Tillage Tools

These hundred years are an era in which the tillage tools that were drawn by animals came to be drawn by tractors, in which ideas changed as to the purposes and methods of plowing, and in which the country gentlemen’s studies of the plow, a mainstay for centuries, were supplemented by scientific and engineering achievements. The era began with the introduction of rotary power from the steam engine, which made possible the preparation of a seedbed in one operation. As an early writer, Chandos W. Hoskyns, argued: “It is not ploughing, it is not digging, it is not harrowing, raking, hoeing, rolling, scarifying, clod-crushing, scuffing, grubbing, ridging, casting, gathering, that we want: all these are the time honored, time bothersome means to a certain result. That result is—a seedbed.” With the exception of the disk, all of the time-honored tools, including the mole plow and the moldboardless plow, were in full use. The practice of chilling and hardening cast iron to maintain cutting edges and the use of segmented steel tools so worn parts could be replaced were common.

The development of tillage tools was tied with the expansion westward, for which more and faster and larger tools were needed and in which different soils, vegetation, and climates had to be considered. Years of plowing with the moldboard plow created soil conditions in the Great Plains that winds turned into duststorms. The moldboardless plow of old was revamped into the subsurface sweep that kept protective plant residues on the soil surface. Special tools to anchor the surface residues, bring erosion-resistant clods to the surface, and plant seeds beneath the stubble mulch helped stabilize the soil. In humid regions, new tools were developed to stop the losses from erosion—terracers, ditchers, and other tools to control water and tools that could handle the protective winter cover crops. Irrigation in the West led to new concepts in leveling land to control water and make cultivation easier. The influence was felt in the East, where field conditions were refined through the use of landplanes and rock pickers, the removal of fences, and the enlargement of fields. The growth of the Nation was not without harm to the soil. The compaction of the soil by machines created harder soils for the tillage tools to break up. Farmers came to realize that with machines they could overtill and damage soil, and tillage systems that did a minimum amount of soil manipulation were de-
In research on tillage tools at the National Tillage Machinery Laboratory, Auburn, Ala., electrical signal outputs from electrical resistance strain gages, generators, and transducers are combined mathematically with transistorized analog computers, and final results are plotted by X-Y recorders.

To develop better tillage tools, the cohesive strength of soil is measured by a tension test.
vised. The pressures of growth brought into cultivation lands that were subject to periodic flooding or had poor texture; special tillage tools to reclaim and alter the texture of such lands were developed.

Such was the history. Such was the background. Such was the importance: The plow that tills the soil so seeds can grow is the symbol of agriculture, and the plowman is the farmer. Farmers over the centuries perfected the sticks, crooked beams, and shares they used to turn the earth and make a seedbed. Beyond a certain point they could not go. They could not make the necessary force measurements, which require the special skills of scientists and engineers. So the Department of Agriculture built the National Tillage Machinery Laboratory at Auburn, Ala. Nine soil bins 20 feet wide and 250 feet long were completed there in 1935 and filled with soils whose physical properties ranged from high contents of sand to high contents of clay. Special machines were made to prepare the soils and to make force measurements on experimental tillage tools. The work now includes studies of tractor tires and crawler tracks.

The purpose of the laboratory is to study the basic principles of the design and use of tillage tools. Engineers and soil scientists measure the forces that tillage tools apply to the soil and the way they break up the soil in order to find ways to increase effectiveness and efficiency of tillage. The type of equipment they use is different from the farmer's equipment. They remove tillage tools from their implements so that they can study only the working parts by special apparatus. It is necessary to control the speed and position of tools in order to make accurate measurements. Instead of the farm fields, they use the special bins; the different soils in them permit a wide choice of stickiness, cloddiness, and hardness, and the men can carry on their studies throughout the year. Artificial soils of clay, sand, and oil mixtures often replace natural soils for special studies with model tools. Electronic sensing devices and computers measure and record the forces exerted on tillage tools. These quantities must be exact so they can be fitted into the mathematical equations that describe tillage tools and their operating conditions. The aim in all this is the rootbed and seedbed.

The engineers give attention to the need to eliminate unnecessary tillage. An example is an attempt to separate fine materials already present into a seedbed rather than to pulverize additional soil. A new machine separates the clods and fine soil into different rows and layers. Crops can be planted in the seedbed rows of fine material and no power is wasted in breaking up large clods, which help prevent erosion between the plant rows. The engineers also study the time-honored tillage systems, in which harrowing and later operations may undo the earlier work of plowing and subsoiling. Repeated trips by heavy machines compact large volumes of loose soils in some places. Machine designs, like low-pressure
tires, four-wheel drive tractors, and cultural practices, such as the so-called minimum tillage systems, are studied with the aim of preventing or minimizing compaction of soil. The engineers examine many new materials and designs for tillage tools to determine their suitability for increased effectiveness and efficiency. Studies of subsoilers have shown that the force required to pull tools with sloped shanks is much less than that for straight-shanked tools. Alternate methods of applying force to the soil by means of rotary, vibratory, or chemical means or compressed gases are investigated. It is likely that more tools will be powered directly from the engine, rather than pulled, so as to avoid power losses by slippage of tires.

A more intensive tillage system and consequently better tillage tools will be needed because of social and economic pressures in the future. The integrating of farm products into an industrialized processing network with scheduled delivery dates for products will make it necessary to till the soil under conditions once considered detrimental to the soil. The natural forces of climate that assist in the creation of tilth will become less important in some instances, and tilth may have to be created entirely by tillage tools. Four trends may develop. First, the construction of tillage tools may be by way of a scientific approach, in which designs are based on mathematical and physical principles; research data in this form can best be utilized by manufacturers, allied scientists, and farmers. Second, emphasis will be directed toward determining the best way to break up soil or to place it in a desired condition. The classical plow cannot be adjusted to varying soil requirements; its influence on the soil is unpredictable. It may be that the pulverization and movement of soil may be influenced by the size of cut and nature of tillage tools. When this is known precisely, the proper machine can be designed in terms of specific soil requirements. Third, the requirements of plants—soil tilth—will be studied more so that a minimum amount of time and energy will have to be expended in tillage. We have equipment to measure the force plants exert to emerge from the soil; better press wheels can be developed for planters to give the ideal firming conditions that different plants need for emergence. Fourth, we may have a new world of possibilities: Air vehicles that can hover above the ground and not compact the soil; atomic energy as a cheap source of power that can be used to grind up stones, level hills or mountains, and drive complex tillage machines; electronic systems that can guide tillage tools, test the condition of the soil, or control irrigation; materials, such as sintered carbides, may reduce wear on tools; plastics may be used to improve scouring; energy transmission systems, such as ultrasonic vibrations, may be used to loosen soil without tillage; electrical systems may be used to drain or heat soil or even melt snow to capture winter moisture. (W. R. Gill and A. W. Cooper)
A till-planter, developed by the Agricultural Engineering Department of the University of Nebraska, accomplishes tillage and planting in one trip over the field. Rows are planted in the same location each year. Research on equipment seeks ways to minimize tillage operations and traffic over fields.

Corn planted with the Nebraska till-planter without plowing. The till-plant system reduces cost and labor requirements, reduces soil compaction, increases the rate of water intake, and reduces the amount of volunteer corn in the rows over the conventional plow-harrow-plant system. Adjustment of equipment is more critical for till-plant than for conventional tillage.

New materials, such as Teflon, cause plows to scour better in sticky soils. Under some soil conditions, the force required to pull the plow has been reduced 25 percent. Other methods of accomplishing this may be the use of electro-osmosis or ultrasonic vibrations.
The use of models such as this disk accelerates the study of soil breakup. In this case, the soil is moved and the tool is stationary so that the action can be easily observed.

A plough used in the 1860's.

THE DOUBLE SHOVEL PLOUGH.