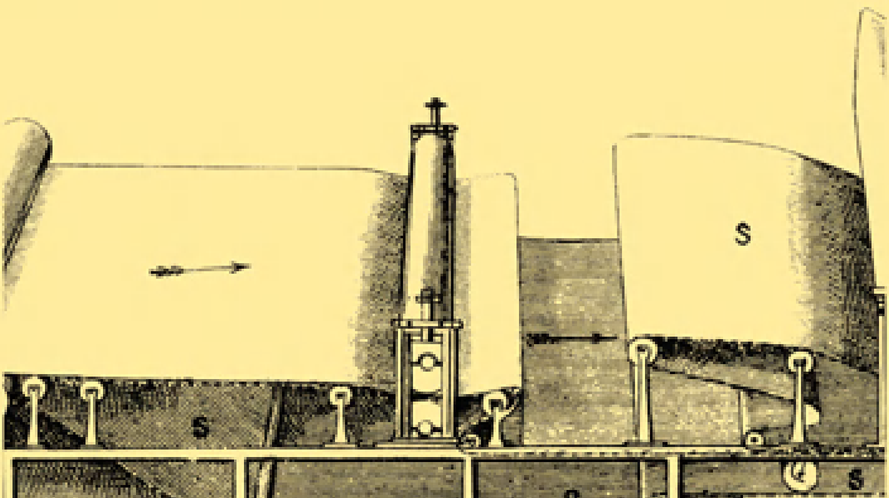
CAMBRIDGE LIBRARY COLLECTION

ON THE ECONOMY OF MACHINERY AND MANUFACTURES

Charles Babbage



CAMBRIDGE

CAMBRIDGE LIBRARY COLLECTION

Books of enduring scholarly value

Printing and Publishing History

The interface between authors and their readers is a fascinating subject in its own right, revealing a great deal about social attitudes, technological progress, aesthetic values, fashionable interests, political positions, economic constraints, and individual personalities. This part of the Cambridge Library Collection reissues classic studies in the area of printing and publishing history that shed light on developments in typography and book design, printing and binding, the rise and fall of publishing houses and periodicals, and the roles of authors and illustrators. It documents the ebb and flow of the book trade supplying a wide range of customers with products from almanacs to novels, bibles to erotica, and poetry to statistics.

On the Economy of Machinery and Manufactures

In this famous book, first published in 1832, Charles Babbage (1791–1871), the mathematician, philosopher, engineer and inventor who originated the concept of a programmable computer, surveys manufacturing practices and discusses the political, moral and economic factors affecting them. The book met with hostility from the publishing industry on account of Babbage's analysis of the manufacture and sale of books. Babbage describes the many different printing processes of the time, analyses the costs of book production and explains the publication process, before discussing the 'too large' profit margins of booksellers. Babbage succeeded in his aim 'to avoid all technical terms, and to describe in concise language', making this an eminently readable historical account. His analysis and promotion of mechanisation and efficient 'division of labour' (still known as the 'Babbage principle') continue to resonate strongly for modern industrial engineering.

Cambridge University Press has long been a pioneer in the reissuing of out-of-print titles from its own backlist, producing digital reprints of books that are still sought after by scholars and students but could not be reprinted economically using traditional technology. The Cambridge Library Collection extends this activity to a wider range of books which are still of importance to researchers and professionals, either for the source material they contain, or as landmarks in the history of their academic discipline.

Drawing from the world-renowned collections in the Cambridge University Library, and guided by the advice of experts in each subject area, Cambridge University Press is using state-of-the-art scanning machines in its own Printing House to capture the content of each book selected for inclusion. The files are processed to give a consistently clear, crisp image, and the books finished to the high quality standard for which the Press is recognised around the world. The latest print-on-demand technology ensures that the books will remain available indefinitely, and that orders for single or multiple copies can quickly be supplied.

The Cambridge Library Collection will bring back to life books of enduring scholarly value (including out-of-copyright works originally issued by other publishers) across a wide range of disciplines in the humanities and social sciences and in science and technology.

On the Economy of Machinery and Manufactures

Charles Babbage

Cambridge
University Press

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore,
São Paolo, Delhi, Dubai, Tokyo

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9781108009102

This edition first published 1832
This digitally printed version 2009

ISBN 978-1-108-00910-2 Paperback

On the ECONOMY OF MACHINERY AND MANUFACTURES

By

CHARLES BABBAGE, ESQ.RE A.M.

Lucasian Professor of Mathematics in the University of Cambridge, and Member of several Academies.

LONDON:
CHARLES KNIGHT, PALL MALL EAST.
1832.

TO

The University of Cambridge

THIS VOLUME

IS INSCRIBED

AS A TRIBUTE OF RESPECT

AND GRATITUDE

BY

THE AUTHOR.

PREFACE.

THE present volume may be considered as one of the consequences that have resulted from the Calculating-Engine, the construction of which I have been so long superintending. Having been induced during the last ten years to visit a considerable number of workshops and factories, both in England and on the Continent, for the purpose of endeavouring to make myself acquainted with the various resources of mechanical art, I was insensibly led to apply to them those principles of generalization to which my other pursuits had naturally given rise. The increased number of curious processes and interesting facts which thus came under my attention, as well as of the reflections which they suggested, induced me to believe that the publication of some of them might be of use to persons who propose to bestow their attention on those inquiries which I have only incidentally considered. With this view it was my intention to have delivered the present work in the form of a course of lectures at Cambridge; an intention which I was subsequently induced to alter. The substance of a considerable portion of it has, however, appeared among the preliminary chapters of the mechanical part of the Encyclopædia Metropolitana.

I have not attempted to offer a complete enumeration of all the mechanical principles which regulate the application of machinery to arts and manufactures, but I have endeavoured to present to the reader those which struck me as the most important, either for understanding the actions of machines, or for enabling the memory to classify and arrange the facts connected with their employment. Still less have I attempted to examine all the difficult questions of *political economy* which are intimately connected with such inquiries. It was impossible not to trace or to imagine, among the wide variety of facts presented to me, some principles which seemed to pervade many establishments; and having formed such conjectures, the desire to refute or to verify them gave an additional interest to the pursuit. Several of the principles which I have proposed, appeared to me to have been unnoticed before. This was particularly the case with respect to the explanation I have given of the *division of labour;* but further inquiry satisfied me that I had been anticipated by M. Gioja, and it is probable that additional research would enable me to trace most of the other principles, which I had thought original, to previous writers, to whose merit I may perhaps be unjust from my want of acquaintance with the historical branch of the subject.

The truth however of the principles I have stated, is of much more importance than their origin; and the utility of an inquiry into them, and of establishing others more correct, if these should be erroneous, can scarcely admit of a doubt.

The difficulty of understanding the processes of manufactures has unfortunately been greatly overrated. To examine them with the eye of a manufacturer, so as to be able to direct others to repeat them, does undoubtedly require much skill and previous acquaintance with the subject; but merely to apprehend their general principles and mutual relations, is within the power of almost every person possessing a tolerable education.

Those who possess rank in a manufacturing country can scarcely be excused if they are entirely ignorant of principles whose development has produced its greatness. The possessors of wealth can scarcely be indifferent to processes which nearly or remotely have been the fertile source of their possessions. Those who enjoy leisure can scarcely find a more interesting and instructive pursuit than the examination of the workshops of their own country, which contain within them a rich mine of knowledge, too generally neglected by the wealthier classes.

It has been my endeavour, as much as possible, to avoid all technical terms, and to describe in concise language the arts I have had occasion to discuss. In touching on the more abstract principles of political economy, after shortly stating the reasons on which they are founded, I have endeavoured to support them by facts and anecdotes; so that whilst young persons might be amused and instructed by the illustrations, those of more advanced judgment may find subject for meditation in the general conclusions to which they point. I was anxious to support the principles which I have advocated by the observations of others, and in this respect I found myself peculiarly fortunate. The Reports of Committees of the House of Commons upon various branches of commerce and manufactures, and the evidence which they have at different periods published on those subjects, teem with information of the most important kind, rendered doubly valuable by the circumstances under which it has been collected. From these sources I have freely taken, and I have derived some additional confidence from the support they have afforded to my views.*

CHARLES BABBAGE.

DORSET STREET, MANCHESTER SQUARE.
June 8, 1832.

* I am happy to avail myself of this occasion of expressing my obligations to the Right Hon. Manners Sutton, the Speaker of the House of Commons, to whom I am indebted for copies of a considerable collection of those reports.

CONTENTS.

INTRODUCTION.

STATEMENT OF THE OBJECT AND PLAN OF THE WORK.

CHAPTER I.

SOURCES OF THE ADVANTAGES ARISING FROM MACHINERY AND MANUFACTURES.

England peculiarly a Manufacturing Country, § 1. Its Manufactures spread throughout the World, 2. Proportions of Agricultural Population in various Countries, its gradual Increase in England, 3.——*Additions to Human Power.* Experiment on Force to move a Block of Stone, 5.——*Economy of Time.* Gunpowder, 6. Diamond for cutting Glass; its Hardness, 7.——*Employment of Materials of little Value.* Goldbeaters' Skin; horny Refuse; old Tin Ware, 8.——*Of Tools*, 9. To arrange Needles, 10. To place their Points in one Direction, 11. Substitute for Hand: Nail-making, 12. Shoe-machinery; Sash-lines, 13.——*Division of the Objects of Machinery.* To produce Power; to transmit Force; general Principles, 14. Wind; Water, 15. Steam; Force not created, 16. Economy of Time in various Modes of dividing Roots of a Tree, 17. Chinese Mode of conveying Cotton compared with European, 18.

CHAPTER II.

ACCUMULATING POWER.

When the Work requires more Force than can be produced in the time allowed for its Operation. Fly-wheel, Rolling-iron, § 19. Anecdote of punching Plate-iron, 20. Pile-engine, 21.

CHAPTER III.

REGULATING POWER.

Governor of Steam-engine. Ditto moving in Water at Chatham. Uniform supply of Fuel to Steam-engine. Consuming Smoke, § 22. Vane regulated by Resistance of Air. Striking Clock, 23. Cataract for regulating Engines in Cornish Mines, 24.

CHAPTER IV.

INCREASE AND DIMINUTION OF VELOCITY.

Fatigue arising from Rapidity of muscular Exertion, contrasted with its Magnitude, § 25. Most advantageous Load for a Porter, 26. Tags of Boot-laces. Spinning by Hand and by Wheel. Machines to wind Ribbon and Sewing Cotton, 27. Tilt-hammer driven down by a Spring, 28. Scythe-making, 29. Smoke-jack, 30.

CHAPTER V.

EXTENDING TIME OF ACTION OF FORCES.

Watches and Clocks. Common Jack. Automatons, § 31. Jack useful for physical Experiments, also to agitate Chemical Solutions, 32.

CHAPTER VI.

SAVING TIME IN NATURAL OPERATIONS.

Tanning, § 33. Impregnation of Timber with Tar, &c. Accident to Boat of a Whaling Ship, 34. Bleaching Linen, 35. Evaporation of Water of Brine Springs, 36, 37. Deepening of Rivers in America, 38. Ascending Rapids, 39.

CHAPTER VII.

EXERTING FORCES TOO GREAT FOR HUMAN POWER, AND EXECUTING OPERATIONS TOO DELICATE FOR HUMAN TOUCH.

Difficulty of making a large Number of Men act simultaneously. Statue of Peter the Great. Egyptian Drawing, § 40. Rivets used when Red-hot, 41. Spinning Cotton. Steamboats, 42, 43. Damping Paper for Bank Notes, 44.

CHAPTER VIII.

REGISTERING OPERATIONS.

Pedometer.. Counting Machines for Carriage. Steam-engine, § 45. Machine for measuring Calicoes, 46. Tell-tale, 47. Instrument to measure Liquor drawn from Casks, 48. To measure Liquor remaining in Casks, 49. Gas-meter, 50. Water-meter, 51. Machine for registering the Average of fluctuating Forces. Barometer Clock, 52. Alarums, Repeating Clocks and Watches, 53.

CHAPTER IX.

ECONOMY OF MATERIALS EMPLOYED.

Cutting Trees into Planks, § 54. Printing-ink Experiment, 55.

CHAPTER X.

OF THE IDENTITY OF THE WORK WHEN IT IS OF THE SAME KIND, AND OF ITS ACCURACY WHEN OF DIFFERENT KINDS.

Top of a Box turned in Lathe, § 56. Accuracy of Work executed by Tools, 57. By Turning, 58.

CHAPTER XI.

OF COPYING.

Of Printing from Cavities. Copper-plate Printing, § 61. Engraving on Steel, 62. Music Printing, 63. Calico Printing from Cylinders, 64. Stencilling, 65. Printing Red Cotton Handkerchiefs, 66.——*Printing from Surface.* Printing from Wooden Blocks, 67. From moveable Type, 68. From Stereotype, 69. Calico Printing, 70. Oil-cloth Printing, 71. Letter Copying, 72. Printing on China, 73. Lithographic Printing, 74. Reprinting old Works by Lithography, 75. Register Printing, 76.——*Copying by Casting*. Iron and Metals, 78. Casts of Vegetable Productions in Bronze, 79. Casts in Plaster, 80. Casting in Wax. Imitations of Plants; of the Human Body, 81.——*Copying by Moulding*. Bricks, Tiles, Cornice of Church of St. Stefano, 83. Embossed China, 84. Glass Seals, 85. Square Glass Bottles with Names, 86. Wooden Snuff-boxes, 87. Horn Knife Handles. Umbrella Handles, 88. Tobacco-pipe making, 90. Embossing on Calico; on Leather, 91, 92. Swaging, 93. Engraving by Pressure on Steel. Bank Notes. Forgery, 94, 95. Gold and Silver Mouldings, 96. Ornamental Papers, 97.——*Copying by Stamping*. Coins and Medals, 98. Military Ornaments, 99. Buttons and Nail Heads, 100. Clichée, 101.——*Copying by Punching*. Boiler-plates, 103. Tinned Iron, 104. Buhl-work, 105. Cards for Guns, 106. Gilt Paper Ornaments, 107. Steel Chains, 108. ——*Copying with Elongations*. Wire Drawing, 110. Brass Tube Drawing, 111. Leaden Pipes, 112. Iron Rolling, 113. Vermicelli, 115.——*Copying with altered Dimensions*. Pentagraph, 116. Turning, 117. Rose Engine Turning, 118. Copying Dies by Lathes, 119. Shoe Lasts, 120. Copying Busts, 121. Screw-cutting, 122. Printing from Copper Plates with altered Dimensions, 123. Engraving from Medals, 124. Veils made by Caterpillars. Weight of various Fabrics, 126. Copying through six Stages in Printing this volume.

CHAPTER XII.

ON THE METHOD OF OBSERVING MANUFACTORIES.

Skeleton, General Inquiries, § 128. Skeleton for each Process, 129.

CHAPTER XIII.

ON THE DIFFERENCE BETWEEN MAKING AND MANUFACTURING.

CHAPTER XIV.

ON THE INFLUENCE OF VERIFICATION ON PRICE.

Modification of general Principles, § 134. Verification of Sugar, Tea, Flour, 135. Doctoring Trefoil, and Clover, 136. Flax, 137. Difficulty of distinguishing "single press" Lace, 138. Stockings, 139. Watches, 140. Measures of articles of Linen Drapery, 141. Apothecaries and Druggists, 142. Effect of Number of Proprietors on Price, 143. Ice. Oil of Cajeput, 144.

CHAPTER XV.

ON THE INFLUENCE OF DURABILITY ON PRICE.

Degree of Durability in Articles. Paper, Pens, Precious Stones, § 146. Tables, Chairs, Looking-glasses, 147.

CHAPTER XVI.

ON PRICE, AS MEASURED BY MONEY.

List of Prices of various Articles in 1818, 1824, 1828, 1830, § 148. Another List, for 1812, 1832. Advice about such Lists, 148. Causes of Alteration of Money Price. Table of Elements of Alteration, 149. Price of Plate Glass in London, Paris, and Berlin. Price of large Plates, 150. Middle-men, 152.

CHAPTER XVII.

OF RAW MATERIALS.

Nature of Raw Material, § 153. Gold and Silver Leaf, 154. Venetian Gold Chains, 155. Watch-spring, 156. Tables of Price of Raw Material and Labour in various Manufacture of France, 157. Price of Bar-iron in various Countries, 158.

CHAPTER XVIII.

OF THE DIVISION OF LABOUR.

Causes of its Advantages, § 159. Time required for learning an Art, 160. Time lost in changing Occupation, 162.

Skill acquired by frequent Repetition of the same Process. Nail-making; Signing Bank Notes, 164, 165. Contrivance of Tools, 166. New Principle of the Advantage of the Division of Labour, 168. Pin-making, English, 170 to 176. Table of Cost of making English Pins, 178. Ditto French Pins, 179. American Pin-making Machine, 181. Examination of its Merits, 182.

CHAPTER XIX.

ON THE DIVISION OF MENTAL LABOUR.

Great French Tables of Logarithms, § 183 to 187. On performing Arithmetical Calculations by Machinery, 189. Explanation of Mathematical Principle. Table of Square Numbers with Differences, 190. Illustration by three Clocks, 191.

CHAPTER XX.

ON THE SEPARATE COST OF EACH PROCESS IN A MANUFACTURE.

Comparative Value of Cotton of Java in various Stages of Manufacture, § 196. Statement of Expense of printing the present Volume, 197. Observations on Statement, 198—200. Effect of Duty on Paper, 201. Charge for Advertisements, 202, 203.

CHAPTER XXI.

ON THE CAUSES AND CONSEQUENCES OF LARGE FACTORIES.

Principle on which large Factories are established, § 204. Transport of Materials, 205. Machine for making Patent-net working eight Hours a-day. Same Machine working twenty-four Hours requires three Sets of Men. Porter to admit different Sets of Workmen. Workman to keep Machines in Repair, 206. Application of Steam to Weaving, 207. Lighting by Gas, 208. Accountant's Department, 209. Importance of making Workmen derive Profit from Success of Factory, 210. System in Cornish Mines, 211. Effects of large Factories, 212. Economy of Raw Produce; exemplified in Horns, 213. Middle-men. Confidence in

Character, 214. Extent of Confidence, 215. Breach of Confidence: Needles without Eyes, 216. Instance of Confidence, 217. Drawbacks, 218. Sending Agents to distant Countries. Extract from the Report of the Committee of the House of Commons relating to Factory System, 219.

CHAPTER XXII.

ON THE POSITION OF GREAT FACTORIES.

In the Line of Cheap Modes of Conveyance; Fuel, Water, Power, § 220. Mississippi, 221. Steam-boats on tbat River, *note*. Accumulation of Factories establishes regular Markets, 222. Removal of Factories, 223, 224. Facilities for removing different Machines, 225. Important Suggestions to Workmen on this Subject, 226.

CHAPTER XXIII.

ON OVER-MANUFACTURING.

Periodical. Effect where there are not large Establishments. System of Compensation, § 227. Effect on large Factories. Two Remedies, 228. Diminished Production. Diminished Cost of Production, 229. Effects in driving Capital to other Employments, 231.

CHAPTER XXIV.

INQUIRIES PREVIOUS TO COMMENCING ANY MANUFACTORY.

Expense of Tools and Machines. Supply of Raw Material, § 233, 234. Probable Demand. Dolls' Eyes, 235. Tolls on Steam-carriages. Effect of Atmosphere, of Wheels, and of Horses' Feet on Roads, 236. Draught of Carriages over various kinds of Roads. Draught up various Inclinations at six, eight, and ten Miles per Hour, 237. Time in which Returns can be made, — Facility of introducing new Articles, 238. Probable Opposition to new Manufacture, 239.

CHAPTER XXV.

ON CONTRIVING MACHINERY.

Power of inventing Mechanical Contrivances not very rare. Projects to prevent Forgery of Bank-notes, § 240. Best

Combinations of Machinery rare, 241. Drawings to be made to determine all the Movements, 241. Experiments for all the physical or chemical circumstances. Punching Letters on Copper, 242. Causes of Failure in Machines, 243. Want of Stiffness in Framing. Experiment should be tried with good Workmanship, 244. Same Experiment repeated at distant Intervals, 245. Expense of new Machine, 247. Advice to Projectors, 248.

CHAPTER XXVI.

PROPER CIRCUMSTANCES FOR THE APPLICATION OF MACHINERY.

When many Things of the same Kind are required, § 249. Where few Things perfectly accurate are required, 250. Where Economy of Time is required. Newspapers, 251. "The Times," 252. Conveyance of Letters, 253. Steam-carriages, 256. Diving Vessel, 257. Slide of Alpnach, 258. Competition between Machine and Hand Labour, 259.

CHAPTER XXVII.

ON THE DURATION OF MACHINERY.

Engines to produce Power last long, § 261. Improvements increase Production, 262. Age of Watches, 263. Machines let for Hire. Unexpected Effect of a Change in the Rent of Stocking Frames, 264. Stamps, and Dies, and Steam Power let out, 266.

CHAPTER XXVIII.

ON COMBINATION AMONGST MASTERS OR WORKMEN AGAINST EACH OTHER.

Rules in particular Factories, § 270. Larger Societies, 276. Objects of them, 277. Effects, 278. Gun Barrels, 279. Fear of Combination causes Expense, 282. Coal and Iron Works, 283. Cause of Removal of Factories, 285. The Truck System 287. Payment of Wages in Goods, 289.

CHAPTER XXIX.

ON COMBINATIONS OF MASTERS AGAINST THE PUBLIC.

Instances, § 291. Gas and Water Companies, 293. Coal-owners, 294. Booksellers, 295. Profits on the present Volume, 296. Combination of Booksellers, 299. Remedy proposed, 302. Reviews, 303.

CHAPTER XXX.

ON THE EFFECT OF TAXES AND OF LOCAL RESTRICTIONS UPON MANUFACTURES.

Taxes on Paper, on Windows, § 304. Excise Regulations, 305. Effects of Duties, 307. Insurance on Smuggling, 308. Bounties, 310. Effects of Removal of a Monopoly in the Bobbin-net Trade, 312. Present State of that Trade, 313. Number and Distribution of Machines, 315. Of Patents, 317. Expence, 318. Of Copyright, 319. Of limited Partnerships, 320.

CHAPTER XXXI.

ON THE EXPORTATION OF MACHINERY.

Reason for and against, § 322. Competition between Manufacturer in poor and in rich Country, 323. Impossible to prevent Exportation of all whilst that of any is permitted, 325. Makers of new Machines interested in supplying the Home Market, 326. Foreign Orders charged higher, 327. Comparison of internal Communications in England and France, 333. Manchester Rail-Road, 334.

CHAPTER XXXII.

ON THE FUTURE PROSPECTS OF MANUFACTURES, AS CONNECTED WITH SCIENCE.

Union of Theory and Practice, § 335. Difficulties opposed to Cultivation of Abstract Science, 336. Royal Society, 337. British Association for the Promotion of Science, 338. Effect of Public Opinion on Science, 339. Manufacturers discovered Iodine and Brome, 340. Peruvian Bark, 341. Views of the Future, 344. Conclusion.

ON THE ECONOMY

OF

MANUFACTURES.

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 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 unadvisable 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.

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 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 con- "sumed in large quantities both by the natives and Chinese." —Crawfurd'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.

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 to 1811.	1811 to 1821.	1821 to 1831.	Total 1801 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.

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 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 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.

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 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 used with the hand, whilst a machine is frequently moved by animal or steam power. The simpler *machines* are often merely one or more *tools* placed in a frame, and acted on by any moving power. In pointing out the advantages of *tools*, we shall commence with some of the simplest.

(10.) To arrange twenty thousand needles thrown promiscuously into a box, mixed and entangled with each other in every possible direction, in such a form that they shall be all parallel to each other, would, at first sight, appear a most tedious occupation; in fact, if each needle were to be separated individually, many hours must be consumed in the process. Yet this is an operation which must be performed many times in the manufacture of needles; and it is accomplished in a few minutes by a very simple *tool;* nothing more being requisite than a small flat tray of sheet iron, slightly concave at the bottom. The needles are placed in it and shaken in a peculiar manner, by throwing them up a very little, and giving at the same time a slight longitudinal motion to the tray. The shape of the needles assists their arrangement; for if two needles cross each other, (unless, which is exceedingly improbable, they happen to be precisely balanced,) they will, when they fall on the bottom of the tray, tend to place themselves side by side, and the hollow form of the tray assists this disposition. As they have no projection in any part to impede this tendency, or to entangle each other, they are, by continually shaking, arranged lengthwise, in three or four minutes. The direction of the shake is now changed, the needles are but little thrown up, but the tray is shaken endways; the result of which is, that in a minute or two the needles which were previously arranged endways become heaped up in a wall, with their ends against the extremity of the tray. They are now removed by hundreds at a time, by raising them with a broad iron spatula, on which they are retained by the fore-finger of the left hand. During the progress of the needles towards their finished state, this parallel arrangement must be repeated many times; and unless a cheap and expeditious method had been devised, the expense of manufacturing needles would have been considerably enhanced.

(11.) Another process in the art of making needles furnishes an example of one of the simplest contrivances which can come under the denomination of a *tool*. After the needles have been arranged in the manner just described, it is necessary to separate them into two parcels, in order that their points may be all in one direction. This is usually done by women and children. The needles are placed sideways in a heap, on a table, in front of each operator, just as they are arranged by the process above described. From five to ten are rolled towards this person by the forefinger of the left hand; this separates them a very small space from each other, and each in its turn is pushed lengthwise to the right or to the left, according as its eye is on the right or the left hand. This is the usual process, and in it every needle passes individually under the finger of the operator. A small alteration expedites the process considerably: the child puts on the forefinger of its right hand a small cloth cap or finger-stall, and rolling out of the heap from six to twelve needles, he keeps them down by the forefinger of the left hand, whilst he presses the forefinger of the right hand gently against their ends: those which have the points towards the right hand stick into the finger-stall; and the child, removing the finger of the left hand, slightly raises the needles sticking into the cloth, and then pushes them towards the left side. Those needles which had their eyes on the right hand do not stick into the finger cover, and are pushed to the heap on the right side previously to the repetition of this process. By means of this simple contrivance each movement of the finger, from one side to the other, carries five or six needles to their proper heap; whereas, in the former method, frequently only one was moved, and rarely more than two or three were transported at one movement to their place.

(12.) Various operations occur in the arts in which the assistance of an additional hand would be a great convenience to the workman, and in these cases tools or machines of the simplest structure come to our aid: vices of different forms, in which the material to be wrought is firmly grasped by screws, are of this kind, and are used in almost every workshop; but a more striking example may be found in the trade of the nail-maker.

Some kinds of nails, such as those used for defending the soles of coarse shoes, called hobnails, require a particular form of the head, which is made by the stroke of a die. The workman holds the red-hot rod of iron out of which he forms them in his left hand; with his right hand he hammers the end of it into a point, and cutting the proper length almost off, bends it nearly at right angles. He puts this into a hole in a small stake-iron immediately under a hammer connected with a treadle, which has a die sunk in its surface corresponding to the intended form of the head; and having given one part of the form to the head by the small hammer in his hand, he moves the treadle with his foot, which disengages the other hammer, and completes the figure of the head; the returning stroke produced by the movement of the treadle striking the finished nail out of the hole in which it was retained. Without this substitution of his foot for another hand, the workman would, probably, be obliged to heat the nails twice over.

(13.) Another, although fortunately a less general substitution of tools for human hands, is used to assist the labour of those who are deprived by nature, or by accident, of some of their limbs. Those who have had an opportunity of examining the beautiful contrivances for the manufacture of shoes by machinery, which we owe to the fertile invention of Mr. Brunel, must have noticed many instances in which the workmen were enabled to execute their task with precision, although labouring under the disadvantages of the loss of an arm or a leg. A similar instance occurs at Liverpool, in the Institution for the Blind, where a machine is used by those afflicted with blindness, for weaving sash-lines: it is said to have been the invention of a person suffering under that calamity. Other instances might be mentioned of contrivances for the use, the amusement, or the instruction of the wealthier classes, who labour under the same natural disadvantages. These triumphs of skill and ingenuity deserve a double portion of our admiration when applied to mitigate the severity of natural or accidental misfortune;—when they supply the rich with occupation and knowledge;—when they relieve the poor from the additional evils of poverty and want.

(14.) *Division of the objects of machinery.* There exists a natural, although, in point of number, a very unequal division amongst machines: they may be classed as; 1*st. Those which are employed to produce power;* and as, 2*dly. Those which are intended merely to transmit force and execute work.* The first of these divisions is of great importance, and is very limited in the variety of its species, although some of those species consist of numerous individuals.

Of that class of mechanical agents by which motion is transmitted,—the lever, the pulley, the wedge, and many others,—it has been demonstrated, that no power is gained by their use, however combined. *Whatever force is applied at one point can only be exerted at some other, diminished by friction and other incidental causes;* and it has been further proved, that *whatever is gained in the rapidity of execution is compensated by the necessity of exerting additional force.* These two principles, long since placed beyond the reach of doubt, cannot be too constantly borne in mind. But in limiting our attempts to things which are possible, we are still, as we hope to shew, possessed of a field of inexhaustible research, and of advantages derived from mechanical skill, which have but just begun their influence on our arts, and may be pursued without limit,—contributing to the improvement, the wealth, and the happiness of our race.

(15.) Of those machines by which we produce power, it may be observed, that although they are to us immense acquisitions, yet in regard to two of the sources of this power,—the force of wind and of water,—we merely make use of bodies in a state of motion by nature; we change the directions of their movement in order to render them subservient to our purposes, but we neither add to nor diminish the quantity of motion in existence. When we expose the sails of a windmill obliquely to the gale, we check the velocity of a small portion of the atmosphere, and convert its own rectilinear motion into one of rotation in the sails; we thus change the direction of force, but we create no power. The same may be observed with regard to the sails of a vessel; the quantity of motion given by them is precisely the same as that which is destroyed in the atmosphere. If we avail ourselves of a descending stream to turn a water-wheel, we are appropriating a power which nature may appear, at first sight, to be uselessly and irrecoverably wasting, but which, upon due examination, we shall find she is ever repairing by other processes. The fluid which is falling from a higher to a lower level, carries with it the velocity due to its revolution with the earth at a greater distance from its centre. It will therefore accelerate, although to an almost infinitesimal extent, the earth's daily rotation. The sum of all these increments of velocity, arising from the descent of all the falling waters on the earth's surface, would in time become perceptible, did not nature, by the process of evaporation, convey the waters back to their sources; and thus again, by removing matter to a greater distance from the centre, destroy the velocity generated by its previous approach.

(16.) The force of vapour is another fertile source of moving power; but even in this case it cannot be maintained that power is created. Water is converted into elastic vapour by the combustion of fuel. The chemical changes which thus take place are constantly increasing the atmosphere by large quantities of carbonic acid and other gases noxious to animal life. The means by which nature decomposes or reconverts these elements into a solid form, are not sufficiently known: but if the end could be accomplished by mechanical force, it is almost certain that the power necessary to produce it would at least equal that which was generated by the original combustion. Man, therefore, does not create power; but, availing himself of his knowledge of nature's mysteries he applies his talents to diverting a small and limited portion of her energies to his own wants: and, whether he employs the regulated action of steam, or the more rapid and tremendous effects of gunpowder, he is only producing on a small scale compositions and decompositions which nature is incessantly at work in reversing, for the restoration of that equilibrium which we cannot doubt is constantly maintained throughout even the remotest limits of our system. The operations of man participate in the character of their author; they are diminutive, but energetic during the short period of their existence: whilst those of nature, acting over vast spaces, and unlimited by time, are ever pursuing their silent and resistless career.

(17.) In stating the broad principle, that all combinations of mechanical art can only augment the force communicated to the machine at the expense of the time employed in producing the effect, it might, perhaps, be imagined, that the assistance derived from such contrivances is small. This is, however, by no means the case: since the almost unlimited variety they afford, enables us to exert to the greatest advantage whatever force we employ. There is, it is true, a limit beyond which it is impossible to reduce the power necessary to produce any given effect, but it very seldom happens that the methods first employed at all approach that limit. In dividing the knotted root of a tree for the purposes of fuel, how very different will be the time consumed, according to the nature of the tool made use of! The hatchet, or the adze, will divide it into small parts, but will consume a large portion of the workman's time. The saw will answer the same purpose more effectually and more quickly. This, in its turn, is superseded by the wedge, which rends it in a still shorter time. If the circumstances are favourable, and the workman skilful, the time and expense may be still further reduced by the use of a small quantity of gunpowder exploded in holes judiciously placed in the block.

(18.) When a mass of matter is to be removed, a certain force must be expended; and upon the proper economy of this force the price of transport will depend. A country must, however, have reached a high degree of civilization before it will have approached the limit of this economy. The cotton of Java is conveyed in junks to the coast of China; but from the seed not being previously separated, three quarters of the weight thus carried is not cotton. This might, perhaps, be justified in Java by the want of machinery to separate the seed, or by the relative cost of the operation in the two countries. But the cotton itself, as packed by the Chinese, occupies three times the bulk of an equal quantity shipped by Europeans for their own markets. Thus the freight of a given quantity of cotton costs the Chinese nearly twelve times the price to which, by a proper attention to mechanical methods, it might be reduced.*

* Crawfurd's *Indian Archipelago.*

CHAP. II.

ACCUMULATING POWER.

(19.) WHENEVER the work to be done requires more force for its execution than can be generated in the time necessary for its completion, recourse must be had to some mechanical method of preserving and condensing a part of the power exerted previously to the commencement of the process. This is most frequently accomplished by a fly-wheel, which is in fact nothing more than a wheel having a very heavy rim, so that the greater part of its weight is near the circumference. It requires great power applied for some time to put this into rapid motion; but when moving with considerable velocity, the effects are exceedingly powerful if its force be concentrated upon a small object. In some of the iron works where the power of the steam-engine is a little too small for the rollers which it drives, it is usual to set the engine at work a short time before the red-hot iron is ready to be removed from the furnace to the rollers, and to allow it to work with great rapidity until the fly has acquired a velocity rather alarming to those unused to such establishments. On passing the softened mass of iron through the first groove, the engine receives a great and very perceptible check; and its speed is diminished at the next and at each succeeding passage, until the iron bar is reduced to such a size that the ordinary power of the engine is sufficient to roll it.

(20.) The powerful effect of a large fly-wheel when its force can be concentrated in a point, was curiously illustrated at one of the largest of our manufactories. The proprietor was shewing to a friend the method of punching holes in iron plates for the boilers of steam-engines. He held in his hand a piece of sheet-iron three-eighths of an inch thick, which he placed under the punch. Observing, after several holes had been made, that the punch made its perforations more and more slowly, he called to the engine-man to know what made the engine work so sluggishly, when it was found that the fly-wheel and punching apparatus had been detached from the steam-engine just at the commencement of his experiment.

(21.) Another mode of accumulating power arises from lifting a weight and then allowing it to fall. A man, even with a heavy hammer, might strike repeated blows upon the head of a pile without producing any effect. But if he raises a much heavier hammer to a much greater height, its fall, though far less frequently repeated, will produce the desired effect.

CHAP. III.

REGULATING POWER.

(22.) UNIFORMITY and steadiness in the rate at which machinery works, are essential both for its effect and its duration. That beautiful contrivance the governor of the steam-engine, must immediately occur to all who are familiar with that admirable machine. Wherever the increased speed of an engine would lead to injurious or dangerous consequences, it is applied; and is equally the regulator of the water-wheel which drives a spinning-jenny, or of the wind-mills which drain our fens. In the dock-yard at Chatham, the descending motion of a large platform, on which timber is raised, is regulated by a governor; but as the weight is very considerable, the velocity of this governor is still further checked by causing its motion to take place in water.

The regularity of the supply of fuel to the fire under the boilers of steam-engines is another mode of contributing to the uniformity of their rate, and also economizes the consumption of coal. Several patents have been taken out for methods of regulating this supply: the general principle being to make the engine supply the fire by means of a hopper, with small quantities of fuel at regular intervals, and to diminish this supply when it works quickly. One of the incidental advantages of this plan is, that by throwing on a very small quantity of coal at a time, the smoke is almost entirely consumed. The dampers of ashpits and chimneys are also in some cases connected with machines in order to regulate their speed.

(23.) Another contrivance for regulating the effect of machinery consists in a vane or a fly, of little weight, but presenting a large surface. This revolves rapidly, and soon acquires a uniform rate, which it cannot greatly exceed, because any addition to its velocity produces a much greater addition to the resistance it meets with from the air. The interval between the strokes on the bell of a clock is regulated by this means; and the fly is so contrived, that this interval may be altered by presenting the arms of it more or less obliquely to the direction in which they move. This kind of fly, or vane, is generally used in the smaller kinds of mechanism, and, unlike the heavy fly, it is a destroyer instead of a preserver of force. It is the regulator used in musical boxes, and in almost all mechanical toys.

(24.) Another very beautiful contrivance for regulating the number of strokes made by a steam-engine, is used in Cornwall: it is called the *cataract*, and depends on the time required to fill a vessel plunged in water, the opening of the valve through which the fluid is admitted being adjustable at the will of the engine man.

CHAP. IV.

INCREASE AND DIMINUTION OF VELOCITY.

(25.) THE fatigue produced on the muscles of the human frame does not altogether depend on the actual force employed in each effort, but partly on the frequency with which it is exerted. The exertion necessary to accomplish every operation consists of two parts: one of these is the expenditure of force which is necessary to drive the tool or instrument; and the other is the effort required for the motion of some limb of the animal producing the action. If we take as an example the act of driving a nail into a piece of wood, the first of these is, the *propelling* the hammer head against the nail; the other is, *raising* the arm in order to lift the hammer. If the weight of the hammer is considerable, the former part will cause the greatest portion of the exertion. If the hammer is light, the exertion of *raising* the arm will produce the greatest part of the fatigue. It does therefore happen, that operations requiring very trifling force, if frequently repeated, will tire more effectually than more laborious work. There is also a degree of rapidity beyond which the action of the muscles cannot be pressed.

(26.) The most advantageous load for a porter who carries wood up stairs on his shoulders, has been investigated by M. Coulomb; but he found from experiment that a man walking up stairs without any load, and raising his burden by means of his own weight in descending, could do as much work in one day, as four men employed in the ordinary way with the most favourable load.

(27.) The proportion between the velocity with which men or animals move, and the weights they carry, is a matter of considerable importance, particularly in military affairs. It is also of great importance for the economy of labour, to adjust the weight of that part of the animal's body which is moved, the weight of the tool it urges, and the frequency of repetition of these efforts, so as to produce the greatest effect. An instance of the saving of time by making the same motion of the arm execute two operations instead of one, occurs in the simple art of making the tags of boot-laces: they are formed out of very thin, tinned, sheet-iron, and were formerly cut out of long strips of that material into pieces of such a breadth that when bent round they just enclosed the lace. Two pieces of steel have recently been fixed to the side of the shears, by which each piece of tinned-iron as soon as it is cut is bent into a semi-cylindrical form. The additional power required for this operation is almost imperceptible; and it is executed by the same motion of the arm which produces the cut. The work is usually performed by women and children; and with the improved tool more than three times the quantity of tags is produced in a given time.*

Whenever the work is itself light, it becomes necessary, in order to economize time, to increase the

* See *Transactions of the Society of Arts*, 1826.

velocity. Twisting the fibres of wool by the fingers would be a most tedious operation : in the common spinning-wheel the velocity of the foot is moderate, but by a very simple contrivance that of the thread is most rapid. A piece of cat-gut passing round a large wheel, and then round a small spindle, effects this change. This contrivance is common to a multitude of machines, some of them very simple. In large shops for the retail of ribands, it is necessary at short intervals to " take stock," that is, to measure and re-wind every piece of riband, an operation which, even with this mode of shortening it, is sufficiently tiresome, but without it would be almost impossible from its expense. The small balls of sewing-cotton, so cheap and so beautifully wound, are formed by a machine on the same principle, and but a few steps more complicated.

(28.) In turning from the smaller instruments in frequent use to the larger and more important machines, the economy arising from the increase of velocity becomes more striking. In converting cast into wrought iron, a mass of metal of about a hundred weight is heated almost to a white heat, and placed under a heavy hammer moved by water or steam power. This is raised by a projection on a revolving axis ; and if the hammer derived its momentum only from the space through which it fell, it would require a considerably greater time to give a blow. But as it is important that the softened mass of red-hot iron should receive as many blows as possible before it cools, the form of the cam or projection on the axis is such, that, the hammer, instead of being lifted to a small height, is thrown up with a jerk, and almost the instant after it strikes against a large beam, which acts as a powerful spring, and drives it down on the iron with such velocity that by these means about double the number of strokes can be made in a given time. In the smaller tilt-hammers, this is carried still further: by striking the tail of the tilt-hammer forcibly against a small steel anvil, it rebounds with such velocity, that from three to five hundred strokes are made in a minute.

(29.) In the manufacture of scythes, the length of the blade renders it necessary that the workman should move readily, so as to bring every part on the anvil in quick succession. This is effected by placing him in a seat suspended by ropes from the ceiling: so that he is enabled, with little bodily exertion, by pressing his feet against the block which supports the anvil, to vary his distance to any required extent. In the manufacture of anchors, an art in which this contrivance is of still greater importance, it has only been recently applied.

(30.) The most frequent reason for employing contrivances for diminishing velocity, arises from the necessity of overcoming great resistances with small power. Systems of pulleys, the crane, and many other illustrations might also here be adduced; but they belong more appropriately to some of the other causes which we have assigned for the advantages of machinery. The common smoke-jack is an instrument in which the velocity communicated is too great for the purpose required, and it is transmitted through wheels which reduce it to a more moderate rate.

CHAP. V.

EXTENDING THE TIME OF ACTION OF FORCES.

(31.) This is one of the most common and most useful of the employments of machinery. The half minute which we daily devote to the winding up of our watches is an exertion of labour almost insensible; yet by the aid of a few wheels its effect is spread over the whole twenty-four hours. In our clocks this extension of the time of action of the original force impressed is carried still further; the better kind usually require winding up once in eight days, and some are occasionally made to continue in action during a month, or even a year. Another familiar illustration may be noticed in our domestic furniture: the common jack by which our meat is roasted, is a contrivance to enable the cook in a few minutes to exert a force which the machine retails out during the succeeding hour in turning the loaded spit; thus enabling her to bestow her undivided attention on the other important duties of her vocation. A great number of automatons and mechanical toys moved by springs, may be classed under this division.

(32.) A small moving power, in the shape of a jack or a spring with a train of wheels, is often of great convenience to the experimental philosopher, and has been used with advantage in magnetic and electric experiments where the rotation of a disk of metal or other body is necessary, thus allowing to the inquirer the unimpeded use of both his hands. A vane connected by a train of wheels, and set in motion by a heavy weight, has also on some occasions been employed in chemical processes, to keep a solution in a state of agitation. Another object to which a similar apparatus may be applied, is the polishing of small specimens of minerals for optical experiments.

CHAP. VI.

SAVING TIME IN NATURAL OPERATIONS.

(33.) THE process of tanning will furnish us with a striking illustration of the power of machinery in accelerating certain processes in which natural operations have a principal effect. The object of this art is to combine a certain principle called *tanning* with every particle of the skin to be tanned. This in the ordinary process is accomplished by allowing the skins to soak in pits containing a solution of tanning matter: they remain in the pits six, twelve, or eighteen months; and in some instances, (if the hides are very thick,) they are exposed to the operation for two years, or even during a longer period. This length of time is apparently required in order to allow the tanning matter to penetrate into the interior of a thick hide. The improved process consists in placing the hides with the solution of tan in close vessels, and then exhausting the air. The consequence of this is to withdraw any air which might be contained in the pores of the hides, and to employ the pressure of the atmosphere to aid capillary attraction in forcing the tan into the interior of the skins. The effect of the additional force thus brought into action can be equal only to one atmosphere, but a further improvement has been made: the vessel containing the hides is, after exhaustion, filled up with a solution of tan; a small additional quantity is then injected with a forcing-pump. By these means any degree of pressure may be given which the containing vessel is capable of supporting ; and it has been found that, by employing such a method, the thickest hides may be tanned in six weeks or two months.

(34.) The same process of injection might be applied to impregnate timber with tar, or any other substance adapted to preserve it from decay; and if it were not too expensive, the deal floors of houses might thus be impregnated with alumine or other substances, which would render them much less liable to be accidentally set on fire. Some idea of the quantity of matter which can be injected into wood, by great pressure, may be formed from considering the fact stated by Mr. Scoresby, respecting an accident which occurred to a boat of one of our whaling-ships. The line of the harpoon being fastened to it, the whale in this instance dived directly down, and carried the boat along with him. On returning to the surface the animal was killed, but the boat, instead of rising, was found suspended beneath the whale by the rope of the harpoon ; and on drawing it up, every part of the wood was found to be so completely saturated with water as to sink immediately to the bottom.

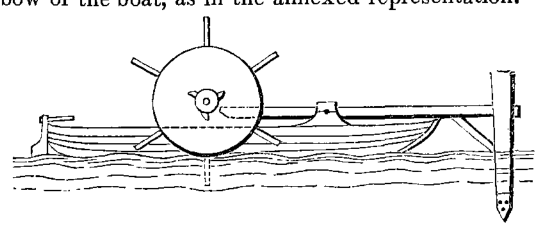
(35.) The operation of bleaching linen in the open air is one for which considerable time is necessary ; and although it does not require much labour, yet, from the risk of damage and of robbery from long exposure, a mode of shortening the process was highly desirable. The method now practised, although not mechanical, is such a remarkable instance of the application of science to the practical purposes of manufactures, that in mentioning the advantages derived from shortening natural operations, it would have been scarcely pardonable to have omitted all allusion to the beautiful application of chlorine, in combination with lime, to the art of bleaching.

(36.) Another instance more strictly mechanical occurs in some countries where fuel is expensive, and the heat of the sun is not sufficient to evaporate the water from brine springs. The water is first pumped up to a reservoir, and then allowed to fall in small streams through fagots. Thus it becomes divided; and, presenting a large surface, evaporation is facilitated, and the brine which is collected in the vessels below the fagots is stronger than that which was pumped up. After thus getting rid of a large part of the water, the remaining portion is driven off by boiling. The success of this operation depends on the circumstance of the atmosphere not being saturated with moisture: if the air at the time the brine falls through the fagots holds in solution as much moisture as it can contain in an invisible state, none can be absorbed from the salt water, and the labour expended in pumping is entirely wasted. The state of the air, as to dryness, is therefore an important consideration in fixing the time when this operation is to be performed; and an attentive examination of its state, by means of the hygrometer, might be productive of some economy of labour.

(37.) In some countries, where wood is scarce, the evaporation of salt water is carried on by a large collection of ropes which are stretched perpendicularly.

The water passing down them, deposits the sulphate of lime which it held in solution, and gradually incrusts the ropes, so that in the course of twenty years, when they are nearly rotten, they are sustained by the surrounding incrustation, thus presenting the appearance of a vast collection of small columns.

(38.) Amongst natural operations perpetually altering the surface of our globe, there are some which it would be advantageous to accelerate. The wearing down of the rocks which impede the rapids of navigable rivers, is one of this class. A very beautiful process for accomplishing this object has been employed in America. A boat is placed at the bottom of the rapid, and kept in its position by a long rope which is firmly fixed on the bank of the river near the top. An axis, having a wheel similar to the paddle-wheel of a steam-boat fixed at each end of it, is placed across the boat; so that the two wheels and their connecting axis shall revolve rapidly, being driven by the force of the passing current. Let us now imagine several beams of wood shod with pointed iron fixed at the ends of strong levers, projecting beyond the bow of the boat, as in the annexed representation.



If these levers are at liberty to move up and down, and if one or more projecting pieces, called cams, are fixed on the axis opposite to the end of each lever, the action of the stream upon the wheels will keep up a perpetual succession of blows. The sharp-pointed shoe striking upon the rock at the bottom, will continually detach small pieces, which the stream will immediately carry off. Thus, by the mere action of the river itself, a constant and most effectual system of pounding the rock at its bottom is established. A single workman may, by the aid of a rudder, direct the boat to any required part of the stream ; and when it is necessary to move up the rapid, as the channel is cut, he can easily cause the boat to advance by means of a capstan.

(39.) When the object of the machinery just described has been accomplished, and the channel is sufficiently deep, a slight alteration converts the apparatus to another purpose almost equally advantageous. The stampers and the projecting pieces on the axis are removed, and a barrel of wood or metal, surrounding part of the axis, and capable, at pleasure, of being connected with, or disconnected from the axis itself, is substituted. The rope which hitherto fastened the boat, is now fixed to this barrel; and if the barrel is loose upon the axis, the paddle-wheels make the axis only revolve, and the boat remains in its place: but the moment the axis is attached to its surrounding barrel, this begins to turn, and winding the rope upon itself, the boat is gradually drawn up against the stream; and may be employed as a kind of tug-boat for all the vessels which have occasion to ascend the rapid. When the tug-boat reaches the summit the barrel is released from the axis, and friction being applied to moderate its velocity, the boat is allowed to descend.

CHAP. VII.

EXERTING FORCES TOO GREAT FOR HUMAN POWER, AND EXECUTING OPERATIONS TOO DELICATE FOR HUMAN TOUCH.

(40.) It requires some skill and a considerable apparatus to enable many men to exert their whole force at a given point, and when this number amounts to hundreds or to thousands, additional difficulties present themselves. If ten thousand men were hired to act simultaneously, it would be exceedingly difficult to discover whether each exerted his whole force, and consequently, to be assured that each man did the duty for which he was paid. And if still larger bodies of men or animals were necessary, not only would the difficulty of directing them become greater, but the expense would increase from the necessity of transporting food for their subsistence.

The difficulty of enabling a large number of men to exert their force at the same instant of time has been almost obviated by the use of sound. The whistle of the boatswain occasionally performs this service; and in removing, by manual force, the vast mass of granite, weighing above 1400 tons, on which the equestrian figure of Peter the Great is placed at St. Petersburgh, a drummer was always stationed on its summit to give the signal for the united efforts of the workmen.

An interesting discovery was made a few years since, by Champollion, of an ancient Egyptian drawing, in which a multitude of men appeared harnessed to a huge block of stone, on the top of which stood a single individual with his hands raised above his head, apparently in the act of clapping them, for the same purpose of insuring the exertion of their combined force at the same moment of time.

(41.) In all our larger manufactories numerous instances occur of the application of the power of steam to overcome resistances which it would require far greater expense to surmount by means of animal labour. The twisting of the largest cables, the rolling, hammering, and cutting large masses of iron, the draining of our mines, all require enormous exertions of physical force continued for considerable periods of time. Other means are had recourse to when the force required is great, and the space through which it is to act is small. The hydraulic press of Bramah can, by the exertion of one man, produce a pressure of 1500 atmospheres, and with such an instrument a hollow cylinder of wrought iron three inches thick has been burst. In rivetting together the iron plates out of which steam engine boilers are made, it is necessary to produce as close a joint as possible. This is accomplished by using the rivets red hot: while they are in that state the two plates of iron are rivetted together, and the contraction which the rivet undergoes in cooling draws them together with a force which is only limited by the tenacity of the metal of which the rivet itself is made.

(42.) It is not alone in the greater operations of the engineer or the manufacturer, that those vast powers which man has called into action, in availing himself of the agency of steam, are fully developed. Wherever the individual operation demanding little force for its own performance is to be multiplied in almost endless repetition, commensurate power is required. It is the same "giant arm which "twists the largest cable," that spins from the cotton plant an "almost gossamer thread." Obedient to the hand which called into action its resistless powers, it contends with the ocean and the storm, and rides triumphant through dangers and difficulties unattempted by the older modes of navigation. It is the same engine that, in its more regulated action, weaves the canvass it may one day supersede; or, with almost fairy fingers, entwines the meshes of the most delicate fabric that adorns the female form.*

(43.) The Fifth Report of the Select Committee of the House of Commons on the Holyhead Roads furnishes ample proof of the great superiority of steam vessels. The following extracts are taken from the evidence of Captain Rogers, the commander of one of the packets :—

"*Question.* Be so good as to acquaint the committee in "what manner the communication has been kept open "between Holyhead and Dublin by steam packets, and "what has been the success of the experiment of establish-"ing them on that station.

"*Answer.* We have done every thing that could be done, "*by steam boats;* and they will go, no doubt, when a sailing "vessel will not,—that has been proved.

* The importance and diversified applications of the steam-engine were most ably enforced in the speeches made at a public meeting, held (June 1824) for the purpose of proposing the erection of a monument to the memory of James Watt; these were subsequently printed.

"*Quest.* Are you not perfectly satisfied, from the ex-
"perience you have had, that the steam vessel you command
"is capable of performing what no sailing vessel can do?

"*Ans.* Yes.

"*Quest.* During your passage from Gravesend to the
"Downs could any square-rigged vessel, from a first-rate
"down to a sloop of war, have performed the voyage you
"did in the time you did it in the steam boat?

"*Ans.* No; it was impossible. In the Downs we passed
"several Indiamen, and 150 sail there that could not move
"down the Channel; and at the back of Dungeness we
"passed 120 more.

"*Quest.* At the time you performed that voyage, with the
"weather you have described, from the Downs to Milford,
"if that weather had continued twelve months would any
"square-rigged vessel have performed it?

"*Ans.* They would have been a long time about it; pro-
"bably, would have been weeks instead of days. A sailing
"vessel would not have beat up to Milford, as we did, in
"twelve months."

(44.) The process of printing on silver paper, which is necessary for bank-notes, is attended with some inconvenience, from the necessity of damping the paper previously to taking the impression. It was difficult to do this uniformly; and in the old process of dipping a parcel of several sheets together into a vessel of water, the outside sheets becoming much more wet than the others were very apt to be torn. A method has been adopted at the Bank of Ireland which obviates this inconvenience. The whole quantity of paper to be damped is placed in a close vessel from which the air is exhausted; water is then admitted and every leaf is completely wetted; the paper is then removed to a press, and all the superfluous moisture is squeezed out.

CHAP. VIII.

REGISTERING OPERATIONS.

(45.) One of the most singular advantages we derive from machinery is in the check which it affords against the inattention, the idleness, or the knavery, of human agents. Few occupations are more wearisome than counting a series of repetitions of the same fact; the number of paces we walk affords a tolerably good measure of distance passed over, but the value of this is much enhanced by possessing an instrument, the pedometer, which will count for us the number of steps we have made. A piece of mechanism of this kind is sometimes applied to count the number of turns made by the wheel of a carriage, and thus to indicate the distance travelled: an instrument similar in its object, but differing in its construction, has been used for counting the number of strokes made by a steam-engine, and the number of coins struck in a press. One of the simplest instruments for counting any series of operations, was contrived by Mr. Donkin.*

(46.) Another instrument for registering is used in some establishments for calendering and embossing. Many hundred thousand yards of calicoes and stuffs pass weekly through these operations, and as the price paid for the process is small, the value of the time spent in measuring them would bear a considerable proportion to the profit. A machine has,

* Transactions of the Society of Arts, 1819, p. 116.

therefore, been contrived for measuring and registering the length of the goods as they pass rapidly through the hands of the operator, and all chance of erroneous counting is thus avoided.

(47.) Perhaps the most useful contrivance of this kind, is one for ascertaining the vigilance of a watchman. It is a piece of mechanism connected with a clock placed in an apartment to which the watchman has not access; but he is ordered to pull a string situated in a certain part of his round once in every hour. The instrument, aptly called a *tell-tale*, informs the owner whether the man has missed any, and what hours during the night.

(48.) It is often of great importance, both for regulations of excise as well as for the interest of the proprietor, to know the quantity of spirits or of other liquors which have been drawn off by those persons who are allowed to have access to the vessels during the absence of the inspectors or principals. This may be accomplished by a peculiar kind of stopcock,—which will, at each opening, only discharge a certain measure of fluid,—the number of times the cock has been turned being registered by a counting apparatus accessible only to the master.

(49.) The time and labour consumed in guaging casks partly filled, has led to an improvement which, by the simplest means, obviates a considerable inconvenience, and enables any person to read off, on a scale, the number of gallons contained in any vessel, as readily as he does the degree of heat indicated by his thermometer. A small stop-cock is inserted near the bottom of the cask, which it connects with a glass tube of narrow bore fixed to a scale on the side of the cask, and rising a little above its top. The plug of the cock may be turned into three positions: in the first, it cuts off all communication with the cask: in the second, it opens a communication between the cask and the glass tube: and, in the third, it cuts off the connexion between the cask and the tube, and opens a communication between the tube and any vessel held beneath the cock to receive its contents. The scale of the tube is graduated by opening the communication between the cask and tube and pouring into the cask a gallon of water. A line is then drawn on the scale opposite the place in the tube to which the water rises. This operation is repeated, and at each successive gallon a new line is drawn. Thus the scale being formed by actual measurement,* both the proprietor and the excise officer see, on inspection, the contents of each cask, and the tedious process of guaging is altogether dispensed with. Other advantages accrue from this simple contrivance, in the great economy of time which it introduces in making mixtures of different spirits, in taking stock, and in receiving spirit from the distiller.

(50.) The gas-meter, by which the quantity of gas used by each consumer is ascertained, is another instrument of this kind. They are of several forms, but all of them intended to register the number of cubic feet of gas which has been delivered. It is very desirable that these meters should be obtainable at a moderate price, and that every consumer should

* This contrivance is due to Mr. Henneky, of High Holborn, in whose establishment it is in constant employment.

employ them; because, by making each purchaser pay only for what he consumes, and by preventing that extravagant waste of gas which we frequently observe, the manufacturer of gas will be enabled to make an equal profit at a diminished price to the consumer.

(51.) The sale of water, by the different companies in London, might also, with advantage, be regulated by a different kind of meter. If such a system were adopted, much water which is now allowed to run to waste would be saved, and an unjust inequality between the rates charged on different houses by the same company be avoided.

(52.) Another subject to which machinery for registering operations is applied with much advantage is the determination of the average effect of natural or artificial agents. The mean height of the barometer, for example, is ascertained by noting its height at a certain number of intervals during the twenty-four hours. The more these intervals are contracted, the more correctly will the mean be ascertained; but the true mean ought to participate in each momentary change which has occurred. Clocks have been proposed and made for this purpose, and the principle adopted has been that of moving a sheet of paper, slowly and uniformly, before a pencil fixed to a float upon the surface of the mercury in the cup of the barometer. Sir David Brewster proposed, several years ago, to suspend a barometer, and swing it as a pendulum. The variations in the atmosphere would thus alter the centre of oscillation, and the comparison of such an instrument with a good clock, would enable us to ascertain the mean altitude of the barometer during any interval of the observer's absence.*

Instruments might also be contrived to determine the average force of traction of horses,—of the wind, —of a stream,—or of any other irregular and fluctuating effort of animal or natural force.

(53.) There are several instruments contrived for awakening the attention of the observer at times previously fixed upon. The various kinds of alarums connected with clocks and watches are of this kind. In some instances it is desirable to be able to set them so as to give notice at many successive and distant points of time, such as those of the arrival of given stars on the meridian. A clock of this kind is used at the Royal Observatory at Greenwich.

Repeating clocks and watches may be considered as instruments for registering time, which communicate their information only when the owner requires it, by pulling a string, or by some similar application.

* About seven or eight years since, without being aware of Sir David Brewster's proposal, I adapted a barometer, as a pendulum, to the works of a common eight-day clock; it remained in my library for several months, but I have mislaid the observations which were made.

CHAP. IX.

ECONOMY OF THE MATERIALS EMPLOYED.

(54.) The precision with which all operations by machinery are executed, and the exact similarity of the articles thus made, produce a degree of economy in the consumption of the raw material which is in some cases of great importance. The earliest mode of cutting the trunks of a tree into planks, was by the use of the hatchet or the adze. It might, perhaps, be first split into three or four portions, and then each portion was reduced to a uniform surface by those instruments. With such means the quantity of plank produced would probably not equal the quantity of the raw material wasted by the process: and, if the planks were thin, would certainly fall far short of it. An improved tool, the saw, completely reverses the case: in converting a tree into thick planks, it causes a waste of a very small fractional part; and even in reducing it to planks, of only an inch in thickness, it does not waste more than an eighth part of the raw material. When the thickness of the plank is still further reduced as is the case in cutting wood for veneering, the quantity of material destroyed again begins to bear a considerable proportion to that which is used; and hence circular saws, having a very thin blade, have been employed for such purposes. In order to economize still further the more valuable woods, Mr. Brunel contrived a machine which, by a system of blades, cut off the veneer in a continuous shaving, thus rendering the whole of the piece of timber available.

(55.) The rapid improvements which have taken place in the printing-press during the last twenty years, afford another instance of saving in the materials consumed, which is interesting from its connexion with literature, and valuable because admitted and well ascertained by measurement. In the old method of inking type, by large hemispherical balls stuffed and covered with leather, the printer, after taking a small portion of ink from the ink-block, was continually rolling them in various directions against each other, in order that a thin layer of ink might be uniformly spread over their surface. This he again transferred to the type by a kind of rolling action. In such a process, even admitting considerable skill in the operator, it could not fail to happen that a large quantity of ink should get near the edges of the balls, which not being transferred to the type became hard and useless, and was taken off in the form of a thick black crust. Another inconvenience also arose,—the quantity of ink spread on the block not being regulated by measure, and the number and direction of the transits of the inking-balls over each other depending on the will of the operator, and being irregular, it was impossible to place on the type a uniform layer of ink, of exactly the quantity sufficient for the impression. The introduction of cylindrical rollers of an elastic substance, formed by the mixture of glue and treacle, superseded the inking-balls, and produced considerable saving in the consumption of ink:—but the most perfect economy was only to be produced by mechanism. When printing-presses, moved by the power of steam, were introduced, the action of these rollers was found well adapted to the performance of the machine; and a reservoir of ink was formed, from which one roller regularly abstracted a small quantity at each impression. From three to five other rollers spread this portion uniformly over a slab, (by most ingenious contrivances varied in almost each kind of press,) and another travelling roller, having fed itself on the slab, passed and re-passed over the type just before it gave the impression to the paper.

The following is an account of the results of an accurate experiment upon the effect of the process just described, made at one of the largest printing establishments in the metropolis.*—Two hundred reams of paper were printed off, the old method of inking with balls being employed; two hundred reams of the same paper, and for the same book, were then printed off in the presses which inked their own type. *The consumption of ink by the machine was to that by the balls as four to nine, or rather less than one half.* In order to shew that this plan of inking puts the proper quantity of ink upon the type, we must prove, first,—that it is not too little: this would soon have been discovered from the complaints of the public and the booksellers; and, secondly,—that it is not too much. This latter point is satisfactorily established by a reference to the frequency of the change of what is called the *set-off sheet*, in the old method. A few hours

* This experiment was made at the establishment of Mr. Clowes, in Stamford Street.

after one side of a sheet of paper has been printed upon, the ink is sufficiently dry to allow it to receive the impression upon the other; and, as considerable pressure is made use of, the tympan on which the side first printed is laid, is guarded from soiling it by a sheet of paper called the *set-off sheet.* This paper receives in succession every sheet of the work to be printed, and acquires from them more or less of the ink, according to their dryness, or the quantity upon them. It was necessary in the former process, after about one hundred impressions, to change the *set-off sheet,* which in that time became too much soiled for further use. In the new method of printing by machinery, no *set-off sheet* is used, but a blanket is employed as its substitute; this does not require changing above once in five thousand impressions, and instances have occurred of its remaining sufficiently clean for twenty thousand. Here, then, is a proof that the quantity of superfluous ink put upon the paper in machine-printing is so small, that if multiplied by five thousand, and in some instances even by twenty thousand, it is only sufficient to render useless a single piece of clean cloth.*

* In the very best kind of printing, it is necessary, in the old method, to change the set-off sheet once in twelve times. In printing the same kind of work by machinery, the *blanket* is changed once in 2000.

CHAP. X.

OF THE IDENTITY OF THE WORK WHEN IT IS OF THE SAME KIND, AND ITS ACCURACY WHEN OF DIFFERENT KINDS.

(56.) NOTHING is more remarkable, and yet less unexpected, than the perfect identity of things manufactured by the same tool. If the top of a circular box is to be made to fit over the lower part, it may be done in the lathe by gradually advancing the tool of the sliding-rest; the proper degree of tightness between the box and its lid being found by trial. After this adjustment, if a thousand boxes are made, no additional care is required; the tool is always carried up to the stop, and each box will be equally adapted to every lid. The same identity pervades all the arts of printing; the impressions from the same block, or the same copper-plate, have a similarity which no labour could produce by hand. The minutest traces are transferred to all the impressions, and no omission can arise from the inattention or unskilfulness of the operator. The steel punch, with which the card wadding for a fowling-piece is cut, if it once perform its office with accuracy, constantly reproduces the same exact circle.

(57.) The accuracy with which machinery executes its work is, perhaps, one of its most important advantages: it may, however, be contended, that a considerable portion of this advantage may be resolved into saving of time; for it generally happens, that any improvement in tools increases the quantity of work done in a given time. Without tools, that is, by the mere efforts of the human hand, there are, undoubtedly, multitudes of things which it would be impossible to make. Add to the human hand the rudest cutting-instrument, and its powers are enlarged: the fabrication of many things then becomes easy, and that of others possible with great labour. Add the saw to the knife or the hatchet, and other works become possible, and a new course of difficult operations is brought into view, whilst many of the former are rendered easy. This observation is applicable even to the most perfect tools or machines. It would be *possible* for a very skilful workman, with files and polishing substances, to form a cylinder out of a piece of steel; but the time which this would require would be so considerable, and the number of failures would probably be so great, that for all practical purposes such a mode of producing a steel cylinder might be said to be impossible. The same process by the aid of the lathe and the sliding-rest is the every-day employment of hundreds of workmen.

(58.) Of all the operations of mechanical art, that of turning is the most perfect. If two surfaces are worked against each other, whatever may have been their figure at the commencement, there exists a tendency in them both to become portions of spheres. Either of them may become convex, and the other concave, with various degrees of curvature. A plane surface is the line of separation between convexity and concavity, and is most difficult to hit; and it is more easy to make a good circle than to produce a straight line. A similar difficulty takes place in figuring specula for telescopes; the parabola is the surface which separates the hyperbolic from the elliptic figure, and is the most difficult to form. If a spindle, not cylindrical at its end, is pressed into a hole not circular, and if the spindle be kept constantly turning, there is a tendency in these two bodies so situated to become conical, or to have circular sections. If a triangular pointed piece of iron be worked round in a circular hole the edges will gradually wear, and it will become conical. These facts, if they do not explain, at least illustrate the principles on which the excellence of work formed in the lathe depends.

CHAP. XI.

OF COPYING.

(59.) THE two last sources of excellence in the work produced by machinery depend on a principle which pervades a very large portion of all manufactures, and is one upon which the cheapness of the articles produced seems greatly to depend. The principle alluded to is that of COPYING, taken in its most extensive sense. Almost unlimited pains are, in some instances, bestowed on the original, from which a series of copies is to be produced; and the larger the number of these copies, the more care and pains can the manufacturer afford to lavish upon the original. It may thus happen, that the instrument or tool actually producing the work, shall cost five or even ten thousand times the price of each individual specimen of its power.

As the system of copying is of so much importance, and of such extensive use in the arts, it will be convenient to classify a considerable number of those processes in which it is employed. The following enumeration is not offered as a complete list; and the explanations are restricted to the shortest possible detail which is consistent with a due regard to making the subject intelligible. Operations of copying are effected under the following circumstances:—

By printing from cavities.	By stamping.
By printing from surface.	By punching.
By casting.	With elongation.
By moulding.	With altered dimensions.

Of Printing from Cavities.

(60.) The art of printing, in all its numerous departments, is essentially an art of copying. Under its two great divisions, printing from hollow lines, as in copper plate, and printing from surface as in block-printing, are comprised numerous arts.

(61.) *Copper-plate Printing.*—In this instance the copies are made by transferring to paper, by means of pressure, a thick ink, from the hollows and lines cut in the copper. An artist will sometimes exhaust the labour of one or two years upon engraving a plate, which will not, in some cases, furnish above five hundred copies in a state of perfection.

(62.) *Engravings on Steel.*—This is an art in most respects similar to engraving on copper, except that the number of copies is far less limited. A bank-note engraved as a copper-plate, will not give above three thousand impressions without a sensible deterioration. Two impressions of a bank-note engraved on steel were examined by one of our most eminent artists,* who found it difficult to pronounce with any confidence, which was the earliest impression. One of these was a proof from amongst the first thousand,

* The late Mr. Lowry.

the other was taken after between seventy and eighty thousand had been printed off.

(63.) *Music-Printing.*—Music is usually printed from pewter plates, on which the characters have been impressed by steel punches. The metal being much softer than copper, is liable to scratches, which detain a small portion of the ink. This is the reason of the dirty appearance of printed music. A new process has recently been invented by Mr. Cowper, by which this inconvenience will be avoided. The improved method, which gives sharpness to the characters, is still an art of copying; but it is effected by surface-printing, nearly in the same manner as calico-printing from blocks, to be described hereafter, (70.) The method of printing music from pewter-plates, although by far the most frequently made use of, is not the only one employed, for music is occasionally printed from stone. Sometimes also it is printed with movable type; and occasionally the musical characters are printed on the paper, and the lines printed afterwards. Specimens of both these latter modes of music-printing may be seen in the splendid collection of impressions from the types of the press of Bodoni at Parma: but notwithstanding the great care bestowed on the execution of that work, the perpetual interruption of continuity in the lines, arising from the use of movable type, when the characters and lines are printed at the same time, is apparent.

(64.) *Calico-Printing from Cylinders.*—Many of the patterns on printed calicos are copies by printing from copper cylinders about four or five inches in diameter, on which the desired pattern has been previously engraved. One portion of the cylinders is exposed to the ink, whilst an elastic scraper of stuffed leather, by being pressed forcibly against another part, removes all superfluous ink from the surface previously to its reaching the cloth. A piece of calico twenty-eight yards in length rolls through this press and is printed in four or five minutes.

(65.) *Printing from perforated Sheets of Metal, or Stencilling.*—Very thin brass is sometimes perforated in the form of letters, usually those of a name; this is placed on any substance which it is required to mark, and a brush dipped in some paint is passed over the brass. Those parts which are cut away admit the paint, and thus a copy of the name appears on the substance below. This method, which affords rather a coarse copy, is sometimes used for paper with which rooms are covered, and more especially for the borders. If a portion is required to match an old pattern, this is, perhaps, the most economical way of producing it.

(66.) The beautiful red cotton handkerchiefs dyed at Glasgow have their pattern given to them by a process similar to this, except that, instead of *printing* from a pattern, the reverse operation,—that of *discharging* a part of the colour from a cloth already dyed,—is performed. A number of handkerchiefs are pressed with very great force between two plates of metal, which are similarly perforated with round or lozenge-shaped holes, according to the intended pattern. The upper plate of metal is surrounded by a rim, and a fluid which has the property of discharging the red dye is poured upon that plate. This liquid passes through the holes in the metal, and also through the calico ; but, owing to the great pressure opposite all the parts of the plates not cut away, it does not spread itself beyond the pattern. After this the handkerchiefs are washed, and the pattern of each is a copy of the perforated metal-plate used in the process.

Of Printing from Surface.

This second department, of printing from surface, is of more frequent application in the arts than that which has just been considered.

(67.) *Printing from wooden Blocks.*—A block of box wood is in this instance the substance out of which the pattern is formed: the design being sketched upon it, the workman cuts away with sharp tools every part except the lines to be represented in the impression. This is exactly the reverse of the process of engraving on copper, in which every line to be represented is cut away. The ink, instead of filling the cavities cut in the wood, is spread upon the surface which remains, and is thence transferred to the paper.

(68.) *Printing from moveable Types.*—This is the most important in its influence, of all the arts of copying. It possesses a singular peculiarity, in the immense subdivision of the parts that form the pattern. After that pattern has furnished thousands of copies, the same individual elements may be arranged again and again in other forms, and thus supply multitudes of originals, from each of which thousands of their copied impressions may flow.

(69.) *Printing from Stereotype.*—This mode of producing copies is very similar to the preceding:

but as the original pattern is incapable of change, it is only applied to cases where an extraordinary number of copies are demanded, or where the work consists of figures, and it is of great importance to ensure accuracy. Alterations may be made in it from time to time; and thus mathematical tables may, by the gradual extirpation of error, at last become perfect. This mode of producing copies possesses, in common with that by moveable types, the advantage of being capable of use in conjunction with wood-cuts, a union frequently of considerable importance, and which is not so readily accomplished with engravings on copper.

(70.) *Calico-Printing from Blocks.*—This is a mode of copying, by surface-printing, from the ends of small pieces of copper wire, of various forms, fixed into a block of wood. They are all of one uniform height, about the eighth part of an inch above the surface of the wood, and are arranged by the maker into any required pattern. If the block be placed upon a piece of fine woollen cloth, on which ink of any colour has been uniformly spread, the projecting copper wires receive a portion, which they give up when applied to the calico to be printed. By the former method of printing on calico, only one colour could be used; but by this plan, after the flower of a rose, for example, has been printed with one set of blocks, the leaves may be printed of another colour by a different set.

(71.) *Printing Oil-Cloth.*—After the canvass, which forms the basis of oil-cloth, has been covered with paint of one uniform tint, the remainder of the processes which it passes through, are a series of copyings by surface-printing, from patterns formed upon wooden blocks very similar to those employed by the calico printer. Each colour requires a distinct set of blocks, and thus those oil-cloths with the greatest variety of colours are most expensive.

There are several other varieties of printing which we shall briefly notice as arts of copying; which, although not strictly surface-printing, yet are more allied to it than to that from copper plates.

(72.) *Letter Copying.*—In one of the modes of performing this process, a sheet of very thin paper is damped, and placed upon the writing to be copied. The two papers are then passed through a rolling press, and a portion of the ink from one paper is transferred to the other. The writing is of course reversed by this process; but the paper to which it is transferred being thin, it is visible on the other side, in an uninverted position. Another common mode of copying letters is by placing a sheet of paper covered on both sides with a substance prepared from lamp-black, between a sheet of thin paper and the paper on which the letter to be despatched is to be written. If the upper or thin sheet be written upon with any hard pointed substance, the words written with this style will be impressed from the black paper upon both those adjoining it. The translucency of the upper sheet, which is retained by the writer, is in this instance necessary to render legible the writing which is on the back of the paper. Both these arts are very limited in their extent, two or three being the utmost number of repetitions they allow.

(73.) *Printing on China.*—This is an art of copying which is carried to a very great extent. As the surfaces to which the impression is to be conveyed are often curved, and sometimes even fluted, the ink, or paint, is first transferred from the copper to some flexible substance, such as paper, or an elastic compound of glue and treacle. It is almost immediately conveyed from this to the unbaked biscuit, to which it more readily adheres.

(74.) *Lithographic Printing.*—This is another mode of producing copies in almost unlimited number. The original which supplies the copies is a drawing made on a stone of a slightly porous nature; the ink employed for tracing it is made of such greasy materials that when water is poured over the stone it shall not wet the lines of the drawing. When a roller covered with printing-ink, which is of an oily nature, is passed over the stone previously wetted, the water prevents this ink from adhering to the uncovered portions; whilst the ink used in the drawing is of such a nature that the printing-ink adheres to it. In this state, if a sheet of paper be placed upon the stone, and then passed under a press, the printing-ink will be transferred to the paper, leaving the ink used in the drawing still adhering to the stone.

(75.) There is one application of lithographic printing which does not appear to have received sufficient attention, and perhaps farther experiments are necessary to bring it to perfection. It is the reprinting of works which have just arrived from other countries. A few years ago one of the Paris newspapers was reprinted at Brussels as soon as it arrived, by means of lithography. Whilst the ink is yet fresh this may easily be accomplished: it is only necessary to place one copy of the newspaper on a lithographic stone; and by means of great pressure applied to it in a rolling press, a sufficient quantity of the printing ink will be transferred to the stone. By similar means, the other side of the newspaper may be copied on another stone, and these stones will then furnish impressions in the usual way. If printing from stone could be reduced to the same price per thousand as that from moveable types, this process might be adopted with great advantage for the supply of works for the use of distant countries possessing the same language. For a single copy of the work might be printed off with *transfer ink*, which is better adapted to this purpose; and thus an English work, for example, might be published in America from stone, whilst the original, printed from moveable types, made its appearance on the same day in England.

It is much to be wished that such a method were applicable to the reprinting of fac-similes of old and scarce books. This, however, would require the sacrifice of two copies, since a leaf must be destroyed for each page. Such a method of reproducing a small impression of an old work, is peculiarly applicable to mathematical tables, the setting up of which in type is always expensive, and liable to error: but how long ink will retain its power of being transferred to stone from paper on which it has been printed, must be determined by experiment. The destruction of the greasy or oily portion of the ink in the character of old books, seems to present the greatest impediment: if one constituent only of the ink were removed by time, it might perhaps be hoped, that chemical means would ultimately be discovered for restoring it: but if this be unsuccessful, an attempt might be made to discover some substance having a strong affinity for the carbon of the ink which remains on the paper, and very little for the paper itself.*

(76.) *Register-Printing.*—It is sometimes thought necessary to print from a wooden block, or stereotype plate, the same pattern reversed upon the opposite side of the paper. The effect of this, which is technically called *Register-Printing*, is to make it appear as if the ink had penetrated through the paper, and rendered the pattern visible on the other side. If the subject chosen contains many fine lines, it seems at first sight extremely difficult to effect so exact a super-position of the two patterns, on opposite sides of the same piece of paper, that it shall be impossible to detect the slightest deviation; yet the process is extremely simple. The block which gives the impression is always accurately brought down to the same place by means of a hinge: this spot is covered by a piece of thin leather stretched over it; the block is now inked, and being brought down to its place, gives an impression of the pattern to the leather: it is then turned back: and being inked a second time, the paper intended to be printed is placed upon the leather, when the block again descending, the upper surface of the paper is printed from the block, and its under surface takes up the impression from the leather. It is evident that the perfection of this mode of printing depends in a great measure on finding some soft substance like leather,

* I possess a lithographic reprint of one page of a table, which appears, from the form of the type, to have been several years old.

which will take as much ink as it ought from the block, and which will give it up most completely to paper. Impressions thus obtained are usually fainter on the lower side; and in order in some measure to remedy this defect, rather more ink is put on the block at the first than at the second impression.

Of Copying by Casting.

(77.) The art of casting, by pouring substances in a fluid state into a mould which retains them until they become solid, is essentially an art of copying; the thing produced resembling entirely, as to shape, the pattern from which it was formed.

(78.) *Of Casting Iron and other Metals.*—Patterns of wood or metal made from drawings are the originals from which the moulds for casting are made: so that, in fact, the casting itself is a copy of the mould; and the mould is a copy of the pattern. In castings of iron and metals for the coarser purposes, and, if they are afterwards to be worked, even for the finer machines, the exact resemblance amongst the things produced, which takes place in many of the arts to which we have alluded, is not effected in the first instance, nor is this necessary. As the metals shrink in cooling, the pattern is made larger than the intended copy; and in extricating it from the sand in which it is moulded, some little difference will occur in the size of the cavity which it leaves. In smaller works, where accuracy is more requisite, and where few or no after operations are to be performed, a mould of metal is employed which has been formed with considerable care. Thus, in casting bullets, which ought to be perfectly spherical and smooth, an iron instrument is used in which a cavity has been cut and carefully ground; and in order to obviate the contraction in cooling, a *jet* is left which may supply the deficiency of metal arising from that cause, and which is afterwards cut off. The leaden toys for children are cast in brass moulds which open, and in which have been graved or chiselled the figures intended to be produced.

(79.) A very beautiful mode of representing small branches of the most delicate vegetable productions in bronze has been employed by Mr. Chantrey. A small strip of a fir-tree, a branch of holly, a curled leaf of broccoli, or any other vegetable production, is suspended by one end in a small cylinder of paper which is placed for support within a similarly formed tin case. the finest river silt, carefully separated from all the coarser particles, and mixed with water so as to have the consistency of cream, is poured into the paper cylinder by small portions at a time, carefully shaking the plant a little after each addition, in order that its leaves may be covered, and that no bubbles of air may be left. The plant and its mould are now allowed to dry, and the yielding nature of the paper allows the loamy coating to shrink from the outside. When this is dry it is surrounded by a coarser substance; and, finally, we have the twig with all its leaves imbedded in a perfect mould. This mould is carefully dried, and then gradually heated to a red heat. At the ends of some of the leaves or shoots, wires have been left to afford air-holes by their removal, and in this state of strong ignition a stream of air is directed into the hole formed by the end of the branch. The consequence is, that the wood and leaves which had been turned into charcoal by the fire, are now converted into carbonic acid by the current of air, and after some time the whole of the solid matter of which the plant consisted is completely removed, leaving a hollow mould, bearing on its interior all the minutest traces of its late vegetable occupant. When this process is completed, the mould being still kept at nearly a red heat, receives the fluid metal, which, by its weight, either drives the very small quantity of air, which at that high temperature remains behind, out through the air-holes, or compresses it into the pores of the very porous substance of which the mould is formed.

(80.) *Casting in Plaster.*— This is a mode of copying applied to a variety of purposes:—to produce accurate representations of the human form,—of statues,—or of rare fossils,—to which latter purpose it has lately been applied with great advantage. In all casting, the first process is to make the mould; and plaster is the substance which is almost always employed for the purpose. The property which it possesses of remaining for a short time in a state of fluidity, renders it admirably adapted to this object, and adhesion, even to an original of plaster, is effectually prevented by oiling the surface on which it is poured. The mould formed round the subject which is copied, removed in separate pieces and then reunited, is that in which the copy is cast. This process gives additional utility and value to the finest works of art. The students of the Academy at Venice are thus enabled to admire the sculptured figures of Egina, preserved in the gallery at Munich; as well as the marbles of the Parthenon, the pride of our own Museum. Casts in plaster of the Elgin marbles adorn many of the academies of the Continent, and the liberal employment of such presents affords us an inexpensive and permanent source of popularity.

(81.) *Casting in Wax.*—This mode of copying, aided by proper colouring, offers the most successful imitations of many objects of natural history, and gives an air of reality to them which might deceive even the most instructed. Numerous figures of remarkable persons, having the face and hands formed in wax, have been exhibited at various times; and the resemblances have in some instances been most striking. But whoever would see the art of copying in wax carried to the highest perfection, should examine the beautiful collection of fruit at the house of the Horticultural Society; the model of the magnificent flower of the new genus Rafflesia—the waxen models of the internal parts of the human body which adorn the anatomical gallery of the Jardin des Plantes at Paris, and the Museum at Florence—or the collection of morbid anatomy, at the University of Bologna. The art of imitation by wax does not usually afford the multitude of copies which flow from many similar operations. This number is checked by the subsequent stages of the process, which, ceasing to have the character of copying by a tool or pattern, become consequently more expensive. In each individual production, form alone is given by casting; the colouring must be the work of the pencil, guided by the skill of the artist.

Of Copying by Moulding.

(82.) This method of producing multitudes of individuals having an exact resemblance in external shape, is adopted very widely in the arts. The substances employed are, either naturally or by artificial preparation, in a soft or plastic state; they are then compressed by mechanical force, sometimes assisted by heat, into a mould of the required form.

(83.) *Of Bricks and Tiles.*—An oblong box of wood fitting upon a bottom fixed to the brickmaker's bench, is the mould from which every brick is formed. A portion of the plastic mixture of which the bricks consist is made ready by less skilful hands; the workman first sprinkles a little sand into the mould, and then throws the clay into it with some force, at the same time rapidly working it with his fingers, so as to make it completely close up to the corners. He next scrapes off, with a wetted stick, the superfluous clay, and shakes the new-formed brick dexterously out of its mould upon a piece of board, on which it is removed by another workman to the place appointed for drying it. A very skilful moulder has occasionally, in a long summer's day, delivered from ten to eleven thousand bricks; but a fair average day's work is from five to six thousand. Tiles of various kinds and forms are made of finer materials, but by the same system of moulding. Amongst the ruins of the city of Gour, the ancient capital of Bengal, are found bricks having projecting ornaments in high relief: these appear to have been formed in a mould, and subsequently glazed with a coloured glaze. In Germany, also, brickwork has been executed with various ornaments. The cornice of the church of St. Stefano, at Berlin, is made of large blocks of brick moulded into the form required by the architect.

(84.) *Of embossed China.*—Many of the forms given to those beautiful specimens of earthenware which constitute the equipage of our breakfast and our dinner tables, are not capable of being executed in the lathe of the potter. The embossed ornaments on the edges of the plates, their polygonal shape, the fluted surface of many of the vases, would all be difficult and costly of execution by the hand; but they become easy and uniform in all their parts when made by pressing the soft material out of which they are formed into a hard mould. The care and skill bestowed on the preparation of that mould are repaid by the multitude it produces. In many of the works of the china manufactory, one part only of the article is moulded; the upper surface of the plate, for example, whilst the under side is figured by the lathe. In some instances the handle, or only a few ornaments, are moulded, and the body of the work is turned.

(85.) *Glass Seals.*—The process of engraving upon gems is one requiring considerable time and skill. The seals thus produced can therefore never become common. Imitations, however, have been made of various degrees of resemblance. The colour which is given to glass is, perhaps, the most successful part of the imitation. A small cylindrical rod of coloured glass is heated in the flame of a blow-pipe, until the extremity becomes soft. The operator then pinches it between the ends of a pair of nippers, which are formed of brass, and on one side of which has been carved in relief the device intended for the seal. When care has been taken in heating the glass properly, and when the mould has been well finished, the seals thus produced are not bad imitations. By this system of copying they are so multiplied, that at Birmingham the more ordinary kinds are to be purchased at threepence a dozen.

(86.) *Square Glass Bottles.*—The round forms which are usually given to vessels of glass are readily produced by the expansion of the air with which they are blown. It is, however, necessary in many cases to make bottles of a square form, and each capable of holding exactly the same quantity of fluid. It is also frequently desirable to have imprinted on them the name of the maker of the medicine or other liquid they are destined to contain. A mould of iron, or of copper, is provided of the intended size, on the inside of which are engraved the names required. This mould, which is used in a hot state, opens into two parts, to allow the insertion of the round, unfinished bottle, which is placed in it in a very soft state before it is removed from the end of the iron tube with which it was blown. The mould is now closed, and by blowing strongly into the bottle the glass is forced against its sides.

(87.) *Wooden Snuff-Boxes.*—Snuff-boxes ornamented with devices, in imitation of carved work or of rose engine-turning, are sold at a price which proves that they are only imitations. The wood, or horn, out of which they are formed, is softened by long boiling in water, and whilst in this state it is forced into moulds of iron, or steel, on which are cut the requisite patterns, where it remains exposed to great pressure until it is dry.

(88.) *Horn Knife-Handles and Umbrella-Handles.*—The property which horn possesses of becoming soft by the action of water and of heat, fits it for many useful purposes. It is pressed into moulds, and becomes embossed with figures in relief, adapted to the nature and use of the objects to which it is to be applied. If curved, it may be straightened; or if straight, it may be bent into any forms which ornament or utility may require; and by the use of the mould these forms may be multiplied in endless variety. The commoner sorts of knives, the crooked handles for umbrellas, and a multitude of other articles to which horn is applied, attest the cheapness which the art of copying gives to the things formed of this material.

(89.) *Moulding Tortoise-shell.*—The same principle is applied to things formed out of the shell of the turtle, or the land tortoise. From the greatly superior price of the raw material, this principle of copying is, however, more rarely employed upon it; and the few carvings which are demanded, are usually performed by hand.

(90.) *Tobacco Pipe-making.*—This simple art is almost entirely one of copying. The moulds are formed of iron, in two parts, each embracing one half of the stem; the line of junction of these parts may generally be observed running lengthwise from one end of the pipe to the other. The hole passing to the bowl is formed by thrusting a long wire through the clay whilst it is enclosed in the mould. Some of the moulds have figures, or names, sunk in the inside. This gives a corresponding figure in relief upon the finished pipe.

(91.) *Embossing upon Calico.*—Calicoes of one colour, but embossed all over with various raised patterns, although not much worn in this country, are in great demand in several foreign markets. This appearance is produced by passing them through a pair of rollers, on one of which is figured in intaglio the pattern to be transferred to the calico. The substance of the cloth is pressed very forcibly into the cavities thus formed, and preserves its figured appearance after considerable use.

(92.) *Embossing upon Leather.*—This art of copying from patterns previously engraved on steel rollers is in most respects similar to the preceding. The leather is forced into the cavities, and that part which is not opposite to any cavity is powerfully condensed between the rollers.

(93.) *Swaging.*—This is an art of copying practised by the smith. In order to fashion his iron and steel into the form demanded by his customers, he has small blocks of steel into which are sunk cavities of various shapes; these are called *swages*, and are generally in pairs. Thus if he wants a round bolt, terminating in a cylindrical head of larger diameter, and having one or more projecting rims, he uses a corresponding *swaging-tool;* and having heated the end of his iron rod, and thickened it by a process which is technically called *upsetting*, he places its head upon one of the parts of the *swage;* and whilst an assistant holds the other part on the top of the hot iron, he strikes it several times with his hammer, occasionally turning the head one quarter round. The heated and softened iron is thus forced by the blows to assume the form of the mould into which it is impressed.

(94.) *Engraving by Pressure.*—This is one of the most beautiful instances of the art of copying carried to an almost unlimited extent; and the delicacy with which it can be executed, and the precision with which the finest traces of the graving tool can be transferred from steel to copper, or even from hard steel to soft steel, is most unexpected. We are indebted to Mr. Perkins for most of the contrivances which have brought this art at once almost to perfection. An engraving is first made upon soft steel, which is hardened by a peculiar process without in the least injuring its delicacy. A cylinder of soft steel, pressed with great force against the hardened steel engraving, is now made to roll slowly backward and forward over it, thus receiving the design, but in relief. This is in its turn hardened without injury; and if it be slowly rolled to and fro with strong pressure on successive plates of copper, it will imprint on a thousand of them a perfect fac-simile of the original steel engraving from which it resulted. Thus the number of copies producible from the same design is multiplied a thousand-fold. But even this is very far short of the limits to which this process may be extended. The hardened steel roller, bearing the design upon it in relief, may be employed to make a few of its first impressions upon plates of *soft steel*, and these being hardened become the representatives of the original engraving, and may in their turn be made the parents of other rollers, each generating copper-plates like their prototype. The possible extent to which fac-similes of one original engraving may thus be multiplied, almost confounds the imagination, and appears to be for all practical purposes unlimited. There are two principles which peculiarly fit this art for rendering the forgery of bank notes (to prevent which it was proposed by Mr. Perkins) a matter of great difficulty. The first is the perfect identity of every impression with every other, so that any variation in the minutest line would at once cause detection. The other principle is, that the plates, from which all the impressions are derived, may be formed by the united labours of artists most eminent in their several departments; and as only one original of each design is necessary, the expense, even of the most elaborate engraving, will be trifling, compared with the multitude of copies produced from it.

(95.) It must, however, be admitted that the principle of copying itself furnishes an expedient for imitating any engraving or printed pattern however complicated; and that it presents a difficulty which none of the schemes devised for the prevention of forgery appear to have yet effectually met. In attempting to imitate the most perfect bank note, the first process would be to place it with the printed side downwards upon a stone or other substance, on which, by passing it through a rolling-press, it might be firmly fixed. The next object would be to discover some solvent which should dissolve the paper but neither affect the printing-ink, nor injure the stone or substance on which it is impressed. Water does not seem to do this effectually, and perhaps weak alkaline or acid solutions would be tried. If, however, this could be fully accomplished, and if the stone or other substance used had those properties which enable us to print from it, then innumerable fac-similes of the note might be made, and the imitation would be complete. Porcelain biscuit, which has recently been used with a black lead pencil for memorandum-books, seems in some measure adapted for such trials, since its porosity may be diminished to any extent by diminishing the dilution of the glazing applied to it.

(96.) *Gold and Silver Moulding.*—Many of the mouldings used by jewellers consist of thin slips of metal, which have received their form by passing between steel rollers, on which the pattern is embossed or engraved; thus taking a succession of copies of the devices intended.

(97.) *Ornamental Papers.*—Sheets of paper coloured or covered with gold or silver leaf, and embossed with various patterns, are used for covering books, and for many ornamental purposes. The figures upon these are produced by the same process, that of passing the sheets of paper between engraved rollers.

Of Copying by Stamping.

This mode of copying is extensively employed in the arts. It is generally executed by means of large presses worked with a screw and heavy fly-wheel. The materials on which the copies are impressed are most frequently metals, and the process is sometimes executed when they are hot, and in one case when the metal is in a state between solidity and fluidity.

(98.) *Coins and Medals.*—The whole of the coins which circulate as money are produced by this mode of copying. The screw-presses are either worked by manual labour, by water, or by steam power. The mint which was sent a few years since to Calcutta was capable of coining 200,000 pieces a day. Medals, which usually have their figures in higher relief than coins, are produced by similar means; but a single blow is rarely sufficient to bring them to perfection, and the compression of the metal which arises from the first blow renders it too hard to receive many subsequent blows without injury to the die. It is therefore, after being struck, removed to a furnace, in which it is carefully heated red-hot and annealed, after which operation it is again placed between the dies, and receives additional blows. For large medals, and those on which the figures are very prominent, these processes must be repeated many times. One of the largest medals hitherto struck underwent them nearly an hundred times before it was completed.

(99.) *Ornaments for military Accoutrements, and Furniture.*—These are usually made of brass, and are stamped up out of solid or sheet brass by placing it between dies, and allowing a heavy weight to drop upon the upper die from a height of from five to fifteen feet.

(100.) *Buttons and Nail-heads.*—Buttons embossed with crests or other devices are produced by the same means; and some of those which are plain receive their hemispherical form from the dies in which they are struck. The heads of several kinds of nails which are portions of spheres, or polyhedrons, are also formed by these means.

(101.) *Of a process for Copying, called in France Clichée.*—This curious method of copying by stamping is applied to medals, and in some cases to forming stereotype plates. There exists a range of temperature previous to the melting point of several of the alloys of lead, tin, and antimony, in which the compound is neither solid, nor yet fluid. In this kind of pasty state it is placed in a box under a die, which descends upon it with considerable force. The blow drives the metal into the finest lines of the die, and the coldness of the latter immediately solidifies the whole mass. A quantity of the half melted metal is driven about by the blow in all directions, and is retained by the sides of the box in which the process is carried on. The work thus produced is admirable for its sharpness, but has not the finished form of a piece just leaving the coining-press: the sides are ragged, and it must be trimmed, and its thickness equalized in the lathe.

Of Copying by Punching.

(102.) This mode of copying consists in driving, either by a blow or by pressure, a steel punch through the substance to be cut. In some cases the object is to make repeated copies of the same aperture, and the substance separated from the plate is rejected; in other cases it is the small pieces cut out which are the objects of the workman's labour.

(103.) *Punching iron Plate for Boilers.*—The steel punch used for this purpose is from three-eighths to three-quarters of an inch in diameter, and drives out from a plate of iron a circular disc from one-quarter to five-eighths of an inch thick.

(104.) *Punching tinned Iron.* — The ornamental patterns of open work which decorate the tinned and japanned wares in general use, are rarely punched by the workman who makes them. In London, the art of punching out these patterns in screw-presses is carried on as a separate trade; and large quantities of sheet tin are perforated for cullenders, wine-strainers, borders of waiters, and other similar purposes. The perfection and the regularity to which the art has been carried are remarkable. Sheets of copper, too, are punched with small holes about the hundredth of an inch in diameter, in such multitudes that more of the sheet of metal is removed than remains behind; and plates of tin have been perforated with above three thousand holes in each square inch.

(105.) The inlaid plates of brass and rosewood, called *buhl work*, which ornament our furniture, are formed by punching; but in this instance, both the parts cut out and those which remain are in many cases employed. In the remaining illustrations of the art of copying by punching, the part made use of is that which is punched out.

(106.) *Cards for Guns.*—The substitution of a circular disc of thin card instead of paper, for retaining in its place the charge of a fowling-piece, is attended with considerable advantage. It would, however, be of little avail, unless an easy method was contrived of producing an unlimited number of cards, each exactly fitting the bore of the barrel. The small steel tool used for this purpose cuts out innumerable circles similar to its cutting end, each of which precisely fills the barrel for which it was designed.

(107.) *Ornaments of gilt Paper.*—The golden stars, leaves, and other devices, sold in shops for the purpose of ornamenting articles made of paper and pasteboard, and other fancy works, are cut by punches of various forms, out of sheets of gilt paper.

(108.) *Steel Chains.*—The chain used in connecting the main-spring and fusee in watches and clocks, is composed of small pieces of sheet steel. It is of great importance that each of these pieces should be of exactly the same size. The links are of two sorts; one of them consisting of a single oblong piece of steel with two holes in it, and the other formed by connecting two of the same pieces of steel, placed parallel to each other, at a short distance, by two rivets. These two kinds of links occur alternately; and the single piece, which forms one of them, has each end placed between the ends of the adjacent double pieces, with which it is connected by the rivets passing through all three. If the double pieces had the holes for the rivets placed at unequal distances, the chain would not be straight, and would, consequently, be unfit for its purpose.

Copying with Elongation.

(109.) In this species of copying there exists but little resemblance between the copy and the original. It is the cross section of the thing produced which is similar to the tool through which it passes. When the substances to be operated upon are hard, they frequently pass in succession through several holes, and it is in some cases necessary to anneal them at intervals.

(110.) *Wire drawing.*—The metal to be converted into wire is made of a cylindrical form, and drawn forcibly through circular holes in plates of steel: at each passage it becomes smaller; and when finished, its section at any point is a precise copy of the last hole through which it passed. Upon the larger kinds of wire, fine lines may frequently be traced, running longitudinally; these arise from a slight imperfection in the holes of the draw-plates. For many purposes of the arts, wire, the section of which is square or half round, is required: the same method of making it is pursued, except that the holes through which it is drawn are in such cases themselves square, or half round, or of whatever other form the wire is required to be. A species of wire is made, the section of which resembles a star with from six to twelve rays; this is called pinion wire, and is used by the clock-makers. They file away all the rays from a short piece, except from about half an inch near one end: this becomes a pinion for a clock; and the leaves or teeth, having passed through the *draw-plate*, are already burnished and finished.

(111.) *Tube drawing.*—The art of forming tubes of uniform diameter is nearly similar in its mode of execution to wire drawing. After the sheet-brass has been bent round and soldered so as to form a hollow cylinder, if the outside diameter is that which is required to be uniform, it is drawn through a succession of holes, as in wire drawing. If the inside diameter is to be uniform, a succession of steel cylinders, called *triblets*, are drawn through the brass tube. In making tubes for telescopes, it is necessary that both the inside and outside should be uniform. A steel *triblet* is passed into the tube, which is then drawn through a succession of holes, until the outside diameter is reduced to the required size. The metal of which the tube is formed is condensed between the holes, and the steel cylinder within it; and when the latter is withdrawn the internal surface appears polished. The brass tube is considerably extended by this process, sometimes even to double its first length.

(112.) Leaden pipes for the conveyance of water were formerly made by casting; but it has been found that they can be made both cheaper and better by drawing them through holes in the manner of wire. A cylinder of lead, of five or six inches in diameter and about two feet long, is cast with a small hole through its axis, and an iron *triblet* of fifteen feet in length is forced into the hole. It is then drawn through a series of holes, until the lead has extended from one end to the other of the *triblet*, and is of the proper thickness in proportion to the size of the pipe.

(113.) *Iron rolling.*—When cylinders of iron of greater thickness than wire are required, they are formed by passing wrought iron between rollers, each of which has sunk in it a semi-cylindrical groove; and as such rollers rarely touch accurately, a longitudinal line will usually be observed in iron so manufactured. Bar iron is thus shaped into all the various forms of round, square, half-round, oval, &c., in which it occurs in commerce. A particular species of moulding is thus made, which resembles in its section that part of the frame of a window which separates two adjacent panes of glass. Being much stronger than wood, it can be considerably reduced in thickness, and consequently offers less obstruction to the light; it is much used for sky-lights.

(114.) It is sometimes required that the iron thus produced shall not be of uniform thickness throughout. This is the case in rolling iron for rail-roads, for which purpose greater depth is required towards the middle of the rail which is at the greatest distance from the supports. This is accomplished by cutting the groove in the rollers deeper at those parts where additional strength is required, so that the hollow which surrounds the roller would, if it could be unwound, be a mould of the shape the iron is intended to fit.

(115.) *Vermicelli.*—The various forms into which this paste is made are given by forcing it through holes in tin plate. It passes through them, and appears on the other side in long strings. The cook and the confectioner make use of the same method; the former in preparing butter and ornamental pastry for the table, the latter in forming the cylindrical lozenges of various composition.

Of Copying with altered Dimensions.

(116.) *Of the Pentagraph.*—This mode of copying is chiefly used for drawings or maps: the instrument is simple; and, although usually employed in reducing, is capable of enlarging the size of the copy produced. An automaton figure, which drew profiles of its visitors, and which was exhibited in London a short time since, was regulated by a mechanism on this principle. A small aperture in the wall, opposite the seat in which the person is placed whose profile is taken, conceals a camera lucida. If an assistant moves a point, connected by a pentagraph with the hand of the automaton, over the outline of the head, a corresponding profile is traced by the figure.

(117.) *By turning.*—The art of turning might perhaps itself be classed amongst the arts of copying. A steel axis, called a *mandril*, having a pulley attached to the middle of it, is supported at one end either by a conical point, or by a cylindrical collar, and at the other end by another *collar*, through which it passes. The extremity which projects beyond this last *collar* is formed into a screw, by which various instruments, called *chucks*, are attached to it. These *chucks* are intended to hold the various materials to be submitted to the operation of turning, and have a great variety of forms. The *mandril* is made to revolve by a strap which passes over the pulley that is attached to it, and likewise over a larger wheel moved either by the foot, or by its connexion with steam or water power. All work which is executed on a *mandril* partakes in some measure of the irregularities of that *mandril;* and the perfect circularity of section which ought to exist at every part, can only be ensured by an equal accuracy in the *mandril* and its *collar*.

(118.) *Rose Engine-turning.*—This elegant art depends in a great measure on copying. The *rosettes*, or circular plates of metal, having various indentations on the faces or edges which are placed on the mandril, oblige the cutting tool to trace out the same pattern on the work, and the distance of the cutting tool from the centre being usually less than the radius of the *rosette*, causes the copy to be much diminished.

(119.) *Copying Dies.*—A lathe has been long known in France, and recently been used at the English mint, for copying dies. A blunt point is carried by a very slow spiral movement successively over every part of the die to be copied, and is pressed by a weight into all the cavities; while a cutting point connected with it by the machine traverses the face of a piece of soft steel, in which it cuts on the same or on a diminished scale, the device on the original die. The degree of excellence of the copy increases in proportion as it is smaller than the original. The die of a crown-piece will furnish by copy a very tolerable die for a sixpence. But the chief use to be expected from this lathe is to prepare all the coarser parts, and leave only the finer and more expressive lines for the skill and genius of the artist.

(120.) An instrument not very dissimilar in principle to this was proposed for the purpose of making shoe-lasts. A pattern last of a shoe for the right foot was placed in one part of the apparatus, and when the machine was moved, two pieces of wood, placed in another part which had been previously adjusted by screws, were cut into lasts greater or less than the original, as was desired; and although the pattern was for the right foot, one of the lasts was for the left, an effect which was produced by merely interposing between the two pieces to be cut into lasts a wheel which reversed the motion.

(121.) *Engine for copying Busts.*—Many years since, the late Mr. Watt amused himself with constructing an engine to produce copies of busts or statues, either of the same size as the original, or in a diminished proportion. The substances on which he operated were various, and some of the results were shewn to his friends, but the mechanism by which they were made has never been described. More recently, Mr. Hawkins, who had also contrived several years ago a similar machine, has placed it in the hands of an artist, who has made copies in ivory of a variety of busts. The art of multiplying in *different sizes* the figures of the sculptor, aided by that of rendering their acquisition cheap through the art of casting, promises to give additional value to his productions, and to diffuse more widely the pleasure arising from their possession.

(122.) *Screw-cutting.*—When this operation is performed in the lathe by means of a screw upon the *mandril*, it is essentially an art of copying, but it is only the number of threads in a given length which is copied; the *form* of the thread, and length as well as the diameter of the screw to be cut, are entirely independent of those from which the copy is made. There is another method of cutting screws in a lathe by means of one pattern screw, which, being connected by wheels with the *mandril*, guides the cutting point. In this process, unless the time of revolution of the *mandril* is the same as that of the screw which guides the cutting point, the number of threads in a given length will be different. If the *mandril* move quicker than the cutting-point, the screw which is produced will be finer than the original; if it move slower, the copy will be more coarse than the original. The screw thus generated may be finer or coarser,—it may be larger or smaller in diameter, — it may have the same or a greater number of threads than that from which it is copied; yet all the defects which exist in the original will be accurately transmitted under the modified circumstances to every individual generated from it.

(123.) *Printing from Copper-Plates with altered Dimensions.*—Some very singular specimens of an art of copying, not yet made public, were brought from Paris a few years since. A watchmaker in that city, of the name of Gonord, had contrived a method by which he could take from the same copper-plate impressions of different sizes, either larger or smaller than the original design. Having procured four impressions of a parrot, surrounded by a circle, executed in this manner, I shewed them to the late Mr. Lowry, an artist equally distinguished by his skill, and for the many mechanical contrivances with which he enriched his art. The relative dimensions of the several impressions were 5·5, 6·3, 8·4, 15·0, so that the largest was nearly three times the linear size of the smallest; and Mr. Lowry assured me, that he was unable to detect any lines in one which had not corresponding lines in the others. There appeared to be a difference in the quantity of ink, but none in the traces of the engraving; and, from the general appearance, it was conjectured that the largest but one was the original impression from the copper-plate. The processes by which this singular operation was executed have not been published; but two conjectures were formed at the time which merit notice. It was supposed that the artist was in possession of some method of transferring the ink from the lines of a copper-plate to the surface of some fluid, and of re-transferring the impression from the fluid to paper. If this could be accomplished, the print would be of exactly the same size as the copper from which it was derived; but if the fluid were contained in a vessel having the form of an inverted cone, with a small aperture at the bottom, the liquid might be lowered or raised in the vessel by gradual abstraction or addition through the apex of the cone; in this case, the surface to which the printing-ink adhered would diminish or enlarge, and in this altered state the impression might be re-transferred to paper. It must be admitted, that this conjectural explanation is liable to very considerable difficulties; for, although the converse operation of taking an impression from a liquid surface has a parallel in the art of marbling paper, the possibility of transferring the ink from the copper to the fluid requires to be proved. Another and more plausible explanation is founded on the elastic nature of the compound of glue and treacle, a substance already in use in transferring engravings to earthenware. It is conjectured, that an impression from the copper-plate is taken upon a large sheet of this composition; that this sheet is then stretched in both directions, and that the ink thus expanded is transferred to paper. If the copy is required to be smaller than the original, the elastic substance must first be stretched, and then receive the impression from the copper-plate: on removing the tension it will contract, and thus reduce the size of the design. It is possible that one transfer may not in all cases suffice; as the extensibility of the composition of glue and treacle, although considerable, is still limited. Perhaps sheets of India rubber of uniform texture and thickness, may be found to answer better than this composition; or possibly the ink might be transferred from the copper-plate to the surface of a bottle of this gum, which bottle might, after being expanded by forcing air into it, give up the enlarged impression to paper. As it would require considerable time to produce impressions in this manner, and there might arise some difficulty in making them all of precisely the same size, the process might be rendered more certain and expeditious, by performing that part of the operation which depends on the enlargement or diminution of the design only once; and, instead of printing from the soft substance, transferring the design from it to stone: thus a considerable portion of the work would be reduced to an art already well known, that of lithography. This idea receives some confirmation from the fact, that in another set of specimens, consisting of a map of St. Petersburg, of several sizes, a very short line, evidently an accidental defect, occurs in all the impressions of one particular size, but not in any of a different size.

(124.) *Machine to produce Engraving from Medals.*—An instrument was contrived, a long time ago, and is described in the *Manuel de Tourneur*, by which copper-plate engravings are produced from medals and other objects in relief. The medal and the copper are fixed on two sliding plates at right angles to each other, so connected that when the plate on which the medal is fixed is raised vertically by a screw, the slide holding the copper-plate is advanced by an equal quantity in the horizontal direction. The medal is fixed on the vertical slide with its face opposite the copper-plate, and a little above it.

A bar, terminating at one end in a tracing-point, and at the other by a short arm, at right angles to the bar, and holding a diamond-point, is placed horizontally above the copper; so that the tracing-point shall touch the medal to which the bar is perpendicular, and the diamond-point shall touch the copper-plate to which the arm is perpendicular.

Under this arrangement, if the bar is moved always parallel to itself, and consequently to the copper, while the tracing-point is kept in contact with the medal, then if the tracing-point pass over a flat part of the medal, the diamond-point will draw a straight line of equal length upon the copper; but, if the tracing-point pass over any projecting part of the medal, the deviation from the straight line by the diamond-point, will be exactly equal to the elevation of the corresponding point of the medal above the rest of the surface. Thus, by the transit of this tracing-point over any segment of the medal, the diamond will draw upon the copper a section of the medal through that plane.

A screw is attached to the apparatus, so that if the medal be raised a very small quantity by the screw, the copper-plate will be advanced by the same quantity, and thus a new line of section may be drawn: and, by continuing this process, the series of sectional lines on the copper produce the representation of the medal on a plane: the outline and the form of the figure arising from the sinuosities of the lines, and from their greater or less proximity. The effect of this kind of engraving is very striking; and in some specimens gives a high degree of apparent relief. It has been practised on plate glass, and is then additionally curious from the circumstance of the fine lines traced by the diamond being invisible, except in certain lights.

From this description, it will be seen that the engraving on the copper must be distorted; that is to say, that the apparent projection on the copper will not be the same as that which arises from a perpendicular projection of each point of the medal upon a plane parallel to itself. Consequently the position of the prominent parts will be more altered than that of the less elevated; and the greater the relief of the medal the more distorted will be its engraved representation. Mr. John Bate, son of Mr. Bate, of the Poultry, has contrived an improved machine, for which he has taken a patent, in which this source of distortion is remedied. The head, in the title-page of the present volume, is copied from a medal of Roger Bacon, which forms one of a series of medals of eminent men, struck at the royal mint at Munich, and is the first of the published productions of this new art.

The inconvenience which arises from too high a relief in the medal, or in the bust, might be remedied by some mechanical contrivance, by which the deviation of the diamond-point from the right line, (which it would describe when the tracing-point traverses a plane), is made proportional,—not to the elevation of the corresponding point above the plane of the medal, but above some other parallel plane removed to a fit distance behind it. Thus busts and statues might be reduced to any required degree of relief.

(125.) The machine just described naturally suggests other views which seem to deserve some consideration, and, perhaps, some experiment. If a medal were placed under the tracing-point of a pentagraph, an engraving tool substituted for the pencil, and a copper-plate in the place of the paper; and if, by some mechanism, the tracing-point, which slides in a vertical plane as it is carried over the different elevations of the medal, could increase or diminish the depth of the engraved line proportionally to the actual height of the corresponding point on the medal, then an engraving would be produced, free at least from any distortion, although it might be liable to objections of a different kind. If, by any similar contrivance, instead of lines, we could make on each point of the copper a dot, varying in size or depth with the altitude of the corresponding point of the medal above its plane, then a new species of engraving would be produced: and the variety of these might again be increased, by causing the graving point to describe a very small circle, of a diameter, varying with the height of the point on the medal above a given plane; or by making the graving tool consist of three equi-distant points, whose distance increased or diminished according to some determinate law, dependent on the elevation of the point represented above the plane of the medal. It would, perhaps, be difficult to imagine the effects of some of these kinds of engraving; but they would all possess, in common, the property of being projections, by parallel lines, of the objects represented, and the intensity of the shade of the ink would either vary according to some function of the distance of the point represented from some given plane, or it would be a little modified by the distances from the same plane of a few of the immediately contiguous points.

(126.) *Lace made by Caterpillars.*—A most extraordinary species of manufacture, which is in a slight degree connected with copying, has been contrived by an officer of engineers residing at Munich. It consists of lace, and veils, with open patterns in them, made entirely by caterpillars. The following is the mode of proceeding adopted.—Having made a paste of the leaves of the plant, on which the species of caterpillar he employs feeds, he spreads it thinly over a stone, or other flat substance, of the required size. He then with a camel-hair pencil dipped in olive oil, draws the pattern he wishes the insects to leave open. This stone is then placed in an inclined position, and a considerable number of the caterpillars are placed at the bottom. A peculiar species is chosen, which spins a strong web; and the animals commence at the bottom, eating and spinning their way up to the top, carefully avoiding every part touched by the oil, but devouring every other part of the paste. The extreme lightness of these veils, combined with some strength, is truly surprising. One of them, measuring twenty-six and a half inches by seventeen inches, weighed only 1.51 grains, a degree of lightness which will appear more strongly by contrast with other fabrics. One square yard of the substance of which these veils are made weighs four grains and one-third, whilst one square yard cf silk gauze weighs one hundred and thirty-seven grains, and one square yard of the finest patent net weighs two hundred and sixty-two grains and a half. The ladies' coloured muslin dresses, mentioned in the table subjoined, cost ten shillings per dress, and each weigh six ounces; the cotton from which they are made weighing nearly six and two-ninth ounces avoirdupois weight.

*Weight of One Square Yard of each of the following Articles.**

Description of Goods.	Value per Yard Measure.		Weight finished of One Square Yard.	Weight of Cotton used in making One Square Yard.
	s.	*d.*	*Troy Grains.*	*Troy Grains.*
Caterpillar Veils	. . . .		$4\frac{1}{3}$	. . . .
Silk Gauze 3-4 wide	1	0	137	. . . .
Finest Patent Net	. . . .		$262\frac{1}{2}$	. . . .
Fine Cambric Muslin	. . . .		551	. . . .
6-4ths Jaconet Muslin	2	0	613	670
Ladies' coloured Muslin Dresses	3	0	788	875
6-4ths Cambric	1	2	972	1069
9-8ths Calico	0	9	988	1085
$\frac{1}{2}$-yard Nankeen	0	8	2240	2432

(127.) This enumeration, which is far from complete, of the arts in which copying is the foundation, may be terminated with an example which has long been under the eye of the reader; although few, perhaps, are aware of the number of repeated copyings of which these very pages are the subject.

* Some of these weights and measures are calculated from a statement in the Report of the Committee of the House of Commons on Printed Cotton Goods; and the widths of the pieces there given are presumed to be the real widths, not those by which they are called in the retail shops.

1. They are copies, by printing, from stereotype plates.

2. These stereotype plates are copied, by the art of casting, from moulds formed of plaster of Paris.

3. Those moulds are themselves copied by casting the plaster in a liquid state upon the movable types set up by the compositor.

[It is here that the union of the intellectual and the mechanical departments takes place. The mysteries, however, of an author's copying, form no part of our inquiry, although it may be fairly remarked, that, in numerous instances, the mental far eclipses the mechanical copyist.]

4. These movable types, the obedient messengers of the most opposite thoughts, the most conflicting theories, are themselves copies by casting from moulds of copper called *matrices*.

5. The lower part of those *matrices*, bearing the impressions of the letter or character intended, are copies, by punching, from steel punches on which the same character exists in relief.

6. These steel punches are not themselves entirely exempted from the great principle of art. Many of the cavities which exist in them, such as those in the middle of the punches for the letters *a*, *b*, *d*, *e*, *g*, &c., are produced from other steel punches in which these parts are in relief.*

* This is not a rigidly accurate account of the volume in the reader's hand, which has not been stereotyped. The passage given in the text was COPIED by *printing*, from a printed account given by the author, respecting which the statement was strictly accurate.

We have thus traced through six successive stages of copying the mechanical art of printing from stereotype plates: the principle of copying contributing in this, as in every other department of manufacture, to the uniformity and the cheapness of the work produced.

CHAP. XII.

ON THE METHOD OF OBSERVING MANUFACTORIES.

(128.) HAVING now reviewed the *mechanical* principles which regulate the successful application of mechanical science to great establishments for the production of manufactured goods, it remains for us to suggest a few inquiries, and to offer a few observations to those whom an enlightened curiosity may lead to examine the factories of this or of other countries.

The remark,—that *it is important to commit to writing all information as soon as possible after it is received, especially when numbers are concerned,*—applies to almost all inquiries. It is frequently impossible to do this at the time of visiting an establishment, although not the slightest jealousy may exist; the mere act of writing information as it is communicated orally, is a great interruption to the examination of machinery. In such cases, therefore, it is advisable to have prepared beforehand the questions to be asked, and to leave blanks for the answers, which may be quickly inserted, as, in a multitude of cases, they are merely numbers. Those who have not tried this plan will be surprised at the quantity of information which may, through its means, be acquired, even by a short examination. Each manufacture requires its own list of questions, which will be better drawn up after the first visit. The following outline, which is very generally applicable, may suffice for an illustration; and to save time, it may be convenient to have it printed, and to bind up, in the form of a pocket-book, a hundred copies of the skeleton forms for processes, with about twenty of the general inquiries.

GENERAL INQUIRIES.

Outlines of a Description of any of the Mechanical Arts ought to contain Information on the following points.

Brief sketch of its history, particularly the date of its invention and its introduction into England.

Short reference to the previous states through which the material employed has passed; the places whence it is procured; the price of a given quantity.

The various processes must now be described successively according to the plan which will be given in § 129; after which the following information should be given:—

Are various kinds of the same article made in one establishment, or at different ones, and are there differences in the processes?

To what defects are the goods liable?

What substitutes or adulterations are used?

What waste is allowed by the master?

What tests are there of the goodness of the manufactured article?

The weight of a given quantity, or number, and a comparison with that of the raw material.

The wholesale price at the manufactory £. s. d. per

The usual retail price £. s. d. per

Who provide tools? Master, or men? Who repair tools? Master, or men?

What is the expense of the machinery?

What is the annual wear and tear, and what its duration?

Is there any particular trade for making it? Where?

Is it made and repaired at the manufactory?

In any manufactory visited, state the number ( ) of processes, and of the persons employed in each process, and the quantity of manufactured produce.

What quantity is made annually in Great Britain?

Is the capital invested in manufactories large or small?

Mention the principal seats of this manufacture in England; and if it flourishes much abroad, the places where it is established.

The duty, excise, or bounty, if any, should be stated, and any alterations in past years; and also the amount exported or imported for a series of years.

Whether the same article, but of superior, equal, or inferior make, is imported?

Does the manufacturer export, or sell, to a middleman, who supplies the merchant?

To what countries is it chiefly sent—and in what goods are the returns made?

(129.) Each process requires a separate skeleton, and the following outline will be sufficient for many different manufactories:—

Process ( ) Manufacture ( )
Place ( ) Name ( )
date 183

The mode of executing it, with sketches of the tools or machine if necessary.

The number of persons necessary to attend the machine.

Are the operatives men, ( ) women, ( ) or children? ( ) If mixed, what are the proportions?

What is the pay of each? (*s.* *d.*) (*s.* *d.*) (*s.* *d.*) per

What number ( ) of hours do they work per day?

Is it usual, or necessary, to work night and day without stopping?

Is the labour performed by piece or by day-work?

Who provide tools? Master, or men? Who repair tools? Master, or men?

What degree of skill is required, and how many years ( ) apprenticeship?

The number of times ( ) the operation is repeated per day or per hour.

The number of failures ( ) in a thousand.

Whether the workman or the master loses by the broken or damaged articles?

What is done with them?

If the same process is repeated several times, state the diminution or increase of measure, and the loss, if any, at each repetition.

(130.) In using this skeleton, the answers to the questions are in some cases printed, as Who repair the tools? Masters, Men; in order that the proper answer may be underlined with a pencil. In filling up the answers which require numbers, some care should be taken: for instance, if the observer stands with his watch in his hand before a person heading a pin, the workman will almost certainly increase his speed, and the estimate will be too large. A much better average will result from inquiring what quantity is considered a fair day's work. When this cannot be ascertained, the number of operations performed in a given time may frequently be ascertained when the workman is quite unconscious that any person is observing him. Thus the sound made by the motion of a loom may enable the observer to count the number of strokes per minute, even though he is outside the building in which it is contained.

M. Coulomb, who had great experience in making such observations, cautions those who may repeat his experiments against being deceived by such circumstances :—"Je prie" (says he) "ceux qui voudront "les repeter, s'ils n'ont pas le temps de mesurer les "resultats après plusieurs jours d'un travail continu, "d'observer les ouvriers à différentes reprises dans "la journée, sans qu'ils sachent qu'ils sont observés. "L'on ne peut trop avertir combien l'on risque de se "tromper en calculant, soit la vitesse, soit le temps "effectif du travail, d'après une observation de quelque "minutes."—*Memoires de l'Institut. Tom. II. p.* 247. It frequently happens, that in a series of answers to such questions, there are some which, although given directly, may also be deduced by a short calculation from others that are given or known ; and advantage should always be taken of these verifications, in order to confirm the accuracy of the statements ; or, in case they are discordant, to correct the apparent anomalies. In putting lists of questions into the hands of a person undertaking to give information upon any subject, it is in some cases desirable to have an estimate of the soundness of his judgment. The questions can frequently be so shaped, that some of them may indirectly depend on others ; and one or two may be inserted whose answers can be obtained by other methods : nor is this process without its advantages in enabling us to determine the value of our own judgment. The habit of forming an estimate of the magnitude or frequency of any object immediately previous to our applying to it measure or number, tends materially to fix our attention and to improve our judgment.

SECTION II.

ON THE DOMESTIC AND POLITICAL ECONOMY OF MANUFACTURES.

CHAP. XIII.

DISTINCTION BETWEEN MAKING AND MANUFACTURING.

(131.) THE *economical principles* which regulate the application of machinery, and which govern the interior of all our great factories, are quite as essential to the prosperity of a great commercial country as are those mechanical principles, the operations of which have been illustrated in the preceding section.

The first object of every person who attempts to make any article of consumption, is, or ought to be, to produce it in a perfect form; but in order to secure to himself the greatest and most permanent profit, he must endeavour by every means in his power to render the new luxury or want which he has created, cheap to those who consume it. The larger number of purchasers thus obtained will, in some measure, secure him from the caprices of fashion, whilst it furnishes a far greater amount of profit, although the contribution of each individual is diminished. The importance of collecting data, for the purpose of enabling the manufacturer to ascertain how many additional customers he will acquire by a given reduction in the price of the article he makes, cannot be too strongly pressed upon the attention of those who employ themselves in statistical inquiries. In some ranks of society, any diminution of price in a commodity will bring forward but few additional customers; whilst, in other classes, a very small reduction will so enlarge the sale as to yield a considerable increase of profit.

(132.) If, therefore, the *maker* of an article wish to become a *manufacturer* in the more extended sense of the term, he must attend to other principles besides those mechanical ones on which the successful execution of his work depends; and he must carefully arrange the whole system of his factory in such a manner, that the article he sells to the public may be produced at as small a cost as possible. Should he not be actuated at first by motives so remote, he will, in every highly civilized country, be compelled, by the powerful stimulus of competition, to attend to the principles of the domestic economy of manufactures. At every reduction in price of the commodity he makes, he will be driven to seek compensation in a saving of expense in some of the processes; and his ingenuity will be sharpened in this inquiry by the hope of being able in his turn to undersell his rivals. The benefit of the improvements thus engendered is, for a short time, confined to those from whose ingenuity they derived their origin; but when a sufficient experience has proved their value, they become generally adopted, until in their turn they are superseded by other more economical methods.

(133.) There exists a considerable difference between the terms *making* and *manufacturing*. The former refers to the production of *a small*, the latter to that of *a very large number of individuals;* and the difference is well illustrated in the evidence given before the Committee of the House of Commons on the Export of Tools and Machinery. On that occasion Mr. Maudslay stated, that he had been applied to by the Navy Board to make iron tanks for ships, and that he was rather unwilling to do so, as he considered it to be out of his line of business; however, he undertook to make one as a trial. The holes for the rivets were punched by hand-punching with presses, and the 1680 holes which each tank required cost seven shillings. The Navy Board, who required a large number, proposed that he should supply forty tanks a week for many months. The magnitude of the order made it worth while to commence *manufacturer*, and to make tools for the express business. Mr. Maudslay therefore offered, if the Board would give him an order for two thousand tanks, to supply them at the rate of eighty per week. The order was given: he made tools, by which the expense of punching the rivet-holes of each tank was reduced from seven shillings to ninepence; he supplied ninety-eight tanks a week for six months, and the price charged for each was reduced from seventeen pounds to fifteen.

CHAP. XIV.

ON THE INFLUENCE OF VERIFICATION ON PRICE.

(134.) THE money price of an article at any given period is usually stated to depend upon the *proportion between the supply and the demand.* The average price of the same article during a long period, is said to depend, ultimately, *on the power of producing and selling it with the ordinary profits of capital.* But these principles, although true in their general sense, are yet so often modified by the influence of others, that it becomes necessary to examine a little into the disturbing forces.

(135.) With respect to the first of these propositions, it may be observed that the cost of any article to the purchaser includes, besides supply and demand, another element, which, though often of little importance, is in many cases of great consequence. *The cost, to the purchaser, is the price he pays for any article, added to the cost of verifying the fact of its having that degree of goodness for which he contracts.* In some cases the goodness of the article is evident on mere inspection: and in those cases there is not much difference of price at different shops. The goodness of loaf sugar, for instance, can be discerned almost at a glance; and the consequence is, that the price of it is so uniform, and the profit upon it so small, that no grocer is at all anxious to sell it: whilst, on the other hand, tea, of which it is exceedingly difficult to judge, and which can be adulterated by mixture so as to deceive the skill even of a practised eye, has a great variety of different prices, and is that article which every grocer is most anxious to sell to his customers. The difficulty and expense of verification are, in some instances, so considerable, as to justify the deviation from well-established principles. Thus it has been found so difficult to detect the adulteration of flour, and to measure its good qualities, that, contrary to the maxim that *Government can generally purchase any article at a cheaper rate than that at which they can manufacture it*, it has been considered more economical to build extensive flour-mills (such are those at Deptford), and to grind their own corn, than to verify each sack purchased, and to employ persons in continually devising methods of detecting the new modes of adulteration which might be resorted to.

(136.) Some years since, a mode of preparing old clover and trefoil seeds by a process called "*doctoring*," became so prevalent as to excite the attention of the House of Commons. It appeared in evidence before a committee, that the old seed of the white clover was *doctored* by first wetting it slightly, and then drying it with the fumes of burning sulphur; and that the red clover seed had its colour improved by shaking it in a sack with a small quantity of indigo; but this being detected after a time, the *doctors* then used a preparation of logwood, fined by a little copperas, and sometimes by verdigris; thus at once improving the appearance of the old seed, and diminishing, if not destroying, its vegetative power already enfeebled by age. Supposing no injury had resulted to good seed so prepared, it was proved that from the improved appearance, its market price would be enhanced by this process from five to twenty-five shillings a hundred-weight. But the greatest evil arose from the circumstance of these processes rendering old and worthless seed in appearance equal to the best. One witness tried some *doctored* seed, and found that not above one grain in a hundred grew, and that those which did vegetate died away afterwards; whilst about eighty or ninety per cent. of good seed usually grows. The seed so treated was sold to retail dealers in the country, who of course endeavoured to purchase at the cheapest rate, and from them it got into the hands of the farmers; neither of these classes being at all capable of distinguishing the fraudulent from the genuine seed. Many cultivators, in consequence, diminished their consumption of the article; and others were obliged to pay a higher price to those who had skill to distinguish the mixed seed, and who had integrity and character to prevent them from dealing in it.

(137.) In the Irish flax trade, a similar example of the high price paid for verification occurs. It is stated in the report of the committee—"That the "natural excellent quality of Irish flax, as contrasted "with foreign or British, has been admitted."—Yet from the evidence before that committee it appears, that Irish flax sells, in the market, from 1*d.* to 2*d.* per pound less than other flax of equal or inferior quality. Part of this difference of price arises from negligence in its preparation, but a part also from the expense of ascertaining that each parcel is free from stones and rubbish to add to its weight: this appears from the evidence of Mr. J. Corry, who was, during twenty-seven years, Secretary to the Irish Linen-Board:—

"The owners of the flax, who are almost always people "in the lower classes of life, believe that they can best "advance their own interests by imposing on the buyers. "Flax being sold by weight, various expedients are used to "increase it; and every expedient is injurious, particularly "the damping of it; a very common practice, which makes "the flax afterwards heat. The inside of every bundle (and "the bundles all vary in bulk) is often full of pebbles, or dirt "of various kinds, to increase the weight. In this state it "is purchased, and exported to Great Britain. The natural "quality of Irish flax is admitted to be not inferior to that "produced by any foreign country; and yet the flax of every "foreign country, imported into Great Britain, obtains a "preference among the purchasers, because the foreign flax "is brought to the British market in a cleaner and more "regular state. The extent and value of the sales of "foreign flax in Great Britain can be seen by reference to "the public accounts; and I am induced to believe, that "Ireland, by an adequate extension of her flax tillage, and "having her flax markets brought under good regulations, "could, without encroaching in the least degree upon the "quantity necessary for her home consumption, supply the "whole of the demand of the British market, to the ex-"clusion of the foreigners."

(138.) The lace trade affords other examples; and, in inquiring into the complaints made to the House of Commons by the frame-work knitters, the committee observe, that, "It is singular that the "grievance most complained of one hundred and "fifty years ago, should, in the present improved "state of the trade, be the same grievance which

" is now most complained of: for it appears, by " the evidence given before your committee, that " *all the witnesses attribute the decay of the trade* " *more to the making of fraudulent and bad articles,* " *than to the war, or to any other cause.*" And it is shewn by the evidence, that a kind of lace called "*single-press*" was manufactured, which was only looped once, and which, although good to the eye, became nearly spoiled in washing by the slipping of the threads; that not one person in a thousand could distinguish the difference between "*single-press*" and "*double-press lace;*" and that, even workmen and manufacturers were obliged to employ a magnifying-glass for that purpose: and that, in another similar article, called "*warp lace,*" such aid was essential. It was also stated by one witness, that

> " The trade had not yet ceased, excepting in those places " where the fraud had been discovered; and from those " places no orders are now sent for any sort of Nottingham " lace, the credit being totally ruined."

(139.) In the stocking trade similar frauds have been practised. It appeared in evidence, that stockings were made of uniform width from the knee down to the ankle, and being wetted and stretched on frames at the calf, they retained their shape when dry; but that the purchaser could not discover the fraud, until, after the first washing, the stocking appeared to hang like a bag about his ankles.

(140.) In the watch trade the practice of deceit, in forging the marks and names of respectable makers, has been carried to a great extent both by natives and foreigners; and the effect upon our export trade has been most injurious, as the following extract from the evidence before a committee of the House of Commons will prove :—

> " *Question.* How long have you been in the trade?
> " *Answer.* Nearly thirty years.
> " *Quest.* The trade is at present much depressed?
> " *Ans.* Yes, sadly.
> " *Quest.* What is your opinion of the cause of that " distress?
> " *Ans.* I think it is owing to a number of watches that " have been made so exceedingly bad that they will hardly " look at them in the foreign markets; all with a handsome " outside show, and the works hardly fit for any thing.
> " *Quest.* Do you mean to say, that all the watches made " in this country, are of that description?
> " *Ans.* No; only a number which are made up by some " of the Jews, and other low manufacturers. I recollect " something of the sort years ago, of a fall-off of the East " India work, owing to there being a number of handsome " looking watches sent out, for instance, with hands on and " figures, as if they shewed seconds, and had not any work " regular to shew the seconds: the hand went round, but it " was not regular.
> " *Quest.* They had no perfect movements?
> " *Ans.* No, they had not; that was a long time since, " and we had not any East India work for a long time " afterwards."

In the home market, inferior but showy watches are made at a cheap rate, which are not warranted by the maker to go above half an hour; about the time occupied by the Jew pedlar in deluding his country customer.

(141.) The practice, in retail linen-drapers' shops, of calling certain articles yard-wide when the real width is, perhaps, only seven-eighths or three-quarters, arose at first from fraud, which being detected, custom was pleaded in its defence: but the result is, that the vender is constantly obliged to measure the width of his goods in the customer's presence. In all these instances the object of the seller is to get a higher price than his goods would really produce if their quality were known; and the purchaser, if not himself a skilful judge (which rarely happens to be the case), must pay some person, in the shape of an additional money price, who has skill to distinguish, and integrity to furnish, articles of the quality agreed on. But as the confidence of persons in their own judgment is usually great, large numbers will always flock to the cheap dealer, who thus, attracting many customers from the honest tradesman, obliges him to charge a higher price for his judgment and character than, without such competition, he could afford to do.

(142.) There are few articles which the public are less able to judge of than the quality of drugs; and when they are compounded into medicines it is scarcely possible, even for medical men, to decide whether pure or adulterated drugs have been employed. This circumstance, concurring with an injudicious mode adopted in the payment for medical assistance, has produced a curious effect on the price of medicines. Apothecaries, instead of being paid for their services and skill, have been remunerated by being allowed to place a high charge upon the medicines they administer, which are confessedly of very small pecuniary value. The tendency of such a system is to offer an inducement to prescribe more medicine than is necessary; and in fact, even with the present charges, the apothecary, in ninety-nine cases out of a hundred, cannot be fairly remunerated unless the patient either takes, or pays for, more physic than is really necessary. The apparent extravagance of the charge of eighteen-pence for a two-ounce phial* of medicine, is obvious to many who do not reflect on the circumstance that the charge is, in reality, for the payment of professional skill. As the same charge is made by the apothecary, whether he attends the patient or merely prepares the prescription of a physician, the chemist and druggist soon offered to furnish the same commodity at a greatly diminished price. But the eighteen-pence charged by the apothecary might have been fairly divided into two parts, three-pence for medicine and bottle, and fifteen-pence for attendance. Now the chemist, although he has reduced the price of the apothecary's draught, from thirty-three to forty-four per cent., yet realises a profit of between two and three hundred per cent. on the ten-pence or shilling which he charges for the same compound. This enormous profit has called into existence a multitude of competitors; and in this instance the impossibility of verifying has, in a great measure, counteracted the beneficial effects of competition. The general adulteration of drugs, even at the extremely high price at which they are retailed as medicine, enables those who are imagined to sell them in an unadulterated state to make large profits, whilst the same evil frequently disappoints the

* Apothecaries frequently purchase these phials at the old bottle-warehouses at ten shillings per gross, so that when their servant has washed them the cost of the phial is nearly one penny.

expectation, and defeats the skill, of the most eminent physician.

It is difficult to point out a remedy for this evil without suggesting an almost total change in the system of medical practice. If the apothecary were to charge for his visits, and to reduce his medicines to one-fourth or one-fifth of their present price, he would still have an interest in procuring the best drugs for the sake of his own reputation or skill. Or if the medical attendant, who is paid more highly for his time, were to have several pupils, he might himself supply the medicines without a specific charge, and his pupils would derive improvement from compounding them, as well as from examining the purity of the drugs he would purchase. The public would derive several advantages from this arrangement. In the first place, it would be greatly for the interest of the medical practitioner to have the best drugs; it would also be his interest not to give more physic than needful; and it would also enable him, through some of his more advanced pupils, to watch more frequently the changes of any malady.

(143.) The principle that *price, at any moment, is dependent on the relation of the supply to the demand*, is true to the full extent only when the whole supply is in the hands of a very large number of small holders, and the demand is caused by the wants of another set of persons, each of whom requires only the same very small quantity. And the reason appears to be, that it is only in such circumstances that a uniform average can be struck between the feelings, the passions, the prejudices, the opinions, and the knowledge, of both parties. If the supply, or present stock in hand, be entirely in the possession of one person, he will naturally endeavour to put such a price upon it as shall produce by its sale the greatest quantity of money; but he will be guided in this estimate of the price at which he will sell both by the knowledge that increased price will cause a diminished consumption, and by the desire to realize his profit before a new supply shall reach the market from some other quarter. If, however, the same stock is in the hands of several dealers, there will be an immediate competition between them, arising partly from their different views of the duration of the present state of supply, and partly from their own peculiar circumstances with respect to the employment of their capital.

(144.) Again, if the commodity itself is of a perishable nature, such, for example, as a cargo of ice imported into the port of London from Norway a few summers since, then time will supply the place of competition; and, whether the article is in the possession of one or of many persons, it will scarcely reach a monopoly price. The history of *cajeput oil* during the last few months, offers a curious illustration of the effect of opinion upon price. In July of last year (1831) cajeput oil was sold, exclusive of duty, at 7*d*. per ounce. The disease which had ravaged the East was then supposed to be approaching our shores, and its proximity created alarm. At this period, the oil in question began to be much talked of, as a powerful remedy in that dreadful disorder; and in September it rose to the price of 3*s*. and 4*s*. the ounce. In October there were few or no sales: but in the early part of November, the speculations in this substance reached their height, and between the 1st and the 15th it realized the following prices: 3*s*.9*d*., 5*s*., 6*s*.6*d*., 7*s*.6*d*., 8*s*., 9*s*., 10*s*., 10*s*.6*d*., 11*s*. After the 15th of November, the holders of cajeput oil were anxious to sell at much lower rates; and in December a fresh arrival was offered by public sale at 5*s*., and withdrawn, being sold afterwards, as it was understood, by private contract, at 4*s*. or 4*s*.6*d*. per oz. Since that time, 1*s*.6*d*. and 1*s*. have been realized; and a fresh arrival, which is daily expected, (March, 1832) will probably reduce it below the price of July. Now it is important to notice, that in November, the time of greatest speculation, the quantity in the market was held by *few* persons, and that it frequently changed hands, each holder being desirous to realize his profit. The quantity imported since that time has also been considerable.*

(145.) The frequent speculations in oil, tallow, and other commodities, which must occur to the memory of most of my readers, were always founded on the principle of purchasing up all the stock on hand, and agreeing for the purchase of the expected arrivals; thus proving the opinion of capitalists to be, that a larger average price may be procured by the stock being held by few persons.

* I have understood that the price of camphor, at the same time, suffered similar changes.

CHAP. XV.

ON THE INFLUENCE OF DURABILITY ON PRICE.

(146.) HAVING now considered the circumstances that modify what may be called the momentary amount of price, we must next examine a principle which seems to have an effect on its permanent average. *The durability of any commodity influences its cost in a permanent manner.* We have already stated, that what may be called the *momentary price* of any commodity depends upon the proportion existing between the supply and demand, and also upon the cost of verification. The *average price*, during a long period, will depend upon the labour required for producing and bringing it to market, as well as upon the average supply and demand; but it will also be influenced by the *durability of the article manufactured.*

Many *things* in common use are substantially consumed in using: a phosphorus match, articles of food, and a cigar, are examples of this description. Some things after use become inapplicable to their former purposes, as paper which has been printed upon; but it is yet available for the cheesemonger or the trunk-maker. Some articles, as pens, are quickly worn out by use; and some are still valuable after a long-continued wear. There are others, few perhaps in number, which never wear out; the harder precious stones, when well cut and polished, are of this latter class: the fashion of the gold or silver mounting in which they are set may vary with the taste of the age, and such ornaments are constantly exposed for sale as second-hand, but the gems themselves, when removed from their supports, are never so considered. A brilliant, which has successively graced the necks of a hundred beauties, or glittered for a century upon patrician brows, is weighed by the diamond merchant in the same scale with another which has just escaped from the wheel of the lapidary, and will be purchased or sold by him at the same price per carat. The great mass of commodities is intermediate in its character between these two extremes, and the periods of respective duration are very various. It is evident that the average price of those things which are consumed in the act of using them, can never be less than that of the labour of bringing them to market. They may for a short time be sold for less, but under such circumstances their production must soon cease altogether. On the other hand, if an article never wears out, the consequence will be, that its price may continue *permanently below* the cost of the labour expended in producing it; and the only consequence will be, that no further production will take place: its price will continue to be regulated by the relation of the supply to the demand; and should that at any after time rise, for a considerable period, above the cost of production, it will be again produced.

(147.) Articles become old from actual decay, or the wearing out of their parts; from improved modes of constructing them; or from changes in their form and fashion, required by the varying taste of the age. In the two latter cases, their utility is but little diminished; and, being less sought after by the classes who have hitherto employed them, they are sold at a reduced price to a class of society rather below that of their former possessors. Many articles of furniture, such as well-made tables and chairs, are thus found in the rooms of those who would have been quite unable to have purchased them when new; and we find constantly, even in the houses of the more opulent, large looking-glasses which have passed successively through the hands of several possessors, changing only the fashion of their frames; and in some instances even this alteration is omitted, an additional coat of gilding saving them from the character of being second-hand. Thus a taste for luxuries is propagated downwards in society; and, after a short period, the numbers who have acquired new wants become sufficient to excite the ingenuity of the manufacturer to reduce the cost of supplying them, whilst he is himself benefited by the extended scale of demand.

There is a peculiarity in looking-glasses with reference to the principle just mentioned. The most frequent occasion of injury to them arises from accidental violence; and the peculiarity is, that, unlike most other articles, when broken they are still of some value. If a large mirror is accidentally cracked, it is immediately cut into two or more smaller ones, each of which may be perfect. If the degree of violence is so great as to break it into many fragments, these smaller pieces may be cut into squares for dressing-glasses; and if the silvering is injured, it can either be re-silvered or used as plate-glass for glazing windows. The addition from our manufactories to the stock of plate-glass in the country is annually about two hundred and fifty thousand square feet. It would be very difficult to estimate the quantity annually destroyed or exported, but it is probably small; and the effect of these continual additions is seen in the diminished price and increased consumption of the article. Almost all the better order of shop fronts are now glazed with it. If it were quite indestructible, the price would continually diminish; and unless an increased demand arose from new uses, or from a greater number of customers, a single manufactory, unchecked by competition, would ultimately be compelled to shut up, driven out of the market by the permanence of its own productions.

CHAP. XVI.

OF PRICE AS MEASURED BY MONEY.

(148.) THE *money price* at which an article sells furnishes us with comparatively little information, if we compare distant intervals of time and different countries; for gold and silver, in which price is usually measured, are themselves subject to variations like all other commodities; nor is there any invariable standard by which such comparisons can be made. The average price of a certain quality of various manufactured or raw produce has been suggested as a permanent standard of price; but a new difficulty then presents itself; for the improved methods of producing such articles render their *money price* extremely variable within very limited periods. The annexed table will afford a striking instance of this kind of variation within a period of only twelve years.

Prices of the following Articles at Birmingham, in the undermentioned Years.

DESCRIPTION.		1818.		1824.		1828.		1830.	
	℔	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
Anvils	cwt.	25	0	20	0	16	0	13	0
Awls, polished, Liverpool	gross	2	6	2	0	1	6	1	2
Bed-Screws, 6 inches long	gross	18	0	15	0	6	0	5	0
Bits, tinned, for Bridles .	doz.	5	0	5	0	3	3	2	6
Bolts for Doors, 6 inches	doz.	6	0	5	0	2	3	1	6
Braces for Carpenters, with 12 bits	set	9	0	4	0	4	2	3	5
Buttons, for Coats	gross	4	6	6	3	3	0	2	2

Prices of the following Articles at Birmingham, in the undermentioned Years—continued.

Description.		1818.		1824.		1828.		1830.	
		s.	d.	s.	d.	s.	d.	s.	d.
Buttons, small, for Waist-coats, &c.	℔ gross	2	6	2	0	1	2	0	8
Candlesticks, 6 in., brass	pair	2	11	2	0	1	7	1	2
Curry-Combs, six barred	doz.	2	9	2	6	1	5	0	11
Frying-Pans	cwt.	25	0	21	0	18	0	16	0
Gun-Locks, single roller	each	6	0	5	2	1	10	1	6
Hammers, Shoe, No. 0	doz.	6	9	3	9	3	0	2	9
Hinges, cast-butts, 1 inch	doz.	0	10	0	7½	0	3¾	0	2¾
Knobs, brass, 2 inches for Commodes	doz.	4	0	3	6	1	6	1	2
Latches for Doors, bright thumb	doz.	2	3	2	2	1	0	0	9
Locks for Doors, iron rim, 6 inches	doz.	38	0	32	0	15	0	13	6
Sad-Irons & other Castings	cwt.	22	6	20	0	14	0	11	6
Shovel & Tongs, fire-irons,	pair	1	0	1	0	0	9	0	6
Stirrups, Plated	pair	4	6	3	9	1	6	1	1
Tinned Table-Spoons	gross	17	0	15	0	10	0	7	0
Trace-Chains	cwt.	28	0	25	0	19	6	16	6
Trays, Japanned Tea, 30 inches	each	4	6	3	0	2	0	1	5
Vices for Blacksmiths, &c.	cwt.	30	0	28	0	22	0	19	6
Wire, Iron, No. 6	bund	16	0	13	0	9	0	7	0
——, Brass	lb.	1	10	1	4	1	0	0	9

I have taken some pains to assure myself of the accuracy of the above table: at different periods of the years quoted the prices may have varied; but I believe it may be considered as a fair approximation. In the course of my inquiries I have been favoured with another list, in which many of the same articles occur; but in this last instance the prices quoted are separated by an interval of twenty years. It is extracted from the books of a highly respectable house at Birmingham; and the prices confirm the accuracy of the former table, so far as they relate to the articles which are found in that list.

Prices of 1812 *and* 1832.

Description.		1812.		1832.		Reduction per cent. in price of 1812.
		s.	*d.*	*s.*	*d.*	
Anvils	per cwt. .	25	0	14	0	44
Awls, Liverpool blades .	,, gross	3	6	1	0	71
Candlesticks, iron, plain	,,	3	10¾	2	3½	41
———————, screwed	,,	6	4½	3	9	41
Bed screws, 6 inch square head	,, gross	7	6	4	6	40
——————, flat head	,, gross	8	6	4	8	45
Curry-Combs, 6 barred .	,, dozen	4	0½	1	0	75
—————, 8 barred .	,, dozen	5	5½	1	5	74
—————, patent, 6 brraed	,, dozen	7	1½	1	5	80
—————, 8 barred .	,, dozen	8	6¾	1	10	79
Fire-irons, iron head, No. 1. . . .		1	4½	0	7¾	53
——————————, No. 2. . . .		1	6	0	8½	53
——————————, No. 3. . . .		1	8¼	0	9½	53
——————————, No. 4. . . .		1	10½	0	10½	53
Gun-locks, single roller . . .	each	7	2½	1	11	73
Locks, 1¼ brass, port. pad.	. .	16	0	2	6	85
——, 2½ inch 3 keyed till-locks,	each	2	2	0	9	65
Shoe tacks	per gross	5	0	2	0	60
Spoons, tinned, iron table	,, gross	22	6	7	0	69
Stirrups, com. tinned, 2 bar	,, dozen	7	0	2	9	61
Trace-chains, iron . . .	,, cwt. .	46	9½	15	0	68

I cannot omit availing myself of this opportunity of calling the attention of the manufacturers, merchants, and factors, in *all* our manufacturing and commercial towns, to the great importance, both for their own interests, and for that of the population to which their capital gives employment, of collecting with care such averages from the actual sales registered in their books. Nor, perhaps, would it be without its use to suggest, that such averages would be still more valuable if collected from as many different quarters as possible; and when the amount of the goods from which they are deduced, together with the greatest deviations from the mean, are given; and that if a small committee were to undertake the task, it would give great additional weight to the information. Political economists have been reproached with too small a use of facts, and too large an employment of theory. If facts are wanting, let it be remembered that the closet-philosopher is unfortunately too little acquainted with the admirable arrangements of the factory; and that no class of persons can supply so readily, and with so little sacrifice of time, the data on which all the reasonings of political economists are founded, as the merchant and manufacturer; and, unquestionably, to no class are the deductions to which they give rise so important. Nor let it be feared that erroneous deductions may be made from such recorded facts: the errors which arise from the absence of facts are far more numerous and more durable than those which result from unsound reasoning respecting true data.

(149.) The great diminution in price of the articles here enumerated may have arisen from several causes: 1. *The alteration in the value of the currency.* 2. *The increased value of gold in consequence of the increased demand for coin.* The first of these causes may have had some influence; and the second may have had a very small effect upon the two first quotations of prices, but none at all upon the two latter ones. 3. *The diminished rate of profit produced by capital however employed.* This may be estimated by the average price of three per cents. at the periods stated. 4. *The diminished price of the raw materials out of which these articles were manufactured.* The raw material is principally brass and iron, and the reduction upon it may, in some measure, be estimated by the diminished price of iron and brass wire, in the cost of which articles, the labour bears a less proportion than it does in many of the others. 5. *The smaller quantity of raw material employed, and perhaps, in some instances, an inferior quality of workmanship.* 6. *The improved means by which the same effect was produced by diminished labour.*

In order to afford the means of estimating the influence of these several causes, the following table is subjoined:—

Average Price of	1812.	1818.	1824.	1828.	1830.	1832.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Gold, per oz. . . .	4 15 6	4 0 0	3 17 $6\frac{1}{2}$	3 17 7	3 17 $9\frac{1}{2}$	3 17 $10\frac{1}{2}$
Value of currency, per cent. . . .	79 5 3	97 6 10	100	100	100	100
Price of 3 per cent. consols	$59\frac{3}{4}$	$78\frac{1}{4}$	$93\frac{5}{8}$	86	$89\frac{3}{4}$	$82\frac{1}{2}$
Wheat, per quarter .	6 5 0	4 1 0	3 2 1	3 11 10	3 14 6	2 19 3
English pig-iron, at Birmingham . .	7 10 0	6 7 6	6 10 0	5 10 0	4 10 0	..
English bar-iron, do.	..	10 10 0	9 10 0	7 15 0	6 0 0	5 0 0
Swedish bar-iron, in London, excluding duty of from 4*l.* to 6*l.* 10*s.* per ton	16 10 0	17 10 0	14 0 0	14 10 0	13 15 0	13 2 0

The most influential of these causes has undoubtedly been the invention of cheaper modes of manufacturing. The extent to which this can be carried, and yet a profit be realized at the reduced price, is truly astonishing, as the following fact, which rests on good authority, will prove. Twenty years since, a brass knob for the locks of doors was *made* at Birmingham; the price, at that time, being 13*s*. 4*d*. per dozen. The same article is now *manufactured*, having the same weight of metal, and an equal, or in fact a slightly superior finish, at 1*s*. 9¼*d*. per dozen. One circumstance which has produced this economy in the *manufacture* is, that the lathe on which these knobs are finished is now turned by a steam-engine; so that the workman, relieved from that labour, can make them twenty times as fast as he did formerly.

(150.) The difference of price of the same article, when of various dimensions—at different periods, in the same country—and in different countries—is curiously contrasted in the annexed Table.

Comparative Price of Plate Glass, at the Manufactories of London, Paris, and Berlin.

Height.	Breadth.	LONDON.			PARIS.	BERLIN.
		1771.	1794.	1832.	1825.	1828.
Inches.	Inches	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
16	16	0 10 3	0 10 1	0 17 6	0 8 7	0 8 11
30	20	1 14 6	2 3 2	2 6 10	1 16 10	1 10 6
50	30	24 2 4	11 5 0	6 12 10	9 4 5	8 13 0
60	40	67 14 10	27 0 0	13 9 6	22 7 5	21 18 0
76	40	......	43 6 0	19 2 9	36 4 5	35 2 11
90	50	......	84 8 0	34 12 9	71 3 8	.....
100	75	......	275 0 0	74 5 10	210 13 3	.....
120	75	......	......	97 15 9	354 3 2	.....

The price of silvering these plates is twenty per cent. on the cost price for English glass; ten per cent. on the cost price for Paris plates; and twelve and a half on those of Berlin.

The following table shews the dimensions and price, when silvered, of the largest plates of glass ever made by the British Plate-Glass Company, which are now at their warehouse in London:

Height.	Breadth.	Price when silvered.
Inches.	*Inches.*	£ s. d.
132	84	200 8 0
146	81	220 7 0
149	84	239 1 6
151	83	239 10 7
160	80	246 15 4
The largest glass in the Paris list when silvered, and its dimensions and price reduced to English measure, is,		
128	80	629 12 0

(151.) If, therefore, we wish to compare the value of any article at different periods of time, it is clear that neither any one substance, nor even the combination of all manufactured goods, can furnish us with an invariable unit by which to form our scale of estimation. Mr. Malthus has proposed for this purpose to consider a day's labour of an agricultural labourer, as the unit to which all value should be referred. Thus, if we wish to compare the value of twenty yards of broad cloth in Saxony at the present time, with that of the same kind and quantity of cloth fabricated in England two centuries ago, we must find the number of days' labour the cloth would have purchased in England at the time mentioned, and compare it with the number of days' labour twenty yards of the same cloth will now purchase in Saxony. Agricultural labour appears to have been selected, because it exists in all countries, and employs a large number of persons, and also because it requires a very small degree of previous instruction. It seems, in fact, to be merely the exertion of a man's physical force; and its value above that of a machine of equal power arises from its portability, and from the facility of directing its efforts to arbitrary and continually fluctuating purposes. It may perhaps be worthy of inquiry, whether a more constant average might not be deduced from combining with this species of labour those trades which require but a moderate exertion of skill, and which exist in all civilized countries, such as those of the blacksmith and carpenter, &c.* In all such comparisons there is another element, which, though not essentially necessary, will yet add much to our means of judging. It is an estimate of the quantity of that food on which the labourer usually subsists, which is necessary for his daily support, compared with the quantity which his daily wages will purchase.

(152.) The existence of a class of middle-men between small producers and merchants is frequently advantageous to both parties; and there are certain periods in the history of several manufactures which

* Much information for such an, inquiry is to be found, for the particular period to which it refers, in the *Report of the Committee of the House of Commons on Manufacturers' Employment, 2d July*, 1830.

naturally call that class of traders into existence. There are also other times when the advantage ceasing, the custom of employing them also terminates; the middle-men, especially when numerous, as they sometimes are in retail trades, enhancing the price without equivalent good. Thus, in the recent examination by the House of Commons into the state of the Coal Trade, it appears that five-sixths of the London public is supplied by a class of middle-men who are called in the trade "*Brass-plate Coal-Merchants*:" these consist principally of merchants' clerks, gentlemen's servants, and others, who have no wharfs, but merely give their orders to some true coal-merchant, who sends in the coals from his wharf. The brass-plate coal-merchant, of course, receives a commission for his agency, which is just so much loss to the consumer.

CHAP. XVII.

OF RAW MATERIALS.

(153.) ALTHOUGH the cost of any article may be reduced in its ultimate analysis to the quantity of *labour* by which it was produced; yet it is usual, in a certain state of the manufacture of most substances, to call them by the term *raw material.* Thus iron, when reduced from the ore and rendered malleable, is in a state of preparation for a multitude of useful purposes, and is the *raw material* out of which most of our tools are made. In this stage of its manufacture, but a moderate quantity of *labour* has been expended on the substance; and it becomes an interesting subject to trace the various proportions in which *raw material*, in this sense of the term, and *labour* unite to constitute the value of many of the productions of the arts.

(154.) Gold-leaf consists of a portion of the metal beaten out to so great a degree of thinness, as to allow a greenish-blue light to be transmitted through its pores. About 400 square inches of this are sold, in the form of a small book containing 25 leaves of gold, for 1*s.* 6*d.* In this case, the raw material, or gold, is worth rather less than two-thirds of the manufactured article. In the case of silver-leaf, the labour considerably exceeds the value of the material. A book of fifty leaves, covering above 1,000 square inches, is sold for 1*s.* 3*d.*

(155.) In the fine gold chains made at Venice, we may trace in the various prices and sizes the relative influence of the two causes above referred to. The sizes of these chains are known by numbers, the smallest having been (in 1828) No. 1, and the numbers 2, 3, 4, &c. progressively increasing in size. The following Table shews the numbers and the prices of those made at that time.* The first column is the number by which the chain is known; the second expresses the weight in grains of one inch in length of each chain; the third column shews the number of links in the same length; and the last expresses the price in francs worth ten-pence each of a Venetian braccio, or about two English feet of each chain.

VENETIAN GOLD CHAINS.

No.	Weight of One Inch, in Grains.	Number of Links in One Inch.	Price of a Venetian Braccio, equal to Two Feet ⅛ Inch English.
0	.44	98 to 100	60 francs.
1	.56	92	40
1½	.77	88	26
2	.99	84	20
3	1.46	72	20
4	1.61	64	21
5	2.09	64	23
6	2.61	60	24
7	3.36	56	27
8	3.65	56	29
9	3.72	56	32
10	5.35	50	34
24	9.71	32	60

* A still finer chain is now manufactured (1832).

Amongst these chains, that numbered 0 and that numbered 24 are exactly of the same price, although the quantity of gold in the latter is twenty-two times as much as in the former. The difficulty of making the smallest chain is so great, that the women who make it cannot work above two hours at a time. As we advance from the smaller chain, the proportionate value of the work to the worth of the material becomes less and less, until, at the numbers 2 and 3, these two elements of cost balance each other; after which, the difficulty of the work decreases, and the value of the material increases.

(156.) The quantity of labour applied to these chains is, however, incomparably less than that which is applied to some of the manufactures of iron. In the case of the smallest Venetian chain the value of the labour is not above thirty times that of the gold. The pendulum spring of a watch, which governs the vibrations of the balance, costs at the retail price two-pence, and weighs fifteen one-hundredths of a grain, whilst the retail price of a pound of the best iron, the raw material out of which fifty thousand such springs are made, is exactly the same sum of two-pence.

(157.) The comparative price of labour and of raw material entering into the manufactures of France, has been ascertained with so much care, in a memoir of M. A. M. Héron de Villefosse, "*Recherches statistiques, sur les Metaux de France,*"* that we shall give an abstract of his results reduced to English

* Memoires de l'Institut, 1826.

measures. The facts respecting the metals relate to the year 1825.

In France the quantity of raw material which can be purchased for 1*l.*, when manufactured into

Silk goods......................is worth	£2·37
Broad cloth and woollens.................	2·15
Hemp and cables......................	3·94
Linen comprising thread laces.............	5·00
Cotton goods	2·44

The price of pig lead was 1*l.* 1*s.* per cwt.; and lead of the value of 1*l.* sterling, became worth, when manufactured into

Sheets or pipes of moderate dimensions......	£1·25
White lead...........................	2·60
Ordinary printing characters..............	4·90
The smallest type......................	28·30

The price of copper was 5*l.* 2*s.* per cwt. Copper worth 1*l.* became when manufactured into

Copper sheeting.......................	£1·26
Household utensils.....................	4·77
Common brass pins tinned...............	2·34
Rolled into plates covered with $\frac{1}{40}$ silver.....	3·56
Woven into metallic cloth, each square inch of which contains 10,000 meshes...........	52·23

The price of tin was 4*l.* 12*s.* per cwt. Tin worth 1*l.* when manufactured into

Leaves for silvering glass............became	£1·73
Household utensils....................	1·85

Quicksilver cost 10*l.* 16*s.* per cwt. Quicksilver worth 1*l.* when manufactured into

Vermilion of average quality.........became	£1·81

Metallic Arsenic cost 1*l.* 4*s.* per cwt. Arsenic worth 1*l.* when manufactured into

White oxide of arsenic	became	£1·83
Sulphuret (orpiment)		4·26

The price of cast iron was 8*s.* per cwt. Cast iron worth 1*l.* when manufactured into

Household utensils	became	£2·00
Machinery		4·00
Ornamental, as buckles, &c.		45·00
Bracelets, figures, buttons, &c.		147·00

Bar iron cost 1*l.* 6*s.* per cwt. Bar iron worth 1*l.* when manufactured into

Agricultural instruments	became	£3.57
Barrels, musket		9·10
Barrels of double-barrel guns, twisted and damasked		238·08
Blades of penknives		657·14
———, razor, cast steel		53·57
———, sabre, for cavalry, infantry, and artillery, &c.	from 9·25. to	16·07
——— of table knives		35·70
Buckles of polished steel, used as jewellery		896·66
Clothiers' pins		8·03
Door-latches and bolts	from 4·85 to	8·50
Files, common		2·55
——, flat, cast steel		20·44
Horse-shoes		2·55
Iron, small slit, for nails		1·10
Metallic cloth, ironwire, No. 80		96·71
Needles of various sizes	from 17·33 to	70·85
Reeds for weaving 3-4ths calico		21·87
Saws (frame) of steel		5·12
—— for wood		14·28
Scissars, finest kind		446·94

Sword-handles, polished steel		972.82
Steel, cast		4·28
——, cast, in sheets		6·25
——, cemented		2·41
——, natural		1·42
Tinned iron	from 2·04 to	2·34
Wire, iron	from 2·14 to	10·71

(158.) The following is stated by M. de Villefosse to be the price of bar iron at the forges of various countries, in January, 1825.

	Per ton. £	s.	d.
France	26	10	0
Belgium and Germany	16	14	0
Sweden and Russia, at Stockholm and St. Petersburg	13	13	0
England, at Cardiff	10	1	0
The price of the article in 1832 was	5	0	0

M. De Villefosse states, that in France bar iron, made as it usually is with charcoal, costs three times the price of the cast iron out of which it is made; whilst in England, where it is usually made with coke, the cost is only twice the price of cast iron.

CHAPTER XVIII.

ON THE DIVISION OF LABOUR.

(159.) Perhaps the most important principle on which the economy of a manufacture depends, is the *division of labour* amongst the persons who perform the work. The first application of this principle must have been made in a very early stage of society; for it must soon have been apparent, that more comforts and conveniences could be acquired by one man restricting his occupation to the art of making bows, another to that of building houses, a third boats, and so on. This division of labour into trades was not, however, the result of an opinion that the general riches of the community would be increased by such an arrangement; but it must have arisen from the circumstance of each individual so employed discovering that he himself could thus make a greater profit of his labour than by pursuing more varied occupations. Society must have made considerable advances before this principle could have been carried into the workshop; for it is only in countries which have attained a high degree of civilization, and in articles in which there is a great competition amongst the producers, that the most perfect system of the division of labour is to be observed. The principles on which the advantages of this system depend, have been much the subject of discussion amongst writers on Political Economy; but the relative importance of their influence does not appear, in all cases, to have been estimated with sufficient precision. It is my intention, in the first instance, to state shortly those principles, and then to point out what appears to me to have been omitted by those who have previously treated the subject.

(160.) 1. *Of the time required for learning.* It will readily be admitted, that the portion of time occupied in the acquisition of any art will depend on the difficulty of its execution; and that the greater the number of distinct processes, the longer will be the time which the apprentice must employ in acquiring it. Five or seven years have been adopted, in a great many trades, as the time considered requisite for a lad to acquire a sufficient knowledge of his art, and to repay by his labour, during the latter portion of his time, the expense incurred by his master at its commencement. If, however, instead of learning all the different processes for making a needle, for instance, his attention be confined to one operation, a very small portion of his time will be consumed unprofitably at the commencement, and the whole of the rest of it will be beneficial to his master: and if there be any competition amongst the masters, the apprentice will be able to make better terms, and diminish the period of his servitude. Again, the facility of acquiring skill in a single process, and the early period of life at which it can be made a source of profit, will induce a greater number of parents to bring up their children to it; and from this circumstance also, the number of workmen being increased, the wages will soon fall.

(161.) A certain quantity of material will be consumed unprofitably, or spoiled by every person who learns an art; and, as he applies himself to each new process, he will waste a certain quantity of the raw material, or of the partly manufactured commodity. But whether one man commits this waste in acquiring successively each process, or many persons separately learn the several processes, the quantity of waste will remain the same; in this view of the subject, therefore, the division of labour will neither increase nor diminish the price of production.

(162.) 2. Another source of the advantage resulting from the division of labour is, that *time is always lost in changing from one occupation to another.* When the human hand, or the human head, has been for some time occupied in any kind of work, it cannot instantly change its employment with full effect. The muscles of the limbs employed have acquired a flexibility during their exertion, and those to be put in action a stiffness during rest, which renders every change slow and unequal in the commencement. A similar result seems to take place in any change of mental exertion; the attention bestowed on the new subject is not so perfect at the first commencement as it becomes after some exercise. Long habit also produces in the muscles exercised a capacity for enduring fatigue to a much greater degree than they could support under other circumstances.

(163.) Another cause of the loss of time in changing from one operation to another, arises from the employment of different tools in the two processes. If these tools are simple in their nature, and the change is not frequently repeated, the loss of time is not considerable; but in many processes of the arts the tools are of great delicacy, requiring accurate adjustment whenever they are used. In many cases the time employed in adjusting bears a large proportion to that employed in using the tool. The sliding-rest, the dividing and the drilling-engine, are of this kind; and hence, in manufactories of sufficient extent, it is found to be good economy to keep one machine constantly employed in one kind of work: one lathe, for example, having a screw motion to its sliding-rest along the whole length of its bed, is kept constantly making cylinders; another, having a motion for rendering uniform the velocity of the work at the point at which it passes the tool, is kept for facing surfaces; whilst a third is constantly employed in cutting wheels.

(164.) 3. *Skill acquired by frequent repetition of the same processes.* The constant repetition of the same process necessarily produces in the workman a degree of excellence and rapidity in his particular department, which is never possessed by one person who is obliged to execute many different processes. This rapidity is still further increased from the circumstance that most of the operations in factories, where the division of labour is carried to a considerable extent, are paid for as piece-work. It is difficult to estimate in numbers the effect of this cause upon production. In nail-making, Adam Smith has stated, that it is almost three to one; for, he observes, that a smith accustomed to make nails, but whose whole business has not been that of a nailer, can make only from eight hundred to a thousand per day; whilst a lad who had never exercised any other trade, can make upwards of two thousand three hundred a day.

(165.) Upon an occasion when a large issue of bank-notes was required, a clerk at the Bank of England signed his name, consisting of seven letters, including the initial of his Christian name, five thousand three hundred times during eleven working hours; and he also arranged the notes he had signed in parcels of fifty each. In different trades the economy of production arising from this cause, will necessarily be different. The case of nail-making is, perhaps, rather an extreme one. It must, however, be observed that, in one sense, this is not a permanent source of advantage; for, although it acts at the commencement of an establishment, yet every month adds to the skill of the workmen; and at the end of three or four years they will not be very far behind those who have practised only the particular branch of their art.

(166.) 4. *The division of labour suggests the contrivance of tools and machinery to execute its processes.* When each process, by which any article is produced, is the sole occupation of one individual, his whole attention being devoted to a very limited and simple operation, any improvement in the form of his tools, or in the mode of using them, is much more likely to occur to his mind, than if it were distracted by a greater variety of circumstances.

Such an improvement in the tool is generally the first step towards a machine. If a piece of metal is to be cut in a lathe, for example, there is one angle at which the cutting-tool must be held to insure the cleanest cut; and it is quite natural that the idea of fixing the tool at that angle should present itself to an intelligent workman. The necessity of moving the tool slowly, and in a direction parallel to itself, would suggest the use of a screw, and thus arises the sliding-rest. It was probably the idea of mounting a chisel in a frame, to prevent its cutting too deeply, which gave rise to the common carpenter's plane. In cases where a blow from a hammer is employed, experience teaches the proper force required. The transition from the hammer held in the hand to one mounted upon an axis, and lifted regularly to a certain height by some mechanical contrivance, requires perhaps a greater degree of invention. Yet it is not difficult to perceive, that, if the hammer always falls from the same height, its effect must be always the same.

(167.) When each process has been reduced to the use of some simple tool, the union of all these tools, actuated by one moving power, constitutes a machine. In contriving tools and simplifying processes, the operative workmen are, perhaps, most successful; but it requires far other habits to combine into one machine these scattered arts. A previous education as a workman in the peculiar trade, is undoubtedly a valuable preliminary; but in order to make such combinations with any reasonable expectation of success, an extensive knowledge of machinery, and the power of making mechanical drawings, are essentially requisite. These accomplishments are now much more common than they were formerly; and their absence was, perhaps, one of the causes of the multitude of failures in the early history of many of our manufactures.

(168.) Such are the principles usually assigned as the causes of the advantage resulting from the division of labour. As in the view I have taken of the question, the most important and influential cause has been altogether unnoticed, I shall re-state those principles in the words of Adam Smith: "The great "increase in the quantity of work, which, in conse- "quence of the division of labour, the same number "of people are capable of performing, is owing to "three different circumstances: first, to the increase "of dexterity in every particular workman; secondly, "to the saving of time, which is commonly lost in "passing from one species of work to another; and, "lastly, to the invention of a great number of ma- "chines which facilitate and abridge labour, and ena- "ble one man to do the work of many." Now, although all these are important causes, and each has its influence on the result; yet it appears to me, that any explanation of the cheapness of manufactured articles, as consequent upon the division of labour, would be incomplete if the following principle were omitted to be stated.

That the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill and force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess *sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided.**

(169.) As the clear apprehension of this principle, upon which so much of the economy arising from the division of labour depends, is of considerable importance, it may be desirable to illustrate it, by pointing out its precise and numerical application in some specific manufacture. The art of making needles is, perhaps, that which I should have selected as comprehending a very large number of processes remarkably different in their nature; but the less difficult art of pin-making, has some claim to attention, from its having been used by Adam Smith, in his illustration of the subject; and I am confirmed in the choice, by the circumstance of our possessing a very accurate and minute description of that art, as practised in France above half a century ago.

(170.) *Pin-making.* In the manufacture of pins in England the following processes are employed:—

Wire-drawing. 1. The brass wire used for making pins is purchased by the manufacturer in coils of about twenty-two inches in diameter, each weighing about thirty-six pounds. The coils are wound off into smaller ones of about six inches diameter, and between one and two pounds' weight. The diameter of this wire is now reduced by drawing it repeatedly

* I have already stated, that this principle presented itself to me after a personal examination of a number of manufactories and workshops devoted to different purposes; but I have since found that it has been distinctly stated, in the work of Gioja, *Nuovo Prospetto delle Scienze Economiche*, 6 tom. 4to. Milano, 1815, tom. i. capo iv.

through holes in steel plates, until it becomes of the size required for the sort of pins intended to be made. During the process of drawing the wire through these holes it becomes hardened, and it is necessary to anneal it in order to prevent its breaking; and, to enable it to be still further reduced, it is annealed two or three times, according to the diminution of diameter required. The coils are then soaked in sulphuric acid, largely diluted with water, in order to clean them, and are then beaten on stone, for the purpose of removing any oxidated coating which may adhere to them. This process is usually performed by men, who draw and clean from thirty to thirty-six pounds of wire a day. They are paid at the rate of five farthings per pound, and generally earn about 3*s.* 6*d.* per day.

M. Perronet made some experiments on the extension the wire undergoes by this process at each hole: he took a piece of thick Swedish brass wire, and found

	Feet.	Inch.
Its length to be before drawing	3	8
After passing the first hole	5	5
———— second hole	7	2
———— third hole.............	7	8

It was now annealed, and the length became

After passing the fourth hole	10	8
———— fifth hole	13	1
———— sixth hole..............	16	8
And finally, after passing through six other holes	144	0

The holes through which the wire was drawn were not, in this experiment, of regularly decreasing diameter; and it is extremely difficult to make such holes, and still more to preserve them in their original dimensions.

(171.) 2. *Straightening the Wire.* The coil of wire now passes into the hands of a woman, assisted by a boy or girl. A few nails, or iron pins, not quite in a line, are fixed into one end of a wooden table about twenty feet in length; the end of the wire is passed alternately between these nails, and is then pulled to the other end of the table. The object of this process is to straighten the wire, which had acquired an uniform curvature in the small coils into which it had been wound. The length thus straightened is cut off, and the remainder of the coil is drawn into similar lengths. About seven nails or pins are employed in straightening the wire, and their adjustment is a matter of some nicety. It seems, that by passing the wire between the first three nails or pins, a bend is produced in an opposite direction to that which the wire had in the coil; this bend, by passing the next two nails, is reduced to another of larger curvature in the first direction, and so on till the curvature is at last so large that it may be confounded with a straight line.

(172.) 3. *Pointing.* A man next takes about three hundred of these straightened pieces in a parcel, and putting them into a gauge, cuts off from one end, by means of a pair of shears, moved by his foot, a portion equal in length to rather more than six pins. He continues this operation until the entire parcel is reduced into similar pieces. The next step is to sharpen the ends: for this purpose the operator sits before a steel mill, which is kept rapidly revolving; and taking up a parcel between the finger and thumb of each hand, he passes the ends before the mill, taking care with his fingers and thumbs to make each wire slowly revolve upon its axis. The mill consists of a cylinder about six inches in diameter, and two and a half inches broad, faced with steel, which is cut in the manner of a file. Another cylinder is fixed on the same axis at a few inches distant; the file on the edge of which is of a finer kind, and is used for finishing off the points. Having thus pointed all the pieces at one end, he reverses them, and performs the same process on the other. This process requires considerable skill, but it is not unhealthy; whilst the similar process in needle-making is remarkably destructive of health. The pieces, now pointed at both ends, are next placed in gauges, and the pointed ends are cut off, by means of shears, to the proper length of which the pins are to be made. The remaining portions of the wire are now equal to about four pins in length, and are again pointed at each end, and their ends again cut off. This process is repeated a third time, and the small portion of wire left in the middle is thrown amongst the waste, to be melted along with the dust arising from the sharpening. It is usual for a man, his wife, and a child, to join in performing these processes; and they are paid at the rate of five farthings per pound. They can point from thirty-four to thirty-six and a half pounds per day, and gain from 6*s*. 6*d*. to 7*s*., which may be apportioned thus: 5*s*. 6*d*. the man, 1*s*. the woman, 6*d*. to the boy or girl.

(173.) 4. *Twisting and Cutting the Heads.* The next process is making the heads. For this purpose a boy takes a piece of wire, of the same diameter as the pin to be headed, which he fixes on an axis that can be made to revolve rapidly by means of a wheel and strap connected with it. This wire is called the mould. He then takes a smaller wire, which having passed through an eye in a small tool held in his left hand, he fixes close to the bottom of the mould. The mould is now made to revolve rapidly by means of the right hand, and the smaller wire coils round it until it has covered the whole length of the mould. The boy now cuts the end of the spiral connected with the foot of the mould, and draws it off. When a sufficient quantity of heading is thus made, a man takes from thirteen to twenty of these spirals in his left hand, between his thumb and three outer fingers: these he places in such a manner that two turns of the spiral shall be beyond the upper edge of a pair of shears, and with the forefinger of the same hand he feels these two projecting turns. With his right hand he closes the shears; and the two turns of the spiral being cut off, drop into a basin. The position of the forefinger prevents the heads from flying about when cut off. The workmen who cut the heads are usually paid at the rate of 2½*d.* to 3*d.* per pound for large, but a higher price is given for the smaller heading. Out of this they pay the boy who spins the spiral; he receives from 4*d.* to 6*d.* a day. A good workman can cut from six to about thirty pounds of heading per day, according to its size.

(174.) 5. *Heading.* The process of fixing the head on the body of the pin is usually executed by women and children. Each operator sits before a small steel stake, having a cavity, into which one half of the intended head will fit; immediately above is a steel die, having a corresponding cavity for the other half of the head: this latter die can be raised by a pedal moved by the foot. The cavities in the centre of these dies are connected with the edge by a small groove, to admit of the body of the pin, which is thus prevented from being flattened by the blow of the die. The operator with his left hand dips the pointed end of the body of a pin into a tray of heads; having passed the point through one of them, he carries it along to the other end with the fore finger. He now takes the pin in the right hand, and places the head in the cavity of the stake, and, lifting the die with his foot, allows it to fall on the head. This blow tightens the head on the shank, which is then turned round, and the head receives three or four blows on different parts of its circumference. The women and children who fix the heads are paid at the rate of 1*s*. 6*d*. for every twenty thousand. A skilful operator can with great exertion do twenty thousand per day; but from ten to fifteen thousand is the usual quantity: children head a much smaller number; varying, of course, with the degree of their skill. The weight of the hammer is from seven to ten pounds, and it falls through a very small space, perhaps from one to two inches. About one per cent. are spoiled in the process; these are picked out afterwards by women, and are reserved with the waste from other processes for the melting-pot. The form of the dies in which the heads are struck is varied according to the fashion of the time; but the repeated blows to which it is subject renders it necessary that it should be repaired after it has been used for about thirty pounds of pins.

(175.) 6. *Tinning.* The pins are now fit to be tinned, a process which is usually executed by a man, assisted by his wife, or by a lad. The quantity of pins operated upon at this stage is usually fifty-six pounds. They are first placed in a pickle, in order to remove any grease or dirt from their surface, and also to render that surface rough, which facilitates the adherence of the tin with which they are to be covered. They are then placed in a boiler full of a solution of tartar in water, in which they are mixed with a quantity of tin in small grains. They are generally kept boiling for about two hours and a half, and are then removed into a tub of water into which some bran has been thrown; this is for the purpose of washing them. They are then taken out, and, being placed in wooden trays, are well shaken in dry bran: this removes any water adhering to them; and by giving the wooden tray a peculiar kind of motion, the pins are thrown up, and the bran gradually flies off, and leaves them behind in the tray. The man who pickles and tins the pins usually gets one penny per pound for the work, and employs himself, during the boiling of one batch of pins, with drying those previously tinned. He can earn about 9*s*. per day; but out of this he pays about 3*s*. for his assistant.

(176.) 7. *Papering.* The arranging of pins side by side in paper is generally performed by women. The pins come from the last process in wooden bowls, with the points projecting in all directions. A woman takes up some, and places them on the teeth of a comb, whilst, by a few shakes, some of the pins fall back into the bowl, and the rest, being caught by their heads, are detained between the teeth of the comb. Having thus arranged them in a parallel direction, she fixes the requisite number between two pieces of iron, having twenty-five small grooves, at equal distances; and having previously doubled the paper, she presses it against the points of the pins until they have passed through the two folds which are to retain them. The pins are then relieved from the grasp of the tool, and the process repeated with others. A woman gains about 1*s.* 6*d.* per day by papering; but children are sometimes employed, who earn from 6*d.* per day, and upwards.

(177.) Having thus described the various processes of pin-making, without entering into the minuter details, and having stated the usual cost of each, it will be convenient to present a tabular view of the time occupied by each process, and its cost, as well as of the sums which can be earned by the persons who confine themselves solely to each process. As the rate of wages is itself fluctuating, and as the prices paid and quantities executed have been given between certain limits, it is not to be expected that this table can represent with the minutest accuracy the cost of each part of the work, nor even that it shall accord perfectly with the prices above given: but it has been drawn up with some care, and will be quite sufficient for that general view, and for those reasonings, which it is meant to illustrate. A table nearly similar will be subjoined, which has been deduced from a statement of M. Perronet, respecting the art of pin-making in France, above seventy years ago.

English Manufacture.

(178.) Pins, "*Elevens,*" 5,546 weigh one pound; "*one dozen*"=6,932 pins weigh twenty ounces, and require six ounces of paper.

NAME OF THE PROCESS.	Workmen.	Time of making 1 lb. of Pins	Cost of making 1 lb. of Pins.	Workman earns per Day.		Price of making each Part of a single Pin, in Millionths of a Penny.
		Hours.	*Pence.*	*s.*	*d.*	
1. Drawing Wire (§ 170.)	Man . .	.3636	1.2500	3	3	225
2. Straightening the wire (§ 171.)	Woman	.3000	.2840	1	0	51
	Girl . .	.3000	.1420	0	6	26
3. Pointing (§ 172.)	Man . .	.3000	1.7750	5	3	319
4. Twisting and Cutting the Heads (§ 173.)	Boy . .	.0400	.0147	0	4½	3
	Man . .	.0400	.2103	5	4½	38
5. Heading (§ 174.)	Woman	4.0000	5.0000	1	3	901
6. Tinning, or Whitening (§ 175.)	Man . .	.1071	.6666	6	0	121
	Woman	.1071	.3333	3	0	60
7. Papering (§ 176.)	Woman	2.1314	3.1973	1	6	576
		7.6892	12.8732			2320

Number of Persons employed:—Men, 4; Women, 4; Children, 2. Total, 10.

French Manufacture.

(179.) Cost of 12,000 pins, No. 6, each being eight-tenths of an English inch in length; with the cost of each operation:—deduced from the observations and statement of M. Perronet:—as they were manufactured in France about 1760.

	NAME OF THE PROCESS.	Time of making Twelve Thousand Pins.	Cost of making Twelve Thousand Pins.	Workman usually earns per Day.	Expense of Tools and Materials.
		Hours.	*Pence.*	*Pence.*	*Pence.*
1.	Wire	...	...	...	24.75
2.	Straightening and Cutting	1.2	.5	4.5	...
3.	Coarse Pointing	1.2	.625	10.0	...
	Turning Wheel*	1.2	.875	7.0	...
	Fine Pointing	.8	.5	9.375	...
	Turning Wheel	1.2	.5	4.75	...
	Cutting off pointed Ends	.6	.375	7.5	...
4.	Turning Spiral	.5	.125	3.0	...
	Cutting off Heads	.8	.375	5.625	...
	Fuel to anneal ditto	...	...	...	.125
5.	Heading	12.0	.333	4.25	...
6.	Tartar for Cleaning	...	...	...	.5
	Tartar for Whitening	...	...	...	.5
7.	Papering	4.8	.5	2.0	...
	Paper	...	...	...	1.0
	Wear of Tools	...	...	...	2.0
		24.3	4.708		

(180.) It appears from the analysis we have given of the art of pin-making, that it occupies rather more than seven hours and a half of time, for ten different individuals working in succession on the same material, to convert it into a pound of pins; and that the total expense of their labour, each being paid in the

* The expense of turning the wheel appears to have arisen from the person so occupied being unemployed during half his time, whilst the pointer went to another manufactory.

joint ratio of his skill and of the time he is employed, amounts very nearly to 1*s*. 1*d*. But from an examination of the first of these tables, it appears that the wages earned by the persons employed vary from $4\frac{1}{2}$*d*. per day up to 6*s*., and consequently the skill which is required for their respective employments may be measured by those sums. Now it is evident, that if one person be required to make the whole pound of pins, he must have skill enough to earn about 5*s*. 3*d*. per day whilst he is pointing the wires or cutting off the heads from the spiral coil,—and 6*s*. when he is whitening the pins; which three operations together would occupy little more than the seventeenth part of his time. It is also apparent, that during more than one half of his time he must be earning only 1*s*. 3*d*. per day in putting on the heads, although his skill, if properly employed, would, in the same time, produce nearly five times as much. If therefore we were to employ, for each of the processes, the man who whitens the pins, and who earns 6*s*. per day, even supposing that he could make the pound of pins in an equally short time, yet we must pay him for his time 46.14 pence, or about 3*s*. 10*d*. *The pins would therefore cost, in making, three times and three quarters as much as they now do by the application of the division of labour.* The higher the skill required of the workman in any one process of a manufacture, and the smaller the time during which it is employed, so much the greater will be the advantage of separating that process from the rest, and devoting one person's attention entirely to it. Had we selected the art of needle-making as our illustration, the economy arising from the division of labour would have been still larger; for the process of tempering the needles requires great skill, attention, and experience, and although from three to four thousand are tempered at once, the workman is paid a very high rate of wages. In another process of the same art, dry-pointing, which is also executed with great rapidity, the wages earned by the workman reach from 7*s*. to 12*s*., 15*s*., and even, in some instances, to 20*s*. per day; whilst other processes in the same art are carried on by children paid at the rate of 6*d*. per day.

(181.) Some further reflections are suggested by the preceding analysis, but it may be convenient previously to place before the reader a brief description of a machine for making pins, invented by an American. It is highly ingenious in point of contrivance, and, in respect to its economical principles, will furnish a strong and interesting contrast with the manufacture of pins by the human hand. In this machine a coil of brass wire is placed on an axis; one end of this wire is drawn by a pair of rollers through a small hole in a plate of steel, and is held there by a forceps. As soon as the machine is put in action—

1. The forceps draws the wire on to a distance equal in length to one pin: a cutting edge of steel then descends close to the hole through which the wire entered, and severs a piece equal in length to one pin.

2. The forceps holding this wire moves on until it brings the wire into the centre of the *chuck* of a small lathe, which opens to receive it. Whilst the forceps returns to fetch another piece of wire, the lathe revolves rapidly, and grinds the projecting

end of the wire upon a steel mill, which advances towards it.

3. After this first or coarse pointing, the lathe stops, and another forceps takes hold of the half-pointed pin, (which is instantly released by the opening of the *chuck*,) and conveys it to a similar *chuck* of another lathe, which receives it, and finishes the pointing on a finer steel mill.

4. This mill again stops, and another forceps removes the pointed pin into a pair of strong steel clams, having a small groove in them by which they hold the pin very firmly. A part of this groove, which terminates at that edge of the steel clams which is intended to form the head of the pin, is made conical. A small round steel punch is now driven forcibly against the end of the wire thus clamped, and the head of the pin is partially formed by compressing the wire into the conical cavity.

5. Another pair of forceps now removes the pin to another pair of clams, and the head of the pin is completed by a blow from a second punch, the end of which is slightly concave. Each pair of forceps returns as soon as it has delivered its burden; and thus there are always five pieces of wire at the same moment in different stages of advance towards a finished pin. The pins so formed are received in a tray, and whitened and papered in the usual manner. About sixty pins can thus be made by this machine in one minute; but each process occupies exactly the same time in performing.

(182.) In order to judge of the value of such a machine, compared with hand labour, it would be necessary to inquire:—1. To what defects pins so made are liable? 2. What advantages they possess over those made in the usual way? 3. What is the prime cost of a machine for making them? 4. What is the expense of keeping it in repair? 5. What is the expense of moving it and attending to it?

1. Pins made by the machine are more likely to bend, because as the head is punched up out of the solid wire, it ought to be in a soft state to admit of this process. 2. Pins made by the machine are better than common ones, because they are not subject to losing their heads. 3. With respect to the prime cost of a machine, it would be very much reduced if numbers should be required. 4. With regard to its wear and tear, experience only can decide the question: but it may be remarked, that the steel clams or dies in which the heads are punched up, will wear quickly unless the wire has been softened by annealing; and that if it has been softened, the bodies of the pins will bend too readily. Such an inconvenience might be remedied, either by making the machine spin the heads and fix them on, or by annealing only that end of the wire which is to become the head of the pin: but this would cause a delay between the operations, since the brass is too brittle while heated to bear a blow without crumbling. 5. On comparing the time occupied by the machine with that stated in the analysis, we find, except in the process of heading, if time alone is considered, that the human hand is more rapid. Three thousand six hundred pins are pointed by the machine in one hour, whilst a man can point fifteen thousand six hundred in the same time. But in the process of heading, the rapidity of the machine is two and a half times that of the human

hand. It must, however, be observed, that the process of grinding does not require the application of force to the machine equal to that of one man; for all the processes we have described are executed at once by the machine, and one labourer can easily work it.

CHAP. XIX.

ON THE DIVISION OF MENTAL LABOUR.

(183.) We have already mentioned what may, perhaps, appear paradoxical to some of our readers, —that the division of labour can be applied with equal success to mental operations, and that it ensures, by its adoption, the same economy of time. A short account of its practical application, in the most extensive series of calculations ever executed, will offer an interesting illustration of this fact, whilst at the same time it will afford an occasion for shewing that the arrangements which ought to regulate the interior economy of a manufactory, are founded on principles of deeper root than may have been supposed, and are capable of being usefully employed in paving the road to some of the sublimest investigations of the human mind.

(184.) In the midst of that excitement which accompanied the Revolution of France and the succeeding wars, the ambition of the nation, unexhausted by its fatal passion for military renown, was at the same time directed to the nobler and more permanent triumphs which mark the era of a people's greatness, — and which receive the applause of posterity long after their conquests have been wrested from them, or even when their existence as a nation may be told only by the page of history. Amongst their enterprises of science, the French government was desirous of producing a series of mathematical tables, which should facilitate the extension of the decimal system they had so recently adopted. They directed, therefore, their mathematicians to construct such tables, on the most extensive scale. Their most distinguished philosophers, responding fully to the call of their country, invented new methods for this laborious task; and a work, completely answering the large demands of the government, was produced in a remarkably short period of time. M. Prony, to whom the superintendence of this great undertaking was confided, in speaking of its commencement, observes: "*Je m'y* " *livrai avec toute l'ardeur dont j'étois capable, et je* " *m'occupai d'abord du plan général de l'exécution.* " *Toutes les conditions que j'avois à remplir nécessi-* " *toient l'emploi d'un grand nombre de calculateurs;* " *et il me vint bientôt à la pensée d'appliquer à la* " *confection de ces Tables* la division du travail, *dont* " *les Arts de Commerce tirent un parti si avantageux* " *pour réunir à la perfection de main-d'œuvre* " *l'économie de la dépense et du temps.*" The circumstance which gave rise to this singular application of the principle of *the division of labour* is so interesting, that no apology is necessary for introducing it from a small pamphlet printed at Paris a few years since, when a proposition was made by the English to the French government, that the two countries should print these tables at their joint expense.

(185.) The origin of the idea is related in the following extract:—

C'est à un chapitre d'un ouvrage Anglais, justement célèbre, (I.) qu'est probablement due l'existence de l'ouvrage dont le gouvernement Britannique veut faire jouir le monde savant :—

[*An Enquiry into the Nature and Causes of the Wealth of Nations, by Adam Smith*:]

Voici l'anecdote: M. de Prony s'était engagé, avec les comités de gouvernement, à composer pour *la division centesimale du cercle, des tables logarithmiques et trigonometriques, qui, non seulement ne laissassent rien à desirer quant à l'exactitude, mais qui formassent le monument de calcul le plus vaste et le plus imposant qui eût jamais été exécuté, ou même conçu.* Les logarithmes des nombres de 1 à 200,000 formaient à ce travail un supplement nécéssaire et exigé. Il fut aisé à M. de Prony de s'assurer que, même en s'associant trois ou quatre habiles co-operateurs, la plus grande durée presumable de sa vie, ne lui suffirai pas pour remplir ses engagements. Il était occupé de cette fâcheuse pensée lorsque, se trouvant devant la boutique d'un marchand de livres, il apperçut la belle edition Anglaise de Smith, donnée à Londres en 1776; il ouvrit le livre au hazard, et tomba sur le premier chapitre, qui traite de *la division du travail*, et où la fabrication des épingles est citée pour exemple. A peine avait-il parcouru les premieres pages, que, par une espèce d'inspiration, il conçut l'expédient de mettre ses logarithmes en *manufacture* comme les épingles. Il faisait, en ce moment, à l'école polytechnique, des leçons sur une partie d'analyse liée à ce genre de travail, *la methode des differences*, et ses applications à *l'interpolation*. Il alla passer quelques jours à la campagne, et revint à Paris avec le plan de *fabrication*, qui a été suivi dans l'exécution. Il rassembla deux ateliers, qui faisaient séparément les mêmes calculs, et se servaient de vérification reciproque.*

* Note sur la publication, proposée par le gouvernement Anglais des grandes tables logarithmiques et trigonometriques de M. de Prony.—De l'imprimerie de F. Didot, Dec. 1, 1820, p. 7.

(186.) The ancient methods of computing tables were quite inapplicable to such a proceeding. M. Prony therefore wished to avail himself of all the talent of his country, and formed the first section of those who were to take part in this enterprise out of five or six of the most eminent mathematicians in France.

First Section.—The duty of this first section was to investigate, amongst the various analytical expressions which could be found for the same function, that which was most readily adapted to simple numerical calculation by many individuals employed at the same time. This section had little or nothing to do with the actual numerical work. When its labours were concluded, the formulæ on the use of which it had decided, were delivered to the second section.

Second Section.—This section consisted of seven or eight persons of considerable acquaintance with mathematics: and their duty was to convert into numbers the formulæ put into their hands by the first section,—an operation of great labour; and then to deliver out these formulæ to the members of the third section, and receive from them the finished calculations. The members of this second section had certain means of verifying these calculations without the necessity of repeating, or even of examining the whole of the work done by the third section.

Third Section.—The members of this section, whose number varied from sixty to eighty, received certain numbers from the second section, and, using nothing more than simple addition and subtraction, they returned to that section the finished tables. It is remarkable that nine-tenths of this class had no knowledge of arithmetic beyond its two first rules which they were thus called upon to exercise, and that these persons were usually found more correct in their calculations, than those who possessed a more extensive knowledge of the subject.

(187.) When it is stated that the tables thus computed occupy seventeen large folio volumes, some idea may perhaps be formed of the labour. From that part executed by the third class, which may almost be termed mechanical, requiring the least knowledge and by far the greatest labour, the first class were entirely exempt. Such labour can always be purchased at an easy rate. The duties of the second class, although requiring considerable skill in arithmetical operations, were yet in some measure relieved by the higher interest naturally felt in those more difficult operations. The exertions of the first class are not likely to require, upon another occasion, so much skill and labour as they did upon the first attempt to introduce such a method; but when the completion of a calculating-engine shall have produced a substitute for the whole of the third section of computers, the attention of analysts will naturally be directed to simplifying its application, by a new discussion of the methods of converting analytical formulæ into numbers.

(188.) The proceeding of M. Prony, in this celebrated system of calculation, much resembles that of a skilful person about to construct a cotton or silk-mill, or any similar establishment. Having, by his own genius, or through the aid of his friends, found that some improved machinery may be successfully applied to his pursuit, he makes drawings of his plans of the machinery, and may himself be considered as constituting the first section. He next requires the assistance of operative engineers capable of executing the machinery he has designed, some of whom should understand the nature of the processes to be carried on; and these constitute his second section. When a sufficient number of machines have been made, a multitude of other persons, possessed of a lower degree of skill, must be employed in using them; these form the third section: but their work and the just performance of the machines, must be still superintended by the second class.

(189.) As the possibility of performing arithmetical calculations by machinery may appear to non-mathematical readers to be rather too large a postulate, and as it is connected with the subject of the *division of labour*, I shall here endeavour, in a few lines, to give some slight perception of the manner in which this can be done,—and thus to remove a small portion of the veil which covers that apparent mystery.

(190.) *That nearly all tables of numbers which follow any law, however complicated, may be formed, to a greater or less extent, solely by the proper arrangement of the successive addition and subtraction of numbers befitting each table*, is a general principle which can be demonstrated to those only who are well acquainted with mathematics; but the mind, even of the reader who is but very slightly acquainted with that science, will readily conceive that it is not impossible, by attending to the following example. Let us consider the subjoined table. This table is the beginning of one in very extensive use, which has been printed and reprinted very frequently in many countries, and is called *a table of square numbers*.

Terms of the Table.	A. Table.	B. First Difference.	C. Second Difference.
1	1		
		3	
2	4		2
		5	
3	9		2
		7	
4	16		2
		9	
5	25		2
		11	
6	36		2
		13	
7	49		

Any number in the table, column A, may be obtained, by multiplying the number which expresses the distance of that term from the commencement of the table by itself; thus, 25 is the fifth term from the beginning of the table, and 5 multiplied by itself, or by 5, is equal to 25. Let us now subtract each term of this table from the next succeeding term, and place the results in another column (B), which may be called first-difference column. If we again subtract each term of this first difference from the succeeding term, we find the result is always the number 2, (column C); and that the same number will always recur in that column, which may be called the second-difference, will appear to any person who takes the trouble to carry on the table a few terms further. Now when once this is admitted as a known fact, it is quite clear that, provided the first term (1) of the Table, the first term (3) of the first differences, and the first term (2) of the second or constant difference, are originally given, we can continue the table of square numbers to any extent, merely by simple addition:—for the series of first differences may be formed by repeatedly adding the constant difference 2 to (3) the first number in column B, and we then necessarily have the series of odd numbers, 3, 5, 7, &c.: and again, by successively adding each of these to the first number (1) of the table, we produce the square numbers.

(191.) Having thus, I hope, thrown some light upon the theoretical part of the question, I shall endeavour to shew that the mechanical execution of such an engine, as would produce this series of numbers, is not so far removed from that of ordinary machinery as might be conceived. Let the reader imagine three clocks, placed on a table side by side, each having only one hand, and each having a thousand divisions instead of twelve hours marked on the face; and every time a string is pulled, let them strike on a bell the numbers of the divisions to which their hands point. Let him further suppose that two of the clocks, for the sake of distinction called B and C, have some mechanism by which the clock C advances the hand of the clock B one division, for each stroke it makes upon its own bell; and let the clock B by a similar contrivance advance the hand of the clock A one division, for each stroke it makes on its own bell. With such an arrangement, having set the hand of the clock A to the division I., that of B to III., and that of C to II., let the reader imagine the repeating parts of the clocks to be set in motion continually in the following order: viz. pull the string of clock A; pull the string of clock B; pull the string of clock C.

Repetitions of Process.	Movements.	Clock A. Hand set to I.	Clock B. Hand set to III.	Clock C. Hand set to II.
		TABLE.	First difference.	Second difference.
1	Pull A.	A. strikes 1	. . . .	. . . .
	— B.	The hand is advanced (by B.) 3 divisions . .	B. strikes 3	. . . .
	— C.	. . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
2	Pull A.	A. strikes 4	. . . .	. . . .
	— B.	The hand is advanced (by B.) 5 divisions . .	B. strikes 5	. . . .
	— C.	. . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
3	Pull A.	A. strikes 9	. . . .	. . . .
	— B.	The hand is advanced (by B.) 7 divisions . .	B. strikes 7	. . . .
	— C.	. . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
4	Pull A.	A. strikes 16	. . . .	. . . .
	— B.	The hand is advanced (by B.) 9 divisions . .	B. strikes 9	. . . .
	— C.	. . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
5	Pull A.	A. strikes 25	. . . .	. . . .
	— B.	The hand is advanced (by B.) 11 divisions .	B. strikes 11	. . . .
	— C.	. . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
6	Pull A.	A. strikes 36	. . . .	. . . .
	— B.	The hand is advanced (by B.) 13 divisions .	B. strikes 13	. . . .
	— C.	. . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2

If now only those divisions struck or pointed at by the clock C be attended to and written down, it will be found that they produce the series of the squares of the natural numbers. Such a series could, of course, be carried by this mechanism only so far as the three first figures; but this may be sufficient to give some idea of the construction, and was, in fact, the point to which the first model of the calculating-engine, now in progress, extended.

(192.) We have seen, then, that the effect of the *division of labour*, both in mechanical and in mental processes, is, that it enables us to purchase and apply to each process precisely that quantity of skill and knowledge which is required for it: we avoid employing any part of the time of a man who can get eight or ten shillings a day by his skill in tempering needles, in turning a wheel, which can be done for sixpence a day; and we equally avoid the loss arising from the employment of an accomplished mathematician in performing the lowest processes of arithmetic.

(193.) The *division of labour* cannot be successfully practised unless there exists a great demand for its produce; and it requires larger capital to be employed in those arts in which it is used. In watchmaking it has been carried, perhaps, to the greatest extent. In an examination before a committee of the House of Commons, it was stated that there are a hundred and two distinct branches of this art, to each of which a boy may be put apprentice; and that he only learns his master's department, and is unable, after his apprenticeship has expired, without subsequent instruction, to work at any other branch. The watch-finisher, whose business is to put together the scattered parts, is the only one out of the hundred and two persons, who can work in any other department than his own.

CHAP. XX.

ON THE SEPARATE COST OF EACH PROCESS IN A MANUFACTURE.

(194.) THE great competition introduced by machinery, and the application of the principle of the subdivision of labour, render it continually necessary for each producer to be on the watch, to discover improved methods by which the cost of the article he manufactures may be reduced; and, with this view, it is of great importance to know the precise expense of every process, as well as of the wear and tear of machinery which is due to it. The same information is desirable for others, through whose hands the manufactured goods are distributed; because it enables them to give reasonable answers or explanations to the objections of inquirers, and also affords them a better chance of suggesting to the manufacturer changes in the fashion of his goods, which may be more suitable either to the tastes or to the finances of his customers. To the statesman such knowledge is still more important; as without it he must trust entirely to others, and can form no judgment worthy of confidence, of the effect any tax may produce, or of the injury the manufacturer or the country may suffer by its imposition.

(195.) One of the first advantages which suggests itself as likely to arise from a correct analysis of the expense of the several processes of any manufacture, is the indication which it furnishes of the course in which improvement should be directed. If any method should be contrived of diminishing by one fourth the time required for fixing on the heads of the pins, the expense of making them would be reduced about thirteen per cent., whilst a reduction of one half the time employed in spinning the coil of wire out of which the heads are cut, would scarcely make any sensible difference in the cost of the manufacture of the whole article. It is therefore obvious, that the attention would be much more advantageously directed to shortening the former than the latter process.

(196.) The expense of manufacturing, in a country where the machinery is of the rudest kind, and manual labour is very cheap, is curiously exhibited in the price of cotton cloth in the island of Java. The cotton, in the seed, is sold by the picul, which is a weight of about 133lbs. Not above one fourth or one fifth of this weight, however, is cotton; and the natives, by means of rude wooden rollers, separate, at the expense of one day's labour, about 1¼lb. of cotton from the seed. In this stage it is worth between four and five times its original cost; and the prices of the same substance, in its different stages of manufacture, are—for one picul:

	Dollars.
Cotton in the seed	2 to 3
Clean cotton	10 — 11
Cotton thread	24
Cotton thread died blue	35
Good ordinary cotton cloth	50

Thus it appears that the expense of spinning in Java is 117 per cent. on the value of the raw material; that the expense of dying thread blue is 45 per cent. on its value; and that the expense of weaving cotton thread into cloth is 117 per cent. on its value. The expense of spinning cotton into a fine thread is, in England, about 33 per cent.*

(197.) As an example of the cost of the different processes of a manufacture, perhaps an analytical statement of the expense of the volume now in the reader's hands may not be uninteresting; more especially as it will afford an insight into the nature and extent of the taxes upon literature. It is found economical to print it upon paper of an unusually large size, so that although thirty-two pages are really contained in each sheet, this work is still called 8vo.

		£	s.	d.
To Printer for composing (per sheet of 32 pages) 3*l.* 1*s.*	10½ sheets	32	0	6
This relates to the ordinary size of the type used in the volume.				
To Printer for composing small type, as in extracts and contents, extra per sheet, 3*s.* 10*d.*	......	2	0	3
To Printer for composing table-work, extra per sheet, 5*s.* 6*d.*	......	2	17	9
Average charge for corrections per sheet, 3*l.* 2*s.* 10*d.*..............	......	33	0	0
Press-work, 3,000 being printed off, per sheet, 3*l.* 10*s.*	......	36	15	0
Paper for 3,000, at 1*l.* 11*s.* 6*d.* per ream, weighing 28lbs.: the duty on paper at 3*d.* per lb. amounts to 7*s.* per ream, so that the 63 reams which are required for the work will cost:—Paper, 77*l.* 3*s.* 6*d.*—Excise Duty, 22*l.* 1*s.* ..		99	4	6
Total expense of printing and paper..		205	18	0

* These facts are taken from Crawfurd's *Indian Archipelago*.

				£	s.	d.
Brought up				205	18	0
Steel-plate for title-page	0	7	6			
Engraving on steel, letters	1	1	0			
Ditto............Head of Bacon	2	2	0			
Total expense of title-page				3	10	6
Printing title-page, at 6*s.* per 100				9	0	0
Paper for ditto, at 1*s.* 9*d.* per 100				2	12	6
Expenses of advertising				40	0	0
Sundries				5	0	0
Total expense in sheets				266	1	0
Cost of a single copy in sheets*				0	1	9¼
Extra boarding				0	0	6
Cost of each copy, boarded				0	2	3¼

(198.) This analysis requires some explanation. The printer usually charges for composition by the sheet, supposing the type to be all of one kind; and as this charge is regulated by the size of the letter, on which the quantity of it in a sheet depends, little dispute can arise after the price is agreed upon. If there are a few extracts, or other parts of the work, which require to be printed in smaller type; or if there are many notes, or several passages in Greek, or in other languages, requiring a different type, these are considered in the original contract, and a small additional price per sheet allowed. If there is a larger portion of small type, it is better to have a specific additional charge for it per sheet. If any work with irregular lines and many figures, and what the printers call rules, occurs, it is called table-work,

* These charges refer solely to the edition prepared for the public, and do not relate to the large paper copies in the hands of some of the author's friends.

and is charged at an advanced price per sheet. Examples of this are frequent in the present volume. If the page consists entirely of figures, as in mathematical tables, which require very careful correction, the charge for composition is usually doubled. A few years ago I printed a table of logarithms, on a large-sized page, which required great additional labour and care from the readers, in rendering the proofs correct, for which several new types were cast, although new punches were not required, and for which stereotype plates were cast, costing about 2*l.* per sheet. In this case 11*l.* per sheet were charged, although ordinary composition, with the same sized letter, in demy octavo, could have been executed at thirty-eight shillings per sheet: but as the expense was ascertained before commencing the work, it gave rise to no difficulties.

(199.) The charge for *corrections* and *alterations* is one which, from the difficulty of measuring it, gives rise to the greatest inconvenience, and is as disagreeable to the publisher (if he be the agent between the author and the printer), and to the master printer or his foreman, as it is to the author himself. If the author study economy, he should make the whole of his corrections in the manuscript, and should copy it out fairly : it will then be printed correctly, and he will have little to pay for corrections. But it is scarcely possible to judge of the effect of any passage correctly, without having it set up in type ; and there are few subjects, to which an author does not find he can add some details or explanation, when he sees his views in print. If, therefore, he wish to save his own labour in transcribing, and to give the last polish to the language, he may accomplish these objects at an increased expense. If the printer possess a sufficient stock of type, it will contribute still more to the convenience of the author to have his whole work put up in what are technically called *slips*,* and then to make all the corrections, and to have as few revises as he can. The present work was set up in slips, but the corrections were unusually large, and the revises frequent.

(200.) The press-work, or *printing off*, is charged at a price agreed upon for each two hundred and fifty sheets; and any broken number is still considered as two hundred and fifty. When a large edition is required, the price for two hundred and fifty is reduced; thus, in the present volume, two hundred and fifty copies, if printed alone, would have been charged eleven shillings per sheet. The principle of this mode of charging is good, as it obviates all disputes; but it is to be regretted that the custom of charging for any small number the same price as for two hundred and fifty is so pertinaciously adhered to, that the master printers cannot get their men to agree to any other terms when only twenty or thirty copies are required, or even when only three or four are wanted for the sake of some experiment. Perhaps if all numbers above fifty were charged as two hundred and fifty, and all below as for half two hundred and fifty, both parties would derive an advantage.

* *Slips* are long pieces of paper on which sufficient matter is printed to form, when divided, from two to four pages of text.

(201.) The effect of the excise duty is to render the paper thin, in order that it may weigh little; but this is counteracted by the desire of the author to make his book look as thick as possible, in order that he may charge the public as much as he decently can; and so on that ground alone it is of no importance. There is, however, another effect of this duty, which both the public and the author feel; for they pay, not merely the duty which is charged, but also the profit on that duty, which the paper-maker requires for the use of additional capital; and also the profit to the publisher and bookseller on the increased price of the volume.

(202.) The estimated charge for advertisements is, in the present case, about the usual allowance for such a volume; and, as it is considered that advertisements in newspapers are the most effectual, where the smallest pays a duty of *3s. 6d.*, nearly one half of the charge of advertising is a tax.

(203.) It appears, then, that, upon an expenditure of 276*l.* on the present volume, 42*l.* are paid in the shape of a direct tax. Whether the profits arising from such a mode of manufacturing will justify such a rate of taxation, can only be estimated when the returns from the volume are considered, a subject that will be discussed in a subsequent chapter.* It is at present sufficient to observe, that the tax on advertisements is an impolitic tax when contrasted with that upon paper, and on other materials employed. The object of all advertisements is, by making known articles for sale, to procure for them

* Chap. XXIX.

a better price, if the sale is to be by auction; or a larger extent of sale if by retail dealers. Now the more any article is known, the more quickly it is discovered whether it contributes to the comfort or advantage of the public; and the more quickly its consumption is assured if it is found valuable. It would appear, then, that every tax on communicating information respecting articles which are the subjects of taxation in another shape, is one which must considerably reduce the amount that would have been raised had no impediment been placed in the way of making known to the public their qualities and their price.

CHAP. XXI.

ON THE CAUSES AND CONSEQUENCES OF LARGE FACTORIES.

(204.) On examining the analysis which has been given in Chap. XVIII. of the operations in the art of pin-making, it will be observed, that ten individuals are employed in it, and also that the time occupied in executing the several processes is very different. In order, however, to render more simple the reasoning which follows, it will be convenient to suppose that each of the six processes there described requires an equal quantity of time. This being supposed, it is at once apparent, that, to conduct an establishment for pin-making most profitably, the number of persons employed must be a multiple of ten. For if a person with small means has only sufficient capital to enable him to employ half that number of persons, they cannot each of them constantly adhere to the execution of one process; and if a manufacturer employs any number not a multiple of ten, a similar result must ensue with respect to some portion of them. The same reasoning extends to all manufactories which are conducted upon the principle of the *division of labour*, and we arrive at this general conclusion—

When (from the peculiar nature of the produce of each manufactory) the number of processes into which *it is most advantageous to divide it is ascertained, as well as the number of individuals to be employed, then all other manufactories which do not employ a direct multiple of this number, will produce the article at a greater cost.* This principle ought always to be kept in view in great establishments, although it is quite impossible, even with the best system of the *division of labour*, to carry it rigidly into execution. The proportion of the persons employed who possess the greatest skill, is of course to be first attended to. That exact ratio which is most profitable for a factory employing a hundred workmen, may not be quite the most fit for one in which there are five hundred; and probably both admit of variations in their arrangements without materially increasing the cost of their produce. But it is quite certain that no individual, nor in the case of pin-making could any five individuals, ever hope to compete with an extensive establishment. Hence arises one of the causes of the great size of manufacturing establishments, which have increased with the progress of civilization. Other circumstances, however, contribute to the same end, and arise also from the same cause—*the division of labour.*

(205.) The material out of which the manufactured article is produced, must, in the several stages of its progress, be conveyed from one operator to the next in succession: this can be done at least expense when they are all working in the same establishment. If the material is heavy, this reason acts with additional force; but in cases where it is light, the danger arising from frequently removing it may render it desirable to have all the processes carried on in the same building. In the cutting and polishing of glass this is the case; whilst in the art of needle-making several of the processes are carried on in the cottages of the workmen. It is, however, clear that the latter plan, which is attended with some advantages to the family of the workmen, can be adopted only where there exists a sure and quick method of knowing that the work has been well done, and that the whole of the materials given out have been really employed.

(206.) The inducement to contrive machines for any process of manufacture increases with the demand for the article; and the introduction of machinery, on the other hand, tends to increase the quantity produced, and to lead to the establishment of large factories. An illustration of these principles may be found in the history of the manufacture of patent net.

The first machines for weaving this article were very expensive, costing from a thousand to twelve or thirteen hundred pounds. The possessor of one of these, though it greatly increased the quantity he could produce, was nevertheless unable, when working eight hours a day, to compete with the old methods. This arose from the large capital invested in the machinery; but he quickly perceived that with the same expense of fixed capital, and a small addition to his circulating capital, he could work the machine during the whole twenty-four hours. The profits thus realized soon induced other persons to direct their attention to the improvement of those machines; and the price was considerably reduced, at the same time that the rapidity of production of the patent net was increased. If machines be kept working through the twenty-four hours, it will be necessary that some person shall attend to admit the workmen at the time they relieve each other; and whether the porter or other servant so employed admit one person or twenty, his rest will be equally disturbed. It will also be necessary occasionally to adjust or repair the machine; and this will be done much better by a workman accustomed to machine making, than by the person who uses it. Now, since the good performance and the duration of machines depend to a very great extent upon correcting, as soon as it appears, every shake or imperfection in their parts, it will soon become apparent that a workman resident on the spot will reduce the expenditure arising from the wear and tear of the machinery. But in the case of a single lace-frame, or a single loom, this would be too expensive a plan. Here then arises another circumstance which tends to enlarge the extent of a factory. It ought to consist of such a number of machines as shall occupy the whole time of one workman in keeping them in order, and in making any casual repairs: if it is extended beyond this, the same principle of economy would point out the necessity of doubling or tripling the number of machines, in order to employ the whole time of two or three skilful workmen.

(207.) Where one part of each workman's labour consists in the exertion of mere physical force, as in weaving and many similar arts, it will soon occur to the manufacturer, that if the loom or lace-frame were driven by a steam-engine, the same man might attend to two or more looms at once; and since we already suppose that he has employed one or more operative engineers, he may so arrange the number of his looms that the charge of keeping them and the steam-engine in order, shall just fully occupy their time. One of the first effects will be, that the steam-engine can drive the looms twice as fast as human force: and as each man, when relieved from bodily labour, can attend to two looms, it will be found that one workman can now make as much cloth as four could do before. This increase was, however, greater than that which really took place at first; for the limit of the velocity of the parts of the loom depended upon the strength of the thread, and the quickness with which it commenced its motion: but an improvement was soon made, by which the motion commenced slowly, and gradually acquired greater velocity than it was safe to give it at once. This improvement increased the speed from 100 to about 120 strokes per minute.

(208.) Pursuing the same principles, the manufactory becomes gradually so enlarged, that the expense of lighting during the night amounts to a considerable sum; and as there are already attached to the establishment persons who are up all night, and can therefore constantly attend to it, and also engineers to make and keep in repair any machinery, the addition of an apparatus for making gas to light the factory introduces a new extension, at the same time that it contributes, by diminishing the expense of lighting, and the risk of accidents from fire, to reduce the cost of manufacturing.

(209.) Long before a factory has reached this extent, it will have been found necessary to establish an accountant's department, with clerks to pay the workmen, and to see that they arrive at their stated times; and this department must be in communication with the agents who purchase the raw produce, and with those who sell the manufactured article.

(210.) It would be of great importance, if, in every large establishment, the modes of paying the different persons employed could be so arranged, that each should derive advantage from the success of the whole, and that the profits of the individuals should advance as the factory itself produced profit, without the necessity of making any change in the wages agreed upon. This it is by no means easy to effect, particularly amongst that class whose daily labour procures for them their daily meal. The system which has long been pursued in working the Cornish mines, although not exactly fulfilling these conditions, yet possesses advantages which make it worthy of attention, as having considerably approached towards them, and as tending to render fully effective the faculties of all engaged in it.

(211.) In the mines of Cornwall almost the whole of the operations both above and below ground are contracted for. The manner of making the contract is nearly as follows. At the end of every two months, the *work* which it is proposed to carry on during the next period is marked out. It is of three kinds. 1. *Tutwork*, which consists in sinking shafts, driving levels, and making excavations : this is paid for by the fathom in depth, or in length, or by the cubic fathom. 2. *Tribute*, which is payment for raising and dressing the ore, by means of a certain part of its value when merchantable. It is this species of payment which produces such admirable effects. The miners, who are to be paid in proportion to the richness of the vein, and the quantity of metal actually extracted from it, naturally become quick-sighted in the discovery of ore, and in estimating its value ; and it is their interest to avail themselves of every improvement that can bring it more cheaply to market. 3. *Dressing.* The tributors, who dig and dress the ore, can seldom afford to dress the coarser parts of that which they raise at their contract price; they therefore leave it, and this portion is again let out to persons who agree to dress it at an advanced price. The lots of ore to be dressed, and the works to be carried on, having been marked out for some days, and having been examined by the men, a kind of auction is held by the captains of the mine, in which each lot is put up, and bid for by different gangs of men. The work is then offered, at a price usually below that bid at the auction, to the lowest bidder, who rarely declines it at the rate proposed. The tribute is a certain sum out of every twenty shillings' worth of ore raised, and may vary from threepence in the pound to fourteen or fifteen shillings. The rate of earnings in tribute is very uncertain : if a vein, which was poor when taken, becomes rich, the men earn money rapidly; and instances have occurred in which each miner of a gang has earned a hundred pounds in the two months. These extraordinary cases are, perhaps, of more advantage to the owners of the mine than even to the men ; for whilst the skill and industry of the workmen are greatly stimulated, the owner himself always derives greater advantage from the improvement of the vein.* This

* For a detailed account of the method of working the Cornish mines, see a paper of Mr. John Taylor's, *Transactions of the Geological Society*, vol. ii. p. 309.

system has been introduced, by Mr. Taylor, into the lead mines of Flintshire, into those at Skipton, in Yorkshire, and into some of the copper mines of Cumberland ; and it is desirable that it should become general, because no other mode of payment affords to the workmen a measure of success so directly proportioned to the industry, the integrity, and the talent, which they exert.

(212.) We have seen that the application of the *division of labour* tends to produce cheaper articles: it thus increases the demand, and gradually, by the effect of competition, or the hope of increased gain, causes large capitals to be embarked in extensive factories. Let us now examine the influence of such accumulation of capital directed to one object. In the first place, it enables the most important principle on which the *division of labour* rests, to be carried almost to its extreme limits : not merely the precise amount of skill is purchased which is necessary for the execution of each process, but throughout every stage from that in which the raw material is procured, to that by which the finished produce is conveyed into the hands of the consumer, the same economy of skill prevails. The quantity of work produced by a given number of people is greatly augmented by such an extended arrangement; and the result is necessarily a great reduction in the cost of the article which is brought to market.

(213.) Amongst the causes which tend to the cheap production of any article, and which require additional capital, may be mentioned, the care which is taken to allow no part of the raw produce, out of which it is formed, to be absolutely wasted. An attention to this circumstance sometimes causes the union of two trades in one factory, which otherwise would naturally have been separated. An enumeration of the arts to which the horns of cattle are applicable, furnishes a striking example of this kind of economy. The tanner who has purchased the hides, separates the horns, and sells them to the makers of combs and lanterns. The horn consists of two parts, an outward horny case, and an inward conical-shaped substance, somewhat intermediate between indurated hair and bone. The first process consists in separating these two parts, by means of a blow against a block of wood. The horny exterior is then cut into three portions by means of a frame-saw.

1. The lowest of these, next the root of the horn, after undergoing several processes, by which it is rendered flat, is made into combs.

2. The middle of the horn, after being flattened by heat, and its transparency improved by oil, is split into thin layers, and forms a substitute for glass in lanterns of the commonest kind.

3. The tip of the horn is used by the makers of knife-handles, and of the tops of whips, and for other similar purposes.

4. The interior, or core of the horn, is boiled down in water. A large quantity of fat rises to the surface; this is put aside, and sold to the makers of yellow soap.

5. The liquid itself is used as a kind of glue, and is purchased by the cloth-dressers for stiffening.

6. The bony substance, which remains behind, is

then sent to the mill, and, being ground down, is sold to the farmers for manure.

Besides these various purposes to which the different parts of the horn are applied, the clippings, which arise in comb-making, are sold to the farmer for manure at about one shilling a bushel. In the first year after they are spread over the soil they have comparatively little effect, but during the next four or five their efficiency is considerable. The shavings which form the refuse of the lantern-maker, are of a much thinner texture : a few of them are cut into various figures and painted, and used as toys ; for being hygrometric, they curl up when placed in the palm of a warm hand. But the greater part of these shavings are sold also for manure, which, from their extremely thin and divided form, produces its full effect upon the first crop.

(214.) Another event which has arisen, in one trade at least, from the employment of large capital, is, that a class of middle-men, who were formerly interposed between the maker and the merchant, now no longer exist. Formerly, when calico was woven in the cottages of the workmen, there existed a class of persons who travelled about and purchased the pieces so made, in large numbers, for the purpose of selling them to the exporting-merchant. But the middle-man was obliged to examine each piece, in order to know that it was perfect, and of full measure. Now, although the greater part of the workmen might be depended upon, yet the fraud of the few would render this examination indispensable: for the value of character, though great in all circumstances of life, can never be so fully experienced by persons possessed of small capital, as by those employing much larger sums. Any single cottager, if he were detected by one purchaser, might hope that the fact would not become known to all the rest; whilst the larger the sums of money for which any merchant deals, the more is his character for punctuality studied and known by others. Thus it happens that high character supplies the place of an additional portion of capital; and the merchant, in dealing with the great manufacturer, is saved from the expense of verification, by knowing that the loss, or even the impeachment, of the manufacturer's character, would be attended with greater pecuniary detriment to himself than any profit upon a single transaction could compensate.

(215.) To such an extent is this confidence in character carried; that, at one of our largest towns, sales and purchases on a very extensive scale are made daily in the course of business without any of the parties ever exchanging a written document. The amount of well-grounded confidence, which such a practice indicates, is one of the many advantages an old manufacturing country always possesses over its rivals.

(216.) A breach of confidence of this kind, which might have been attended with very serious embarrassment, occurred in the recent expedition to the mouth of the Niger.

"We brought with us from England," Mr. Lander states, "nearly a hundred thousand needles of various "sizes, and amongst them was a great quantity of "'*Whitechapel Sharps*' warranted '*superfine, and not* "*to cut in the eye*.' Thus highly recommended, we

"imagined that these needles must have been excel-
"lent indeed; but what was our surprise, some time
"ago, when a number of them which we had disposed
"of were returned to us, with a complaint that they
"were all eyeless, thus redeeming with a vengeance
"the pledge of the manufacturer, 'that they would
"not cut in the eye.' On an examination afterwards,
"we found the same fault with the remainder of the
"'Whitechapel sharps,' so that to save our credit we
"have been obliged to throw them away."*

(217.) The influence of established character in producing confidence operated in a very remarkable manner at the time of the exclusion of British manufactures from the Continent during the last war. One of our largest establishments had been in the habit of doing extensive business with a house in the centre of Germany; but, on the closing of the continental ports against our manufactures, heavy penalties were inflicted on all those who contravened the Berlin and Milan decrees. The English manufacturer continued, nevertheless, to receive orders, with directions how to consign them, and appointments for the time and mode of payment, in letters, the handwriting of which was known to him, but which were never signed, except by the Christian name of one of the firm, and even in some instances they were without any signature at all. These orders were executed; and in no instance was there the least irregularity in the payments.

(218.) Another circumstance may be noticed, which to a small extent is more advantageous to

* Lander's *Journal of an Expedition to the Mouth of the Niger*, vol. ii. p. 42.

large than to small factories. In the export of several articles of manufacture, a drawback is allowed by government, of a portion of the duty paid on the importation of the raw material. In such circumstances, certain forms must be gone through in order to protect the revenue from fraud; and a clerk, or one of the partners, must attend at the custom-house. If the quantity exported is inconsiderable, the small manufacturer frequently does not find the drawback will repay him for his loss of time; whilst the agent of the large establishment occupies nearly the same time in receiving a drawback of several thousands, as the smaller exporter does of a few shillings.

(219.) In many of the large establishments of our manufacturing districts, substances are employed which are the produce of remote countries, and which are, in several instances, almost peculiar to a few situations. The discovery of any new locality, where such articles exist in abundance, is a matter of great importance to any establishment consuming them largely; and it has been found, in some instances, that the expense of sending persons to great distances, purposely to discover and to collect such produce, has been amply repaid. Thus it has happened, that the snowy mountains of Sweden and Norway, as well as the warmer hills of Corsica, have been almost stripped of one of their vegetable productions, by agents sent expressly from one of our largest establishments for the dying of calicos. It is owing to the same command of capital, and to the scale on which the operations of a large factory are carried, that their returns will admit of the expense of sending out agents to examine into the wants and tastes of distant countries, as well as of trying experiments, which, although profitable to them, would be ruinous to smaller establishments possessing more limited resources.

These opinions have been so fully expressed in the Report of the Committee of the House of Commons on the Woollen Trade, in 1806, that we shall close this chapter with an extract, in which the advantages of great factories are summed up.

" Your committee have the satisfaction of seeing, that the " apprehensions entertained of factories are not only vicious " in principle, but they are practically erroneous ; to such a " degree, that even the very opposite principles might be " reasonably entertained. Nor would it be difficult to prove, " that the factories, to a certain extent at least, and in the " present day, seem absolutely necessary to the well-being " of the domestic system ; supplying those very particulars " wherein the domestic system must be acknowledged to be " inherently defective : for it is obvious, that the little " master manufacturers cannot afford, like the man who " possesses considerable capital, to try the experiments " which are requisite, and incur the risks, and even losses, " which almost always occur, in inventing and perfecting " new articles of manufacture, or in carrying to a state of " greater perfection articles already established. He can" not learn, by personal inspection, the wants and habits, " the arts, manufactures, and improvements of foreign " countries ; diligence, economy, and prudence, are the " requisites of his character, not invention, taste, and enter" prise ; nor would he be warranted in hazarding the loss " of any part of his small capital. He walks in a sure " road as long as he treads in the beaten track ; but he " must not deviate into the paths of speculation. The " owner of a factory, on the contrary, being commonly "possessed of a large capital, and having all his workmen "employed under his own immediate superintendence, "may make experiments, hazard speculation, invent shorter "or better modes of performing old processes, may intro- "duce new articles, and improve and perfect old ones, "thus giving the range to his taste and fancy, and, thereby "alone, enabling our manufacturers to stand the compe- "tition with their commercial rivals in other countries. "Meanwhile, as is well worthy of remark (and experience "abundantly warrants the assertion), many of these new "fabrics and inventions, when their success is once esta- "blished, become general among the whole body of ma- "nufacturers; the domestic manufacturers themselves thus "benefiting, in the end, from those very factories which "had been at first the objects of their jealousy. The his- "tory of almost all our other manufactures, in which great "improvements have been made of late years, in some "cases at an immense expense, and after numbers of "unsuccessful experiments, strikingly illustrates and en- "forces the above remarks. It is besides an acknowledged "fact, that the owners of factories are often amongst the "most extensive purchasers at the halls, where they buy "from the domestic clothier the established articles of ma- "nufacture, or are able at once to answer a great and sudden "order; while, at home, and under their own superinten- "dence, they make their fancy goods, and any articles of a "newer, more costly, or more delicate quality, to which they "are enabled by the domestic system to apply a much larger "proportion of their capital. Thus, the two systems, in- "stead of rivalling, are mutual aids to each other; each "supplying the other's defects, and promoting the other's "prosperity."

CHAP. XXII.

ON THE POSITION OF LARGE FACTORIES.

(220.) It is found in every country, that the situation of large manufacturing establishments is confined to particular districts. In the earlier history of a manufacturing community, before cheap modes of transport have been extensively introduced, it will almost always be found that the article will be manufactured near those spots in which nature has produced the raw material. In the heavier articles, and in those the value of which depends more upon the material than upon the labour expended on it, this will most frequently be the case. Most of the metallic ores being exceedingly heavy, and being mixed up with large quantities of weighty and useless materials, must be smelted at no great distance from the spot which affords them: fuel and power are the requisites for reducing them; and any considerable fall of water in the vicinity will naturally be resorted to for aid in all the coarser exertions of physical force; for pounding the ore, blowing the furnaces, or for hammering and rolling out the iron. There are indeed peculiar circumstances which will modify this. Iron, coal, and limestone, frequently occur in the same district; but the union of the fuel in the same locality with the ore does not happen with respect to other metals. In Cornwall there exist mines of copper and of tin, but none of coal. The copper ore, which requires the largest quantity of fuel for its reduction, is conveyed by ships to the coal fields of Wales, and is smelted at Swansea; whilst the vessels which convey it, take back cargoes of coals to supply the steam-engines for draining the mines, and to smelt the tin, which requires for that purpose a much less quantity of fuel than copper.

(221.) Rivers passing through districts rich in coal and metals, will form the first high roads for the conveyance of weighty produce to stations in which other conveniences present themselves for the further application of human skill. Canals will succeed, or lend their aid to these; and the yet unexhausted applications of steam and of gas, hold out a hope of attaining almost the same advantages for countries to which nature seemed for ever to have denied them. Manufactures, commerce, and civilization, ever follow the line of new and cheap communications. Twenty years ago, the Mississippi poured the vast volume of its waters in lavish profusion through thousands of miles of countries, which scarcely supported a few wandering and uncivilized tribes of Indians. The power of the stream seemed to set at defiance the efforts of man to ascend its course; and, as if to render the task still more hopeless, large trees, torn from the surrounding forests, were planted in its bottom, forming in some places barriers, in others the nucleus of banks, and accumulating in the same spot, which but for accident would have been free from either, the difficulties and dangers of sandbanks and of rocks. Four months of incessant toil could scarcely convey a small bark with its worn-out crew two thousand miles up this stream. The same voyage is now performed by large vessels impelled by steam, carrying hundreds of passengers enjoying all the comforts and luxuries of civilized life, in the short period of fifteen days. Instead of the hut of the Indian,—and the far more unfrequent log-house of the thinly scattered settlers,—villages, towns, and cities have arisen on its banks ; and the same engine which stemmed the force of these powerful waters, will probably tear from their bottom the obstructions which have hitherto impeded and rendered dangerous their navigation.*

(222.) The accumulation of many large manufacturing establishments in the same district has a tendency to bring together purchasers or their agents from great distances, and thus to cause the institution of a public mart or exchange. This contributes to increase the information relative to the supply of raw material, and the state of demand for their produce, with which it is necessary manufacturers should

* The amount of obstructions arising from the casual fixing of trees in the bottom of the river, may be estimated from the proportion of steam-boats destroyed by running upon them. The subjoined statement is taken from the American Almanack for 1832:—

" Between the years 1811 and 1831, three hundred and " forty-eight steam-boats were built on the Mississippi and its " tributary streams. During that period a hundred and fifty " were lost or worn out.

" Of the hundred and fifty lost or worn out . . .	worn out	63
	lost by snags	36
	burnt	14
	lost by collision	3
	by accidents not ascertained.	34"

Thirty-six, or nearly one fourth, being destroyed by accidental obstructions.

be well acquainted. The very circumstance of collecting periodically, at one place, as large a number as possible both of those who supply the market and those who require its produce, tends strongly to check those accidental fluctuations to which a small market is ever subject, as well as to render the average of the prices paid much more uniform in its course.

(223.) When capital has been invested in machinery, and in buildings for its accommodation, and when the inhabitants of the neighbourhood have acquired a knowledge of the modes of working at it, reasons of considerable weight are required to cause its removal. Such changes of position do however occur; and they have been alluded to by the Committee on the Fluctuation of Manufacturers' Employment, as one of the sources interfering most materially with an uniform rate of wages: it is therefore of particular importance to the workmen to be acquainted with the real causes which have driven manufactures from their ancient seats.

"The migration or change of place of any manufacture "has sometimes arisen from improvements of machinery "not applicable to the spot where such manufacture was "carried on, as appears to have been the case with the "woollen manufacture, which has in great measure migrated from Essex, Suffolk, and other southern counties, "to the northern districts, where coal for the use of the "steam-engine is much cheaper. But this change has, in "some instances, been caused or accelerated by the conduct "of the workmen, in refusing a reasonable reduction of "wages, or opposing the introduction of some kind of improved machinery or process; so that, during the dispute, "another spot has in great measure supplied their place in "the market. *Any violence used by the workmen against "the property of their masters, and any unreasonable com- "bination on their part, is almost sure thus to be injurious "to themselves.*"*

(224.) These removals become of serious consequence when the factories have been long established, because a population commensurate with their wants invariably grows up around them. The combinations, in Nottinghamshire, of persons under the name of Luddites, drove a great number of lace-frames from that district, and caused establishments to be formed in Devonshire. We ought also to observe, that the result of driving any establishment into a new district, where similar ones have not previously existed, is not merely to place it out of the reach of such combinations; but, after a few years, the example of its success will most probably induce other capitalists in the new district to engage in the same manufacture: and thus, although only one establishment should be driven away, the workmen, through whose combination its removal was effected, will not merely suffer by the withdrawing of that portion of demand for their labour which the factory caused; but the value of that labour itself will be reduced by the competition of a new field of production.

(225.) Another circumstance which has its influence on this question, is the nature of the machinery. Heavy machinery, such as stamping-mills, steam-engines, &c., cannot readily be moved, and must

* This passage is *not* printed in Italics in the original; but it has been thus marked in the above extract, from its importance, and from the conviction that the most extended discussion will afford additional evidence of its truth.

always be taken to pieces for that purpose; but where the machinery of a factory consists of a multitude of separate machines, each complete in itself, and all put in motion by one source of power, such as a water-wheel or a steam-engine, then the removal is much less inconvenient. Thus, stocking-frames, lace-machines, and looms, might, with but a small separation of their parts, be transported to more favourable positions.

(226.) It is of great importance that the more intelligent amongst the class of workmen should examine into the correctness of these views; because, without having their attention directed to them, the whole class may, in some instances, be led by designing persons to pursue a course, which, although apparently plausible, is in reality directly at variance with their own best interests. I confess I am not without a hope that this volume may fall into the hands of workmen, perhaps better qualified than myself to reason upon a subject which requires only plain common sense, and whose powers are sharpened by its importance to their personal happiness. In asking their attention to the preceding remarks, and to those which I shall offer respecting combinations, I can claim only one advantage over them; namely, that I never have had, and in all human probability never shall have, the slightest pecuniary interest, to influence even remotely, or by anticipation, the judgments I have formed on the facts which have come before me.

CHAP. XXIII.

ON OVER-MANUFACTURING.

(227.) ONE of the natural and almost inevitable consequences of competition is the production of a supply far larger than the demand requires. This usually arises periodically; and it is equally important, both to the masters and to the workmen, to prevent its occurrence, or to foresee its arrival. In situations where a great number of very small capitalists exist,—where each master himself works and is assisted by his own family, or by a few journeymen,—and where a variety of different articles are produced, a curious system of compensation has arisen which in some measure diminishes the extent to which fluctuations of wages would otherwise reach. This is accomplished by a species of middle-men or factors, persons possessing greater or less capital, who, whenever the price of any of the articles in which they deal is greatly reduced, purchase it at a low price on their own account, in the hopes of selling it at a profit when the market for it is better. These persons, in ordinary times, act as salesmen or agents, and make up assortments of goods at the market price, for the use of the home or foreign dealer. They possess large warehouses in which to make up their orders, or keep in store articles purchased during periods of depression; thus acting as a kind of fly-wheel in equalizing the market price.

(228.) In the greater establishments, the effect of over-manufacturing is different. When an over supply has reduced prices, one of two events usually occurs: the first is a diminished payment for wages; the other is a diminution of the number of hours during which the labourers work, together with a diminished rate of wages. In the former case production continues to go on at its ordinary rate: in the latter, the production itself being checked, the supply again adjusts itself to the demand as soon as the stock on hand is worked off, and prices then regain their former level. The latter course appears, in the first instance, to be the best both for masters and men; but there seems to be a difficulty in accomplishing this, except where the trade is in few hands. In fact, it seems to be necessary, for its success, that there should be a combination amongst the masters or amongst the men; or, what is always far preferable to either, a mutual agreement for their joint interests. But a combination among the men is difficult, and is always attended with the evils arising from the ill-will which exists against any who, in the perfectly justifiable exercise of their judgment, are disposed not to act with the majority. The combination of the masters is on the other hand unavailing, unless the whole body of them agree: for if any one master can procure more labour for his money than the rest, he must be able to undersell them.

(229.) If we look only at the interests of the consumer, the case is different. When too large a supply has produced a great reduction of price, it has opened the consumption of the article to a new class, and has increased the consumption of those who previously employed it: it is therefore against the interest of both these parties that a return to the former price should occur. It is also certain, that by the diminution of profit which the manufacturer suffers from the diminished price, his ingenuity will be additionally stimulated; and that he will apply himself to discover other and cheaper sources for the supply of his raw material,—to contrive improved machinery which shall manufacture it at a cheaper rate,—or to introduce new arrangements into his factory, which shall render the superintendence of it more perfect. In the event of his success by any of these courses, or by their joint effects, a real and substantial good will be effected. A larger portion of the public will receive advantage from the use of the article, and they will procure it at a lower price; and the manufacturer, although his profit per cent. on each operation is reduced, will yet, by the more frequent returns on the larger produce of his factory, find his real gain per cent., at the end of the year, nearly the same as it was before; whilst the wages of the workman will return to their level, and both the manufacturer and the workman will find the fluctuations of demand less considerable from being dependent on a larger number of customers.

(230.) It would be highly interesting, if we could trace, even approximately, through the history of any great manufacture, the effects of gluts in producing improvements in machinery, or in methods of working; and if we could shew what addition to the annual quantity of goods previously manufactured, was produced by each alteration. It would probably be found, that *the increased quantity manufactured by the same capital, when worked with the new improvement, would produce nearly the same rate of profit as other modes of investment.*

(231.) Supposing new and cheaper modes of producing not to be discovered, and that the production continues to exceed the demand, then it is apparent, that too much capital is employed in the trade; and after a time, the diminished rate of profit will drive some of the manufacturers to other occupations. What particular individuals will leave it must depend on a variety of circumstances. Superior industry and attention will enable some factories to make a profit rather beyond the rest; superior capital in others will enable them, without these advantages, to support competition longer, even at a loss, with the hope of driving the smaller capitalists out of the market, and then reimbursing themselves by an advanced price. It is, however, better for all parties, that this contest should not last long; and it is important, that no artificial restraint should interfere to prevent it. An instance of such restriction and of its injurious effect occurs at the port of Newcastle, where a particular act of parliament requires that every ship shall be loaded in its turn. The Committee of the House of Commons, in their Report on the Coal Trade, state that, "Under the regulations "contained in this act, if more ships enter into "the trade than can be profitably employed in "it the loss produced by detention in port, and "waiting for a cargo, which must consequently take "place, instead of falling, as it naturally would

" upon particular ships, and forcing them from the " trade, is now divided evenly amongst them; and " the loss thus created is shared by the whole num- " ber."—*Report*, p. 6.

(232.) It is not pretended, in this short view, to trace out all the effects or remedies of over-manufacturing; it is a difficult subject, and, unlike some of the questions already treated, requires a very extensive combination of the relative influence of many causes.

CHAP. XXIV

INQUIRIES PREVIOUS TO COMMENCING ANY MANUFACTORY.

(233.) THERE are many inquiries which ought always to be made previous to the commencement of the manufacture of any new article. These chiefly relate to the expense of tools, machinery, raw materials, and all the outgoings necessary for its production,—to the extent of the demand which is likely to arise,—to the time in which the circulating capital will be replaced,—and to the quickness or slowness with which the new article will supersede those already in use.

(234.) The expense of tools and of new machines will be more difficult to ascertain, in proportion as they differ from those already employed; but the variety in constant use, in our various manufactories, is such, that few inventions now occur in which some considerable portion may not be found resembling others already constructed. The cost of the raw material is usually less difficult to determine; but there occasionally arise cases in which it becomes important to examine whether the supply, at the given price, can be depended upon: for, in the case of a small consumption, the additional demand arising from a factory may produce a considerable temporary rise in price; although the same circumstance may ultimately reduce its price.

(235.) The quantity of any new article likely to be consumed is a most important subject for the consideration of the projector of a new manufacture. As these pages are not intended for the instruction of the manufacturer, but rather for the purpose of giving a general view of the subject, an illustration of the way in which such questions are regarded by practical men, will, perhaps, be most instructive. The following extract from the evidence given before a Committee of the House of Commons, in the Report on Artizans and Machinery, shews the extent to which articles, apparently the most insignificant, are consumed, and the view which the manufacturer takes of them.

The person examined on this occasion was Mr. Ostler, a manufacturer of glass beads and other toys of the same substance, from Birmingham. Several of the articles made by him were placed upon the table, for the inspection of the Committee of the House of Commons, which held its meetings in one of the committee-rooms.

" *Question*. Is there any thing else you have to state " upon this subject?

" *Answer*. Gentlemen may consider the articles on the " table as extremely insignificant; but perhaps I may sur- " prise them a little, by mentioning the following fact. " Eighteen years ago, on my first journey to London, a " respectable-looking man, in the city, asked me if I could " supply him with dolls' eyes; and I was foolish enough " to feel half offended; I thought it derogatory to my new " dignity as a manufacturer, to make dolls' eyes. He took " me into a room quite as wide, and perhaps twice the " length of this, and we had just room to walk between " stacks, from the floor to the ceiling, of parts of dolls. He

"said, 'These are only the legs and arms; the trunks
"are below.' But I saw enough to convince me, that
"he wanted a great many eyes; and, as the article ap-
"peared quite in my own line of business, I said I would
"take an order by way of experiment; and he showed me
"several specimens. I copied the order. He ordered
"various quantities, and of various sizes and qualities.
"On returning to the Tavistock hotel, I found that the
"order amounted to upwards of 500*l*. I went into the
"country, and endeavoured to make them. I had some
"of the most ingenious glass toy-makers in the kingdom
"in my service; but when I showed it to them, they
"shook their heads, and said they had often seen the
"article before, but could not make it. I engaged them
"by presents to use their best exertions; but after trying
"and wasting a great deal of time for three or four weeks,
"I was obliged to relinquish the attempt. Soon afterwards
"I engaged in another branch of business (chandelier
"furniture), and took no more notice of it. About
"eighteen months ago I resumed the trinket trade, and
"then determined to think of the dolls' eyes; and about
"eight months since, I accidentally met with a poor fellow
"who had impoverished himself by drinking, and who
"was dying in a consumption, in a state of great want.
"I showed him ten sovereigns; and he said he would in-
"struct me in the process. He was in such a state that
"he could not bear the effluvia of his own lamp; but
"though I was very conversant with the manual part of
"the business, and it related to things I was daily in the
"habit of seeing, I felt I could do nothing from his de-
"scription. (I mention this to show how difficult it is to
"convey, by description, the mode of working.) He took
"me into his garret, where the poor fellow had economized
"to such a degree, that he actually used the entrails and fat
"of poultry from Leadenhall market to save oil (the price
"of the article having been latterly so much reduced by
"competition at home.) In an instant, before I had seen

" him make three, I felt competent to make a gross; and " the difference between his mode and that of my own work- " men was so trifling, that I felt the utmost astonishment.

" *Quest.* You can now make dolls' eyes?

" *Ans.* I can. As it was eighteen years ago that I " received the order I have mentioned, and feeling doubtful " of my own recollection, though very strong, and suspect- " ing that it could [not] have been to the amount stated, I last " night took the present very reduced price of that article " (less than half now of what it was then), and calculating " that every child in this country not using a doll till two " years old, and throwing it aside at seven, and having a " new one annually, I satisfied myself that the eyes alone " would produce a circulation of a great many thousand " pounds. I mention this merely to shew the importance " of trifles; and to assign one reason, amongst many, for " my conviction, that nothing but personal communication " can enable our manufactures to be transplanted."

(236.) In many instances it appears to be exceedingly difficult to estimate the sale of an article, or the effects of a machine; a case, however, occurred in a recent inquiry, which, although not quite appropriate as an illustration of probable demand, is highly instructive as a guide in such inquiries. A committee of the House of Commons was appointed to inquire into the tolls proper to be placed on steam-carriages; a question, apparently, of difficult solution, and one on which widely different opinions had been formed, if we may judge by the very different rate of tolls imposed upon such carriages by different " turnpike trusts." The principles on which the committee conducted the inquiry were these. They first endeavoured to ascertain, from competent persons, the effect of the atmosphere alone on deteriorating a well-constructed road. The next step was, to determine the proportion in which the road was injured, by the effect of the horses' feet compared with that of the wheels. Mr. Macniell, the superintendent under Mr. Telford of the Holyhead roads, was examined, and proposed to estimate the relative injury, from the comparative quantities of iron worn off, from the shoes of the horses, and from the tire of the wheels. From the data he possessed respecting the consumption of iron for the tire of the wheels, and for the shoes of the horses, of one of the Birmingham day-coaches, he estimated the wear and tear of roads, arising from the feet of the horses, to be three times as great as that arising from the wheels. Supposing repairs amounting to a hundred pounds to be required on a road travelled over by a fast coach at the rate of ten miles an hour, and the same amount of injury to occur on another road, used only by waggons, moving at the rate of three miles an hour, Mr. Macneill divides the injury in the following proportions :—

Injury arising from	Fast Coach.	Heavy Waggon.
Atmospheric changes	20	20
Wheels	20	35.5
Horses' Feet drawing	60	44.5
Total Injury	100	100

One of the results of these experiments is, that every coach which travels from London to Birmingham distributes about eleven pounds of wrought iron along the line of road between those two places. The committee agreed that " The only ground on which " a fair claim to toll can be made on any public road, " is to raise a fund, which, with the strictest economy, " shall be just sufficient, first, to repay the expense " of its original formation ; secondly, to maintain it " in good and sufficient repair." Supposing it also to be ascertained that the wheels of steam-carriages do no more injury to roads than other carriages of equal weight travelling with the same velocity, the committee now possessed the means of approximating to a just rate of toll for steam-carriages.

(237.) As connected with this subject, and as affording most valuable information upon points in which, previous to experiment, widely different opinions had been entertained ; the following extract is inserted from Mr. Telford's Report on the State of the Holyhead and Liverpool Roads. The instrument employed for the comparison was invented by Mr. Macneill; and the road between London and Shrewsbury was selected for the place of experiment.

The general results, when a waggon weighing 21 cwt. was used on different sorts of roads, are as follows :

	lbs.
1. On well-made pavement, the draught is . .	33
2. On a broken stone surface, or old flint road .	65
3. On a gravel road	147
4. On a broken stone road, on a rough pavement foundation	46
5. On a broken stone surface, upon a bottoming of concrete, formed of Parker's cement and gravel	46

The following statement relates to the force required to draw a coach weighing 18 cwt., exclusive of seven passengers, up roads of various inclinations:

RATE OF INCLINATION.	Force required at Six Miles per Hour.	Force at Eight Miles per Hour.	Force at Ten Miles per Hour.
	lbs.	*lbs.*	*lbs.*
1 in 20	268	296	318
1 in 26	213	219	225
1 in 30	165	196	200
1 in 40	160	166	172
1 in 600	111	120	128

(238.) The time in which the goods produced by any new factory can be brought to market and the returns realized, should also be well considered, as well as the time the new article will take to supersede those already in use. If the article is consumed in using, the new produce will be much more easily introduced. Steel pens readily took the place of quills; and a new form of pen would, if it possessed any advantage, as easily supersede the present one. A new lock, however secure, and however cheap, would not so readily make its way. If less expensive than the old, it would be employed in new work: but old locks would rarely be removed to make way for it; and even if perfectly secure, its advance would be slow.

(239.) Another element in this question which should not be altogether omitted, is the opposition which the new manufacture may create by its real or apparent injury to other interests, and the probable extent of the influence of that opposition. This is not always foreseen; and when anticipated is often inaccurately estimated. On the first establishment of steam-boats from London to Margate, the proprietors of the coaches running on that line of road petitioned the House of Commons against them, as likely to lead to the ruin of the coach proprietors. It was, however, found that the fear was imaginary; and in a very few years, the number of coaches on that road was considerably increased, apparently through the very means which were thought to be adverse to it. The fear, which is now entertained, that steam power and rail-roads may drive out of employment a large portion of the horses now used, is probably not less unfounded. On some particular lines such an effect may be produced; but in all probability the number of horses employed in conveying goods and passengers to the great lines of rail-road, will exceed that which is at present used.

CHAP. XXV.

ON CONTRIVING MACHINERY.

(240.) THE power of inventing mechanical contrivances, and of combining machinery, does not appear, if we may judge from the frequency of its occurrence, to be a difficult or a rare gift; and, amongst the vast multitude of inventions which have been produced almost daily for a series of years, a large part has failed from the imperfect nature of the first trials; whilst a still larger portion, which had escaped the mechanical difficulties, failed only because the economy of their operations was not sufficiently attended to.

The commissioners appointed to examine into the methods proposed for preventing the forgery of bank notes, state in their report, that, out of one hundred and seventy-eight projects communicated to the Bank and to the commissioners, there were only twelve of superior skill, and nine which it was necessary more particularly to examine.

(241.) It is however a curious circumstance, that although the power of combining machinery is so common, yet the more beautiful combinations are exceedingly rare. Those which command our admiration equally by the perfection of their effects and the simplicity of their means, are found only amongst the happiest productions of genius.

To produce movements even of a complicated kind is not difficult. There exist a great multitude of known contrivances for all the more usual purposes, and if the exertion of moderate power is the end of the mechanism to be contrived, it is possible to construct the whole machine upon paper, and to judge of the proper strength to be given to each part as well as to the frame-work which supports it, and also of its ultimate effect, long before a single part of it has been executed. In fact, all the contrivance, and all the improvements, ought to be made in the drawings.

(242.) On the other hand, there are circumstances dependent upon physical or chemical properties, for which no drawings will be of any use. These are the legitimate objects of direct trials. For example;—if the ultimate result of an engine is to be that it shall impress letters upon a copper-plate by means of steel punches pressed into it, all the mechanism by which the punches and the copper are to be moved at stated intervals, and brought into contact, is within the province of drawing, and the machinery may be arranged entirely upon paper. But a doubt may reasonably spring up, whether the bur that will be raised round the letter, which has been punched upon the copper, may not interfere with the proper action of the punch for the letter which is to be punched next adjacent to it. It may also be feared that the effect of punching the second letter, if it be sufficiently near to the first, might distort the form of that first figure. And if neither of these evils should arise, still the burs produced by the punching might be expected to interfere with the goodness of the impression produced by the copper-plate; and the plate itself, after having all but its edge covered with figures, might, from the unequal condensation which it must suffer in this process, change its form, so as to render it very difficult to take off impressions from it. It is impossible by any drawings to solve these difficulties, experiment alone can determine their nature. Such experiments have been made, and it is found that if the sides of the steel punch are nearly at right angles to the face of the letter, a very inconsiderable bur is produced;—that at the depth which is sufficient for copper-plate printing, no distortion of the adjacent letters takes place, although those letters are placed very close to each other;—that the small bur which arises may easily be scraped off;—and that the copper-plate is not distorted by the condensation of the metal, and is perfectly fit to print from, after it has undergone this process.

(243.) The next stage in the progress of an invention, after the drawings are finished and the preliminary experiments have been made, if any such should be requisite, is the execution of the machine itself. It can never be too strongly impressed upon the minds of those who are devising new machines, that to make the most perfect drawings of every part tends essentially both to the success of the trial, and to economy in arriving at the result. The actual execution from working drawings is comparatively an easy task; provided always that good tools are employed and that methods of working are adopted, in which the perfection of the part constructed depends less on the personal skill of the workmen, than upon the certainty of the methods they employ.

The causes of failure in this stage most frequently arise from errors in the preceding one; and it is sufficient merely to indicate a few of their sources. They usually arise from having neglected to take into consideration that metals are not perfectly rigid but elastic. A steel cylinder of small diameter must not be considered as an inflexible rod; but in order to ensure its perfect action as an axis, it must be supported at proper intervals. Again, the strength and stiffness of the framing which supports the mechanism must be carefully attended to. It should always be recollected, that the addition of superfluous matter to the immovable parts of a machine is not accompanied with the same evil that arises when the moving parts are increased in weight; since no additional momentum is thus generated.

(244.) The stiffness of the framing of a machine draws after it another important advantage. If the bearings of the axis (those places at which they are supported) are once placed in a straight line, they will continue so, if the framing be immovable, whereas if the framework changes its form, although ever so slightly, considerable friction will immediately arise. This effect is so well understood in the districts in which our spinning factories are numerous, that, in estimating the expense of working a new factory, it is allowed that five per cent. on the power of the steam-engine will be saved if the building is fire-proof. This saving arises entirely from the greater strength and rigidity of a fire-proof building preventing the long shafts or axes that drive the machinery from being impeded by the friction which would arise from the slightest deviation in any of the bearings.

(245.) It is quite a mistaken idea, to suppose that any imperfect mechanical work is good enough for a trial. If the experiment is at all worth trying, it ought to be tried with all the advantages of which the state of mechanical art admits; for an imperfect trial may cause an idea to be given up, which better workmanship might have proved to be practicable. On the other hand, when once its success has been established with good workmanship, it will be easy to ascertain that degree of perfection which is necessary for its due action.

It is partly owing to this circumstance, *the imperfection of the original trials*, and partly owing to the gradual improvement in the art of making machinery, that many inventions which have been tried, and have been given up in one state of art, have, at another period, been eminently successful. The idea of printing by means of moveable types had probably suggested itself to the imagination of many men conversant with impressions taken either from blocks or seals. We find amongst the instruments discovered in the remains of Pompeii and Herculaneum, stamps for words formed out of one piece of metal, and including several letters. The idea of separating these letters, and of recombining them into other words, for the purpose of stamping a book, could scarcely have failed to have occurred to many: but it would almost certainly have been rejected by those best versed in the mechanical arts of that time; for any workman of those days, would have instantly perceived the impossibility of producing many thousand pieces of wood or metal fitting so perfectly, and ranging so uniformly, as the types or blocks of wood used in the art of printing.

The principle of the press which bears the name of Bramah, was known about a century and a half before the machine, to which it gave rise, existed; but the imperfect state of mechanical art in the time of its inventor, would have effectually deterred him, if it had occurred to his mind, from attempting to apply it as an instrument for exerting force in practice.

These considerations prove the propriety of repeating, at the termination of intervals, during which the art of making machinery has undergone any great improvement, the trials of methods which may have previously failed, although they were founded upon just principles.

(246.) When the drawings have been properly made, and the machine has been well executed, and when the work it produces possesses all the qualities which were anticipated, still the invention may fail; that is, *it may fail of being brought into general practice.* This will most frequently arise, from the circumstance of its producing its work at a greater expense than that at which it can be made by other methods.

(247.) Whenever the new, or improved machine, is intended to become the basis of a manufacture, it is essentially requisite that the whole expense attending its operations should be fully considered before its construction is undertaken. It is almost always very difficult to make this estimate of the expense; but the more complicated the mechanism, the less easy is the task; and in cases of great complexity and extent of machinery it is almost impossible. It has been estimated roughly, that the expense of making the first individual of any newlyinvented machine, will cost about five times as much as the construction of the second, an estimate which is, perhaps, sufficiently near the truth. If the second machine is to be precisely like the first, the same drawings, and the same patterns will answer for it; but if, as usually happens, some improvements have been suggested by the experience of the first, more or less of these must be altered. When, however, two or three machines have been completed, and many more are wanted, they can usually be produced at much less than one-fifth of the expense of the original invention.

(248.) The arts of contriving, of drawing, and of executing, do not usually reside in their greatest perfection in one individual; and in this, as in other arts, *the division of labour* must be applied. The best advice which can be offered to a projector of any mechanical invention, is to employ a respectable draughtsman, who, if he has had a large experience in his profession, will assist in finding out whether the contrivance is new, and can then make working drawings of it. The first step, however, the ascertaining whether the contrivance has the merit of novelty, is most important; for it is a maxim equally just in all arts, and in every science, that *the man who aspires to fortune or to fame by new discoveries, must be content to examine with care the knowledge of his contemporaries, or to exhaust his efforts in inventing again what he will most probably find has been better executed before.*

This, nevertheless, is a subject upon which even ingenious men are often singularly negligent. There is, perhaps, no trade or profession existing in which there is so much quackery, so much ignorance of the scientific principles, and of the history of their own art, with respect to its resources and extent, as is to be met with amongst mechanical projectors. The self-constituted engineer, dazzled with the beauty of some, perhaps, really original contrivance, assumes his new profession with as little suspicion that previous instruction, that thought and painful labour, are necessary to its successful exercise, as does the statesman or the senator. Much of this false confidence arises from the improper estimate which is entertained of the difficulty of invention in mechanics; and it is of great importance, to the individuals and to the families of those who are thus led away from more suitable pursuits, the dupes of their own ingenuity and of the popular voice, to convince both them and the public that the power of making new mechanical combinations is a possession common to a multitude of minds, and that it by no means requires talents of the highest order. It is still more important that they should be convinced that the great merit, and the great success of those who have attained to eminence in such matters, was almost entirely due, to the unremitted perseverance with which they concentrated upon the successful invention the skill and knowledge which years of study had matured.

CHAP. XXVI.

PROPER CIRCUMSTANCES FOR THE APPLICATION OF MACHINERY.

(249.) THE first object of machinery, and the chief cause of its extensive utility, is the cheap production of the articles to which it is applied. Wherever it is required to produce a great multitude of things, all of exactly the same kind, the proper time has arrived for the construction of tools or machines by which they may be manufactured. If only a few pairs of cotton stockings should be required in a country, or in circumstances in which it is impossible to purchase them, it would be an absurd waste of time, and of capital, to construct a stocking-frame to weave them, when, for a few pence, four steel wires can be procured by which they may be knit. If, on the other hand, many thousand pairs were wanted, the time employed, and the expense incurred in constructing a stocking-frame, would be more than repaid by the saving of time in making that large number of stockings. The same principle is applicable to the copying of letters: if only three or four copies are required, the pen and the human hand furnish the cheapest resource; but, if hundreds are called for, lithography may be brought to our assistance, and if hundreds of thousands are wanted, the machinery of a printing establishment is the most economical method of accomplishing the object.

(250.) There are, however, many cases in which machines or tools must be made, where economical production is not the most important object. Whenever it is required to produce a few articles,—parts of machinery, for instance, which must be executed with the most rigid accuracy or be perfectly alike,—it becomes nearly impossible to fulfil this condition, even with the aid of the most skilful hands. In such circumstances, it is necessary to make tools expressly for the purpose, although those tools should, as frequently happens, cost more in constructing than the things they are destined to make.

(251.) Another instance of the just application of machinery, even at an increased expense, arises where the shortness of time in which the article can be produced, has an important influence on its value. In the publication of our daily newspapers, it frequently happens that the debates in the Houses of Parliament are carried on to three and four o'clock in the morning, that is, to within a very few hours of the time for the publication of the newspaper. The speeches must be taken down by reporters, conveyed by them to the establishment of the newspaper, perhaps at the distance of one or two miles, transcribed by them in the office, set up by the compositor, the press corrected, and the papers be printed off and distributed before the public can read them. Some of these Journals have a circulation of from five to ten thousand daily. Supposing four thousand to be wanted, and that they could be printed only at the rate of five hundred per hour upon one side of the paper, (which was the greatest number two journeymen and a boy could take off by the old hand-presses), sixteen hours would be required for printing the complete edition; and the news conveyed to the purchasers of the latest portion of the impression, would be out of date before they could receive it. To obviate this difficulty, it was often necessary to set up the paper in duplicate, and sometimes, when late, in triplicate: but the improvements in the printing-machines have been so great, that four thousand copies are now printed on one side in an hour.

(252.) The establishment of "The Times" newspaper is an example, on a large scale, of a manufactory in which the division of labour, both mental and bodily, is admirably illustrated, and in which also the effect of the domestic economy is well exemplified. It is scarcely imagined, by the thousands who read that paper in various quarters of the globe, what a scene of organized activity the factory presents during the whole night, or what a quantity of talent and mechanical skill is put in action for their amusement and information.* Nearly a hundred per-

* The Author of these pages, with one of his friends, was recently induced to visit this most interesting establishment, after midnight, during the progress of a very important debate. The place was illuminated with gas, and was light as the day:—there was neither noise nor bustle;—and the visitors were received with such calm and polite attention, that they did not, until afterwards, become sensible of the inconvenience which such intruders, at a moment of the greatest pressure, must occasion, nor reflect that the tranquillity which they admired, was the result of intense and regulated occupation. But the effect of such checks in the current of business will appear on recollecting that, as four thousand newspapers are printed off on one side within the hour, every *minute* is attended with a

sons are employed in this establishment; and, during the session of parliament, at least twelve reporters are constantly attending the Houses of Commons and Lords; each in his turn, after about an hour's work, retiring to translate into ordinary writing, the speech he has just heard and noted in short-hand. In the mean time fifty compositors are constantly at work, some of whom have already set up the beginning, whilst others are committing to type the yet undried manuscript of the continuation of a speech, whose middle portion is travelling to the office in the pocket of the hasty reporter, and whose eloquent conclusion is, perhaps, at that very moment, making the walls of St. Stephen's vibrate with the applause of its hearers. These congregated types, as fast as they are composed, are passed in portions to other hands; till

loss of sixty-six impressions. The quarter of an hour, therefore, which the stranger may think it not unreasonable to claim for the gratification of his curiosity (and to him this time is but a moment), may cause a failure in the delivery of one thousand copies, and disappoint a proportionate number of expectant readers, in some of our distant towns, to which the morning papers are despatched by the earliest and most rapid conveyances of each day.

This note is inserted with the further and more general purpose of calling the attention of those, especially foreigners, who are desirous of inspecting our larger manufactories, to the chief cause of the difficulty which frequently attends their introduction. When the establishment is very extensive, and its departments skilfully arranged, the exclusion of visitors arises, not from any illiberal jealousy, nor, generally, from any desire of concealment, which would, in most cases, be absurd; but from the substantial inconvenience and loss of time, throughout an entire series of well-combined operations, which must be occasioned even by short and casual interruptions.

at last the scattered fragments of the debate, forming, when united with the ordinary matter, eight-and-forty columns, re-appear in regular order on the platform of the printing press. The hand of man is now too slow for the demands of his curiosity, but the power of steam comes to his assistance. Ink is rapidly supplied to the moving types, by the most perfect mechanism ; — four attendants incessantly introduce the edges of large sheets of white paper to the junction of two great rollers, which seem to devour them with unsated appetite ; — other rollers convey them to the type already inked, and having brought them into rapid and successive contact, re-deliver them to four other assistants, completely printed by the almost momentary touch. Thus, in one hour, four thousand sheets of paper are printed on one side ; and an impression of twelve thousand copies, from above three hundred thousand moveable pieces of metal, is produced for the public in six hours.

(253.) The conveyance of letters is another case, in which the importance of saving time would allow of great expense in any new machinery for its accomplishment. There is a natural limit to the speed of horses, which even the greatest improvements in the breed, aided by an increased perfection in our roads, can never surpass ; and from which, perhaps, we are at present not very remote. When we reflect upon the great expense of time and money which the last refinements of a theory or an art usually require, it is not unreasonable to suppose that the period has arrived in which the substitution of machinery for such purposes ought to be tried.

(254.) The post-bag despatched every evening by the mail to one of our largest cities, Bristol, usually weighs less than a hundred pounds. Now, the first reflection which naturally presents itself is, that, in order to transport these letters a hundred and twenty miles, a coach and apparatus weighing above thirty hundred weight, is put in motion, and also conveyed over the same space.*

It is obvious that, amongst the conditions of machinery for accomplishing such an object, it would be desirable to reduce the weight of matter to be conveyed with the letters: it would also be desirable to reduce the velocity of the animal power employed; because the faster a horse is driven, the less weight he can draw. Amongst the variety of contrivances which might be imagined for this purpose, we will mention one, which, although by no means free from objections, fulfils some of the prescribed conditions, and is not a purely theoretical speculation; since some few experiments, though on an extremely limited scale, have been made upon it.

(255.) Let us imagine a series of high pillars erected at frequent intervals, perhaps every hundred feet, as nearly as possible in a straight line between the two post towns. An iron or steel wire of some thickness must be stretched over proper supports, fixed on each of these pillars, and terminating at the end of every three or five miles, as may be found expedient, in a very strong support, by which it may be stretched.

* It is true that the transport of letters is not the only object which this apparatus answers; but the transport of passengers, which is a secondary object, does in fact put a limit to the velocity of that of letters, which is the primary one.

At each of these latter points a man ought to reside in a small station-house. A narrow cylindrical tin case, to contain the letters, might be suspended by two wheels rolling upon this wire; these might be so constructed as to enable them to pass unimpeded by the fixed supports of the wire. An endless wire of much smaller size must pass over two drums, one at each end. This wire should be supported on rollers, fixed to the supports of the great wire, and at a short distance below it. With this arrangement there would be the two branches of the smaller wire always accompanying the larger one; and the attendant at either station might, by turning the drum, cause these two branches of the small wire to move with great velocity in opposite directions. In order to convey the cylinder which contains the letters, it would only be necessary to attach it, by a string, or by a catch, to either of the branches of the endless wire. Thus it would be conveyed speedily to the next station, where it would be removed by the attendant to the commencement of the next wire, and thus transmitted on. It is unnecessary to enter into the details which this, or any similar plan, would require. The difficulties are obvious; but if these were overcome, it would present many advantages besides velocity: for if an attendant reside at each station, the additional expense of having two or three deliveries of letters every day, and even of sending expresses at any moment, would be comparatively trifling; and it is not impossible that the stretched wire might itself be available for a species of telegraphic communication yet more rapid.

Perhaps if the steeples of churches, properly selected, were made use of, connecting them by a few intermediate stations with some great central building, as, for instance, with the top of St. Paul's; and if a similar apparatus were placed on the top of each steeple, and a man to work it during the day, it might be possible to diminish the expense of the two-penny post, and make deliveries every half hour over the greater part of the metropolis.

(256.) The power of steam, however, bids fair almost to rival the velocity of these contrivances; and the fitness of its application to the purposes of conveyance, particularly where great velocity is required, is now beginning to be generally admitted. The following extract from the Report of the Committee of the House of Commons on steam-carriages, explains clearly its various advantages:—

"Perhaps one of the principal advantages resulting from "the use of steam, will be, that it may be employed as "cheaply at a quick as at a slow rate; 'this is one of the "'advantages over horse labour, which becomes more and "'more expensive as the speed is increased. There is "'every reason to expect, that in the end the rate of tra- "'velling by steam will be much quicker than the utmost "'speed of travelling by horses; in short, the safety to "'travellers will become the limit to speed.' In horse "draught the opposite result takes place; 'in all cases "'horses lose power of draught in a much greater propor- "'tion than they gain speed, and hence the work they do "'becomes more expensive as they go quicker.'

"Without increase of cost, then, we shall obtain a power "which will insure a rapidity of internal communication "far beyond the utmost speed of horses in draught; and "although the performance of these carriages may not have

" hitherto attained this point, when once it has been esta-
" blished, that at equal speed we can use steam more
" cheaply in draught than horses, we may fairly anticipate
" that every day's increased experience in the management
" of the engines, will induce greater skill, greater confi-
" dence, and greater speed.

" The cheapness of the conveyance will probably be, for
" some time, a secondary consideration. If, at present, it
" can be used as cheaply as horse power, the competition
" with the former modes of conveyance will first take place
" as to speed. When once the superiority of steam car-
" riages shall have been fully established, competition will
" induce economy in the cost of working them. The evi-
" dence, however, of Mr. Macneil, shewing the greater
" efficiency, with diminished expenditure of fuel, by loco-
" motive engines on railways, convinces the committee,
" that experience will soon teach a better construction of
" the engines, and a less costly mode of generating the
" requisite supply of steam.

" Nor are the advantages of steam power confined to the
" greater velocity attained, or to its greater cheapness than
" horse draught. In the latter, danger is increased, in as
" large a proportion as expense, by greater speed. In
" steam power, on the contrary, 'there is no danger of
" 'being run away with, and that of being overturned is
" 'greatly diminished. It is difficult to control four such
" 'horses as can draw a heavy carriage ten miles per hour,
" 'in case they are frightened, or choose to run away; and
" 'for quick travelling they must be kept in that state of
" 'courage, that they are always inclined for running away,
" 'particularly down hills, and at sharp turns of the road.
" 'In steam, however, there is little corresponding danger,
" 'being perfectly controllable, and capable of exerting its
" 'power in reverse in going down hills.' Every witness
" examined has given the fullest and most satisfactory evi-
" dence of the perfect control which the conductor has
" over the movement of the carriage. With the slightest

" exertion it can be stopped or turned, under circumstances " where horses would be totally unmanageable."

(257.) Another instance may be mentioned in the which object to be obtained is so important, that although it might be rarely wanted, yet machinery for that purpose would justify considerable expense. A vessel to contain men, and to be navigated at some distance below the surface of the sea, would, in many circumstances, be almost invaluable. Such a vessel, evidently, could not be propelled by any engine requiring the aid of fire. If, however, by condensing air into a liquid, and carrying it in that state, a propelling power could be procured sufficient for moving the vessel through a considerable space, the expense would scarcely render its occasional employment impossible.*

(258.) *Slide of Alpnach.*—Amongst the forests which flank many of the lofty mountains of Switzerland, some of the finest timber is found in positions almost inaccessible. The expense of roads, even if it were possible to make them in such situations, would prevent the inhabitants from deriving any advantages from these almost inexhaustible supplies. Placed by Nature at a considerable elevation above the spot on which they are required, they are precisely in fit circumstances for the application of machinery; and the inhabitants constantly avail themselves of it, to enable the force of gravity to relieve them from some portion of their labour. The inclined planes which they have established in various forests, by

* A proposal for such a vessel, and description of its construction may be found in the *Encyclopædia Metropolitana*, Art. DIVING BELL.

which the timber has been sent down to the water-courses, must have excited the admiration of every traveller; and these slides, in addition to the merit of simplicity, have that of economy, as their construction requires scarcely any thing beyond the material which grows upon the spot. Of all these specimens of carpentry, the Slide of Alpnach was by far the most considerable, both from its great length, and from the almost inaccessible position from which it descended. The following is the description of that work given in Gilbert's Annalen, 1819, and translated in the second volume of Brewster's Journal:—

"For many centuries, the rugged flanks and the deep gorges of Mount Pilatus were covered with impenetrable forests. Lofty precipices encircled them on all sides. Even the daring hunters were scarcely able to reach them; and the inhabitants of the valley had never conceived the idea of disturbing them with the axe. These immense forests were therefore permitted to grow and to perish, without being of the least utility to man, till a foreigner, conducted into their wild recesses in the pursuit of the chamois, was struck with wonder at the sight, and directed the attention of several Swiss gentlemen to the extent and superiority of the timber. The most intelligent and skilful individuals, however, considered it quite impracticable to avail themselves of such inaccessible stores. It was not till November, 1816, that M. Rupp, and three Swiss gentlemen, entertaining more sanguine hopes, drew up a plan of a slide, founded on trigonometrical measurements. Having purchased a certain extent of the forests from the commune of Alpnach for 6000 crowns, they began the construction of the slide, and completed it in the spring of 1818.

"The Slide of Alpnach is formed entirely of about 25,000 large pine trees, deprived of their bark, and united together in a very ingenious manner, without the aid of iron. It occupied about 160 workmen during eighteen months, and cost nearly 100,000 francs, or 4,250*l*. It is about three leagues, or 44,000 English feet long, and terminates in the Lake of Lucerne. It has the form of a trough, about six feet broad, and from three to six feet deep. Its bottom is formed of three trees, the middle one of which has a groove cut out in the direction of its length, for receiving small rills of water, which are conducted into it from various places, for the purpose of diminishing the friction. The whole of the slide is sustained by about 2,000 supports; and in many places it is attached, in a very ingenious manner, to the rugged precipices of granite.

"The direction of the slide is sometimes straight, and sometimes zig-zag, with an inclination of from 10 to 18°. It is often carried along the sides of hills and the flanks of precipitous rocks, and sometimes passes over their summits. Occasionally it goes under ground, and at other times it is conducted over the deep gorges by scaffoldings 120 feet in height.

"The boldness which characterises this work, the sagacity displayed in all its arrangements, and the skill of the engineer, have excited the wonder of every person who has seen it. Before any step could be taken in its erection, it was necessary to cut several thousand trees to obtain a passage through the impenetrable thickets ; and, as the workmen advanced, men were posted at certain distances in order to point out the road for their return, and to discover, in the gorges, the places where the piles of wood had been established. M. Rupp was himself obliged, more than once, to be suspended by cords, in order to descend precipices many hundred feet high ; and, in the first months of the undertaking, he was attacked with a violent fever, which deprived him of the power of superintending his workmen. Nothing, however, could diminish his invincible perseverance. He was carried every day to the mountain in a barrow, to direct the labours of the workmen, which was absolutely necessary, as he had scarcely two good carpenters among them all ; the rest having been hired by accident, without any of the knowledge which such an undertaking required. M. Rupp had also to contend against the prejudices of the peasantry. He was supposed to have communion with the devil. He was charged with heresy, and every obstacle was thrown in the way of an enterprise, which they regarded as absurd and impracticable. All these difficulties, however, were surmounted, and he had at last the satisfaction of observing the trees descend from the mountain with the rapidity of lightning. The larger pines, which were about a hundred feet long, and ten inches thick at their smaller extremity, ran through the space of *three leagues*, or nearly *nine miles, in two minutes and a half*, and during their descent, they appeared to be only a few feet in length. The arrangements for this part of the operation were extremely simple. From the lower end of the slide to the upper end, where the trees were introduced, workmen were posted at regular distances, and as soon as every thing was ready, the workman at the lower end of the slide cried out to the one above him, "*Lachez*" (Let go). The cry was repeated from one to another, and reached the top of the slide in *three* minutes. The workmen at the top of the slide then cried out to the one below him, "*Il vient*" (It comes), and the tree was instantly launched down the slide, preceded by the cry which was repeated from post to post. As soon as the tree had reached the bottom, and plunged into the lake, the cry of *Lachez* was repeated as before, and a new tree was launched in a similar manner. By these means a tree descended every five or six minutes, provided no accident happened to the slide, which sometimes took place, but which was instantly repaired when it did.

" In order to shew the enormous force which the trees acquired from the great velocity of their descent, M. Rupp made arrangements for causing some of the trees to spring from the slide. They penetrated by their thickest extremities no less than from eighteen to twenty-four feet into the earth; and one of the trees having by accident struck against the other, it instantly cleft it through its whole length, as if it had been struck by lightning.

" After the trees had descended the slide, they were collected into rafts upon the lake, and conducted to Lucerne. From thence they descended the Reuss, then the Aar to near Brugg, afterwards to Waldshut by the Rhine, then to Basle, and even to the sea when it was necessary.

" In order that none of the small wood might be lost, M. Rupp established in the forest large manufactories of charcoal. He erected magazines for preserving it when manufactured, and had made arrangements for the construction of barrels for the purpose of carrying it to the market. In winter, when the slide was covered with snow, the barrels were made to descend on a kind of sledge. The wood which was not fit for being carbonized, was heaped up and burnt, and the ashes packed up and carried away, during the winter.

" A few days before the author of the preceding account visited the slide, an inspector of the navy had come for the purpose of examining the quality of the timber. He declared that he had never seen any timber that was so strong, so fine, and of such a size ; and he concluded an advantageous bargain for 1000 trees.

" Such is a brief account of a work undertaken and executed by a single individual, and which has excited a very high degree of interest in every part of Europe. We regret to add, that this magnificent structure no longer exists, and that scarcely a trace of it is to be seen upon the flanks of Mount Pilatus. Political circumstances having taken away the principal source of the demand for timber ; and no other market having been found, the operation of cutting and transporting the trees necessarily ceased."

Professor Playfair, who visited this singular slide, states, that six minutes was the usual time occupied in the descent of a tree ; but that in wet weather, it reached the lake in three minutes.

(259.) One of the most common effects of the introduction of new machinery into manufactures, is to drive out of employment much of the hand-labour which was previously used. This, for a time, produces a considerable suffering amongst the working classes; and it is of great importance for their happiness that they should be aware of the effects, and that they should be enabled to foresee them at an early period, in order to diminish, as much as possible, their injurious results. It is almost the invariable consequence of such improvements ultimately to cause a greater demand for labour; and often the new labour requires a higher degree of skill than the old: but, unfortunately, the class of persons who have been driven out of the old employment are not always qualified for the new one; and in all cases a considerable time elapses before the whole of their labour is wanted. One very important inquiry which this subject presents is the question, *Whether it is for the interest of the working classes, that any improved machinery should be so perfect as to defy the competition of hand-labour, and that they should be at once driven out of the trade by it; or whether it is more advantageous for them to be gradually forced to quit the trade by the slow and successive advances of the machine?* The suffering which arises from a quick transition is undoubtedly more intense; but it is also much less permanent than that which results from the slower process. If the competition is perceived at once to be perfectly hopeless, the workman will at once set himself to learn a new department of his art. The use of power-looms is an instance of a slow change, which has gradually been diminishing the wages of the hand-weavers. It appears that the number of hand-looms in use in England and Scotland in 1830, was about 240,000; nearly the same number existed in the year 1820: whereas the number of power-looms which, in 1820, was 14,000, had, in 1830, increased to 55,000. When it is considered that each of these looms, at that time, did as much work as three hand-looms, the increased amount of work produced was equal to that of 123,000 hand-looms. During the whole of this period the wages and employment of hand-loom weavers has been very precarious.

(260.) Increased intelligence amongst the working classes, may enable them to foresee some of those improvements which are likely for a time to affect the value of their labour; and the assistance of Savings Banks and Friendly Societies, (the advantages of which can never be too frequently, or too strongly, pressed upon their attention,) may be of some avail in remedying the evil: but it seems also desirable to suggest to them, that a diversity of employments amongst the members of one family, will tend, in some measure, to mitigate the privations which arise from fluctuation in the value of labour.

CHAP. XXVII.

ON THE DURATION OF MACHINERY.

(261.) THE time during which a machine will continue effectually to perform its work, will depend mainly upon the perfection with which it was originally constructed, upon the care taken to keep it in proper repair, particularly to correct every shake or looseness in the axes, and upon the small mass and slow velocity of its moving parts. Every thing approaching to a blow, all sudden change of direction, is injurious. Engines for producing power, such as wind-mills, water-mills, and steam-engines, usually last a long time.* But machinery for producing any commodity in great demand, seldom actually wears out; new improvements, by which the same operations can be executed either more quickly or better, generally superseding it long before that period arrives: indeed, to make such an improved machine profitable, it is usually reckoned that in five years it ought to have paid itself, and in ten to be superseded by a better.

"A cotton manufacturer," says one of the witnesses before a Committee of the House of Commons, "who left

* The return which ought to be produced by a fixed steam-engine employed as a moving power, is frequently estimated at ten per cent. on its cost.

"Manchester seven years ago, would be driven out of the "market by the men who are now living in it, provided "his knowledge had not kept pace with those who have "been, during that time, constantly profiting by the pro- "gressive improvements that have taken place in that "period."

(262.) The effect of improvements in machinery, seems incidentally to increase production, through a cause which may be thus explained. A manufacturer making the usual profit upon his capital, invested in looms or other machines in perfect condition, the market price of making each of which is a hundred pounds, invents some improvement. But this is of such a nature, that it cannot be adapted to his present engines. He finds upon calculation, that at the rate at which he can dispose of his manufactured produce, each new engine would repay the cost of its making, together with the ordinary profit of capital, in three years: he also concludes from his experience of the trade, that the improvement he is about to make, will not be generally adopted by other manufacturers before that time. On these considerations, it is clearly his interest to sell his present engines, even at half-price, and construct new ones on the improved principle. But the purchaser who gives only fifty pounds for the old engines, has not so large a fixed capital invested in his factory, as the person from whom he purchased them; and as he produces the same quantity of the manufactured article, his profits will be larger. Hence, the price of the commodity will fall, not only in consequence of the cheaper production by the new machinery, but also by the more profitable working of the old, when sold at a reduced price. This change, however, can be only transient; for a time will arrive when the old machinery, although in good repair, must become worthless. The improvement which took place not long ago in frames for making patent-net was so great, that a machine, in good repair, which had cost 1200*l*., sold a few years after for 60*l*. During the great speculations in that trade, the improvements succeeded each other so rapidly, that machines which had never been finished were abandoned in the hands of their makers, because new improvements had superseded their utility.

(263.) The durability of common watches, when well made, is very considerable. One was produced, in "*going order*," before a committee of the House of Commons to inquire into the watch trade, which was made in the year 1660; and there are many of ancient date, in the possession of the Clock-maker's Company, which are actually kept going. The number of watches manufactured for home consumption was, in the year 1798, about 50,000 annually. If this supply was for Great Britain only, it was consumed by about ten and a half millions of persons.

(264.) Machines are, in some trades, let out to hire, and a certain sum is paid for their use in the manner of rent. This is the case amongst the frame-work knitters: and Mr. Henson, in speaking of the rate of payment for the use of their frames, states, that the proprietor receives such a rent that, besides paying the full interest for his capital, he clears the value of his frame in nine years. When the rapidity with which improvements succeed each other are considered, this rent does not appear exorbitant. Some of these frames have been worked for thirteen years with little or no repair. But circumstances occasionally arise which throw them out of employment, either temporarily or permanently. Some years since, an article was introduced called "*cut-up work*," by which the price of stocking frames was greatly deteriorated. From the evidence of Mr. J. Rawson, it appears that, in consequence of this change in the nature of the work, *each frame could do the work of two*, and many stocking frames were thrown out of employment, and their value reduced *full three-fourths*.*

This information is of great importance, if the numbers here given are nearly correct, and if no other causes intervened to diminish the price of frames; for it shews the numerical connexion between the increased production of those machines and their diminished value.

The great importance of simplifying all transactions between masters and workmen, and of dispassionately discussing with the latter the influence of any proposed regulations, is well exemplified by a mistake into which both parties unintentionally fell, and which was productive of very great misery. Its history is so well told by William Allen, a frame-work knitter, who was a party to it, that an extract from his evidence, as given before the Frame-work Knitter's Committee of 1812, will best explain it.

"I beg to say a few words respecting the frame-rent; "the rent paid for lace-frames, until the year 1805, was

* Report from the Committee of the House of Commons on the Frame-Work Knitters' Petition, April, 1819.

" 1s. 6*d*. a frame per week; there then was not any very " great inducement for persons to buy frames and let them " out by the hire, who did not belong to the trade; at that " time an attempt was made, by one or two houses, to " reduce the prices paid to the workmen, in consequence of " a dispute between these two houses and another great " house: some little difference being paid in the price " among the respective houses, I was one chosen by the " workmen to try if we could not remedy the impending " evil: we consulted the respective parties, and found them " inflexible; these two houses that were about to reduce " the prices, said that they would either immediately re- " duce the price of making net, or they would increase the " frame-rent: the difference to the workmen was consi- " derable, between the one and the other; they would " suffer less, in the immediate operation of the thing, by " having the rent advanced, than the price of making net " reduced. They chose at that time, as they thought, the " lesser evil, but it has turned out to be otherwise; for, " immediately as the rent was raised upon the per-centage " laid out in frames, it induced almost every person, who " had got a little money, to lay it out in the purchase of " frames; these frames were placed in the hands of men " who could get work for them at the warehouses; they " were generally constrained to pay an enormous rent, and " then they were compelled, most likely, to buy of the per- " sons that let them the frames, their butcher's-meat, their " grocery, or their clothing: the encumbrance of these " frames became entailed upon them: if any deadness took " place in the work they must take it at a very reduced " price, for fear of the consequences that would fall upon " them from the person who bought the frame: thus the " evil has been daily increasing, till, in conjunction with " the other evils crept into the trade, they have almost " crushed it to atoms."

(265.) The evil of not assigning fairly to each tool, or each article produced, its *proportionate value*, or even of not having a perfectly distinct, simple, and definite *agreement* between a master and his workmen, is very considerable. Workmen find it difficult to know the probable produce of their labour; and both parties are often led to adopt arrangements, which, had they been well examined, would have been rejected as equally at variance in the results with the true interests of both.

(266.) At Birmingham, stamps and dies, and presses for a great variety of articles, are let out: they are generally made by men possessing small capital, and are rented by workmen. Power also is rented at the same place. Steam engines are erected in large buildings containing a variety of rooms, in which each person may hire one, two, or any other number of horse power, as his occupation may require. If any mode could be discovered of transmitting power, without much loss from friction, to considerable distances, and at the same time of registering the quantity made use of at any particular point, a considerable change would probably take place in many parts of the present system of manufacturing. A few central engines to produce power, might then be erected in our great towns, and each workman, hiring a quantity of power sufficient for his purpose, might have it conveyed into his own house; and thus a transition might in some instances be effected, if it should be found more profitable, from the system of great factories back to that of domestic manufacture.

(267.) The transmission of water through a system of pipes, might be employed for the distribution of power, but the friction would consume a considerable portion. Another method has been employed in some instances, and is practised at the Mint. It consists in exhausting the air from a large vessel by means of a steam-engine. This vessel is connected by pipes, with a small piston which drives each coining press; and, on opening a valve, the pressure of the external air forces in the piston. This air is then admitted to the general reservoir, and pumped out by the engine. The condensation of air might be employed for the same purpose; but it must be admitted, that there are some unexplained facts relative to that elastic fluid, which require further observations and experiment before it can be used for the conveyance of power to any considerable distance. It has been found, for instance, in attempting to blow a furnace by means of a powerful water wheel driving air through a cast-iron pipe of above a mile in length, that scarcely any sensible effect was produced at the opposite extremity. In one instance, some accidental obstruction being suspected, a cat put in at one end found its way out without injury at the other, thus proving that the phenomenon did not depend on interruption within the pipe.

(268.) The most portable form in which power can be condensed is, perhaps, by the liquefaction of the gases. It is known that, under considerable pressure, several of these became liquid at ordinary temperatures. Carbonic acid, for example, requires a pressure of sixty atmospheres to reduce it to a liquid state. One of the advantages attending the use of these fluids is, that the pressure exerted by them remains constant until the last drop of liquid becomes gaseous. If either of the elements of common air should be found to be capable of reduction to a liquid state before it unites into a corrosive fluid with the other ingredient, then we shall possess a ready means of conveying power in any quantity and to any distance. Probably hydrogen will require the strongest compressing force to render it liquid, and may, therefore, possibly be applied where still greater condensation of power is wanted. In all these cases the condensed gases may be looked upon as enormous springs, which have been wound up by the exertion of power, and which will deliver the whole of it back again when required. These springs of nature differ in some respects from the steel springs formed by our art; for in the compression of the natural springs an enormous quantity of latent heat is forced out, and in their return to the state of gas an equal quantity is absorbed. May not this very property be employed with advantage in these applications?

The mechanical difficulty which will remain to be overcome, will consist in the valves and packing necessary to retain the fluids under the pressures to which they will be submitted; and the effect of heat on these gases has not yet been sufficiently tried to lead us to any very precise notions of the additional power which its application to them will supply.

The elasticity of air is sometimes employed as a spring instead of steel: in one of the large printing-presses the momentum of a considerable mass of matter is destroyed by making it condense the air included in a cylinder, by means of a piston against which it impinges.

(269.) The effect of competition in cheapening articles of manufacture sometimes operates in rendering them less durable. When such articles are conveyed, for consumption, to a distance from the place where they are made, if they are broken, it often happens, from the different price of labour, that it is more expensive to mend the old, than to purchase a new article. Such is usually the case, in great cities, with some of the commoner locks, with hinges, and with a variety of articles of hardware.

CHAP. XXVIII.

ON COMBINATIONS AMONGST MASTERS OR WORKMEN AGAINST EACH OTHER.

(270.) THERE exist amongst the workmen of almost all classes, certain rules or laws which govern their actions towards each other, and towards their employers. But, besides these general principles, there are frequently others peculiar to each factory, which have derived their origin, in many instances, from the mutual convenience of the parties engaged in them. Such rules are little known except to those actually pursuing the several trades; and, as it is of importance that their advantages and disadvantages should be canvassed, we shall offer a few remarks upon some of them.

(271.) The principles by which such laws should be tried are,

1*st. That they conduce to the general benefit of the whole of the persons employed.*

2*dly. That they prevent fraud.*

3*dly. That they interfere as little as possible with the free agency of each individual.*

(272.) It is usual in many workshops, that, on the first entrance of a new journeyman, he shall pay a small fine to the rest of the men. It is clearly unjust to insist upon this payment; and when it is spent in drinking, which is, unfortunately, too often the case, it is injurious. The reason assigned for the demand is, that the new comer will require some instruction in the habits of the shop, and in the places of the different tools, and will thus waste the time of some of his companions until he is instructed. If this fine were added to a fund, managed by the workmen of the establishment, and divided at given periods, or destined for their relief in sickness, it would be less objectionable, since its tendency would be to check the too frequent change of the men from one shop to another. But it ought, at all events, not to be compulsory; and the advantages to be derived from the fund to which the workman is invited to subscribe, ought to be his sole inducement.

(273.) In many workshops, the workmen, although employed on totally different parts of the objects manufactured, are yet dependent, in some measure, upon each other. Thus a single smith may be able to forge, in one day, work enough to keep four or five turners employed during the next. If, from idleness or intemperance, the smith neglects his work, and does not furnish the usual supply, the turners (supposing them to be paid by the piece), will have their time partly unoccupied, and their gains consequently diminished. It is reasonable, in such circumstances, that a fine should be levied, in order to prevent their recurrence; but it is desirable that the master should have concurred with his workmen in establishing such a rule, and that it should be shown to each individual previous to his engagement; and it is very desirable that such fine should not be spent in drinking.

(274.) In some establishments, it is customary for the master to give a small gratuity whenever any workman has exercised a remarkable degree of skill, or has economized the material employed. Thus, in splitting horn into layers for lanterns, one horn usually furnishes from five to eight layers; but if a workman split the horn into ten layers or more, he receives a pint of ale from the master. These premiums should not be too high, lest the material should be wasted by the workman in unsuccessful attempts: but such regulations, when judiciously made, are beneficial, as they tend to promote skill amongst the men, profit to the masters, and diminished cost to the consumers.

(275.) In some few factories, in which the men are paid by the piece, it is usual, when any portion of work, delivered in by a workman, is rejected by the master on account of its being badly executed, to fine the delinquent. Such a practice tends to remedy one of the evils attendant upon that mode of payment, and greatly assists the master, since his own judgment is thus supported by competent and unprejudiced judges.

(276.) Societies exist amongst some of the larger bodies of workmen, and there are also others formed by the masters engaged in the same branches of trade. These have different objects in view; but it is very desirable that their effects should be well understood by the individuals who compose them; and that the advantages arising from them, which are certainly great, should be separated as much as possible from the evils which they have, unfortunately, too frequently introduced. Associations of workmen and of masters may, with advantage, agree upon rules to be observed by both parties, in the estimation of the proportionate value of various kinds of work executed in their trade, in order that time may be saved, and disputes between them may be prevented. They may also be most usefully employed in acquiring accurate information of the number of persons working in the various departments of any manufacture, their rate of wages, the number of machines in use among them, and other statistical details. Information of this nature is extremely valuable, both for the guidance of the parties who are themselves most interested, and also to enable them, on any application to Government for assistance, or with a view to legislative enactments, to supply those details, without which the propriety of any proposed measure cannot be fitly decided upon. Such details may be collected by men actually engaged in any branch of trade, at a much smaller expense of time than by persons less acquainted with, and less interested in it.

(277.) One of the most legitimate and most important objects of such associations as we have just mentioned, is to agree upon ready and certain modes of measuring the quantity of work done by the workmen. For a long time a difficulty upon this point existed in the lace trade, which was justly complained of by the men as a serious grievance; but the introduction of the "*rack*," which counts the number of holes in the length of the piece, has entirely put an end to the most fertile cause of disputes. This was adverted to by the Committee of 1812, and a hope expressed, that the same contrivance would be applied to stocking-frames. It would, indeed, be of great mutual advantage to the industrious workman, and to the master-manufacturer in every trade, if the machines employed in it could register the quantity of work done, in the same manner as a steam-engine does the number of strokes it makes. The introduction of such contrivances gives a greater stimulus to honest industry than can readily be imagined, and removes one of the sources of disagreement between parties, whose real interests must always suffer by any estrangement between them.

(278.) The effects arising from combinations amongst the workmen, are almost always injurious to the parties themselves. There are numerous instances, in which the public suffer by increased price at the moment, but are ultimately gainers from the permanent reduction which results; whilst, on the other hand, the improvements which are often made in machinery in consequence of "a strike" amongst the workmen, most frequently do an injury, of greater or less duration, to that particular class which gave rise to them. As the injury to the men and to their families is almost always greater than that which affects their employers, it is of the utmost importance to the comfort and happiness of the former class, that sound views should be entertained by them upon this question. For this purpose a few illustrations of the principle which is here maintained, will probably have greater weight than any reasoning of a more general nature, though drawn from admitted principles of political economy. Such instances will, moreover, present the additional advantage of appealing to facts known to many individuals of those classes for whose benefit these reflections are intended.

(279.) There is a process in the manufacture of gun-barrels for making what, in the language of the trade, are called *skelps*. The *skelp* is a piece or bar of iron, about three feet long, and four inches wide, but thicker and broader at one end than at the other: and the barrel of a musket is formed by forging out such pieces to the proper dimensions, and then folding or bending them round into a cylindrical form, until the edges overlap, so that they can be welded together.

About twenty years ago, the workmen, employed at a very extensive factory in forging these skelps out of bar-iron, "struck" for an advance of wages, and as their demands were very exorbitant, they were not immediately complied with. In the mean time, the superintendent of the establishment directed his attention to the subject; and it occurred to him, that if the circumference of the rollers, between which the bar-iron was rolled, were to be made equal to the length of a *skelp*, or of a musket barrel, and if also the grooves in which the iron was compressed, instead of being equally deep and wide, were cut gradually deeper and wider from a point in the rollers, until it returned to the same point, then the bar-iron passing between such rollers, instead of being uniform in width and thickness, would have the form of a *skelp*. On making the trial, it was found to succeed perfectly, a great reduction of human labour was effected by the process, and the workmen who had acquired peculiar skill in performing it ceased to derive any advantage from their dexterity.

(280.) It is somewhat singular that another and a still more remarkable instance of the effect of combination amongst workmen should have occurred but a few years since in the very same trade. The process of welding the "skelps," so as to convert them into gun-barrels, required much skill, and after the termination of the war, the demand for muskets having greatly diminished, the number of persons employed in that line was very much reduced. This circumstance rendered combination more easy; and upon one occasion, when a contract had been entered into for a considerable supply to be delivered on a fixed day, the men all struck for such an advance of wages as would have caused the completion of the contract to be attended with a very heavy loss. In this difficulty, the contractors resorted to a mode of welding the gun-barrel, according to a plan for which a patent had been taken out by them some years before this event. It had not then succeeded so well as to come into general use, in consequence of the cheapness of the usual mode of welding by hand-labour, combined with some other difficulties with which the patentee had had to contend. But the stimulus produced by the combination of the workmen for this advance of wages, induced him to make new trials, and he was enabled to introduce such a facility in welding gun-barrels by rollers, and such perfection in the work itself, that, in all probability, very few will in future be welded by hand-labour.

The process consisted in turning a bar of iron, about a foot long, into the form of a cylinder, with the edges a little overlapping. It was then placed in a furnace, raised to a welding heat, and taken out, when a triblet, or cylinder of iron, being placed in it, it was passed quickly through a pair of rollers. The effect of this was, that the welding was performed at a single heating, and the remainder of the elongation necessary for bringing it to the length of the musket barrel, was performed in a similar manner, but at a lower temperature. The workmen who had combined were, of course, no longer wanted, and instead of benefiting themselves by their combination, they were reduced permanently, by this improvement in the art, to a considerably lower rate of wages: for as the process to which they had been habituated required peculiar skill and considerable experience, they had hitherto been in the habit of earning much higher wages than other workmen of their class. On the other hand, the new method of welding was far less injurious to the texture of the iron, which was now exposed only once, instead of three or four times, to the welding heat, so that the public derived advantage from the superiority, as well as from the economy of the process. Another advantage has also arisen from its introduction; for the new process is now applied to the manufacture of iron tubes, which can thus be made at a price which renders their employment very general. They are now to be found in the shops of all our larger ironmongers, in various lengths, and of different diameters, with screws cut at each end; and are in constant use for the conveyance of gas for lighting, or of water for warming our houses.

(281.) Similar examples must have presented themselves to those who are familiar with the details of our manufactories, but these are sufficient to illustrate one of the results of combinations. It would not, however, be fair to push the conclusion deduced from these instances to its extreme limit. Although it is very apparent, that in the two cases which have been stated, the effects of combination were permanently injurious to the workman, by almost immediately placing him in a lower class (with respect to his wages) than he occupied before; yet they do not prove that *all* such combinations have this *effect.* It is quite evident that they have all this *tendency;* it is also certain that considerable stimulus must be applied to induce a man to contrive a new and expensive process; and that in both these cases, unless the fear of pecuniary loss had acted powerfully, the improvement would not have been made. If, therefore, the workmen had in either case combined for only a small advance of wages, they would, in all probability, have been successful, and the public would have been deprived, for many years, of the invention to which these combinations gave rise. It must, however, be observed, that the same skill which enabled them to obtain, after long practice, higher wages than the rest of their class, would prevent many of them from being *permanently* thrown back into the class of ordinary workmen. Their diminished wages will continue only until they have acquired, by practice, a facility of execution in some other of the more difficult operations:—But a diminution of wages, even for a year or two, is still a very serious inconvenience to any person who lives by his daily exertion. The consequence of combination has then, in these instances, been, to the workmen who combined—reduction of wages; to the public—reduction of price; and to the manufacturer—increased sale of his commodity, resulting from that reduction.

(282.) It is, however, important to consider the effects of combination in another and less obvious point of view. The fear of combination amongst the men whom he employs, will have a tendency to induce the manufacturer to conceal from his workmen the extent of the orders he may at any time have in hand; and, consequently, they will always be less acquainted with the extent of the demand for their labour than they otherwise might. This is injurious to their interests; for instead of foreseeing, by the gradual falling off in the orders, the approach of a time when they must be unemployed, and preparing accordingly, they are liable to much more sudden changes than those to which they would otherwise be subject.

In the evidence given by Mr. Galloway, the engineer, he remarks, that, "When employers are competent to show their men that their business is steady and certain, and when men find that they are likely to have permanent employment, they have always better habits, and more settled notions, which will make them better men, and better workmen, and will produce great benefits to all who are interested in their employment."

(283.) As the manufacturer, when he makes a contract, has no security that a combination may not arise amongst the workmen, which may render that contract a loss instead of a benefit; besides taking precautions to prevent them from becoming acquainted with it, he must also add to the price at which he could otherwise sell the article, some small increase to cover the risk of such an occurrence. If an establishment consist of several branches which can only be carried on jointly, as, for instance, of iron mines, blast furnaces, and a colliery, in which there are distinct classes of workmen, it becomes necessary to keep on hand a larger stock of materials than would be required, if it were certain that no combinations would arise. Suppose, for instance, the colliers were to "strike" for an advance of wages;—unless there was a stock of coal above-ground, the furnaces must be stopped, and the miners also would be thrown out of employ.

Now the cost of keeping a stock of iron ore, or of coals above-ground, is just the same as that of keeping in a drawer, unemployed, its value in money, (except, indeed, that the coal suffers a small deterioration by exposure to the elements.) The interest of this sum must, therefore, be considered as the price of an insurance against the risk of combination amongst the workmen; and it must, so far as it goes, increase the price of the manufactured article, and, consequently, limit the demand which would otherwise exist for it. But every circumstance which tends to limit the demand, is injurious to the workmen; because the wider the demand, the less it is exposed to fluctuation. The effect to which we have alluded, is by no means a theoretical conclusion; the proprietors of one establishment in the trade which has been mentioned, think it expedient always to keep above-ground a supply of coal for six months, which is, in that instance, equal in value to about 10,000*l.*

(284.) That combinations amongst workmen are productive of serious inconveniences to themselves, is admitted by all parties ; and it is equally true, that, in many cases, a successful result does not leave them in as favourable a position as they were previous to "the strike." The little capital they possessed, which ought to have been hoarded with care for days of illness or distress, is exhausted ; and frequently, in order to gratify a pride at the existence of which we cannot but rejoice, even whilst we regret its misdirected energy, they will undergo the severest privations rather than return to work at their former wages. With many of the workmen, unfortunately, during such periods, habits of idleness are formed which it is difficult to eradicate ; and, in all those engaged in such occurrences, the kinder feelings of the heart are chilled, and passions are called into action injurious to the happiness of the individual, and destructive of those sentiments of confidence which it is equally the interests of the master-manufacturer and of his workman to maintain. If any of the trade refuse to join in the strike, the majority too frequently forget, in the excitement of their feelings, the dictates of justice, and endeavour to exert a species of tyranny, which can never be permitted to exist in a free country. In conceding therefore to the working classes, that they have a right, if they consider it expedient, to combine for the purpose of procuring higher wages (provided always, that they have completed all their existing contracts), it ought ever to be kept before their attention, that the same freedom which they claim for themselves they must allow to others, who may have different views of the advantages of combination: and whilst every effort which reason and kindness can dictate, should be made to show them the true consequences which will result from their conduct, the strong arm of the law, backed, as in such cases it ever will be, by public opinion, should be instantly and unhesitatingly applied, to prevent them from violating the liberty of a portion of their own, or of any other class of society.

(285.) Amongst the evils which ultimately fall heavy on the working classes themselves, when, through mistaken views, they attempt to interfere with their employers in the mode of carrying on their business, may be mentioned the removal of factories to other situations, where the proprietors may be free from the improper control of their men. The removal which took place, in consequence of the combinations in Nottinghamshire, of a considerable number of lace-frames to the western counties, has already been mentioned. Other instances have occurred, where the injury has been still greater by the removal of a portion of the skill and capital of the country to a foreign land. Such was the case at Glasgow, as stated in the fifth Report respecting artizans and machinery. One of the partners in an extensive cotton-factory, disgusted by the unprincipled conduct of the workmen, removed to the state of New York, where he re-established his machinery, and thus afforded, to rivals already formidable to our trade, at once a pattern of our best machinery, and an example of the most economical modes of employing it.

(286.) One of the remedies employed by the masters against the occurrence of combinations, is to make engagements for long periods with the men, and to arrange them in such a manner, that they shall not all terminate together. This has been done in some cases at Sheffield, and also in other places.

(287.) A system of paying the wages of workmen in articles which they consume, has been introduced into some of our manufacturing districts, which has been called the "*truck system*." As in many instances it has almost the effect of a combination of the masters against the men, it is a fit subject for discussion in the present chapter. It should, however, be separated from another system of a very different tendency, which will be first described.

The principal necessaries for the support of a workman and his family are few in number, and are usually purchased by him in small quantities weekly. Upon such quantities, sold by the retail dealer, a large profit is generally made; and if the article is one whose quality, like that of tea, is not readily estimated, then a great additional profit is made by the retail dealer selling an inferior article.

In such circumstances, where the number of workmen living on the same spot is large, it may be thought desirable that they should unite together and have an agent, to purchase wholesale such articles as tea, sugar, bacon, &c. in most demand, and to retail them out at prices which will just repay their wholesale cost, and the expense of the agent they employ. If this be wholly managed by a committee of workmen, aided perhaps by advice from the master, and if the agent is paid in such a manner as to be interested in procuring good and reasonable articles, it may be a benefit to the workmen: and if the plan succeed in reducing the cost of articles of necessity to the men, it is clearly the interest of the master to encourage it. The master may indeed be enabled to afford them facilities in making their wholesale purchases; but he ought never to be in such a position as to have the least interest in the profit made by the articles sold. The men, on the other hand, who subscribe to set up the shop, ought not, in the slightest degree, to be compelled to make their purchases at it: the goodness and cheapness of the article ought to be their sole inducements.

It may perhaps be objected, that this plan is only employing a portion of the capital belonging to the workmen in a retail trade; and that, without it, competition amongst small shopkeepers will reduce the articles to nearly the same price. Perhaps there would be less reason to have recourse to it, if the objects of consumption required no *verification;* but combining what has been stated on that subject in the fourteenth chapter, on price, with the present argument, the plan seems liable to no serious objections.

(288.) The *truck system* is quite different in its effects. The master-manufacturer keeps a retail shop for articles in demand by his men, and either pays their wages in goods, or compels them by direct agreement, or incidentally by unfair means, to expend the whole or a certain part of their wages at his shop. If the manufacturer kept this shop merely for the purpose of securing good articles, at fair prices, to his workmen, and if he offered no inducement to them to purchase at his shop, except the superior cheapness of his articles, it would certainly be advantageous to the men. But, unfortunately, this is not always the case; and the temptation to the master, in times of depression, to reduce in effect the wages which he pays (by increasing the price of articles at his shop), without altering the nominal rate of payment, is frequently too great to be withstood. If the object be solely to procure for his workmen better articles, it would be more effectually accomplished by supplying a small capital, at a moderate rate of interest, and allowing the details of the shop to be conducted by a committee of workmen, in conjunction with his own agent, and allowing the books of the shop to be audited monthly by the men.

(289.) Wherever the workmen are paid in goods, or are compelled to purchase at the master's shop, the evils are very great; much injustice is done to the men, and much misery results from it. Whatever may have been the intentions of the master in such a case, the real effect is, to deceive the workman as to the amount he receives in exchange for his labour. Now, the principles on which the happiness of that class of society depends, are sufficiently difficult to be thoroughly understood, even by those who are blessed with far better opportunities of investigating them: and the importance of being acquainted with those which relate to themselves, is of more vital consequence to the workmen, than to many other classes. It is therefore highly desirable to assist them in comprehending those principles, by rendering all the relations in which they stand to each other, and to their employers, as simple as possible. Workmen should be paid entirely in money;—

their work should be measured by some unbiassed, some unerring piece of mechanism;—the time during which they are employed should be definite, and punctually adhered to. The payments they make to their benefit societies should be fixed on such just principles, as not to require extraordinary contributions. In short, the object of all who wish to promote their happiness should be, to give them, in the simplest form, the means of knowing beforehand, the sum they are likely to acquire by their labour, and the money they will be obliged to expend for their support: thus putting before them, in the clearest light, the certain result of persevering industry.

(290.) The cruelty which is inflicted on the workman by the payment of his wages in goods, is often very severe. The little purchases necessary for the comfort of his wife and children, perhaps the medicines he occasionally requires for them in illness, must all be made through the medium of barter, and he is obliged to waste his time in arranging an exchange, in which the goods which he has been compelled to accept for his labour are invariably taken at a lower price, than that at which his master charged them to him. The father of the family perhaps, writhing under the agonies of the toothache, is obliged to make his hasty bargain with the village surgeon, ere he will remove the cause of his pain; or the disconsolate mother is compelled to sacrifice her depreciated goods in exchange for the last receptacle of her departed offspring. The subjoined evidence from the Report of the Committee of the House of Commons on Framework-Knitters' Petitions, shows that these are not exaggerated statements.

"It has been so common in our town to pay goods "instead of money, that a number of my neighbours have "been obliged to pay articles for articles, to pay sugar for "drugs out of the druggist's shop; and others have been "obliged to pay sugar for drapery goods, and such things, "and exchange in that way numbers of times. I was "credibly informed, that one person paid half a pound of "tenpenny sugar and a penny to have a tooth drawn; "and there is a credible neighbour of mine told me, that "he had heard that the sexton had been paid for digging "a grave with sugar and tea; and before I came off, "knowing I had to give evidence upon these things, I "asked this friend to inquire of the sexton, whether this "was a fact: the sexton hesitated for a little time, on "account of bringing into discredit the person who paid "these goods; however, he said at last, 'I have received "'these articles repeatedly—I know these things have "'been paid to a great extent in this way.'"

CHAP. XXIX.

ON COMBINATIONS OF MASTERS AGAINST THE PUBLIC.

(291.) A SPECIES of combination occasionally takes place amongst manufacturers against persons having patents: and these combinations are always injurious to the public, as well as unjust to the inventors. Some years since, a gentleman invented a machine, by which modellings and carvings were cut in mahogany, and other fine woods. The machine resembled, in some measure, the drilling apparatus employed in ornamental lathes; it produced beautiful work, at a very moderate expense: but the cabinet-makers met together, and combined against it, and the patent has consequently never been *worked*. A similar fate awaited a machine for cutting veneers by means of a species of knife. In this instance, the wood could be cut thinner than by the circular saw, and no waste of it was incurred; but "the trade" set themselves against it, and after a heavy expense, it was given up.

Similar examples of combination seem not to be unfrequent, as appears by the Report of the Committee of the House of Commons on Patents for Inventions, June, 1829. See the evidence of Mr. Holdsworth.

(292.) There occurs another kind of combination against the public, with which it is difficult to deal. It usually ends in a monopoly, and the public are then left to the discretion of the monopolists not to charge them above the "*growling point*,"—that is, *not to make them pay so much as to induce them actually to combine against the imposition.* This occurs when two companies supply water or gas to consumers by means of pipes laid down under the pavement in the streets of cities: it may possibly occur also in docks, canals, rail-roads, &c., and in other cases where the capital required is very large, and the competition very limited. If water or gas companies combine, the public immediately loses all the advantage of competition, and it has generally happened, that at the end of a period during which they have undersold each other, the several companies have agreed to divide the whole district supplied, into two or more portions, and that each company has removed its pipes from all streets but those in its own portion of the district. This removal causes great injury to the pavement, and when the pressure of increased rates induce a new company to start, the same inconvenience is again produced. Perhaps one remedy to evils of this kind might be, when a charter is granted to such companies, to restrict, to a certain amount, the rate of profit to be divided on the shares, and to direct that any profits beyond, shall accumulate for the repayment of the original capital. This has been done in several late acts of parliament, establishing companies. The maximum rate of profit allowed ought to be liberal, to compensate for the risk, and the public ought to have auditors on their part, and the accounts should be annually published, for the purpose of preventing the object of the limitations from being defeated. It must however be admitted, that this is an interference with capital, which, if allowed, should be examined with great circumspection in each individual case, until some general principle is established on well-admitted grounds.

(293.) An instrument called a gas-meter, which ascertains the quantity of gas used by each consumer, has been introduced, and furnishes a satisfactory mode of determining the payments to be made by individuals to the Gas companies. An instrument somewhat similar in its nature, might be contrived for the sale of water; but in that case, a difficulty is to be apprehended, arising from the diminished quantity which would then run to waste: the streams of water running through the sewers in London, are largely supplied from this source; and if the quantity of water flowing through them, were diminished, the drainage of the metropolis might be injuriously affected.

(294.) A powerful combination has long existed amongst the coal-owners in the north of England, by which the public has suffered in the payment of increased price. The late examination of evidence before a Committee of the House of Commons, has explained its mode of operation, and the Committee have recommended, that for the present the sale of coal should be left to the competition of other districts.

(295.) A powerful combination, of another kind, exists at this moment to a great extent, and operates upon the price of the very pages which are now communicating information respecting it. A subject so interesting to every reader, and still more so to every manufacturer of the article which the reader consumes, deserves an attentive examination.

We have shown in Chap. XX. p. 166, the component parts of the expense of each copy of the present work; and we have seen that the total amount of its cost of production, exclusive of any payment to the author for his labour, is 2*s.* 3¼*d.*

Another fact, with which the reader is more practically familiar, is, that he has paid, or is to pay, his bookseller six shillings for the volume. Let us now examine into the distribution of these six shillings, and then, having the facts of the case before us, we shall be better able to judge of the merits of the combination, and to explain its effects.

Distribution of the Profits on a Six Shilling Book.

	BUYS AT	SELLS AT	PROFIT on Capital expended.
	s. *d.*	*s.* *d.*	
No. I.—*The publisher* who accounts to the author for every copy received . .	3 10	4 2	10 per cent.
No. II.—*Bookseller* who retails to the public	4 2	6 0	44 —
——— Or, ...	4 6	6 0	33⅓ —

No. I. the *Publisher*, is a bookseller; he is, in fact, the author's agent. His duties are to receive and take charge of the stock, for which he supplies warehouse-room; to advise the author about the times and methods of advertising; and to insert the advertisements. As he publishes other books, he will advertise lists of those sold by himself; and thus, by combining many in one advertisement, diminish the expense to each of his principals. He pays the author only for the books actually sold, consequently, he makes no outlay of capital, except that which he pays for advertisements: but he is answerable for any bad debts he may make in disposing of them. His charge is usually ten per cent. on the returns.

No. II. is the *Bookseller* who retails the work to the public. On the publication of a new book, the publisher sends round to the trade, to receive subscriptions from them for any number of copies not less than two. These copies are usually charged to the subscribers, on an average, at about four or five per cent. less than the wholesale price of the book: in the present case they pay 4*s*. 2*d*. for each copy. After the day of publication, the price charged by the publisher to the booksellers is 4*s*. 6*d*. Different publishers offer different terms to the subscriber; and it is usual, after intervals of about six months, for the publisher again to open a subscription list, so that if the work be one for which there is a steady demand, the trade avail themselves of these opportunities of purchasing, at the reduced rate, enough to supply their probable demand.

(296.) The volume thus purchased of the publisher at 4*s*. 2*d*. or 4*s*. 6*d*. is retailed by the bookseller to the public at 6*s*. In the one case he makes a profit of forty-four, in the other of thirty-three per cent. Even the smaller of these two rates of profit, on the capital employed, certainly appears to be too large. It sometimes happens that when a purchaser inquires for a book, the retail dealer sends across the street to the wholesale agent, and receives, for this trifling service, one fourth part of the money the purchaser pays; and perhaps the retail dealer also takes six months' credit for the price which the volume actually cost him. It is stated that all retail booksellers allow to their customers a discount of ten per cent. upon orders above 20*s*., and that, therefore, the nominal profit of forty-four or thirty-three per cent. is considerably reduced. If this is the case, it may fairly be inquired why the price of 2*l*. for example, is printed upon the back of a book, when every bookseller is ready to sell it at 1*l*. 16*s*., and why those who are unacquainted with that circumstance, should be made to pay more than others who are better informed? Another reason has been assigned for the great profit charged upon books, namely, that the purchasers take long credit. This is probably a fact, and admitting it, no reasonable person can object to a proportionate increase of price. But certainly, it is equally clear, that gentlemen who do pay ready money, should not be charged the same price as those who defer their payments to a very remote period. In the country, there is a greater appearance of reason for a considerable allowance between the retail dealer and the public; because the profit of the country bookseller will be diminished by the expense of the conveyance of the books from London: but even in this case, it appears to be too large, when compared with the rate of interest which capital produces in other trades.

(297.) That the profit in retailing books is really too large, is proved by two circumstances: — First, That the same nominal rate of profit has existed in the bookselling trade for a long series of years, notwithstanding the great fluctuations in the rate of profit on capital invested in every other business. Secondly, That, until very lately, a multitude of booksellers in all parts of London, were willing to be satisfied with a much smaller profit, and to sell, for ready money, or at short credit, to persons of undoubted character, at a profit of only ten per cent., and in some instances even at a still smaller percentage, instead of that of twenty-five per cent. on the published prices.

It cannot be pretended that this high rate of profit is necessary to cover the risk of the bookseller having some copies left on his shelves; because he need not buy of the publisher a single copy more than he has orders for: and even if he do purchase more at the subscription price, he proves, by that very purchase, that he himself does not estimate that risk at above from four to eight per cent. It should also be remarked, that the publisher is generally a retail, as well as a wholesale, bookseller; and that, besides the profit which he realises on every copy sold by him in his capacity of agent, he is allowed to charge the author as if every copy had been subscribed for at 4*s.* 2*d.*, and of course he receives the same profit as the rest of the trade for those retailed in his shop.

(298.) Now, a certain number of the London booksellers, have combined together. One of their objects is to prevent any bookseller from selling a book at less than ten per cent. under the published price; and in order to enforce this principle, they refuse to sell books, except at the publishing price, to any bookseller who declines signing their agreement. By degrees, many were prevailed upon to join this combination; and the effect of the exclusion it inflicted, left the small capitalist no option between signing or having his business destroyed.

Ultimately, nearly the whole trade, comprising about two thousand four hundred persons, have signed the agreement.

As might be naturally expected from an agreement so injurious to many of the parties to it, disputes have arisen; several booksellers have been placed under the ban of the combination, who allege that they have not violated its rules, and who accuse the opposite party of using spies, &c. to entrap them.

(299.) The origin of this combination has been explained by Mr. Pickering, of Chancery-lane, himself a publisher, in a printed statement entitled, BOOKSELLERS' MONOPOLY.

The following list of booksellers has been copied from that printed at the head of each of the cases published by Mr. Pickering, of the booksellers who form the committee for conducting this combination:—

Allen, J., 7, Leadenhall-street.
Arch, J., 61, Cornhill.
Baldwin, R., 47, Paternoster-row.
Booth, J.
Duncan, J., 37, Paternoster-row.
Hatchard, J., Piccadilly.
Marshall, R., Stationers' Court.
Murray, J., Albemarle-street.
Rees, O., 39, Paternoster-row.
Richardson, J. M., 23, Cornhill.
Rivington, J., St. Paul's Church-yard.
Wilson, E., Royal Exchange.

(300.) In whatever manner the profits are divided between the publisher and the retail bookseller, the fact remains, that the reader has paid for the volume in his hands 6*s.*, and that the author will receive only

3*s*. 10*d*.; out of which latter sum, the expense of printing the volume must be paid; so that in passing through two hands this book has produced a profit of forty-four per cent. This excessive rate of profit has drawn into the book trade a larger share of capital than was really advantageous; and the competition between the different portions of that capital has naturally led to the system of underselling, to which the committee above-mentioned are endeavouring to put a stop.*

There are two parties who chiefly suffer from this combination,—the public and authors. The first party can seldom be induced to take an active part against any grievance; and in fact, little is required from it, except a cordial support of the authors, in any attempt to destroy a combination so injurious to the interests of both.

Many an industrious bookseller would be glad to sell for 5*s*. the volume which the reader holds in his hand, and for which he has paid 6*s*.; and, in doing so for *ready money*, the tradesman who paid 4*s*. 6*d*. for the book, would realise, without the least risk, a profit of eleven per cent. on the money he had advanced. It is one of the objects of the combination we are discussing, to prevent the small capitalist from employing his capital at that rate of

* The Monopoly Cases, Nos. 1, 2, and 3, of those published by Mr. Pickering, should be consulted; and, as the public will be better able to form a judgment by hearing the other side of the question, perhaps the Chairman of the Committee (Mr. Richardson) would print those Regulations respecting the trade, a copy of which, Mr. Pickering states, is refused by the Committee *even to those who sign them.*

profit which he thinks most advantageous to himself; and such a proceeding is decidedly injurious to the public.

(301.) Having derived little pecuniary advantage from my own literary productions; and being aware, that from the very nature of their subjects, they can scarcely be expected to reimburse the expense of preparing them, I may be permitted to offer an opinion which I believe to be as little influenced by any expectation of advantage from the future, as it is by any disappointment at the past.

Before, however, we proceed to sketch the plan of a campaign against Paternoster-row, it will be fit to inform the reader of the nature of the enemies' forces, and of his means of attack and defence. Several of the great publishers find it convenient to be the proprietors of *Reviews*, *Magazines*, *Journals*, and even of *Newspapers*. The *Editors* are paid, in some instances very handsomely, for their superintendence; and it is scarcely to be expected that they should always mete out the severest justice on works by the sale of which their employers are enriched. The great and popular works of the day are, of course, reviewed with some care, and with deference to public opinion. Without this, the journals would not sell; and it is convenient to be able to quote such articles as instances of impartiality. Under shelter of this, a host of ephemeral productions are written into a transitory popularity; and by the aid of this process, the shelves of the booksellers, as well as the pockets of the public, are disencumbered. To such an extent are these means employed, that some of the periodical publications of the day ought to be regarded merely as *advertising machines.* That the reader may be in some measure on his guard against such modes of influencing his judgment, he should examine whether the work reviewed is published by the bookseller who is the proprietor of the review; a fact which can sometimes be ascertained from the title of the book as given at the head of the article. But this is by no means a certain criterion, because partnerships in various publications exist between houses in the book trade, which are not generally known to the public; so, that in fact, until Reviews are established in which booksellers have no interest, they can never be safely trusted.

(302.) In order to put down the combination of booksellers, no plan appears so likely to succeed as a counter-association of authors. If any considerable portion of the literary world were to unite and form such an association; and if its affairs were directed by an active committee, much might be accomplished. The objects of this union should be, to employ some person well skilled in the printing, and in the bookselling trade; and to establish him in some central situation as their agent. Each member of the association to be at liberty to place any, or all of his works in the hands of this agent for sale; to allow any advertisements, or list of books published by members of the association, to be stitched up at the end of each of his own productions; the expense of preparing them being defrayed by the proprietors of the books advertised.

The duties of the agent would be to retail to the public, for *ready money*, copies of books published by members of the association. To sell to the trade at prices agreed upon, any copies they may require. To cause to be inserted in the journals, or at the end of works published by members, any advertisements which the committee or authors may direct. To prepare a general catalogue of the works of members. To be the agent for any member of the association in treating respecting the printing of any work.

Such a union would naturally present other advantages; and as each author would retain the liberty of putting any price he might think fit on his productions, the public would still have the advantage of reduction in price produced by competition between authors on the same subject, as well as of that arising from a cheaper mode of publishing the volumes sold to them.

(303.) Possibly, one of the consequences resulting from such an association, would be the establishment of a good and an impartial Review, a work whose want has been felt for several years. The two long-established and celebrated Reviews, the unbending champions of the most opposite political opinions, are, from widely differing causes, exhibiting unequivocal signs of decrepitude and decay. The Quarterly advocate of despotic principles is fast receding from the advancing intelligence of the age; and the new strength and new position which that intelligence has acquired for itself, demands for its expression, new organs, equally the representatives of its intellectual power, and of its moral energies: whilst, on the other hand, the sceptre of its Northern rival has passed, from the vigorous grasp of those who established its dominion, into feebler hands.

A difficulty has been stated that those most competent to supply periodical criticism, are already engaged. But it is to be observed, that there are many who now supply literary criticisms to journals whose political principles they disapprove; and that if once a respectable and well-supported review* were established, capable of competing, in payment to its contributors, with the wealthiest of its rivals, it would very soon be supplied with the best materials the country can produce.†

* At the moment when this opinion as to the necessity for a new Review was passing through the press, I was informed that the elements of such an undertaking were already organized.

† It has been suggested to me, that the doctrines maintained in this chapter may subject the present volume to the opposition of that combination which it has opposed. I do not entertain that opinion; and for this reason, that the booksellers are too shrewd a class to supply such an admirable passport to publicity. But should my readers take a different view of the question, they can easily assist in remedying the evil, by each mentioning the existence of this little volume to two of his friends.

CHAP. XXX.

ON THE EFFECT OF TAXES AND OF LEGAL RESTRICTIONS UPON MANUFACTURES.

(304.) As soon as a tax is put upon any article, the ingenuity of those who make, and of those who use it, is directed to the means of evading as large a part of that tax as they can; and this may often be accomplished in ways that are perfectly fair and legal. An excise duty exists at present of 3*d.** per pound upon all writing-paper. The effect of this impost is, that much of the paper which is employed, is made extremely thin, in order that the weight of a given number of sheets may be as small as possible. Soon after the first imposition of the tax upon windows, which depended upon their number, and not upon their size, new-built houses began to have fewer windows and of a larger size than before. Staircases were lighted by extremely long windows, illuminating three or four flights of stairs. When the tax was increased, and the *size* of windows charged as single was limited, then still greater care was taken to have as few windows as possible, and internal lights became frequent. These internal lights in their turn became the subject of taxation; but it was easy to evade

* Twenty-eight shillings per cwt. for the finer, twenty-one shillings per cwt. for the coarser papers.

the discovery of them, and in the last act of parliament, reducing the assessed taxes, they ceased to be chargeable.

From the changes thus successively introduced in the number, the forms, and the positions of the windows, a tolerable guess might, in some instances, be formed of the age of a house.

(305.) The effects of regulations of excise upon our home manufactures are often productive of inconvenience; and check, in some measure, the natural progress of improvement. It is frequently necessary, for the purposes of revenue, to oblige manufacturers to take out a license, and to compel them to work according to certain rules, and to make stated quantities at each operation. When these quantities are large, as they usually are, they deter manufacturers from making experiments upon new materials: they likewise prevent them from discovering by trial, improved methods of conducting their processes. Difficulties of this nature have occurred in experimenting upon glass for optical purposes; and in this case, permission has been obtained by fit persons to make the experiments, without the interference of the excise. It ought, however, to be remembered, that such permission, if frequently granted, might be abused; and that the greatest protection against such an abuse will be found, in bringing the force of public opinion to bear upon scientific men,—and thus enabling the proper authorities, although themselves but moderately conversant with science, to judge of the propriety of the permission, by the public character of the applicant.

(306.) From the evidence given, in 1808, before the Committee of the House of Commons, *On Distillation from Sugar and Molasses*, it appeared that, by a different mode of working from that prescribed by the Excise, the spirits from a given weight of corn, which then produced eighteen gallons, might easily have been increased to twenty gallons. Nothing more was required than to make what is called the *wash* weaker; the consequence of which is, that fermentation goes on to a greater extent. It was stated, however, that such a deviation would render the collection of the duty liable to great difficulties; and that it would not benefit the distiller much since his price was enhanced to the customer by any increase of expence in the fabrication. Here then was an instance in which a quantity, amounting to one-ninth of the total produce, was actually lost to the country. A similar effect arises in the coal-trade, from the effect of a duty; for, according to the evidence before the House of Commons, it appears that a considerable quantity of the very best coal is actually wasted. The amount of waste is very various in different mines; but in some cases it amounts to one-third.

(307.) The effects of duties upon the import of foreign manufactures are equally curious. A singular instance occurred in the article *bar-iron*, which was liable to a duty of 140 per cent. *ad valorem*, on introduction into the United States, whilst that upon *hardware* was 25 per cent. In consequence of this tax, large quantities of malleable iron rails for rail-roads were imported into America under the denomination of hardware; and the difference of 115 per cent. in duty more than counter-balanced the expense of fashioning the iron into rails prior to its importation.

(308.) Duties, drawbacks, and bounties, when considerable in amount, are all liable to objections of a very serious nature, from the frauds to which they give rise. It has been stated before Committees of the House of Commons, that calicoes made up in the form, and with the appearance of linen, have frequently been exported for the purpose of obtaining the bounty. The calico made up in this way sells at 1*s*. 4*d*. per yard, whereas linen of equal fineness is worth from 2*s*. 8*d*. to 2*s*. 10*d*. per yard. It appeared from the evidence, that one house in six months sold five hundred such pieces.

In all cases heavy duties, or prohibitions, are ineffective as well as injurious; for unless the articles excluded are of very large dimensions, there constantly arises a price at which they will be clandestinely imported by the smuggler. The extent, therefore, to which smuggling can be carried, should always be considered in the imposition of new duties, or in the alteration of old ones. Unfortunately it has been pushed so far, and is so systematically conducted, that the price per cent. at which most contraband articles can be procured from France is well known. From the evidence of Mr. Galloway, it appears that, from 30 to 40 per cent. was the rate of insurance on exporting prohibited machinery from England, and that the larger the quantity the less was the per-centage demanded.

(309.) In examining into the effect produced, or to be apprehended from any particular mode of taxation, it is neoessary to inquire a little into the interests of the parties who approve of the plan in question, as well as of those who object to it. Instances have occurred where the persons paying a tax into the hands of government have themselves objected to any reduction. This happened in the case of one class of calico-printers, whose interest was injured by a removal of the tax on the printing. They received from the manufacturers, payment for the duty, about two months before they were called on to repay it to government: the consequence was, that a considerable capital always remained in their hands. The evidence which states this circumstance is well calculated to promote a reasonable circumspection in such inquiries.

"Do you happen to know any thing of an opposition "from calico printers to the repeal of the tax on printed "calicoes?

"I have certainly heard of such an opposition, and I am "not surprised at it. There are a very few individuals "who are, in fact, interested in the non-repeal of the tax: "there are two classes of calico printers; one, who print "their own cloth, send their goods into the market, and "sell them on their own account; they frequently advance "the duty to government, and pay it in cash before their "goods are sold, but generally before the goods are paid "for, being most commonly sold on a credit of six months: "they are of course interested on that account, as well as "on others that have been stated, in the repeal of the tax. "The other class of calico printers print the cloth of other "people; they print for hire, and on re-delivery of the "cloth when printed, they receive the amount of the duty, "which they are not called upon to pay to government "sooner, on an average, than nine weeks from the stamping "of the goods. Where the business is carried on upon a "large scale, the arrears of duty due to government often "amount to eight, or even ten thousand pounds, and furnish "a capital with which these gentlemen carry on their "business; it is not, therefore, to be wondered at that they "should be opposed to the prayer of our petition."

(310.) The policy of giving Bounties, and of enforcing restrictions against foreign articles, which can be produced more cheaply in other countries, is of a very questionable nature: and, except for the purpose of introducing a new manufacture in a country where there is not much commercial or manufacturing spirit, is scarcely to be defended. All incidental modes of taxing one class of the community, the consumers, to an unknown extent, for the sake of supporting another class, the manufacturers, who would otherwise abandon that mode of employing their capital, are highly objectionable. One part of the price of any article which is so produced, consists of the expenditure, together with the ordinary profits of capital: the other part of its price may be looked upon as charity, given to induce the manufacturer to continue an unprofitable use of his capital, in order to give employment to his workmen. Now, in many instances, if the actual amount of the latter part of the price were known, the extent of the payment made by consumers, on account of restrictions only, would astonish *even those who advocate them;* and it would be evident to both parties, that the employment of capital in that particular trade ought to be abandoned.

(311.) The restriction of articles produced in a manufactory to certain sizes, is attended with an economical effect. This arises chiefly from the smaller number of different tools required in making them, as well as from less frequent change in the adjustment of those tools. A similar economy prevails in the navy; by having ships divided into a certain number of classes, each of which comprises vessels of the same dimensions, the rigging made for one vessel will fit any other of its class.

(312.) The effects of the removal of a monopoly are often very important, and they were perhaps never more remarkable than in the bobbin-net trade, in the years 1824 and 1825. These effects were, however, considerably enhanced by the general rage for speculations which was so prevalent during that singular period. One of the patents of Mr. Heathcote for a bobbin-net machine had expired, whilst another, for an improvement in a particular part of such machines, called a *turn-again*, had yet a few years to run. Many licenses had been granted to use the former patent, which were charged at the rate of about five pounds per annum for each quarter of a yard in width, so that what is termed *a six-quarter frame*, (which makes bobbin-net a yard and a half wide), paid thirty pounds a year. The second patent was ultimately abandoned in August, 1823, infringements of it having taken place.

The bobbin-net machine occupies little space; and is, from that circumstance, well adapted for a domestic manufacture. It had also hitherto yielded a very large profit; it was therefore not surprising that, on the removal of the monopoly arising from this patent, a multitude of persons became desirous of embarking in the trade. The machines which already existed, were principally in the hands of the manufacturers; but, a kind of mania for obtaining them seized on persons of all descriptions, who could raise a small capital; and, under its influence, butchers, bakers, small farmers, publicans, gentlemen's servants, and, in some cases, even clergymen, became anxious to possess bobbin-net machines.

Some few machines were rented; but, in most of these cases, the workman purchased the machine he employed, by instalments of from 3*l.* to 6*l.* weekly, for a *six-quarter machine;* and many individuals, unacquainted with the mode of using the machines so purchased, paid others of more experience for instructing them in their use; 50*l.* or 60*l.* being sometimes given for this instruction. The success of the first speculators induced others to follow the example; and the machine-makers were almost overwhelmed with orders for lace-frames. Such was the desire to procure them, that many persons deposited a large part, or the whole, of the price, in the hands of the frame-makers, in order to insure their having the earliest supply. This, as might naturally be expected, raised the price of wages amongst the workmen employed in machine-making; and the effect was felt at a considerable distance from Nottingham, which was the centre of this mania. Smiths not used to *flat filing*, coming from distant parts, earned from 30*s.* to 42*s.* per week. Finishing smiths, accustomed to the work, gained from 3*l.* to 4*l.* per week. The forging smith, if accustomed to his work, gained from 5*l.* to 6*l.* per week, and some few earned 10*l.* per week. In making what are technically called *insides*, those who were best paid, were generally clock and watch makers, from all the districts round, who received from 3*l.* to 4*l.* per week. The *setters-up* persons, who put the parts of the machine together, charged 20*l.* for their assistance; and, a *six-quarter machine*, could be put together in a fortnight or three weeks.

Good workmen, being thus induced to desert less profitable branches of their business, in order to supply this extraordinary demand, the masters, in other trades, soon found their men leaving them, without being aware of the immediate reason; some of the more intelligent, however, ascertained the cause; and went from Birmingham to Nottingham, in order to examine into the circumstances which had withdrawn almost all the journeymen clockmakers from their own workshops. It was soon apparent, that the men who had been making clocks at Birmingham, at the rate of 25*s.* a week, could earn 2*l.* by working at lace-frame-making at Nottingham.

On examining the nature of this profitable work, the clock-makers perceived that one part of the bobbin-net machines, that which held the bobbins, could be easily made in their own workshops. They therefore contracted with the machine-makers, who had already more work ordered than they could execute, to supply the *bobbin-carriers*, at a price which enabled them, on their return home, to give such increased wages as should retain their own workmen, as well as yield themselves a good profit. Thus an additional facility was afforded for the construction of these bobbin-net machines. The conclusion was not difficult to be foreseen; the immense supply of bobbin-net thus poured into the market, speedily reduced its price. This reduction in price, rendered the machines by which the net was made, less valuable; some few of the earliest producers, for a short time, carried on a profitable trade; but multitudes were disappointed, and many ruined. The low price at which the fabric sold, together with its lightness and beauty, combined to extend the sale, and ultimately, new improvements in the machines, rendered the older ones still less valuable.

(313.) The bobbin-net trade is at present, both extensive and increasing; and, as it may, probably, at some future time, claim a larger portion of public attention, it will be interesting to describe briefly its actual state.

A lace-frame *at the present day*, on the most improved principle, manufacturing a piece of net two yards wide, when worked night and day, will produce six hundred and twenty *racks* per week. A *rack* is two hundred and forty holes; and as in the machine to which we refer, three *racks* are equal in length to one yard, it will produce twenty-one thousand four hundred and ninety-three square yards of bobbin-net annually. Three men keep this machine constantly working; and, they were paid by piece-work about 25*s.* each per week in 1830. Two boys, working only in the day-time, can prepare the bobbins for this machine, and are paid from 2*s.* to 4*s.* per week, according to their skill. Forty-six square yards of this net weigh two pounds three ounces; so that each square yard weighs a little more than three-quarters of an ounce.

For a condensed and general view of the present state of this trade, we shall avail ourselves of a statement by Mr. William Felkin, of Nottingham, entitled "*Facts and Calculations illustrative of the* "*Present State of the Bobbin-net Trade*," dated September, 1831. It appears to have been collected with care, and contains, in a single sheet of paper, a body of facts of the greatest importance.*

(314.) The total capital employed in the factories, for preparing the cotton, in those for weaving the bobbin-net, and in various processes to which it is subject, is estimated at above 2,000,000*l*., and the number of persons who receive wages, at above two hundred thousand.

" *Comparison of the Value of the Raw Material imported with*
" *the Value of the Goods manufactured therefrom.*

" Amount of Sea Island cotton annually used " 1,600,000lbs., value 120,000*l*. ; this is manufac- " tured into yarn, weighing 1,000,000lbs., value " 500,000*l*.

" There is also used 25,000lbs. of raw silk, which " costs 30,000*l*., and is doubled into 20,000lbs. " thrown, worth 40,000*l*.

RAW MATERIAL.	MANU-FACTURE.	SQUARE YARDS PRODUCED.	Value per Sq. Yd.		TOTAL VALUE.
			s.	*d.*	£
Cotton, 1,600,000 *lbs.*	Power Net .	6,750,000	1	3	421,875†
	Hand ditto .	15,750,000	1	9	1,378,125‡
	Fancy ditto	150,000	3	6	26,250
Silk, 25,000 *lbs.*	Silk Goods .	750,000	1	9	65,625
		23,400,000			1,891,875

* I cannot omit the opportunity of expressing my hope that this example will be followed by other trades; since by such means we shall obtain a body of information equally important to the workman, the capitalist, the philosopher, and the statesman.

† Being on an average " coarse 11-point," and nearly all in plain net.

‡ Being on an average " fine 11-point," and two-thirds in " quillings."

" The brown nets which are sold in the Notting-
" ham market, are in part disposed of by the agents
" of twelve or fifteen of the larger makers, *i. e.* to the
" amount of about 250,000*l.* a year. The principal
" part of the remainder, *i. e.* about 1,050,000*l.* a
" year, is sold by about two hundred agents, who
" take the goods from one warehouse to another for
" sale.

" Of this production, about half is exported in
" the unembroidered state, and in the white princi-
" pally ; yet a large quantity is sent in the unbleached
" state, and is embroidered abroad, and much is
" figured in the white on the continent. So that
" it is probable that as much is figured abroad as at
" home ; and this principally on account of wages
" being lower there than here, notwithstanding the
" low rate of embroiderers' earnings in this country.
" This foreign embroidery is chiefly done in Belgium,
" Saxony, and until recently, Poland. The exports
" of bobbin-net are in great part to Hamburgh, for
" sale at home and at Leipzic and Frankfort fairs,
" Antwerp, and the rest of Belgium ; to France,
" by contraband ; to Italy, and North and South
" America. Though a very suitable article, yet the
" quantity sent eastward of the Cape of Good Hope,
" has hitherto been too trifling for notice. Three-
" eighths of the whole production are sold unem-
" broidered at home. The remaining one-eighth is
" embroidered in this country, and increases the
" ultimate value as under, *viz.*

Embroidery.	Increases Value.	Ultimate Worth.
	£.	£.
" On power net	131,840	553,715
" On hand net	1,205,860	2,583,985
" On fancy net	78,750	105,000
" On silk net	109,375	175,000
Total embroidery, wages, and profit,	1,525,825	Ultimate total value 3,417,700

" From this it appears, that in the operations of " this trade, which had no existence twenty years " ago, 120,000*l.* original cost of cotton becomes, " when manufactured, of the ultimate value of " 3,242,700*l.* sterling.

" There are about seventy houses engaged chiefly " in embroidering goods, and about seventy houses " engaged in the preparation and sale of plain goods " principally. The *cash* paid to small owners, for " the purchase of hand nets, about equals the amount " of capital created by the credit given in this market " by the power-net manufacturers.

" As to weekly wages paid, I hazard the following " as the judgment of those conversant with the " respective branches, *viz.*

" In fine spinning and doubling, adults 25*s.*; " children 7*s.*: work twelve hours per day.

" In bobbin-net making; men working machines, " 18*s.*; apprentices, youths of fifteen or more, 10*s.*; " by power, fifteen hours; by hand, eight to twelve " hours, according to width.

" In mending; children 4*s.*: women 8*s.*; work " nine to fourteen hours, *ad libitum.*

" In winding, threading, &c., children and young

" women, 5*s.*; irregular work, according to the pro-
" gress of machines.

" In embroidery; children, seven years old and " upwards, 1*s.* to 3*s.*; work ten to twelve hours; " women, if regularly at work, 5*s.* to 7*s.* 6*d.*; twelve " to fourteen hours.

" As an example of the effect of the wages of lace " embroidery, &c. it may be observed, it is often the " case that a stocking weaver in a country village " will earn only 7*s.* a week, and his wife and children " 7*s.* to 14*s.* more at the embroidery frame."

(315.) The principal part of the hand-machines employed in the bobbin-net manufacture are worked in shops, forming part of, or attached to private houses. The subjoined list will show the kinds of machinery employed, and classes of persons to whom it belongs.

Bobbin-net Machinery now at work in the Kingdom.

Hand Levers	6-quarter	500	
	7-quarter	200	
	8-quarter	300	
	10-quarter	300	
	12-quarter	30	
	16-quarter	20	
	20-quarter	1	
			1351
Hand Rotary	10-quarter	50	
	12-quarter	50	
			100
Hand Circulars,	6-quarter	100	
	7-quarter	300	
	8-quarter	400	
	9-quarter	100	
	10-quarter	300	
	12-quarter	100	
			1300

Hand Traverse, Pusher, Straight Bolt, &c. averaging 5-quarters			750
Total, hand machines			3501
Power	6-quarter	100	
	7-quarter	40	
	8-quarter	350	
	10-quarter	270	
	12-quarter	220	
	16-quarter	20	
Total power machines			1000
Total number of Machines			4501

700 persons own	1 machine,	700 machines.
226	2	452
181	3	543
96	4	384
40	5	200
21	6	126
17	7	119
19	8	152
17	9	153
12	10	120
8	11	88
6	12	72
5	13	65
5	14	70
4	16	64
25 own respectively 18, 19, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 35, 36, 37, 50, 60, 68, 70, 75, 95, 105, 206		1192
Number of owners of machines 1382		Holding together 4500 machines.

The hand workmen consist of the above-named owners	1000
And of journeymen and apprentices	4000
	5000

These Machines are distributed as follows:

Nottingham	1240
New Radford	140
Old Radford and Bloomsgrove	240
Ison Green	160
Beeston and Chilwell	130
New and Old Snenton	180
Derby and its vicinity	185
Loughborough and its vicinity	385
Leicester	95
Mansfield	85
Tiverton	220
Barnstable	180
Chard	190
Isle of Wight	80
In sundry other places	990
	4500

" Of the above owners, one thousand work in their " own machines, and enter into the class of journey- " men as well as that of masters in operating on the " rate of wages. If they reduce the price of their " goods in the market, they reduce their own wages " first; and, of course, eventually the rate of wages " throughout the trade. It is a very lamentable " fact, that one-half, or more, of the one thousand " one hundred persons specified in the list as own- " ing one, two, and three machines, have been " compelled to mortgage their machines for more " than their worth in the market, and are in many " cases totally insolvent. This has chiefly arisen

" from the fall in prices of nets beyond the reduction " in the prices of cotton and wages. This class " of persons having become indebted to the cotton " merchant, have been compelled to pay a com- " paratively excessive price for the thread they have " used, and to sell their goods at the lowest prices " of the market. Besides, their machines are princi- " pally narrow and making short pieces, while the " absurd system of bleaching at so much a piece " goods of all lengths and widths, and dressing at " so much all widths, has caused the new machines " to be all wide, and capable of producing long " pieces; of course to the serious disadvantage, " if not utter ruin, of the small owner of narrow " machines.

" It has been observed above, that wages have " been reduced, say 25 per cent. in the last two " years, or from 24*s*. to 18*s*. a week. Machines " have increased in the same time one-eighth in " number, or from four thousand to four thousand " five hundred, and one-sixth in capacity of produc- " tion. It is deserving the serious notice of all " proprietors of existing machines, that machines " are now introducing into the trade of such power " of production as must still more than ever depre- " ciate (in the absence of an immensely increased " demand) the value of their property, have a direct " tendency to sink the small owners into journeymen, " and either greatly increase the labour, or depreciate " the workman's wages. It is a curious fact, as " illustrative of the progress of machinery, that there " are bobbin-net machines, which being worked by " three men, six hours each, or eighteen hours per "day, are turning off twenty thousand square yards "of good net per annum. Now it is not to be fairly "denied, that such machines being multiplied to "some extent, must, with only the actual demand, "lower even the present trifling value of the six- "teen hundred or seventeen hundred narrow hand- "machines, one half or more, and reduce the rate of "wages of those who work in them one-third, and "that of the remaining hand-machine workmen at "least one-fourth; or, which is the same thing, compel them to increase their labour in the same proportion."

(316.) From this abstract, we may form some judgment of the importance of the bobbin-net trade. But the extent to which it bids fair to be carried in future, when the eastern markets shall be more open to our industry, may be conjectured from the fact which Mr. Felkin subsequently states,—that, "We "can export a durable and elegant article in cotton "bobbin-net, at 4*d.* per square yard, proper for cer- "tain useful and ornamental purposes, as curtains, "&c.; and another article used for many purposes "in female dress at 6*d.* the square yard."

(317.) *Of Patents.* In order to encourage the importation, the improvement, or the invention of machines, and discoveries relating to manufactures, it has been the practice in many countries, to grant to the first introducers, an exclusive privilege for a term of years. Such monopolies are termed Patents; and they are granted, on the payment of certain fees, for different periods, from five to twenty years.

The following table, compiled from the Report of the Committee of the House of Commons "*on*

Patents," 1829, shows the expense and duration of patents in various countries :—

COUNTRIES.	EXPENSE.	TERM OF YEARS.	Number granted in Six Years, ending in 1826.—(*Rep.* p. 243.)
	£ s. d.		
England	120 0 0	14	914
Ireland	125 0 0	14	. . . .
Scotland	100 0 0	14	. . . .
America	6 15 0	14	. . . .
France	12 0 0 32 0 0 60 0 0	5 10 15	1091
Netherlands	£6 to £30	5, 10, 15	. . . .
Austria	42 10 0	15	1099
Spain*—Inventor	20 9 4	15	. . . .
„ Improver	12 5 7	10	. . . .
„ Importer	10 4 8	6	. . . .

(318.) It is clearly of importance to preserve to each inventor the sole use of his invention, until he shall have been amply repaid for the risk and expense to which he has been exposed, as well as for the talent he has exerted. But, the varieties in the degree of merit are so numerous, and the difficulties of legislating upon the subject are so great, that it has been found almost impossible to frame a law which shall not, practically, be open to the most serious objèctions.

* The expense of a patent in Spain is stated in the Report to be respectively 2000, 1200, and 1000 reals. If these are reals of *Vellon*, in which accounts are usually kept at Madrid, the above sums are correct; but if they are reals of *Plate*, the above sums ought to be nearly doubled.

The difficulty of defending an English patent in any judicial trial, is very great; and the number of instances on record in which the defence has succeeded, are comparatively few. This circumstance has induced some manufacturers, no longer to regard a patent as a privilege by which a monopoly price may be secured; but they sell the patent article at such a price, as will merely produce the ordinary profits of capital; and thus secure to themselves the fabrication of it, because no competitors can derive a profit from invading a patent so exercised.

(319.) The law of Copyright, is, in some measure, allied to that of Patents ; and it is curious to observe, that those species of property which require the highest talent, and the greatest cultivation,—which are, more than any other, the pure creations of mind, should have been the latest to be recognized by the state. Fortunately, the means of deciding on an infringement of property in regard to a literary production, are not by any means difficult; but the present law is, in some cases, productive of considerable hardship, as well as impediment to the advancement of knowledge.

(320.) Whilst discussing the general expediency of limitations and restrictions, it may be desirable to point out one which seems to promise advantage, although it is by no means free from grave objections. The question of permitting by law, partnerships in which the responsibility of one or more of the partners is limited in amount, is peculiarly important in a manufacturing, as well as a commercial point of view. In the former light, it appears calculated to aid that division of labour, which we have already proved to be as advantageous in mental as it is in bodily operations; and it might possibly give rise to a more advantageous distribution of talent, and its combinations, than at present exists. There are in this country, many persons possessed of moderate capital, not themselves enjoying the power of invention in the mechanical and chemical arts, but who are tolerable judges of such inventions, and who are also excellent judges of human character. Such persons might, with great success, employ themselves in finding out inventive workmen, whose want of capital prevents them from realizing their projects. If they could enter into a limited partnership with persons so circumstanced, they might restrain within proper bounds the imagination of the inventor, and by supplying capital to judicious schemes, render a service to the country, and secure a profit for themselves.

(321.) Amongst the restrictions intended for the general benefit of our manufacturers, there existed one by which workmen were forbidden to go out of the country. A law so completely at variance with every principle of liberty, ought never to have been enacted. It was not, however, until experience had convinced the legislature of its inefficiency, that it was repealed. When, after the last war, the renewed intercourse between England and the continent became extensive, it was soon found that it was impossible to discover the various disguises which the workmen could assume; and the effect of the law was rather, by the fear of punishment, to deter those who had left the country from returning, than to check their disposition to migrate.

CHAP. XXXI.

ON THE EXPORTATION OF MACHINERY.

(322.) A FEW years only have elapsed since our workmen were not merely prohibited by act of Parliament from transporting themselves to countries in which their industry would produce for them higher wages, but it was forbidden to export the greater part of the machinery which they were employed to manufacture at home. The reason assigned for this prohibition was, the apprehension that foreigners might avail themselves of our improved machinery, and thus compete with our manufacturers. It was, in fact, a sacrifice of the interests of one class of persons, the makers of machinery, for that of another class, those who use it. Now, independently of the impolicy of interfering unnecessarily between these two classes it may be observed, that the first class, or the makers of machinery, are, as a body, far more intelligent than those who only use it; and although, at present, they are not nearly so numerous, yet, when the removal of the prohibition which cramps their ingenuity shall have had time to operate, there appears good reason to believe, that their numbers will be greatly increased; and that it may, in time, surpass that of those who use machinery.

(323.) The advocates of these prohibitions seem to rely greatly upon the possibility of preventing the knowledge of new contrivances being conveyed from one country to another; and they appear to take much too limited a view of the possible, and even probable, improvements in mechanics. For the purpose of examining the question, let us consider the case of two manufacturers of the same article, one situated in a country in which labour is very cheap, the machinery bad, and the modes of transport slow and expensive; the other engaged in manufacturing in a country in which the price of labour is very high, the machinery excellent, and the means of transport expeditious and economical. Let them both send their produce to the same market, and let each receive such a price as shall give to him the profit ordinarily produced by capital in his own country. It is almost certain that in such circumstances the first improvement in machinery will occur in the country which is most advanced in civilization; because, even admitting that the ingenuity to contrive were the same in the two countries, the means of execution are very different. The effect of improved machinery in the rich country will be perceived in the common market, by a small fall in the price of the manufactured article. This will be the first intimation to the manufacturer of the poor country, who will endeavour to meet the diminution in the selling price of his article by increased industry and economy in his factory; but he will soon find that this remedy is temporary, and that the market-price continues to fall. He will thus be induced to examine the rival fabric, in order to detect from its structure any improved mode of making it. If, as would most usually happen, he should be unsuccessful in this attempt, he will be forced to endeavour to contrive some improvement in his machinery, or to acquire information respecting that which has taken place in the factories of the richer country. Perhaps after an ineffectual attempt to attain by letters the information he requires, he sets out to visit the factories of his rivals. To a foreigner and rival manufacturer such establishments are not easily accessible; and the more recent the improvement, the less likely he will be to gain access to them. His next step, therefore, will be to obtain the knowledge he is in search of from the workmen employed in using or making the machines. Without *drawings* or an examination of the *machines* themselves, this process will be slow and tedious; and he will be liable after all to be deceived by artful and designing workmen, and be exposed to many chances of failure. But suppose he returns to his own country with perfect drawings and instructions, he must then begin to construct his improved machines: and these he cannot execute either so cheaply or so well as his rivals in the richer country; but after the lapse of some time, we shall suppose them to be completed and in working order.

Let us now consider what will have occurred to the manufacturer in the rich country. He will, in the first instance, have realized a profit by supplying the home market, at the usual price, with an article which it costs him less to produce; he will then reduce the price both in the home and foreign market in order to produce a more extended sale. It is in this stage that the manufacturer in the poor country first feels the effect of the competition; and if we suppose that from the first application of the new improvement in the rich country, and the commencement of its employment in the poor country only two or three years elapse, yet will the manufacturer who contrived the improvement, even supposing that during the whole of this time he has made only one step, have realized so large a portion of the outlay which it rendered necessary, that he will now be in a state to make a much greater reduction in the price of his produce, and thus render the gains of his rivals quite inferior to those which his own ingenuity has produced for himself.

(324.) It is contended that by admitting the exportation of machinery, foreign manfacturers will be supplied with machines equal to our own. Now the first answer to this argument which presents itself is supplied by almost the whole of the present volume, viz. *That in order to succeed in a manufacture, it is necessary not merely to possess good machinery, but that the domestic economy of the factory should be most carefully regulated.*

The truth, as well as the importance of this principle is so well established in the Report of a Committee of the House of Commons " On the Export of Tools " and Machinery," that I shall avail myself of the opinions and evidence there stated, before I offer any observations of my own:

" Supposing, indeed, that the same machinery " which is used in England could be obtained on the " Continent, it is the opinion of some of the most " intelligent of the witnesses that a want of arrange- " ment in foreign manufactories, of division of labour " in their work, of skill and perseverance in their

" workmen, and of enterprise in the masters, together " with the comparatively low estimation in which the " master-manufacturers are held on the Continent, " and with the comparative want of capital, and of " many other advantageous circumstances detailed in " the evidence, would prevent foreigners from inter- " fering in any great degree by competition with " our principal manufacturers ; on which subject the " Committee submit the following evidence as worthy " the attention of the House : —

' I would ask whether, upon the whole, you consider any ' danger likely to arise to our manufactures from competi- ' tion, even if the French were supplied with machinery ' equally good and cheap as our own ?—They will always be ' behind us until their general habits approximate to ours; ' and they must be behind us for many reasons that I have ' before given.

' Why must they be behind us ?—One other reason is, that ' a cotton manufacturer who left Manchester seven years ago, ' would be driven out of the market by the men who are now ' living in it, provided his knowledge had not kept pace with ' those who have been during that time constantly profiting ' by the progressive improvements that have taken place in ' that period; this progressive knowledge and experience is ' our great power and advantage.'

" It should also be observed, that the constant, " nay, almost daily, improvements which take place " in our machinery itself, as well as in the mode of " its application, require that all those means and ad- " vantages alluded to above, should be in constant " operation; and that, in the opinion of several of " the witnesses, although Europe were possessed of " every tool now used in the United Kingdom, along

" with the assistance of English artisans, which she " may have in any number, yet, from the natural and " acquired advantages possessed by this country, the " manufacturers of the United Kingdom, would for " ages continue to retain the superiority they now " enjoy. It is indeed the opinion of many, that if " the exportation of machinery were permitted, the " exportation would often consist of those tools and " machines, which, although already superseded by " new inventions, still continue to be employed, from " want of opportunity to get rid of them; to the " detriment, in many instances, of the trade and " manufactures of the country: and it is matter " worthy of consideration, and fully borne out by the " evidence, that by such increased foreign demand for " machinery, the ingenuity and skill of our workmen " would have greater scope; and that, important as " the improvements in machinery have lately been, " they might, under such circumstances, be fairly " expected to increase to a degree beyond all pre- " cedent.

" The many important facilities for the construc- " tion of machines and the manufacturing of com- " modities which we possess, are enjoyed by no other " country; nor is it likely that any country can " enjoy them to an equal extent for an indefinite " period. *It is admitted by every one, that our skill* " *is unrivalled; the industry and power of our people* " *unequalled; their ingenuity, as displayed in the con-* " *tinual improvement in machinery, and production of* " *commodities, without parallel; and apparently, with-* " *out limit.* The freedom which, under our govern- " ment, every man has, to use his capital, his labour,

" and his talents, in the manner most conducive to
" his interests, is an inestimable advantage; canals
" are cut, and rail-roads constructed, by the voluntary
" association of persons whose local knowledge en-
" ables them to place them in the most desirable
" situations; and these great advantages cannot
" exist under less free governments. These circum-
" stances, when taken together, give such a decided
" superiority to our people, that no injurious rivalry,
" either in the construction of machinery or the
" manufacture of commodities, can reasonably be an-
" ticipated."

(325.) But even if it were desirable to prevent the exportation of a certain class of machinery, it appears abundantly evident, that, whilst the exportation of other kinds is allowed, it is impossible to prevent the forbidden kind from being smuggled out; and that, in point of fact, the additional risk had been well calculated by the smuggler.

(326.) It would appear, also, that there are circumstances which show that the immediate exportation of improved machinery is not quite so certain as has been assumed; and that the powerful principle of self-interest will urge the makers of machinery to push its extension in a different direction. When a great maker of machinery has contrived a new machine for any particular process, or has made some great improvement on those in common use, to whom will he naturally apply for the purpose of selling his new machines? Undoubtedly, in by far the majority of cases, he will communicate the circumstance to his nearest and best customers, those to whom he has immediate and personal access, and whose capability to fulfil any contract is best known to him. He will communicate with them, and offer to take their orders for the new machine; nor will he think of writing to inform foreign customers, so long as he finds the home demand sufficient to employ the whole force of his establishment. Thus then, the machine-maker is himself interested in giving the first advantage of any new improvement to his own countrymen.

(327.) In point of fact, the machine-makers in London prefer home orders, and do usually charge an additional price to their foreign customers. Even the amount by which this preference is measured, may be found in the evidence before the Committee on the Export of Machinery. It is differently estimated by various engineers; but appears to vary from five up to twenty-five per cent. on the amount of the order. The reasons for this are:—1. If the machinery be complicated, one of their best men, well accustomed to the mode of work in the factory, must be sent out to put it up; and there is always a considerable chance of his having offers which will induce him to remain abroad. 2. If the work be of a more simple kind, and can be put up without an English workman, yet for the credit of the house which supplies it, and to prevent accidents which may occur from the want of sufficient instruction in those who use it, the parts are sometimes made stronger, and examined more attentively than they would be for an English purchaser. Any defect or accident also would be attended with more expense to repair, if it occurred abroad, than in England.

(328.) The class of workmen who make machinery, possess much more skill, and are paid much more highly than that class who merely use it; and, if a free exportation of machinery were allowed, this higher and more valuable class, would, undoubtedly, be greatly increased; for, notwithstanding the high price of wages, there is no country in which machinery can at this moment be made, either so well or so cheaply as in England. We might, therefore, supply the whole world with machinery, at an evident advantage, both to ourselves and our customers. In Manchester, and in the surrounding district, many thousand men are employed wholly in making machinery, which gives employment to many hundred thousands who use it; but the period is not very remote, when the whole number of those who then *made use* of machinery, was not greater than the number of those who now *manufacture* machines. Hence, then, if England should ever become a great exporter of machinery, she would necessarily contain a large class of workmen, to whom skill would be indispensable, and, consequently, to whom high wages would be paid; and although her manufacturers might probably be fewer in numbers, yet they would undoubtedly have the advantage of being the first to derive profit from improved machinery. Under such circumstances, any diminution in the demand for machinery, would, in the first instance, be felt by a class much better able to meet it, than the class which now suffers upon every check in the consumption of manufactured goods; and the resulting misery would therefore assume a mitigated character.

(329.) It has been feared, that when other countries have purchased our machines, they will cease to demand new ones. The statement which has been given of the usual progress in the improvement of the machinery employed in any manufacture, and of the average time which elapses before it is superseded by such improvements, is a complete reply to this objection. If our customers did not adopt the new machinery contrived by us as soon as they could procure it, then our manufacturers would extend their establishments, and undersell their rivals in their own markets.

(330.) It may also be urged, that in each kind of machinery a maximum of perfection may be imagined, beyond which it is impossible to advance; and certainly the last advances are usually the smallest when compared with those which precede them: but it should be observed, that these advances generally occur when the number of machines in employment is already large; and consequently, their effects on the power of producing are very considerable. But though it should be admitted that any individual species of machinery may arrive, after a long period, at a degree of perfection which would render further improvement nearly hopeless, yet it is impossible to suppose that this can be the case with all kinds of mechanism. In fact the limit of improvement is rarely approached, except in extensive branches of national manufactures, and the number of such branches is, even at present, very small.

(331.) Another argument in favour of the exportation of machinery, is, that *it would facilitate the transfer of capital to any more advantageous mode of employment which might present itself.* If the exportation of machinery were permitted, there would doubtless arise a considerable demand; and, supposing any particular branch of our manufactures to cease to produce the average rate of profit, the loss to the capitalist would be much less if a market were opened in which he could sell his machinery to customers more favourably circumstanced for its employment. If, on the other hand, new improvements in machinery should be imagined, the manufacturer would be more readily enabled to carry them into effect, by having the foreign market opened to him for the sale of his old machines. The fact that England can, notwithstanding her taxation, and her high rate of wages, undersell other nations, seems to be well established: and it appears to depend on the superior goodness and cheapness of those raw materials of machinery, the metals,—on the excellence of the tools,—and on the admirable arrangements of the domestic economy of our factories.

(332.) The different degrees of facility with which capital can be transferred from one mode of employment to another, has an important effect on the rate of profits in different trades and in different countries. Supposing every other cause, which influences the rate of profit at any period, to act equally on capital employed in different occupations, yet the real rates of profit would soon alter, on account of the different degrees of loss in removing it from one mode of investment to another, or any variation in the action of those causes. This principle will appear more clearly by taking an example. Let two capitalists have embarked 10,000*l.* each, in two trades: A in supplying a district with water, by means of a steam-engine and iron pipes; B in manufacturing bobbin-net.

The capital of A will be expended in building a house and erecting a steam-engine, which costs, say 3000*l.*; and in laying down iron pipes to supply his customers, costing, say 7000*l.* The greatest part of this latter expense is payment for labour; and if the pipes were to be taken up, the damage to them would render them of little value, except as old metal, whilst the expense of removing them would be considerable. Let us, therefore, suppose, that if A were obliged to give up his trade, he could only realize 4000*l.* by the sale of his stock. Let us suppose, that B, by the sale of his bobbin-net factory, and machinery, could realize 8000*l.* Further, let us suppose the usual rate of interest made on the capital employed by each is the same, say 20 per cent.: then we have

	Capital invested.	Money which would arise from sale of machinery.	Annual rate of profit per cent.	INCOME.
Water-works	£10,000	£4,000	£20	£2,000
Bobbin-net Factory	10,000	8,000	20	2,000

Now, if, from competition, or any other causes, the rate of profit arising from water-works should fall to 10 per cent., that circumstance would not cause a transfer of capital from water-works to bobbin-net making; because the reduced income from the water-works, 1000*l.* per annum, would still be greater than that produced by investing 4000*l.*, (the whole sum arising from the sale of the materials of the water-works), in a bobbin-net factory, which sum, at 20 per cent., would only yield 800*l.* per annum. In fact, the rate of profit, arising from the water-works, must be reduced below 8 per cent., before it would benefit the proprietor's income to remove his capital into the bobbin-net trade.

(333.) In any inquiry into the probability of the injury arising to our manufacturers from the competition of foreign countries, particular regard should be had to the facilities of transport, and to the existence in our own country of a mass of capital in roads, canals, machinery, &c., the greater portion of which may fairly be considered as having repaid the expense of its outlay, and also to the cheap rate at which the abundance of our fuel enables us to produce iron, the basis of almost all machinery. It has been justly remarked by M. de Villefosse in the memoir before alluded to, that "Ce que l'on nomme en France, la "*question du prix des fers*, est, à proprement parler, "la *question du prix des bois*, et *la question, des moyens* "*de communications interieures par les routes, fleuves,* "*rivières et canaux*."

On referring to page 130 of the present volume, the price of iron in various countries in Europe has been stated; and it appears, that in England, it is produced at the least, and in France at the greatest expense. The length of the roads which cover England and Wales may be stated roughly at twenty thousand miles of turnpike, and one hundred thousand miles of road, not turnpike. The internal water communication of England and France, as far as I have been able to collect information on the subject, may be stated as follows:

IN FRANCE.

	Miles in Length.
Navigable Rivers	4668
Navigable Canals	915·5
Navigable Canal in progress of execution (1824)	1388
	6971·5 *

But, if we reduce these numbers in the proportion of 3·7 to 1, which is the relative area of France as compared with England and Wales, then we shall have the following comparison:

		ENGLAND.†	Portion of France equal in size to England and Wales.
		Miles.	*Miles.*
Navigable Rivers		1275.5	1261.6
Tidal Navigation‡		545.9	
Canals, direct	2023.5		
——, branch . . .	150.6		
	2174.1	2174.1	247.4
Canals commenced		—	375.1
Total . .		3995.5	1884.1
Population in 1831		13,894,500	8,608,500

* This table is extracted and reduced from one in the *Ravinet Dictionnaire Hydrographique*, 2 vols. 8vo. Paris, 1824.

† I am indebted to F. Page, Esq. of Speen, for that portion of this table which relates to the internal navigation of England: those only who have themselves collected statistical details, can be aware of the time and labour, of which the few lines in the above table are the result.

‡ The tidal navigation includes—the Thames from the mouth of the Medway,—the Severn from the Holmes,—the Trent from Trent-falls in the Humber,—the Mersey from Runcorn Gap.

This comparison, between the internal communications of the two countries, is not offered as complete; nor is it a fair view, to contrast the wealthiest portion of one country with the whole of the other: but it is offered with the hope of inducing those who possess more extensive information on the subject, to supply the facts on which a better comparison may be instituted. The information to be added, would consist of the number of miles, in each country, of sea-coast,—of public roads,—of rail-roads,—of rail-roads on which loco-motive engines are used.

(334.) One point of view, in which rapid modes of conveyance increase the power of a country, deserves attention. On the Manchester rail-road, for example, above half a million of persons travel annually; and supposing each person to save only one hour in the time of transit, between Manchester and Liverpool, a saving of five hundred thousand hours, or of fifty thousand working days, of ten hours each, is effected. Now this is equivalent to an addition to the actual power of the country of one hundred and sixty-seven men, without increasing the quantity of food consumed; and it should also be remarked, that the time of the class of men thus supplied, is far more valuable than that of mere labourers.

CHAP. XXXII.

ON THE FUTURE PROSPECTS OF MANUFACTURES, AS CONNECTED WITH SCIENCE.

(335.) In reviewing the various processes which have been offered in the course of the present volume, as illustrations of those general principles which it has been its main object to support and establish, it is impossible not to perceive that the arts and manufactures of the country are intimately connected with the progress of the severer sciences; and that, as we advance in the career of improvement, every step requires, for its success, that this connexion should be rendered more intimate.

The applied sciences derive their facts from experiment; but the reasonings, on which their chief utility depends, come more properly within the province of what is called abstract Science. It has been shown, that the division of labour is no less applicable to mental productions than to those in which material bodies are concerned; and it follows, that the efforts for the improvement of its manufactures, which any country can make with the greatest probability of success, must arise from the combined exertions of all those most skilled in the theory, as well as in the practice of the art; each labouring in that department for which his natural capacity and acquired habits have rendered him most fit.

(336.) The profits arising from the successful application to practice of theoretical principles, will, in most cases, amply reward, in a pecuniary sense, those by whom they are first employed; yet even here, what has been stated with respect to *Patents*, will prove that there is room for considerable amendment in our legislative enactments: but the discovery of the great principles of nature demands a mind almost solely devoted to such investigations; and these, in the present state of science, frequently require costly apparatus, and exact an expense of time quite incompatible with professional avocations. It becomes, therefore, a fit subject for consideration, whether it would not be politic in the state to compensate for some of those privations, to which the cultivators of the higher departments of science are exposed; and the best mode of effecting this compensation, is a question which interests both the philosopher and the statesman. Such considerations appear to have had their just influence in other countries where the pursuit of Science is regarded as a profession, and where those who are successful are not shut out from almost every object of honourable ambition to which their fellow-countrymen may aspire. Having, however, already expressed some opinion upon these subjects in another publication,* I shall here content myself with referring to that work.

(337.) But it is of something beyond neglect, of which the Science of England complains: for whilst in our own country, whose advancement in wealth and strength so peculiarly depends upon the aid of the sciences, no encouragement is held out to that which must ever precede their application to the practical

* Reflections on the Decline of Science in England, and on some of its Causes, 8vo. 1830. Fellowes.

purposes of life;—whilst abstract Science, the prolific parent of the useful arts—the unfailing guide in tracing to their remotest conclusions the natural laws which observations may have detected—is allowed by the state to entail upon its cultivators the sacrifice of all those personal interests which the exercise of the same powers of mind might command in any other pursuit: —Englishmen are precluded from accepting those distinctions from the enlightened Sovereigns of other countries, by which they might desire to express their respect for British Science.*

There was, indeed, in our own country, one single position to which science, when concurring with independent fortune, might aspire, as conferring rank and station, an office deriving, in the estimation of the public, more than half its value from the commanding knowledge of its possessor; and it is extraordinary, that even that solitary dignity—that barony by tenure in the world of British science—the chair of the Royal Society, should have been coveted for adventitious rank. It is more extraordinary, that a Prince, distinguished by the liberal views he has invariably taken of public affairs,—and eminent for his patronage of every institution calculated to alleviate those miseries from which, by his rank, he is himself exempted—who is stated by his friends to be the warm admirer of knowledge, and most anxious for its advancement, should have been so

* The intentions of a Northern Sovereign distinguished by his attachment to science, were sometime ago defeated, by information from his ambassador in London, of the existence of the regulation by which it was understood that the acceptance of such honours by British subjects is forbidden.

imperfectly informed by those friends, as to have wrested from the head of science, the only civic wreath which could adorn its brow.*

In the meanwhile the President may learn, through the only medium by which his elevated station admits approach, that those evils which were anticipated from his election, have not proved to be imaginary, and that the advantages by some expected to result from it, have not yet become apparent. It may be right also to state, that whilst many of the inconveniences, which have been experienced by the President of the Royal Society, have resulted from the conduct of his own supporters, those who were compelled to differ from him, have subsequently offered no vexatious opposition :—they wait in patience, convinced that the force of truth must ultimately

* The Duke of Sussex was proposed as President of the Royal Society in opposition to the wish of the Council—in opposition to the public declaration of a body of Fellows, comprising the largest portion of those by whose labours the character of English science had been maintained. The aristocracy of rank and power, aided by such allies as it can always command, set itself in array against the prouder aristocracy of science. Out of about seven hundred members, only two hundred and thirty balloted; and the Duke of Sussex had a majority of EIGHT. Under such circumstances, it was indeed extraordinary, that His Royal Highness should have condescended to accept the fruits of that doubtful and inauspicious victory.

The circumstances preceding and attending this singular contest have been most ably detailed in a pamphlet, entitled "*A Statement of the Circumstances connected with the late Election for the Presidency of the Royal Society*, 1831, printed by R. Taylor, Red-lion-court, Fleet-street." The whole tone of the tract is strikingly contrasted with that of the productions of some of those persons by whom it was His Royal Highness's misfortune to be supported.

work its certain, though silent course; and not doubting that when His Royal Highness is correctly informed, he will himself be amongst the first to be influenced by its power.

(338.) But younger institutions have arisen to supply the deficiencies of the old; and very recently a new combination, differing entirely from the older societies, promises to give additional steadiness to the future march of science. The "*British Association for the Promotion of Science*," which held its first meeting at York in the year 1831, would have acted as a powerful ally even if the Royal Society were all that it might be: but in the present state of that body such an association is almost necessary for the purposes of science. The periodical assemblage of persons, pursuing the same or different branches of knowledge, always produces an excitement which is favourable to the development of new ideas; whilst the long period of repose which succeeds, is advantageous for the prosecution of the reasonings or the experiments then suggested; and the recurrence of the meeting in the succeeding year, will stimulate the activity of the inquirer, by the hope of being then enabled to produce the successful result of his labours. Another advantage is that such meetings bring together a much larger number of persons actively engaged in science, or placed in positions in which they can contribute to it, than can ever be found at the ordinary meetings of other societies, even in the most populous capitals; and combined efforts towards any particular object can thus be more easily arranged.

But perhaps the greatest benefit which will accrue to science from these assemblies, is the intercourse which they cannot fail to promote between the different classes of society. The man of science will derive practical information from the great manufacturers;—the chemist will be indebted to the same source for substances which exist in such minute quantity, as only to become visible in most extensive operations;—and persons of wealth and property, resident in each neighbourhood visited by these migratory assemblies, will derive greater advantages than either of those classes, from the real instruction they may procure respecting the produce and manufactures of their country, and the enlightened gratification which is ever attendant on the acquisition of knowledge.*

(339.) Thus it may be expected that public opinion shall be brought to bear upon the world of science; for by this intercourse light will be thrown upon the characters of men, and the pretender and the charlatan will be driven into merited obscurity. Without the action of public opinion, any administration, however anxious to countenance the pursuits of science, and however ready to reward, by wealth or honours, those whom they might think most eminent, would run the risk of acting like the blind man recently couched, who, having no mode of estimating

* The advantages likely to arise from such an association, have been so clearly stated in the address delivered by the Rev. Mr. Vernon Harcourt, at its first meeting, that I would strongly recommend its perusal by all those who feel interested in the success of English science.—Vide *First Report of the British Association for the Advancement of Science. York*, 1832.

degrees of distance, mistook the nearest and most insignificant for the largest objects in nature: it becomes, therefore, doubly important, that the man of science should mix with the world.

It is highly probable that in the next generation, the race of scientific men in England will spring from a class of persons altogether different from that which has hitherto scantily supplied them. Requiring, for the success of their pursuits, previous education, leisure, and fortune, few are so likely to unite these essentials as the sons of our wealthy manufacturers, who, having been enriched by their own exertions, in a field connected with science, will be ambitious of having their children distinguished in its ranks. It must, however, be admitted, that this desire in the parents would acquire great additional intensity, if worldly honours occasionally followed successful efforts; and that the country would thus gain for science, talents which are frequently rendered useless by the unsuitable situations in which they are placed.

(340.) The discoverers of Iodine and Brome, two substances hitherto undecompounded, were both amongst the class of manufacturers, one being a maker of saltpetre at Paris, the other a manufacturing chemist at Marseilles; and the inventor of balloons filled with rarefied air, was a paper manufacturer near Lyons. The descendants of Mongolfier, the first aërial traveller, still carry on the establishment of their progenitor, and still continue to combine great scientific knowledge with every department of the arts, to which the various branches of the family have applied themselves.

(341.) Chemical science may, in many instances, be of great importance to the manufacturer, as well as to the merchant. The quantity of Peruvian bark which is imported into Europe is very considerable; but chemistry has recently proved that a large portion of the bark itself is useless. The alkali Quinia which has been extracted from it, possesses all the properties for which the bark is valuable, and only forty ounces of this substance, when in combination with sulphuric acid, can be extracted from a hundred pounds of the bark. In this instance then, with every ton of useful matter, thirty-nine tons of rubbish are transported across the Atlantic.

At the present time, the greatest part of the sulphate of quinia used in this country is imported from France, where the low price of the alcohol, by which it is extracted from the bark, renders the process cheap; but it cannot be doubted, that when more settled forms of government shall have given security to capital, and when advancing civilization shall have spread over the States of Southern America, the alkaline medicine will be extracted from the woody fibres by which its efficacy is almost lost, and that it will be exported in its most condensed form.

(342.) The aid of chemistry, in extracting and in concentrating substances used for human food, is of great use in distant voyages, where the space occupied by the stores must be economised with the greatest care. Thus, the essential oils supply the voyager with flavour; the concentrated and crystallized acids preserve his health; and alcohol, when sufficiently diluted, supplies the spirit necessary for his daily consumption.

(343.) When we reflect on the very small number of species of plants, compared with the multitude that are known to exist, which have hitherto been cultivated, and rendered useful to man ; and when we apply the same observation to the animal world, and even to the mineral kingdom, the field that natural science opens to our view seems to be indeed unlimited. These productions of nature, numerous and varied as they are, may each, in some future day, become the basis of extensive manufactures, and give life, employment, and wealth, to millions of human beings. But the crude treasures perpetually exposed before our eyes, contain within them other and more valuable principles. All these, in their innumerable combinations, which ages of labour and research can never exhaust, may be destined to furnish, in perpetual succession, new sources of our wealth and of our happiness. Science and knowledge are subject, in their extension and increase, to laws quite opposite to those which regulate the material world. Unlike the forces of molecular attraction, which cease at sensible distances ; or that of gravity, which decreases rapidly with the increasing distance from the point of its origin; the further we advance from the origin of our knowledge, the larger it becomes, and the greater power it bestows upon its cultivators, to add new fields to its dominions. Yet, does this continually and rapidly increasing power, instead of giving us any reason to anticipate the exhaustion of so fertile a field, place us at each advance, on some higher eminence, from which the mind contemplates the past, and feels irresistibly convinced, that the whole, already gained, bears a constantly diminishing ratio to that which is contained within the still more rapidly expanding horizon of our knowledge.

But, if the knowledge of the chemical and physical properties of the bodies which surround us, as well as our acquaintance with the less tangible elements, light, electricity, and heat, which mysteriously modify or change their combinations, all concur to convince us of the same fact; we must remember that another and a higher science, itself still more boundless, is also advancing with a giant's stride, and having grasped the mightier masses of the universe, and reduced their wanderings to laws, has given to us in its own condensed language, expressions, which are to the past as history, to the future as prophecy. It is the same science which is now preparing its fetters for the minutest atoms that nature has created: already it has nearly chained the ethereal fluid, and bound in one harmonious system all the intricate and splendid phenomena of light. It is the science of *calculation*,—which becomes continually more necessary at each step of our progress, and which must ultimately govern the whole of the applications of science to the arts of life.

But perhaps a doubt may arise in the mind, whilst contemplating the continually increasing field of human knowledge, that the weak arm of man may want the physical force requisite to render that knowledge available. The experience of the past, has stamped with the indelible character of truth, the maxim, that "*Knowledge is power*." It not merely gives to its votaries control over the mental faculties of their species, but is itself the generator of physical force. The discovery of the expansive power of steam, its condensation, and the doctrine of latent heat, has already added to the population of this small island, millions of hands. But the source of this power is not without limit, and the coal-mines of the world may ultimately be exhausted. Without adverting to the theory, that new formations of that mineral are now depositing under the sea, at the estuaries of some of our larger rivers; without anticipating the application of other fluids requiring a less supply of caloric than water:—we may remark that the sea itself offers a perennial source of power hitherto almost unapplied. The tides, twice in each day, raise a vast mass of water, which might be made available for driving machinery. But supposing heat still to remain necessary when the exhausted state of our coal-fields renders it expensive: long before that period arrives, other methods will probably have been invented for producing it. In some districts, there are springs of hot water, which have flowed for centuries unchanged in temperature. In many parts of the island of Ischia, by deepening the sources of the hot springs but a few feet, the water boils; and there can be little doubt that, by boring a short distance, steam of high pressure would issue from the orifice.*

In Iceland, the sources of heat are still more plentiful; and their proximity to large masses of ice,

* In 1828, the author of these pages visited Ischia, with a committee of the Royal Academy of Naples, deputed to examine the temperature and chemical constitution of the springs in that island. During the few first days, several springs which had been represented in the instructions as under the boiling temperature, were found, on deepening the excavations, to rise to the boiling point.

seems almost to point out the future destiny of that island. The ice of its glaciers may enable its inhabitants to liquefy the gases with the least expenditure of mechanical force; and the heat of its volcanoes may supply the power necessary for their condensation. Thus, in a future age, *power* may become the staple commodity of the Icelanders, and of the inhabitants of other volcanic districts;* and possibly the very process by which they will procure this article of exchange for the luxuries of happier climates may, in some measure, tame the tremendous element which occasionally devastates their provinces.

(344.) Perhaps to the sober eye of inductive philosophy, these anticipations of the future may appear too faintly connected with the history of the past. When time shall have revealed the future progress of our race, those laws which are now obscurely indicated, will then become distinctly apparent; and it may possibly be found that the dominion of mind over the material world advances with an ever-accelerating force.

Even now, the imprisoned winds which the earliest poet made the Grecian warrior bear for the protection of his fragile bark; or those which, in more modern times, the Lapland wizards sold to the deluded sailors;—these, the unreal creations of fancy or of fraud, called, at the command of science, from their shadowy existence, obey a holier spell: and the unruly masters of the poet and the seer become the obedient slaves of civilized man.

Nor has the wild imagination of the satirist been quite unrivalled by the realities of after years:

* See § 268, p. 237.

as if in mockery of the College of Laputa, light almost solar has been extracted from the refuse of fish; fire has been sifted by the lamp of Davy; and machinery has been taught arithmetic instead of poetry.

(345.) In whatever light we examine the triumphs and achievements of our species over the creation submitted to its power, we explore new sources of wonder. But if science has called into real existence the visions of the poet—if the accumulating knowledge of ages has blunted the sharpest and distanced the loftiest of the shafts of the satirist, the philosopher has conferred on the moralist an obligation of surpassing weight. In unveiling to him the living miracles which teem in rich exuberance around the minutest atom, as well as throughout the largest masses of ever-active matter, he has placed before him resistless evidence of immeasurable design. Surrounded by every form of animate and inanimate existence, the sun of science has yet penetrated but through the outer fold of Nature's majestic robe; but if the philosopher were required to separate, from amongst those countless evidences of creative power, one being, the masterpiece of its skill; and from that being to select one gift, the choicest of all the attributes of life;—turning within his own breast, and conscious of those powers which have subjugated to his race the external world, and of those higher powers by which he has subjugated to himself that creative faculty which aids his faltering conceptions of a deity,—the humble worshipper at the altar of truth would pronounce that being,—man; that endowment,—human reason.

But however large the interval that separates the lowest from the highest of those sentient beings which inhabit our planet, all the results of observation, enlightened by all the reasonings of the philosopher, combine to render it probable that, in the vast extent of creation, the proudest attribute of our race is but, perchance, the lowest step in the gradation of intellectual existence. For, since every portion of our own material globe, and every animated being it supports, afford, on more scrutinizing inquiry, more perfect evidence of design, it would indeed be most unphilosophical to believe that those sister spheres, glowing with light and heat radiant from the same central source—and that the members of those kindred systems, almost lost in the remoteness of space, and perceptible only from the countless multitude of their congregated globes—should each be no more than a floating chaos of unformed matter;—or, being all the work of the same Almighty architect, that no living eye should be gladdened by their forms of beauty, that no intellectual being should expand its faculties in decyphering their laws.

THE END.