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978-1-108-00910-2 - On the Economy of Machinery and Manufactures

Charles Babbage

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ON THE ECONOMY  
OF  
MANUFACTURES.

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INTRODUCTION.

THE object of the present volume is to point out the effects and the advantages which arise from the use of tools and machines;—to endeavour to classify their modes of action;—and to trace both the causes and the consequences of applying machinery to supersede the skill and power of the human arm.

A view of the mechanical part of the subject will, in the first instance, occupy our attention, and to this the first section of the work will be devoted. The first chapter of the section will contain some remarks on the general sources from whence the advantages of machinery are derived, and the succeeding nine chapters will contain a detailed examination of principles of a less general character. The eleventh chapter contains numerous subdivisions, and is important from the extensive classification it affords of the arts in which copying is so largely

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employed The twelfth chapter, which completes the first section, contains a few suggestions for the assistance of those who propose visiting manufactories.

The second section, after an introductory chapter on the difference between *making* and *manufacturing*, will contain, in the succeeding chapters, a discussion of many of the questions which relate to the political economy of the subject. It was found that the domestic arrangement, or interior economy of factories, was so interwoven with the more general questions, that it was deemed inadvisable to separate the two subjects. The concluding chapter of this section, and of the work itself, relates to the future prospects of manufactures, as arising from the application of science.

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OF MANUFACTURES.

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## CHAP. I.

SOURCES OF THE ADVANTAGES ARISING FROM  
MACHINERY AND MANUFACTURES.

(1.) THERE exists, perhaps, no single circumstance which distinguishes our country more remarkably from all others, than the vast extent and perfection to which we have carried the contrivance of tools and machines for forming those conveniences, of which so large a quantity is consumed by almost every class of the community. The amount of patient thought, of repeated experiment, of happy exertion of genius, by which our manufactures have been created and carried to their present excellence, is scarcely to be imagined. If we look around the rooms we inhabit, or through those storehouses of every convenience, of every luxury that man can desire, which deck the crowded streets of our larger cities, we shall find in the history of each article, of every fabric, a series of failures which have gradually led the way to excellence; and we shall notice, in the art of making even the most insignificant of them, processes calculated to excite our admiration by their simplicity, or to rivet our attention by their unlooked-for results.

(2.) The accumulation of skill and science which has been directed to diminish the difficulty of producing

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manufactured goods, has not been beneficial to that country alone in which it is concentrated; distant kingdoms have participated in its advantages. The luxurious natives of the East,\* and the ruder inhabitants of the African desert, are alike indebted to our looms. The produce of our factories has preceded even our most enterprising travellers.† The cotton of India is conveyed by British ships round half our planet, to be woven by British skill in the factories of Lancashire: it is again set in motion by British capital; and, transported to the very plains whereon it grew, is repurchased by the lords of the soil which gave it birth, at a cheaper price than that at which their coarser machinery enables them to manufacture it themselves.‡

(3.) The large proportion of the population of this country, who are engaged in manufactures, appears from the following table deduced from a statement in an Essay on the Distribution of Wealth, by the Rev. R. Jones.—

\* “The Bandana handkerchiefs manufactured at Glasgow have long superseded the genuine ones, and are now consumed in large quantities both by the natives and Chinese.”—Crawford’s *Indian Archipelago*, vol. iii. p. 505.

† Captain Clapperton, when on a visit at the court of the Sultan Bello, states, that “provisions were regularly sent me from the sultan’s table on pewter dishes with the London stamp: and I even had a piece of meat served up on a white wash-hand basin of English manufacture.”—Clapperton’s *Journey*, p. 88.

‡ At Calicut, in the East Indies (whence the cotton cloth called calico derives its name), the price of labour is *one-seventh* of that in England, yet the market is supplied from British looms.

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## OF MACHINERY.

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*For every Hundred Persons employed in Agriculture, there are,*

	Agriculturists.	Non-agriculturists.
In Italy . . . . .	100 . . . . .	31
In France . . . . .	100 . . . . .	50
In England . . . . .	100 . . . . .	200

The fact that the proportion of non-agricultural to agricultural persons is continually increasing, appears both from the Report of the Committee of the House of Commons upon Manufacturers' Employment, July, 1830, and also from the still later evidence of the last census, from which document the annexed table of the increase of population in our great manufacturing towns, has been deduced.

## INCREASE OF POPULATION PER CENT.

NAMES OF PLACES.	1801	1811	1821	TOTAL 1801 to 1831.
	to 1811.	to 1821.	to 1831.	
Manchester . . . .	22	40	47	151
Glasgow . . . . .	30	46	38	161
Liverpool * . . . .	26	31	44	138
Nottingham . . . .	19	18	25	75
Birmingham . . . .	16	24	33	90

Thus, in three periods of ten years each, during each of which the general population of the country

\* Liverpool, though not itself a manufacturing town, has been placed in this list, from its great connexion with Manchester, of which it is the port.

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has increased about 15 per cent., or nearly 51 per cent. upon the whole period of thirty years, the population of these towns has, on the average, increased 123 per cent. After this statement, the vast importance to the well-being of this country, of making the interests of its manufacturers well understood and attended to, needs no further argument.

(4.) The advantages which are derived from machinery and manufactures seem to arise principally from three sources : *The addition which they make to human power.—The economy they produce of human time.—The conversion of substances apparently common and worthless into valuable products.*

(5.) *Of additions to human power.* With respect to the first of these causes, the forces derived from wind, from water, and from steam, present themselves to the mind of every one ; these are, in fact, additions to human power, and will be considered in a future page : there are, however, other sources of its increase, by which the animal force of the individual is itself made to act with far greater than its unassisted power ; and to these we shall at present confine our observations. The construction of palaces, of temples, and of tombs, seems to have occupied the earliest attention of nations just entering on the career of civilization ; and the enormous blocks of stone moved from their native repositories to minister to the grandeur or piety of the builders, have remained to excite the astonishment of their posterity, long after the purposes of many of these records, as well as the names of their founders, have been forgotten. The different degrees of force necessary to move these ponderous masses, will have varied

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according to the mechanical knowledge of the people employed in their transport; and that the extent of power required for this purpose is widely different under different circumstances, will appear from the following experiment, which is related by M. Redelet, *Sur L'Art de Bâtir*.

A block of squared stone was taken for the subject of experiment;

	lbs.
1. Weight of stone . . . . .	1080
2. In order to drag this stone along the floor of the quarry, roughly chiselled, it required a force equal to . . . . .	758
3. The same stone, dragged over a floor of planks required . . . . .	652
4. The same stone placed on a platform of wood, and dragged over a floor of planks, required . . . . .	606
5. After soaping the two surfaces of wood which slid over each other, it required . . . . .	182
6. The same stone was now placed upon rollers of three inches diameter, when it required to put it in motion along the floor of the quarry . . . . .	34
7. To drag it by these rollers over a wooden floor . . . . .	28
8. When the stone was mounted on a wooden platform, and the same rollers placed between that and a plank floor, it required . . . . .	22

From this experiment it results, that the force necessary to move a stone along the roughly chiselled floor of its quarry is nearly two-thirds of its weight; to move it along a wooden floor, three-fifths; by wood upon wood, five-ninths; if the wooden surfaces are soaped, one-sixth; if rollers are used on the floor of

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the quarry, it requires one thirty-second part of the weight; if they roll over wood, one-fortieth; and if they roll between wood, one-fiftieth of its weight. At each increase of knowledge, as well as on the contrivance of every new tool, human labour becomes abridged. The man who contrived rollers, invented a tool by which his power was quintupled. The workman who first suggested the employment of soap, or grease, was immediately enabled to move, without exerting a greater effort, more than three times the weight he could before.\*

(6.) *The economy of human time* is the next advantage of machinery in manufactures. So extensive and important is this effect, that we might, if we were inclined to generalize, embrace almost all the advantages under this single head; but the elucidation of principles of less extent will contribute more readily to a knowledge of the subject; and, as numerous examples will be presented to the reader in the ensuing pages, we shall restrict our illustrations upon this point.

As an example of the economy of time, the use of gunpowder in blasting rocks may be noticed. Several pounds of that substance may be purchased for a sum acquired by a few days' labour; yet when this is employed for the purpose alluded to, effects are frequently produced which could not, even with the

\* So sensible are the effects of grease in diminishing friction, that the drivers of sledges in Amsterdam, on which heavy goods are transported, carry in their hand a rope soaked in tallow, which they throw down from time to time before the sledge, in order that it may by passing over the rope become greased.



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best tools, be accomplished by other means in less than many months.

(7.) The art of using the diamond for cutting glass has undergone, within a few years, a very important improvement. A glazier's apprentice, when using a diamond set in a conical ferrule, as was always the practice about twenty years since, found great difficulty in acquiring the art of using it with certainty, and at the end of a seven years' apprenticeship many were found but indifferently skilled in its employment. This arose from the difficulty of finding the precise angle at which the diamond cuts, and of guiding it along the glass at the proper inclination when that angle is found. Almost the whole of the time consumed and of the glass destroyed in acquiring the art of cutting glass, may now be saved by the use of an improved tool. The gem is set in a small piece of squared brass with its edge nearly parallel to one side of the square. A person skilled in its use now files away one side of the brass, until, by trial, he finds that the diamond will make a clean cut, when guided by keeping this edge pressed against a ruler. The diamond and its mounting are now attached to a stick similar to a pencil, by means of a swivel allowing a small angular motion. Thus the merest tyro at once applies the cutting edge at the proper angle, by pressing the side of the brass against a ruler; and even though the part he holds in his hand should deviate a little from the required angle, it communicates no irregularity to the position of the diamond, which rarely fails to do its office when thus employed.

The relative hardness of the diamond, in different

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directions, is a singular fact. An experienced workman, on whose judgment I can rely, informed me that he had seen a diamond ground with diamond powder on a cast-iron mill for three hours without its being at all worn, but that, changing its direction with reference to the grinding surface, the same edge was ground down.

(8.) *Employment of materials of little value.* The skins used by the goldbeater are produced from the offal of animals. The hoofs of horses and cattle, and other horny refuse, are employed in the production of the prussiate of potash, that beautiful, yellow, crystallized salt, which is exhibited in the shops of some of our chemists. The worn-out saucepans and tin ware of our kitchens, when beyond the reach of the tinker's art, are not utterly worthless. We sometimes meet carts loaded with old tin kettles and worn-out iron coal-scuttles traversing our streets. These have not yet completed their useful course; the less corroded parts are cut into strips, punched with small holes, and varnished with a coarse black varnish for the use of the trunk-maker, who protects the edges and angles of his boxes with them; the remainder are conveyed to the manufacturing chemists in the outskirts of the town, who employ them, in conjunction with pyroligneous acid, in making a black die for the use of calico printers.

(9.) *Of tools.* The difference between a *tool* and a *machine* is not capable of very precise distinction; nor is it necessary, in a popular explanation of those terms, to limit very strictly their acceptation. A *tool* is usually more *simple* than a machine; it is generally