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Lacks pages
i & ii of preface.

Robert Kenrick Foulkes

THE PRINCIPLES OF MR. HARRISON'S TIME-KEEPER,

WITH

PLATES OF THE SAME.

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vvill receive the impreſſion from the plates perfect, and vvill not ſhrink at all in the drying.

It may not be improper to take notice here of a difference in the poſition of the pallets in the 8th and 9th figures, vvhich might othervviſe puzzle the inſpector, or, at leaſt, induce him to think there vvas ſome error made in engraving the plates from the original.

In figure 8th, the centre of the curve of the pallets lies in the circumference of the dotted circle, vvhoſe radius is tvvo fifths of the radius of the circle deſcribed by the edge of the pallets; but, in figure 9th, the centre of the pallets lies juſt vvithout the circumference of the little black circle, repreſenting the ſpindle, vvhoſe radius is one fourth of the radius of the circle deſcribed by the edge of the pallets. The latter figure ſhevvs Mr. Harriſon's former deſign, vvhich he has ſince altered, as is repreſented in the 8th figure.

NOTES

TAKEN AT THE

DISCOVERY

OF

M^R. HARRISON'S TIME-KEEPER.

THE balance naturally vibrates largeſt arcs, vvhen in a horizontal poſition; next greateſt, vvhen the hours XII and VI are uppermoſt, and the vvatch is in a vertical poſition; leaſt, vvhen the hours III and IX are uppermoſt.

Large arcs are naturally performed in leſs time than ſmall ones. This Mr. Harriſon inferred, becauſe the vvatch, before any correction vvas applied, vvent ſlovver in a vertical poſition than in the horizontal one, and the vibrations are viſibly larger in the latter caſe.

The vvatch is adjusted to vibrate great and small arcs in equal times, in the follovving manner:

To go the same vvhen placed vertically vvith the hours III, VI, IX, XII upvvards successively, by making the vveight of the balance different in different parts. — To go the same vvhen placed horizontal as vvhen vertical, by the joint effect of the back of the pallets and the cycloid-pin.

The curve of the back of the pallets is an arch of a circle, vvhose centre lies in the line joining the edges of the pallets and the centre of the spindle, the distance of the tvvo centres being tvvo fifths, and the radius of the curve of the pallets three fifths of the radius of the circle described by the edge of the pallets.

The action of the cycloid-pin, vvhen it touches the balance-spring, tends to quicken its vibrations; and the spring, leaving the pin for a longer time in the large vibrations than in the small ones, is less accelerated by it in the former than in the latter case; and, consequently, the action of the pin tends to reduce the time of the different vibrations nearer to equality. The cycloid-pin vvas not applied to the vvatch till after it came back from the voyage to Jamaica.

If the balance-spring is too strong, it must be made vveaker by rubbing it avvay a little; but, if it be too vveak, it must be changed for a stronger.

The balance-ſpring is faſtened at the outer end to a ſtud, vvhich takes off the plate vvith a ſcrevv, and is put on again vvith the ſame ſcrevv, and ſteady-pins, exactly in the ſame poſition as before, vvithout undoing the faſtening of the ſpring to the ſtud at the end.

There is no adjuſtment for mean time, as in common vvatches; there vvas once, but it did not anſvver.

As ſoon as the vvatch is put together, Mr. Harriſon ſays, it vvill ſhevv its rate of going in three hours accurately the ſame vvhich it vvill keep aftervvards; ſo that he can ſoon determine it by compariſon vvith his pendulum clock.

The balance-ſpring, vvhen at reſt, touches the cycloid-pin; and does not begin to leave it, till the balance has vibrated an arch of forty five degrees beyond the point of reſt, vvhile the ſpring is in the ſtate of coiling itſelf up.

The thermometer kirb is compoſed of tvvo thin plates of braſs and ſteel rivetted together in ſeveral places, vvhich, by the greater expanſion of braſs than ſteel by heat, and contraction by cold, becomes convex on the braſs ſide in hot vveather, and convex on the ſteel ſide in cold vveather; vvhence, one end being fixed, the other end obtains a motion correſponding vvith the changes of heat and cold, and the tvvo pins at this end, betvveen vvhich the balance-ſpring paſſes, and vvhich it touches alternately as the ſpring bends and unbends itſelf, vvill ſhorten or lengthen the ſpring, as the chan-

ges

ges of heat and cold vvould othervviſe require to be done by the hand, in the manner uſed for regulating a common vvatch.

Mr. Harriſon requires cold vveather for adjuſting the thermometer kirb, and he places the vvatch near a fire, vvith a common thermometer by it, to try if it keeps the ſame time as in the cold air. If not, he alters or adjuſts the thermometer kirb till it goes the ſame in theſe tvvo different degrees of temperature of the air.

The thermometer kirb takes heat ſooner than the balance-ſpring, and he thence concludes that braſs takes heat ſooner than ſteel, and that the braſs rods of a gridiron pendulum ſhould be made thicker than the ſteel ones.

Whilſt the heat is increaſing, the vvatch vvill ſome-times go one tenth of a ſecond ſlovver in three hours, than vvhen the heat is come to a ſtand.

The effect of the thermometer is increaſed by rubbing the ſides thinner, and is leſſened by thickening the edge by burniſhing it.

Mr. Harriſon adjuſts the thermometer kirb firſt, that is to ſay, before he adjuſts the vvatch to go the ſame in different poſitions.

The vvatch may be put vvith figure XII turned each day alternately different vvays, for fear one part of the box in vvhich it is kept may be hotter than the other.

The force or momentum of the balance, Mr. Harriſon ſays, is as the ſquare of its diameter, alſo as the ſquare of the velocity, its vveight being given.

The momentum of the balance acquired by increaſing the velocity is better than that acquired by increaſing the vveight; as friction is not thereby increaſed, perhaps, if any thing, diminiſhed, and the reſiſtance of the air only is increaſed, the effect of vvhich is tolerably uniform, and of great ſervice.

The diameter of the balance is 2, 2 inches, of the plate 3, 8 inches.

The balance ſhould be a little larger, or $2\frac{1}{4}$ inches, according to a memorandum taken by Mr. Bird.

The vvatch makes juſt five beats in a ſecond of time.

If the balance vibrated faſter, the reſiſtance of the air vvould be too great.

A pocket vvatch of this kind vvould do better vvith ſix beats in a ſecond.

A certain ſize is beſt for the pallets, or rather a certain proportion betvveen the diameter of the circle deſcribed by the edge of the pallets and the diameter of the balance-vvheel. This vvas firſt ſuggeſted to Mr. Harriſon from bell-ringing; for he could bring the bell better into a motion, by touching it from time to time ſomevvhere near the centre than near the circumference; becauſe in the firſt caſe his hand moved quick enough to follovv the bell.

The grand principle of the vvatch is that of giving the greateft motion poffible to the balance vvith a given force. This is done by the fcaping and proper quantity of the arc defcribed.

This note vvas communicated by Mr. Mudge, as alfo the follovving; That the balance, by the force from the vvheels, vvithout its fpring, tends to vibrate once in tvvo feconds.

There are four fprings in the vvatch; firft, a main fpring; fecondly, a fpring in the infide of the fufee, to keep it going vvhile it is vvinding up; thirdly, a fpring, vvhich is vvound up eight times every minute; fourthly, the balance-fpring. The three firft vvere made by Maberley.

The fufee has fix turns and a quarter.

The fly ferves to moderate the velocity vvith vvhich the fpring neareft the balance vvould othervvife be vvound up.

The pivot-holes are all made in rubies, vvith diamonds at the ends.

The pallets are diamonds.

One end of the vvatch in the late voyage to Barbadoes vvas fet higher, becaufe it vvas not equally adjufted in all pofitions. Alfo it vvas altered and brought back to the fame pofition, vvith refpect to the horizon, as the fhip lay dovvn on the one or the other tack, by the help of a moveable box, vvith a divided arch.

Mr. William Harrifon reckons the greateft roll of a fhip fifteen degrees, and the greateſt lie-dovvn, vvhen going upon one tack, tvvelve degrees.

Hold the vvatch a little back, vvhen in a vertical poſition, that the face may be a little up.

If the balance-ſpring be not exactly parallel to the plates, there vvill be a ſmall difference in the going of the vvatch, vvhen the face is up or dovvn.

Care is to be uſed in moving the vvatch, or in turning it about, in order to vvind it up, not to give it any quick circular motion in the plane of the balance, as it might poſſibly ſtop it. A pocket-vvatch, vvhich Mr. Harriſon has made of this kind, once ſtopped this vvay. Turn the vvatch over upon ſome diameter of the dial-plate, as an axis, in order to bring it into a convenient poſition, vvhen you vvant to vvind it up.

Oil muſt be applied to the pallets and pivot-holes of the vvatch, but very ſparingly.

The vvatch vvill go three years vvithout requiring to be cleaned.

At the time of the diſcovery, in Auguſt 1765, M. Harriſon ſaid, that the vvatch then vvent a little ſlovver than it had done, ovving to its vvanting to be cleaned, viz. tvvo or three ſeconds per day.

The vvatch ſhould have a cap, and no outer caſe, the vvooden box, in vvhich it ſhould be kept, ſerving that purpoſe better.

NEVIL MASKELYNE,
ASTRONOMER ROYAL.

PRINCIPLES

OF

Mr. HARRISON'S TIME-KEEPER.

IN this Time-keeper there is the greateſt Care taken to avoid Friction as much as can be, by the Wheels moving on ſmall Pivots, and in Ruby-holes, and high Numbers in the Wheels and Pinions.

The Part vvhich meaſures Time goes but the eighth Part of a Minute vvithout vvinding up; ſo that Part is very ſimple, as this Winding-up is performed at the Wheel next to the Balance-wheel; by which Means, there is alvvays an equal Force acting at that Wheel, and all the reſt of the Work has no more to do in meaſuring Time, than the Perſon that vvinds them up once a Day.

There is a Spring in the Inſide of the Fuſee, vvhich I vvill call a ſecondary Main-ſpring. This Spring is alvvays kept ſtretched to a certain Tenſion by the Main-ſpring, and during the Time of vvinding up the Time-keeper, at vvhich Time the Main-ſpring is not ſuffered to act, this ſecondary Spring ſupplies its Place.

In common Watches in general the Wheels have about One-third the Dominion over the Balance that the Balance-fpring has ; that is, if the Povver the Balance-fpring has over the Balance be called *Three*, that from the Wheels is *One*; but in this my Time-keeper, the Wheels have only about *One-eightieth* Part of the Povver over the Balance that the Balance-fpring has; and it muft be allovved, the lefs the Wheels have to do vvith the Balance, the better. The Wheels in a common Watch having this great Dominion over the Balance, they can, vvhen the Watch is vvound up, and the Balance at reft, fet the Watch a-going; but when my Time-keeper's Balance is at reft, and the Spring is vvound up, the Force of the Wheels can no more fet it a-going, than the Force of the Wheels of a common Regulator can, vvhen the Weight is vvound up, fet the Pendulum a-vibrating; nor vvill the Force from the Wheels move the Balance, vvhen at reft, to a greater Angle in Proportion to the Vibration that it is to fetch, than the Force of the Wheels of a common Regulator can move the Pendulum from the Perpendicular, vvhen it is at reft.

My Time-keeper's Balance is more than three times the Weight of a large fized common Watch-balance, and three times its Diameter; and a common Watch-balance goes through about fix Inches of Space in a Second, but mine goes through about tvventy-four Inches in that Time: So that had my Time-keeper only thefe Advantages over a common Watch, a good Performance might be expected from it. But my Time-keeper is not affected by the different Degrees of Heat and Cold, nor Agitation of the Ship; and the Force from the

Wheels is applied to the Balance in fuch a Manner, together with the Shape of the Balance-fpring, and (if I may be allovved the Term) an artificial Cycloid′, vvhich acts at this Spring; fo that from thefe Contrivances, let the Balance vibrate more or lefs, all its Vibrations are performed in the fame Time; and therefore, if it go at all, it muft go *true*. So that it is plain from this, that fuch a Time-keeper goes intirely from Principle, and not from Chance.

The follovving is a Defcription of the DRAWINGS from which my *fourth* Time-keeper was made, and the Drawings are alfo hereunto annexed.

FIG. I.

AA is the Chain-barrel, and BB is a Section of it.

CC is the Spring-barrel, and DD is a Section of it.

EE is a Ratchet at the Spring-barrel, and FF is a Section of it. This Ratchet is fcrevved to the Spring-barrel by four fmall Screvvs at *aaaa*. There is a Hole in the Pillar-plate of the Diameter from the dotted Lines *bb*, and that Part of the Spring-barrel *cc* is to move in this Hole vvithout any Shake, in order to fet the Spring up. The Ratchet is alfo fhevvn in Figure 13th, by the Circle *bb*, and it has thirty Teeth, and *e* is the Click that holds it.

Diameter of the spring Arbor........about 1, 64 of $\frac{1}{4}$ Inch.

Diameter of the Hole in the Centre of the Chain Barrel about..........................0, 38

Diametre of the upper pivot..............0, 23

Diameter of the lovver................0, 215

Diameter of the spring Barrel vvithin......1, 4 Inch.

FIG. 2.

AA is the Brass Edge, BB the Hole in the Middle of it, and CC is a Section of it. This Brass Edge is supported by six Pillars, and their Places are represented in Figures 13 and 14, by six Circles *aaaaaa*.

FIG. 3.

AA represents the second Wheel acting in a Pinion at *a*. BB represents the third Wheel, vvhich is concave, and acts in a Pinion at *b*. The second Wheel is described in Figure 14 by the Circle *dd*, and acts in a Pinion of 18 at *e*. The third Wheel is represented in Figure 14 by the Circle *ff*, acting in a Pinion of 16 at *g*.

Note, The third Wheel is larger than is represented in Figure 14, and has 144 Teeth, and the second Wheel has 120 Teeth.

FIG. 4.

FIG. 4.

A A repreſents the contrate Wheel, BB a Section of it, vvith a Section of the Spring-barrel *aa*. At *cc* is a Piece vvith eight Pins in it, that diſcharges the running Wheels every eighth Part of a Minute. This Wheel is alſo repreſented in Figure 14 by the Circle *hh*; it has 120 Teeth, and acts in a Pinion of 12 at *i*.

Thickneſs of the Rim about 0, 048 of $\frac{1}{4}$ inch.

The diſcharger and vvheel for the ſeconds, muſt be a little nearer the dial plate than according to this dravving ſo that the tops of the pins of the diſcharger may be even vvith the plain of the pillar plate.

The croſſes of the vvheel are alſo dravvn too broad at the outer end.

Diameter of the hole in the centre of the vvheel about 0, 23 of $\frac{1}{4}$ inch.

Diameter of that part of the ſpindle vvhich goes thro' the fourth vvheel arbor (thicker end) about 0, 108 of $\frac{1}{4}$ inch.

Diameter of each pivot 0, 045.

Length of the ſpring 10 inches, it's vveight 3 $\frac{1}{2}$ grains.

FIG. 5.

A A is the firſt Wheel, and *aaaa* is a Section of it. *bbb* is a Section of the Fuſee. BB is the outer Diameter of a Ratchet which is fixed to the Inside of the Fusee, and the inner Circle CC is its inner Diameter, and it has 55 Teeth in it. *dddd* is what I call the perpetual Ratchet, of which *cccc* is a Section; there is a Ratchet with 75 Teeth in it on that Part marked *ff*, this is also shewn in Figure 13 by the Circle *ee*, and this perpetual Ratchet is to carry the Barrel DD, which Barrel contains the secondary Main-spring, and will be in the Inside of the Fusee at *gg*, and at that Part of the first Wheel *hh* the inner End of this Spring is to act, as that Part *hh* will be its Arbor. The dotted Lines E represent the Grooves in the Fusee. The dotted Lines *ll* represent the upper Plate. The dotted Lines *mm* represent the Pillar Plate. The dotted Lines *nn* represent the Cock, which carries the lower End of the Arbor of the first Wheel. This Cock is also represented in Figure 13 at *dddd*. The Ratchet *ee* in Figure 13 has two Clicks, whose Centres are at *ff*, and *gg* are the Springs which act at these Clicks. In Figure 14 *bb* represents the first Wheel with 96 Teeth, acting in a Pinion of 21 at *c*.

FIG. 6.

A is a Section of the Frame, with the Balance-cock, the Slide, and the Brass Edge; and *a* is the Centre of the Joint-pin. B is a Section, where *aa* represents the Balance-cock, *bb* the third Wheel-cock.

c the Cock at the End of the contrate Wheel.

d the Cock at the End of the fourth Wheel.

e the fourth Wheel.

f the Follovver.

g the Balance-vvheel.

h the Potence.

i the Balance-vvheel Pinion.

k the Counter-potence, vvhich alſo carries the other End of the fourth Wheel.

m the Spring-barrel.

n the Hook in it, vvhere the out End of the Spring hangs.

o the Hook at the contrate Wheel, vvhere the inner End of the Spring is hung.

r the fifth Wheel, vvith the Pin vvhere the Dittent is to ſtop;

S the upper Plate.

T the Pillar-plate.

Fig. 7.

Is the Dittent, by vvhich is the Diſcharge for vvinding up eight Times in a Minute. The Part *a* acts at the eight Pins on the contrate Wheel-arbor. *b* is a Roller acting againſt a Piece of Braſs on the fifth Wheel-arbor. *c* is a Piece that ſtops againſt a Pin in the Rim of the fifth Wheel. *dd* are Pieces of Braſs to make it in an Equilibrium in itſelf; and E is the Spring vvhich acts upon it. The Centre of this Dittent is at *x* in Figure 14.

FIG. 8.

aa are the Pallets of ten times the Size that they are in the Time-keeper. The dotted Lines from 24ths of the Circle, fhevv the Povver the Balance-vvheel has to impede the Motion of the Balance by the Declivity on the Back of the Pallets, at any the fame time vvhenever it fhall have the greateft Povver to give it Motion.

FIG. 9.

Is to fhevv the Proportion betvveen the Balance, the Balance-vvheel, the Balance-vvheel Teeth, the Pallets, and at vvhat Diftance the Wheel acts from the Centre of the Balance. AA reprefents the Balance, BB the Balance-vvheel, *aa* the Pallets, and *bbbbbb* the Balance-vvheel Teeth.

FIG. 10.

A is the Counter-potence, vvith the Follovver *a*, and a fmall Screvv at *c*, to ftop vvhen at its proper Place, and *x* is the Centre of the fourth Wheel.

B is the Cock for the Minute-vvheel.

C is the Steel Bridge.

D is a Cock for the contrate Wheel.

E is a Cock at the firft Wheel.

F is a Cock at the contrate Wheel on the Pillar-plate.

FIG. 11.

FIG. 11.

Is the Dittent, vvhich is to stop the Balance before the Watch be dovvn. It turns upon a Centre at *t* in Figure 14. A is the Locking-spring.

Diameter of the hole in the Socket. (Its' vvider end) about 0, 19 of $\frac{1}{4}$ inch.

Diameter of the upper pivot 0, 22. Diameter of the lovver pivot 0, 09.

FIG. 12.

A A represents the upper Plate. BB the Balance.

a a the Thermometer.

b b the Balance-spring.

c c Slider to adjust the Thermometer end-vvay.

d the Stud.

e the artificial Cycloid.

f a Piece to adjust it so as to bear properly against the Spring.

FIG. 13.

aaaaaa the Feet of the Brass Edge.

bb the Ratchet at the Spring-barrel.

c the Click.

dddd the Cock at the End of the first Wheel.

ee a Ratchet.

ff the Centres of the tvvo Clicks vvhich act in it.

gg the tvvo Springs that act at them.

hhhhhh the six Pillars of the Frame.

ii the Steel Bridge.

kkk tvvo Wheels that carry the Seconds, one being on the contrate Wheel-arbor, the other moving on the Cannon-pinion.

l the Cannon-pinion.

mm the Minute-vvheel.

n the Hour-pinion.

oo the Hour-vvheel.

Fig. 14.

aaaaaa the six Pillars of the Brass Edge.

bb the first Wheel.

c the Centre-pinion.

dd the second Wheel.

e the second Pinion.

ff the third Wheel.

g the third Pinion.

hh the contrate Wheel, and the fourth Wheel.

i the Balance-vvheel Pinion.

k the fourth Pinion.

ll the fifth Wheel.

m the fifth Pinion.

nn the Fly.

oo the Balance-vvheel.

p the Potence.

rrrrrr the ſix Pillars of the Frame.

s the Stud.

t the Centre of the Dittent, to ſtop the Balance.

x the Centre of the diſcharging Dittent.

uu the upper Plate.

zz the Pillar-plate.

FIG. 15.

Is vvhat vvas deſigned for the Work on the upper Plate, vvhich is novv done in the Manner as repreſented in Figure 12.

For tempering the Balance-ſpindle, the Balance-ſpring, and the Pinions.

Before their being immerſed in the Metal (as juſt melted) let them be oiled over.

The Heat for the Balance-ſpindle 567 on Fahrenheit's Scale, the vvhich is given by one of Pevvter to 12 of Lead; but for the Balance-ſpring and the Pinions, let the Mixture be One of Pevvter to 17 of Lead.

Each Turn of the firſt Wheel (or Fuſee) is $4\frac{4}{7}$ Hours; ſo $5\frac{1}{4}$ of its Turns is juſt 24 Hours; and $6\frac{1}{4}$ is $28\frac{4}{7}$ Hours; and $6\frac{9}{16}$ Turns equal to 30 Hours.

FINIS.

Fig. 1.

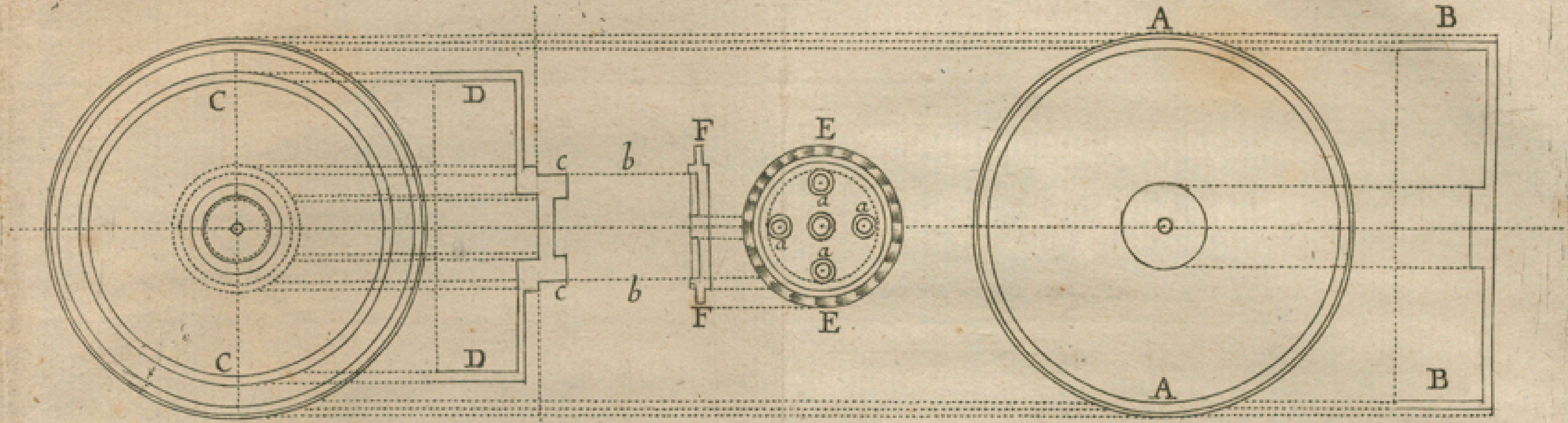


Fig. 2.

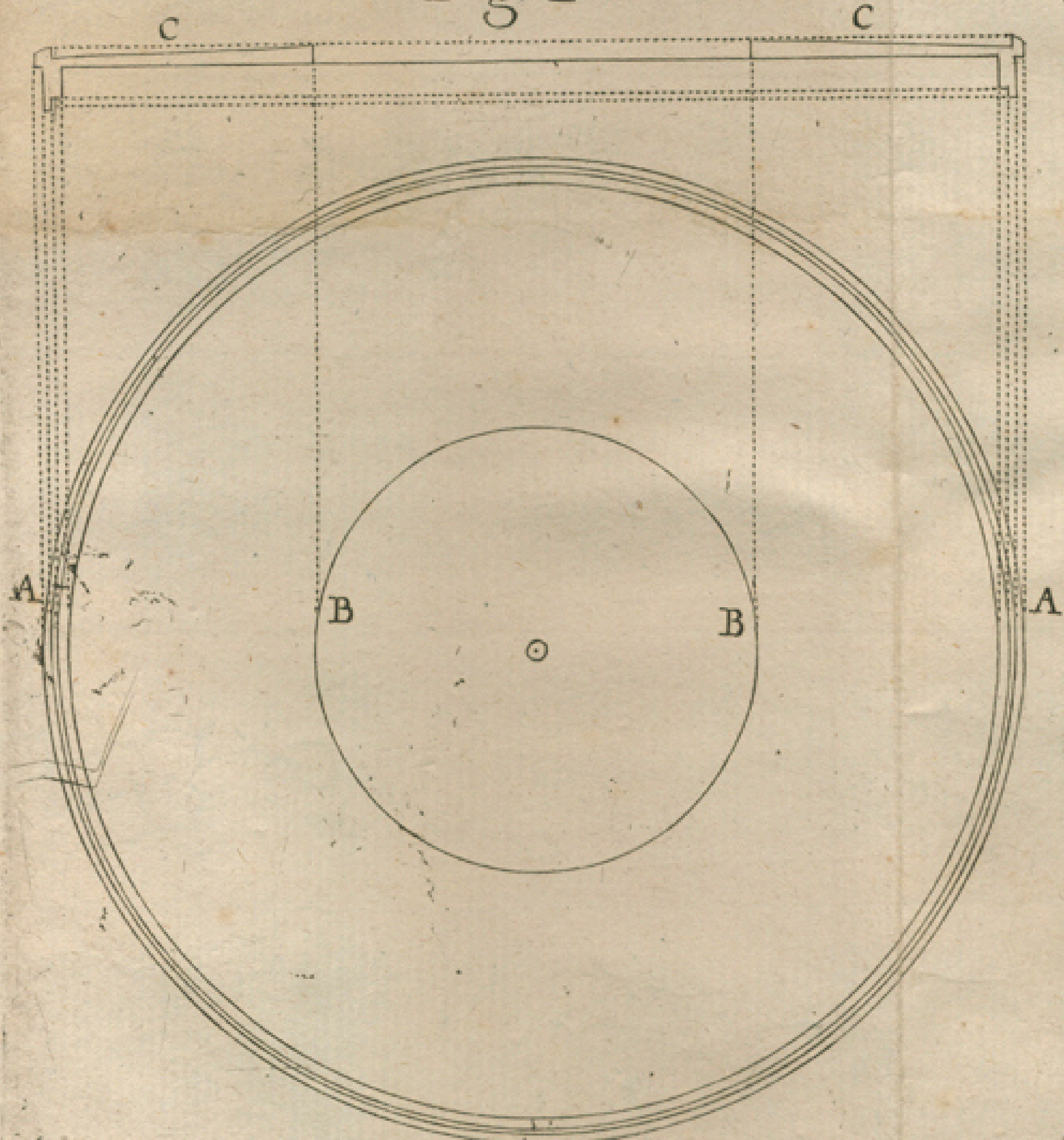


Fig. 3.

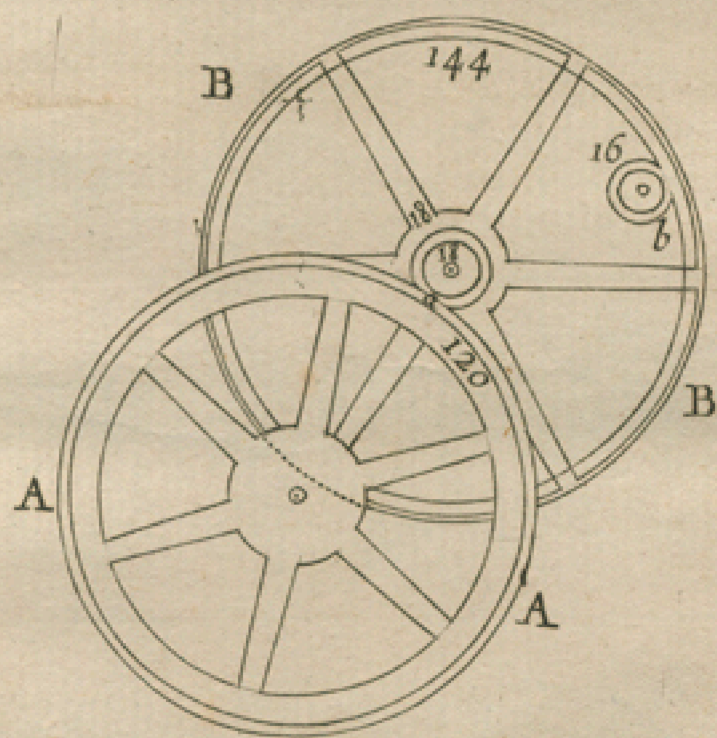


Fig. 4.

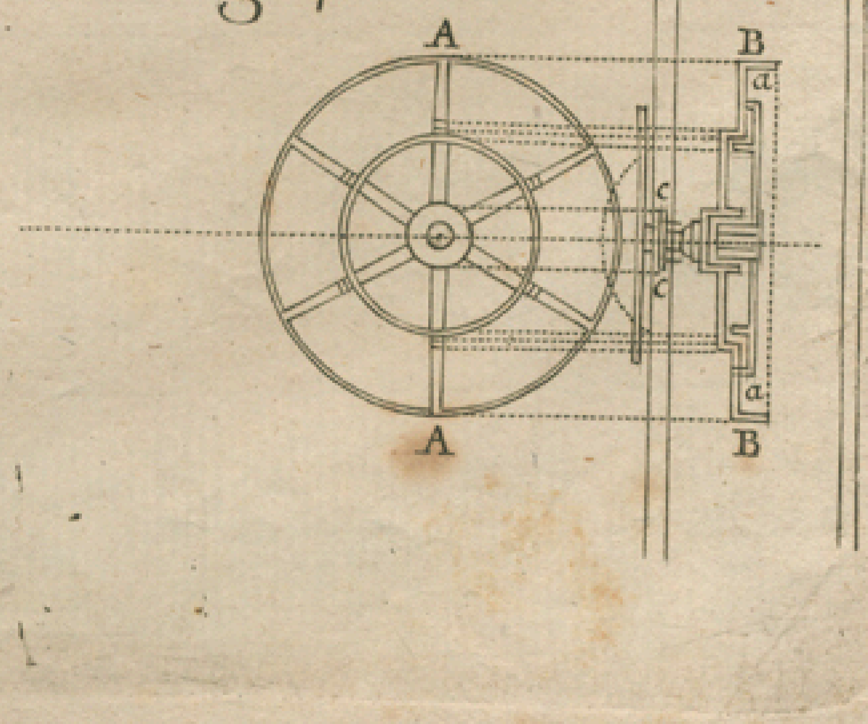
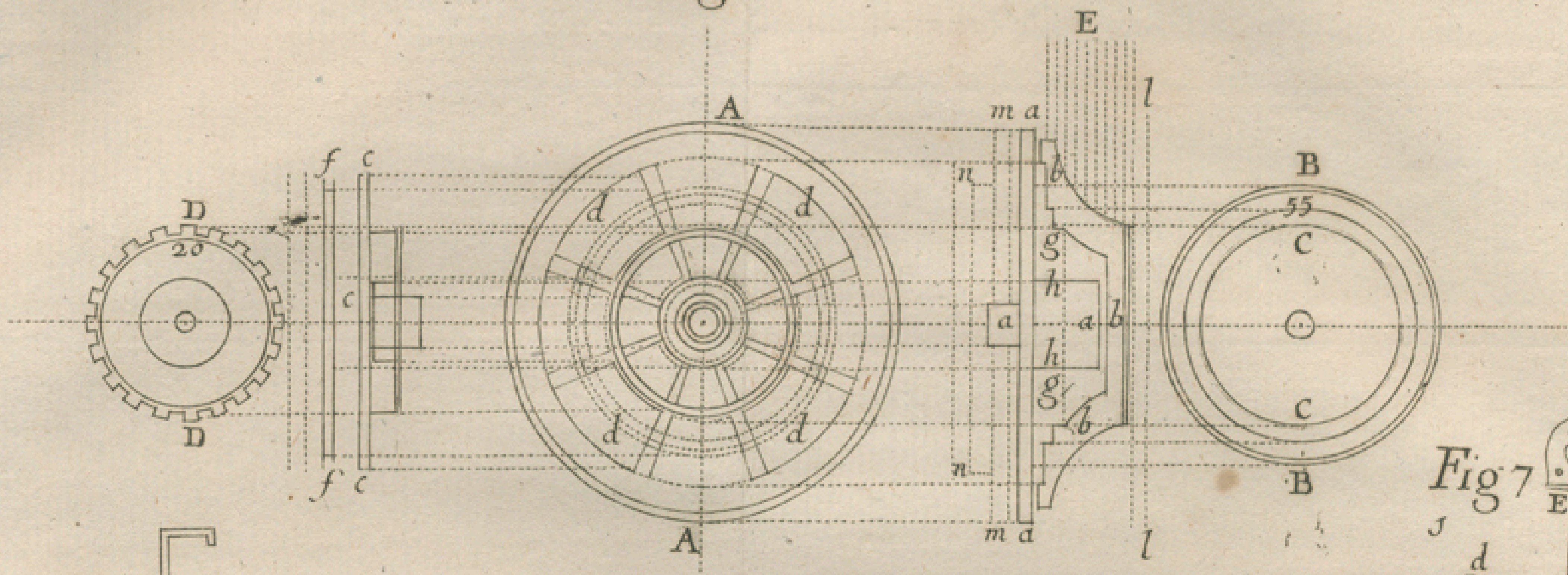


Fig 5.



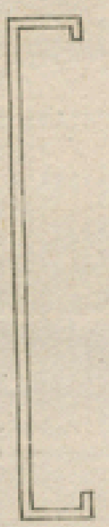


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Fig. 7 est un peu trop courte

Fig 7

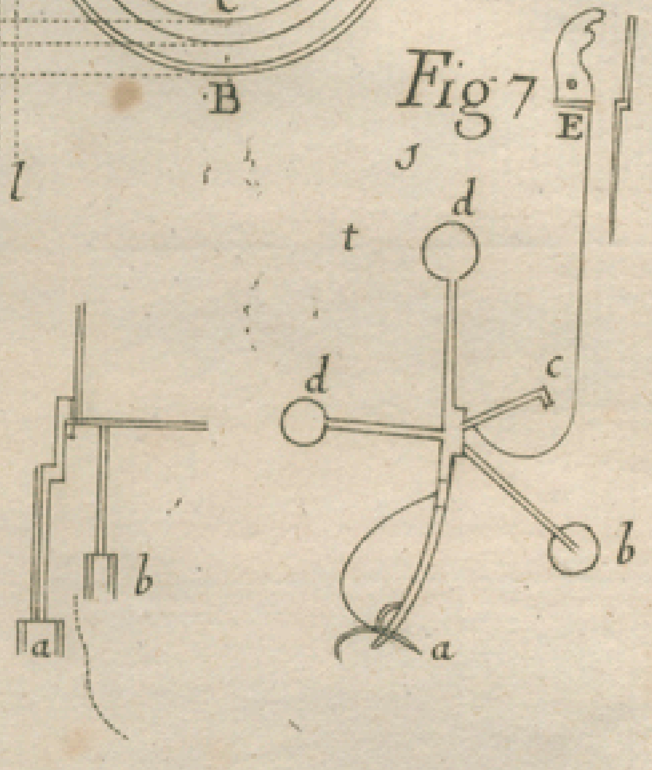
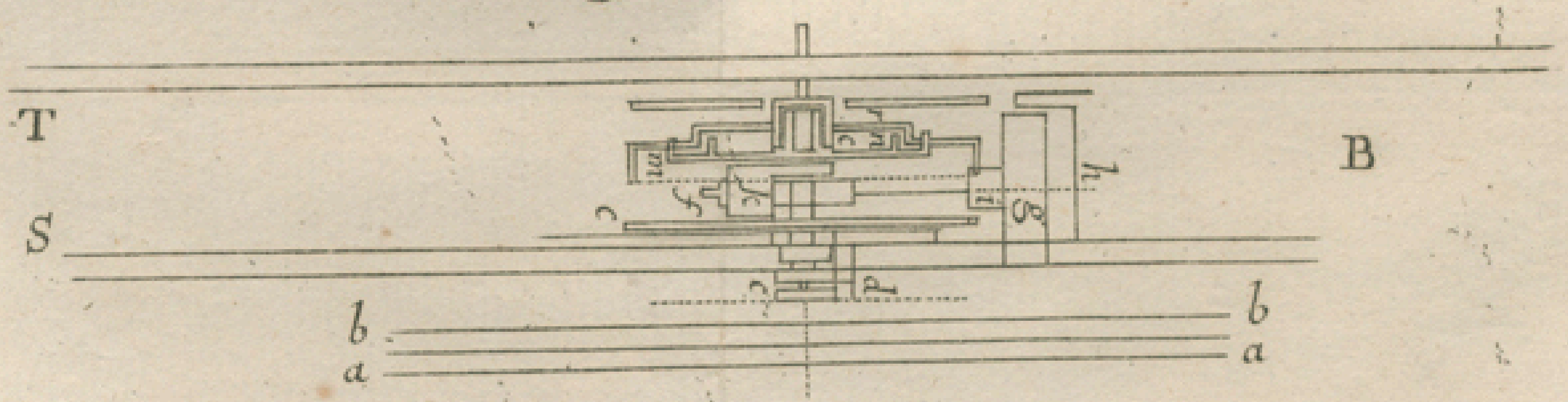
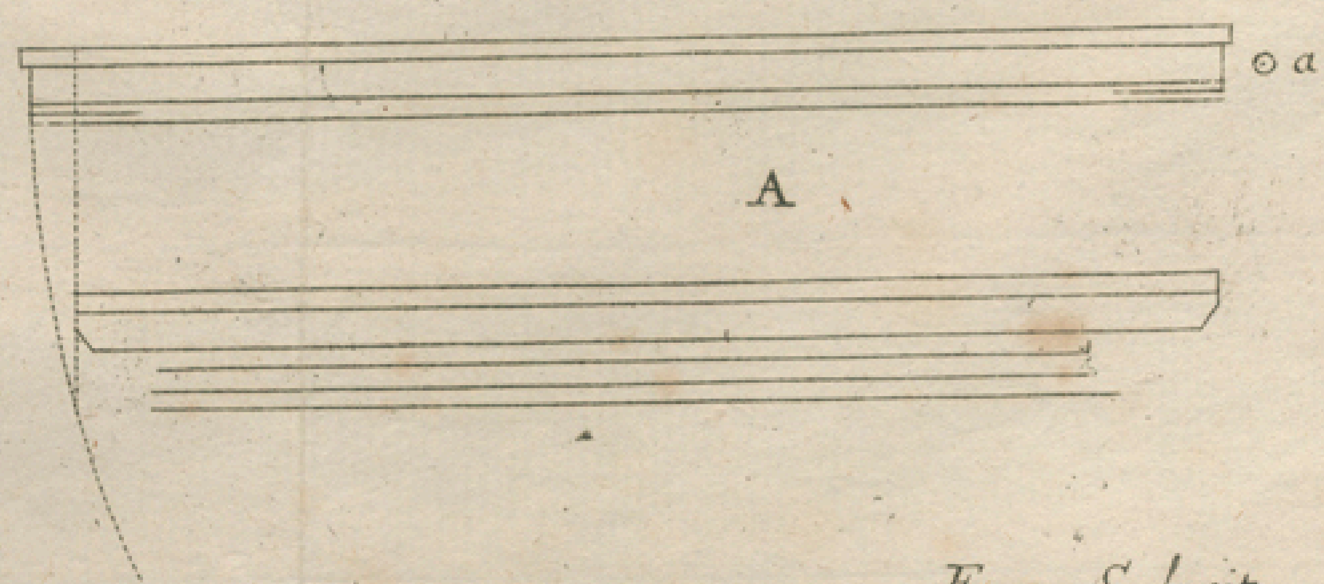


Fig. 6.





Faure Sculpsit

Fig. 8.

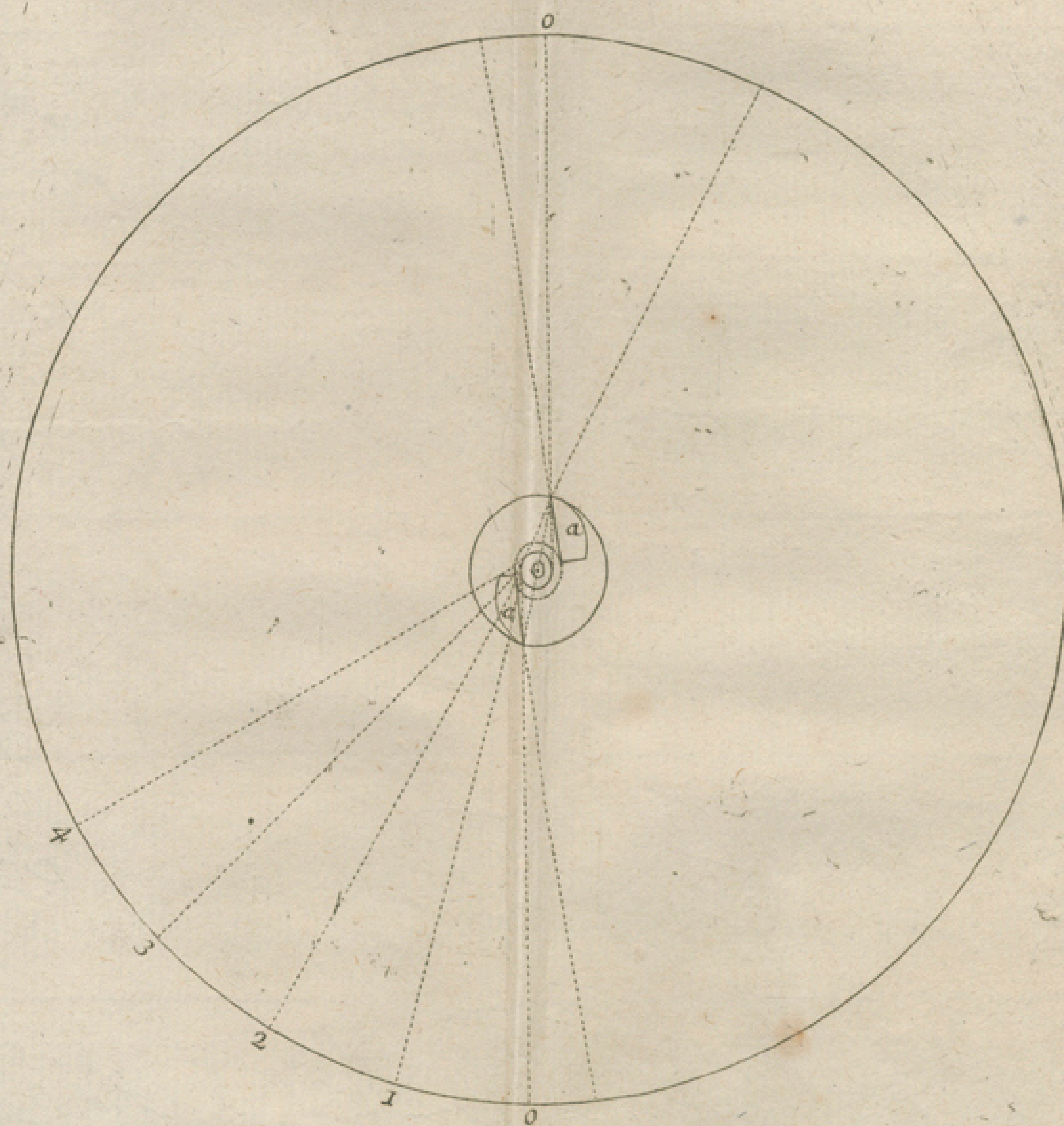


Fig 9.

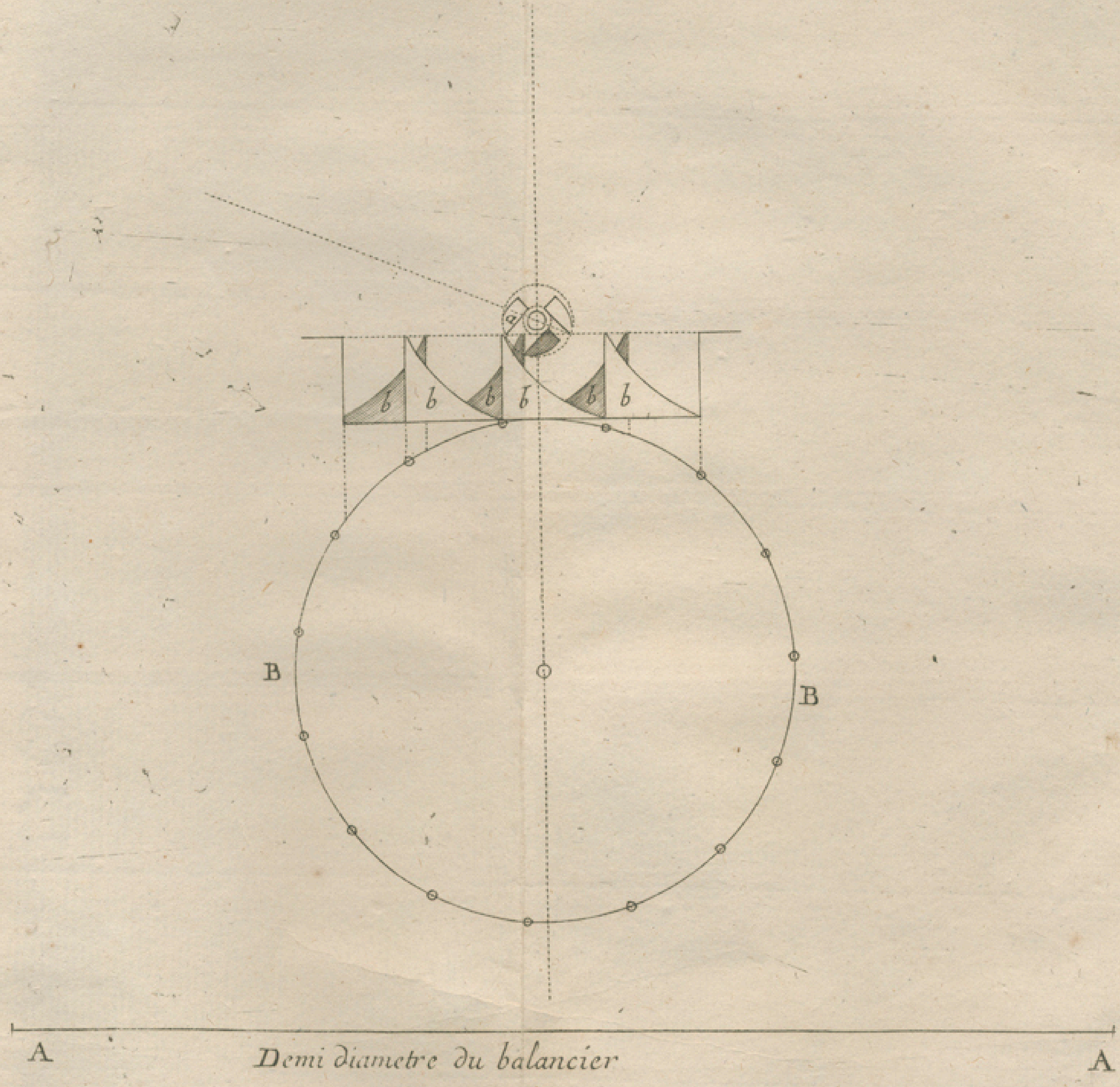


Planche V

Fig. 10.

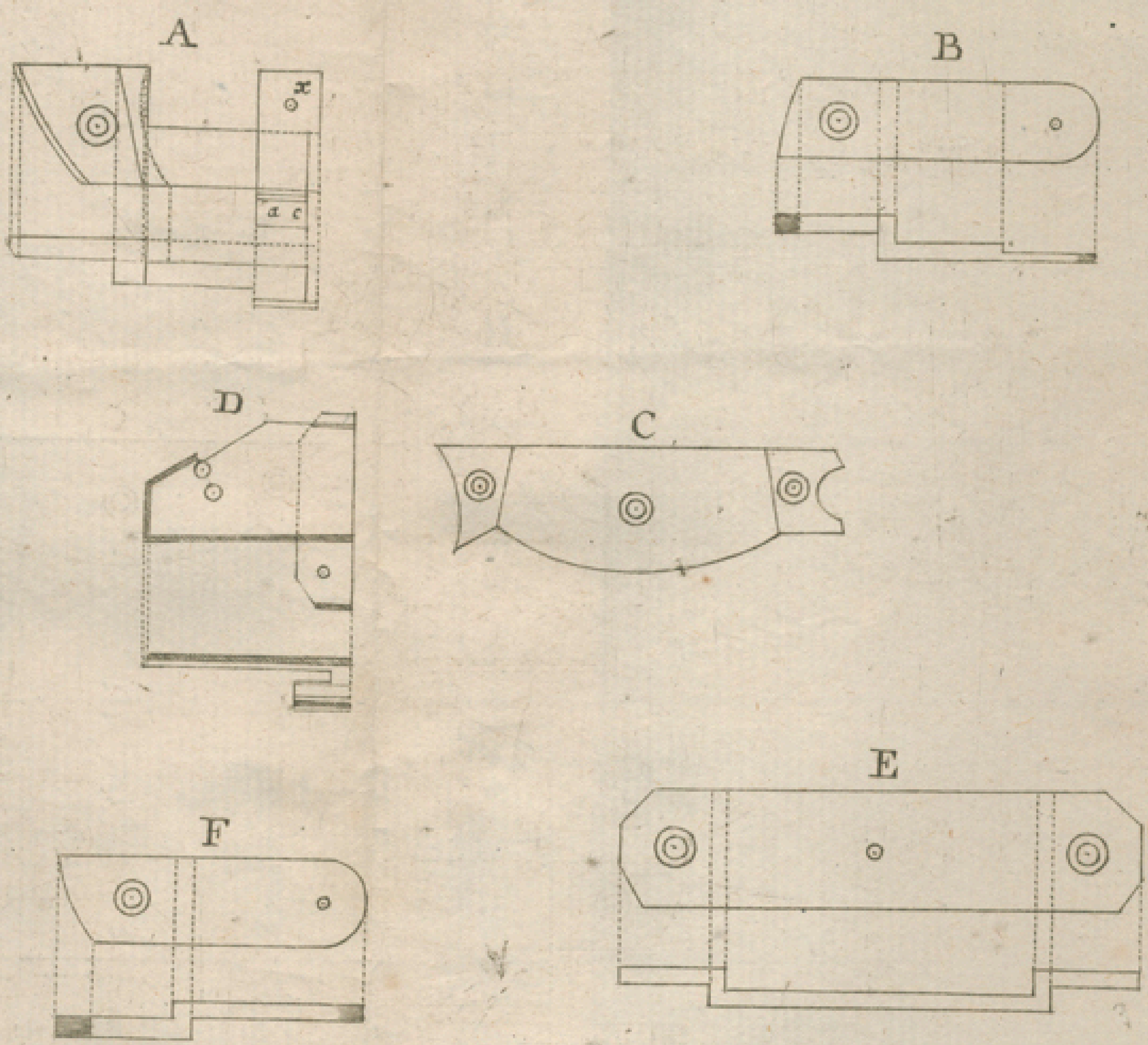


Fig. 11.

Planche VI.

Fig. 12

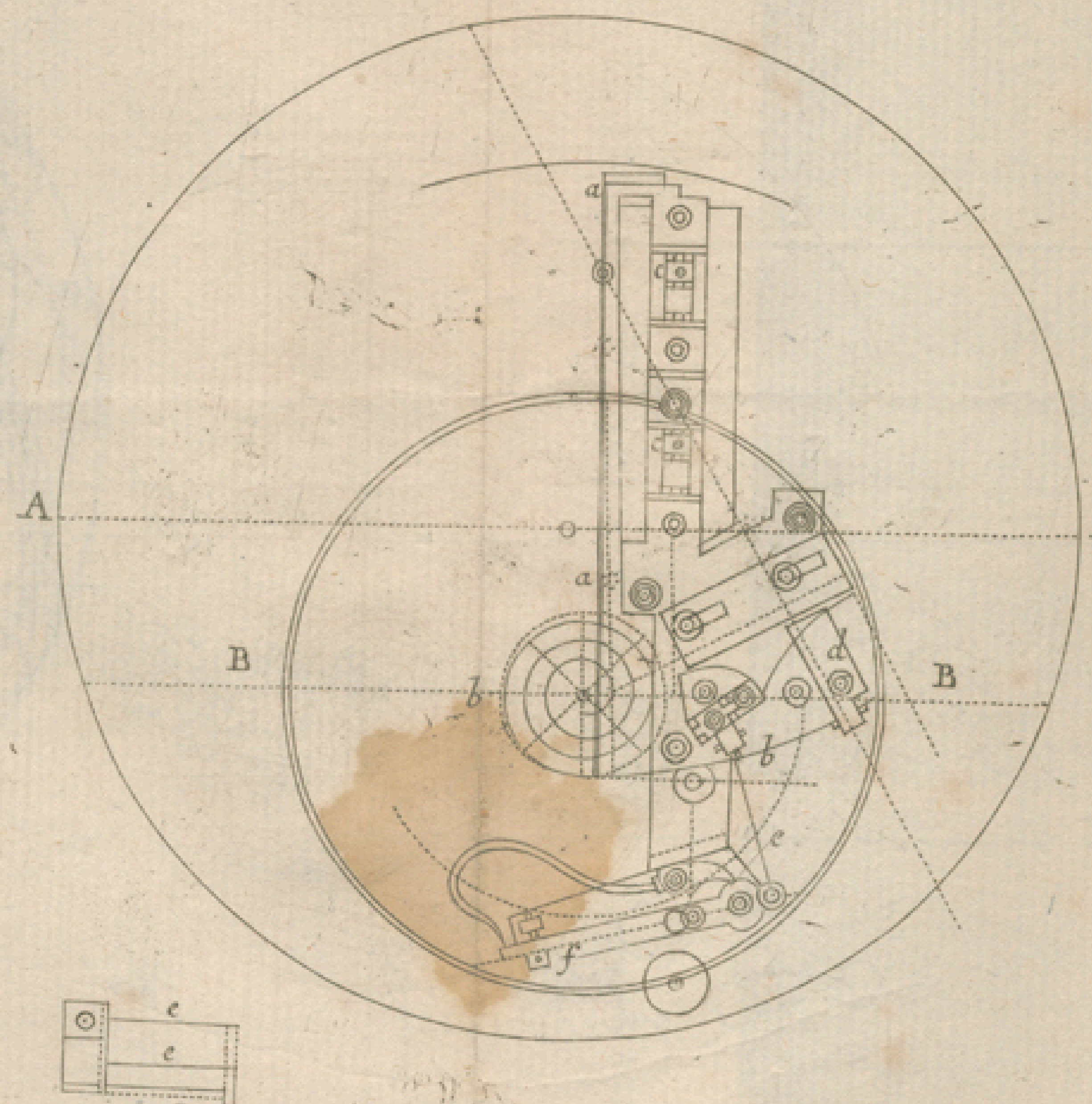


Fig. 13.