.

Mr. WRIGHT's METHOD.

" Suppofe a fpherical fuperficies, with meridians,
" parallels, rhumbs, and the whole hydrographical
" defcription drawn thereupon, to be infcribed into
" a concave cylinder, their axes agreeing in one."
" Let this fpherical fuperficies fwell like a bladder
" (whiles it is in blowing) equally always in every
" part thereof (that is, as much in longitude as in
" latitude) till it apply, and join itfelf (round about,
" and all along alfo towards either pole) unto the
" concave fuperficies of the cylinder: each parallel upon
" this fpherical fuperficies, increafing fucceffively from
" the equinoctial towards either pole, until it come to
" be of equal diameter with the cylinder, and con-
" fequently the meridians ftill widening themfelves,
" till they come to be fo far diftant every where each
" from the other, as they are at the equinoctial. Thus
" it may moft eafily be underftood, how a fpherical
" fuperficies may (by extenfion) be made a cylindri-
" cal, and confequently a plane parallelogram fuper-

ficies;

" ficies; becaufe the fuperficies of a cylinder is no-
" thing elfe but a plain parallelogram wound about
" two equal equidiftant circles that have one com-
" mon axtree perpendicular upon the centers of them
" both" &c — " So as the nautical planifphere may
" be defined to be nothing elfe but a parallelogram
" made of the fpherical fuperficies of an hydrogra-
" phical globe infcribed into a concave cylinder, both
" their axes concurring in one; and the fpherical fu-
" perficies fwelling in every part equally in longitude
" and latitude, till every one of the parallels there-
" upon be infcribed into the cylinder (each parallel
" growing as great as the equinoctial) or till the
" whole fpherical fuperficies touch and apply itfelf
" every where to the concavity of the cylinder".—

" In this nautical planifphere thus conceived to be
" made, all places muft needs be fituate in the fame
" longitudes, latitudes, and directions or courfes, and
" upon the fame meridians, parallels, and rhumbs, that
" they were in the globe; becaufe, that at every point
" between the equinoctial and the pole, we under-
" ftand the fpherical fuperficies whereof this plani-
" fphere is conceived to be made, to fwell equally as
" much in longitude as in latitude (till it join itfelf
" unto the concavity of the cylinder) fo as hereby no
" part thereof is any way diftorted or difplaced out
" of his true and natural fituation upon his meridian,
" parallel or rhumb, but only dilated and enlarged:
" the meridians alfo, parallels and rhumbs dilating
' and enlarging themfelves likewife, at every point
' of latitude in the fame proportion".

By comparing thefe two modes of conftruction to-
gether I think it is not very difficult to difcover that Mr.
Weft's derives its original from Wright's; for right
lines

lines drawn from the center thro' all the points in the fpheric furface, and terminating in the concave furface of the tube, are fecants, and the tube becomes a tangent line to all thofe refpeative fecants: And, does not Wright's uniform dilatation, by the fecond law of motion, produce the fame?

Weft ftops here, and gives us a chart at once; Wright calls thefe his geometrical lineaments only, by which he obtains a rectilinear planifphere, and from whence he demonftrates the principles upon which his table of meridional parts are founded.

And that he does not efteem this as a chart compleated, but only his apparatus, and preparative work, which requires yet to be applied and moulded into a true nautical chart, is evident from the next paragraph, " Now then (faies he) let us diligently confider of the " geometrical lineaments, that is, the meridians, rhumbs, " and parallels of this *imaginary* nautical planifphere, " that we may in like manner exprefs the fame in " the mariner's chart: For fo undoubtedly we fhall " have therein a true hydrographical defcription of " all places in their longitudes, latitudes, and directions, " or refpective fituations each from other according " to the points of the compafs in all things corref- " pondent to the globe, without either fenfible, or " explicable error".

And hence he proceeds to the proof and application of thefe his lineaments, to the conftruction of his table of latitudes, as he calls it; which is, in this edition, computed to minutes of parallel-dif- 'ance, but with a little contrivance in the calculus to educe the fame yet fomewhat nearer the truth.

Notwithftanding this care and nicety in computa-ion, he is duly fenfible that his increments of latitude
calculated

calculated to minutes, altho' without any fenfible
error, are yet not abfolutely true, becaufe they ought
to flow with an uniform, and uninterrupted motion;
He therefore cautioufly guards againft critical remarks
hereupon, in the following paragraph :

" In this table it was thought fufficient to ufe fuch
" exactnefs, as that thereby (in drawing the lineaments
" of the nautical planifphere) fenfible error might
" be avoided. He that lifteth to be more precife
" may make the like table to decades, or tens of fe-
" conds, out of Joachimus Rheticus his Canon Mag-
" nus Triangulorum : notwithftanding the geome-
" trician that defireth exact truth, cannot be fo fatisfy-
" ed neither; for whofe fake and further fatisfaction, I
" thought good to adjoin alfo this geometrical conceit
" of dividing a meridian of the nautical planifphere."

" Let the equinoctial and a meridian be drawn
" upon a globe: Let the meridian, divided into
" degrees, minutes, feconds, &c. roul upon a ftreight
" line, beginning at the equinoctial, the globe fwell-
" ing in the mean time in fuch fort, that the femidi-
" ameter thereof may be always equal to the fecant
" of the angle, or arch contained between the equi-
" noctial and femidiameter infifting at right angles
" upon the forefaid ftreight line: The degrees, mi-
" nutes, feconds, &c. of the meridian, noted in
" the ftreight line, as they come to touch the fame,
" are the divifions of the meridian in the nautical
" planifphere: And this conceit of dividing the meri-
" dian of the nautical planifphere may fatisfy the curi-
" ous exactnefs of the geometrician; but for mecha-
" nical ufe, the table before mentioned may fuffice."

More might be faid in favour of Wright's chart,
but I think it is altogether unneceffary; if his own

5   principles

principles and documents be duly confidered; if almoft
general practice and experience for a century and an
half paft can have any weight; and, if the concur-
rent teftimony and authority of fo many eminent
mathematicians who have handled this fubject fince
his time, and fome of them in a quite different
method, can have any poife in the fcale of reafon.

I have carefully endeavoured not to miftake the true
fenfe and meaning of Mr. Weft's propofition in any
part thereof; if I have not, I cannot pronounce what
kind of chart may be formed from his tangent line
being made the line of latitudes, or that meridian line
whereupon the tangents are to determine the fections
of their refpective parallels: I fhall only obferve, that,
if the meridians be right lines, and parallel to each
other, the rhumbs muft be right lines alfo; but by this
tangential projection, *thefe* will be deflected from their
true bearings, or make the angles of the courfes too
great, unlefs fome expedient be devifed to accommo-
date this error; and if the rhumbs be not right lines,
fuch chart will then be embarraffed with more diffi-
culties in practice than Mr. Wright's.

Upon the whole, it feems as if the editor, confiding
in Mr. Weft's abilities, hath, without examination, pub-
lifhed this propofition (found amongft many other loofe
papers, none of which were, perhaps, ever intended for
public infpection, as himfelf faies in his apology) juft
as he found it; and that the Reviewers in good opi-
nion of both, and out of tendernefs to the widow and
family, the book being publifhed for their benefit, have
not fo critically examined and compared it with what
has been already done.—But, notwithftanding what is
fpoken in favour thereof, I fufpect it will have little
weight with the mariners, who very well know the
value

value of the Mercator's chart (as they call it) nor are they ever very eafily induced to adopt new notions or inventions, and thofe contrary to what they are familiarized unto by conftant practice.

The Critical Reviewers do indeed hint as if this paper had been heretofore communicated by Mr. Weft to the Royal Society, and that in the following terms: — " Mr. Weft lays down the following very ingeni-
" ous propofition, which, if we do not greatly
" miftake, we have feen, with little variation, in the
" Philofophical Tranfactions, communicated pof-
" fibly by the fame hand".—In this, I believe, they are miftaken, for I cannot find any thing like it in the tranfactions fince the date 1746, the year in which it is faid to be wrote.

I am duly fenfible of the frequent monitions, and fincere defire of the Royal Society, that its members may avoid all poffible occafions of controverfy; and whether this account has not a tendency thereunto, if it fhould, in other refpects, be thought worthy of a place in the public Tranfactions, is fubmitted, with all due refpect, to the determination of the Committee of papers.

I have the honour to be, Sir,

With the greateft efteem,

The Royal Society's,

Gainsford - Street, Southwark; Jan. 26th, 1763.

and alfo

your moft obedient, and faithful humble fervant,

William Mountaine.

XXI. *An*