

PHILOSOPHICAL TRANSACTIONS.

April 26. 1675.

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An Extract of a Letter of the Learned Dr. Gothofredus Guil. Leibnitz, concerning the Principle of exactness in the portable Watches of his invention.

THE Principle I thought upon some years ago for making exact portable Watches, is altogether different from that which consists in an Equal duration of Unequal vibrations of pendulums or Springs, applyed to Watches by M. *Hugens* with so general an applause; this depending upon a Physical Observation; but mine being grounded upon a meer Mechanical reflexion, which is easie enough, and whereof the reason and demonstration it self is manifest to our senses, which hath not been taken notice of, for want of the Art of Combination, the use of which is far more general than that of *Algebra*. For having consider'd with my self, that a Spring being bent to the same degree, will always unbend it self in the same time, provided it find the same freedom of unbending it self suddenly; I inferred from thence, that there might be employ'd two such, one of which should play, whilst the first

P p

Mover

Mover of the Watch did bend the other again ; since it will be no matter in this way, whether it bend again more or less speedily, so it bend only again before the other have done unbending it self ; and consequently, the one delivering the other at the end of its motion, this play will always continue uniform, and so by letting go, at every turn or period of these two Springs, a tooth of a wheel carried about by the ordinary motion, which counts seconds or other parts of time, equal to the periods, we shall have such a Watch as is desired by us.

These thoughts of mine I have executed in the following manner ||: Let AB be one of the Watch-plates ; C and M. || See Fig. I. two indented barrels, wherein the small Springs are inclosed. The teeth of the barrels catch those of the pignons d, d. which carry the ballances e, e ; and other teeth of the said barrels are catch'd by those of the interrupted wheel FG. Now let us imagine, that this wheel FG, being moved towards HF by the force of the first Mover of the Watch, and turning the barrel C, bends the Spring inclosed in it, and stops with the barrel as soon as it hath bent this Spring. This piece which serves to stop, is easie, and hath not been thought necessary to be marked here, to avoid embarassing the Figure. But whilst one indented part of the interrupted Wheel FG, *viz.* F. turns the barrel C, the empty part, opposed thereunto, which is G, answers to the other barrel M, and gives liberty to the Spring, it incloseth, to unbend it self. Thus whilst the movement of the Watch bends the small Spring of the barrel C, in the same time the small Spring of the other barrel M, unbends of it self. I say, *in the same time*, except the Spring C shall have done bending a little sooner, than the Spring M shall have unbent it self: So that the Spring C. being bent, and the Wheel FG stopped ; both of them stay in this posture, till the Spring M, when it shall be quite unbent, do, at the end of its motion, touch a piece which delivers it. And then the Spring C unbends of it self in its turn ; the teeth of the interrupted Wheel, which continues its motion the same way as before, since 'ti deliver'd, not being any more able to hinder it therefrom, because the barrel C doth now meet with the empty part H of the said Wheel. But before it hath done unbending it self, the indented part L, being opposite to the empty part H, that turns the barrel M, bends its Spring again, and having done so, stops with it, whilst the Spring C, making an end of unbending it self, delivers

delivers them by a reciprocal good office, and renders to the Spring M the same services, which it had received from it, with an expectation of receiving the like again.

Which being well consider'd, 'tis manifest, *that* the same alternative Motions will continue always: *that* the periods taken from the very moment that one Spring begins to unbend, until the moment it once unbends it self again, will always be of equal duration, though the two small Springs be not equally strong: *that* the Ballance of such a Watch will be double, and be charged more or less, and receive delay, by advancing or recoiling, along the two arms, two equal weights, counter-balancing one another, that so the change of the scituation may not at all prejudice the Equality of the Watch. For the rest, we may in this kind of Watches spare the fusee, and consequently the string or chain. 'Tis also easie to judge, *that* such Watches as these may be of a size sufficiently small; *that* they will make no more noise then ordinary Watches; *that* they will be as exact as pendulums, and cease not to go whilst they are winding up. And though the motion of the Watch-wheels may be alter'd by many accidents, such as are, the inequality of the motion of the great ordinary Spring, I mean, the first Mover; the more or less rubbing of the wheels according as the oyl grows thinner or thicker; the rust, the verdigrease, the play of the pieces, the inequality of the teeth, and the like; yet the periods of the small Springs will not be concern'd in all or any of them, provided the motion of the Watch-wheels have always more strength than it needs to bend them again; which is in our power. And so the Principle of Equality here is sure by a kind of demonstration altogether Geometrical, and withal very evident even to ordinary capacities.

It remains to touch in a few words the objections that have been made against this contrivance by some intelligent persons. They have all acknowledged, that this would be a perfectly exact Watch for common use, but if employed for finding the Longitudes, there would occur these difficulties, viz. *That* tossing of Ships would shake the Springs as well as other pieces; *that* rust would spoil them, since the saltish humidity of the Sea in remote voyages spares not the vey needles of Compasses though inclosed in boxes; *that* the changes of seasons and climats will sensibly alter the Springs, especially the great heats, or rains within

the Tropiques, which at length will somewhat untemper the Steel; as is confirmed by the Experiments of the Illustrious Academy of *Florence*, showing, how easily that Heat and Cold do change slender Springs: Besides, that the Air more or less condensed will also more or less resist the motion of the ballance. To which may be added, that Springs by working are weakned; and lastly, that there will be always some little friction, that will make the several pieces go more or less easily, and that even in length of time they will wear out.

But I answer, that all these defects, that proceed from the imperfection of the matter, may be surmounted by a general remedy, without examining them here in particular. And that is, that for executing it in great, we may make use of massy Springs, as are those of Cross-bowes, we being Masters of them, not wanting force or place in a Ship to govern a great weight that may serve to bend them continually again. Now these massy Springs may be so great, and their restitution so speedy by augmenting their number, that all the above-named defects will have no considerable proportion to this strength, and the aggregate of their repetitions will not be sensible till after a very long time. And 'tis easie to demonstrate, that by augmenting the bigness of the Engin, and the force of the massy Springs, we may make the error as small as we will, provided we pass not the bounds of conveniency, and content our selves with an exactness sufficient for the end, they are principally designed for, which is the finding of the Longitudes: Which answer is so clear and so universal, that all those that have considered it, have expressed their satisfaction therein.

Fig. 1.

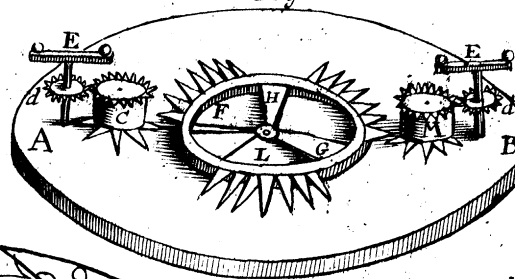


Fig. 2.

