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A Treatise on Mills

From the 1770s onwards, John Banks (1740–1805) lectured on natural philosophy across the north-west of England. Much of his work aimed to show engineers, mechanics and artisans how they could benefit from expanding their theoretical knowledge. First published in 1795, and reissued here in its 1815 second edition, this work shows how to calculate the power limits of waterwheels, millstones and other commercially important machines. In the author's words, a key aim is to avoid wasted effort 'in attempting what men of science know to be impossible'. Starting with the mechanics of circular motion, he leads the reader step by step through a series of worked problems, showing the theory's practical applications. He then moves on to his experiments on the flow of water, and uses his results to better analyse the various types of waterwheel. Banks' *On the Power of Machines* (1803) is also reissued in this series.

A Treatise on Mills

In Four Parts

John Banks

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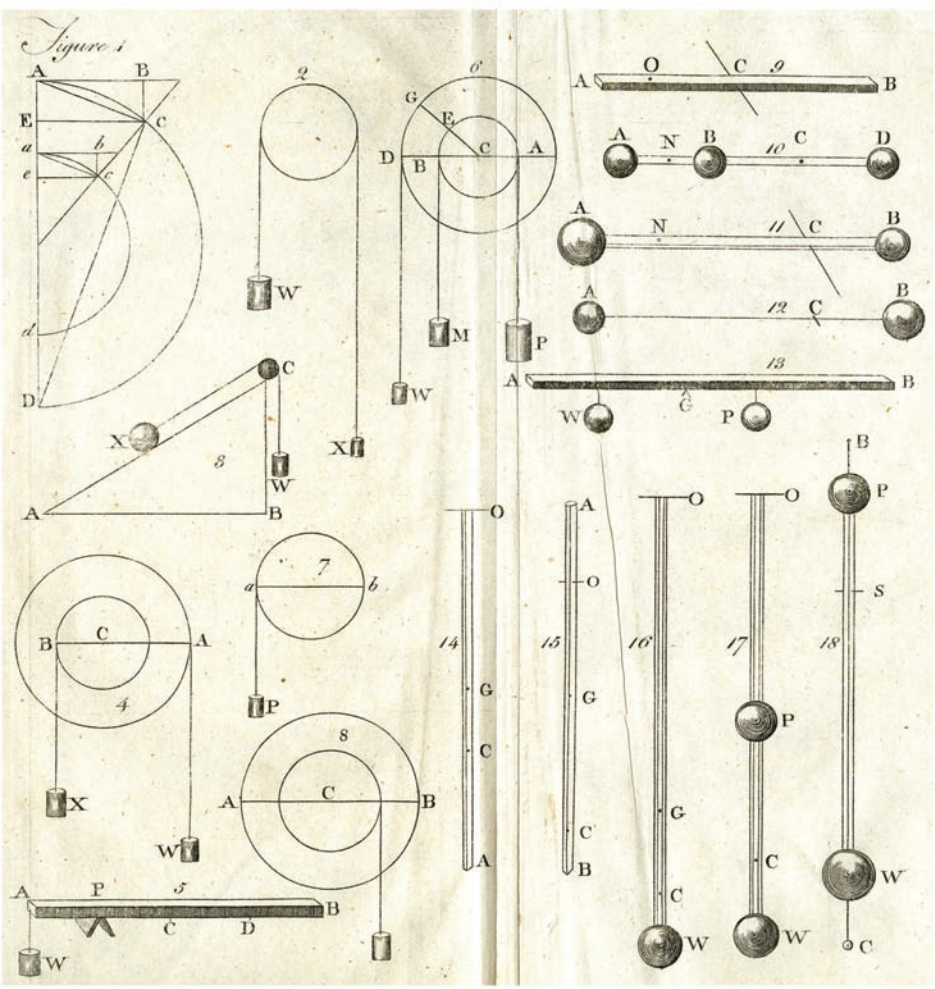

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A

Treatise on Mills,

IN FOUR PARTS.

PART FIRST,

ON CIRCULAR MOTION.

PART SECOND,

ON THE MAXIMUM OF MOVING BODIES, MACHINES, ENGINES, *&c.*

PART THIRD,

ON THE VELOCITY OF EFFLUENT WATER.

PART FOURTH,

EXPERIMENTS ON CIRCULAR MOTION, WATER WHEELS, *&c.*

BY JOHN BANKS,

LECTURER IN EXPERIMENTAL PHILOSOPHY.

Second Edition.

THEY CONTINUE THIS DAY ACCORDING TO THINE ORDINANCES.
PSALM cxix. 91.

LONDON:

PRINTED FOR LONGMAN, HURST, REES, ORME, AND BROWNE;
AND FOR
W. GRAPEL, LIVERPOOL.

1815.

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Water-street, Liverpool.

Preface.

THE experiments contained in the fourth part of this treatise, and some of these in the third, have been the subject of a public lecture, which I have occasionally delivered, for about twenty years. At the request of many of my hearers, I have made it public; and have prefixed a few problems on circular motion, &c. For in order to know the powers of different wheels, or which is best able to overcome an obstacle, it is necessary to know their central forces.

Where different powers are compared, as in Prob. XII, &c. they are supposed to act upon the wheel, while they descend through the same space. When a wheel or fly, of any given weight or magnitude, has received a given degree of velocity, no more power is required to continue that velocity than what is sufficient to overcome the friction. Yet if it moves twice as fast, it will require four times the former power to continue that motion: hence, one would be apt to infer, that the friction increases with the square of the velocity. In a water-wheel, the same power is not constant; for the same particles act upon the wheel during only a part of a re-

volution; their places are constantly supplied, or they are succeeded by others which act for their time, &c.: hence, a water-wheel soon acquires an uniform velocity.

In the second part, the third problem has three solutions; the two first on principles the most common, but not perfectly just; but as they are sufficiently near in practice, and much easier than the third, they are continued till the eighth problem, inclusive, which, in fact, is but one problem, for the fourth, &c. are illustrations of the theorems drawn from the third, and ought rather to have been examples. In this, as well as in many of the following problems, I have endeavoured to shew the impossibility of a given power producing more than a given effect, or of raising more than a certain quantity of water, weight, &c. to a given altitude, in a limited time. For, in this case, combinations of machinery afford no assistance, but the contrary. For if one pound in one scale cannot raise one pound in the other, we shall get nothing by suspending a weight from the circumference of a wheel, in order to raise a greater at the circumference of its axle. For if the machine is so constructed that one pound will raise ten pounds, the pound must descend more than ten times as fast as the other rises, and of consequence it must descend more than ten successive times through a given space, to raise ten pounds through the same space.

It is true, that we have in the kingdom many intelligent engineers, and excellent mechanics; and there are others who can execute better than they can design, otherwise there would not have been so much money expended in attempting what men of science know to be impossible.

When a man tells me he can construct a water-wheel in such a manner that, when once put in motion, it shall raise water to keep itself moving; or that he has constructed a pump in such a manner, that one man may do the work of ten, &c. I pay the same attention to him, as if he told me he could create a system of worlds, and command them to move. Or, is he less to be credited who says he can communicate perpetual motion to dead matter? Both are indirectly saying, I can reverse the laws of nature.

Many of the problems in this part are intended not only to prove that a given power can only produce a given effect, but at the same time to demonstrate what the greatest effect is which a given power can produce. For a power is often applied in such a manner as to cause the effect to fall short of the maximum, as demonstrated in the third problem, when the time is given, and in the thirty-fifth, &c. when the space is given, where it appears, that if the power and resistance be equally distant from the centre, in case of a maximum, or when the power produces the greatest possible effect, the former will be to the latter as 1000 to 618. Or if the power be applied ten times as far from the centre as the resistance, when reduced they will be as 1000 to 659, the weight of the machine not considered, for which see Prob. XXXVII, XXXVIII, &c. When the power and resistance are both given, by Prob. XXX, a machine may be constructed, by which the power shall produce the greatest effect in a given time.

In the third part, the experiments on effluent water differ considerably from any theory; and, contrary to expectation, more water is discharged, in proportion.

from small than from large apertures. The quantity through small holes, I have endeavoured to ascertain, by different processes, all of which bring out nearly the same conclusions. And though I have had much practice in making experiments, I have not trusted entirely to my own observations, but have been assisted in the whole by one or more gentlemen well acquainted with the subject. At Coventry, by the Rev. Mr. Banks, of Monks Kirkby; by Messrs. Baines, Watson, Dicas, &c. of Liverpool; by Mr. Priestly, and Mr. Peckover, of Bradford; by my eldest son, and by my wife, who, *though a woman*, is perhaps as accurate in making experiments in philosophy, and some branches of chemistry, as most of men. Upon the whole, I presume the rules contained in this part, for finding the quantity of water discharged in a given time, will be found sufficiently accurate in practice.

However satisfactory mathematical reasoning may be to some, yet experimental proof is desirable, and, to many, much more so than the former; and without experiments, we often want *data* to reason from. But if we have certain principles, the conclusions drawn therefrom will often differ considerably from experiment, or rather the experiment from the theory. For the theory supposes the bodies to move in free space, without friction, or any kind of resistance; but as these impediments cannot be entirely removed, the experiments cannot perfectly coincide with the theory, though in some cases they come exceedingly near.

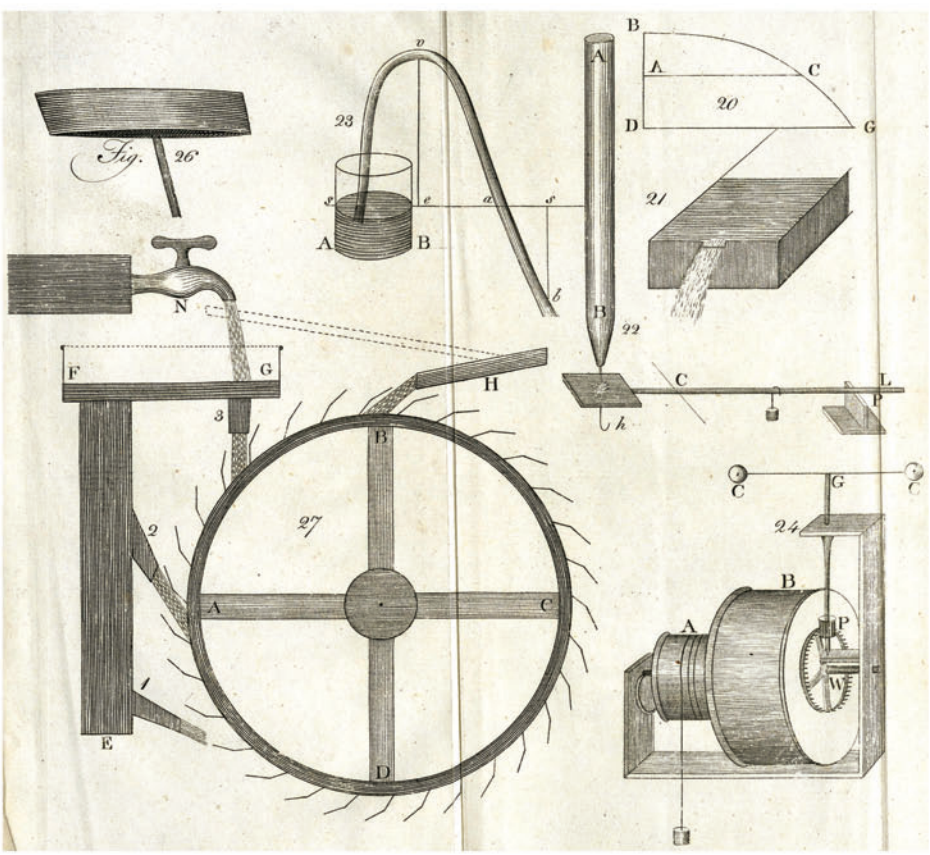
In the fourth part, the experiments on circular motion, &c. are sufficiently accurate to prove the truth of the theory, and the utility thereof, when applied to

the construction of machines. I have thought the preceding theory and experiments a necessary introduction to the principal subject, the experiments on wheels, &c.; in which I have endeavoured to investigate the truth, without a view to support any particular system, sentiments, or opinion. And if some of the experiments happen to recommend any construction or application different to the practice of some professional men, it might be well to enquire into the foundation of their practice, whether it is supported by experiments, or whether it rests upon the opinions of their predecessors. To rest satisfied with the opinions of others, however great their reputation, tends much to retard the progress of knowledge; for error is often found in high places.

It will not be expected that I should attempt to instruct the mechanic how to form his cogs, divide the wheels, proportion their diameters, bevels, &c. as numbers of men may be found who can both plan and execute these parts well. The chief end in view is, how to make the most of a given stream; and what the experiments recommend, has long since been put in practice, with acknowledged advantage. If this treatise, in proportion to its sale, proves equally useful with the public lecture, I shall be satisfied.

To conclude: if, through mistake, I have advanced any thing erroneous in theory, or drawn any false conclusions from the experiments, I hope those who discover them will candidly correct them.

JANUARY 29th, 1795.



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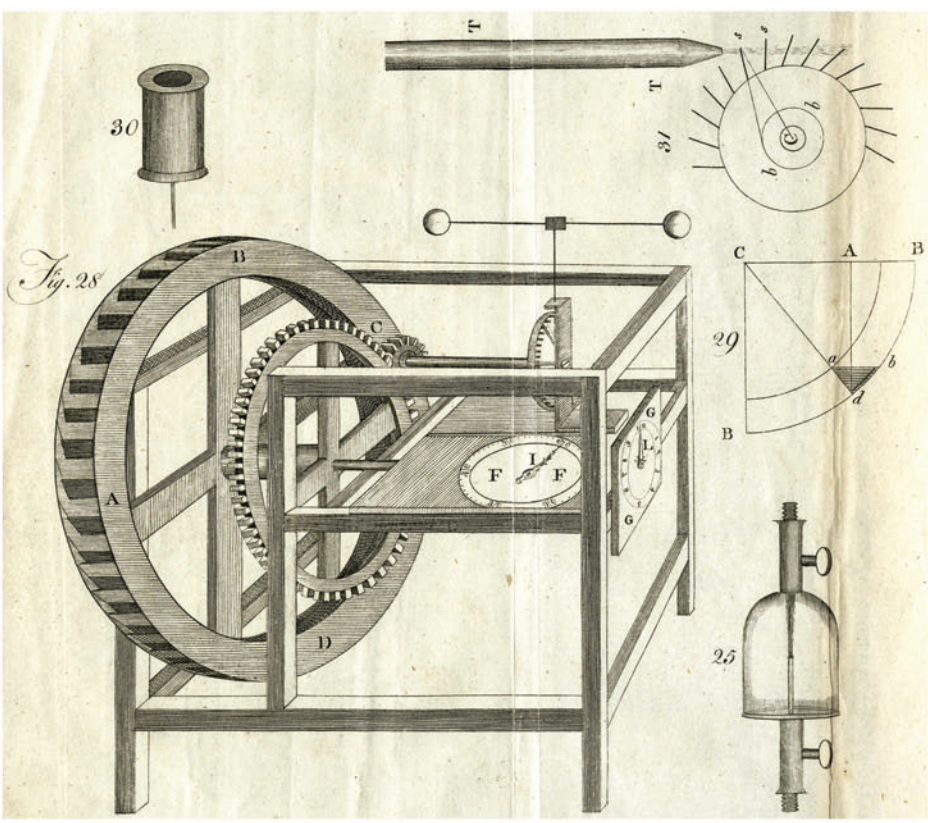

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