The PALIMPSEST

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The Meaning of Palimpsest

In early times a palimpsest was a parchment or other material from which one or more writings had been erased to give room for later records. But the erasures were not always complete; and so it became the fascinating task of scholars not only to translate the later records but also to reconstruct the original writings by deciphering the dim fragments of letters partly erased and partly covered by subsequent texts.

The history of Iowa may be likened to a palimpsest which holds the records of successive generations. To decipher these records of the past, reconstruct them, and tell the stories which they contain is the task of those who write history.

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THE PALIMPSEST

EDITED BY WILLIAM J. PETERSEN

VOL. XXXI ISSUED IN MARCH 1950 NO. 3

J. Brownlee Davidson

In 1905 J. Brownlee Davidson came to Iowa State College to head up the department of agricultural engineering. Born on a Nebraska farm in 1880, Davidson had graduated from the University of Nebraska in 1904 and had served one year as instructor at that school before coming to Ames. During the next forty-five years Davidson was almost continuously associated with Iowa State College, gaining an international reputation during that time. In 1907 he sent out the call for the organization meeting of the American Society of Agricultural Engineers. He served as its first president and helped start its technical journal. His special courses and high professional reputation attracted graduate students from all over the world to Ames. His students head the departments of agricultural engineering in seventeen states and three Canadian provinces.

The Nebraska farm boy who had migrated to the richest agricultural state in the Union was ever mindful of keeping in close touch with the practical, while teaching and writing textbooks and numerous articles at Iowa State College. As a young man he held summer positions at both the John Deere and the International Harvester plants. In 1933 he was awarded the Cyrus Hall McCormick medal for distinguished service in agricultural engineering. In 1942 he won "Estranger" membership in the Swedish Royal Agricultural Society.

Prof. Davidson's contributions to national and world improvement in agricultural engineering are numerous and significant. He served on an American commission to Russia to study and report on colonization in the Far East in 1929. He was consultant on the War Production Board in 1943 and acted as consultant to the United Nations Relief and Rehabilitation Administration in 1944. He was chairman of the committee on agricultural engineering for China, which was appointed by the Republic of China and sponsored by twenty-five American farm implement firms.

Food production played a major part in winning the war and food surpluses for distressed nations may play an equally important part in present world unrest. Iowa's preeminent role as a food producer, and as a market for agricultural machinery as well as a manufacturer of farm implements, makes Prof. Davidson's contribution to THE PALIMPSEST a particularly timely one.

WILLIAM J. PETERSEN

Primitive Farm Implements

Archaeologists have estimated that agriculture as an occupation had its beginning about 7,000 years ago. It was then that man first established fixed places of abode with improved facilities for shelter and defense. He also began to cultivate the soil, to save and plant seeds, and to domesticate animals. In so doing, man made an important advance toward the assurance of a more adequate and dependable supply of food.

Nature did not endow man with natural means for loosening the soil, such as the claws with which many animals burrow in the earth. The pig can successfully root into the ground for a depth of several inches to secure roots and grubs for food. This is not the case with man, who needs the aid of hand tools for the cultivation of the soil. A study of the drawings and sketches on the walls of ancient habitations furnishes much information concerning these early hand tools.

Primitive agricultural implements were devices provided by nature, which could be used with little modification. The branch of a tree with a hook point could be made into a hoe for loosening the soil. Sharp stones and shells tied to handles were also used for hoes and even for certain forms of sickles. Hollowed-out stones, into which grain could be placed and crushed with another stone, something after the order of a mortar and pestle, served as mills. These simple tools were the agricultural implements used by man for many centuries, as archaeological studies indicate. As late as the nineteenth century, on the Iowa frontier, "hominy blocks" or "corn crushers" were used — crude homemade mortars made from a tree stump in which the corn was pounded into meal. The settlers of Van Buren County called these hand-operated mortars "Armstrong mills."

The first important improvement in hand implements for agriculture came about with the discovery of metal. This was particularly true in the case of tools requiring sharp edges for cutting, such as hoes or sickles.

The story of the development of hand tools after the introduction of metal is well told in an old Chinese classic written by a king of the Han Dynasty some 2,000 years ago. "In ancient times, wooden hoes were used for plowing; shells sharpened for cultivation; wooden hooks for logging; buckets for drawing water. The people were toilsome and their profits small. Now-a-days, chopping and scraping hoes are used for plowing and cultivation; axes for cutting trees; sweeps for raising water. The people have more leisure but make a good profit." Thus in a few sentences the use of metal hand tools is described and the important philosophy is set forth that an improvement in farm implements made a very definite beneficial contribution to the well-being of the farmer.

The function of hand implements is to apply the forces exerted by the muscles of a man in such a way as to make labor more effective or to make it possible to accomplish more of a certain task in a given amount of time. The ripe heads of grain might be plucked with the hands without the aid of a tool, as was done in earliest times, but a cutting edge made into the form of a sickle, by which a handful of stalks could be cut free with one motion, not only increased the accomplishment of the worker but made the operation easier to perform.

Hand machines with moving parts, by which they are distinguished from hand tools, have the same general function of applying the forces exerted by human muscles in such a way as to be more effective in performing certain operations. The hand corn sheller is a good example of the way in which labor is made more effective through machines. At one time in the early days of America, it was common practice to shell the corn grains from the cob by rasping the ear over a metal edge such as that furnished by a shovel. The hand sheller is a machine which performs the same operation by a combination of rough wheels which rub the grains from the cob with the same effort but much faster. Many other illustrations of the effective application of hand labor could be cited.

When metal became available, hoes for digging and scraping and sickles for reaping and cutting of forage and fiber crops used in the various countries took on a surprising amount of similarity. Usually hoes were made in two weights — a light hoe for cultivation and planting and a heavy hoe for digging into the ground in the preparation of a seed bed. The oldest literature and drawings on ancient buildings describe these tools.

It is surprising to note how little change was made in these implements down through many centuries from 500 B. C. to the eighteenth century. It has been stated by a Secretary of Agriculture of the United States that if an American farmer of the Revolutionary Days could have been moved back in history 2,500 years to an Egyptian farm, he would have found himself thoroughly familiar with the hand tools of that age and could have taken them up and proceeded to use them skillfully.

The sickle was later developed in many countries, notably in America, into a two-handed implement. For mowing grass the blade was lengthened and attached to a longer bent handle called a snath, with hand holds set at convenient places and angles. For the harvesting of ripened grain, a rack or group of slender wooden fingers was attached to the snath but placed directly back of the blade to receive the severed stalks. By a long swinging motion these stalks were placed in neatly laid bunches or gavels to be gathered and bound into bundles. This implement was called the cradle and represented the most advanced development of hand harvesting implements.

The earliest threshing implement was the flail which consisted of a wooden bar or blade attached either loosely or with a hinged joint to a long handle. The grain to be threshed was placed in a thin layer on a threshing floor and beaten with this device. Often in America the threshing floor was placed in the farm barn. After threshing, the straw was removed with a fork and the chaff separated from the grain by winnowing or throwing the grain mixed with chaff into the air for the wind to separate out the chaff.

A significant aspect of the development of farm machines, from a world-wide viewpoint, is the fact that manual methods of farming involving the use of hand tools have continued unchanged to the present in certain countries, particularly in Asia.

Another important function of farm machines is that of applying power or energy from a motor, or a source other than human muscles, to perform a desired operation in agricultural production. As a motor, man has a very limited capacity. For instance, a sturdy laborer is able to develop power, or do work, such as in turning a crank or lifting weights, at the rate of 1/10 to 1/8 horsepower. The extreme high cost of power from human muscles can be estimated by considering a normal wage. If the wage should be seventy-five cents per hour, the present minimum rate in the United States, the cost of power from human muscles would be six dollars per horsepower hour. At present, the cost of power from work animals or mechanical motors used on the farm is usually from three to twenty cents per horsepower-hour.

Furthermore, the cost of the labor used in performing an operation is influenced by the amount of power that can be utilized by the individual worker. For instance, the cost of labor for plowing with a four-horse plow will be about one-half that with a two-horse plow, or one-half when plowing with a two-plow tractor as compared with a one-plow tractor. Although in principle the rate of accomplishing work varies with the amount of power directed by the workman, there are economic and practical limits to the size of a machine which may be successfully used.

J. Brownlee Davidson

Advent of Machine Production

The conditions in the United States have always been favorable to the use of farm machines. There never has been a great surplus of labor in the country. This resulted in comparatively high wages, and provided the most important incentive for using methods of saving labor. During a great period of the nation's history, new land was being brought under cultivation and large areas were available for extensive methods. The topography, the soil, and other physical conditions were favorable to the introduction of machines. Compared with the farmers of other countries, American farmers have consistently had the money with which to purchase new equipment. Thus the development of the American plow, the invention of the seeding machines, and particularly the invention and manufacture of reaping and threshing machines, were stimulated by the favorable conditions for their use.

The shortage of labor following the Civil War encouraged in a most definite way the use of machines. A review of the development of farm machines indicates that the farmers of America used primitive implements for many decades, like the farmers of other parts of the world. An extremely rapid change to machines was underway in the United States during the middle of the nineteenth century. This change is substantiated by the following statement which appeared in the twelfth census report. "The year 1850 practically marks the close of the period in which the only farm implements and machinery other than the wagon, cart and cotton gin were those which, for want of a better designation, may be called implements of hand production."

The United States census further emphasized the mid-century as the time of the general introduction of machines by the inclusion of information pertaining to the value of farm machines manufactured during the census years. In 1849, the first year in which the census included this data, the value of machines manufactured was $6,842, 611, but in 1859, the value of manufactured machinery increased to $20,831,904. On Iowa farms, in 1850, there was $1,172,869 worth of machinery while in 1860 this figure had increased to $5,327, 033. The reports for the later census years indicate a rapidly continuing increase in the value of machines manufactured.

The pioneer settlers of Iowa, as they drove their covered wagons over the early trails into the state from the East, had a few of the basic implements of farming in their outfits. The plow was often tied onto the side of the wagon, and elsewhere were to be found such hand implements as hoes, scythes, grain cradles, flails, forks, and axes. These simple tools, together with a supply of seed, were essential to getting started with crop production in the Black Hawk Purchase, where settlement was largely concentrated prior to statehood in 1846.

The flat or gently rolling, fertile land of Iowa was particularly well adapted to the use of farm machines, but the first breaking of the native sod was found to be too difficult for the ordinary plow used in turning the old ground of the East. It was also found that the native grass could be killed by cutting a thin furrow slice like a giant ribbon and completely inverting it. The grass was thus killed and the tough sod rotted quickly. A most satisfactory crop of corn could be grown without cultivation by planting corn in each third or fourth furrow. After the first year the sod, if laid evenly and smoothly, was sufficiently rotted to be plowed and sown to wheat.

Special large plows were developed for the breaking of the raw prairie sod, and breaking for the most part became a contract job carried out by those with special equipment. In Iowa the cost of prairie breaking varied. In the 1840's from $1.50 to $2.00 was charged, while in 1855 the usual price in the more settled eastern counties was $2.25 per acre. By 1870 farmers in western Iowa paid as high as $3.00 to $4.00 per acre. It is reported that a large breaking plow, often with a beam ten feet long and with a thin sharp share, a long landside, and long rods to receive and turn the furrow slice, did most excellent work with little attention from the plowman. Often as many as ten yoke of oxen were used, since these big plows required a great deal of power. After the breaking of the sod, the broad fields offered ideal conditions for the use of machines which made hand labor more effective.

The deep interest in farm machines in the early days of the state of Iowa is indicated by the fact that the Iowa State Agricultural Society of 1867 had a standing committee on the "Implements of Husbandry." An extended report of the committee is to be found in the annual report of the society for 1867 which for the most part is a description of the machines exhibited at the State Fair of that year, together with other particulars, such as the number of machines sold in the state, the capacity of the machines, and the cost of each.

The committee report revealed that there were 379 entries at the Fair in the several classes allotted to farm tools and machinery. It is stated: "These afforded an exhibition of great interest. Several acres were covered with labor-saving machines, which were the admiration of all beholders." Incidentally, the committee reported that the price of farm products, much to its surprise, had been maintained.

The report concluded: "The great mass of the people would be delighted to enjoy the sight of the spectacle, presented to only twenty-five thousand of our people at the State Fair." In order to gratify them, the committee requested the exhibitor to supply information about each machine in the following particulars:

1. The name, style, and date of patent of the machine.
2. Can it be bought in Iowa; if not, where?
3. What can the machine do?
4. Its claim of superiority.
5. Amount of sales in Iowa in 1867.
6. Price and terms of payment.

The report covers some 55 pages of the *Report of the State Agricultural Society* for 1867 and includes ninety illustrations of machines. It is very clear that the Iowa farmer was interested in machines operated by horses rather than by hand. This author does not know of a better source of information pertaining to the farm machines of that period.

In 1934 Ray Murray, Secretary of Agriculture for Iowa, requested this author and C. H. Chase, Secretary of the Iowa Retail Farm Equipment Association, to prepare an article comparing the machines of 1867 with those used in Iowa in 1934, two-thirds of a century later. This article was published in the *Iowa Yearbook of Agriculture* for 1934.

Steam traction engines came into general use following the Civil War. It is estimated that there were 24,000 on the farms of the United States in 1880, the number increasing to 40,000 in 1890, and continuing at about this number until 1910 when the number in use began to decline rapidly, as the gas tractor came into use. It is generally agreed that the use of steam power in agriculture represented a desire to provide a larger unit of power than was practicable with animals. These large units were needed to drive threshing machines and to some extent for the breaking of prairie land in the newer states. The main objection to the steam traction engine was its weight; also, the need of a fireman and often a water tender in addition to the engineer made it an expensive plant to operate.

In England it is reported that David Ramsay and Thomas Wildgoose attempted to build a steam plow as early as 1618 but gave up the effort because the steam engines experimented with were too heavy. More than two centuries later, equipment for a successful system of plowing with steam power came into general use in England and many steam plows were exported. This equipment, manufactured by the Fowler Company of England, consisted of two steam traction engines, each of which had winches mounted on them. These engines were placed at opposite ends of the field and pulled a double plow with two gangs back and forth by means of a cable. The gang not in use was carried high in the air.

However, it was proved that steam engines were not well adapted for agricultural uses, and mechanical power made little headway until the internal combustion engine became available. A liquid fuel, readily available from petroleum, made the gasoline engine particularly well suited to the farm. Stationary gasoline engines were introduced in a limited number before 1900 and increased in number until a few years before 1930 when tractors took over much of the work performed by the larger gasoline engines.

The internal combustion engine, on account of its automatic stoking and its lighter weight, was recognized as well adapted for a traction engine, or the tractor, a name now generally accepted. Two young Iowa farm men should be credited for much of the early development of the gas tractor. C. W. Hart, of Charles City, after attending Iowa State College for a year, changed to the University of Wisconsin where he met C. H. Parr of Iowa City. Both were interested in designing a tractor powered with a gas engine, and they became close friends.

Hart and Parr established a factory at Madison, Wisconsin, upon graduation in 1896. In 1898 they produced their first oil cooled engine which was later incorporated in their first tractor which was made in a factory at Charles City, Iowa, to which place they had moved. This early tractor was essentially a stationary engine mounted on a chassis of structural steel carried on steel wheels.

The introduction of the gas tractor was one of the most significant events in the history of American agriculture, as the productive output of workers in doing field work was greatly increased.

The use of the gas tractor grew at a phenomenal rate after it was once accepted by the farmer. The United States census indicates that there were about 10,000 gas tractors in use on farms in 1910 and 246,000 ten years later. The number continued to grow rapidly until in July, 1949, it was estimated that the number of gas tractors in use on farms was 3,375,919 of which 232,344 or about 7 per cent were in Iowa.

There were a number of reasons why the gas tractor met with such favor. The internal combustion engine was a light motor; petroleum fuel became universally available at a low cost; and its machine equipment was made more universal in its application. It should be recognized that the rapid development of the automobile helped with the refinement of the tractor.

The gas tractor not only reduced the labor of crop production but made many millions of acres, then used for growing horse feed, available for growing food crops. The early attempts to substitute mechanical power for animal power consisted, in a sense, of making a mechanical horse with wheels for propulsion and guiding, instead of legs. This effort continued for many years.

Horses and oxen could be organized conveniently into various sizes of power units, a single horse could be worked alone, or a two-three-four or even a larger team could be used if desired. The tractor, on the other hand, was a power plant of a fixed size.

It was soon found that machines, such as the plow, the cultivator, and the planter, could be mounted on or carried by the tractor which enabled the tractor and machines to be controlled as a unit. Also, power for certain parts of the machine could be supplied directly from the motor through a suitable transmission called the power take-off. Such an arrangement made for efficiency in the application of power.

It is generally recognized that the development of the automobile was largely dependent upon rubber tires whose shock-absorbing capacity made higher road speeds practicable. The high road speeds for the self-propelled vehicles would be entirely impractical without the cushioning effect of rubber tires. A few pneumatic tires were tried on farm tractors about 1932, and the results were so satisfactory that immediately there was a rapidly increasing demand for such tires for tractor and farm machines. These tires made it possible to operate at higher field speeds and with greater comfort to the operator. There was also a reduction in the rolling resistance of the tractor and machines over the comparatively soft ground surfaces. The higher field speeds made it possible for a tractor of a given weight to do more work in a given time. In the short period of eight years, or by 1940, 90 per cent of the farm tractors were equipped with pneumatic tires.

The incentive to develop and use machines in agricultural production is clearly understood when the relationships between the various items of cost are established. Briefly this can be explained by the use of an equation in which the cost items for a unit of area, an acre for instance, are included viz:

$$C = L + P + M + Ld + S + Misc.$$

Where C = Cost of crop production per acre

L = Cost of labor per acre

P = Cost of power

M = Cost of machinery

Ld = Cost of use of land

S = Cost of seed

Misc. = Other miscellaneous items of expense such as storage, hauling, fertilizer, etc.

In some instances, the amount of the miscellaneous items may be considerable, such as expense for fertilizer, when used. In fertile areas well adapted to crop production the cost of the use of land, either by ownership or by rental, is the largest item. The next largest item is usually labor. A typical situation for corn production follows:

Labor — 6 hours @ $1.00	$ 6.00
Power — 35 horsepower-hours @ 8 cents	2.80
Machinery — Annual cost — 12½ per cent of a $16.00 investment per acre	2.00
Use of land — two-fifths of crop or $12.00 per acre	12.00
Seed — per acre	1.20
Other expenses	6.00
Total cost	$30.00

In contrast, in 1848 John Bangs of Henry County estimated the cost of an acre of corn, including plowing, marking off and planting, cultivating, and harvesting at $2.87½. On the basis of 40 bushels per acre, the corn cost 7 cents per bushel to raise. It was sold at 12½ cents, making a profit for the farmer of 5½ cents on each bushel.

This outline of costs is intended to emphasize the relationship and magnitude of the various items entering into the cost of producing corn in the central part of the Corn Belt. These are the items which concern the person interested in the engineering or managerial aspect of growing corn and in no way minimizes the importance of following a good agronomic practice.

J. Brownlee Davidson

History of Farm Machines

The Plow

After the hoe, the plow was the first implement devised to assist the farm worker in tilling the soil. This was due to the availability of work animals and to the large amount of energy required for preparing a seed bed. Looking back into the far distant past it is easy to imagine how the farmer, who used a crude forked stick for loosening the soil, conceived of using a larger stick of the same general form to which he could attach his faithful ox, thus greatly reducing his effort and increasing the area of land cultivated. Even today, with modern plows, often one-half or more of the total energy used in growing a crop is used in plowing or the primary tillage operation. Iowa Experiment Station studies reveal that in a normal situation, where a total of 31 horsepower-hours is used for growing and harvesting one acre of corn, 13 to 15 horsepower-hours were used for plowing.

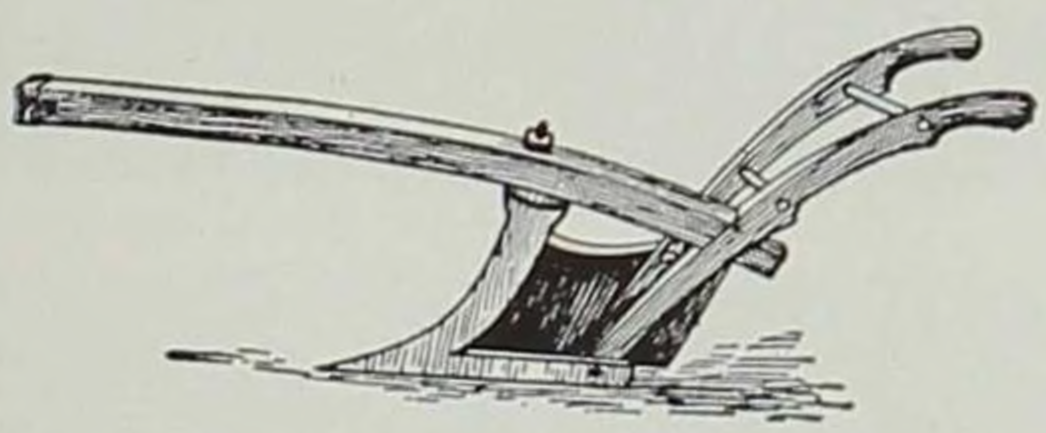
The primitive plow has been described as "a mere wedge with a short beam and crooked handle." In time, it was "fitted with a removable share of wood, stone, copper or iron wrought to a suitable shape." The next step was to add a rude wooden moldboard to turn a furrow slice.

Early Egyptian Plow.
From Butterworth.

Ancient British Caschrom.
From N. Y. Agr. Soc. Trans. 1867.

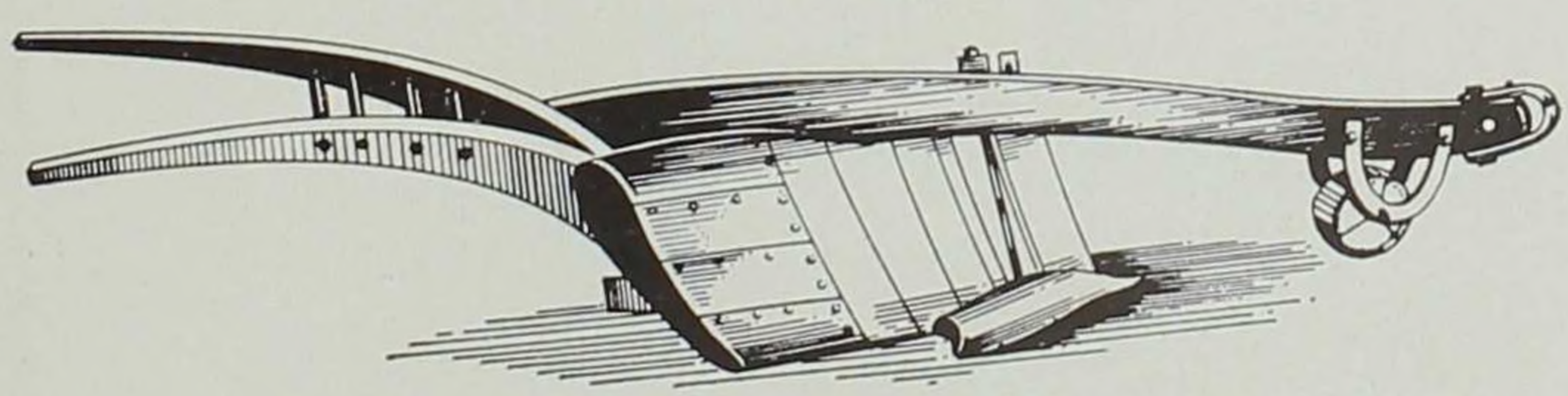
Hand plowing with swing fork in China.

Chinese native plow.
Photos by author. 1947.

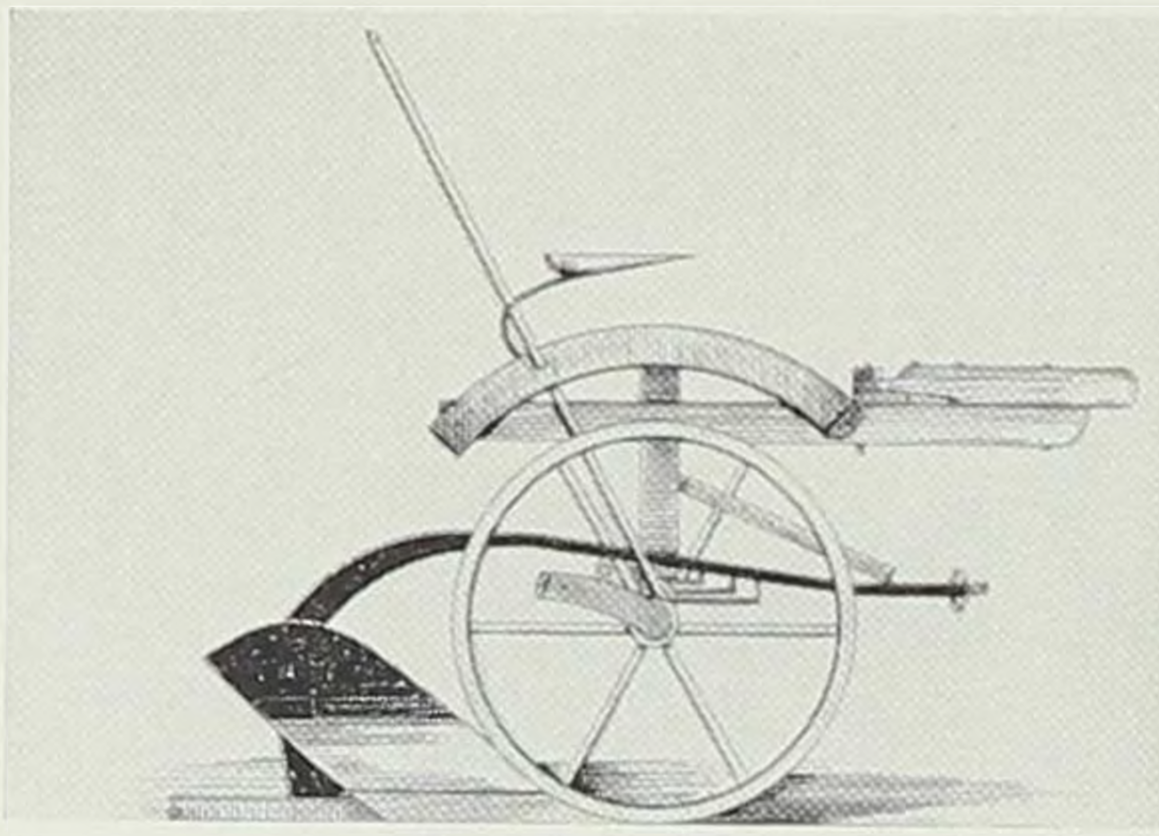


Charles Newbold plow—patented 1797.
From N. Y. Agr. Soc. Trans. 1867.

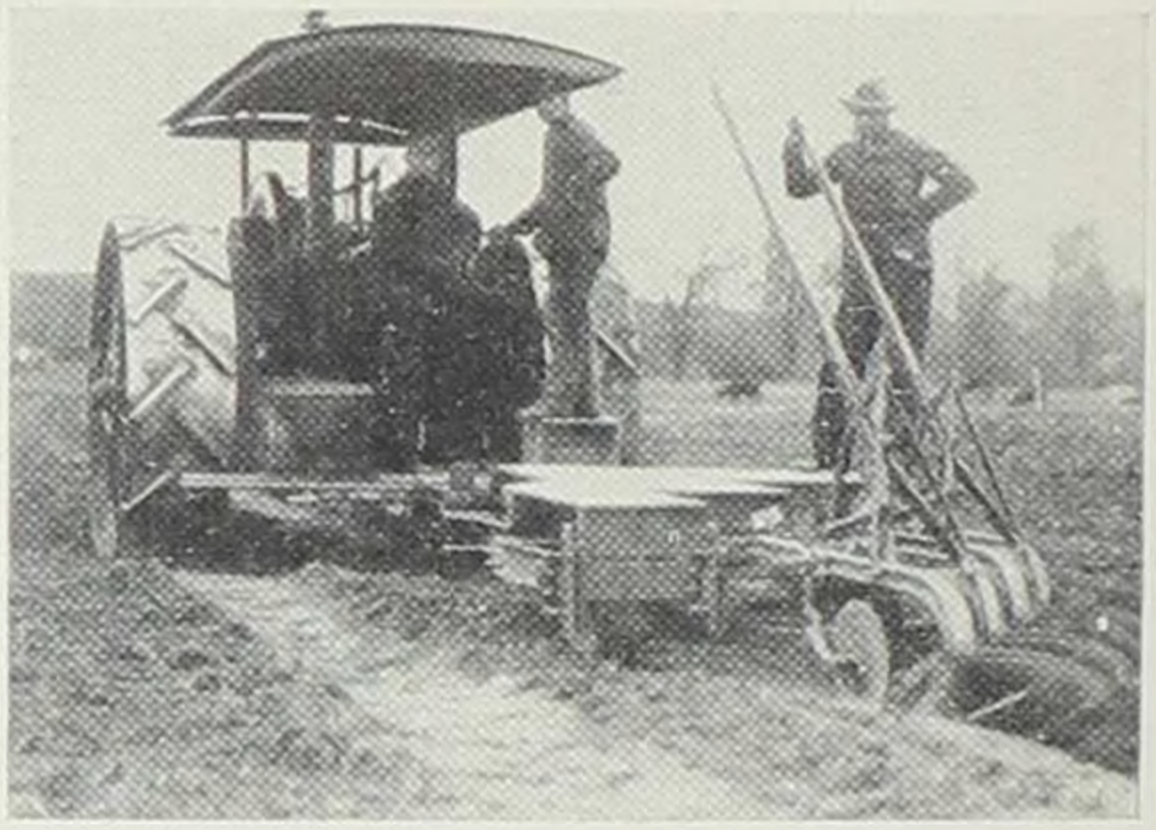
John Deere steel walking plow.
From Ia. Agr. Soc. Rept. 1867.



From N. Y. Agr. Soc. Trans. 1867.
Daniel Webster's Plow—12 feet long and capable of turning furrow 2 feet wide and 1 foot deep, 1837.



Sulky plow patented 1875.
Sketch after Ardrey.



Early tractor-drawn plow.
Photo by author.

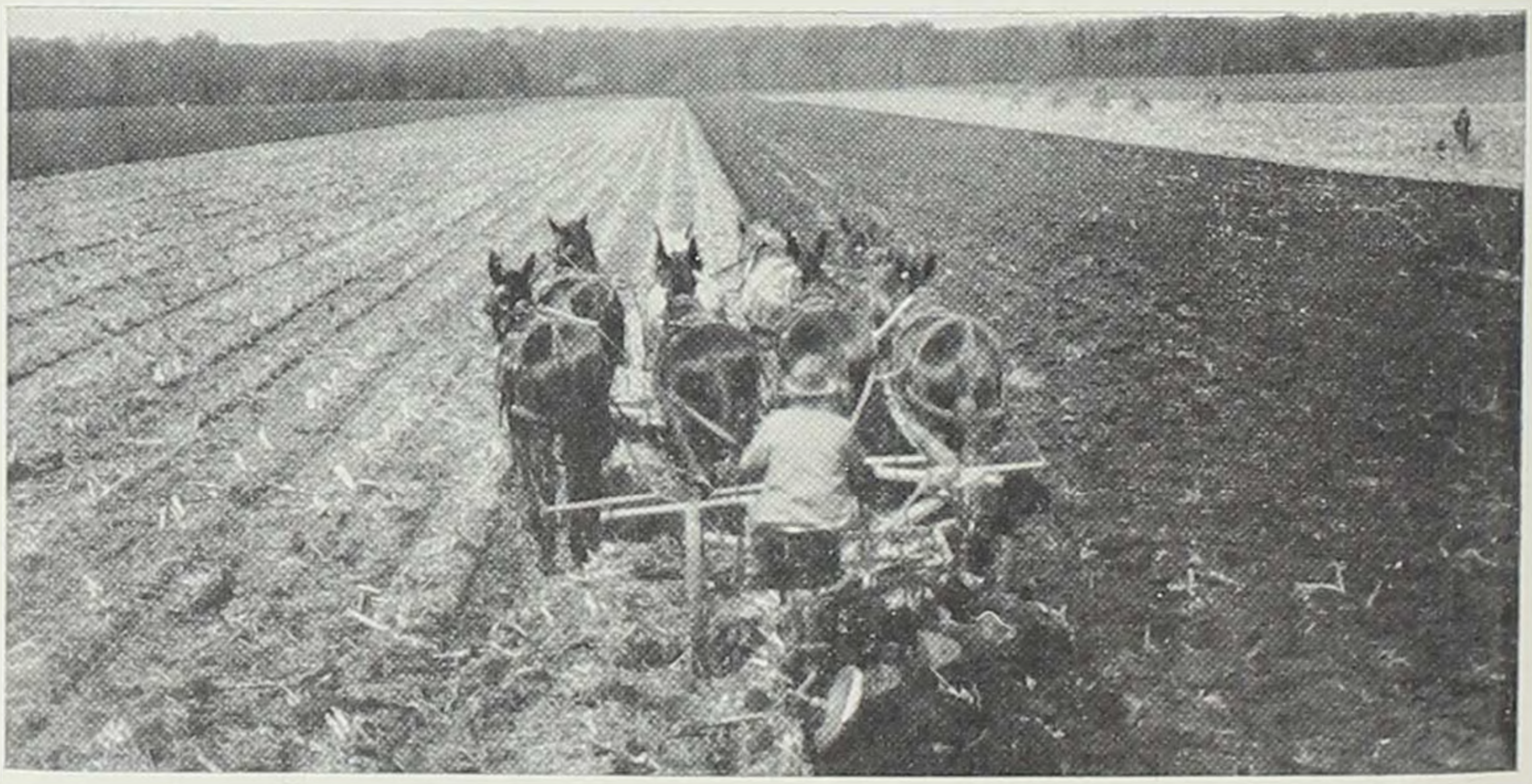
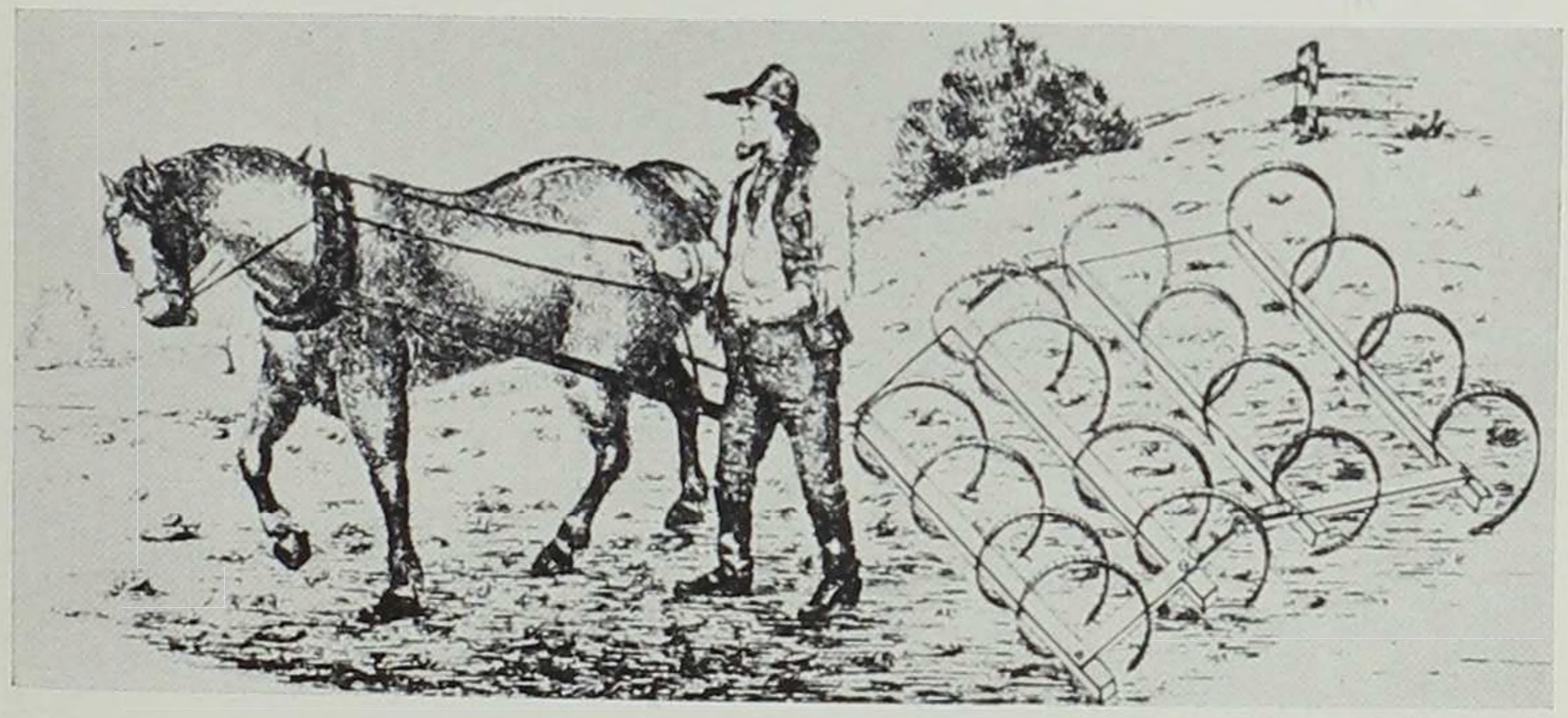


Photo by author.
High-lift sulky for horses, designed to compete with tractors.

Photo by J. I. Case Co.
One-way or harrow disk plow.

Primitive brush harrow.
From Butterworth.

Early disk harrow of 1877.
From Butterworth.



From Butterworth.
Early spring tooth harrow of 1869.

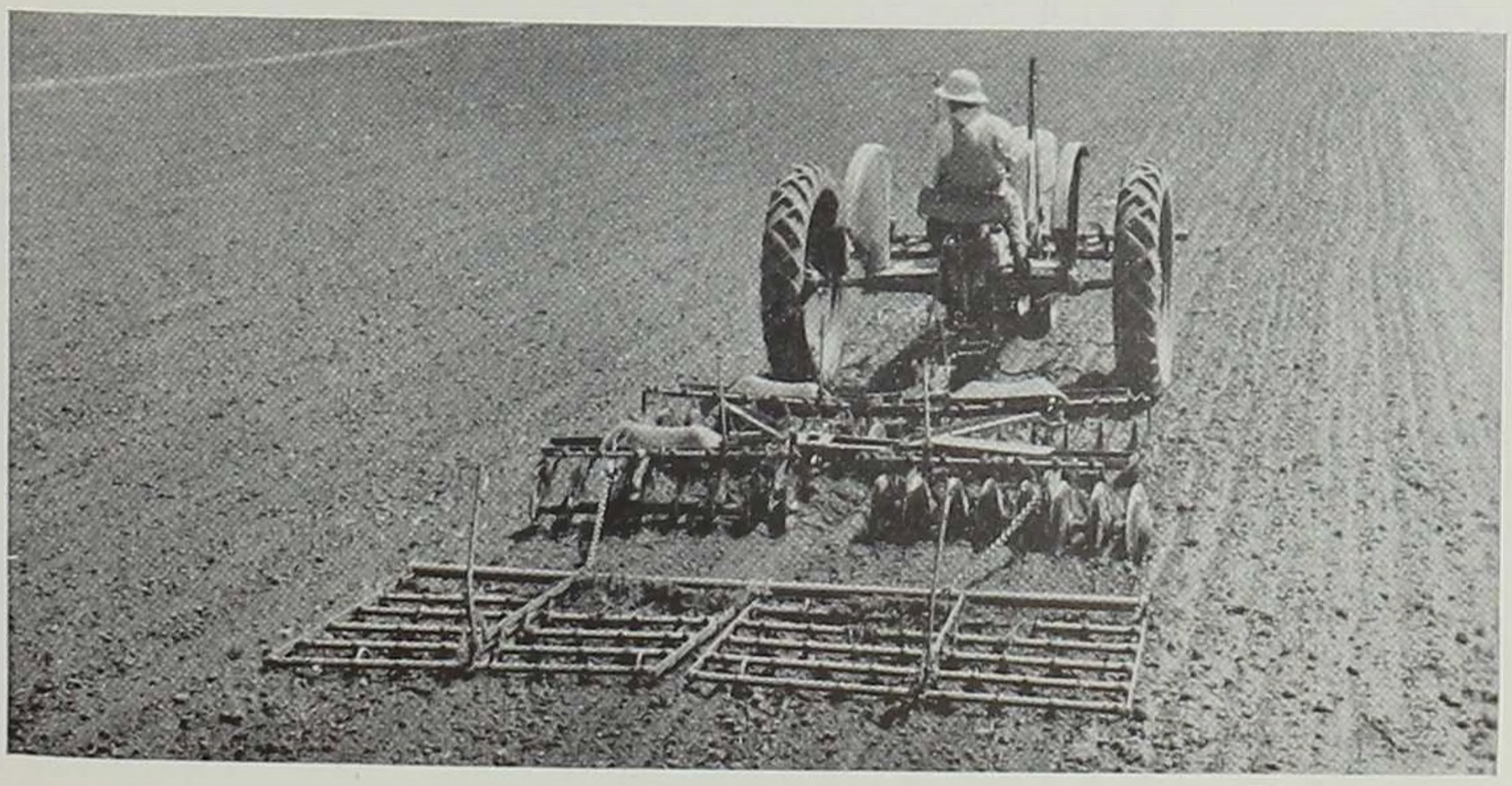
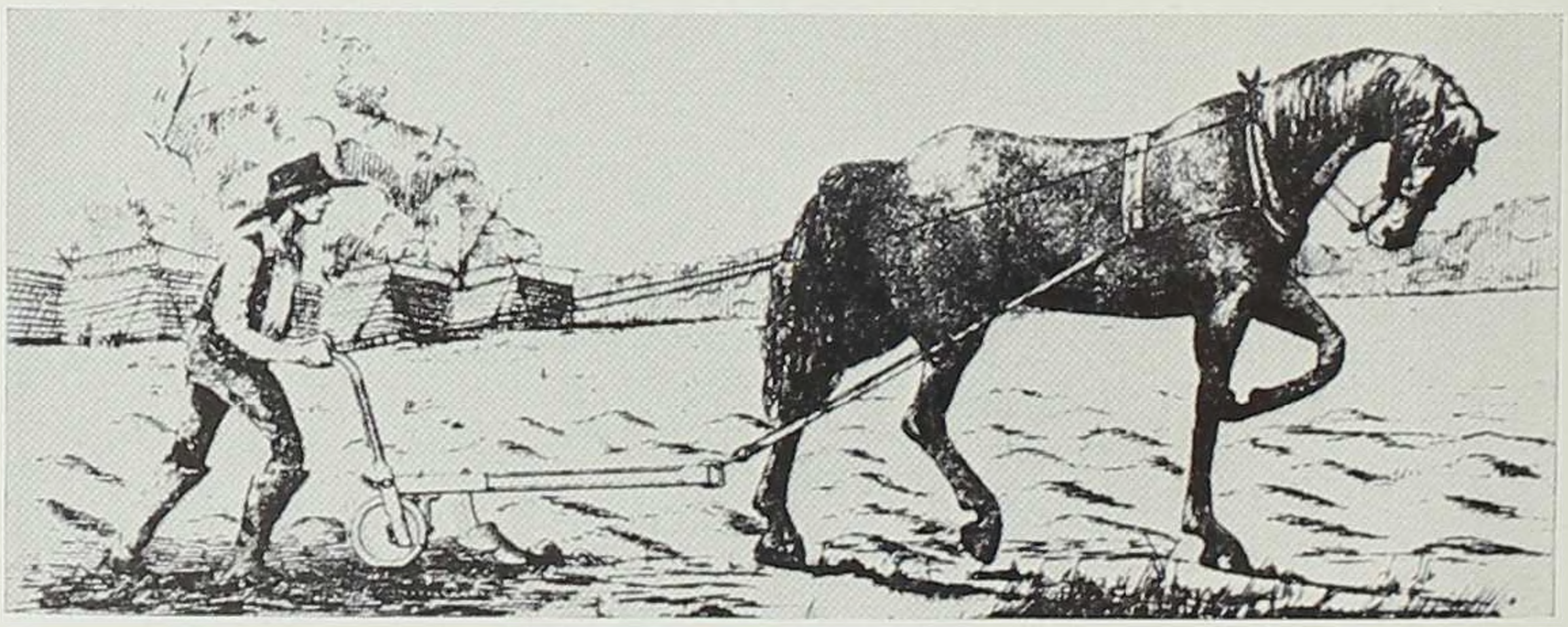


Photo by Spedd.
Modern tandem disk harrow with adjustable spike tooth harrow.

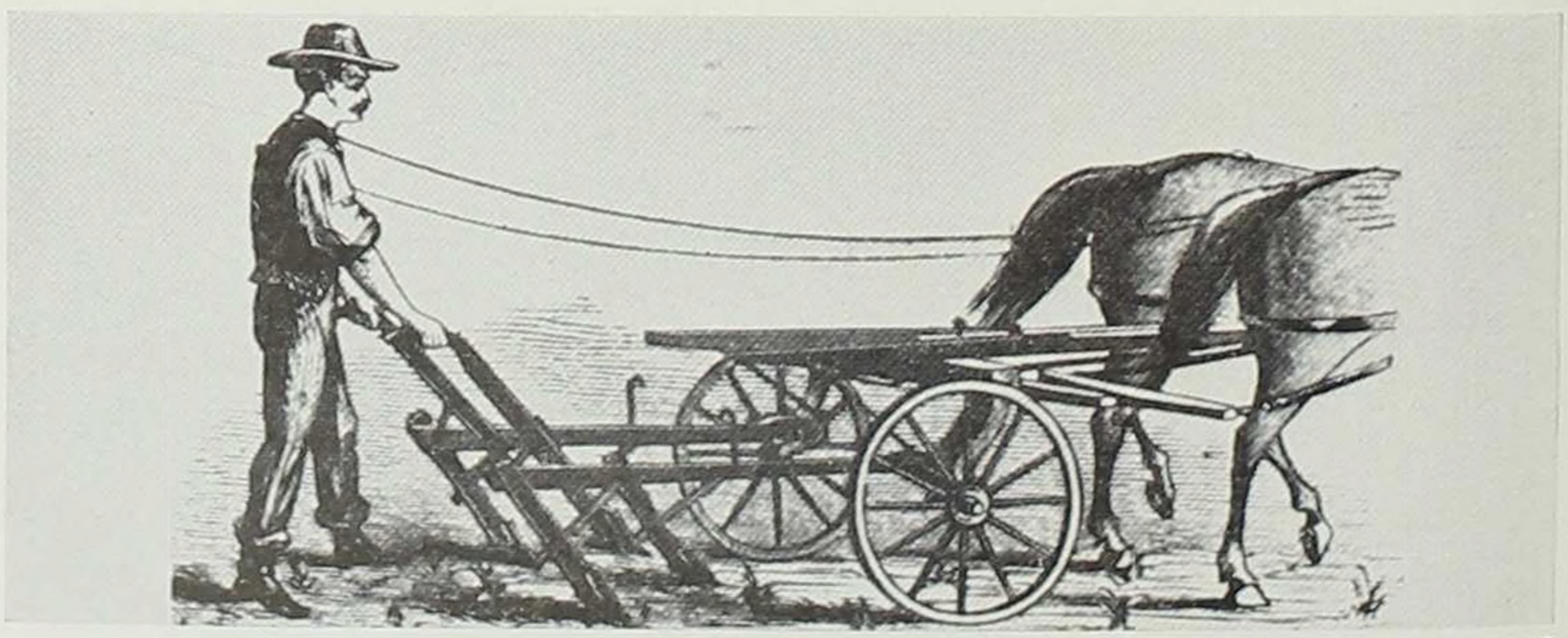
From Butterworth.

Egyptian harrow as reconstructed from ancient records.



From Butterworth.

Horse drawn cultivator of 1837.

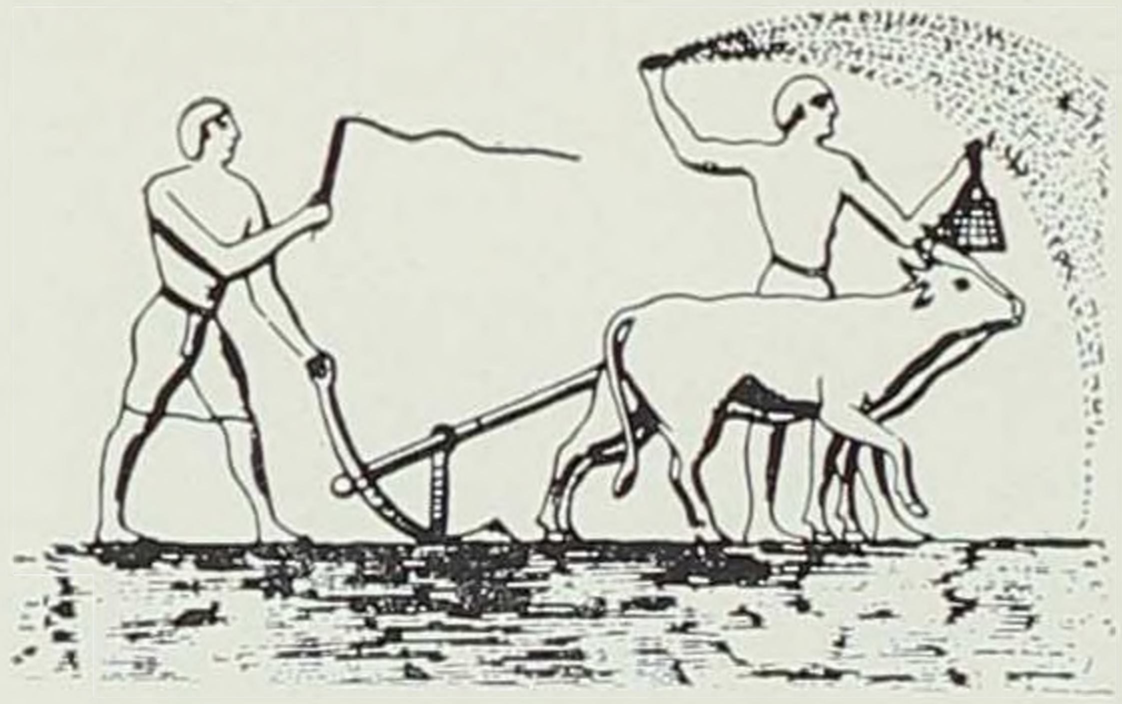


Ia. Agr. Soc. Rpt. for 1867.

Straddle row cultivator shown at Iowa State Fair.

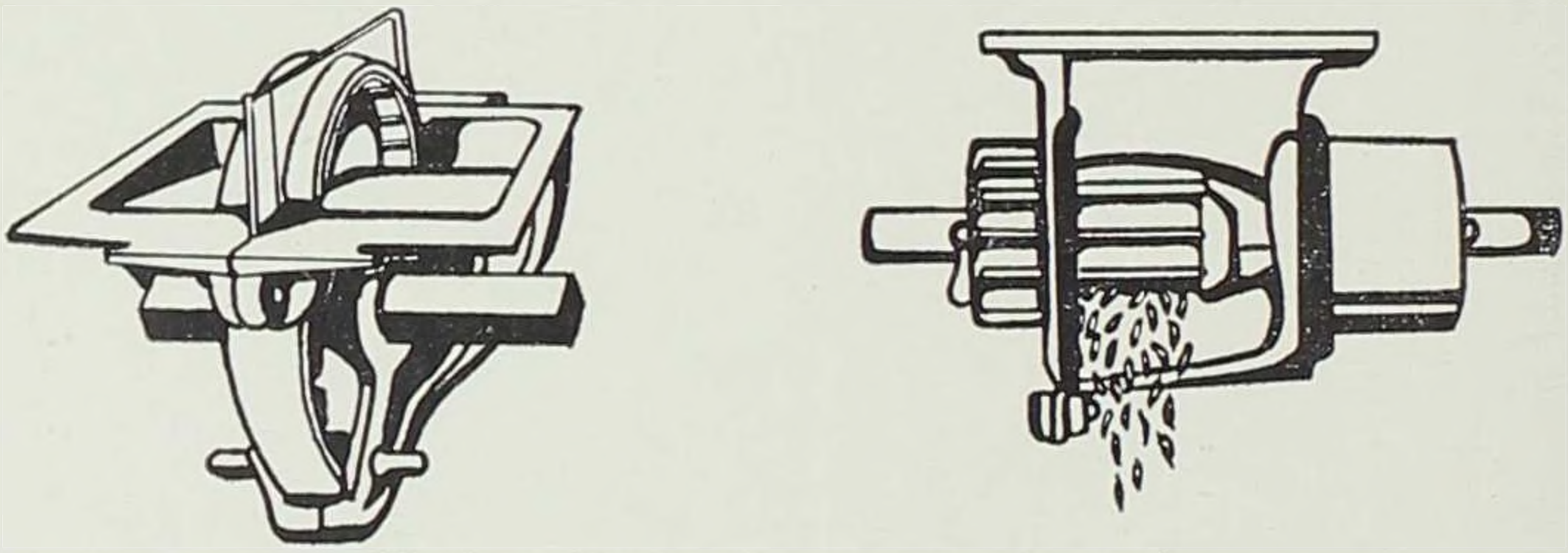
Photo by Oliver.

Mounted corn cultivator.



Early wheelbarrow seeder.
Still used for grass seeding.

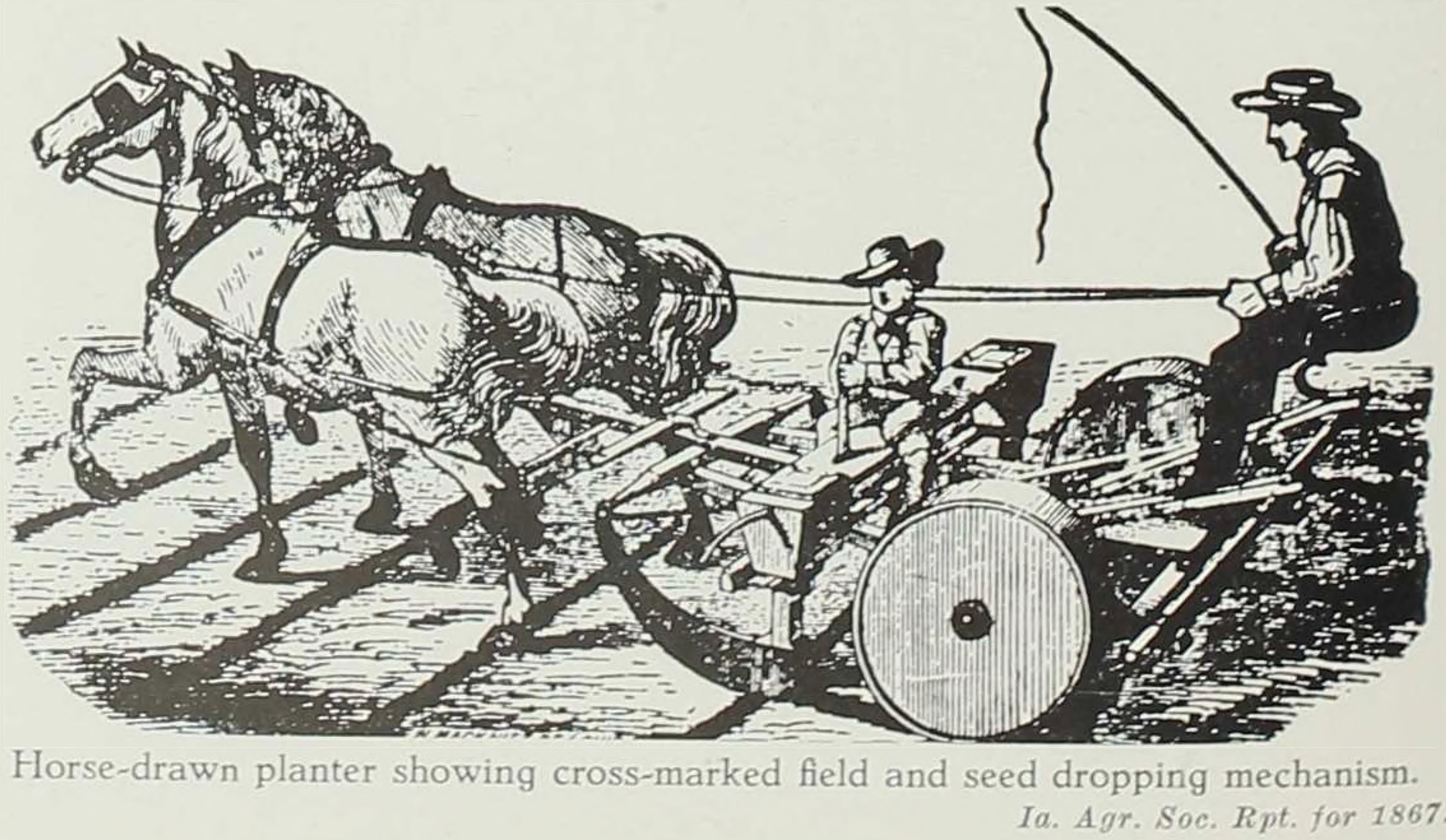
Left — Egyptian sowing by hand.
From Butterworth.



Feed mechanism for metering the seed.

Hand planting with hoe.
From Butterworth.

Hand planter.
Opening handles releases seed.



Horse-drawn planter showing cross-marked field and seed dropping mechanism.
Ia. Agr. Soc. Rpt. for 1867.

SEEDING & PLANTING MACHINES

Modern disk drill. *From Minneapolis-Moline.*

Horse-drawn corn planter. *Photo by International.*

Photo by author.
Direct connected four-row tractor garden drill.

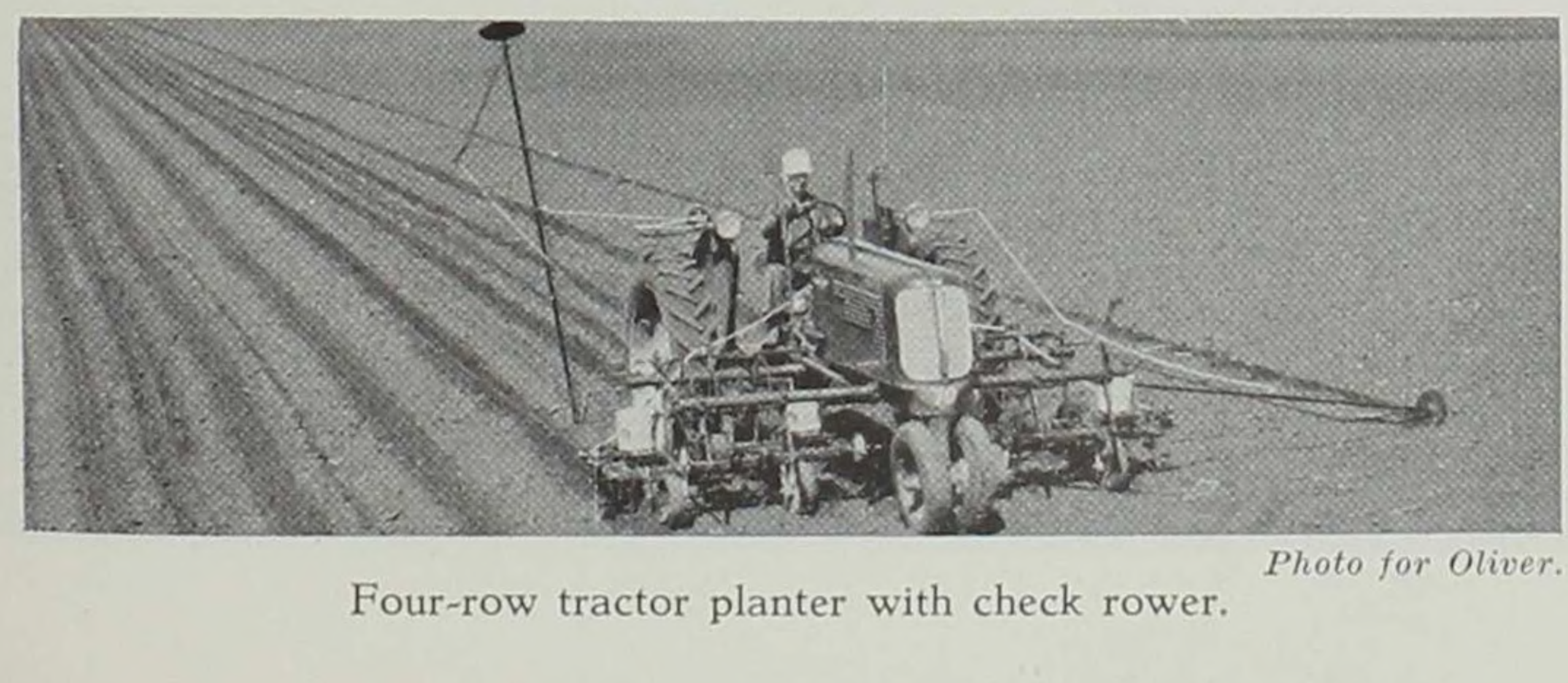
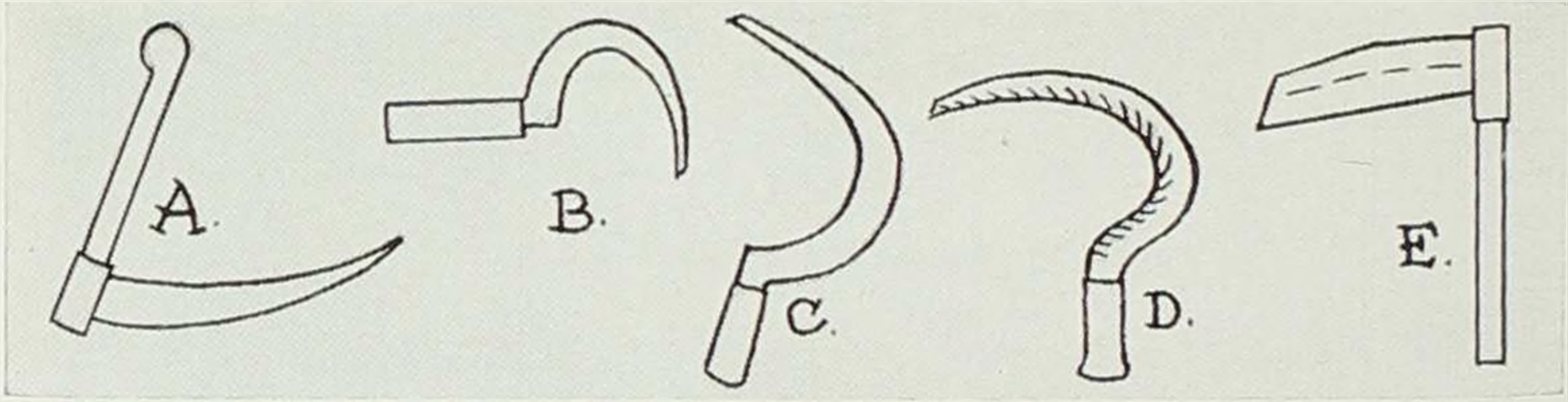


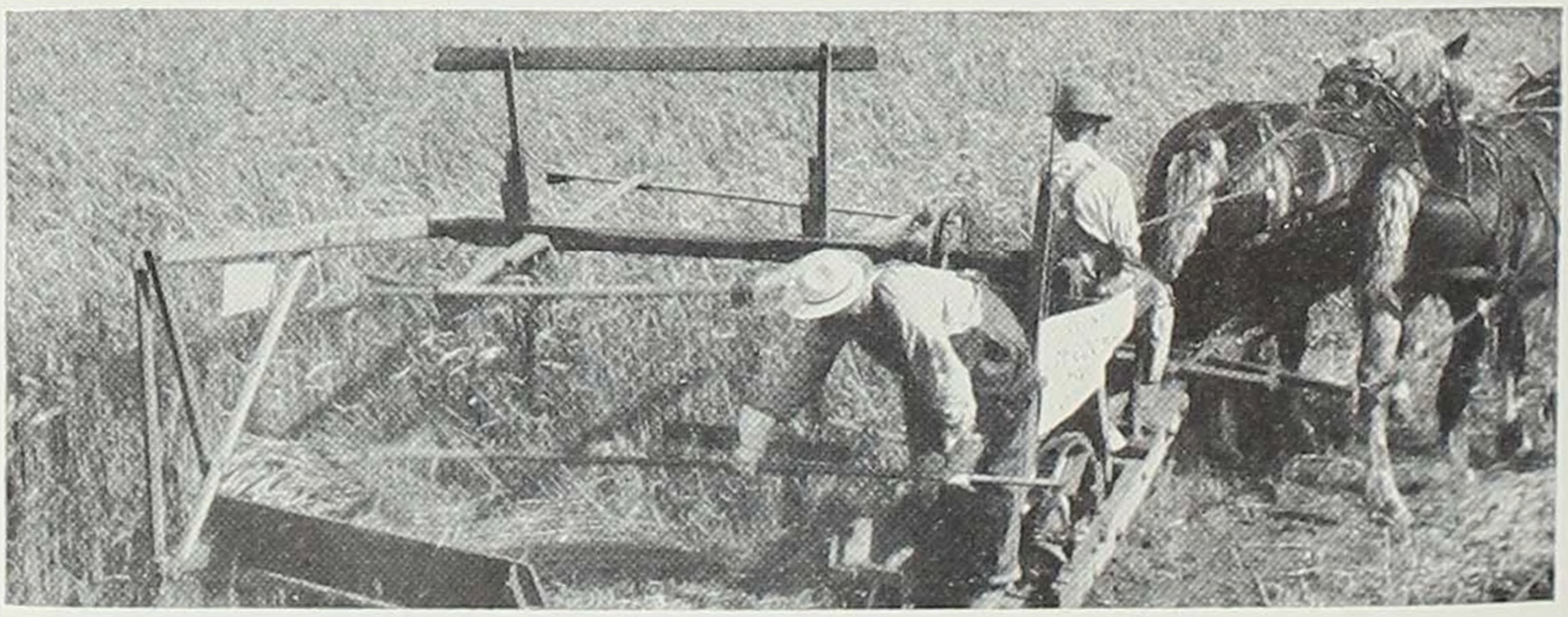
Photo for Oliver.
Four-row tractor planter with check rower.



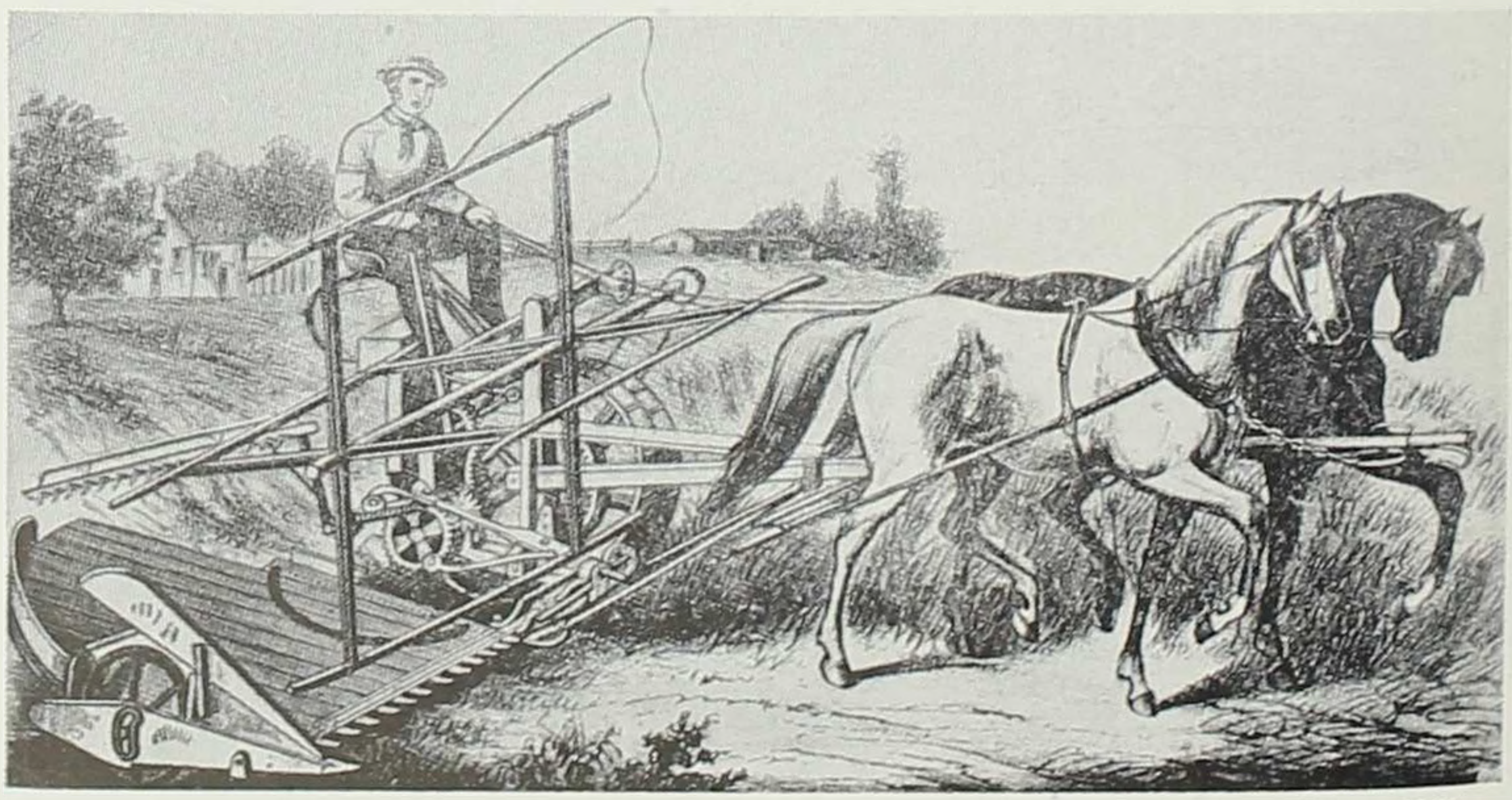
Sketches of hand sickles by author.
a. Egyptian; *b*. early Middle Ages; *c*. late Middle Ages; *d*. toothed; *e*. Chinese.

Harvesting rice with hand sickle.

American grain cradle.
Photo by Deere.



Replica of McCormick harvester of 1831.



A self-rake reaper of about 1879. *From Miller.*

Photo by Oliver.

The self binder of 1890 and later.

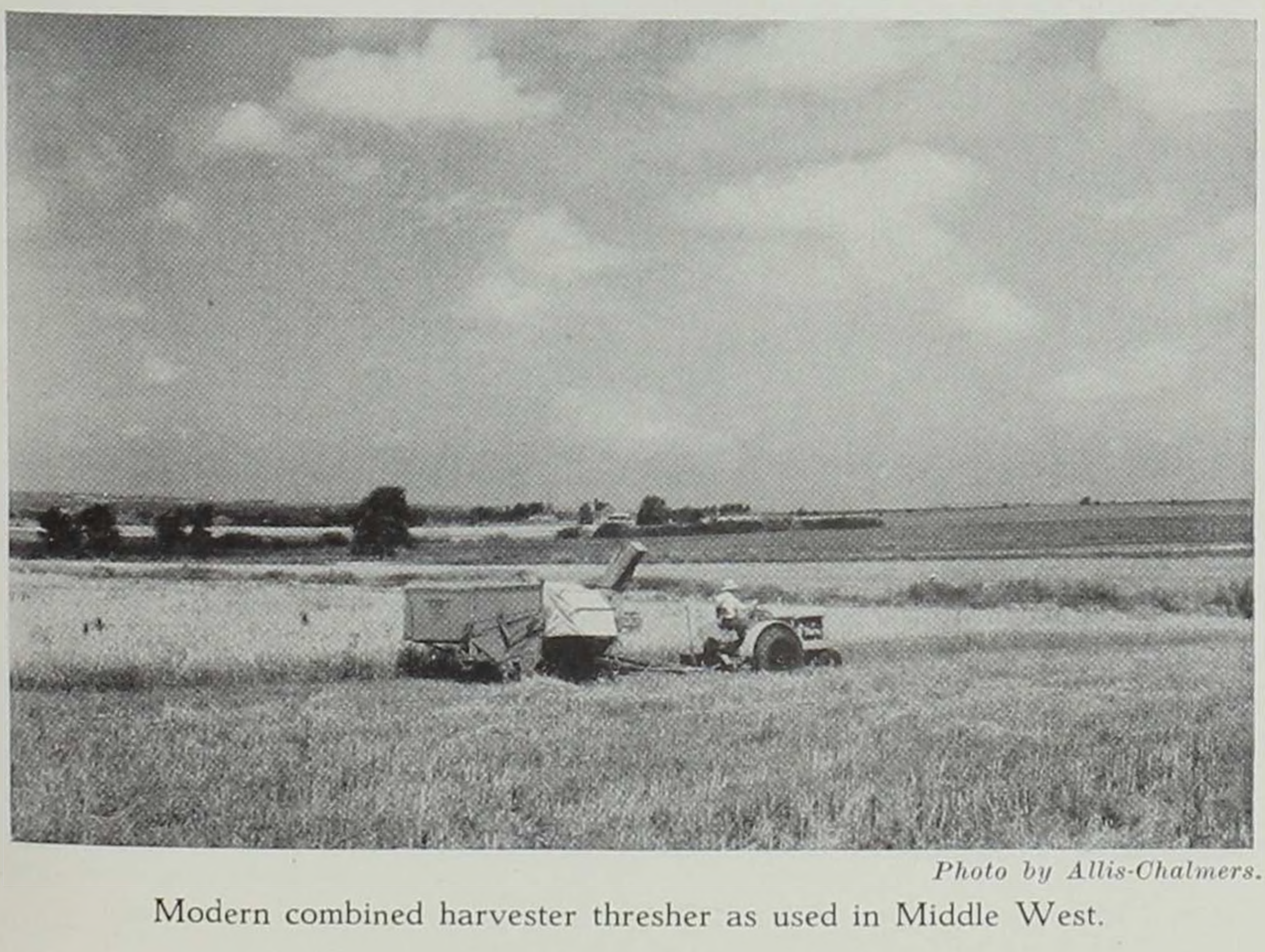
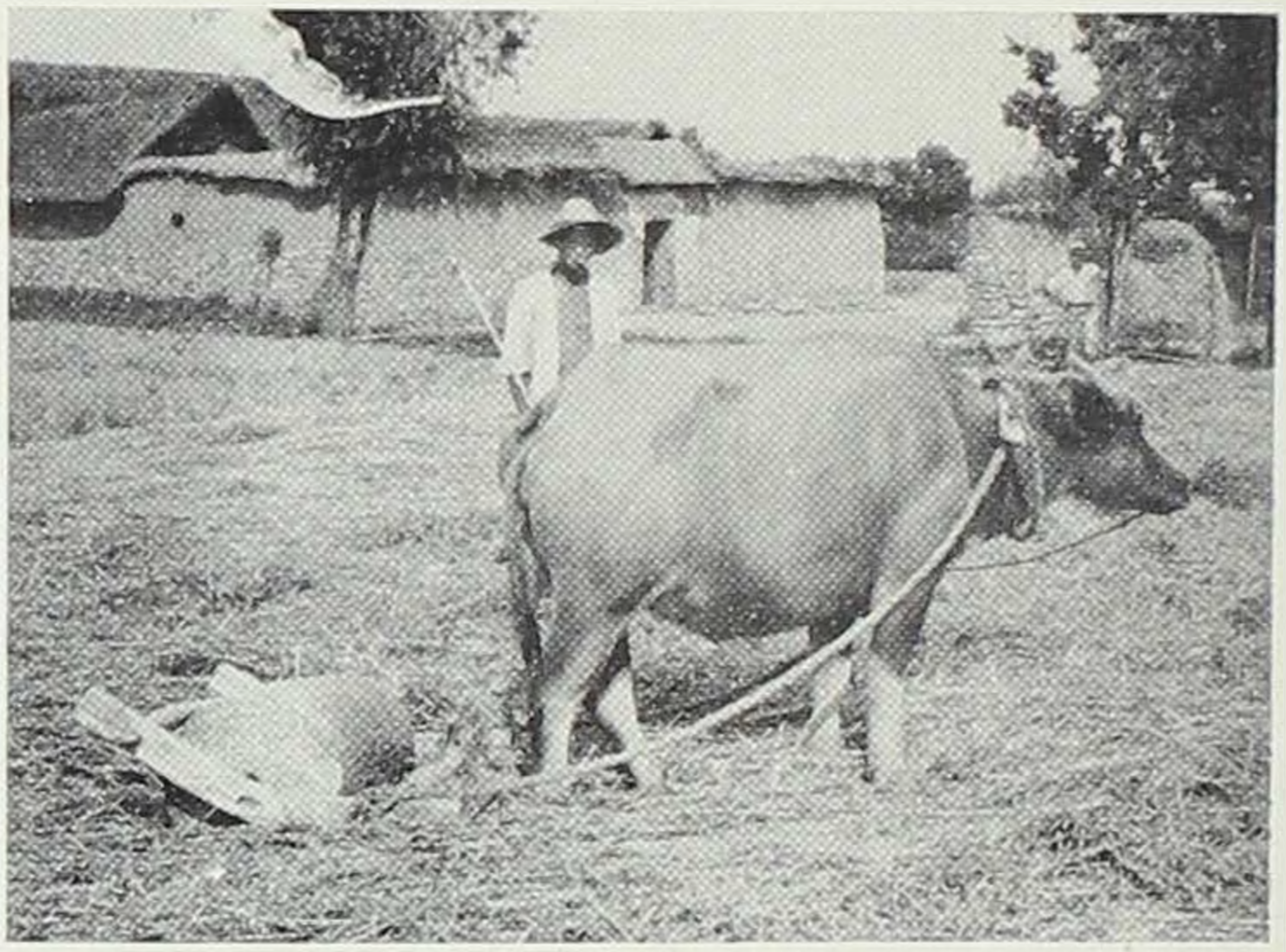


Photo by Allis-Chalmers.

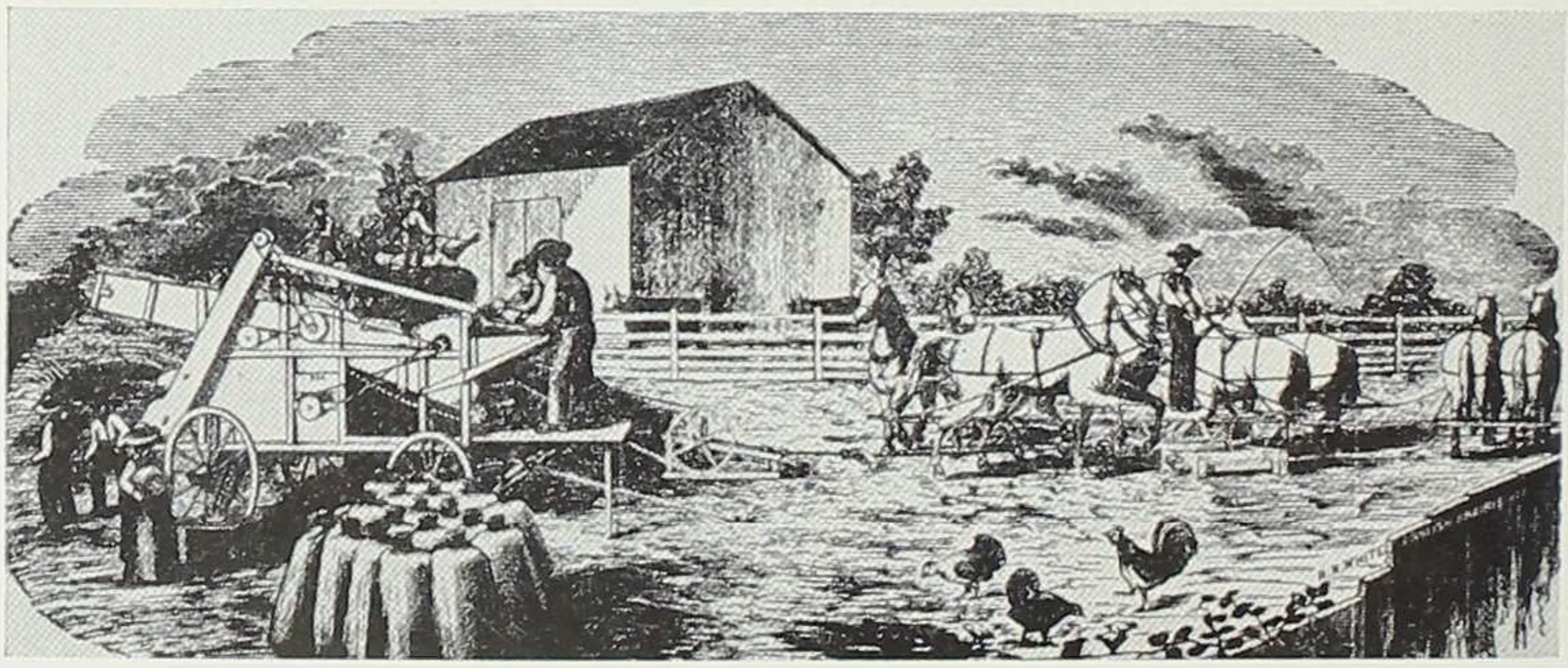
Modern combined harvester thresher as used in Middle West.

Photos by author in 1947.

Flail still used in China.



Stone roller drawn by buffalo.



Hand fed stationary thresher of 1873 as used in Iowa.

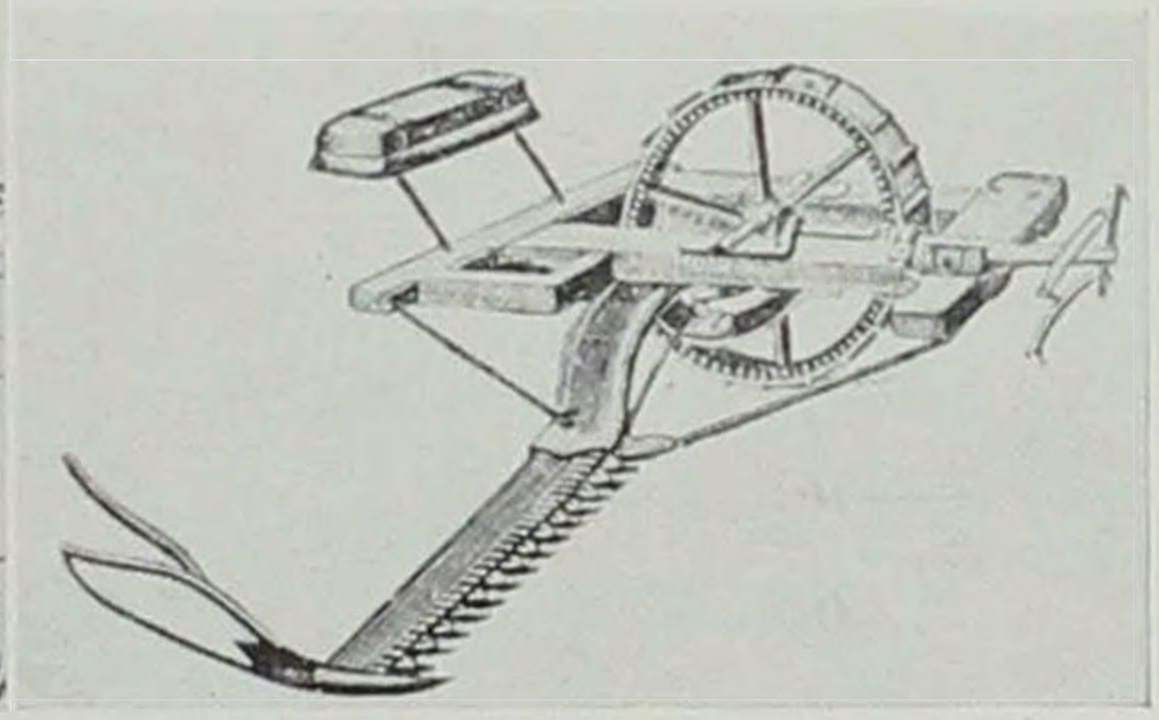
Photo by Case about 1920.

Thresher equipped with self-feed, wind stacker, and grain weigher.

HAY MAKING MACHINES

Left — after Butterworth.
Right — after Miller.

The scythe.



Mowing machine, 1847.

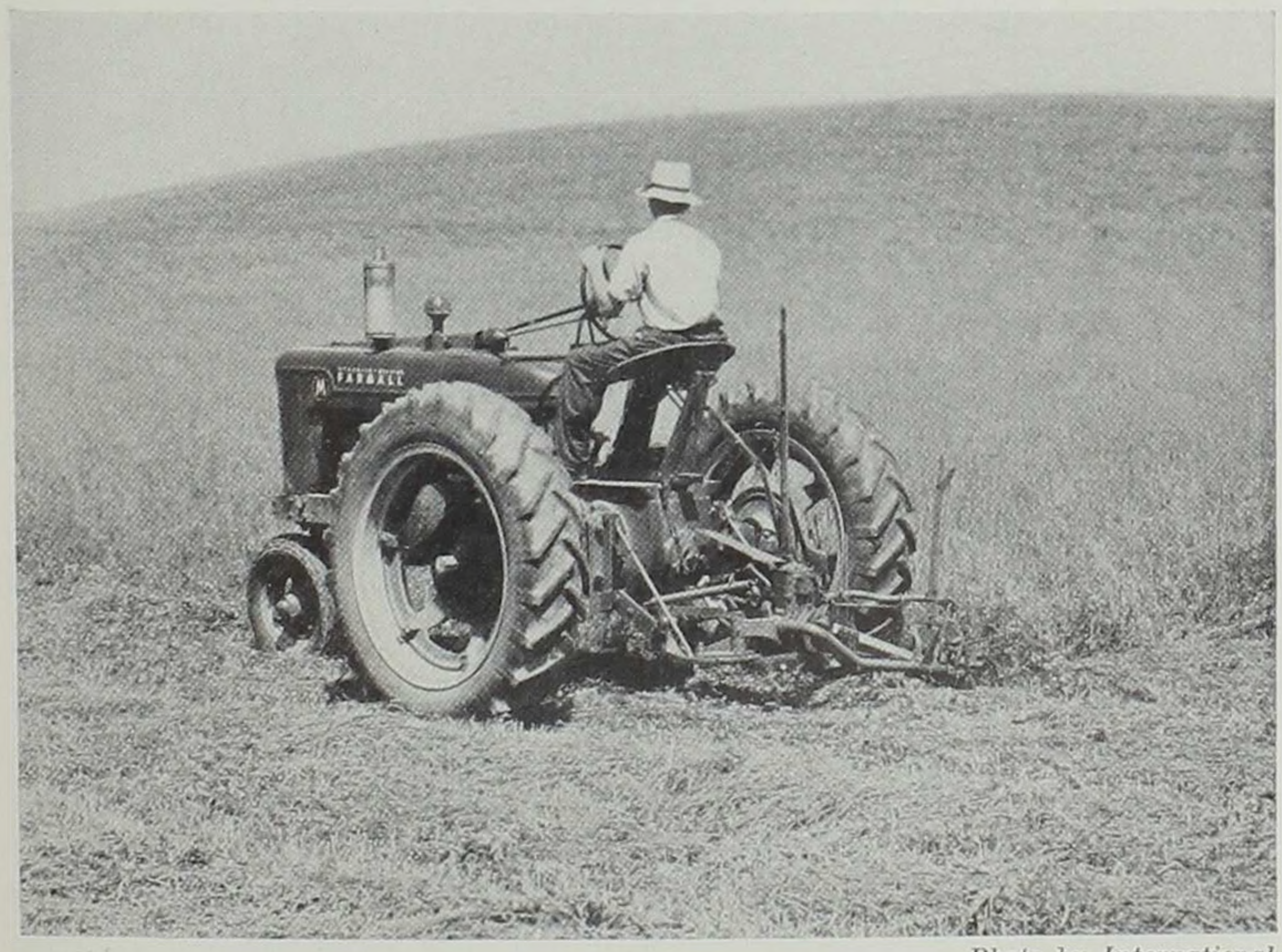


Photo by International.

A direct connected tractor mower.

HAY MAKING MACHINE

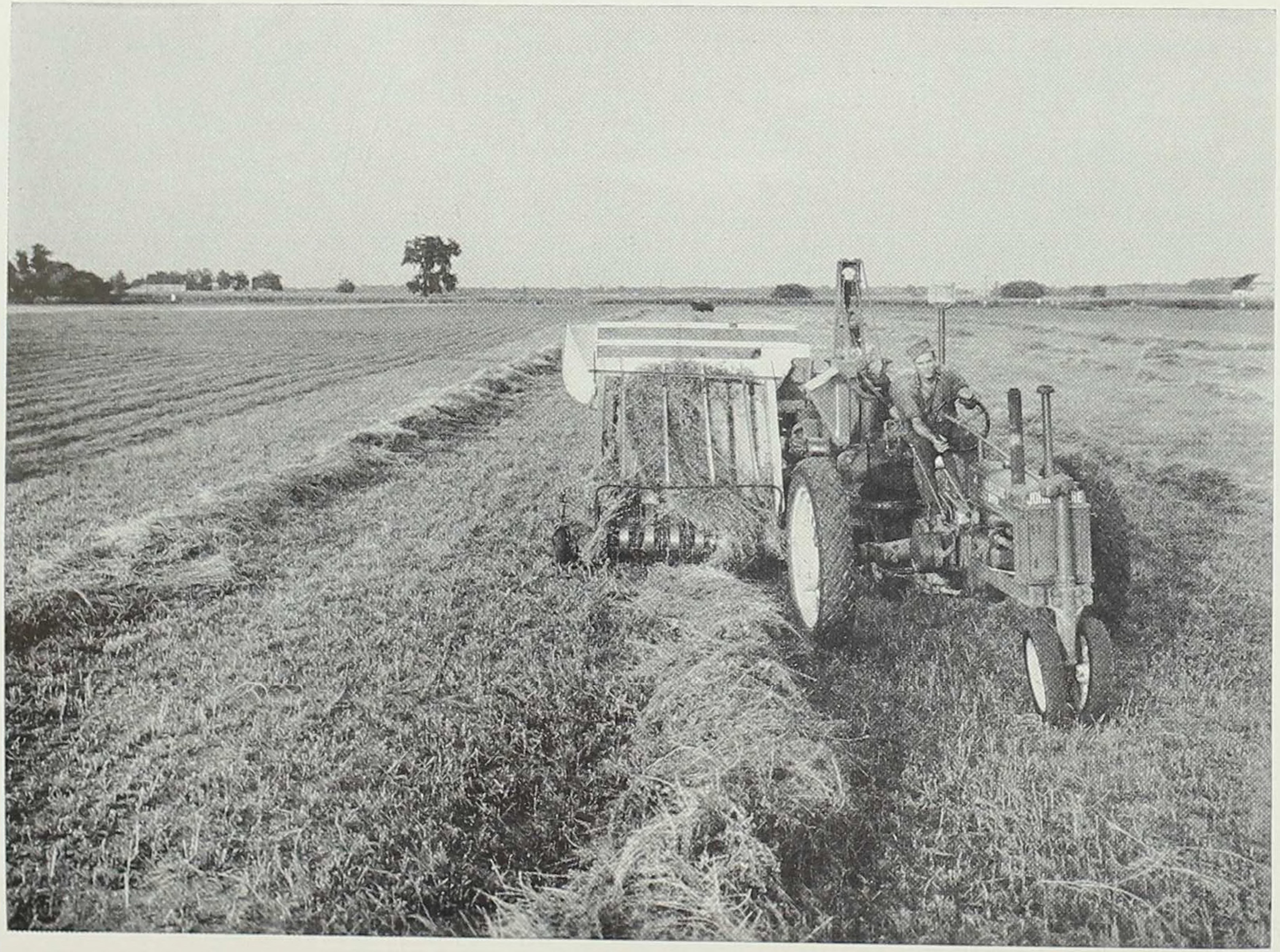


Photo by Deere.

A windrow pick-up field baler.

Oxen were used at a very early date to pull plows, as indicated by the diagrams on the most ancient monuments of Egypt, dating back as far as 3,000 years before the Christian era.

Some of the oldest records mention the plows of the time. The book of Job, believed by scholars to contain some of the earliest writings of the Old Testament, speaks of "the oxen plowing" and again it is stated that "Elisha was summoned from plowing to assume the role of the Hebrew prophet."

A description of the plow used by Cincinnatus and Cato is given by Virgil in the *Georgics*. This plow, although formed with pieces of wood and pointed with metal, did not have a moldboard for turning the furrow slice.

There is no record that the Pilgrims brought a plow with them when they came to America in 1620 although it was mentioned in the records of the colonies that they brought wheat and oats for seeding. The soil in the forest areas, which the Indians had cleared by burning, was loosened by hand tools, spades, mattocks, and hoes. The seed was broadcast by hand and covered with a crude harrow made of tree branches.

The Indians showed the Pilgrims how corn could be planted in beds of soil prepared with a rake. The production of grain was so low that the farmer could raise but little more than the requirements of his family. Later, plows were imported, and by 1637 there were thirty plows in the Massachusetts Bay Colony. It appears that the Pilgrims learned considerable about plow making during their stay in Holland on their way to America. This may have been responsible for the importation of the Dutch plow later.

The Dutch are credited with important improvements in the making of plows and appear to have made the first attempt to devise one which would turn a furrow slice rather than simply loosen the soil. To turn a furrow, provision for a landside to receive the side thrust of the moldboard was necessary.

The Dutch plows were sent to England and Scotland and underwent considerable improvement there. Rotherham, England, became the center of plow making and its name was given to the plows produced there. It is recorded that in 1720, Joseph Foljamke took out the first English patent on a plow with moldboard and landside sheathed with iron. The Rotherham plow continued in use without much change for several decades. George Washington imported a Rotherham plow to the United States and used it for many years, but it is recorded that when the plow needed repairs there were no skilled smiths available.

Another step ahead was the making of the share, moldboard, and landside all of iron. James Small of Scotland introduced such a plow, with the share made of wrought iron, and he continued to manufacture it for more than fifty years. In 1785 Robert Ransome of Ipswitch, England, introduced chilled iron shares which were harder than steel.

The historical records pertaining to the development and introduction of the all iron or steel plow indicate that, in spite of the fact that the improved implement performed superior work with the consumption of less power than that required by the clumsy wooden plow, it was not readily received by the farmers of the time.

In England in 1835 Sir Robert Peel presented a farmers' club with two of the most advanced types of iron plows. Some years later he visited the neighborhood and found, much to his amazement, that the new plows were idle and the old clumsy wooden ones still in use. Upon inquiry as to the reason, a member of the farmer group replied, "Sir, we tried the iron, and we are all of one mind that they made the weeds grow."

A similar story is related concerning the introduction of cast-iron plows in America. An improved plow, the first of its kind, was patented in 1797 by Charles Newbold of New Jersey. After spending a considerable sum furthering its introduction, he abandoned the attempt because the farmers of the time asserted that the iron plow poisoned the soil and prevented the growth of crops but stimulated the growth of weeds.

Thomas Jefferson became much interested in the improvement of the plow and prepared and presented a treatise on the proper form of the moldboard to the French Academy in about 1788 when he was the American ambassador to France. His interest in the plow was stimulated by watching farmers at work. The following entry was made in his diary while stopping for the night at Nancy, the capital of the duchy of Lorraine: "Oxen plow here with collars and hames. The awkward figure of their mould-boards leads one to consider what its form should be. The offices of the mould-board are to receive the sod after the share has cut under it, to raise it gradually and to reverse it." The entry was accompanied with sketches showing the form of the moldboard as Jefferson would have designed it.

Daniel Webster, the American statesman, was also interested in the improvement of the plow and had a very large and cumbersome model built after his plans. At one time Webster is reported to have said, "When I have hold of the handles of my big plow — and observe the clean mellowed surface of the plowed land, I feel more enthusiasm over my achievement than comes from my encounters in public life at Washington."

Jethro Wood of Scipio, New York, who received his first patent on a plow in September, 1819, is given credit for a very large contribution toward improving the form and shape of the plow. Although Wood's plow, through his continued effort to improve it, became a standard generally copied by plow manufacturers, he was unrewarded for his efforts and died a poor man with his family in want. William H. Seward said of Wood, "No man has benefited his country pecuniarily more than Jethro Wood and no man has been as inadequately rewarded."

In 1833, John Lane, a blacksmith of Chicago, made a plow with a wooden foundation but armored with steel strips cut from a saw blade. This plow proved to be eminently successful in the black loams. John Deere, of Grand Detour, Illinois, in 1837 was making plows in a similar manner using first saw blade steel and later specially rolled steel plate imported for the purpose. In 1847 Deere moved to Moline, Illinois, and established the first of the factories that now bear his name.

Some difficulty was experienced in using steel: if it was made as hard as desired it was brittle. In 1868 John Lane, a son of the blacksmith who made the steel plow of saw steel, was given a patent on soft-center steel. By welding two high carbon steel blocks on either side of a low carbon block, the welded block could be rolled into a plate with the hard steel on both surfaces. This soft-center steel plate could be heat-treated, making the surface very hard while the center remained tough and strong. Soft-center steel has been used continuously to the present in the manufacture of plows for the black soil of the Midwestern states.

With all of the early plows, the plowman walked behind the plow and guided it with one or two handles extending to the rear. In 1864, F. S. Davenport patented a "sulky" plow attached to a carriage on which the operator could ride. Many accessories and conveniences were added as the years passed such as colters, high lift, steering with a tongue, and interchangeable parts. Even in the midst of general enthusiasm for new machinery, however, some farmers held back and decided that riding plows and cultivators were for lazy farmers. Others promptly rose to defend the new machines, one farmer in Van Buren County stating that "having followed the plow for over thirty years" he would "just as soon ride as walk."

The disk plow has received much attention from inventors and designers seeking to reduce the draft of the plow. Two brothers, M. A. and I. N. Cravath, were among the first to secure patents on the disk plow. Although the disk plow has not come into general use, it has been especially adapted to hard or sticky soils which are not easily worked with a moldboard plow. A wide disk plow with disks mounted on a common shaft, known as a one-way or harrow plow, has been developed for the shallow cultivation of semi-arid land, but such a machine unfortunately has never been introduced in Asiatic countries.

Perhaps the latest important development in the plow has been the mounting of it directly on the tractor with a power operated lift and control. These mechanical controls relieve the operator of any strenuous effort in adjusting or raising the plow. This plow, controlled through "finger-tip" or "feather touch" levers, is very fascinating and appeals to the operator. These lifts and controls have become so popular that they have been adapted to many machines. Power lifts and controls are also provided for machines drawn behind the tractor.

The Harrow

Since the earliest times, it has been customary to complete the seed bed after plowing it with an implement to pulverize the soil and smooth the surface. The earliest harrows were made of branches of trees arranged to lie flat on the surface of the ground. Animals were used at a very early date to draw these harrows. Iron was used as early as available for making harrows. The twentieth chapter of Second Chronicles contains the following reference to harrows of iron: "He cut them with saws and with harrows of iron." Pliny, in 79 A. D., wrote, "After the seed is put into the ground, harrows with long teeth are drawn over it."

The harrows that took the place of tree branches had wooden frames and metal teeth or spikes. These have been succeeded by all-metal harrows with levers for varying the pitch of the teeth.

According to the patent office records, the spring tooth harrow was patented in 1869. This implement cultivated the soil deeper than the spike tooth harrow. In 1877 a harrow with sharp edged concave disks was patented and has become an implement of almost universal use. It has good penetration and does not clog in the stubble or crop residues left on the surface of the fields. A number of forms or types of rollers, pulverizers, and packers have been developed and used for reducing the clods and firming the soil.

Often it is desired to loosen soil without the inversion obtained with a plow. In fact, a system of crop growing known as "mulch culture" is based upon the premise that it is best to leave the crop residues, such as stubble, on the surface to aid in controlling loss of moisture and in reducing the erosive effects of surface run-off.

The Cultivator

Many crops, notably corn, require cultivation of the soil between the rows for loosening the soil to receive rain and for the control of weeds. The lighter hoes were formerly used for this purpose and in a sense the first cultivator was an enlarged hoe with two handles, one to which the animal was attached and the other held by the operator for steering the implement. The second step was to make a gang of two shovels, called the "double shovel," and the third was to attach two gangs to a cart forming a "straddle row" cultivator. The early single and double shovel cultivators were made by local blacksmiths, but the general form or type was quite well established.

In 1867, Blanchard's *Hand-Book of Iowa* described the planting of corn as follows:

> The ground is plowed in early spring, one team and a man plowing two and one half acres per day. Next, the field is laid out in rows four feet apart, one team marking four rows at once with a marking machine, which is a simple shaft or piece of joist, sixteen feet long, with four sled-runner shaped planks inserted in it four feet apart, and a tongue attached to hitch the horses to. The next process is to drive across these rows thus made with a corn planter. One man and team will plant ten acres per day. When the corn is well up in the blade the cultivating process is commenced by dragging or harrowing it. Two rows are gone over at once, the team straddling a row, and the harrow teeth so set as to stir the ground thoroughly each side of this row to the next row, each way. A sulky plow is sometimes used instead of a harrow. This is a gig-shaped machine on two wheels, with diamond shaped teeth projecting downwards from the axle. The driver rides on his seat and goes over the field two rows at a time, in the same manner as with the harrow. Next comes the cultivator, drawn by a single horse, going through one row at a time. After the corn has been gone through with the cultivator, it is generally ploughed through twice more with a shovel plough, and laid by till harvest. The corn is generally husked on the stalk, and stored in rough cribs made of rails built cob-house fashion, when it is ready for market.

When tractors were first available to the farmers they were not suited for the cultivation of intertilled crops. Important improvements in the design of the tractor for such crops was to provide clearance to pass over growing crops and the design of the cultivating machines for direct attachment to the tractor.

Seeders and Planters

Machines for seeding and planting crops developed slowly. This may have been due to the fact that seeding and planting can be carried out effectively with hand tools. Seed broadcast by hand can be covered with a harrow and larger seed can be placed in a soil pocket made and covered with a hoe.

Jethro Tull, of England, an ardent advocate of thorough tillage, wrote a treatise on the subject "Horse Hoeing Husbandry." He urged that grain should not be broadcast but planted in rows and cultivated. He devised a combination drill and cultivator.

An American patent was granted in 1799 to Eliakim Spooner but nothing came of his machine. M. and S. Pennock, of East Marboro, Pennsylvania, obtained a patent on a drill in 1841. The Pennock Brothers made their machine in considerable numbers. Agents in Iowa did everything possible to increase the use of wheat drills. In Mount Pleasant, Renchelor and O'Daniels were agents for the Pennock wheat drill in 1858 and offered to take as their pay "the increase over the common method of sowing, off of forty acres."

One of the essential requirements of a grain drill is to supply the seed evenly in the row. This led to the development of various styles of "force feeds" for metering out the seed. The early furrow openers were simply pointed tubes. Later the shoe was devised, which consisted of a long sloping curved blade spread and open at the rear through which the seed could be dropped. This type of furrow opener is universally adapted to corn planters. The sharp runners assisted in the making of straight rows. Now nearly all drills are supplied with single or double disk furrow openers because this type gives less trouble from clogging.

In 1839 D. S. Rockwell was granted a patent on a corn planter, which had many of the features of a modern machine. The number of kernels was metered out by a pocket or cell in a slide which passed under the seed box. The early machines were operated manually — the field being laid out with a cross-marker indicating where the hills should be placed. First a marker was added to help with the spacing of the rows, and the location of the hill in the row was determined by a wire having buttons spaced to locate the hill where desired. An improvement in accuracy was obtained with the "cumulative drop" or the use of single kernel cells in the seed plate for counting the kernels one at a time to form a hill of any desired number of kernels. With the coming of the tractor, corn planters were designed to plant two, four or more rows at a time.

The Harvester

The first tool devised for harvesting was the one-hand sickle. With this tool the standing grain is grasped with one hand and severed with the sickle held in the other hand. The sickle continued in use for many centuries without much change; in fact it is still used in some countries today. In the United States it was enlarged into a two-hand tool and provided with fingers for gathering the grain into an even bunch as it was cut. This hand tool, called the "cradle," easily doubled the capacity of the reaper. It is reported in the United States census for 1880 that the cradle came into general use in America during the last quarter of the eighteenth century.

A review of the work on reaping machines indicates that there were a number of machines made during the eighteenth century but none were made in sufficient quantity greatly to affect the harvesting task. In 1828 Patrick Bell, a minister of England, built a harvesting machine. The grain was cut with oscillating knives similar to scissors. A canvas apron carried the cut grain to one side, depositing it in a windrow. A reel was also provided for holding the grain against the cutter bar.

During the second quarter of the nineteenth century, when Iowa was being opened to settlement, there was a very active interest in harvesting machines. Two men stand out prominently in the development of the reaper — Obed Hussey of

Baltimore, who was granted a patent December 31, 1833, and Cyrus Hall McCormick, who received a patent June 21, 1834. Hussey's machine had a reciprocating sickle but no reel or outside divider. McCormick's machine had both but used a saw to cut the standing grain. At first the honors for inventing the reaper were equally divided, but as the years passed, McCormick received more and more recognition and Hussey dropped out of the manufacture. In 1878 McCormick was elected corresponding member of the French Academy of Science as "having done more for the cause of agriculture than any other living man."

In 1858 C. W. and W. W. Marsh of Illinois designed and built the Marsh harvester which provided an elevator for elevating the cut but unbound grain to a table where attendants, riding on the machine, could receive it and bind it into bundles. In 1870 the Marsh Harvester Company made over 1,000 machines. This company later became the Deering Harvester Company of Chicago. In 1870 George H. Spaulding invented the packer, a device for making a bundle. In 1869 John P. Appleby furnished the twine knotter which completed the self-binder.

The expense of reapers would have been a deterrent to their use, had it not been for the credit system. The big selling point of the reaper was that the farmer could pay for it out of his profits. Notes carried a 6 per cent interest charge and were payable, in the Corn Belt states, after "hog-killing time." At the agricultural fairs reapers "drew almost as large a crowd as the horse races." By the end of the sixties a wide assortment of "imported" agricultural implements was supplied to the farmers of Iowa by the merchants of the market towns. Of the reapers, Manny's and McCormick's were the most popular.

The old and the new carried on, side by side. While the scythe, the hoe, and the grain cradle were still used, the new reapers, mowers, threshers, cultivators, corn planters, and wheat drills were gaining in popularity. Many of these implements were manufactured in the east, particularly in Ohio and New York. Frontier localism opposed buying these "foreign" importations, however, and each new manufacturing plant in Iowa was greeted with an elaborate "puff" in the newspapers. Plows were manufactured in almost every town in Iowa, while a "very superior" reaper and mower was made by Rose and Harrington in Washington County. Patented tools of popular makes were also manufactured in various Iowa localities on a royalty basis, thus satisfying the desire to patronize local industries.

The Thresher

The original method of threshing grain was to beat the grain loose from the straw and chaff while spread on the threshing floor with a flail or by the treading of animals, or a roller drawn by oxen.

Threshing machines were developed in Scotland and England by Michael Menzies and Andrew Merkle, respectively. These machines simulated hand threshing in that there were flails driven by water power.

In the United States there were a number of patents granted on threshing apparatus, but to Hiram A. and John A. Pitts of Maine is given credit for designing and building a successful machine. In the twelfth census in 1900 it was reported that "the first noteworthy threshing or separating machine in the United States which was noticeable was that of Hiram A. and John A. Pitts of Windrop, Maine, and it is said to be the prototype of the machines used at the present time."

During the period while the reaper was under development, the header, which clipped only the heads to be elevated into a wagon, was proposed. Such a machine was patented by George Esterly of Wisconsin in 1844. Several combined harvester-threshers were made as early as 1846 by John Hiram Moore and his family, residents of Michigan. One of these machines was shipped to California in 1854 where it is said that 600 acres were harvested in that year. It was not until the years during and following World War I that the combined harvester-thresher was tried in the wheat area of the Middle Western states. It at once came into great favor. New varieties of grain have been developed, making such a machine more practicable. These varieties stand well and do not shatter when ripe.

Iowa farmers bought an increasing number of new machines until their investment in farm equipment at the present time exceeds by 40 per cent that of any other state. In early days farm machines were often not housed between periods of use but left exposed to the weather. For such neglect farmers were often criticized. The editor of the Osceola *Republican* complained in 1870:

> Pass through the county and it is no infrequent sight to see a costly mower on the prairie just where the farmer concluded that if we had a mild winter he had enough hay cut. It is true the "implement" will be handy to hitch to next haying but how long will it last exposed to sunshine, rain, or prairie fires, and is it paid for; other costly labor savers are remaining in the last ditch, others stacked against a breach in the fence, and so we might point out what we consider some of the causes why our farmers have long faces because of the low prices of pork.

J. BROWNLEE DAVIDSON

Influence of Farm Machinery

All careful observers and students of mechanization or the introduction of engineering techniques of agricultural production agree that it has been one of the most significant factors in the development and progress of agriculture in Iowa. These machines, and techniques for their use, have made the farm worker a larger producer and have thus advanced his economic position. He has a larger volume of product to trade for the commodities and services produced by others, which he cannot produce efficiently, if at all, for himself.

The influence of mechanization on the production of the individual worker is made clear by a study of the labor required to produce the crops that have been fully mechanized, like corn, wheat, or oats. It should be remembered that advance practice is usually much more efficient of labor expenditures than average practice, and the physical conditions such as topography and character of the soil determine the practicability of introducing machine methods. Data from the Iowa Agricultural Experiment Station report that corn has been produced with an expenditure of 3.88 man-hours per acre; thus in the case of a yield of 70 bushels per acre, the labor per bushel is less than

4 minutes. Furthermore, with favorable conditions it is entirely practicable for one worker to produce 6,000 or more bushels in a season.

In the wheat growing area the wheat production in the Great Plains in 1933 was 3.3 hours per acre. Since that time, still further advances have been made. It is now possible for one worker to grow 150 to 200 acres or to produce a total of 3,000 to 5,000 bushels in a year, in addition to other duties.

In Iowa, the second most important cereal crop is oats. The harvesting methods now used for oats are similar to those for harvesting wheat, except a more extensive use is made of the self-binder and the stationary threshing machine. Oat straw is valued by many farmers for feed and for bedding. Recently plant breeders have developed varieties of oats which may be allowed to ripen fully in the field without endangering the crop. When the combined harvester-thresher is used, the oat straw may be harvested with hay-making machines.

Soya beans have become the third most important field crop in Iowa. Here again the combined harvester-thresher is generally recognized as the most satisfactory and economical machine for harvesting this crop.

The introduction of machines has greatly improved the character of farm labor. With hand tools, farm work was more a matter of brawn than of brains. Work with hoes, sickles, scythes, forks, and other hand tools was necessarily slow and laborious. With hand implements, farm labor was looked upon as of the lowest grade. With farm machines, farm labor for the most part not only requires skill and intelligence, but it is also pleasant and fascinating. The economic and social status of the farm worker has been greatly advanced. The wages and working conditions of farm workers compare favorably with those in other vocations.

When hand tools were used, it was necessary to labor from early to late during the rush seasons of planting and harvesting. It was customary in New England to store the small grain crops in a barn where most of the winter was spent in threshing with the flail. When hand implements were used, the entire family, young and old, the women as well as the men, were needed to do the farm work. Now, in countries using machines, the services of women are not needed in the fields.

A smaller and smaller proportion of the workers has been needed to achieve the ever increasing agricultural production in the United States. In 1820, 83.1 per cent of the persons gainfully employed in the United States were engaged in agriculture. In 1840 the percentage had declined to 77.5 per cent; in 1870 to 47.4 per cent; in 1900 to 35.7 per cent; in 1930 to 21.5 per cent; and in 1949 the percentage is estimated at 15 per cent. No other change in American agriculture is so significant. It has been beneficial to all people and has strengthened our country economically and in resources of defense.

J. R. Dodge summarized the benefits of mechanized agriculture when he wrote, "As to the influence of farm machinery on farm labor, all intelligent expert observation declares it beneficial. It has relieved the laborer of much drudgery; made his work and hours of service shorter; stimulated his mental faculties; given an equilibrium of effort to mind and body; and made the laborer a more efficient worker, a broader man and a better citizen."

The question is often raised as to whether the use of engineering techniques in agriculture has just about run its course and whether changes will be less rapid in the future. There is no evidence or indication that this is the case. On the other hand, there are many influences which may justify the view that changes will be more rapid in the future than in the past. Labor continues to be high priced and farmers and farm workers are more mechanically minded than at any time in history. The manufacturers now have capable engineering departments which are effective in developing new and better equipment, which the prosperous Iowa farmer buys. Lastly, rural education has cultivated a desire on the part of farmers for a larger measure of well-being. This can be satisfied only by increased production per worker.

J. Brownlee Davidson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