MECHANICS AND MECHANISM: BEING ELEMENTARY ESSAYS AND EXAMPLES FOR THE USE OF SCHOOLS, STUDENTS, AND ARTISANS

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ROBERT SCOTT BURN

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Trieste

MECHANICS AND MECHANISM:

A. C. Jewett. Ann Arbor.

BEING

Michigan.

ELEMENTARY ESSAYS AND EXAMPLES

University of Michigan.

FOR THE USE OF

SCHOOLS, STUDENTS, AND ARTISANS.

EDITED BY

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INTRODUCTION.

A WORK like the present, treating exclusively on "Mechanics and Mechanism," and forming part of an educational series, would, at a period not very remote in our social history, have been looked upon as an innovation, and considered to be upon the whole as useless as it appeared strange and uncalled for. And this view, singular as it may now appear, would have been founded upon a comparatively correct estimate of the importance of the subject. Mechanism then occupied but a very subordinate position in the ranks of our social powers, and mechanicians were as few in numbers and unimportant in influence as were their works and labours. Not so, however, now; the position of affairs is singularly changed. "Mechanicians and mechanism, the emanations of their genius," as we have elsewhere remarked, "occupy an important position in our social and commercial system. It is now scarcely, if at all, an exaggeration to affirm, that to the improvements recently effected in the various branches of the mechanical arts we owe our present position as a nation. The steam-engine, and the powers it gave us, enabled us to cope successfully with the otherwise overwhelming disadvantages which a long and expensive war entailed upon us. To mechanism we owe the factories from which we send out our cloths to supply the world's markets; to mechanism we owe that giant power which, with equal facility, propels our ships in the ocean-storm, as in the calm waters of our inland rivers. It is mechanism, well arranged and modified, which whirls the traveller along the iron way with an untiring speed which the swiftest race-horse bred by man can never rival; it is mechanism, finely constituted and cunningly devised, which forms the plainly useful as well as the beautifully elegant of our numerous and varied fabrics; in fact and in short there is scarcely an article we use but what owes its production to one of the many combinations of mechanism. Nothing to the accomplished mechanician comes amiss; constructing the simple mechanism which effects a single purpose with ease, he as freely masters that which is imitative of operations which, apparently, nothing less than human skill could execute or human brains dictate. No

matter what the operation to be effected: let it be complex in its details to a degree stultifying to an ordinary mind, no sooner is it required than machinery is devised and set to work; and the operation is effected apparently with as much ease as the forms are made which constitute written language by the pen of the ready writer, or the throwing of the shuttle in the weaver's hand-loom." Seeing, then, the important part played in all our social movements by the mechanic, using the term in its widest acceptation, we think that it is scarcely necessary to dilate as to the expediency of imparting a knowledge of the elements of mechanics and mechanism to the rising generation. A nation which owes so much to the results of these powers should not, in its schemes of education, ignore the necessity of explaining their principles, or adopt a system of instruction in which this important subject is altogether overlooked. As mathematics are said to impart a healthy invigorating tone to the reasoning faculties, so the study of mechanics, in like manner, may be said to teach directly the value of system, and the advantages of "doing the right thing in its right place." We are scarcely prepared to go the length of an eminent engineer, whose opinion was, that if all were taught "mechanics" generally, not with reference to following out any distinct profession or calling, they would perform their various duties quicker and with greater ease to themselves; and that even females, if possessed of this knowledge, would make better housewives: nevertheless, we conceive there is much truth in the idea, which would become more apparent if generally acted upon. Not further to go into the benefit to be derived from the study of mechanics, we shall proceed to explain briefly the nature of our present treatise, and the method we have adopted in its treatment.

The work is essentially popular, and we may add practical; we have given results and arrangements only, refraining from an exposition of those strictly theoretical rules and mathematical formularies which serve, in many instances, to confuse rather than to enlighten, to deter rather than induce the pupil to proceed. Not that we deem this theory and that mathematical formula useless or unnecessary; but we have so frequently been impressed with the benefit to be derived, in the study of *mechanical arrangement*, from separating the purely theoretical from the purely practical, that we have determined to adopt in this work the principle of giving only practical arrangements and their results.

Thus, supposing a pupil desirous of becoming acquainted with the arrangement by which the rectilineal motion of a steam-engine piston-rod was changed into the circular one of the fly-wheel, we proceed to explain, in the first instance, how this change is produced; but we proceed a step further, and instead of giving a theoretical exercise, or entering into an exposition of the nature of the acting force at various points in the revolution

of the crank, or the estimated loss entailed by its use, we suppose the pupil actuated by a still greater degree of curiosity, desirous of going deeper into the details of this movement. Thus, he will at once perceive from our explanation, how pieces of thin iron-wire may produce the desired movement; but this would not explain the method by which *mechanics in actual practice* availed themselves of the principle. We consider the gratification of this curiosity essential, and proceed therefore to explain how a crank is actually made, what is its form, how it is fixed in the shaft, what constitutes a connecting-rod, how it is constructed, how connected with the crank; in short, the arrangement of the various parts and how fitted together, as exemplified in actual working machinery. Again, in describing the nature and uses of a shaft, we first give an explanation of its distinguishing features and how it may be used; then divide it into its component parts, explain their actual construction, the method of making the journals on which they revolve, and the means of reducing the friction of their revolutions. These details we consider preferable, for the purposes of the treatise, to entering into a theoretical disquisition, shewing how the shaft should be proportioned to ensure proper strength, without undue outlay of material, &c.

All the explanations we attempt to carry out in such a manner that the pupil, after studying them, could point out the various parts of an actual machine, and say, "this is a pedestal, that a cottar; these brasses are made to embrace this crank-pin by such a means; this is made in such a manner, that so secured; this motion is produced, and that changed, reversed, or altered by these various arrangements." But we go a step further; and not satisfied with these explanations, we suppose the pupil anxious to become acquainted with the *preliminary operations or processes* which must be gone through before the various movements can be made available for practical use. We then proceed to explain these processes: how this part is made circular, and what the means employed, thus necessitating an explanation of the turning-lathe; how this aperture is produced, thus involving the explanation of boring tools and machines; how this surface is made smooth, the chisel and planing machine being then described; and so on throughout the whole range of operations of the machine-shop. From this exposition the reader will at once perceive the distinguishing feature of our present treatise. It is not designed to serve as a guide to the practical mechanic, to enable him to proportion the various parts of his machines according to correct theory, or to assist him in drawing up his calculations. But as a means of giving a ready insight into the constructive forms and arrangements of general mechanism, as well as the methods by which the movements are produced, we venture to hope that our treatise will present some claim to be considered as a useful

auxiliary in an educational series. We have aimed at using the simplest language, avoiding the use of technicalities as far as the nature of the subject would admit of. We have endeavoured to give a consecutive arrangement to the various departments, giving these, as far as possible, in the order of their general sequence. The illustrations, unsparingly given, will render the text, it is hoped, much more easily understood. For a considerable portion of the first three chapters the reader is indebted to the pen of an able and pleasing writer.

To the reader anxious to go into the study of the action of various machines, as well as the theory of their construction, we cordially recommend the perusal of *The Engineer's and Machinist's Assistant*, published by Messrs. Blackie of Glasgow and London; and the large work of Buchanan on millwork, with two volumes of plates, edited by Sir John Rennie, and published by Weale of London. These, though expensive, will be of eminent service to those of our readers who may be contemplating the following out of professions in which the theory as well as the practice of mechanics is desiderated. A knowledge of the current inventions of the day, and of the progression of practical mechanics as applied to labour-saving conveniences, may best be derived from an examination of the pages of those valuable mechanical journals, *The Artisan*, *The Practical Mechanic's Journal*, *The Mechanic's Magazine*, and the *Patent Journal*; all of which abound with very interesting and valuable information. To the pages of some of these we have been, in one or two instances, indebted for illustrations of mechanical movements recently introduced; for the great majority of our examples, however, we are indebted either to a practical acquaintance with the subjects, or to sources available through a business connexion.

In concluding, it may be necessary to state, that we have not gone so deeply into the mechanical details of the steam-engine as at a first glance at the following pages might be considered essential, inasmuch as we have fully gone into these details in a special volume (now in course of preparation) on the very interesting subject, entitled, *The Steam-Engine, its History and Mechanism*.

R. S. B.

January 1853.

MECHANICS AND MECHANISM.

CHAPTER I.

THE CENTRE OF GRAVITY.

Every atom of matter is equally attracted to the earth. When the atoms form a solid, they cannot separately act, but as it were concentrate the whole weight of the body at a point which, if supported or suspended, will balance, hold in equilibrium, or keep in a state of rest the entire mass: this point is called the *centre of gravity*, *centre of inertia*, or *centre of parallel forces*.

If a stick be laid across a finger, one particular part will be found where it will balance and remain at rest; that part is the centre of gravity in the stick. The bulk and density on both sides of this point of the stick will be equal; and thus by a sufficient support at this part the attraction of the earth is successfully resisted, for in any other position the stick would fall to the ground. The centre of gravity appears, then, to be the point which seeks the lowest level, and exists in every thing, of whatever shape it may be, in the universe.

By lifting a solid body at this point, the whole is lifted; or by preventing this part being moved, the mass is at rest.

A rod of iron having equal quantities of matter throughout its length will have its centre of gravity exactly in the middle. If a piece of wood or any other substance in the shape of a triangle be hung up so as to swing freely, and a string with a plummet attached, it will exactly cut the triangle in two from each point; and in the centre, where the lines cross each other, will be the point of gravity. By marking the lines with a pencil or piece of chalk, the exact spot can be found. Any irregular shaped thing, as a painter's palette, freely suspended from different parts, will have the plummet-line crossing at one point, which is the centre of gravity.

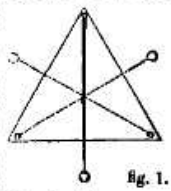

Fig. 1.

A line drawn from the centre of gravity direct to the earth is called the *line of direction*. This is only an imaginary line, but one of great importance in the concerns of life; for if a square