V. *Effay on a new Method of applying the Screw. By Mr.*
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neral Melville, *F. R. S.*

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I HAVE fome time ago been led to think, that the fcrew,
which of all the mechanical powers is the moft commonly
employed in performing motions which require great accuracy,
might be applied in a manner which would better anfwer many
intentions than that commonly ufed. The plan is fomewhat
fimilar to NONIUS's divifion of the circle; but before I explain
myfelf farther it may be proper to lay down a few general
rules on which we may found a comparifon.

The perfection of any machine confifts in accomplifhing the
end propofed in a manner the moft effectual, the moft expedi-
tious, and the leaft cumberfome poffible. In order to attain
this end the following things are required.

1. That the ftrength of the feveral parts of the engine be fo
adjufted to the force they are intended to exert, as that they
fhall not break under the weight they ought to counteract, nor
yet encumber the motion by a greater quantity of matter than
is neceffary to give them a proper degree of ftrength.

2. That the increafe of power, by means of the machine,
be fo regulated, that while the force we can exert is thereby
rendered adequate to the effect, it may not be retarded in pro-
curing it more than is abfolutely neceffary.

3. That

3. That the machine be as fimple as is confiftent with other conditions.

4. That it be as portable and as little troublefome in the application as poffible.

5. That the contrivance be fuch that the moving power may be applied in fuch a way as to act to the greateft advantage ; and that the motion ultimately produced may have that direction and velocity which is moft adapted to the execution of the defign propofed by the whole.

6. Of two machines, equal in other refpects, that deferves the preference in which the friction leaft diminifhes the effect propofed by the whole.

It will eafily appear, that fome of thefe conditions, if carried to an extreme, will be inconfiftent with fome of the others. Here the proper medium confifts in adapting them to each other in fuch a manner, as that the refult of the advantages of both may be the greateft, and that of the defects the leaft, that is poffible.

The following method of applying the fcrew, I think, may in certain cafes be attended with fome of thefe advantages to a greater degree than by thofe commonly practifed.

Let AB (fig. 1.) be a plate of metal in which the fcrew CD plays, having a number of threads in an inch equal to a. Within the fcrew CD there is a female fcrew, by which is received the fmaller fcrew DE of $a + 1$ threads in an inch. This fcrew is retained from moving round along with the fcrew CD by means of the apparatus at AFGB.

Now, if the handle CKL be turned a times round the fcrew, CD will advance upwards an inch, and if we fuppofe the fcrew DE to move round along with CD, the point E will alfo advance an inch. If we now turn the fcrew DE a times backwards, the

point

point E will move downwards $\frac{a}{a+1}$ of an inch, and the refult

of both motions will be to lift the point E upward $(1 - \frac{a}{a+1} =)$

$\frac{1}{a+1}$ of an inch. But if, while the fcrew CD is turned a times

round, DE be kept from moving, the effect will be the fame as

if it had moved a times round with CD and been a times turned

back, that is, it will advance $\frac{1}{a+1}$ of an inch. At one turn

therefore of the handle CKL it will move upwards $(\frac{1}{a+1} \times \frac{1}{a} =)$

$\frac{1}{a^2+a}$ of an inch. If then we fuppofe the handle CKL to be

b inches long, the power gained by the machine will be as

$\overline{a^2+a} \times 6,2832\ b$ to unity.

To illuftrate this by a particular example, let the fcrew CD
have 10 threads in an inch, and DE 11 : then, while the handle
CKL is turned 10 times round, the point D will rife one inch
above its former fituation. But at 10 turns it can only pafs over
10 threads of the fcrew DE, and confequently it will advance
upon that fcrew $\frac{10}{11}$ths of an inch. The point E therefore muft
rife $\frac{1}{11}$th of an inch, that the point D may have room to rife a
complete inch above its former place : therefore, at one turn of
the handle, the point E will rife $\frac{1}{110}$th of an inch ; and if the
handle be fuppofed half a foot long, the power, to produce an
equilibrium, muft be to the weight as 1 to $110 \times 6,2832 \times 6 =$
4146,912, which is the very number exprefled by the general
theorem, *viz.* $\overline{a^2+a} \times 6,2832\ b$, calling $a = 10$ and $b = 6$.

Now let us compare, according to the rules before laid down,
this method of ufing the fcrew with the common one. And,
firft, in order to have the fame power by means of the common
fcrew that is exerted by this machine, it muft have a number of
                                                                  threads

threads in an inch equal to $a^2 + a$, which would render it too weak to refift any confiderable violence. For example, if DC have five threads in an inch, and DE fix, and if the handle CKL is a foot in length, the power gained by the engine will be nearly as $(\overline{a^2 + a} \times 6\,b =)$ 2160 to 1; whereas, to have the fame force by means of the common fcrew, it muft have 30 threads in an inch, and fo muft yield under a refiftance which the other fcrew would overcome without any difficulty. Upon this principle, the fcrew may be applied with advantage in preffes of different kinds, by fixing one of the plates of the prefs to the end of the fcrew at E.

As to the fecond requifite, both methods may be equally adapted to it; yet other circumftances will determine us to apply the common fcrew where a fmall increafe of power is neceffary, and the prefent contrivance, when we ftand in need of a greater.

This will follow from the third rule, as in the method now propofed a double number of fcrews is required, which makes the ftructure more complicated, occafions more expence, and requires a greater accuracy of conftruction, fince, unlefs this is attended to, the machine will not move.

However, the machine may, in fome cafes, anfwer the fourth intention better than the common one, as the power gained by the additional fcrew enables us to fhorten the handle which will tend to make the whole more portable.

The power is here applied in the fame direction as in the common fcrew, fo that both equally anfwer the firft part of the fifth rule; but as to the laft, the motion *ultimately* produced, it will depend on particular circumftances which of them is moft fit for ufe in any cafe. Thus, if the fcrew DE be intended to carry an index which muft turn round at the fame time that it rifes upwards, the common fcrew is preferable; for although I

can

can fee a method by which the machine before defcribed may
be made to anfwer this purpofe, I am almoft afraid to propofe
it. I mean, that within the fcrew DE another ftill fmaller
fhould be made to play, and be conne&ed with the fcrew CD, fo
as to move round along with it. It muft have $a^2 + a + 1$ threads
in an inch, and they muft be in the contrary dire&ion to thofe
of CD, fo that when they are both turned together, and CD
moves upwards, this other one may move downwards. At one

turn of the handle this will move upwards $\dfrac{1}{a^2+a} \times \dfrac{1}{a^2+a+1}$

$= \dfrac{1}{a^4 + 2a^3 + 2a^2 + a}$ of an inch, and at the fame time will move

round in a circular dire&ion. For example, let CD have 5
threads $(=a)$ in an inch, DE 6 $(=a1)$, and a third fcrew within
DE, but conne&ed with CD fo as to partake of its motion, 31
$(= a^2 + a + 1)$. At one turn of the handle, this fcrew will rife
upwards $\frac{1}{5} \times \frac{1}{6} \times \frac{1}{31} = \frac{1}{930}$ of an inch; but this appears too
complicated for ufe, and the leaft inaccuracy in the conftruc-
tion would hinder it from moving.

But, on the other hand, if while the point E rifes it is of
confequence that it be kept from going round, the machine
under confideration will beft anfwer this purpofe. On this
principle it may be ufeful in feveral refpe&s : fot inftance, let
A (fig. 2.) reprefent a magnifying lens, and let it be moveable
upon the fcrew BC of 16 threads in an inch, which turns within
the larger fcrew CD of 15 threads in an inch, and that again
moves within the plate EF in the end of the cylinder GF *.
To ufe the inftrument, fix the obje& to be magnified upon the
pin GL, and then turn the lens A upon the fcrew BC, till it be

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* The fcrew BC is reftrained from moving along with CD by the fmall pillar HK,
which flides backwards and forwards in a groove in the cylinder GF.

nearly

nearly at the proper diſtance from the pin, and oppoſite to it. You may then adjuſt the diſtance more accurately by turning the ſcrew DC, at each turn of which the lens will recede from, or approach to, the pin $\frac{1}{240}$th of an inch. This it will do and not turn aſide, but ſtill remain oppoſite to the pin LG. A double microſcope might be fitted on in the place of the lens A. The whole inſtrument may be furniſhed with a handle, as at M; or, if larger, it may have three feet to ſtand on a table.

On the laſt principle it muſt be owned, the common ſcrew has the advantage, as two ſcrews will produce more friction than one; and, beſides, in the compound engine there is an additional friction from the piece FG (fig. 1.) upon the pillars between which it moves.

Another caſe in which this machine may be employed is in the micrometer. Thus, let the ſcrew AB (fig. 3.) of 50 threads in an inch be turned round by the index c, which moves upon the graduated circle ECD in the direction CD. Within the ſcrew AB is the ſmaller one AF of 51 threads in an inch, retained from moving round by the bar GFH. The piece AF is continued to K, where it forms a fine point. To uſe the inſtrument, let it be adjuſted to the teleſcope or microſcope by which you are to view a ſtar, or ſome ſmall object, and let the point K appear juſt to touch one edge of the object. Then turn the index c, and the point K will advance upwards till it appears to cover the other edge of the object, and thus you can determine its ſize. The point K will advance at each complete turn of the index $\frac{1}{2550}$ of an inch; and if the circle be divided into 80 equal parts, one of which, if it is an inch in diameter, will be very obſervable, while the index moves over one of theſe, the point K will advance $\frac{1}{204000}$ of an inch.

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Thus,

Thus, for example, fuppofe I am to meafure the diameter of a nervous fibre in the medullary fubftance of the brain, I make the point κ appear clofe to one edge, and turn the index till the fame point pafs over the fibre, and appear to touch the other edge : I then look on the graduated circle ECD, and perceive that the index c has paffed over, fuppofe, 23,2 divifions. Hence I conclude the diameter of the fibre to be $23,2 \times \frac{1}{204800} = \frac{1}{8790}$ of an inch, which is nearly the fize as found by the accurate obfervations of Dr. MONRO. There fhould be a NONIUS's fcale on the index which will meafure to one tenth of a divifion.

As the index c muft continue clofe to the plate ECD, while at the fame time it turns round the fcrew AB, which is continually rifing, it muft be made as in fig. 4. where *a*, *b*, are two fmall pieces which play in a groove in the fcrew AB (fig. 3.) while the groove CD (fig. 4.) in the index is filled up by a protuberance of the plate ECD (fig. 3.); the piece below the groove *c d* (fig. 4.) being funk into that plate. The whole machinery may be in-clofed in a cylinder of brafs reaching from B to L (fig. 3.), fo that the point of the fcrew KL may be without it, and the fides of the cylinder may be open at ECD.

It is farther to be obferved, that what has been faid goes on the fuppofition that the point κ, in the micrometer, is equally mag-nified with the object we are to meafure. But, if this point be placed in the focus of the eye-glafs of a double microfcope; when it moves it will pafs over, not the object itfelf, but its image, magnified by the object-glafs. In this cafe, if the object-glafs magnify the diameter 10 times, while the index paffes over one divifion, the point κ will pafs over the image of an object, the diameter of which is $\frac{1}{2048000}$ of an inch. As in this mode of application the point κ muft fall between the

object

object and eye-glafs, the fcrews may be contained within the *fulcrum* by which the microfcope is fupported.

The machine (fig. 1.) may be applied as a jack to raife great weights a little way from the ground, by fubftituting two crofs hand-fpikes for the handle CKL; or a vertical handle may be employed in the following manner. Let A (fig. 5.) be a pinion turned by the handle AB, which we fuppofe a foot in length. Let the pinion A have 4 teeth, and move the wheel CD of 16 teeth. The fcrew EF of 4 threads in an inch is fixed in this wheel, and turns round along with it. Within it plays the fcrew FG of 5 threads in an inch, and which we fuppofe prevented from following the motion of EF : it terminates in fuch a fhoulder as that reprefented at G, and being continued to H ends in a foot as in the figure. The whole is inclofed in a ftrong frame. The pinion A muft be connected in fuch a manner with the wheel CD as to rife within the frame along with it, which may eafily be done by making its axis play in a piece of wood or metal, which is connected by the end to the fcrew EF. Or, if this fhould be deemed inconvenient, as the rifing of the pinion muft raife the handle AB, the wheel CD may be hindered from rifing, and at the fame time turn the fcrew EF, by a contrivance fimilar to that ufed with the index c (fig. 3.) in the micrometer. In either cafe, the axis of the pinion fhould be continued through the oppofite fide of the frame, and armed with a heavy fly to regulate the motion. When the machine is to be applied to ufe, the bottom of the frame refting on the ground, if the body to be lifted is already as high as the top G, that top is applied below it; but if it is clofe to the ground, we put below it the foot H; then, if the handle AB be turned once round, the wheel CD and fcrew EF will turn $\frac{1}{4}$ part round, and the point F will rife ($\frac{1}{4} \times \frac{1}{4} =$) $\frac{1}{16}$th of an inch. The point G or H will

therefore

therefore be lifted upwards $(\frac{1}{16} \times \frac{1}{5} =)$ $\frac{1}{80}$th of an inch. But the end B of the handle AB has defcribed above fix feet; therefore the velocity of the point G is to that of the point B as one to $(72 \times 80 =)$ 5760. Therefore, if we fuppofe a man to act at the handle with a force equal to 30 lbs. he may keep in equilibrio a weight of 172800 lbs. But a fubduction of perhaps more than one half of this muft be made, that he may raife the weight, as the friction of the engine will be confiderable. Suppofe it to be two-thirds, the effect ftill remains equal to 57600 lbs. or 25 tons 14 cwts. and 32 lbs.

It will eafily appear, that this method of applying the fcrew may have a place in many other engines, particularly where great accuracy is required; or we want a motion to be performed with great power, while at the fame time it need not have any large compafs. The few examples given above may ferve as a fpecimen.
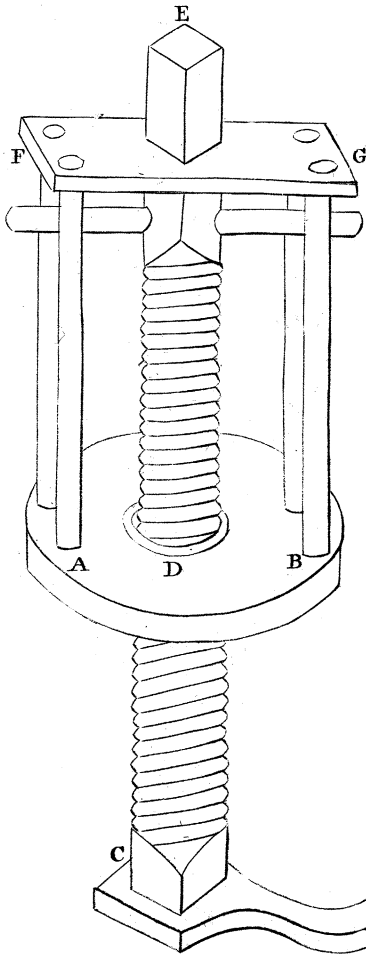
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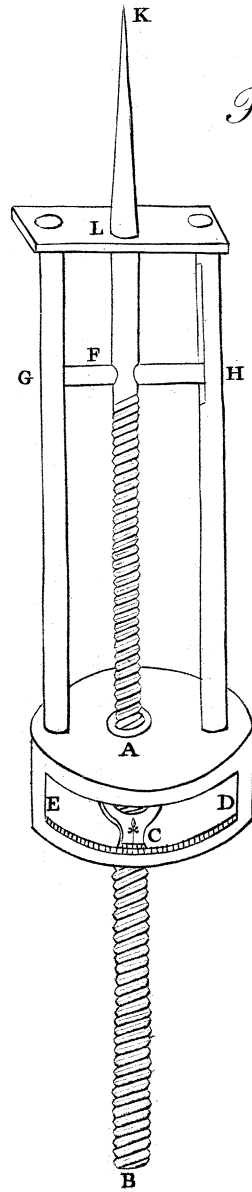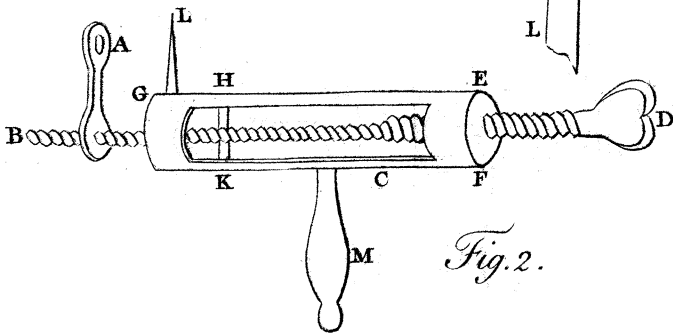F   G

Fig. 1.

A   D   B

C   K

L

L

Fig. 3.

K

L

G   F   H

A

E   C   D

B

Fig. 4.

a   d

b   c

L

A

G   H   E

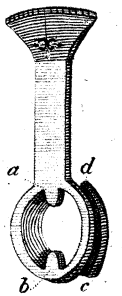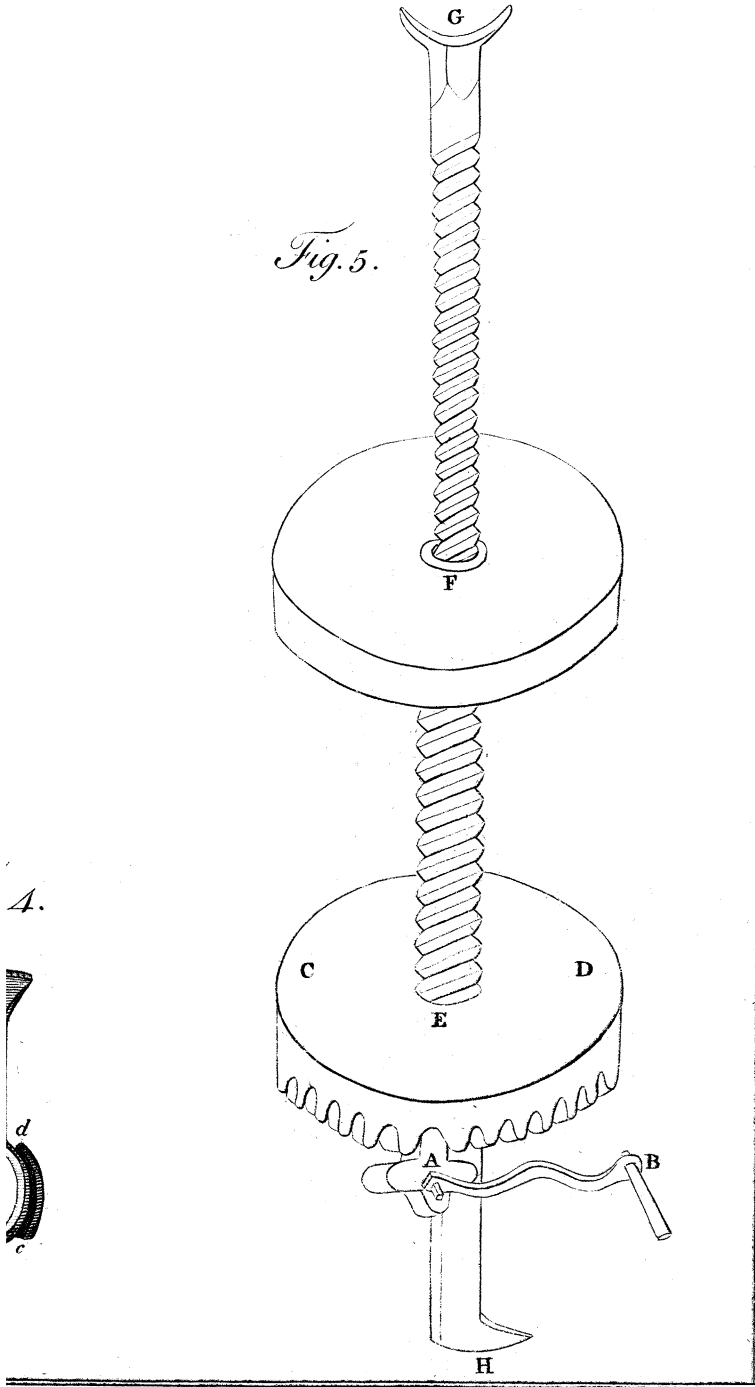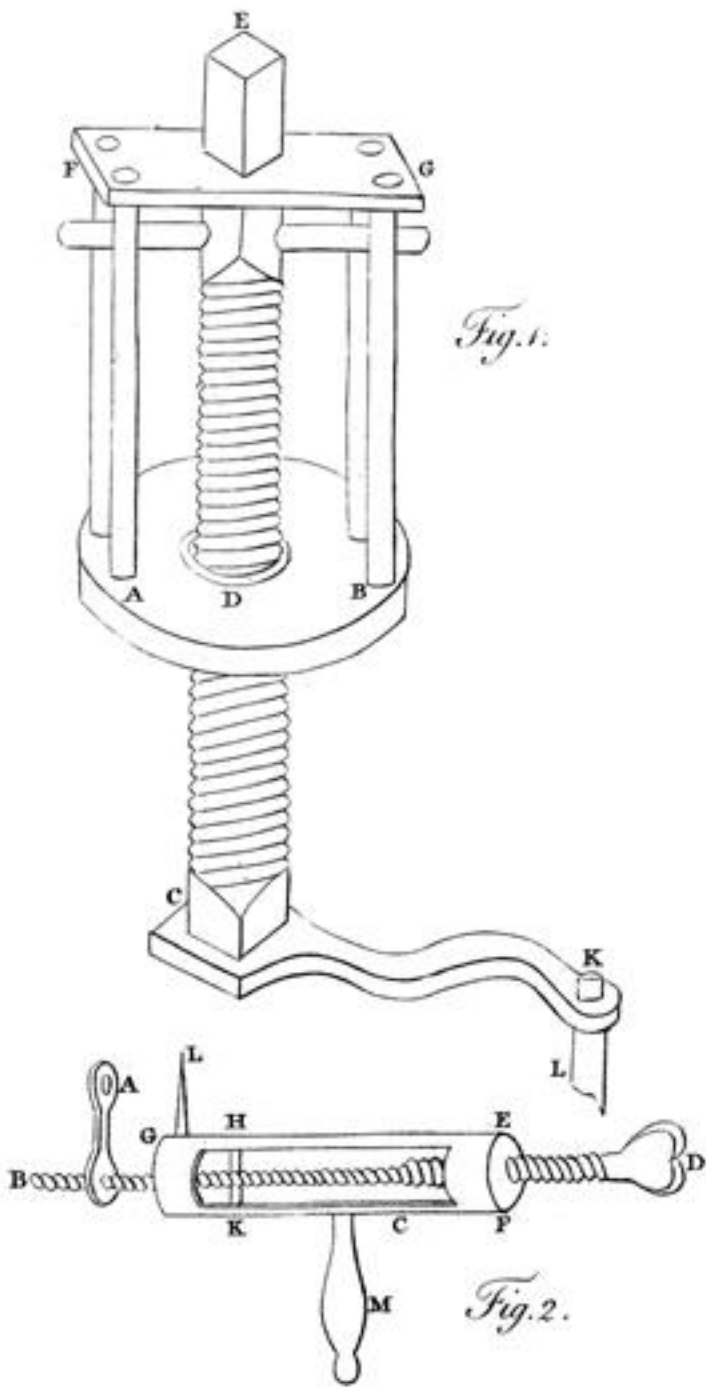B   D

K   C   F

M

Fig. 2.

Fig.5.

4.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.