THE FIRST CENTURY OF THE REPUBLIC.

[Second Paper.]

UNITED STATES PATENT-OFFICE, WASHINGTON, D. C.

MECHANICAL PROGRESS.—I.

IT is no common century. Compared with its predecessors, it appears rather as a contrast than a development. It is not easy to state its relation to the past in terms of progression, since it may be said to have leaped into existence, and an adequate statement describes radical changes rather than evolution.

The search for the "lost arts" is an agreeable literary and scientific ramble, with nooks containing treasures which well reward the explorer; but one's eyes must be sadly out of focus if the distant, laborious ingenuities of remote ages are more distinct in the field of vision than the majestic works of the present. A locomotive is a more pregnant fact than a pyramid or a sculptured cavern. The subject is one to which it is not possible to do full justice, even in a volume, either by a general sketch or by particular instances. We purpose to take a rapid preliminary survey of the field of mechanical activity, and then to devote the principal portion of our space to details respecting a few prominent subjects, thereby enabling the reader to form a judgment from the sum of the parts, instead of a superficial estimate from a cursory glance at the multitudinous whole.

The inquiry, whether it proceed by a general survey or by investigation of detached portions, will reveal the following facts:

1. No nation has had exclusive concern in the production of any one class of inventions, and yet we need not go beyond the area of the English-speaking nations to make a thorough exhibit of the mechanical progress of the period under review.

2. Nations allied by ties of blood and similarities of tone, temper, taste, and opportunity develop in parallel lines which continually inosculate. This is well illustrated in the tools and methods of the machine-shop. England and America are rich in coal and iron, have the same incentives to industry, and the machines of each are largely the growth of successive improvements from the respective nations, in each of which a host of inventors are laboring at the solution of the same problems.*

3. Peculiar conditions of peoples, even of the same race, elicit distinct varieties of tools and methods. This diversity is exemplified in the appliances used in America for subduing the wilderness and cultivating lately cleared land, as compared with the husbandry implements of Britain.

Our people in the colonial period were generally engaged in husbandry, lumbering, trading, hunting, and fishing. The exports were grain, meat, naval stores, tobacco, and pelts. But few mechanic arts were carried on systematically, except ship-building. Carpentry, blacksmithing, and tanning were regular trades. In the cities other industries engaged attention, but in the country the clothes, hats, and shoes of the people and the harness of the horses were made by the people at their houses in the winter or in seasons of inclement weather.

There were some other industries in a few favored localities—some paper mills in Massachusetts and Pennsylvania, some cloth mills at Boston and Germantown, Pennsylvania. Beaver hats were made in a few places; linen, at a settlement near Boston; glass was manufactured in Massachusetts and New Hampshire; the hand card, the spinning-wheel, and the loom constituted almost always a part of the furnishing of country houses.

The roads were bad, the equipages clum-

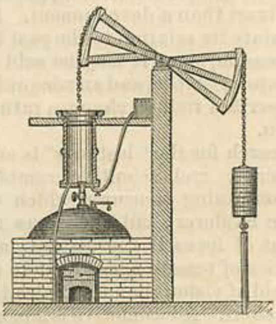
* It is our purpose in this series to treat of *American* progress in the various fields of activity. But in this field of Mechanical Progress, as in some others, it is plainly impossible to exclude what has been accomplished by other nations.—Ed. Harper.

sy, as they were, indeed, in England at that time. Twenty-four gentlemen's carriages were owned in Philadelphia in 1761. Country squires and patricians rode in their coaches and four, or even six, when the journey was long or the season unpropitious. Postilions and outriders were the acme of style. Judge Reed, of Pennsylvania, imported a skillful "whip" for his four-in-hand. The country wagons and the agricultural implements were rude and ineffective. Carts, plows, and hoes were made by the country mechanic of such material as he could procure, little metal being used in either. Strips of iron made by hammering out old horseshoes were the facings of the wooden mould-boards of plows. The laws of England had rigorously maintained the dependence of the provinces, forbidding all important works in iron, and the war found the people unprepared to supply their sudden needs. The war was to a large degree fought by men in homespun and hunting shirts, armed with the frontiers-man's trusty rifle.

When peace rendered possible commercial and mechanical enterprise, a new era dawned. Many things which the colonists had cheerfully imported from the mother country began to be made at home, and many industries which had been repressed by law to keep the colonies subordinate and dependent began to be developed. In 1787 the first cotton mill in America was built at Beverly, Massachusetts. In 1789 Samuel Slater introduced the Arkwright system of mill spinning. The exportation of machinery from England was successfully prevented, and Slater was obliged to make the carding, drawing, roving, and spinning mechanism from memory. In 1783 Oliver Evans had introduced his improvements in grain mills, and a few years afterward his steam-engine—the first double-acting high-pressure steam-engine on record. In 1785 Rumsey, and in 1784 Fitch, had their boats on the Potomac and Delaware respectively. In 1787 Jacob Perkins had his nail-cutting machines and dies for coin. In 1793 Whitney's cotton-gin, and in 1797 Whittemore's card-sticking machine, came to the help of the cotton interest. Other inventions followed in rapid succession.

The progress above noted occurred within fifteen years after the treaty of peace. It is doubtful whether on the 4th of July, 1776, there were more than two steam-engines in the thirteen colonies, one at Passaic, New Jersey, the other in Philadelphia. The Newcomen engine was as yet only partially supplanted by the Watt, and offered but moderate inducements for any purpose except pumping water from copper and lead mines, whose rich ores paid for the wasteful use of wood or coal.

The great advance in machinery, and especially our own active part in it, is very recent. Persons yet alive remember the first crossing of the Atlantic by a steamboat, the *Savannah*. Those yet in the prime of life recollect the opening of the first railway to passenger traffic. Horatio Allen drove the first locomotive which was imported. Thus the century under consideration, from a mechanical point of view, is most readily segregated from its predecessors. It is not saying too much to assert that at its commencement the coal of England was scarcely valued except for household uses. As to the coal of America, its extent and its utility were not even suspected. Machinery as yet was not. The steam-engine of Newcomen was pumping in some few mines in England. This engine condensed its steam in the cylinder beneath the piston, cooling the cylinder at each stroke, and using the condensation of the steam as a means of producing a partial vacuum, in order to obtain the value of the atmospheric pressure above the piston. The *duty* or valuable effect of the Newcomen engine in 1769 was

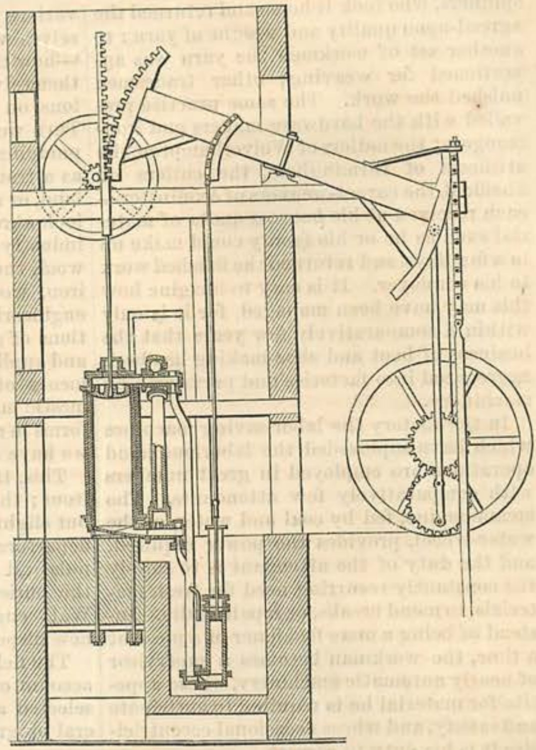


NEWCOMEN'S STEAM-ENGINE.

5,500,000 pounds of water raised one foot high by one bushel of Welsh coal. Watt's inventions were made between the years 1769 and 1784, and before the year 1800 the duty of the Cornish engine was quadrupled; by 1840 it was again quadrupled. Watt added to the steam-engine the *separate condenser* and the *air-pump*. By the former he avoided the cooling of the cylinder before each effective stroke of the piston; by the latter he made the vacuum more perfect. He subsequently made the additions of the *parallel motion*, of the *steam-jacket* to the cylinder, and of the *cylinder cover*, and made the steam act positively against the piston, instead of merely using it to produce a vacuum. Afterward he made the engine *double acting*, that is, used pressure of steam on the sides of the piston alternately; then he increased the strength of the parts, the rapidity of the stroke, and the pressure of the steam. Coal, the black slave, had been chained below from time immemorial, and Watt contrived a way of setting him to work. Up to this period there had been scarcely any progress; after it hosts of inventions crowd upon the scene and clamor for notice. The Watt period inaugurates the century whose progress in the mechanic arts is under consideration.

The utilization of coal in the production of steam for driving machinery is the turning-point in the history of mechanical evolution and development, and made possible improvements in various other directions.

If there had been no Watt, Smeaton, Arkwright, Hargreaves, Cartwright, Cort, Murdoch, Whitney, Trevethick, and Stephenson, the victory of Colonel Clive at Plassey might not have proved the precursor of the occupation of the whole of Hindostan. But for the machinery which by gradual accretions gave to England an increased power of production more than equivalent to the addition of a population equal to that of China to her industrial forces, the farther works of Clive, the victories of Hastings, Cornwallis, Wellesley, Napier, Hardinge, and Gough, would not have occurred, and in their places would have been mere raids or desultory expeditions, half commercial and half military, after the first burst of conquest and spoliation.



WATT'S DOUBLE-ACTING STEAM-ENGINE, 1769.

This accession of labor was in a shape more tense and patient than even the enduring Chinaman, for its muscles were of iron, its food could be dug from the earth, and when at last worn out, it could be worked over again, and had not to be boxed, labeled, and sent back to be deposited near the tablets of its ancestors.

The capacity of the steam-engines of England may be otherwise stated. It is estimated that the great Pyramid of Ghizeh occupied the labor of 100,000 men for twenty years in the erection alone. The steam-engines of England, worked by 36,000 men, would raise the same quantity of material to the same height in eighteen hours. Thus reckoning ten hours to the day, and three hundred working days to the year, three thousand pyramids might be erected by the steam-power of England in the period occupied by the builders of that of Ghizeh.

The multiplication, in the course of years, by fiftyfold of the working power of England caused such an enormous increase of material that privy councils, armies, and fleets vied with each other in explorations by sea and land. The Northwest Passage, which has a literature and a history of its own—a history exultant and yet sad—only meant a short road to India around one end of that terribly long continent which barred Europe from sailing westward to Asia.

There is no more truthful accessible test of the comparative ingenuity of periods in a given country than the number of patents granted therein. Our national patent system has been in operation only since 1790, but that of England is much older. The following table gives the numbers of patents granted in decades for the two centuries.

Previous to 1790 patents were granted by individual States, as to Fulton, Fitch, Rumsey, Evans, and others.

Decade ending	England.	Decade ending	England.	United States.
1680	49	1780	297	....
1690	55	1790	512	....
1700	101	1800	675	306
1710	20	1810	936	1,086
1720	45	1820	1,125	1,748
1730	94	1830	1,533	2,986
1740	48	1840	2,710	5,488
1750	85	1850	4,666	5,942
1760	99	1860	25,201	23,140
1770	221	1870	35,079	79,612

The factory system is the growth of the century now closing. When Richard Arkwright was traveling over the hills of Lancashire, buying the tresses of the country lasses to make wigs, and Hargreaves was working at the rudimentary carding-machine, the artisans of the country worked each in his little shop. The wool-stapler dealt out his lots of wool to the carders and spinners, who took it home and returned the agreed-upon quality and weight of yarn; to another set of workmen the yarn was apportioned for weaving; other tradesmen finished the work. The same practice prevailed with the hardware makers and ironmongers; the nailers of Wolverhampton, the artificers of Birmingham, the cutlers of Sheffield, the carpet-weavers of Axminster—each received at his house a quota of material such as he or his family could make up in a few days, and returned the finished work to his employer. It is easy to imagine how this may have been managed, for it is only within a comparatively few years that the business of boot and shoe making has been aggregated into factories and performed by machinery.

In the factory the labor-saving machines which have superseded the laborious hand operations are employed in great numbers with comparatively few attendants. The steam-engine, fed by coal and water, or the water-wheel, provides the power required, and the duty of the attendant is to supply the constantly recurring need for fresh materials, to mend breaks, or repair faults. Instead of being a mere fashioner of a piece at a time, the workman becomes a supervisor of nearly automatic machinery, whose appetite for material he is required to anticipate and satisfy, and whose occasional eccentricities it is his duty to correct.

The development of the cotton manufacture furnishes the best and perhaps earliest example of the factory system. Arkwright appears to have worked at his cotton machinery for several years, and in company with several partners, who successively furnished means and then tired of the project, before he erected the mill at Nottingham, which was worked by horse-power. This mill was erected in 1770; another one was established in 1771, in which the machinery was driven by a water-wheel. So new was the idea of employing other than hand or foot labor that his spinning-machine was long known as the "water-frame," and the product as the "water-twist." His other improvements were patented in 1775, and thus the century starts with Mr. Arkwright fresh upon the track, leading in a race the success of which has changed the aspect of our commercial and social systems.

Arkwright, in spite of fraudulent trespassers and expensive lawsuits, lived to see the perfect triumph of his ingenuity and sedulous care. His suits developed the conditions and situations which taxed the wisdom of the judges, and elicited the decisions and maxims that have given shape to the patent system of England and the United States. Arkwright *v.* Nightingale, the King *v.* Arkwright, are cases that form the "hard pan" of the Patent Law.

We shall see how well the facts of the various branches of invention arrange themselves within the period we are considering—how the rank and file of inventions array themselves in battalions, brigades, divisions, on one side of the line chronological. Turn we to steam in its original form as a pumping engine, or to its subsequent duties as a transporting agent on water or on the land, or as a driver of machinery; or, if we look abroad to other lines of enterprise and industry—the manufacture of cotton and wool, the production and manufacture of iron, wood-working machinery, hydraulic engineering, the manufacture and applications of gas, electricity in its various forms and applications, the construction of instruments of measurement and precision, domestic machinery—we find that each group forms in regimental order within the bounds we have indicated.

This, though unexampled, was not fortuitous; the time was ripe. Yet there was but slight indication beforehand of the new departure. It was as if by a mysterious impulse all started at once, the utilization of the buried stores of coal by means of the Watt engine being the great fact of the new dispensation.

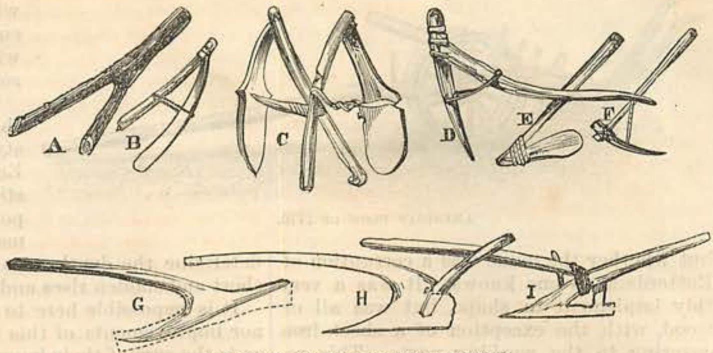
The field is too great to give even a brief account of each division, and a few must be selected as examples from which the general progress may be deduced.

AGRICULTURAL IMPLEMENTS.

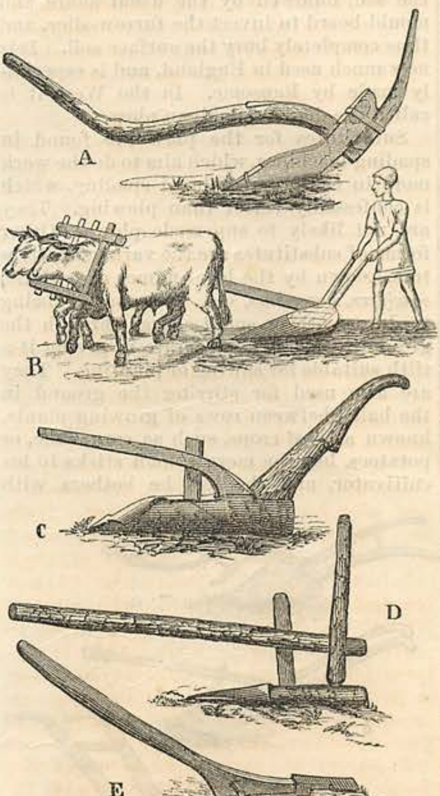
There is no apology needed for beginning our review with farming implements. However disinclined a citizen may be to blister his hands by chopping fire-wood or mauling rails, he freely admits the respectability of the employment and its ancient fame. Admitting, then, the precedence of the husbandman, we will first look at the principal agricultural tool—the plow.

This tool has never outgrown its resemblance to the forked limb which was first used as a hoe and then as a plow. With such tools as they could muster, men shaped the tough limbs and crotches of trees into implements. The forked piece (A) was trimmed and became the hoe (B), a thong binding the handle and blade portions to prevent their splitting apart. We give pictures (C) of two ancient Egyptian hoes now in the Berlin Museum. A similar one may be seen in the Abbott Museum, New York. Two suitable sticks (D) were notched and lashed together. Two other resources of a people destitute of metal are shown (E, F), one, of the South Sea Islanders, the blade made of a scapula, the other made of a walrus tooth on a handle. It is shown (G, H, I) how men made plows from similar materials; one limb formed the share, the other the beam; or (as in I) one the beam and the other the handle and sole, with a point which forms the share.

The actual change in the plow for more than thirty centuries has been but local. The greater part of the world uses a plow much like those pictured on the palaces of Thebes. Those used in our colonial period were a very slight departure from that pattern. The plow was of wood; it was formed of pieces whose shape adapted them to become parts of the structure. The beam, standard, and handles—if the plow had two, which was not always the case—were of seasoned stuff; the mould-board was a block of wood which had a winding grain approximating the curve required.



THE ORIGIN OF THE HOE AND THE PLOW.



RUDE MODERN PLOWS.

A, an East Indian plow. B, a modern Egyptian plow. C, a Mexican plow. D, a Chinese plow. E, an ancient British implement, which yet survives in the western wilds of Scotland. The latter is pointed with iron, and may have been the origin of the *bull-tongue* plow, more familiar to men of '76 than to the farmer of the present day.

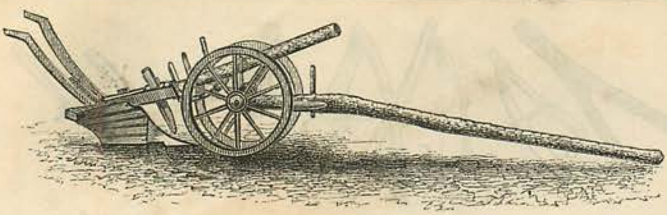
The accompanying figures show a number of plows yet used in some foreign countries. These differ in no essential respect from plows shown on the tombs of Egypt, the vases of Etruria, the bass-reliefs of Greece, and the medals of Rome. The plows of the south of France, of Spain, of Calabria, Greece, Turkey, and Syria are very similar.

The plow of the past is now utterly abandoned, and we have a new tool of a different material, still, however, preserving the peculiar family feature; it will never get over the resemblance to that primordial limb.

The plow of 1776 was all of wood except the wrought iron share and some bolts and nuts whereby the parts were fastened together. The standard rose nearly vertically, having attached to it the beam and the sole-piece. On the nose of the beam hung the clevis; the mould-board and share were attached to a frame braced between the beam and the sole. The wooden mould-board was sometimes plated with sheet-iron or by strips made by hammering out old horseshoes. A clump of iron shaped like a half spear formed the point. It was known as a "bull plow," "bull-tongue," or "bar-share" plow. Two pins in the standard formed the handles, and it required the strength of a man to manage it. The work was slowly and ill performed by cattle.

The shovel plow, which until lately was the principal plow of the South, and is yet largely used in furrowing out ground for hoed crops, such as corn, cane, and potatoes, and in tending the same, is clearly a derivative from the old crotched stick.

The order of improvement is about as follows: Some time in the last century a certain plow was imported into England, probably from Flanders, which had been long far in advance of England in gardening and horticulture. Queen Elizabeth used to get salads from Flanders as a change from the interminable beef and beer. This implement was known as the *Rotherham* plow;



AMERICAN PLOW OF 1776.

but whether the name was a corruption of Rotterdam no one knows. It was a very tidy implement in shape, but was all of wood, with the exception of a sheet-iron covering to the working parts. This required frequent renewal. James Small, of Berwickshire, Scotland, introduced the plow (*a*) with a cast iron mould-board and a wrought iron share. His was the first cast iron plow. He made the shares also of cast iron in 1785.

Thomas Jefferson from 1788 to 1793 studied and experimented to determine the proper shape of the mould-board to do the work effectively and offer the least resistance, treating it as consisting of a lifting wedge and an upsetting wedge, with an easy connecting curve.

Newbold, of Burlington, New Jersey, in 1797 patented a plow with a mould-board, share, and land-side all cast together.

Peacock in his patent of 1807 cast his plow in three pieces, the point of the colter entering a notch in the breast of the share.

Ransome, of Ipswich, England, in 1803 chilled the cast shares on the under side, so that they might keep sharp by wear.

Jethro Wood, of Scipio, Cayuga County, New York, patented improvements in 1819. He made the best and most popular plow (*b*) of its day, and was entitled to much credit for skill and enterprise, but lost his fortune in developing his invention and defending his rights. He, however, overestimated the extent of novelty in his invention. He seems to have thought it the first iron plow. Its peculiar merit consisted in the mode of securing the cast iron portions together by lugs and locking pieces, doing away with screw-bolts and much weight, complexity, and expense. Wood did more than any other person to drive out of use the cumbrous contrivances common throughout the country, giving a lighter, cheaper, and more effective implement. It was the first plow in which the parts most exposed to wear could be renewed in the field by the substitution of cast pieces.

In 1820 Timothy Pickering, of Salem, Massachusetts, first recognized the importance of straight transverse lines on the mould-board. The shape was such that it might be cut from a conical frustum.

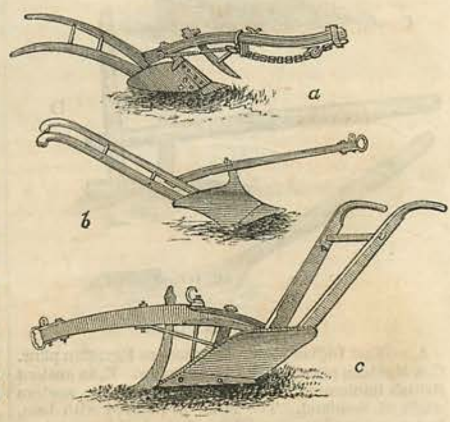
In 1854 the Gibbs plow (*c*) had its straight transverse lines horizontal, the surface from which it might be cut being a cylinder with its axis horizontal.

The Howard plow shows the favorite style of plow in England. The long stilts give great power to the plowman. The wheels determine the depth accurately, except in short and sudden rises and hollows.

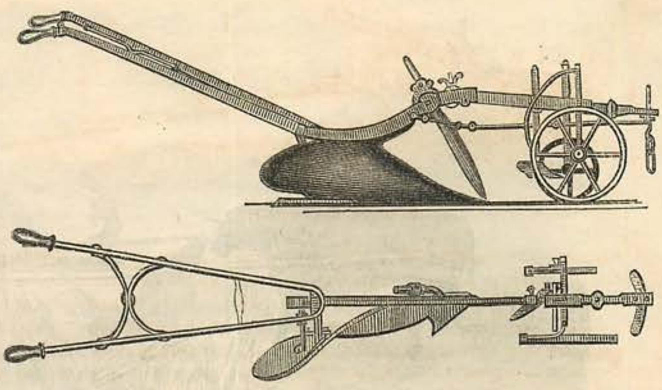
It is impossible here to describe the minor improvements of this implement, great as is the sum of their importance—the rolling colter, the wheel which takes the place of the sliding sole, adaptations for setting the plow for *depth* and for *land*, to prevent clogging, etc.

Aaron Smith, of England, first made that form of double plow which has a small advance share and mould-board to turn over the sod, followed by the usual share and mould-board to invert the furrow-slice, and thus completely bury the surface soil. It is now much used in England, and is especially made by Ransome. In the West it is called the double Michigan plow.

Substitutes for the plow are found in spading machines, which aim to do the work more in the order of hand spading, which is confessedly better than plowing. They are not likely to supersede plows. Other forms of substitutes are the various cultivators, known by the local names of *grubbers*, *scarifiers*, *horse-hoes*, etc., their action being to drag teeth or small shares through the ground to loosen and aerate it, giving it a tilth suitable for sowing or planting. They are also used for stirring the ground in the balks between rows of growing plants, known as *hoed* crops, such as corn, cane, or potatoes, but the more a man sticks to his cultivator, and the less he bothers with



PLOWS: 1785-1874.
a, Small's. *b*, Wood's. *c*, Gibbs's.



HOWARD WHEEL-PLOW.

the hoe, the better will be the result, if the amount of the planting be large.

The steam-plow has proved a success under favorable circumstances. Few are at work in the United States; many hundreds in England. A large number were sent to Egypt, where the Khedive is determined to be a second Pharaoh on the old order announced by Joseph, who bought the personal property, then the land, then the people, and then rented the land to them for a fifth of the produce—the same share as Solomon received for his vineyard.

Steam-plows are constructed on several principles:

1. A traction engine dragging plows: this is not a success as yet.

2. A pair of engines on trucks on the sides of the field, and dragging gangs of plows back and forth, the engines moving a piece ahead between each pull. The cut shows a modified form with a single engine, endless rope, and a traveling truck on the opposite side of the field to carry the pulley over which the rope runs and returns.

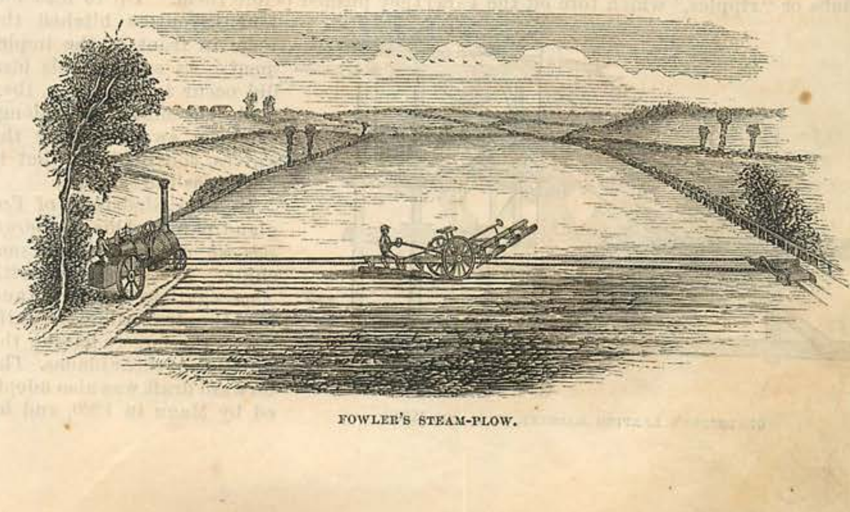
3. A single engine, and ropes so arranged around the field on bearers, known as *porters*, as to drag the plow-gang in any required direction by suitably changing the position of the porters which determine the direction of motion of the rope.

The improvements in seeding machines and grain drills have effected a saving of seed, more careful planting or sowing, and greater economy in labor.

One hundred years ago our fathers toiled in the harvest field with the sickle. In Flanders they had a kind of cradle known as the Hainault scythe, but it was unknown to English-speaking peoples. The bent back, the gathering left arm, and the sweeping sickle painfully reaped the bunches of grain, which were thrown into heaps large enough to form gavels for binding. The cradle was a great improvement upon the sickle, the long and deep-reaching blade of the grain scythe, aided by the fingers of the cradle, making a progress in the harvest field which left the sickle and reaping-hook far in the rear.

The American War of Independence was not long over before attempts were made to construct machines which would bring into use horse labor as a substitute for the severe hand-work.

The reaping machine has attained its present degree of completeness after seventy-five years of persistent effort. General attention had been but little directed to the subject until the year 1851, when at the World's Fair in London the American machines created much excitement, and caused the forgotten experiments of half a century to be withdrawn from their limboes and exhibited to cool the enthusiasm of "those for-



FOWLER'S STEAM-PLOW.

REAPING IN GAUL, FIRST TO FOURTH CENTURY A.D.

eigners." Experiments in reaping machines had been pursued to a much greater extent in Britain than in the United States until within a then comparatively recent period; but the essential features which secured success were American.

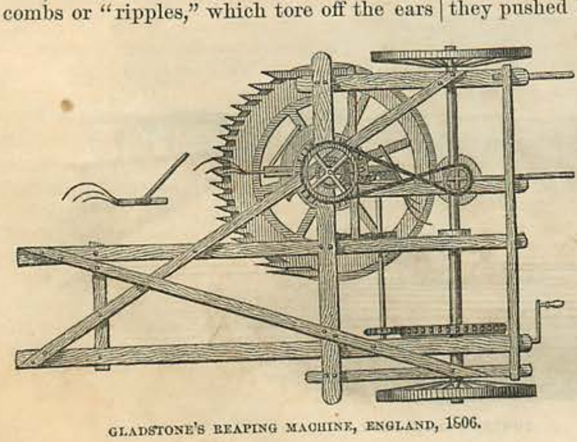
The first reaping machine on record is that described by Pliny about A.D. 60, and by Palladius some centuries later. It is stated by these authors to have been used in Gaul; the former writer says in the extensive plains in that part known as Rhætia. It consisted of a cart pushed by an ox, and having a comb-like bar in front which stripped off the ears of the wheat and allowed them to fall into the box, while the straw remained on the ground. It was used in level places, and where the straw was not wanted for winter fodder. The implement has been re-invented after the lapse of fourteen centuries, and is now used as a "header" for gathering clover seed.

After this Gallic implement there is a long gap, and the first machine, or rather suggestion, of the moderns is that of Pitt, in 1786, which had a cylinder with rows of combs or "ripples," which tore off the ears and discharged them into the box of the machine.

It is a part of our purpose to show the cumulative character of invention, and also to illustrate the fact that nearly the whole aim seëms to be fixed in a particular direction for a long course of years; then the germ of the eventual success enters unexpectedly, and remains unnoticed for a period, after which the interest is transferred to the previously overlooked type, which in its immature form gave little prospect of success.

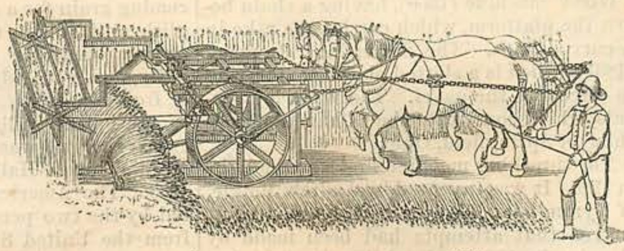
For about twoscore years attention was principally directed to revolving cutters or systems of revolving blades. The motion of the cutting apparatus being derived from the rotary motion of the wheels supporting the implement, it naturally occurred to connect the axle or wheels with a rotary cutter, and later with an oscillating one, which had its analogues in the swing of the scythe and the reach of the sickle. The first reciprocating knife was in 1822.

As to the mode of attaching the horses, it was almost universally deemed necessary to hitch them behind the implement, which they pushed before them. Up to 1823 but four inventors hitched the team in front of the implement. As soon as this idea did occur to inventors, they made the horse walk alongside the swath cut by the knives, constituting what is known as the *side cut*.



GLADSTONE'S REAPING MACHINE, ENGLAND, 1806.

In 1806 Gladstone, of England, patented his *front-draft side-cut* revolving-knife machine. A segment *bar* with *fingers* gathered the grain and held the straw while the knife cut it, the fingers having the function of shear blades. The forward draft was also adopted by Mann in 1820, and by



BELL'S REAPING MACHINE, ENGLAND, 1826.

Ogle, of England, in 1822, who shows the first *reciprocating knife bar*. It is the type of the successful machines, but was constructed so poorly that its merits never became apparent. It was drawn by horses *in advance;* the cutter bar *projected* at the *side*, and it had a *reel* to gather the grain to the cutter. The machine had a *grain platform*, which was tilted to drop the gavel. This was the *first dropper*. In 1826 Bell made a working machine. It was pushed before the horse; the grain was cut by *knives vibrating* on *pivots*. It had a grain reel; the grain fell upon an *inclined traveling apron*, which carried it off and delivered it at the side.

In 1828 Samuel Lane, of Maine, combined the reaper and the thresher.

In 1833 Hussey, of Maryland, made the first valuable harvester. It had open fingers, with the knife reciprocating in the space. The open-topped slotted finger was patented by Hussey in 1847. The cutter bar was on a hinged frame.

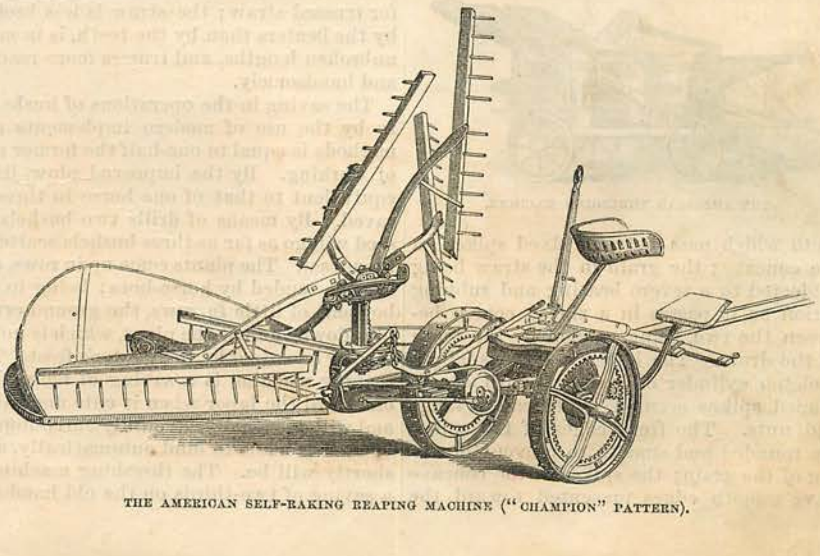
In 1834 M'Cormick, of Virginia, patented his reaper, which, with various improvements in 1845 and 1847, received a Council medal at the London World's Fair in 1851. This machine had a sickle-edged sectional knife reciprocated by crank and pitman by gear connection to the drive-wheel on which the frame rested; spear-shaped fingers gathered the grain, which was laid over to the cutter by a revolving reel. A *divider* was used on each end of the platform. The driver and raker had seats on the machine.

In 1849 Haines, of Illinois, suspended the frame carrying the conveyer, reel, and cutter to the axles of the bearing-wheels, and hinged the frame to the tongue, so that it was capable of turning upon its bearings by means of a lever to elevate and depress the cutter.

Since 1851 nearly 3000 patents have been granted in the United States for harvesters and attachments therefor.

In the summer of 1855, at a competitive trial of reapers, about forty miles from Paris, France, three machines were exhibited from America, England, and Algiers. The following was the result in a field of oats: the American machine cut an acre in twenty-two minutes; the English machine cut an acre in sixty-six minutes; the Algerian machine cut an acre in seventy-two minutes.

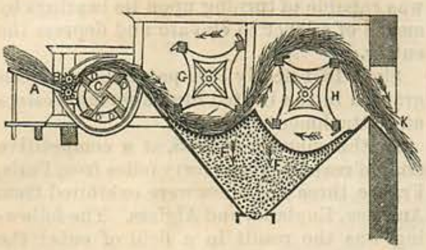
Some of the subsequent improvements may be enumerated as follows: The Sylla and Adams patent (1853), having a cutter bar hinged to a frame, which is in turn hinged to the main frame. This is the principal feature of the "Aultman and Miller," or "Buckeye," harvester. The combined rake and reel of the "Dorsey" machine (1856), sweeping in a general horizontal direction across the quadrantal platform. The "Henderson" rake, on what is known as the



THE AMERICAN SELF-RAKING REAPING MACHINE ("CHAMPION" PATTERN).

"Wood" machine (1860), having a chain below the platform, which carries the rake in a curved path. The Sieberling "dropper" (1861), which is a slatted platform vibrating to discharge the gavel. The Whiteley patents, which constitute the "Champion" machine of Springfield, Ohio.

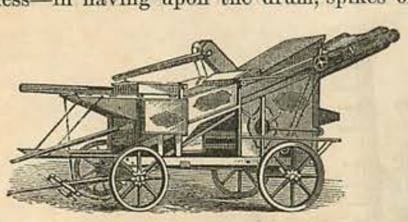
The threshing machine first saw the light in 1786. It was invented by Andrew Meikle, of Tyningham, East Lothian, Scotland. It is true that attempts had been made by Menzies in 1732 and Stirling in 1758, but they proceeded on a wrong principle, and were abandoned. Menzies's had a series of revolving flails, and Stirling's had a cylinder with arms upon a vertical shaft running at high velocity. Meikle invented the drum



MEIKLE'S THRESHING MACHINE, 1786—INTERIOR VIEW.

with beaters acting upon the grain in the sheaf, which was fed between rollers. The English improvement was to make the beating drum work in a concave known as the *breasting*, the grain and straw being scutched and rubbed between the two and carried to the shaker, which removed the straw from the grain and chaff, a large amount of grain also falling through the bars of the concave.

The American improvement upon this consists mainly—besides numerous details which secure speed, lightness, and effectiveness—in having upon the drum, spikes or



THE AMERICAN THRESHING MACHINE.

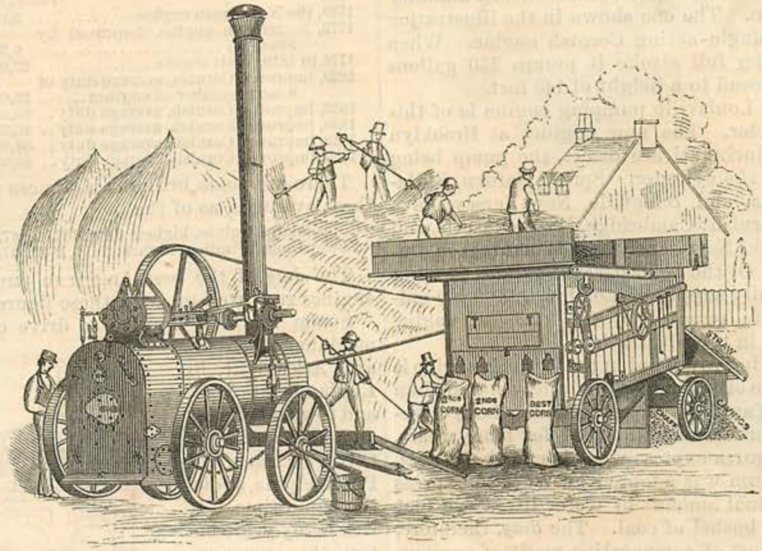
teeth which pass between fixed spikes on the concave; the grain in the straw being subjected to a severe beating and rubbing action as it passes in a zigzag course between the two, being carried by the teeth of the drum. The latter is now usually a skeleton cylinder of iron bars with sword-shaped spikes secured by threaded tangs and nuts. The front edges of the spikes are rounded and smooth to prevent breaking of the grain; the spikes of the concave have smooth edges presented toward the coming grain for a similar reason. The English still adhere to the flat beaters, like narrow wings or slats, placed longitudinally, and with edges projecting outwardly from the drum. The Americans adhere to the spiked cylinder. A fair trial between the two was had on the farm of Mr. Mechi, Tiptree Hall, Kelvedon, England, in 1853. The American machine was operated by the two persons who had shipped it from the United States; one of them was the present writer. The trial was conclusive. The American machine was driven by a portable engine of six horse-power, and averaged sixty-four bushels of wheat per hour; 448 bushels of barley were threshed in six hours, nearly treble the work of the English competing machines, and the grain in much cleaner condition.

The editor of the London *Times*, Mr. Mowbray Morris, himself witnessed the operation, and wrote as follows in an editorial of the following day, November 1, 1853:

"The machine, which is portable, weighs only fourteen hundred-weight, threshes easily, and without waste, at the rate of one bushel in forty seconds, and turns out the grain perfectly clean and ready for market. It is therefore about twice as light in draught as the lightest of our machines of the same description; does as much if not more work than the best of them, and, with much less power, dresses the grain, which they do not, and can be profitably disposed of at less money than our implement-makers charge.....We build threshing-machines strong and dear enough and tremendously heavy either to work or to draw. The American farmer demands and gets a machine which does not ruin him to buy or his horse to pull about, which runs on coach and not wagon wheels, and which, without breaking the heart of the power that drives it, yields the largest and most satisfactory results. Nothing, therefore, can better illustrate the difference in mechanical genius in the two countries than this grain separator as compared with its British rivals."

It may be mentioned that the apparent perversity with which the British retain flat beaters instead of the teeth is that in many parts of Britain there is a profitable market for trussed straw; the straw is less broken by the beaters than by the teeth, is in more unbroken lengths, and trusses more readily and handsomely.

The saving in the operations of husbandry by the use of modern implements and methods is equal to one-half the former cost of working. By the improved plow, labor equivalent to that of one horse in three is saved. By means of drills two bushels of seed will go as far as three bushels scattered broadcast. The plants come up in rows, and may be tended by horse-hoes; being in the bottoms of little furrows, the ground crumbles down against the plant, which is not so readily *heaved out* by the winter's frost. The reaping machine is a saving of more than one-third the labor when it cuts and rakes, and will eventually save fully three-fourths when it is made to bind automatically, as it shortly will be. The threshing machine is a saving of two-thirds on the old hand-flail



ENGLISH THRESHING MACHINE.

mode. The root-cutters for stock in England, and in some places in the Northern States and Canada, much reduce the labor of winter feeding. The saving in the labor of handling hay in the field and barn by means of horse-rakes and horse hay-forks is equal to one-half. With the exception of the grain drill, which had a precarious existence previous to 1776, all these improvements have been commenced and brought to the present relative perfection within the century now closing.

THE STEAM-ENGINE AND ITS APPLICATIONS.

We have no space for the repetition of the history of the steam-engine—to recite the toys and experiments of Hero, Da Vinci, De Garay, Porta, the mythical De Caus, the water-raising apparatus, not engines, of Worcester and Savary, and the engine of Papin, in which steam was first used against a piston in a cylinder.

Our century opens with the engine of Newcomen in action, as shown on page 68. This engine had a vertical open-topped cylinder above the boiler. It had two valves, which were operated by hand; one admitted steam below the piston, which was raised by the weight of the pump-rod. The steam having filled the space below the piston, was then shut off, and the valve of the water-injection pipe was opened. The jet of water condensed the steam in the cylinder, and produced a partial vacuum therein; the weight of the atmosphere pressed down the piston, and raised the pump-rod. This was really quite excellent in its way, and the atmospheric engine is yet a very useful pumping engine. It was as great an advance on Captain John Savary's water elevator as James Watt's subsequent improvement was upon itself. To recite its faults and inefficiencies—for it had both—is but to recite the inventions of Watt.

Watt's first patent was taken out in 1769, in conjunction with a Mr. Roebuck, who afterward retired from the partnership, and Watt found an excellent successor to him in Matthew Boulton, of Soho, near Birmingham.

The fame of the steam-engine traveled to the English colonies even before the date of the invention of Watt, but, for such mills as the colonists erected, the water-powers on the streams were yet abundantly sufficient. It is doubtful whether there were more than two steam-engines in the colonies. They were both of the Newcomen kind. One was imported in 1736 for the Schuyler copper mines at Passaic, New Jersey; the other was built in 1772 by Christopher Coles, of Philadelphia, for use in a distillery.

The principal use, for a long time, of the steam-engine in England continued to be in pumps for draining mines and for supplying water to cities. London for this latter purpose had a Boulton and Watt engine in the vicinity of London Bridge. This type of engine has permanently received its name from the locality of its first triumphs, and is known as the Cornish. It is the largest, heaviest, most expensive, and most economically driven engine known to the engineer—a valuable stationary engine when parties are capable of spending a large sum to secure a machine which may be run at a small outlay. It is a large investment of capital for the sake of an economic administration. The one shown in the illustration is a single-acting Cornish engine. When working full stroke it pumps 150 gallons per second to a height of 140 feet.

The Louisville pumping engine is of this character. The new engines at Brooklyn and Cincinnati are direct, the pump being below the cylinder. Spring Garden, Philadelphia, and Belleville, New Jersey, have the Cornish; Cambridge, Massachusetts, and Newark, New Jersey, the Worthington Duplex. Of the 115,000,000 of gallons forming the daily supply of London, 79,000,000 gallons are pumped by the class of engine shown in the illustration.

The improvement in the Cornish engine is capable of being more definitely stated than that of any other form, for it has been closely observed and tabulated for many years. The figures express what is called the *duty*. This term was adopted by Watt to express the actual amount of water lifted one foot by the bushel of coal. The *duty*, therefore, is the test of comparative merit of engines, and the figures following clearly indicate the improvement in the Cornish pumping engine:

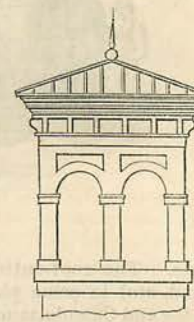
Year.	Pounds, 1 foot high.
1769, the Newcomen engine	5,500,000
1772, Newcomen engine, improved by Smeaton	9,500,000
1778 to 1815, Watt engine	20,000,000
1820, improved Cornish, average duty of a large number of engines	28,000,000
1826, improved Cornish, average duty	30,000,000
1830, improved Cornish, average duty	43,350,000
1839, improved Cornish, average duty	54,000,000
1850, improved Cornish, average duty	60,000,000

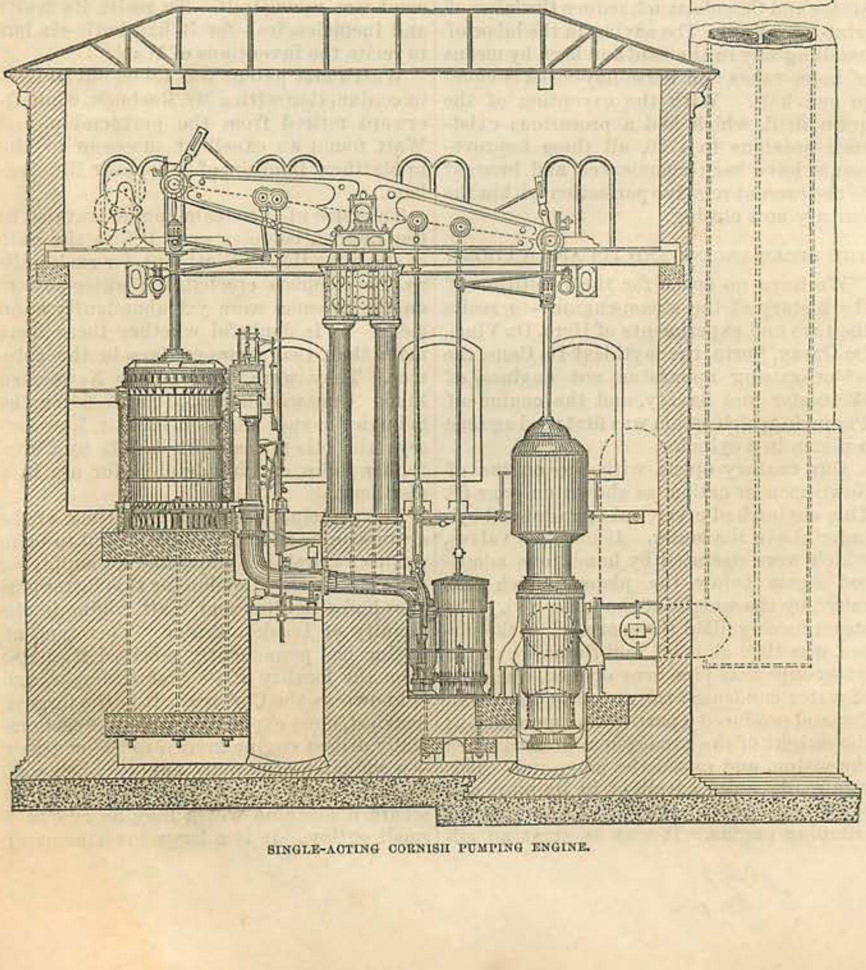
There are some brilliant instances above these averages, as of the

"Consolidated" mines, highest duty, 1827	67,000,000
"Fowey Consols" mines, highest duty, 1842	97,000,000

The *duty* of the best American pumping engines runs well up with these figures.

Steam was first applied to drive cotton machinery by Richard Arkwright, in England, in 1785, and to grind plaster and saw stone by Oliver Evans, in Philadelphia, about the same time. It was many years before the steam-engine was applied in the United States to factory use, but





SINGLE-ACTING CORNISH PUMPING ENGINE.

that application of the engine rapidly increased in England. It was Watt's engine in substantial respects, though other persons increased and harmonized the proportions, giving it a power and completeness far beyond what its admirable inventor lived personally to witness.

STEAM NAVIGATION.

The steam-engine was used for transportation on the water before it was adapted to land carriages. This was owing to its having started as an atmospheric engine, where the force was derived from the pressure of air upon the piston when a partial vacuum was produced by the condensation of steam in the cylinder. The engine was relatively large and heavy, and in its proportions was better suited to a boat than to a wagon. The use of high-pressure steam was an afterthought. Though Watt, with his singular sagacity, added to his specification the idea of adapting high-pressure steam to the purposes of river and land locomotion, it was but as a caveat, for he built none.

The origin of the steamboat has been a vexed question for nearly a century. As the parties who first worked at the problem with success could not apportion among themselves the exact measure of credit to which each was entitled, so by carefully fanning the flames of national vanity the subject has been kept afloat, and of three nations each has its advocates, who feel bound to depreciate the claims of all others. The truth is, the engine was Newcomen's, and then Watt's, and the boat was any body's; and persons went to work here and there, with varying degrees of success, depending upon political influence, social standing, moneyed resources, or friends thus provided, and last, not least, mechanical talent for harnessing the engine to the paddle or propeller used to push against the water.

In this struggle great pertinacity was exhibited in Scotland and America. To deal out the exact proportion of credit due to each man is not easy; one measure is to be awarded to skill in mechanical adaptation, another to skill in fitting and proportioning.

In 1780 was patented the present arrangement of connecting-rod, crank, and fly-wheel. The Marquis de Jouffroy in that year successfully worked a steamboat 140 feet long on the Saône. Joseph Bramah (1785) patented a rotatory engine on a propeller shaft. Here occurs the term "screw-propeller," since so common. In 1787 Patrick Miller, of Dalswinton, published a specification of a triple boat, with paddles in the intervals, and a deck over the three boats. The same year a double boat was steamed on the Frith of Forth. John Fitch, of Philadelphia, the next year obtained a patent for the application of steam to navigation in Pennsylvania, New York, New Jersey, and Delaware. The boat had vertical reciprocating paddles, and made eighty miles per day. It proceeded upon an entirely wrong principle.

In 1802 Symington ran the *Charlotte Dundas* on the Forth and Clyde Canal. She had a double-acting Watt engine, working by a

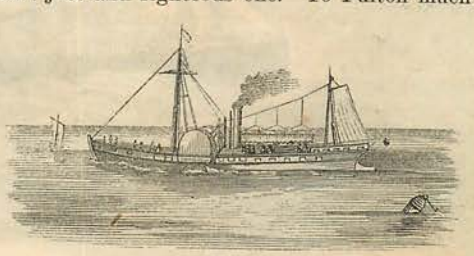
SYMINGTON'S STEAMBOAT, "CHARLOTTE DUNDAS."

connecting-rod to a crank on the paddle-wheel shaft. This is the first instance of these parts being thus combined.

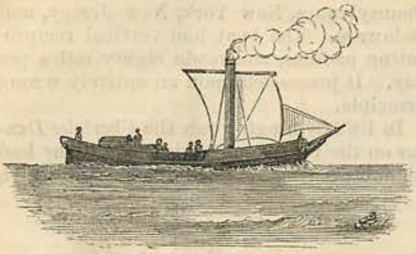
The idea of canal use alone engaged the inventor, and the boat was rejected because the canal banks were likely to be damaged.

In 1804 John Cox Stevens, of New Jersey, constructed a boat on the Hudson, driven by a Watt engine, with a tubular boiler of his own invention. It had a bladed screw-propeller. The same year Oliver Evans had a stern-paddle-wheel boat on the Delaware and Schuylkill rivers. It was driven by a double-acting high-pressure steam-engine, which was the first of its kind, and was geared to rotate the wheels by which the boat was moved on land, and driven in the water when the power was transferred to the paddle-wheel at the stern.

In 1807 Robert Fulton, of New York, went from that city to Albany in the *Clermont*, a boat of 160 tons burden, with side paddle-wheels, driven by an engine which he purchased when in England of Boulton and Watt. She ran during the remainder of the year as a passenger boat. She was the first that ran for practical purposes, and proved of value. The outside bearing of the paddle-wheel shaft and the guard were invented by Fulton. The boat may be considered to have been about the sixteenth steamboat; nevertheless the popular verdict is a just and righteous one. To Fulton much



FULTON'S STEAMBOAT, "CLERMONT," 1807.



BELL'S STEAMBOAT, "COMET," 1812.

more than to any other one man is due the credit of the introduction of steam navigation. His enterprise opened the way, and he was the first to apportion the strength and sizes of parts to the respective strains and duties. He had previously seen Symington's boat, and had launched an experimental one, 66 feet long, on the Seine. The former may have directed his attention to the matter, and the latter was a useful apprenticeship. Mr. Charles Brown had built for Mr. Fulton, between 1806 and 1812, six steamboats of lengths varying from 78 to 175 feet, and tonnage 120 to 337, prior to the practical working of any steamboat in Europe.

The first steamboat in the Mississippi Valley was the *Orleans*, of 100 tons, built at Pittsburg by Fulton and Livingston in 1811. She had a stern wheel, and went from Pittsburg to New Orleans in fourteen days. The next was the *Comet*, of 25 tons, in 1814. She made three or four trips, was taken to pieces, and the engine was set up in a cotton factory. The *Vesuvius*, in 1814, was the next. She made a number of trips, but eventually exploded.

Henry Bell, of Scotland, in 1812 built the *Comet*, of 30 tons, with side paddle-wheels, which plied between Glasgow and Greenock on the Clyde, and the next year around the coasts of the British Isles.

In 1818 the *Walk-in-the-Water*, of 360 tons, was built at Black Rock, Niagara River, by Noah Brown, of New York, for traffic on the lakes. Her Boulton and Watt engine was made in New York and transported by boat to Albany and by teams to Black Rock. The boilers were prepared in New York and sent piecemeal to the lake. The vessel was lost in a gale in 1821.

In 1819 the *Savannah*, 380 tons burden, crossed the Atlantic from America, visited Liverpool, St. Petersburg, and Copenhagen, and returned. Six years later the *Enterprise* rounded the Cape of Good Hope and went to India.

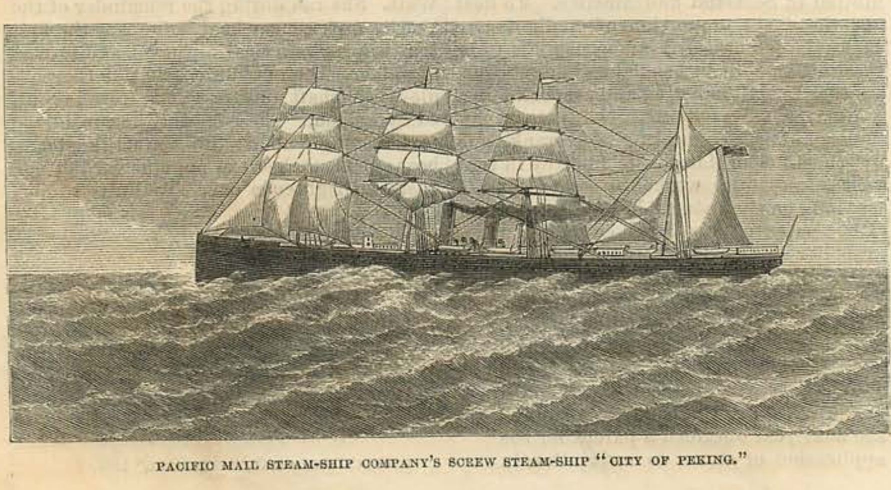
In 1838 the *Great Western* (1340 tons) and the *Sirius* steamed across the Atlantic from England. Two years afterward the Cunard line was started, and was followed by the Collins line in 1850. The *Great Eastern* was built in 1858, the French iron-clad *La Gloire* in 1859, the English iron-clad *Warrior* in 1860, and the Ericsson *Monitor* in 1862.

Feathering paddle-wheels, such as Morgan's, were largely used in the British navy. Manly's are somewhat noted here. Holland's oblique paddle float, and many others, might be noted were there room for detail.

The steamboats of our American rivers and lakes have no equals in the world, nor are there such waters elsewhere to afford a theatre for such boats.

The paddle-wheel has to a large extent given place to the screw-propeller. There is perhaps but one paddle-wheel steamer in the United States navy, the *Powhatan*.

The screw-propeller was invented by numerous people, if we are to assume that each person who put forward a claim or who patented it supposed himself to be an original inventor. Several notices of it occur, but it came more distinctly into notice when brought forward by Ericsson in 1836. The supernaturally wise old sea-dogs and



PACIFIC MAIL STEAM-SHIP COMPANY'S SCREW STEAM-SHIP "CITY OF PEKING."

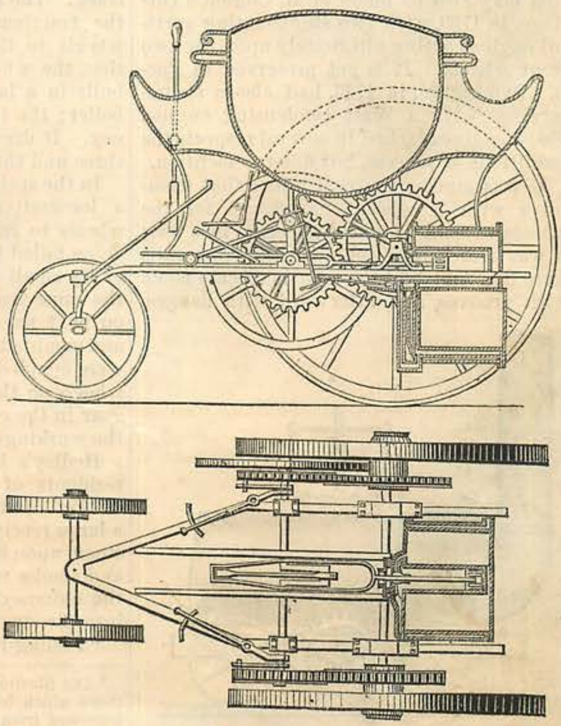
landsmen of the British Admiralty sneered at the innovation, but Captain Robert F. Stockton and Francis B. Ogden, of New Jersey, appreciated it. The former introduced it to the United States Navy Department, and the war steamer *Princeton* was launched upon the Delaware. The *Robert F. Stockton*, an iron vessel fitted with a screw-propeller, was launched upon the Mersey in 1838, and crossed to the United States the next year. Her name was changed to *New Jersey*, and she was the first screw-propeller vessel practically used in America, as Ericsson's *Francis B. Ogden* was the first in Europe. Ericsson accomplished for the screw-propeller in England and America what Fulton did for the paddle-wheel in America and Bell in England.

Other improvements have been added, including Woodcroft's increasing pitch screw and Fowler's and Hunter's vertical submerged paddle-wheels.

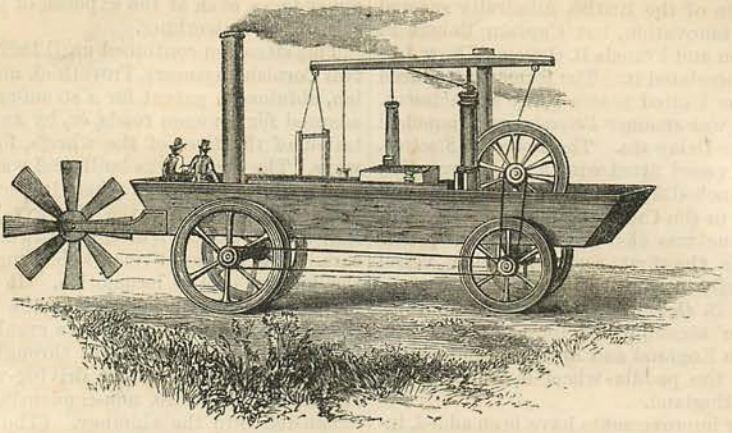
THE LOCOMOTIVE.

It is not easy from the stand-point of the present to realize the original difficulty in adapting the steam-engine to the propulsion of carriages. There was a fixed belief in regard to steam, derived from the mode of using it in the atmospheric engine of Newcomen and from the cautious habit of Watt, that the safest method was merely to obtain a vacuum by its condensation, so as to bring the unbalanced atmospheric pressure upon one side of the piston. This involved a great weight and bulk of machinery, and long prevented the adaptation of the engine to land transportation. The steamboat engine used by Miller, of Dalswinton, in 1787 differed from Watt's in the saving of weight by the abolition of the air-pump, and depended upon abundant injection of water to produce a vacuum. Watt was afraid of high-pressure steam, and we can fancy, had he lived to be on board one of our Western river boats, and heard the energetic cough of the escaping steam, he would have wished himself safely back again with Brother Boulton, and among the models and drawing-boards of his sanctum at the "Soho Works." He had no faith in an engine without a condenser, and, as the event proved, no steam-carriage could succeed till the weight of the engine was reduced by the removal of the condenser, air-pump, and their cumbrous appendages, even at the expense of greater cost of fuel in working.

This situation continued until 1802, when two Cornish engineers, Trevethick and Vivian, obtained a patent for a steam-carriage adapted for common roads, or, by an adaptation of the tires of the wheels, for railways. The engine was built, and was tried and modified till 1805, when it became a useful locomotive on the Merthyr-Tydvil Railway, in South Wales, in drawing coal cars. It is the most remarkable engine in the history of the locomotive. It had a horizontal cylinder inclosed in the boiler, the piston and rod operating a crank axle, which communicated power through gear wheels to the axle of the driving-wheels. It was high-pressure, non-condensing, and exhausted into the chimney. (The latter is not shown in their official drawing.) It was the first locomotive to run on tram-ways or on rails. The steam-cocks were operated from the crank axle, as were also the feed-pump and the bellows for urging the fire. The body of the carriage followed the old English stage shape. It was not alone that these men devised several features that experience has retained, but they were the first to disregard the prejudice against high steam, and to make a compact engine which would neither overtax the wheels nor take up all the room, to the exclusion of passengers and goods.



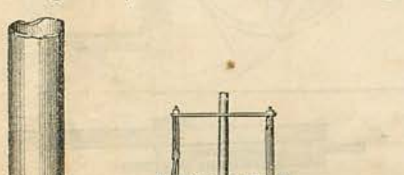
TREVETHICK AND VIVIAN'S LOCOMOTIVE, "MERTHYR-TYDVIL," 1805.



EVANS'S LOCOMOTIVE.

Oliver Evans, of Philadelphia, labored for a number of years to obtain help to construct his high-pressure engine, which was built in 1802 for running a marble saw and plaster mill, and in 1804 was adapted to a scow for dredging in the Delaware River. By an ingenious band connection to wheels, or to a stern-wheel paddle shaft, he made his scow travel on land or water, as the case might be. It was an ungainly affair, with vertical cylinder, working-beam, and fly-wheel—useless for land locomotion. Mention may also be made of M. Cugnot's carriage, in 1769, with two single-acting vertical engines acting alternately upon the two front wheels. It is yet preserved in Paris. Symington, in 1786, had also a steam-carriage with a Watt condensing engine. These engines lacked in several respects the conditions of success, but deserve mention.

It was among the coal mines that tram-ways with tracks of flag-stones for the wheels of coal wagons first came into use; it was also in the collieries that iron rails were first laid, and the wheels of cars made with grooves, and afterward with flanges,



BLENKINSOP'S LOCOMOTIVE, "LORD WELLINGTON," 1811.

to enable them to keep on the track. It was twenty-five years after the use of the locomotive in South Wales before the rail-way was used, except for transporting coal.

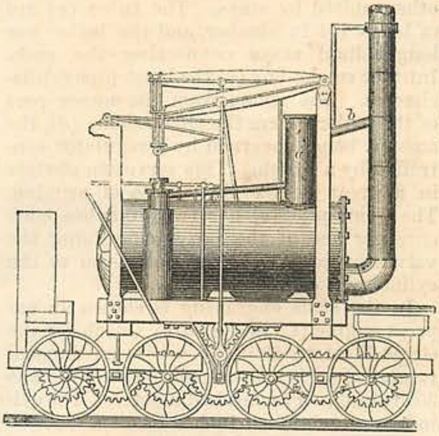
The next locomotive after that of Trevethick and Vivian was one made by Blenkinsop in 1811 for working at the Hunslet-Moor Colliery, near Leeds.* The flat-faced wheels ran upon a tram-way, and a cog-wheel, driven by pinions and connecting rods from the pair of vertical cylinders, drove the engine by meshing into a rack on one side of the track. The idea prevailed at the time that the tractional adherence of the driving-wheels to the rail was not sufficient, but that the wheels would slip. The fire was built in a large tube passing through the boiler; the tube was bent to form a chimney. It drew trains of thirty tons weight three and three-quarter miles per hour.

In the spring of 1813 William Hedley built a locomotive with four smooth driving-wheels to run on a smooth rail. The machine failed to accomplish much on account of its small boiler. Hedley thereupon in the same year built another engine, shown on next page, having a return flue boiler, and mounted on eight driving-wheels, which were coupled together by intermediate gear wheels on the axles, and all propelled by a gear in the centre, driven by a pitman from the working-beam.

Hedley's locomotive was objected to by residents of Newcastle on account of the smoke. He therefore passed the smoke into a large receiver (*a*), and turned the exhaust steam upon it. From the receiver the steam and smoke were conveyed by a pipe (*b*) to the chimney, which device soon developed into the steam blast.

"Puffing Billy" was at work more or less

* The illustration of Blenkinsop's locomotive, and those which follow, on p. 82, 83, 84, 85, and 86, are borrowed from *Knight's Mechanical Dictionary*, published by J. B. Ford and Co., New York.



HEDLEY'S LOCOMOTIVE, "PUFFING BILLY," 1813.

until 1862, when it was laid up as a memorial in the British Patent-office Museum. Hedley died in 1842.

In 1815 Dodd and Stephenson patented an engine with vertical cylinders. The adherence to this form was on account of its supposed value in pressing the wheels down upon the track. Stephenson, in 1825, made an engine for the Killingworth Railway, and his engines were employed on iron tracks by the Stockton and Darlington Railway, and at the Newcastle collieries. His first locomotive on this railway had two vertical cylinders, and the driving-shaft had cranks at an angle of ninety degrees. The axles of the wheels were coupled by an endless chain passing around both axles.

In 1829 the Liverpool and Manchester Railway, then the most extensive and finished work of the kind ever undertaken, and the first passenger railway, was completed, and the directors offered a reward of £500 for the best locomotive which should fulfill certain imposed conditions. Among these were that it was to consume its own smoke, draw three times its own weight at a rate of not less than ten miles an hour, and the boiler pressure was not to exceed fifty pounds per square inch. The weight was not to exceed six tons, nor the cost £550.

Three engines competed—the "Rocket," constructed by George Stephenson; the "Sanspareil," by Timothy Hackworth; the "Novelty," by Messrs. Brathwaite and Ericsson.

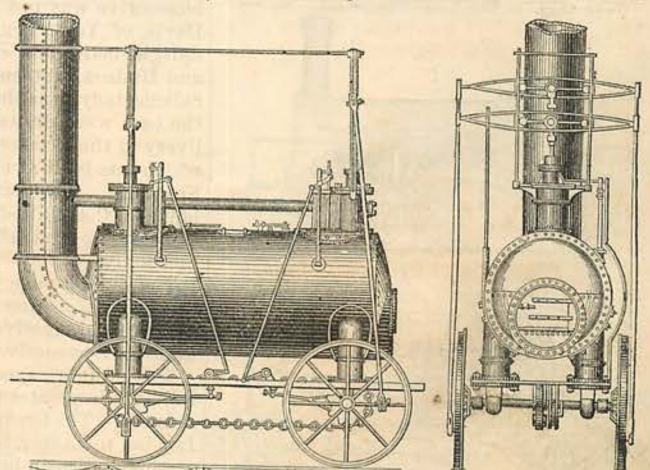
The "Rocket" weighed 4 tons 5 hundred-weight, and its tender, with water and coke, 3 tons 4 hundred-weight. It had two loaded carriages attached, weighing a little over 9 tons 10 hundred-weight. The greatest velocity attained was $24\frac{1}{4}$ miles per hour, and the average consumption of coke per hour 217 pounds.

The "Sanspareil" attained a speed of $22\frac{3}{5}$ miles per hour, but with an expenditure of fuel per hour of 692 pounds.

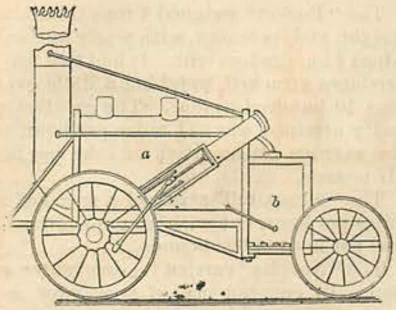
The "Novelty" carried its own water and fuel. In consequence of successive accidents to the working arrangements, this engine was withdrawn from competition. A fourth engine, the "Perseverance," by Burstall, not being adapted to the track, was withdrawn.

The opening of the Liverpool and Manchester Railway, September 15, 1829, was an era in civilization, and one of the first victims of the iron horse was slain on that day—Mr. Huskisson, Home Secretary in the British cabinet. Eight locomotives were used on that day, and while the engines were watering at the Parkside station, some of the guests descended to the road. While Mr. Huskisson was talking to the Duke of Wellington the famous "Rocket" came by, knocked down Mr. Huskisson, and the wheels passed over his left leg. He was placed on board the "Northumbrian," driven by George Stephenson, who conveyed him fifteen miles in twenty-five minutes, at the rate of thirty-six miles an hour—the most marvelous achievement yet. Mr. Huskisson died the same night at Eccles.

The "Rocket" engine was superseded in 1837, as too light for the work, and was condemned for life to the collieries. Here it proved itself capable of a rate of sixty miles an hour; but being again convicted of levity while on duty, it was cashiered, and its place filled by heavier machines of twelve



DODD'S AND STEPHENSON'S LOCOMOTIVE, 1815.

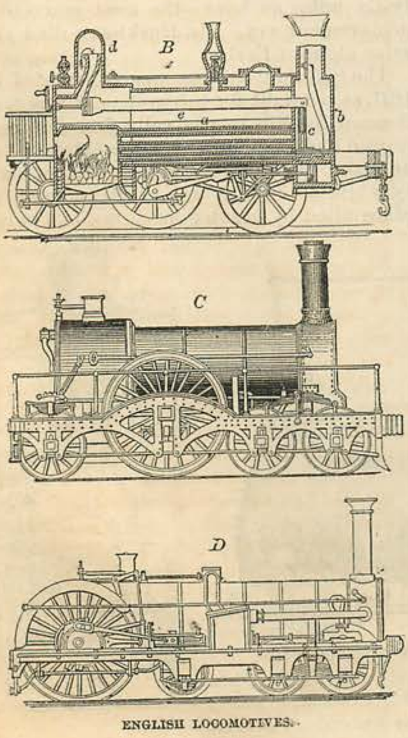


STEPHENSON'S LOCOMOTIVE "ROCKET," 1829.

tons. After a few years of inglorious retirement, some one, not totally oblivious of how it would look in history, recalled the old soldier from his limbo, and he now enjoys the company of his elder brother, Hedley's "Puffing Billy," in the English Patent-office Museum.

The boiler (*a*) of the "Rocket" was a cylinder six feet long, and had twenty-five tubes. The fire-box (*b*) had two tubes communicating with the boiler below and above, and was surrounded by an exterior casing, into which the water from the boiler flowed, and was maintained at the same level as that in the boiler.

In the accompanying engraving (B) is shown a longitudinal vertical section of a modern English locomotive. The boiler is surrounded by two casings, one within the other, united by stays. The tubes (*a*) are of brass, 124 in number, and the boiler has longitudinal stays connecting the ends. Into the smoke-box (*b*) the blast-pipe (*c*) discharges. The steam from the upper part of the boiler enters the steam-dome (*d*), the amount being governed by a regulator controlled by a winch. This serves to obviate in a great degree the effects of priming. The steam-pipe (*e*) has two branches, each entering one of the boxes containing the valves by which the flow of steam to the cylinders is controlled.



ENGLISH LOCOMOTIVES.

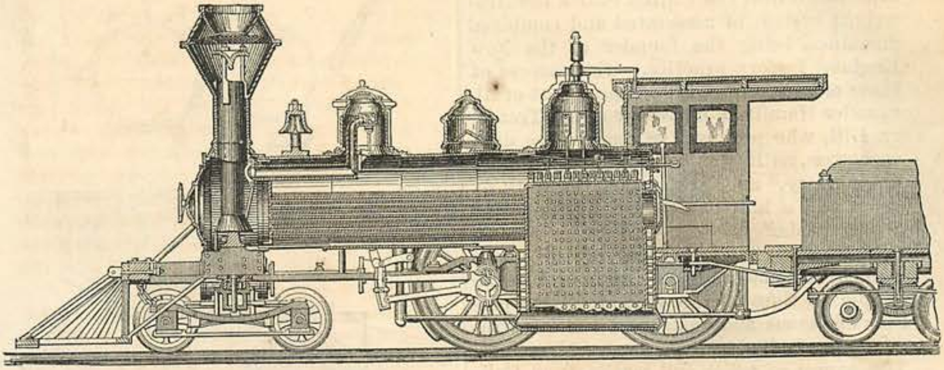
In the same engraving is shown an express engine (C) designed by Gooch for the Great Western Railway, where an unusual rate of speed is maintained. The boiler has 305 tubes, two inches in diameter. The cylinders are eighteen inches in diameter, and twenty-four stroke, the driving-wheels eight feet in diameter, the heating surface of the fire-box 153 square feet. There is also an illustration (D) of an express engine designed by Crampton for the narrow gauge.

The first locomotive run on rails outside of England was the "Stourbridge Lion," made by Stephenson, and brought from England for the Delaware and Hudson Canal and Railroad Company by Horatio Allen. This was in August, 1829. It was soon found that English locomotives, adapted for gentle curves, were ill suited for the exigencies of American railroads, where curves of as small a radius as 200 feet were sometimes employed. Mr. Peter Cooper devised an engine which solved the difficulty. This was also in 1829.

The first railway in the United States was one of two miles long, from Milton to Quincy, Massachusetts, in 1826. The cars were drawn by horses. The Baltimore and Ohio was the first passenger railway in America, fifteen miles being opened in 1830, the cars being drawn by horses till the next year, when a locomotive was put on the track, built by Davis, of York, Pennsylvania. It had an upright boiler and cylinder. The Mohawk and Hudson, sixteen miles, from Albany to Schenectady, was the next line opened, and the cars were drawn by horses till the delivery of the locomotive "De Witt Clinton," which was built at the West Point Foundry, New York. This was the second locomotive built in the United States; the first was made at the same shop for the South Carolina Railway.

The cut on page 85 represents a central longitudinal section of an approved form of American locomotive engine as made at the Baldwin Locomotive Works, Philadelphia.

The ordinary speed attained on English railways is greater than that usual in this country. The Great Western Express, from London to Exeter, travels at the rate of forty-three miles an hour, including stoppages, or fifty-one miles an hour while actually

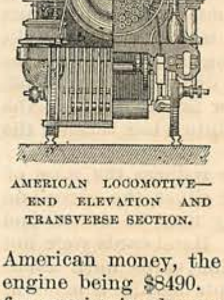


AMERICAN LOCOMOTIVE—CENTRAL LONGITUDINAL SECTION.

The engine has four drivers, 60¾ inches in diameter, and a four-wheeled swing-bolster truck, and weighs, with water and fuel, about 65,000 pounds. The flues, 144 in number, are 2 inches in diameter, and 11 feet 5 inches in length. The fire-box, of cast steel, is 66 inches long, 34⅜ inches wide, and 63 inches deep. Water space, 3 inches sides and back, 4 inches front. Grates, cast iron. The cylinders are horizontal. Valve motion graduated to cut off equally at all points of the stroke. The tires are of cast steel, and the wheel centres of cast iron with hollow spokes and rims; the wrist pins of cast steel, the connecting rods of hammered iron. The truck wheels are 28 inches in diameter. All the principal parts of these engines are interchangeable.

running. Midway between some of the stations a speed of sixty miles an hour is attained, and on experimental trips seventy miles an hour has been reached, or nearly thirty-three yards per second.

Very high speed has been attained on special occasions on American roads, probably fully equal to any time ever made in England. For instance, it is stated that a train conveying some officials of the New York Central Railroad made the distance from Rochester to Syracuse, eighty-one miles, in sixty-one minutes—said to be the fastest time ever made in America.



AMERICAN LOCOMOTIVE—END ELEVATION AND TRANSVERSE SECTION.

The life of a locomotive engine is stated in a paper read before the British Association at thirty years. Some of the small parts require renewal every six months. The boiler tubes last five years, and the crank axles six years; tires, boilers, and fire-boxes, seven to ten years; the side frames, axles, and other parts, thirty years. During this period the total cost of repairs is estimated at $24,450 in American money, the original cost of the engine being $8490. It therefore requires for repairs in eleven years a sum equal to its original cost. In this time it is estimated that an engine in average use has run 220,000 miles.

COTTON MANUFACTURE.

Cotton was known to the ancients as *tree-wool*, being mentioned by Herodotus, Pliny, and many others. It was introduced into Spain by the Arabs, and flourished as long as religious toleration existed in the peninsula, and from this land it reached the less civilized parts of Europe. When the best part of the inhabitants was expelled, when the University of Cordova became a thing forgotten in the peninsula, when the memory of Alhazen was lost, and the era of the Pedros and Philips commenced, then the cotton-plant too faded away, and all the industries growing out of this beautiful staple expired.

Cotton was, however, known to the Mexicans when discovered by Cortez. This man without a conscience sent of his stolen goods to Charles V. "cotton mantles, some all white, others mixed with white and black, or red, green, yellow, and blue; waistcoats, counterpanes, tapestries, and carpets of cotton; and the colors of the cotton were extremely fine."*

Although there are several native American varieties of cotton, our plant is a native of India, and it has formed the staple material of garments there from time immemorial.

Cotton goods were made in Manchester in 1641, of "cotton-wool brought from Smyrna and Cyprus." Cotton seed was brought to England from the Levant, taken thence to the Bahamas, and thence to Georgia in 1786. The first cotton mill in America was at Beverly, Massachusetts, 1787. Slater's mill was erected at Pawtucket in 1789. Slater was an apprentice of Strutt and Arkwright, and

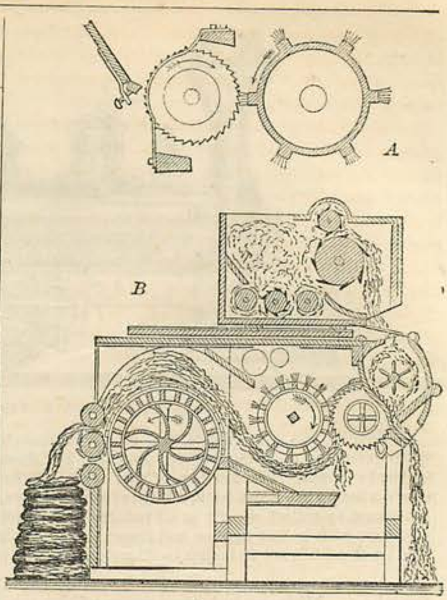
* Clavigero's *Conquest of Mexico.*

introduced into the United States the Arkwright system of associated and combined machines, being the founder of the New England factory practice. The success of these mills is referred to in the report of Alexander Hamilton, Secretary of the Treasury, 1791, who proposed to remove the duty on cotton, as it was "not a production of the country," and to "extend the duty of seven and a half per cent. to all imported cotton goods."

The beauty and softness of the goods made of this material, which was new to the people of Europe, recommended it to persons of means and taste, and the importation from India assumed large proportions. The names of *calico* and *muslin*, from Calicut and Moussoul, indicate clearly enough whence the market was supplied at an early day. The English manufacturers struggled against many difficulties, three of which may be named—the lack of suitable machinery; the opposition of the wool trade, which induced the authorities even to hang criminals in cotton garments to render the goods unpopular; and the lack of supply of cotton.

The cotton from the boll yields only from one-quarter to one-third ginned fibre, and the labor of removing the seed by hand seemed at this critical moment to set a limit to the production, or at least render it so expensive that the goods could not come into general use among the masses of the people, who were used to being tolerably well fed and housed, and could not live on twopence a day and support their families, like the Hindoos. It is true that in India a sort of roller-gin had been in use from time immemorial—one which pinched the fibre and carried it away from the seed, whose size prevented it from passing between the rollers; but this was comparatively slow, and does not appear to have been known in America, where the hand-picking was in vogue. Besides, it is only suitable for certain staples of cotton. The great need of the producer and the manufacturer was a machine to remove the cotton from the seed with rapidity and economy.

At this juncture appears Eli Whitney, of Massachusetts, who in 1794 patented the *cotton-gin*. The name *gin* is short for *engine*, and is a frequent curt expression for a handy machine. Whitney's *saw-gin* (A) comprises two cylinders of different diameters mounted in a wooden frame, and turned by a handle or belt and pulley so as to rotate in opposite directions, the brush cylinder the faster. The smaller cylinder carries on its circumference from sixty to eighty circular saws, and the larger cylinder a series of brushes. The teeth of the saws pass in between a number of bars, forming a grating. The cotton, as picked from the pods, is thrown into the hopper; the saws strip the fibre from the seeds, which fall through



WHITNEY'S COTTON-GIN.

the bottom of the hopper, while the wool is cleansed from the teeth of the saws, and delivered by a sloping table into a receptacle below. A more modern and complete form of the machine (B) is shown in our engraving.

The crop of cotton increased from 189,316 pounds in 1791 to 2,000,000,000 pounds in 1859. Whitney and his partner received $50,000 from the State of South Carolina, and a tariff of so much per saw per annum from the States of North Carolina and Georgia for a short term of years.

After the gin come the *opener* and *scutcher*, which separate the locks of cotton, remove the dirt, and convert the tangled fibre into a light and flocculent *bat* or *lap*. The machines of this stage of the process have a number of names, the marks of the rough humor of the Lancashire men among whom they originated. They were known as *willowers*, from the practice of beating with willow wands, or as *devils* and *wolves*, from their toothed drums, which tore the locks apart, the fibre passing from one to another, and the dust and dirt being carried off by a suction blast, or falling through the meshes of wire-cloth into a box beneath the machine.

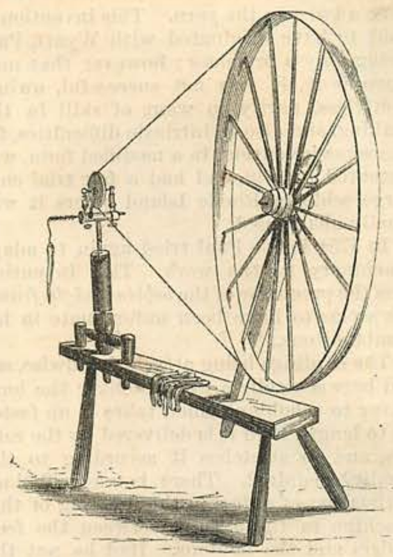
The *carding-machine* reduces the mass of cotton to a fleece or sliver, the fibres laid parallel, so that they may be drawn and twisted into a yarn. Hand cards were not superseded by machine cards until about 1770, although attempts had been made at carding-machines by Lewis Paul in 1748, and by Hargreaves in 1760. To the latter, to Arkwright, and to Mr. Peele, the father of the first Sir Robert and the grandfather of the statesman, the invention is ascribed. It was hardly possible that this necessary link in the chain of machines should long lack a discoverer.

Lewis Paul in his patent of 1748 had a number of parallel cards on a bed, or on a cylinder, with intervening spaces. It was used in connection with an upper card or a concave, and when the strips were full they were taken off, and the roving removed from each. Peele in 1779 introduced the cylinder. His machine had strips of card around the drum to give separate *slivers* or *cardings*, and a can, which rotated on its base, to give a slight twist to the rovings. This was perhaps the first *roving can*. The *card-sticking* machine was invented by Amos Whittemore, of Massachusetts, and patented by him in 1797.

Next in order of operation, though the first to feel the rising tide of invention, was the *spinning machine*. In ancient Egypt, Phœnicia, Arabia, India, Greece, and Rome the *distaff* and *spindle* were the means of spinning. The *spinning-wheel* may have originated among our cousins of Hindostan, as it was certainly known there at a somewhat distant period; it appears in our illuminated missals of the fourteenth century, but only among the lady population, being used by spinsters and matrons of rank. The great bulk of the spinning was by the distaff, which indeed is still used in many parts of the continent of Europe. Among English-speaking peoples it survived latest in the *flax-wheel*, in which a continuous thread was spun from a tussock of combed flax held upon a distaff at one end of the machine.

So far as we are concerned, the commencement of our century finds the spinning of cotton and wool in the condition of many previous ages and centuries; it was done upon hand spinning-wheels. This was true as to work done for the household and that which was done in the way of business, being distributed by the spinning masters of a neighborhood to the operatives, who did the work at their own houses.' When Hargreaves invented the spinning-jenny in 1768 cotton and woolen mills were unknown.

The wool being carded into rolls in which the fibres were arranged in one direction, the spinner attached the end of one to the spindle, which was then revolved by whirling the large wheel, a band passing over the periphery of the latter and over a little pulley on the spindle. The left hand of the operator drew out the roll as it was twisted, the degree of its elongation and the hardness of the twist depending upon the distance it was pulled out and the number of revolutions. In practice, the spinner steps back a distance after setting the wheel a-whirling, and, when the twist is satisfactory, by shifting the yarn from the point to the shaft of the spindle, and reversing the direction of rotation, the yarn is wound upon the spindle, excepting the end of the yarn, which is left projecting from the point for the attachment of another roll. Another feature must also be noticed, as it has a very close bearing upon what was followed in the most perfect known spinning machine, the *mule*, of which more presently. The spinner, after drawing out the roll, giving the wheel a whirl, and walking backward from it, dropped the roving, and then, advancing to the spindle, took the roving between the finger and thumb; then, giving a rapid revolution to the wheel, she walked backward away, allowing the roving to slip through the grip with just such friction as would secure the required tightness of twist. This done, the yarn was wound upon the spindle, and the double process repeated with another carded roll.



SPINNING-WHEEL.

This was the way with wool, and subsequently with cotton; but it was not until the rising demand for cotton yarn occurred that machinery was invented to supplement the individual exertions of the spinner. Machinery was first applied to silk, but the material was expensive, the demand limited, and the process essentially different. Lewis Paul led off in this line of invention in his patent of 1738, in which he introduced the idea of successive pairs of *drawing rollers* for elongating the roving, the speed of the consecutive pairs increasing so that each pulled upon the roving between it and the preceding pair, the eventual extension depending upon the relative rates of the increase of speed of the successive pairs. He also gave to one or more of the pairs of rollers a revolution in a plane at right angles to that of their individual rotation, so as to give a twist to the yarn. This invention is said to have originated with Wyatt, Paul being only a promoter; however that may have been, it was not successful, owing, doubtless, partly to want of skill in the making, and also to intrinsic difficulties, for the same invention, in a modified form, was patented in 1848, and had a fair trial on a large scale in Rhode Island before it was finally abandoned.

In 1758 Lewis Paul tried again to adapt machinery to the work. This invention was the precursor of the *bobbin-and-fly frame.* He seems to have been unfortunate in his combinations.

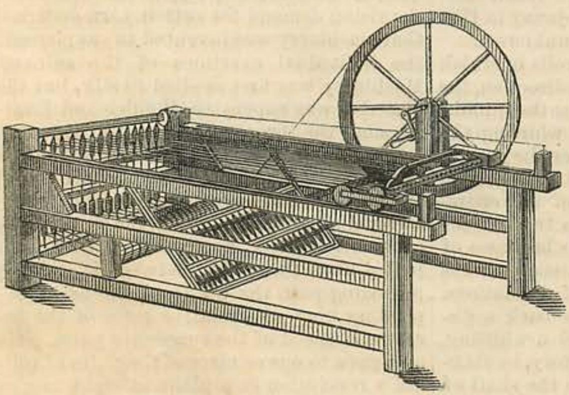
The cardings being attached endwise, are fed between rollers which deliver the long sliver to a bobbin, which takes it up faster as to length than it is delivered by the rollers, and so stretches it according to the quality required. There is an indistinct intimation of a *flyer* in the drawing of this machine in the stretch between the feed rollers and the bobbins. Had he put the *drawing rollers* of his former patent to the *feed rollers* and *bobbin* of his new one, he might, perhaps, have forestalled Arkwright.

Hargreaves's *spinning-jenny* was the direct outgrowth of the spinning-wheel, unlike the Paul *drawing head,* which had a radically different construction. Something had to be done to meet the increased demand for cotton yarn. James Hargreaves was the man for the occasion. It is said that the first suggestion in the right direction was caused by the upsetting of a spinning-wheel by one of his children. *It continued to run when the spindle was vertical.* Here was the solution. He had frequently tried to spin several yarns at once on as many spindles, but the latter being horizontal, the yarns interfered. He made a machine in 1764 with eight vertical spindles in a row, fed by eight rovings, which were held by a fluted wooden clasp of two parallel slats. The ends of the rovings being attached to the spindles, the wheel was revolved by the right hand, rotating the spindles, and the clasp which lightly clipped the rovings was drawn away from the spindles, paying out the roving, which was twisted by the rotation of the spindles, and stretched by the retraction of the clasp and the amount taken up by the twist. When the clasp reached the back of the machine the yarn was wound on the spindles, the clasp resumed its place near them, fresh rovings were pieced on to the ends of the former ones, and the work was repeated.

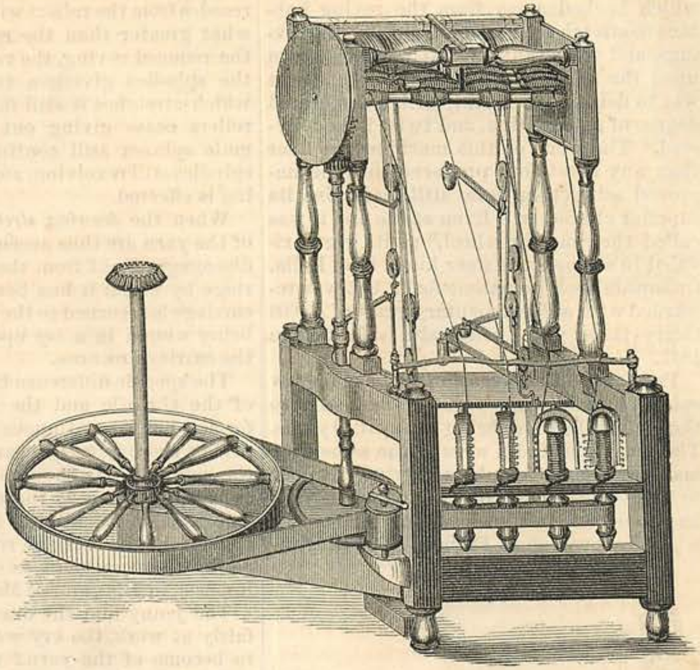
The clasp was, as it were, a long finger and thumb to hold a row of rovings, and the machine was eventually made to contain as many as eighty spindles. Hargreaves spun in secret so much yarn that the jealous workmen broke into his house and destroyed the machine. He deviated a little from his first design in drafting the specification for his patent of 1770. He there had a series of bobbins holding *slubs*—soft rovings having but little twist—which pass from thence to a row of spindles, all rotated from a common driving-wheel. Between the two, with divisions for the slubs, was a clasp, which was managed by the left hand, to bring such a pressure upon the roving as the required twist might warrant. A *presser-wire* regulated the winding of the yarn on the spindles in the intervals of spinning.

It being proved that he had sold several of his machines before his application for a patent, the latter was set aside, and he never was reasonably remunerated.

When the machine of Arkwright, which is next in order of date, came into use, the *spinning-jenny* of Hargreaves still held its superiority in yarn, the product being used for the *weft,* while the *water-twist* of the Arkwright *roller-machine* was used for the *warp.* Subsequently the principal features of the jenny were embodied with others selected from the Arkwright *drawing frame* to form what was playfully termed the *mule,* by which name it is universally known up to date. It was said also that until the invention of the Arkwright machine cotton yarn was seldom used for warp, owing to its softness and weakness, the jenny not giving a sufficiently hard twist to bear the strain of the loom. Goods were therefore usually made, at the period referred to, with a *linen warp* and *cotton woof.*


HARGREAVES'S SPINNING-JENNY.

Arkwright's invention for "making of weft or yarn from cotton, flax, and wool," patented 1769, was the most brilliant of its time and class. It was designed to be driven by horse-power, a band from a drum on the master - wheel shaft giving motion to the various parts. It was much improved in later years, and was driven by water-power after its success justified larger operations. This soon followed, and in 1785 steam - power was first applied to cotton spinning. The cotton rovings were wound upon large bobbins at the back upper part of the machine, and were drawn from them by four pairs of *drawing rollers*, which, moving with a graduated accelerated speed, elongated the rovings, and passed them to the flyers and spindles on the lower part of the machine. The four essential parts of this apparatus have not been dispensed with in ordinary spinning, and constitute the *bobbin-and-fly frame*, or *roving-frame*, which bids fair to hold its ground for spinning ordinary numbers to the end of time.



ARKWRIGHT'S SPINNING MACHINE (FROM THE ORIGINAL DRAWING).

The drawing rollers were suggested by the Lewis Paul machine of 1738; but the *flyers* and the general combination are of the highest order of merit, and are to be attributed to Arkwright.

Reference has been made in the introductory remarks to the factory system initiated by Arkwright in his cotton mills, 1768–1785. Arkwright was the first man to associate consecutively the various processes in cotton manufacture under the same roof. This series of machines for carding, drawing, and roving was patented in 1785, and from Arkwright's period we date the origin of the factory system. This was the year after the ratification by Congress of the definitive treaty of peace signed at Paris, and four years before Washington became President.

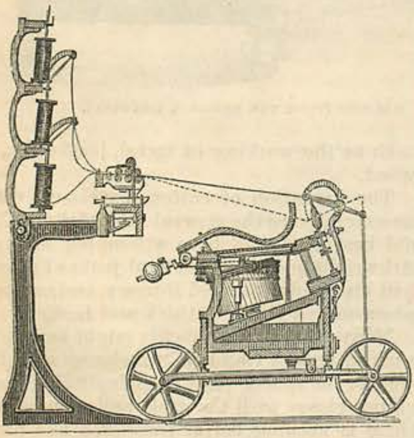
Thenceforward the system had but to grow and extend; to grow, in bringing other departments of the cotton manufacture, and eventually those of wool, flax, and hemp, into the same method; to extend, in respect of its boundaries, geographical and economical—the latter by the inauguration of parallel practices in other interests, such as the working of metal, leather, and wood.

The invention of cotton machinery was no exception to the general rule: Arkwright did best what had been attempted before. Arkwright had his Lewis Paul, just as Fulton had his Symington and Rumsey, and as Stephenson had his Trevethick and Hedley.

Many other improvements might be cited, such as Jenks's ring-and-traveler spinner, if we had the space. The list of spinning machines closes with the *mule*, and at present there is nothing better to offer. The perfected mule has been called the "iron man" from the wondrous skill with which it operates. Apparently instinct with life and feeling, it performs its allotted course as implicitly as a mere water-wheel, but the exquisite provisions for timing—what may be called the opportuneness of its movements —give it an air of volition and prevision. These features belong to the *automatic mule*, or the *self-acting mule*, as it also called. It was not thus in the original mule of Crompton. In this the main features were present, but were brought into and continued in action by the care and judgment of the operator.

Samuel Crompton was a young weaver when he applied his mind to the solution of the problem how to make a machine which should avoid certain faults present in the Hargreaves and the Arkwright machines. This he succeeded in doing in 1779. He placed his spindles on a traveling carriage, which backed away from the roving bobbins to stretch and twist a length of the rovings, and then ran back to wind the yarn upon the spindles. The immediate object was to deliver the roving with the required degree of attenuation, and twist it as delivered. The work of this machine was finer than any heretofore produced, and the improved self-acting mule still maintains its superior character. Even at the first it was called the "muslin wheel," as its yarns rivaled in softness the finer kinds from India. Crompton took no patent for it, but was rewarded with a Parliamentary grant of £5000 thirty-three years afterward. He died in 1827.

Previous to the invention of the mule few spinners could make yarns of 200 hanks to the pound, the hank being always 840 yards. The natives of India were at the same time making yarns of numbers varying from 300 to 400. By the best constructed mules yarn has been made in Manchester of number 700, which was woven in France. The illustra-



MULE SPINNER.

tion will give an idea of the machine, though it has not the complicated parts of the self-acting mule.

The mule of Crompton had only twenty to thirty spindles, and the distance traveled by the carriage was five feet. The distance traveled is now much greater, and some mules carry 1200 spindles.

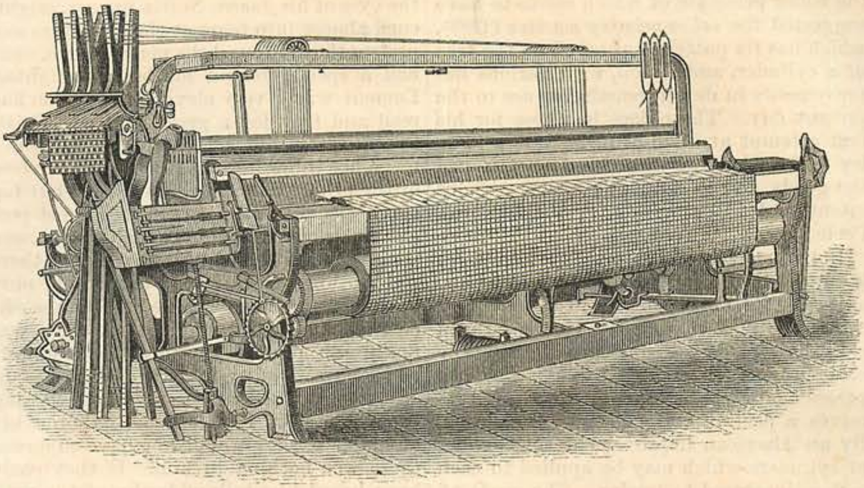
The drawing and stretching action of the mule spinner makes the yarn finer and of a more uniform tenuity than the mere drawing and twisting action of the *throstle*. As delivered by the rollers, the thread is thicker in some parts than in others; these thicker parts, not being so effectually twisted as the smaller parts, are softer, and yield more readily to the stretching power of the mule; by this means the twist becomes more equable throughout the yarn.

The mule carriage carrying the spindles recedes from the rollers with a velocity somewhat greater than the rate of delivery of the reduced roving, the rapid revolution of the spindles giving a twist to the yarn, which stretches it still farther. When the rollers cease giving out the rovings, the mule spinner still continues to recede, its spindles still revolving, and thus the stretching is effected.

When the *drawing, stretching*, and *twisting* of the yarn are thus accomplished, the mule disengages itself from the parts of the carriage by which it has been driven, and the carriage is returned to the rollers, the thread being wound in a *cop* upon the spindle as the carriage returns.

The specific difference between the action of the throstle and the mule is, that the former has a continuous action upon the roving, *drawing, twisting*, and *winding* it upon the *spindle*, while the mule *draws* and *twists* at one operation as the carriage runs out, and then *winds* all the lengths upon the spindles as the carriage runs in. The automatic disengagement is the invention of Roberts, in 1830, and of Mason.

The jenny and the drawing frame being fairly at work, the cry was now, "What is to become of the yarn? there will not be hands enough to weave it." The Rev. Edmund Cartwright set himself to the solution of the problem, and took out a patent for a power-loom in 1785, and a second in 1787. He was at great expense, and worked under the disadvantage of being a poor mechanic, having very little judgment in the proportion of parts or the convenient modes for the transmission of motion. One of the great difficulties in his way was in the fluffy and spongy character of the warp, and in the necessity for stopping the loom to dress a length of warp. This was avoided by the invention of the sizing and dressing machine of Radcliffe, of Stockport, in 1802, which took the yarns from the warping machine, carried them between two rollers, one of which revolved in a reservoir of thin paste, then between brushes, which rid the yarns of superfluous and uneven paste, then over a heated copper box, which dried them, and then wound them on the yarn-beam of the loom. The power-loom was only extensively adopted about 1801—the year of expiration of Cartwright's principal patent. He received £10,000 from Parliament. The justness of Cartwright's claim to the power-loom may be appreciated when it is stated that his loom, patented in 1787, has automatic mechanical devices to operate all parts. It was a memorable success for a man of letters, whose first attempt at a power-loom was made in 1784, before he had ever seen a loom. Eventually, by the exertions of Horrocks, of Stockport, in 1803, and the adaptation of the steam-engine to the work, the power-loom became fixed in use. Jacquard, of Lyons, France,



CROMPTON'S FANCY LOOM.

Roberts, of Manchester, England, and more lately Bigelow, Crompton, and Lyall, of this country, have brought the machine to a degree of perfection which is a marvel to the uninitiated, and an object of respect to those who happen to be a little better informed in technical matters.

It may be mentioned that the mill at Waltham, Massachusetts, erected in 1813, was the first in the world in which were combined machines for all the processes which convert the raw cotton into cloth. The mills of Arkwright, at Cromford, in Derbyshire, erected 1771–75, and that of Slater, at Pawtucket, Rhode Island, 1790, had no power-looms.

Crompton is a name twice famous in the history of the manufacture of fibre. His loom, represented in the accompanying cut, is not a loom for cotton, but a more complicated structure for figure-weaving, as in carpet-making.

The Jacquard loom is the most distinctively curious in the list of looms. Jacquard, of Lyons, is reported to have conceived the idea in 1790, and in 1801 he received from the National Exposition a bronze medal for his invention of a machine for figure-weaving, which he patented.

The appendage to the loom which constitutes the Jacquard attachment is to elevate or depress the warp threads for the reception of the shuttle, the action being produced by cards with punched holes, which admit the passage of needles which govern the warp threads. The holes in a card represent the warps to be raised for a certain passage of the shuttle, and the needles, dropping into the holes, govern the formation of the shed so that the required threads of warp come to the surface. The next card governs the next motion of the warps; and so on, the required color being brought up or kept up, as the case may be. For figured stuff, from the finest silk to the most solid carpet, figured velvets and Wilton carpets, we are indebted to the genius of Jacquard, who made it possible to do by machinery what was before an expensive operation requiring skillful hands.

While the art of the dyer is as old as Tyre, and the colors of antiquity are not, perhaps, excelled in lustre and stability, the variety has increased, and the modes have become more numerous and cheap. Dye baths and mordants were well understood in India two thousand years ago, as were also one or more styles of calico-printing, including chintz patterns and the resist process, which helped to make the fortunes of the Peele family.

Pliny refers to the skill of the Egyptians as "wonderful" in imparting to white robes a number of colors by steeping "with dye-absorbing drugs" (mordants), after which the goods take on several tints when boiled in a dye bath of one color. Cortez was met in Mexico by people who wore cotton dresses with Dolly Varden patterns in black, blue, red, yellow, and green.

These instances, which are but a tithe of what offers, show that calico-printing is old enough, and, indeed, it was practiced as a profession at Augsburg at the latter part of the seventeenth century, about which time it was introduced into England. Hand processes, however, were all that were known. Their nature it is not so easy to determine, but Robert Peele, a farmer of Blackburn, invented the method of *printing by blocks*, each cut out to correspond with its part of the pattern, and laid in apposition by means of *register pins*. This may have been about 1776, a year or two before his invention of the *mangle* and the *cylinder carding-machine*, the roller principle of which seems to have suggested the *calico-printing machine* (1785), which has its pattern engraved on the face of a cylinder, and which, with various improvements in detail, remains in use to the present day. The object he chose for his first attempt at hand-printing was a parsley leaf. The women of his family ironed the goods, and he was long called, without intentional disparagement, "Parsley-leaf Peele."

In this machine the pattern for each color is engraved on a cylinder which revolves so as to dip its lower surface in a trough of color; the face of each cylinder is scraped clean by a blade called a *doctor*, leaving the color only in the engraved lines; the cloth passes against the cylinders in turn, and receives a portion of its pattern from each. By an American improvement the number of cylinders which may be applied to each web is increased to twelve. The mode of engraving the cylinders has undergone a complete change since the invention by Jacob Perkins, of Massachusetts, of the roller die and transfer process, in which a design on an engraved and subsequently hardened steel die is impressed into the copper cylinder in repetition to any required extent.

Robert Peele was also fortunate in securing two very valuable processes, known as the *discharge* and *resist* styles. The latter he is said to have bought of a commercial traveler for £5, and to have made £250,000 by it. The *discharge* style is a process in which the cloth is printed with a material which prevents the mordant from becoming fast, so that when the dye is applied and the cloth washed, the dye is not fast at those places. The *resist* style is one in which the cloth has a pattern printed in paste, and is then dyed in indigo. The paste resists the coloring matter, and these parts are white on a blue ground when the cloth is washed.

The name of Peele, the self-taught dyer and mechanic, and his son and grandson, the two Sir Roberts, the latter being the statesman who was killed by a fall from his horse in 1850, are indissolubly associated with the cotton manufacture, and more specifically with the carding and the calico-printing.

WASHINGTON, D. C. EDWARD H. KNIGHT.

A CHARACTER MASK.

BY JUSTIN M'CARTHY.

YES, it was a great success, that wonderful piece of amateur acting. The applause of the audience was not only beyond mistake genuine and spontaneous, but it was beyond mistake the irrepressible outburst of admiring surprise. Lamont was the hero of the evening, and if his personal friends, of whom he had many, were pleased with his success, it need hardly be said that the eyes of his *fiancée*, Nettie Burnet, brightened almost into tears at the applauses and praises that followed the performance. She had a special reason for being delighted. Lamont was a very clever fellow, who had read and traveled a great deal, and Nettie knew it was not a girl's partiality which made her think him far superior to the best of the other young men she knew; but Lamont was shy and reserved with most people, and perhaps especially with women, and many persons therefore believed that there was nothing in him. If they could only have heard him as he talked to her, she often thought, they would not say there was nothing in him. If they could have followed the stream of fresh, vivid ideas, odd fancies, curious illustrations, that came flowing from him when he felt himself thoroughly at his ease, they would not have supposed there was nothing in him. If they could have heard him talk of books, of the various literatures whose masterpieces were familiar to him, they would have known there was something in him. She had known him always, but that was not enough. She wanted other people to know him too. Women have always in them something of the spirit of that king of Lydia whose story is told by Herodotus, and who was not content to be himself the possessor of a treasure unless his friend could also see and appreciate it. Therefore Nettie Burnet was especially delighted because now every one must know what a wonderfully clever fellow she had for a lover.

The amateur performance in which Lamont so distinguished himself took place at the house of a lady who claimed to be at once a leader of fashion and of culture, and who lived in the Fifth Avenue region, but not on Fifth Avenue. Lamont had been pressed into the service as a performer, being at first only invited as an ordinary guest. But one of the actors had suddenly to leave for Europe within a few days of the performance, and the hostess besought Lamont, whom she knew to be a man of taste and talent, and a remarkably obliging person, to undertake the part. The play was adapted from the French by the hostess herself; the part offered to Lamont seemed to promise little difficulty of study; Lamont was taken suddenly and at a disadvantage, and he consented.

Then, as he could not back out, and was impelled by desperation, he resolved to make the very most he could of the part. In itself the part was secondary and feeble. It was that of a man who never could make up his mind in time to do any thing, but always doubted and hesitated until the chance had gone by. He might have made a success here and a success there; he might have married a charming girl; but he always doubted, and so on—every one knows