# WILLIAM HENRY DOOLITTLE

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# INVENTIONS IN THE CENTURY.

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# CHAPTER I.

## INTRODUCTORY—INVENTIONS AND DISCOVERIES—THEIR DEVELOPMENT.

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In treating of the subject of Inventions it is proper to distinguish them from their scientific kindred—Discoveries.

The history of inventions is the history of new and useful contrivances made by man for practical purposes. The history of scientific discoveries is the record of new things found in Nature, its laws, forces, or materials, and brought to light, as they exist, either singly, or in relation, or in combination.

Thus Galileo invented the telescope, and Newton discovered the law of gravitation. The practical use of the invention when turned to the heavenly bodies served to confirm the truth of the discovery.

Discovery and invention may be, and often are, united as the soul is to the body. The union of the two produces one or more inventions. Thus the invented electro-telegraph consists of the combination of discoveries of certain laws of electricity with an apparatus, by which signs are communicated to distances by electrical influence.

Inventions and discoveries do not precede or follow each other in order. The instrument may be made before the laws which govern its operation are discovered. The discovery may long precede its adaptation in physical form, and both the discovery and adaptation may occur together.

Among the great *inventions* of the past are alphabetical writing, Arabic notation, the mariner's compass, the telescope, the printing-press, and the steam-engine. Among the great *discoveries* of the past are the attraction of gravitation, the laws of planetary motion, the circulation of the blood, and velocity of light. Among the great inventions of the nineteenth century are the spectroscope, the electric telegraph, the telephone, the phonograph, the railways, and the steam-ships. Among the great discoveries of this century are the correlation and conservation of forces, anæsthetics, laws of electrical energy, the germ theory of disease, the molecular theory of gases, the periodic law of Mendeljeff in chemistry, antiseptic surgery, and the vortex theory of matter. This short enumeration will serve to indicate the different roads along which inventions and the discoveries of science progress.

By many it is thought that the inventions and discoveries of the nineteenth century exceed in number and importance all the achievements of the kind in all the ages of the past.

So marvellous have been these developments of this century that, not content with sober definitions, men have defined *invent*, even when speaking only of mechanical productions, as "creating what had not before existed;" and this period has been described as an age of new creations. The far-off cry of the Royal Preacher, "There is no new thing under the sun: Is there anything whereof it may be said, see this is new, it hath been already of old time which was before us," is regarded as a cry of satiety and despair, finding no responsive echo in the array of inventions of this bright age.

But in one sense the Preacher's words are ever profoundly true. The forces and materials of Nature always exist, awaiting man's discovery, and at best he can but vary their relations, re-direct their course, or change their forms. In a still narrower sense the truth of the Preacher's declaration is apparent:—

In an address before the Anthropological Society of Washington in 1885, the late Prof. F. A. Seely, of the United States Patent Office, set forth that it was one of the established laws of Invention, that,

"Every human invention has sprung from some prior invention, or from some prior known expedient."

Inventions, he said, do not, like their protectress, Pallas Athene, spring forth full grown from the heads of their authors; that both as to modern inventions and as to those whose history is unrecorded, each exhibits in itself the evidence of a similar sub-structure; and that, "in the process of elimination we go back and back and find no resting place till we reach the rude set of expedients, the original endowment of men and brutes alike."

Inventions, then, are not creations, but the evolution of man-made contrivances.

It may be remarked, however, as was once said by William H. Seward: "The exercise of the inventive faculty is the nearest akin to that of the Creator of any faculty possessed by the human mind; for while it does not create in the same sense that the Creator did, yet it is the nearest approach to it of anything known to man."

There is no history, rock-record, or other evidence of his existence as man, which discloses a period when he was not

an inventor.

Invention is that divine spark which drove, and still drives him to the production of means to meet his wants, while it illuminates his way. From that inward spark must have soon followed the invention of that outer fire to warm and cheer him, and to melt and mould the earth to his desires. Formed for society, the necessity of communication with his fellows developed the power of speech. Speech developed written characters and alphabets. Common communication developed concert of action, and from concert of action sprung the arts of society.

But the evolution of invention has not been uniform. Long periods of slowness and stagnation have alternated with shorter or longer periods of prolific growth, and these with seasons of slumber and repression.

Thus, Prof. Langley has said that man was thousands of years, and possibly millions, in evolving a cutting edge by rubbing one stone on another; but only a few thousand years to next develop bronze tools, and a still shorter period tools of iron.

We cannot say how long the period was from the age of iron tools to the building of the pyramids, but we know that before those stupendous structures arose, the six elementary mechanical powers, the lever, the wheel, the pulley, the inclined plane, the wedge and the screw, were invented. And without those powers, what mechanical tool or machine has since been developed? The age of inventions in the times of the ancients rested mainly upon simple applications of these mechanical powers. The middle ages slumbered, but on the coming of the fifteenth and

sixteenth centuries, the inventions of the ancients were revived, new ones added, and their growth and development extended with ever-increasing speed to the present time.

The inventions of the nineteenth century, wonderful and innumerable as they are, and marvellous in results produced, are but the fruit of the seed sown in the past, and the blossom of the buds grown upon the stalks of former generations. The early crude stone hatchet has become the keen finished metal implement of to-day, and the latter involves in itself the culmination of a long series of processes for converting the rough ore into the hard and glistening steel.

The crooked and pointed stick with which the Egyptian turned the sands of the Nile has slowly grown to be the finished plough that is now driven through the sod by steam.

The steam-operated toys of Hero of Alexandria were revived in principle and incorporated in the engines of Papin and the Marquis of Worcester in the seventeenth century; and the better engines of Savery, Newcomen, and more especially of James Watt in the eighteenth century, left the improvements in steam-engines of the nineteenth century—great as they are—inventions only in matter of detail.

It has been said that electrical science began with the labours of Dr. Gilbert, published in 1600. These, with the electrical discoveries and inventions of Gray, Franklin, Galvani, and others in the next century, terminating with the invention of his battery by Volta in 1800, constituted the

framework on which was built that world of flashing light and earth-circling messages in which we now live.

The study of inventions in any one or all eras cannot proceed intelligently unless account is taken not only of their mode of construction, and of their evolution one from another, but of the evolution of distinct arts, their relation, their interdependence in growth, and their mutual progress.

The principles adopted by the ancients in weaving and spinning by hand are those still in force; but so great was the advance of inventions from hand-operated mechanisms to machines in these and other arts, and especially in steam, in the last half of the eighteenth century, that it has been claimed that the age of machine production or invention then for the first time really began.

When the humble lift became the completed elevator of to-day, the "sky-scraper" buildings appeared; but these buildings waited upon the invention of their steel skeletons, and the steel was the child of the Bessemer process.

The harp with which David stirred the dead soul of Saul was the prototype of the sweet clavichord, the romantic virginal, the tinkling harpsichord, and the grand piano. The thrumming of the chords by the fingers was succeeded by the striking keys; and the more perfect rendition of tones awaited the application of new discoveries in the realm of musical sounds. The keys and the levers in the art of musical instruments were transferred to the art of printing, and are found to-day striking a more homely music on the type-writer and on those other and more wonderful printing instruments that mould, and set, and distribute the type. But these results of later days did not reach their perfected

operations and forms until many other arts had been discovered and developed, by which to treat and improve the wood, and the wire, and all the other materials of which those early instruments were composed, and by which the underlying principles of their operations became known.

Admitting that man possesses the faculty of invention, what are the motives that induce its exercise? Why so prolific in inventions now? And will they continue to increase in number and importance, or decrease?

An interesting treatise of bulky dimensions might be written in answer to these queries, and the answers might not then be wholly satisfactory. Space permits the submission of but a few observations and suggestions on these points:——

*Necessity* is still the mother of inventions, but not of all of them. The pressing needs of man in fighting nakedness and hunger, wild beasts and storms, may have driven him to the production of most of his early contrivances; but as time went on and his wants of every kind multiplied, other factors than mere necessity entered into the problem, and now it is required to account for the multiplicity of inventions under the general head of *Wants*.

To-day it is the want of the luxuries, as well as of the necessities of life, the want of riches, distinction, power, and place, the wants of philanthropy and the wants of selfishness, and that restless, inherent, unsatisfied, indescribable want which is ever pushing man onward on the road of progress, that must be regarded as the springs of invention.

*Accident* is thought to be the fruitful source of great inventions. It is a factor that cannot be ignored. But accidents are only occasional helps, rarely occurring,—flashes of light suddenly revealing the end of the path along which the inventor has been painfully toiling, and unnoticed except by him alone. They are sudden discoveries which for the most part simply shorten his journey. The rare complete contrivance revealed by accident is not an invention at all, but a discovery.

The greatest incentive in modern times to the production of inventions is governmental protection.

When governments began to recognize the right of property in inventions, and to devise and enforce means by which their author should hold and enjoy the same, as he holds his land, his house, or his horse, then inventions sprung forth as from a great unsealed fountain.

This principle first found recognition in England in 1623, when parliament, stung by the abuse of the royal prerogative in the grant of exclusive personal privileges that served to crush the growth of inventions and not to multiply them, by its celebrated Statute of Monopolies, abolished all such privileges, but excepted from its provisions the grant of patents "for the sole working or making of any manner of new manufactures within this realm to the true and first inventor" thereof.

This statute had little force, however, in encouraging and protecting inventors until the next century, and until after the great inventions of Arkwright in spinning and James Watt in steam-engines had been invaded, and the attention of the courts called more seriously thereby to the property

rights of inventors, and to the necessity of a liberal exposition of the law and its proper enforcement.

Then followed in 1789 the incorporation of that famous provision in the Constitution of the United States, declaring that Congress shall have the power "To promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

In 1791 followed the law of the National Assembly of France for the protection of new inventions, setting forth in the preamble, among other things, "that not to regard an industrial invention as the property of its author would be to attack the essential rights of man."

These fundamental principles have since been adopted and incorporated in their laws by all the nations of the earth.

Inventions in their nature being for the good of all men and for all time, it has been deemed wise by all nations in their legislation not to permit the inventor to lock up his property in secret, or confine it to his own use; and hence the universal practice is to enact laws giving him, his heirs, and assigns, exclusive ownership to this species of his property for a limited time only, adjudged sufficient to reward him for his efforts in its production, and to encourage others in like productions; while he, in consideration for this protection, is to fully make known his invention, so that the public may be enabled to freely make and use it after its exclusive ownership shall have expired.

In addition to the motives and incentives mentioned inducing this modern mighty outflow of inventions, regard

must be had to the conditions of personal, political and intellectual freedom, and of education. There is no class of inventors where the mass of men are slaves; and when dense ignorance abounds, invention sleeps.

In the days of the greatest intellectual freedom of Greece, Archimedes, Euclid, and Hero, its great inventors, flourished; but when its political *status* had reduced the mass of citizens to slaves, when the work of the artisan and the inventor was not appreciated beyond the gift of an occasional crown of laurel, when manual labour and the labourer were scorned, inventions were not born, or, if born, found no nourishment to prolong their lives.

In Rome, the labourer found little respect beyond the beasts of burden whose burdens he shared, and the inventor found no provision of fostering care or protection in her mighty jurisprudence. The middle ages carefully repressed the minds of men, and hid away in dark recesses the instruments of learning. When men at length awoke to claim their birthright of freedom, they invented the printing-press and rediscovered gunpowder, with which to destroy the tyranny of both priests and kings. Then arose the modern inventor, and with him came the freedom and the arts of civilisation which we now enjoy.

What the exercise of free and protected invention has brought to this century is thus summarised by Macaulay:

"It has lengthened life; it has mitigated pain; has extinguished diseases; has increased the fertility of the soil; given new security to the mariner; furnished new arms to the warrior; spanned great rivers and estuaries with bridges of form unknown to our fathers; it has guided the

thunderbolt innocuously from heaven to earth; it has lighted up the night with splendour of the day; it has extended the range of human vision; it has multiplied the power of the human muscles; it has accelerated motion; it has annihilated distance; it has facilitated intercourse, correspondence, all friendly offices, all despatch of business; it has enabled man to descend to the depths of the sea, to soar into the air, to penetrate securely into the noxious recesses of the earth; to traverse the land in carts which whirl along without horses; to cross the ocean in ships which run many knots an hour against the wind. Those are but a part of its fruits, and of its first fruits, for it is a philosophy which never rests, which is never perfect. Its law is progress. A point which yesterday was invisible is its goal to-day, and will be its starting point to-morrow."

The onward flow of inventions may be interrupted, if not materially stayed, by the cessation of some of the causes and incentives which now give them life. When comfort for all and rest for all, and a suitable division of labour, and an equal distribution of its fruits are reached, in that state of society which is pictured in the visions of the social philosopher, or as fast as such conditions are reached, so soon will cease the pricking of those spurs of invention,—individual rewards, the glorious strife of competition, the harrowing necessities, and the ambitions for place and power. If all are to co-operate and share alike, what need of exclusive protection and fierce and individual struggle? Why not sit down now and break the loaf and share it, and pour the wine, and enjoy things as they are, without a thought for the morrow?

The same results as to inventions may be reached in different but less pleasant ways: When all the industries are absorbed by huge combinations of capital the strife of competition among individuals, and the making of individual inventions to meet such competition, will greatly disappear. Or, the same results may be effected by stringent laws of labour organisations, in restricting or repressing all individual independent effort, prescribing what shall be done or what shall not be done along certain lines of manufacture or employment. So that the progress of future inventions depends on the outcome of the great economic, industrial, and social battles which are now looming on the pathway of the future.

But what the inventions of the nineteenth century were and what they have done for Humanity, is a chapter that must be read by all those now living or to come who wish to learn the history of their race. It is a story which gathers up all the threads of previous centuries and weaves them into a fabric which must be used in all the coming ages in the attainment of their comforts, their adornments, and their civilisations.

To enumerate all the inventions of the century would be like calling up a vast army of men and proclaiming the name of each. The best that can be done is to divide the wide field into chapters, and in these chapters give as best one may an idea of the leading inventions that have produced the greatest industries of the World.

# CHAPTER II.

## AGRICULTURE AND ITS IMPLEMENTS.

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The Egyptians were the earliest and greatest agriculturists, and from them the art was learned by the Greeks. Greece in the days of her glory greatly improved the art, and some of her ablest men wrote valuable treatises on its different topics. Its farmers thoroughly ploughed and fertilised the soil, used various implements for its cultivation, paid great attention to the raising of fruits,—the apple, pear, cherry, plum, quince, peach, lemon, fig and many other varieties suitable to their climate, and improved the breeds of cattle, horse and sheep. When, however, social pride and luxurious city life became the dominant passions, agriculture was left to menials, and the art gradually faded with the State. Rome in her best days placed farming in high regard. Her best writers wrote voluminously on agricultural subjects, a tract of land was allotted to every citizen, which was carefully cultivated, and these citizen farmers were her worthiest and most honoured sons. The condition and needs of the soil were studied, its strength replenished by careful fertilisation, and it was worked with care. There were ploughs which were made heavy or light as the different soils required, and there were a variety of farm implements, such as spades, hoes, harrows and rakes. Grains, such as wheat, barley, rye and oats, were raised, a variety of fruits and vegetables, and great attention paid to the breeding of stock. Cato and Varro,

Virgil and Columella, Pliny and Palladius delighted to instruct the farmer and praise his occupation.

But as the Roman Empire grew, its armies absorbed its intelligent farmers, the tilling of the soil was left to the menial and the slave, and the Empire and agriculture declined together.

Then came the hordes of northern barbarians pouring in waves over the southern countries and burying from sight their arts and civilisation. The gloom of the middle ages then closed down upon the European world. Whatever good may have been accomplished in other directions by the crusades, agriculture reached its lowest ebb, save in those instances where the culture of the soil received attention from monastic institutions.

The sixteenth century has been fixed upon as the time when Europe awoke from its long slumber. Then it was after the invention of the printing press had become well established that publications on agriculture began to appear. The *Boke of Husbandrie*, in 1523, by Sir Anthony Fitzherbert; Thomas Tusser's *Five Hundred Points of Good Husbandry*; Barnaby Googe's *The Whole Art of Husbandry*; *The Jewel House of Art and Nature*, by Sir Hugh Platt; the *English Improver* of Walter Blithe, and the writings of Sir Richard Weston on the husbandry of Brabant and Flanders, were the principal torches by which the light on this subject was handed down through the sixteenth and seventeenth centuries. Further awakening was had in the eighteenth century, the chief part of which was given by Jethro Tull, an English agriculturist, who lived, and wrote, and laboured in the cause between 1680 and 1740. Tull's leading idea was

the thorough pulverisation of the soil, his doctrines being that plants derived their nourishment from minute particles of soil, hence the need of its pulverisation. He invented and introduced a horse hoe, a grain drill, and a threshing machine.

Next appeared Arthur Young, of England, born in 1741, whose life was extended into the 19th century, and to whom the world was greatly indebted for the spread of agricultural knowledge. He devoted frequent and long journeys to obtaining information on agricultural subjects, and his writings attracted the attention and assistance of the learned everywhere. His chief work was the making known widely of the beneficial effects of ammonia and ammoniacal compounds on vegetation. Many other useful branches of the subject, clearly treated by him, are found in his *Annals of Agriculture*. It was this same Arthur Young with whom Washington corresponded from his quiet retreat at Mount Vernon. After the close of the War of Independence in 1783 and before the adoption of the Constitution in 1789 and his elevation to the Presidency in that year, Washington devoted very much of his time to the cultivation of his large estate in Virginia. He took great interest in every improvement in agriculture and its implements. He invented a plough and a rotary seed drill, improved his harrows and mills, and made many inquiries relative to the efficacy of ploughs and threshing machines made in England and other parts of Europe. It was during this period that he opened an interesting correspondence with Young on improvements in agriculture, which was carried on even while he was President, and he availed himself of the proffer of Young's

services to fill an order for seeds and two ploughs from a London merchant. He also wrote to Robert Cary & Co., merchants in London, concerning an engine he had heard of as being constructed in Switzerland, for pulling up trees and their stumps by the roots, and ordered one to be sent him if the machine were efficient.

Jefferson, Washington's great contemporaneous statesman and Virginia planter, and to whom has been ascribed the chief glory of the American patent system, himself also an inventor, enriched his country by the full scientific knowledge he had gained from all Europe of agricultural pursuits and improvements.

The progress of the art, in a fundamental sense, that is in a knowledge of the constituents, properties, and needs of the soil, commenced with the investigations of Sir Humphry Davy at the close of the 18th century, resulting in his celebrated lectures before the Board of Agriculture from 1802 to 1812, and his practical experiments in the growth of plants and the nature of fertilisers. Agricultural societies and boards were a characteristic product of the eighteenth century in Europe and America. But this birth, or revival of agricultural studies, the enthusiastic interest taken therein by its great and learned men, and all its valuable publications and discoveries, bore comparatively little fruit in that century. The ignorance and prejudice of the great mass of farmers led to a determined, and in many instances violent resistance to the introduction of labour-saving machinery and the practical application of what they called "book-farming." A fear of driving people out of employment led them to make war upon new agricultural machines and

their inventors, as they had upon weaving and spinning inventions. This war was more marked in England than elsewhere, because there more of the new machines were first introduced, and the number of labourers in those fields was the greatest. In America the ignorance took the milder shape of contempt and prejudice. Farmers refused, for instance, to use cast-iron ploughs as it was feared they would poison the soil.

So slow was the invention and introduction of new devices, that if Ruth had revisited the earth at the beginning of the nineteenth century, she might have seen again in the fields of the husbandmen everywhere the sickle of the reapers behind whom she gleaned in the fields of Boaz, heard again the beating on the threshing floor, and felt the old familiar rush of the winnowing wind. Cincinnatus returning then would have recognised the plough in common use as about the same in form as that which he once abandoned on his farm beyond the Tiber.

But with the spread of publications, the extension of learning, the protection now at last obtained and enforced for inventions, and with the foundations laid and the guide-posts erected in nearly every art and science by previous discoverers, inventors and writers, the century was now ready to start on that career of inventions which has rendered it so glorious.

As the turning over and loosening of the sod and the soil for the reception of seed was, and still is the first step in the art of agriculture, the plough is the first implement to be considered in this review.

A plough possesses five essential features,—a frame or beam to which the horses are attached and which is provided with handles by which the operator guides the plough, a share to sever the bottom of a slice of land—the furrow—from the land beneath, a mould board following the share to turn the furrow over to one side, and a landside, the side opposite the mould board and which presses against the unploughed ground and steadies the plough. To these have been commonly added a device called the coulter, which is a knife or sharp disk fastened to the frame in advance of the share and adapted to cut the sod or soil so that the furrow may be more easily turned, an adjustable gauge wheel secured to the beam in advance of the coulter, and which runs upon the surface of the soil to determine by the distance between the perimeter of the wheel at the bottom and the bottom of the plough share the depth of the furrow, and a clevis, which is an adjustable metal strap attached to the end of the beam to which the draught is secured, and by which the pitch of the beam and the depth and width of the furrow are regulated. The general features, the beam, handles, and share, have existed in ploughs from the earliest ages in history. A plough with a metal share was referred to by the prophecy of Isaiah seven centuries before Christ, "They shall beat their swords into plough-shares;" and such a plough with the coulter and gauge wheel added is found in the Caylus collection of Greek antiquities. The inventions of centuries in ploughs have proceeded along the lines of the elements above enumerated.

The leading features of the modern plough with a share and mould board constructed to run in a certain track and

turn its furrows one over against the other, appear to have originated in Holland in the 18th century, and from there were made known to England. James Small of Scotland wrote of and made ploughs having a cast-iron mould board and cast and wrought iron shares in 1784-85.

In America, about the same time, Thos. Jefferson studied and wrote upon the proper shape to be given to the mould board.

Charles Newbold in 1797 took out the first patent in the United States for a plough—all parts cast in one piece of solid iron except the beam and handles.

It is a favourite idea with some writers and with more talkers, that when the necessity really arises for an invention the natural inventive genius of man will at once supply it. Nothing was more needed and sought after for thirty centuries among tillers of the soil than a good plough, and what finally supplied it was not necessity alone, but improved brains. Long were the continued efforts, stimulated no doubt in part by necessity, but stimulated also by other motives, to which allusion has already been made, and among which are the love of progress, the hope of gain, and legislative protection in the possession of inventive property.

The best plans of writers and inventors of the eighteenth century were not fully developed until the nineteenth, and it can be safely said that within the last one hundred years a better plough has been produced than in all of the thousands of years before. The defects which the nineteenth century's improvements in ploughs were designed to remedy can best be understood by first realising what was

the condition of ploughs in common use when the century opened.

Different parts of the plough, such as the share and coulter, were constructed of iron, but the general practice among farmers was to make the beam and frame, handles and mould board of strong and heavy timber. The beam was straight, long, and heavy, and that and the mould generally hewed from a tree. The mould board on both sides to prevent its wearing out too rapidly was covered with more or less thick plates of iron. The handles were made from crooked branches of trees. "The beam," it is said, "was set at any pitch that fancy might dictate, with the handles fastened on almost at right angles with it, thus leaving the ploughman little control over his implement which did its work in a very slow and imperfect manner." It was some such plough that Lord Kames complained about in the *Gentleman Farmer* in 1768, as being used in Scotland—two horses and two oxen were necessary to pull it, "the ridges in the fields were high and broad, in fact enormous masses of accumulated earth, that could not admit of cross ploughing or cultivation; shallow ploughing universal; ribbing, by which half the land was left untilled, a general practice over the greater part of Scotland; a continual struggle between the corn and weeds for superiority." As late as 1820 an American writer was making the same complaint. "Your furrows," he said, "stand up like the ribs of a lean horse in the month of March. A lazy ploughman may sit on the beam and count every bout of his day's work; besides the greatest objection to all these ploughs is that they do not perform the work well and the expense is enormous for blacksmith

work." It was complained by another that it took eight or ten oxen to draw it, a man to ride upon the beam to keep it on the ground, and a man followed the plough with a heavy iron hoe to dig up the "baulks."

The improvements made in the plough during the century have had for their object to lessen the great friction between the wide, heavy, ill-formed share and mould board, and the ground, which has been accomplished by giving to the share a sharp clean tapering form, and to the mould board a shape best calculated to turn the furrow slice; to improve the line of draught so that the pull of the team may be most advantageously employed, which has been effected after long trials, study and experiment in the arrangement of beam, clevis and draft rod, setting the coulter at a proper angle and giving the landside a plane and parallel surface; to increase the wear and lessen the weight of the parts, which has been accomplished by ingenious processes in treating the metal of which the parts are composed, and lessening the number of parts; to render the plough easily repairable by casting the parts in sets and numbering them, by which any part may be replaced by the manufacturer without resort to the blacksmith. In short there is no part of the plough but what has received the most careful attention of the inventor. This has been evidenced by the fact that in the United States alone nearly eleven thousand patents on ploughs were issued during the nineteenth century. When it is considered that all the applications for these patents were examined as to their novelty, before the grant of the patent, the enormous amount of study and invention expended on this article can be appreciated. Among the century's

improvements in this line is the use of disks in place of the old shovel blades to penetrate the earth and revolve in contact therewith. Cutting disks are harnessed to steam motors and are adapted to break up at one operation a wide strip of ground. The long-studied problem of employing a gang of ploughs to plough back and forth and successfully operated by steam has been solved, and electricity is now being introduced as a motor in place of steam. Thus millions of broad acres which never would have been otherwise turned are now cultivated. The tired muscle-strained ploughman who homeward plodded his weary way at night may now comfortably ride at his ease upon the plough, while at the same time the beasts that pull it have a lighter load than ever before.

Next to the plough among the implements for breaking, clearing and otherwise preparing the soil for the reception of seed, comes the *harrow*. From time immemorial it has been customary to arm some sort of a frame with wooden or iron spikes to scratch the earth after the ploughing. But this century has greatly improved the old constructions. Harrows are now found everywhere made in sections to give flexibility to the frame; collected in gangs to increase the extent of operation; made with disks instead of spikes, with which to cut the roots of weeds and separate the soil, instead of merely scratching them. A still later invention, curved spring teeth, has been found far superior to spikes or disks in throwing up, separating and pulverising the soil. A harrow comprising two ranks of oppositely curved trailing teeth is especially popular in some countries. These three distinct classes of harrows, the disk type, the curved spring

tooth type, and gangs of sections of concavo-convex disks, particularly distinguish this class of implements from the old forms of previous ages.