I. *The* Description *and* Use *of an* Arithmetical Machine *invented* by Christian-Ludovicus Gersten, *F. R. S. Professor of Mathematicks in the University of* Gießen. *Inscribed to* Sir Hans Sloane, *Bart.* President *of the* Royal Society. [*See* TAB. *Fig.* 1, 2, 3, 4, 5.]

SIR,

BEING at present on the Point of returning Home, I think myself obliged before my Departure, to return my humble Thanks to that Learned Body the *Royal Society,* over which you preside, for the Honour they have lately done me, in chusing me a Member ; and to make a grateful Acknowledgment to you in particular, for the many Favours and Civilities, which, according to that amiable Character of Benevolence to all Strangers in general, you have been pleased to bestow on me.

It is now a Duty incumbent on me to communicate to the *Royal Society* from time to time any thing new and curious, which may fall in my way : Therefore I now lay before them a Draught and Description of an *Arithmetical Machine,* which I invented about twelve or thirteen Years ago.

Sir *Samuel Morland* was, for ought I know, the first who undertook to perform Arithmetical Operations by Wheel-work. To this end he invented two different Machines, one for *Addition* and *Substraction,* the other for *Multiplication,* which he published in *London,* in the Year 1673, in *small*

Twelves

Twelves. He gives no more than the outward Figure of the Machines, and shews the Method of working them. But as by this every one, who has any Skill in Mechanicks, will be able to guess, how the inward Parts ought to be contrived ; so it cannot be denied, that these are two different Machines, independent of one another ; that the last, which is for *Multiplication*, is nothing else but an Application of the *Neipperian* Bones on flat moveable Disks ; consequently that his Invention alone is not fit to perform justly all Arithmetical Operations.

After him the celebrated Baron *de Leibnitz*, the Marchese *Poleni*, and Mr. *Leupold* took this Undertaking in hand, and attempted to perform it after different Methods.

The first published his Scheme in the Year 1709, in the *Miscellanea Berolinensia*, but then he gave only the outward Figure of the Machine. Signor *Poleni* communicated his, but explaining at the same time its inward Construction, in his *Miscellanea* of the same Year, 1709. Mr. *Leupold*'s Machine, together with those of Mr. *de Leibnitz* and Signor *Poleni*, were inserted in his *Theatrum Arithmetico-Geometricum*, published at *Leipzig* in 1727, after the Author's Death, yet imperfect, as it is owned in the Book itself.

Besides these, I learned from several *French* Journals, that *Charles Pascal* invented one, which however I never had the sight of.*

* The Description of this Machine is since printed by *M. Gallon* in his Collection of Machines and Inventions approved by the *Academy of Sciences* at *Paris* (published in *French* at *Paris*, 1735. in *Quarto*, in Six *Tomes*) in Tom. IV. *p.* 137 ; and likewise another by M. *Lespine*, Tom. IV. *p.* 131 ; and three more by M. *Hellerin de Boisfissandeau*, Tom. V. *p.* 103, 117, & 121.

I took

I took the Hint of mine from that of Mr. *de Leibnitz*, which put me upon thinking how the inward Structure might be contrived : But as it was not possible for me to hit upon the original Ideas of that Great Man, an exact Enquiry into the Nature of Arithmetical Operations furnished me at last with others, which I expressed in a rough Model of Wood, and shewed to some Patrons and Friends, who encouraged me to have another made of Brass : But the want of an Artificer, able enough to execute my Ideas, made me delay it till the Year 1725 ; when having spare Time, and finding an Inclination to divert myself with Mechanical Operations, I set about it, and finished the whole Work, fitted to a Reckoning not exceeding seven Places. And in *December* of the same Year, I had the Honour to lay this Machine before my Sovereign, the present Landgrave of *Hessen Darmstadt*, and the Hereditary Prince his Son, to whom I demonstrated the Mechanism of the whole Invention.

I own that the gracious Reception it met with from both their Highnesses, as well as the express Recommendation of Mr. *de Wieger*, one of the Prince's Privy-Council, would have been powerful Inducements for me to have publish'd at that time an Account of my Machine ; but I was checked by the Uncertainty I was under, whether possibly Mr. *Leibnitz*'s Machine had not been brought to its Perfection ; in which case there is no doubt but the Operation of his Machine, if it would really perform what is promised in the Description, would have been easier than mine, and consequently preferable to it, provided its Structure did not prove

too

too intricate, nor that the working of it took up too much time.

But at prefent, being certain that none of Mr. *Leibnitz*'s Invention has yet appeared in fuch a State of Perfection, as to have anfwer'd the Effect propofed, and that thefe of mine differ from all thofe mentioned above, fancying at the fame time, that Perfons who underftand Mechanicks, will find it plain, practicable, and exact, in regard to its various Effects, I make no Scruple to prefent to the *Royal Society* this Invention, the Product of my younger Years indeed, but now with the feveral Amendments I have fince added to it, as a Mark of the Refpect and Veneration I have for this illuftrious Body.

The Particulars of it are as follows :

There are as many Sets of Wheels and moveable Rulers as there are Places in the Numbers to be calculated. *Fig.* 1. fhews three of them, by which one may eafily conceive the reft. A A fhews the firft Syftem or the Figures of Unites, according to its inward Structure. B B and C C fhews the fecond and third Syftem, *viz.* of Tens and Hundreds, according to their outward Form. We fhall firft confider A A ; where $\alpha \alpha \alpha$ is a flat Bottom of a Brafs Plate, which may be skrewed on either upon a particular Iron Frame, or only upon a ftrong Piece of Walnut-Tree, doubled with the Grain crofs'd. In this Syftem are two moveable Rules *gggg*, and *kkk*, the firft of which I call the Operator, the fecond the Determinator. There are befides two Wheel-Works, the upper one is for *Addition* and *Subftraction*, the lower one ferves for *Multiplication* and

and *Division*. The upper one is provided first with *a*, an oblique Ratchet-Wheel of 10 Teeth, of what Diameter you please, on which, however, depends the Length and Breadth of the System itself. This Wheel has a Stop *r*, with a depressing Spring *t* ; Under the Wheel *a* is a smaller Wheel *b* of the same Shape : Both *a* and *b* are rivetted together, and fixed on a common Axis. Under the Wheel *b* lies a third *f*, which is a common Tooth-Wheel of 20 or more Teeth, according as one pleases : It is larger than *b*, and smaller than *a*, turns about the same Axis with the other two above it, and upon it is fixed a Stop *c*, with the Spring *d*, which catches the oblique Teeth of the Wheel *b*. Immediately under this Wheel lies the upper Part of the Opera·tor, which may be best made of Iron or Steel. The Wheels may all be of Brass, except the upper one. The Operator is of the same Thickness all over, and in its upper Part are fixed as many round Steel Pins as there are Teeth in the Wheel *f*, which are to catch the Teeth of this Wheel, and move it backwards and forwards. The Height of those Pins ought exactly to answer the Thickness of the Wheel *f*. The Axis of the Wheels *a* and *b* is kept perpendicularly by the Bridge *ee*, which is skrewed to the Bottom, as appears by the Figure. The Operator *gggg* moves on the Side, above, and in the Middle in two Brass Grooves *iii* and *qq* ; about D it jets out, on which Projection a Piece of Iron *h* must be well fastened, having a strong Pin, on which the Handle *z* fits, as you see in the System B B. The Side D itself slides in another Groove *ss*, and in its inner Corner joins to it the Determinator *kkk*, of the

the fame Thicknefs with the Operator, the Shape
of which is fufficiently expreffed in the Figure.
This flides alfo up and down, on the one Side in
the Groove *s s*, and *v* on the other Side, where it is
fmalleft, in a fmall Piece of Brafs *u*, and where it
is broadeft, above in the Operator itfelf, which is
either hollowed out into another Groove, or filed
off obliquely. The fliding Part of the Determina-
tor ought afterwards alfo to be fitted to it. Its
chief Part is the Lock *u*, ftanding perpendicular on
its broad Part. I have drawn it feparately in *Fig. 4.*
B B, in which the fliding Stop *c*, which is preffed
down by its Spring *d*, but raifed by the Tricker *a a*.
That Tricker has a Pin *b*, on which is skrewed on
the fmall Handle *l l* (*Fig.* 1. in the Syftems B B and
C C.) In the Brafs Bottom A A (or *a a Fig.* 1.) you
muft file out 10 Ratchet-Teeth or Kerfs, purpofely
for the Stop of this Lock, or, which is better, you
may infert into the Brafs Bottom a fmall Piece of Iron
filed out according to this Figure. The Partition
and Length of thefe Rachet-Teeth in the Bottom
muft fit exactly with the Circumference of the
Wheel *f*, (*Fig.* 1. *Syftem* A A,) with this Direction,
that if the Lock is kept by the uppermoft Tooth
in the Bottom, the Operator cannot be moved at
all ; but when by preffing down the Tricker *a a*,
(*Fig.* 4) the Determinator is fhoved down, and is
ftopp'd by the fecond or third Tooth in the Bottom,
the Operator being alfo drawn down as far as the
Determinator permits, makes the Stop *c* (*Fig.* 1.
Syft. A A) flide over 1 or 2 Teeth of the fecond
Wheel *b* ; confequently the fame Stop *c*, muft flide
over 9 Teeth, when the Lock of the Determinator
will

will ſtand before the 10th Tooth in the Bottom, and
the Operator is pulled down ſo far. If you have a
mind to apply theſe Rachet-Teeth on the Outſide of
the Plate ⊙ ⊙, that covers the Whole, you may fit
the Lock to it accordingly : But in this Caſe the
Covering-Plate muſt be well faſtened.

For *Multiplication* and *Diviſion*, there is pro-
perly in each Syſtem but one Wheel, likewiſe di-
vided into 10 Rachet-Teeth, on which is rivetted
the round Plate *l*, on which are engraved the Num-
bers or Figures : Theſe Wheels have no occaſion
for any Bridge, but may turn about a ſtrong Pin of
Steel, ſolder'd to the Bottom. The Rachet-Wheel *m m*
reſts on one Side upon the Determinator, and upon
a Piece of Braſs of the ſame Thickneſs, to which
are faſtened the Stop *n*, and the Spring *p*. Upon
the Operator is another Stop *o*, with its Spring ;
which Stop has a ſmall Arm at *o*, which is checked
by a ſmall Studd, to hinder the Spring's preſſing
the Stop lower down than it ought : By which
Contrivance it is ſo order'd, that after the Operator
is ſlid down ſo far as it can go, in being ſlid up
again, the Stop *o* will turn but one Tooth of the
Wheel *m m*. The round Plate *l* has in its Middle a
ſmall hollow Axis, on which are turned firſt two
Shoulders, and then a Skrew : This Skrew in the
Syſtem A A is an ordinary one, winding from the
left to the right.

But as each Syſtem ought to have Communication
with the preceding one, though not with that which
follows ; to this end a projecting Tooth of Commu-
nication made of Steel *ℊ* is rivetted to the upper
Plane of the uppermoſt Wheel *a*. This Tooth

muſt

muſt be placed exactly on the Point of a Tooth of
the Wheel, and by its Revolution catches and turns
every time but one Tooth of the uppermoſt Wheel
of the preceding Syſtem, ſliding over the following
one (if there be any) without touching it. For this
reaſon the Planes of the Braſs Bottoms in all the
Syſtems ought to incline a little. This will beſt ap-
pear from the Vertical Section, *Fig.* 2. (cut in *Fig.* 1.
in the Direction from ♭ to *f*) in which *α* is the
Braſs-Bottom, H H the Wood-Bottom, *g* the Ope-
rator, *i* the Groove, *f* the third common Tooth-
Wheel, *b* the ſecond Wheel, *a* the firſt or upper-
moſt Ratchet-Wheel, *e* the Bridge, ☉ the Covering-
Plate, and ♀ the Tooth of Communication. I have
repreſented all theſe Pieces of one Thickneſs ; but
every Artiſt will eaſily know where to add or
take off.

Fig. 5. ſhews the Plan and true Diſpoſition of the
Teeth in the ſeveral uppermoſt Wheels ; that is to
ſay, The Parallel Lines A B and C D ought always
to cut the Braſs Bottoms (which are like one ano-
ther in Length and Breadth) length-wiſe into two
equal Parts : Then the perpendicular Interſection
E F will determine the Centers *a* and *b*, of the two
Wheels H and G. The Stop *r* ought every time
to hold its Wheel in ſuch a manner, that the Points
of two Teeth coincide with the Line A B or C D.
The Obliquity of the Teeth is the ſame in both,
with this difference however, that in G, which is a
Wheel of the Syſtem A A, (*Fig.* 1.) they are cut
in from the left to the right, but in H (a Wheel of
the Syſtem B B) from right to the left. I need not
take notice, that for making the Work more durable,
the

the Teeth are not to be cut out into quite sharp
Points, but blunted a little, as in the Wheel H.
The Nicety of the whole Machine chiefly consists
in placing the Center *a* and *b,* or (which amounts to
the same thing) after having chosen the Breadth of
the Brass-Bottoms, in determining the Diameter of
the uppermost Wheel : For if that should prove so
large, as that the two Wheels H and G should very
near touch one another, the Tooth of Communica-
tion will be short, its Operation will be of a small
Force, and the Wheels themselves will require a very
great Exactness, lest by turning about the Wheel H,
and the Tooth of Communication standing in the
Position as it is represented in *Fig.* 5, a Tooth of
the Wheel H may touch it, and stop the Motion.
Whereas, on the other hand, supposing the Centers at
the same Distance, and the Diameters of both Wheels
less, the Tooth of Communication will be longer :
then such an Exactness is not requir'd in the Wheel,
yet more Force is necessary for making the Tooth
of Communication lay hold the better. Furthermore,
it will be well for you to make the undermost com-
mon Tooth-Wheel as large as you can.

From the Construction of this first System, with
which the 3d, 5th, 7th, *&c.* entirely agree, one may
easily imagine the 2d, 4th, 6th, 8th, *&c.* for every
thing there also is the same, except only, that it is
inverted ; so that what in the first stands on the
Right-hand, is on the Left in the second.

The Plate for *Multiplication* has on its hollow
Axis, as it is said before, two Shoulders, the lower-
most of which is very small, the Sum of its Height,
the Thickness of the Plate of the Wheel *m m,* and of

M   the

the Operator muſt amount to as much as anſwers to the Heighth of the Bridge *e e*. On both Ends of the Braſs-Bottoms, the two Piece of Braſs ꜩ ꜩ, of the ſame Height, are rivetted on. This being done, at laſt the Covering-Plates ⊙ ⊙ is prepared and skrewed on the Piece of Braſs ꜩ ꜩ. If the Machine be made pretty large, the Covering-Plate muſt be skrewed faſt, not only to the Bridge *e e*, but alſo not far from the Wheel of Multiplication. It muſt be provided not only with round Holes, through which are to go the Axis of each upper-moſt Wheel *a*, and the hollow Axis of the Plate *l*; but it muſt alſo have a long Slit, in which the Operator and Determinator may be moved up and down, and laſt of all a ſmall Window over the Plate of *Multiplication*, through which the Figure or Number engraved on the Plate may appear diſtinctly. To the projecting Skrew *l*, of the Plate *l*, is fitted an Handle *ff*, joined to an Index in the Shape of a Scythe. The Skrew in the Syſtem A A is a common Skrew, conſequently the Roundneſs of the Scythe muſt turn from the left to the right; but in the Syſtem B B, where it ought to be inverted, like all the other Parts, the Scythe muſt turn from the right to the left, as in the Figure. The Uſe of this is to ſhew which Way the Wheels are to be turned; and the Skrews are to prevent the Machine's being hurt by unskilful Hands.

On the Side of the Determinator, *viz.* on that Piece which cannot be preſſed down, is alſo skrewed a ſmall Index, which may be directed to ſuch Numbers or Figures as is required. Theſe Figures are to be engraved in the Covering-Plate, according

to the Figure, and their Diſtance depends on the Ratchet-Teeth *e e* (*Fig.* 4.) in the Braſs-Bottom.

On the Axis of each uppermoſt Wheel *a* (which Axis muſt be made ſquare as far as it projeɑs over the Covering-Plate) is fixed a thin round Silver-Plate *x x* (in the Syſtems BB and CC) or *a d* in *Fig.* 3. yet ſo that it may not rub againſt the Covering-Plate. It has a hollow Axis *b c* (*Fig.* 3.) on which is a right or left Skrew, according to the Syſtem it belongs to, and a ſmall Shoulder *c*. To the Skrew is ſkrewed the Handle *ſs* (Syſtem BB and CC, *Fig.* 1.) which is vertically flat on the Extremity, in order to turn by it the Plate and the Wheels. The Plate (as appears by the Figure) is divided by 3 concentrick Circles into two Rings, in the outmoſt of which are engraved the Numbers for *Addition*, in the inmoſt thoſe for *Subſtraɑion*. I will hereafter call this Plate only the *Silver-Plate*, the firſt Ring the *Addition-Ring*, the ſecond the *Subſtraɑion-Ring* : Moreover two Indexes *w* and *y* are ſkrewed to the Covering-Plate ; *w* ſhews the Numbers of the outmoſt or *Addition-Ring*, and *y* thoſe of the *Subſtraɑion-Ring*. They have Hinges, that they may be lifted up, and the *Silver-Plate* taken out or put in again : Their Curvature ſerves for a Direɑion, which way the Plates ought to be turned. A ſkilful Artificer will be able to give them a neater and handſomer Shape, than here in the Draught, where I would not cover the Numbers.

All this being done, there remains now the Figures or Numbers to be engraved, in the manner following : Place each uppermoſt Wheel *a* (Syſtem AA) ſo, that the Tooth of Communication be ready to

catch

catch (as in G, *Fig. 5*) which may be eafily felt. Obferve in the Silver-Plate, where the Index *w* points, and there engrave the Number or Figure 9, lower down in the *Subftraction-Ring*, where the Index *y* points, engrave the Cypher *o*. After this divide both Rings into 10 equal Parts, one of which is already defigned for 9 in the *Addition*, and another for *o* in the *Subftraction-Ring* ; then obferve which way the Wheel turns, if from the right to the left, as in Syftem BB ; then you muft from the engraved Number 9 in the *Addition-Ring*, towards the right engrave *o* next, then 1, 2, 3, 4, *&c.* and in the *Subftraction-Ring* towards the right alfo, from the already engraved *o*, firft engrave 9, then 8, 7, 6, *&c. ordine inverfo*. But if the Wheel turns from the left to the right, as in the Syftems AA and CC, you engrave the Numbers or Figures in the fame Order, but from the right to the left (See in *Fig.* 1. the *Syftems* BB and CC.)

In the *Multiplication-Wheels mm* you muft conduct the Index *ff* exactly to the Window, as it is drawn in the Syftem BB ; mark the Place on the round *Multiplication-Plate* under the Window, and engrave upon it the Cypher or *o* : Then make, by two concentrick Circles, a Ring upon this Plate, and divide this Ring into ten equal Parts, and after the *o* (already engraved) engrave on the Numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, in the fame Order as it was done in the *Addition-Ring* of the Silver-Plate of the fame Syftem. Laft of all, if you think fit, you may skrew on thin Ivory Plates, to note upon them the Numbers which are to be calculated, particularly a long fmall one on that Side of the Slit of the Determinator, where there are no Numbers, and alfo two

shorter

shorter broader ones, one under the Window of *Multiplication*, the other above the Silver-Plate. All this together composes a Machine, by the help of which you may perform all the four Arithmetical Rules or Operations. The Way of working it, is as follows :

1. *As to Addition :* For instance, if you are to add 32 and 59 ; because the hindmost System A A in the Figure, which ought to represent the Place of Unites, is not cover'd, let us take the System B B for the Place of the Unites, and the System C C for the Place of the Tens ; turn the Silver-Plates *x x* in these two Systems, that the Indexes *w w* point to the two Numbers 5 and 9 ; then make the De-terminators *ll, ll,* point also to 3 and 2 : next take one of the two Operators, *ex. gr.* in B B, and pull it down as far as you can, and move it upwards again. This done, the Number 1 of the Silver-Plate in B B will come by this means under the Index *w,* and the Number 6 of the Silver-Plate in the System C C under its Index at the same time, which is 61, the Sum, 59 and 2. After this move the Operator of the System C C also up and down, when instead of 6, 9 will come under the Index ; consequently you have 91 under the Indexes *w w,* which is the Sum requir'd of 59 and 32 added together. The Reason of it is plain ; for by pulling down the Operator of the System B B so far, the Stop *c* of the lower-most or common Tooth-Wheel *f* (*vid.* Syst. A A) will slide over two Teeth of the Ratchet-middle-most Wheel *b* ; and by moving the Operator up again, the same Stop *c* will turn the two Ratchet-Wheels *a* and *b* together, and cause the Stop *r* of

the

the great or uppermoft Wheel *a* to flide alfo over two Teeth ; at the fame time the Tooth of Communication *ρ* will move forward one Tooth of the uppermoft Ratchet-Wheel in the Syftem C C ; confequently on the Silver-Plate in B B, inftead of 9 the Number 1, and in Syftem C C, inftead of 5 the Number 6 muft appear under their Indexes *w w* ; and fo for the fame reafon, having pulled up and down the Operator of the Syftem C C, the Number 6 pointed to by the Index muft be at laft changed into 9.

II. *Subftraction.* Suppofe 40 the Sum, from which you are to fubftract 24 : Here you muft put your Sum 40 in the *Subftraction-Rings* ; that is to fay, turn the Cypher *o* in the Syftem B B, and the Number 4 in the Syftem C C, under the Indexes *y y*, as the Figure fhews : Set the Determinators at 24, as in *Addition* ; move alfo the Operators only once up and down, the Remainder 16 will appear under the Indexes *y y*. As for the Reafon of this Operation, when you confider, that the Numbers in the *Subftraction-Rings* are engraved *inverfo ordine,* as it is faid before, you will find that it is the fame as in *Addition.*

III. *Multiplication.* For inftance ; if you are to multiply 43 by 3, bring the *o* in all your *Addition-Rings* to the Indexes, as alfo in all your *Multiplication-Plates* in the Windows. Write down (which is more particularly neceffary if the Numbers are larger than here) the Multiplicand 43 upon the Ivory-Plates near the two Determinators in the two Syftems B B and C C : But the Multiplicator 3, you may write only on the Ivory-Plate under the

Window of the System B B. Set the Determinators
at 43 ; then move your Operators successively as
often up and down, till there appears in both Windows the Number 3 ; then you will see on your
Addition-Rings under the Indexes, the Product 129.

It is easy to understand, that as the *Multiplication* is nothing else than a repeated *Addition*, the
Machine does also perform its Operation by a repeated *Addition* only : For the Number 3, which
appears in the Window of the System B B, shews how
many times you have added the Number 3, pointed
by the Determinator to itself, which when done
3 times, is 9. And so the same Number 3, which
appears in the Window of the System C C, after
your Operation, shews how many times you
have added the Number 4 to itself. I need not to
make you observe, that besides the two Systems B B
and C C, there must be supposed another, not express'd in the Figure, which will shew the Number 1 of the Product 129.

IV. *Division.* If you are, for instance, to divide
40 by 3, set your Dividend 40 in the *Substraction-Rings* under the Indexes *y y*, in the System B B
and C C ; turn the Indexes *ff*, *ff*, near the Windows
to make *o* appear ; write your Divisor near the
Determinator of the System C C, and set the Determinator at 3 ; pull the Operator up and down, then
you will have 1 under the Index *y*, and 1 likewise
in the Window. By this you see, that you cannot
work further in this System C C, because you cannot substract 3 from 1 : You must therefore go on,
to the other Figure of the Dividend, *viz.* o, and
in the System B B set the Determinator again at 3.

This

This being done, the first pulling of the Operator up and down will produce 1 in the Window, and 7 in the *Subſtraction-Ring* under the Index, and the Number 1 which remained before in the Syſtem C C will be changed into *o*. Now as 7 is more than 3, you muſt work on accordingly; having done it twice more, you will find that there remains under the Index *y* but 1, (which is the Numerator of your Fraction) and below in the two Windows the Quotient 13. When you conſider that *Diviſion* is nothing elſe but a repeated *Subſtraction*, you will alſo eaſily underſtand the reaſon of this Operation.

Thoſe that underſtand the matter ever ſo little, may now eaſily conceive how they are to proceed with this Machine in larger *Examples* : However, for greater Clearneſs, I will explain it by two *Examples*.

Suppoſing there are ſix Syſtems, *a, b, c, d, e, f*; Let all the Numbers pointed to by the Indexes *ww* be in A B; thoſe which are to be pointed to by the Determinators, in C D; and thoſe which are ſeen in the Windows, in E F. Firſt of all,

	f	e	d	c	b	a	
A	o	o	o	o	o	o	B
C			3	5	6	3	D
E	o	o	o	o	o	o	F
					5	8	

you muſt turn all your *Addition-Rings* of the *Silver-Plates* and your *Multiplication-Plates* to *o* ; *viz*. that under all the Indexes *w w*, and in the Windows nothing may appear but *o*. Write the Number 3563 near the Determinator, in the Syſtems *a, b, c, d,* and direct them accordingly : The other Number 58, you muſt write down likewiſe, but under the Windows in Syſtem *a* and *b*, as you ſee in this Scheme.

Scheme. Move the feveral Operators, which are moveable, fucceffively as often up and down, till 8 appears below in the Windows, and you will have under the Indexes above 28504, the Product of 3563 × 8. And fo the Numbers of the Machine will appear thus.

	f	e	d	c	b	a	
A	o	2	8	5	o	4	B
C			3	5	6	3	D
E	o	o	8	8	8	8	F
					5	8	

Next advance your Multiplicand 3563, from the Right to the Left ; that is to fay, place the Determinator in the Syftem *b* at 3, in *c* at 6, in *d* at 5, in *e* at 3, and reduce every Number in the Windows to o, except in the Syftem *a*. See the *Scheme* following.

	f	e	d	c	b	a	
A	o	2	8	5	o	4	B
C			3	5	6	3	D
E	o	o	o	o	o	8	F
					5	8	

Then pull all the Operators again fucceffively in *b*, *c*, *d*, and *e*, up and down, till 5 appears in the Windows below, and you will find at laft under the Indexes 206654, the Product of 3563 × 58.

	f	e	d	c	b	a	
A	2	o	6	6	5	4	B
C			3	5	6	3	D
E		5	5	5	5	8	F
					5	8	

N

But

But if you are to divide again 206654 by 3563, you muſt place the Dividend above in the *Sub-ſtraction-Rings* under the Indexes. In the Windows below, every Figure muſt be 0, likewiſe as in the *Multiplication*; and write the Diviſor under the Dividend, according to *Vulgar Arithmetick,* and as in the *Figure* here annexed.

	f	e	d	c	b	a	
A	2	0	6	6	5	4	B
C			3	5	6	3	D
E	0	0	0	0	0	0	F

If you direct the Determinators in *e, d, c, b,* to their Numbers, and ſubſtract this Diviſor by pulling up and down the Operators as often as you can, you will have in theWindows in *e, d, c, b,* every where 5; but on the *Silver-Plates* there will remain 28504. Now advancing your Diviſor from the Left to the Right, bringing to the Windows in *d, c, b,* all the Cyphers 0, and operating as before, there will at laſt appear on the *Silver-Plates* nothing at all, but below in theWindows 5888. See the *Figure* following:

	f	e	d	c	b	a	
A	0	0	0	0	0	0	B
C			3	5	6	5	D
E		5	8	8	8	8	F

And here you have only this to obſerve, that in ſuch Caſes, you cut off all the hindermoſt Figures or Numbers in E F, except that which ſtands under the firſt Figure of the Diviſor; what remains is your Quotient.

As for what remains, if it be objected that this Machine cannot be fitted for ſo many and long Numbers,

Numbers, as one would pleafe, becaufe the Multiplication of fo many Syftems would require too great a Force for one Operator to move fo many Wheels, kept by Springs, fuppofing the cafe that all the Teeth of Communication fhould duly catch ; I own that this Objection is but too well grounded : However, I cannot help obferving at the fame time, that this Defect can hardly be avoided, in any Arithmetical Machine, for performing all thofe Operations of itfelf, without the help of the Mind : For there muft certainly be a particular Syftem for each Place of Figures, which is to communicate with the next ; confequenly, as the Syftems encreafe in Number, the Force muft encreafe alfo which is requir'd for moving them all. Befides, it ought to be confider'd, of what Size fuch a Machine ought to be, which might ferve for common Ufe. I think few Calculations could be required, for which 14 or 16 Syftems might not fuffice. That which I made was of 7 Syftems, as I have already mention'd. The Difpofition of it was neither fo well contrived as I have explained it here, nor were its feveral Parts fo well wrought, as a good Artificer, who makes Profeffion of fuch Work, might have performed it ; yet thofe 7 Syftems were very eafily put in Motion ; and if in a Machine for 14 Figures made by a skilful Hand, it could not be fo eafily practicable, this Defect, I believe, might be eafily remedied, by applying the other Hand in the fifth or fixth Syftem to the Handle *fs*, in order to eafe and affift the Operator.

I am your humble Servant,

C. L. GERSTEN.

II. *Of*