

LXXXII. *Observations upon Father Kircher's Opinion concerning the burning of the Fleet of Marcellus by Archimedes.* By James Parsons, M. D. F. R. S.

Read June 13, 1754. **W**HEN Marcellus besieg'd the city of Syracuse, it is well known, by the authority of those great historians Livy, Polybius, and Plutarch, that the incomparable skill and devices of Archimedes were the only obstacles to his succeeding in his enterprize, much sooner than he did. These authors tell us of his having invented machines, with which he threw stones of an enormous weight, into the ships of the besieger; with showers of darts, flints, pieces of timber, and such like; and had so prepar'd his engines, as to be proper for any distance the vessels might lie at, in the harbour. And they are minute in their descriptions of some of them; particularly, in his having destroy'd the *sambuca*, a machine contriv'd by Marcellus. Nor does it appear that the forces, investing the city by land, far'd any better than those by water; for it is said he gall'd them in all quarters. And tho' the machines, as describ'd by these great authors, were wonders, surpassing the comprehensions of the generality of mankind, yet I believe their accounts have credit with the candid part of the learned, who delight in history and antiquities.

But what was most discredited, was Archimedes's setting fire to the ships, by a burning speculum. Indeed so distinguish'd a genius, if he could not destroy

stroy them in that manner, must know, that he might have thrown combustible matter, sufficient to burn the galleys, from his projectile machines: For we cannot imagine that he was ignorant of every kind of these, and not even of the wildfire of the Greeks. But, however, to account for his burning the fleet, by a speculum, was the difficult point.

When philosophers began to increase their catoptrical experiments, which they did very early, they found the focus, of every speculum that was concave, so short, that they were easily inclin'd to conclude, that Archimedes could not set fire to the fleet by a speculum; and hence the fact became intirely discredited, till the famous Kircher, and his pupil Schottus, whose characters and works the learned world are well enough acquainted with, resolv'd to consider not only the story of Archimedes, but also that of Proclus, who is said to have destroy'd a fleet at Constantinople in the same manner.

Kircher, however, notwithstanding the incredulity that appear'd every-where among the learned of his time, concerning those facts, was not deterr'd from giving great attention to the matter himself; which led him to make innumerable experiments, in order to see whether it was possible to be done or not, before he would give any opinion about it; and at length, when he had commended the parabolical speculum, which he, and others, were inclin'd to think the most likely to succeed in such an enterprize; he was inclin'd to think, Archimedes made use of such a speculum.

But, soon after, he was discontented with this notion, and began to make new essays; and, being
happy

happy in his invention, he fell upon one, which less'n'd his former good opinion of the parabolical speculum, and made him more sensible of the inconveniencies attending it, or those of any other form, that had any great degree of concavity; and, in a word, engag'd him intirely in favour of his new thought, which was put in execution in the following manner:

He erected a frame, on which he placed five plane specula, of equal given dimensions, with such inclinations as made them all throw their reflected rays upon the same place, at more than one hundred feet distance. When he had set the first speculum, he went and laid his hand upon the place, whereupon he caus'd the rays to fall, and found it warm; when he added those of the second, the heat was doubled; the third increas'd the heat in the same proportion; and the fourth being added, the heat was scarce to be borne; but the fifth made it intolerable. From whence he concludes, that, by multiplying those specula, the heat might be so increas'd, as to set fire to combustible matter at greater distances, according to the number apply'd.

Now because I think it a matter of some consequence, in the learned world, to ascertain to every author the praises due to his labours and discoveries, and to shew this author's application of the invention to the confirmation of this Archimedean fact; I think it also incumbent on me to give the Society his own words upon it, which he himself has reduced to a problem.

PROBLEMA IV.

Machinam ex speculis planis construere ad centum pedes & ultra urentem.

“ Suppono igitur primo, speculum planum tanto
 “ majorem lucem reflectere, quanto illud majus fu-
 “ erit ; ita pedale speculum in vicino pariete, lucem
 “ pedalem, in remoto, ad centum pedes lucem tan-
 “ tam, quanta pars quarta pedis est, projiciere, expe-
 “ rientia comperi. Supponendum secundo infinitos
 “ radios, ex singulis speculi punctis, reflexos, hanc
 “ lucem constituere. Si itaque aliud speculum pla-
 “ num ita constituas ut reflexa lux duplicatæ paulo
 “ ante luci congruat, dico & lucem & calorem tri-
 “ platum iri, & sic in infinitum procedendo. Sup-
 “ ponendum tertio, lucem & calorem hujusmodi spe-
 “ culorum reflectione, in unum spatium reflexum,
 “ pro multitudine speculorum multiplicari; quem-
 “ admodum fuse ostendimus lib. 2^o de Actinobolismis,
 “ part. 1^a. Ego certe hujus rei in quinque speculis
 “ experimentum sumpsi ; & prima quidem lux, a
 “ luce directâ, diversum calorem habebat ; duplata
 “ lux notabile caloris augmentum jam suscipiebat ;
 “ triplata calorem ignis præferēbat ; quadruplicata
 “ calorem utcunque tollerabilem adhuc præstabat ;
 “ quintuplicata, pene intolerabilem ; unde certo &
 “ indubitate conclusi, multiplicatis speculis planis, &
 “ ea ratione collocatis, ut omnia, reflexam solis lucem,

* Kircheri *Ars magna lucis & umbræ*, lib. X. pars III. cap. i. distinctio 3.

“ in unum spatium cogant, futurum, ut non tantum
 “ majorem ustionis effectum, quam quælibet ustoria
 “ parabolica, hyperbolica, elliptica, præstent; sed &
 “ in multo majus spatium, radiosam lucem reflectant,
 “ quemadmodum me in quinque speculis ad spatium
 “ centum & amplius pedum, experientia docuit.”

Schottus gives the same account of Kircher's experiment. He accompanied him in all his trials, as well as in his journey to Syracuse, after he had brought his plane mirrours to answer his purpose; and, upon viewing the place, they both concluded, the galleys of Marcellus could not be farther than thirty paces from Archimedes. And yet Schottus declared, that if a concave speculum could be constructed, as large as the rotunda, it could not have a sufficient focus to effect what both Archimedes and Proclus are said to have done.

Thus we see Kircher had scientifically establish'd the problem, for the construction of a burning machine, consisting of any number of plane specula; which was afterwards farther confirm'd by the ingenious Monsieur de Buffon, a worthy member of our Society, at Paris; as it appears in two letters, one from Mr. Needham, fellow of the Royal Society, to me; and the other from the marquis Nicolini to our late worthy president; both read before this Society in April 1747, and since printed in these *Transactions*; in which Monsieur de Buffon is said to be the inventor*. If so, we cannot suppose he could have seen what either Kircher or Schottus had wrote about it.

* Since this paper was committed to the press, the author has found, that Monf. de Buffon, at the close of his discourse on this subject, printed in the *Memoirs of the Royal Academy of Sciences*, has mentioned that himself had solved the problem, before he knew that it had been done by Kircher.