THE "ONE-WAY" DISK PLOW: 
ITS HISTORICAL DEVELOPMENT AND ECONOMIC ROLE

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Redacted Signature
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For the Department

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Figure 1. Official Photograph of the Angell "One-Way" Disk Plow
CHAPTER I

INTRODUCTION--THE "ONE-WAY" DISK FLOW

The Great Plains of the United States have become one of the largest and most productive agricultural regions in the world. To attain this position the region had to experience many changes. Such factors as the transfer of the public lands into private ownership, the settlement of the lands by waves of settlers, the development of the transportation and communication systems, the mechanization of agriculture, the introduction of new crop varieties and drought resistant strains, and the growth of domestic and foreign markets all contributed to the agricultural empire that now exists in the Great Plains.¹

I. STATEMENT OF THE PROBLEM

Before a complete understanding of all the forces that had a part in the transformation of the Great Plains is possible the individual changes need to be studied. The adaptation of the agricultural system is particularly important as the environment of the Plains presented to the settler

a structure that was radically different from that with which he was familiar. Many of the farming practices applicable to the forest environment were not satisfactory for the new environment. The settlers soon realized that if a permanent type of agriculture was to be established they were going to have to make adjustments.

One of the most important forces within the adaptation of the agricultural system was the invention and adoption of new farm machines. The Great Plains were settled in a time when there was already much accumulated knowledge of agriculture, technology, and power. This knowledge, when it was integrated with further developments and applied directly to the Great Plains, was able to speed the process of adaption along. The topography of the area is well adapted to the use of farm machinery on a much larger basis than was possible in the timber regions. The Great Plains was able to make use of the new developments in power quite rapidly. New implements were also being manufactured to utilize the new source of power. These implements were the result both of the ideas of the farm implement engineers and the skills developed by the farmers themselves. "In the use of existing machinery and the invention of new machinery the common man was doing more, much more, than selection, he was engaged in creative work in the best sense."2

The success of these machines depended upon the ability of the area to make practical and economical use of them, the ability of the market to absorb the increased production and the degree of success the machine had in fitting into the individual farmers organization. It was not until the period from 1915 to 1930 that the farms in the Great Plains reached any degree of full mechanization. Up to this time hand labor and horse power were a very significant part of farm production.

During this period large tracts of new land were brought into production. This was a result of the increased demand and high prices for foodstuffs during and immediately following World War I, and the improvements in motor power and farm implements. When the prices of farm products began to fall in the early 1920's and with the increased acreage that was now being farmed, it became evident that individual farmers were going to have to make adjustments. These adjustments resulted in a greater degree of mechanization, larger acreage per farm, larger investment, and a greater emphasis on managerial ability.

The increased use of machinery made possible better farming methods. Faster completion of farming operations, made farm work easier and raised the standard of living for

those who were able to make the adjustment. Acres handled per man-hour were increased, workers were released from agriculture, investment per acre in machinery rose and the use of power per acre went up. Leonard J. Fletcher states that if the energy used today is compared with that used in the early days of hand production by reducing the energy furnished by man, animals, and machines to equivalent man-hours of labor, "it is evident that there is not less, but actually more energy per acre being devoted to the growing of wheat today."4 This additional energy had made possible a reduction in the laboriousness of work. Man is now the director not the source of power. It has also made possible fewer hours of work per day and per year for the farmer, with the work of women and children being confined mostly to domestic tasks.5 "The real contribution that farm machinery has made is not alone reducing the amount of time actually spent in production, but how this time is spent in terms of human toil."6

Purpose of the study. The production of a seedbed is one of the most important aspects of Great Plains farming. During the 1920's a new tillage implement called the "One-Way" disk plow came into widespread use. The purpose of this


5 Ibid.

6 Ibid., p. 268.
paper is to put the invention and adoption of the "One-Way" disk plow into historical perspective. Moreover, this implement will be considered as a technological innovation which merits economic analysis in its impact on wheat production.

Scope of the problem. The adoption and use of this implement resulted from the fact that it was able to better meet the requirements of seedbed preparation in the Great Plains. The use of this tillage implement was just one of the many adjustments that was being made during the Twenties. Each one in its own way had an impact upon the total scene. The adoption of the tractor, harvesting machinery, and a changing concept of seedbed preparation all helped to make possible the rapid acceptance of the "One-Way" plow of the size and design Mr. Angell manufactured.

The "One-Way" disk plow that was adopted in the Great Plains was of the type that had been experimented with for many years. It will be argued that the implement invented and manufactured by Mr. C. J. Angell of Plains, Kansas, was the most successful one of the period, and, in effect, represented a technological innovation. His implement is shown in Figure 1. He constructed and manufactured this machine on his farm southeast of Plains from 1924 to 1926. After this, his plow was manufactured by the Ohio Cultivator Company of Bellevue, Ohio, with the other large manufacturers starting production of an almost identical implement in 1927.
The "One-Way," along with other advancements in the agricultural machinery used in the Great Plains, made possible a great increase in the productive capacity of the region. This tillage implement was one of many improvements in the technique of production which made possible a better adaptation to this particular geographic region. This implement should be looked upon as another step forward in this process and not as any final breakthrough. This study is limited to the early development and later use of the plow from 1924 to the late Forties.

The term, the Great Plains, is used by some to designate a very large area in the central United States and by others to represent the region known as the High Plains or the Plains proper. "The High Plains constitute the heart of what may be called the Great Plains and exemplify to the highest degree the features of a plane surface, a treeless region, and a sub-humid one." This area is where the "One-Way" had its greatest impact and is what is meant by this paper when the term the Great Plains is used. This region comprises approximately the western halves of Texas, Oklahoma, Kansas, Nebraska, North and South Dakota, and the eastern halves of Montana, Wyoming, Colorado, and New Mexico, and is known today as "The Great Wheat Belt." The "One-Way"

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disk has also been used in the Canadian Prairies, and in Australia. Mention will be made of these areas as they fit into the historical development and use of the "One-Way."

**Relation to innovation theory.** Technological change as represented by the introduction of the "One-Way" disk plow is an important force which has changed the agricultural production process. "Each specific innovation calls for the readjustments of resources within the farm while technical change in the aggregate calls for changes in the total amount of resources in agriculture relative to other industries."\(^3\) Innovation in some production function upsets the state of general equilibrium. Schumpeter defines an innovation simply as the setting up of a new production function.\(^9\) These changes are the result of the total preceding situation but are generally studied as internal forces operating in a given economy. Thus it is not a general theory of economic change.

Innovations may consist of new methods of production, new products, new firms, new markets, or the utilization of new sources of supply of raw materials or half-manufactured goods. These new forces are initiated by the entrepreneur, who is simply the "bearer of the mechanism of change." He is

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not a concrete factor of change but merely the method by
which change takes place.\textsuperscript{10} The carrying out of new combi-
nations is considered a special process which is not carried
out by all individuals, or "constitute neither a circular
process nor pendulum movements about a centre."\textsuperscript{11}

Inventions are important to the further development
of an economy, but until they are carried into practice they
have no direct bearing on the process of innovation. John
D. Black states that, "... to invent a new device, or de-
velop a new method, and then get it used, are two different
steps in human progress, oftentimes with a long lag between."\textsuperscript{12}

Gilfillan believes that:

The most striking trait of invention is evolution
—the great inventions are enormous and never ceasing
aggregations of countless inventions of detail, im-
provements whose weight and total worth contribute the
main value of invention. Just as agriculture consists
mostly of other work than sowing seed, so inventing is
almost all developing. Big starting ideas come cheap,
and are often duplicated; it is the vast labor of
development that is most worth while.\textsuperscript{13}

The entrepreneur plays a very important part in the process
whereby inventions become innovations.

\textsuperscript{10}Joseph A. Schumpeter, \textit{The Theory of Economic Develop-

\textsuperscript{11}\textit{Ibid.}, p. 53.

\textsuperscript{12}John D. Black, "Factors Conditioning Innovations in
Agriculture," \textit{Mechanical Engineering}, Vol. XXXI, No. 6 (March,

\textsuperscript{13}S. C. Gilfillan, "Invention as a Factor in Economic
History," \textit{Journal of Economic History}, (December, 1945, Sup-
plement V), p. 68
This study uses the above tools in analyzing the role of the "One-Way" disk plow in transforming the agricultural industry of the Great Plains region. Economic history is concerned with the problem of resource management by different economies over a relatively long period of time. "Economic history," wrote Usher, "is therefore intimately concerned with the explicit geographic environment, and with the techniques by which resources are utilized at any given moment."  

The physical features of any environment are only important in an economic sense as the society is able to make use of the physical features. The earth possesses all known and unknown resources, but they are available only to a society technically capable of utilizing them. "Agricultural resources are, therefore, determinate only in terms of some defined technology of production and transportation."  

New machines are economically important only to the extent that they expand and make possible better resource utilization. James C. Malin writes as follows concerning different geographic regions and man's success in adjusting to them:

The degree of success in the occupation by man of any of these land regions could be measured in terms of his ability to fit his culture into conformity with the requirements of maintaining rather than disrupting environmental equilibrium. The differences among the several regions did not represent deficiencies, rather

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15 Ibid., p. 5.
each difference represented an advantage useful to other regions by which they supplemented each other, and by which each made its own unique contribution to the world. If man found himself unable to cope with more than one of these several kinds of environment, it was man and not nature in that region that was deficient.

The ideas that help in the understanding of economic change will be used to better relate the role of the "One-Way" disk plow to the economic forces that prevailed during the period and to the requirements that the geographic environment imposed upon any new improvement.

Relation to economic efficiency analysis. The ideas of innovation analysis help to explain the process whereby innovations are introduced into the economy. Another aspect of the total effect of innovations is how they change the allocation of resources. Heady says:

Problems in economic progress are only special cases of economic efficiency analysis. Each new technique for the use of known resources (or each discovery of new resources) causes previous equilibrium or optimum allocations of resources to become obsolete and calls for readaptation of resources in line with their changed opportunities. In this sense economic progress, from whichever source it stems, is simply a continuum of production economics or resource efficiency analysis.

The tools of economic efficiency analysis help to explain the effect of any one technological innovation.

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17 Heady, op. cit., p. 794.
These technological improvements have two general properties. The first, development of a new production function such that a greater output of product is forthcoming from a given total input of resources, is illustrated in Figure 2.

![Figure 2. Effect of Development of New Production Function](image)

Production function I represents technological advance as compared to production function II, since with an input of resources of (say) OX, output is OF and OE respectively.¹⁸

In a purely physical and firm sense it is possible for an innovation to be either factor-saving, factor-using, or output-increasing. For agriculture most of the technical innovations have been of an output-increasing nature, "to the extent that they have lowered the average per unit cost of producing farm products," and have been factor using, "in the sense that the lower marginal costs have caused farm

¹⁸Ibid., p. 302.
firms to employ more resources (and also to increase output for the latter reason). Agriculture in the United States has seen a great advancement in output while input of all factors has not risen.

The second universal property of innovations in agriculture is this: the marginal physical rates of substitution (the elasticity of substitution) are always altered in favor of one factor by specific innovations. This property is illustrated geometrically by the iso-product contour of Figure 3.

![Iso-product Contour Showing Elasticity of Substitution of Factors of Production](image)

**Figure 3.** Iso-product Contour Showing Elasticity of Substitution of Factors of Production

For a given output of product the iso-product line representative of a new technique, F, will always have a greater slope in the direction of one factor than under the old technique, E.

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Thus a smaller quantity of one factor such as "capital" will be necessary to replace a given quantity of another factor such as "labor" after the innovation (in terms of a given product) has been introduced. The marginal physical and value productivity of "capital" has been increased relative to that of "labor." This characteristic is obvious for engineering innovations in which machines substitute for labor.  

Many times after a new process has proven itself farmers may be slow in adopting it. This will depend on the ease in which it can be incorporated into the farmer's practices. Some factors which effect this are the cost of the new process, uncertainty about the future, new managerial requirements, inadequate demand and low farm prices, and excess labor supply in some agricultural areas. "The process of innovation is particularly interesting to observe in agriculture because of its gradualness. One has a chance to observe it, as it were, in slow motion in agriculture." Such areas as the Great Plains have had a faster adoption of power machinery than other regions. Most of the crops were cash crops, a labor shortage existed, and the natural environment was well suited for extensive farming. "Thus, we find

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21 Ibid., p. 306.

22 Black, op. cit., p. 130.
large power equipment adopted most rapidly in areas with level or gently rolling topography and with large crop acreages per farm.23 Technological innovations have had a great impact on the Great Plains. These innovations have represented the area in which practices have been adapted to the region to a greater extent than any of the other institutions.

II. THE PRODUCTION OF A SEEDBED

The concept of tillage. Tillage is the practice of modifying the state of the soil in order to provide conditions as experience and research has shown to be favorable to crop growth. It is the most costly single item on the budget of an arable farmer and is a part of the business of farming which still contains some elements of being an art. Tillage practices vary widely from area to area as soil conditions, climate, crops, and the general object of tillage changes.

Plowing is usually recognized as the basic tillage operation. Culpin says that its essential feature:

Is that a layer of soil is separated from the underlying subsoil and is inverted, so that any vegetation or manure present on the surface is buried, and a layer of soil from below is brought to the surface, where it is exposed to the action of weathering agents and of other implements . . . 24


Plowing incorporating these features is accomplished mainly by the moldboard plow. As the objects of plowing have changed the word has come to have a much wider meaning. In some instances the surface of the soil needs to be left rough with a certain amount of stubble or heavy clods to prevent erosion or soil blowing. Both the burying of plant residues and the incorporation of them into the total soil structure have come to be known as plowing.

Plowing in the Great Plains is described by the second definition given above, which some feel should not be called plowing at all. Kraenzel in writing about the Great Plains says that:

Truly adapted dry-land farming today, on the Plains, is a "plowless" type of agriculture. Truly adapted dry-land farming has a new way for the plow. There is no word for this plowless operation other than the word "tillage."

What is this new way of the plow? What instruments are used? In place of the plow, the dry-land farmer uses the one-way, which is a disklike operation. The soil is not turned over as in plowing, but is simply disturbed. A substitute for the one-way are the lister, the gold-digger, or the duckfoot. These, too, do not turn the soil, but permit the stubble to remain on top of the soil in the form of trash—a protection against soil blowing, and an aid in moisture penetration.25

The "One-Way" disk has historically been called a plow when it has an action such as was described by Kraenzel. In the original meaning this implement is not a plow at all but more of a heavy cultivator.

The concept of plowing has come under sharp attack in recent years. "The moldboard plow," Faulkner wrote, "which is in use on farms throughout the civilized world, is the least satisfactory implement for the preparation of land for the production of crops."

He believed that everything the farmer was now plowing under should be incorporated into the soil structure. This method was supposed to follow closely the natural laws of nature. This plant material in a decayed form becomes a choice building material for later crops. Farmers must build up the supply of organic as well as inorganic substances in the soil. Faulkner believed that the moldboard plow did not return the organic matter to the soil in an effective way. The "One-Way" disk, as will be shown later, was able to meet this problem in the Great Plains for farmers that did not burn their stubble.

The "One-Way" as a tillage implement. The "One-Way" disk, pictured in Figure 1, consists of a series of disks spaced a fixed distance apart on a common axle or gang bolt. The axle with the vertically mounted disks rotates as a unit at an angle of 35 to 40 degrees to the line of travel. The entire unit is connected by bearing arms to the main frame. Three wheels support the main frame, each of which, in most types, has its own adjustable lever. One of the most important construction features of the vertical disk plow is the

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provision made for absorbing the end thrust of the disk gang. The end thrust, which is heavy in this type of plow, is usually taken by a single antifriction thrust bearing or by a well constructed plain thrust bearing. The most common size of the implement is the ten-foot. The units can be hooked together if a larger plowing implement is needed.

The "One-Way" is used both as a primary and a secondary tillage implement. As a primary implement it is used to work the stubble into the soil during the first and second plowings. For this operation the "One-Way" works the soil to a depth of around four inches. When the plow is used as a secondary implement a wider width is pulled. The soil is cultivated to a depth of two inches or less. The "One-Way" thus performs both these operations and eliminates the need for additional tillage implements except when conditions call for a special implement to meet emergency blowing conditions or to break a light crust right before drilling.
HISTORICAL PERSPECTIVE

The history of agriculture in the Great Plains is the history of the adaptation of the farming methods and cultural complexes of a humid, forest type of agriculture to the radically changed environment of the Plains area. Settlers who were not able to make the adaptation, for a wide variety of reasons, either moved back to the east or on farther west. As more and more was learned about the environment and about the forces that molded the Plains area, men were able to develop new machines, production methods, and crop varieties. These along with advancements such as the development of new means of communication and transportation, made possible a relatively stable agricultural society.

Webb believes that the Great Plains environment constituted a "geographic unity whose influences have been so powerful as to put a characteristic mark upon everything that survives within its borders."27 The process of adaptation utilized two main forces, that of creative work and that of the process of selection. The two working together produced a somewhat continual stream of new processes.

Farming in this area took a great deal of managerial ability and it was not surprising to see one man make a success while a neighbor would soon move on. "Except in the best years, the critical margin of tolerance is so small in Plains agriculture only those possessing both the skills and the managerial ability can have a reasonable safe chance of success." The failure to recognize that the Plains demanded a new combination of resources for man’s survival led many settlers into disaster. "In reviewing man’s adaptations to environment the most conspicuous act that stands out is the wide disparity between the best knowledge of what should be done and the common practices." In the development and use of machinery the process was slow and rather erratic at times. A stage of rapid growth was never reached until the introduction of the mechanical power unit for agricultural use.

The following sections of this chapter relate first the structure of the soil. The soil of the Great Plains has its own characteristics which influence the farming of the area. The different soil forming factors are important to the structure of agriculture and are a part of the forces that influence soil productivity. The maintenance of soil productivity in the Plains also presents its own problems. The next section concerns adaptation to the subhumid climate. It will


29 Ibid., p. 59.
look at the early settlement, the culture of dry-farming and the developments in tillage implements until the time of the "One-Way" disk. All these developments will be pointed out as they relate to the specific problems of the Great Plains.

I. SOIL STRUCTURE

Soil forming factors. The structure of the soil is very important in the relation of tillage implements to Great Plains agriculture. Soil science now recognizes the soil as "a physical system" not a natural body, and as an open system that might be added to or subtracted from. Every soil has its own element of organization.

Soil has been found to be a very complex system possessing a great number of properties. Jenny lists five independent variables or soil-forming factors which he thinks define the soil system. For a given combination of these factors only one type of soil exists. The five factors are: (1) climate, (2) organisms, (3) topography, (4) parent material, and (5) time.30 The first three are related to environment. These factors may act independently or enter into functional relationships among themselves. Soil is considered as a dynamic system but not one that is living since it has no power of reproduction and no heredity.31 Unlike

31 Ibid., p. 266.
organisms, soil properties are solely determined by the soil-forming factors.

Some of these soil forming factors present unique characteristics that help make the Great Plains region different from other areas in the United States. Rainfall is a part of the climatic structure that is important since from the point of view of the forestman it is deficient. The rainfall at times is very uncertain and in some years there will be plenty of rain, while in others drought may destroy all farming efforts. It is these extremes that influence the farming methods of the High Plains more than the averages. These extremes offer, "No known clues to suggest when they will occur in the future and no reason to believe that a rather irregular sequence will not occur indefinitely."\(^3\)

The hundredth meridian represents approximately a twenty inch rainfall line. Precipitation in Kansas runs from 16-18 inches on the extreme western border to 24-26 inches at the ninety-eighth meridian.

This amount of rainfall means that this region, in its own natural equilibrium, is not deficient in rainfall but that this area must employ different methods of crop production as compared to those followed in wetter regions. Distribution of rainfall is also important for the production of crops. In

\(^3\) Leo H. Hoover, *Kansas Agriculture after 100 Years*, Kansas State College of Agriculture and Applied Science, Agricultural Experiment Station, Bulletin 392 (Manhattan, August, 1957), p. 9.
the High Plains rainfall starts in April reaching a maximum in May or June, and reverting to the minimum in November and December. This means that drought-resistant crops which matured early and quickly were necessary. Also tillage methods which conserved moisture by preventing its evaporation and by destroying the weeds had to be developed.

Wind is another climatic factor in the High Plains. "On the whole, the wind blows harder and more constantly on the Plains than it does in any other portion of the United States, save on the seashore." Winds move a great amount of soil in the High Plains particularly during the early spring and the drier years. The hot winds that blow in the summer cause evaporation to become a serious problem and can be a real menace to the areas where corn is grown, and also to the areas where the final stages of seedbed preparation are taking place for the drilling of winter wheat.

The topography and the parent materials also play a big part. The topography is relatively flat with no large obstructions of any kind to break the free play of the winds. Stream deposits had the greatest influence in the formation of the topography. Webb in his study states that:

The surface of the Great Plains, as it appears today, is mantled by a debris apron composed of the material brought by the "swinging rivers" down from the mountains, or, to put it another way, the Great Plains (that is, the level surface) were created by

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33Webb, op. cit., p. 21.
the wearing down of the mountains and the spreading of the debris as a foot-slope.\textsuperscript{34}

This idea is still considered accurate but it has been shown that during the Pleistocene the material probably was eroded away and redeposited. This mantle of soil varies from a few feet at the base of the mountains to 500 feet. The Great Plains consists then of a deep footage of potential topsoil that can be developed without waiting for the rock to decompose as is the case for the Eastern section of this country.\textsuperscript{35}

\textbf{Maintenance of soil productivity.} Soil productivity as compared to soil fertility includes the actions of men. The maintenance of soil productivity is a constant problem for farmers everywhere. On the Plains the problem is one of keeping the soil from blowing, from being eroded by the heavy rainstorms, and from deteriorating through the loss of plant material.

Soil conservation is very important in the Plains region. Even though it does not take as long to produce a new top soil as in the East, it still is quite a loss to have the top soil blown away. Many farmers were able to stop their fields from blowing during the Thirties and also to

\textsuperscript{34}Ibid., p. 11.

\textsuperscript{35}For studies of the other soil forming factors see James C. Malin, \textit{The Grasslands of North America Prolegomena to Its History with Addenda} (Lawrence, published by the author, 1961), Chapters 2, 3 and 7; Walter Prescott Webb, \textit{The Great Plains}, (New York: Grosset and Dunlap, by arrangement with Ginn and Company, 1931), Chapter 2, Part 3.
collect top soil blown from other fields. Today these fields are some of the most productive in the country. One man's loss was another's gain. Malin states that, "Sand and dust are moved by the wind from place to place, but the net loss is negligible, and probably not greater than formerly—that is, prior to occupation by Americans within the century." 36

The propaganda connected with the drought of the Thirties left many people with erroneous ideas about the causes of wind erosion, and dust storms. Man needs to improve his farming methods in order to better adapt to the conditions of the High Plains. The farmers who practiced good methods, did not burn their stubble through the Twenties, and also used emergency tillage methods when the blowing started were able to a great extent to control the blowing. A soil that was lacking in plant residue and then went through the drouth years without the addition of any more plant material had deteriorated so much that control of blowing was practically impossible. "The only remedy was the restoration of moisture, and of organic matter to the soil, when the weather changed to a wet phase." 37

Tillage methods need to be practiced which conserve moisture, keep the soil in a condition that resists blowing

37 Ibid., p. 134.
and erosion, and maintains long-run fertility and productivity of the soil. The type of tillage implements used and the distinct way in which it is used, in different areas in response to different conditions, have a definite effect upon the structure of the soil.

Such implements as the "One-Way," the duckfoot cultivator and subsurface tillage tools made the system known as stubble mulching a recognized practice. It has been found that a mulch of plant material is more effective than a mulch of pulverized soil. This mulch prevents blowing, incorporates plant material into the soil structure, and allows more rain to be absorbed by the soil. The "One-Way" was the first implement to be used on a large scale that practiced the principles of stubble mulching. Much work needs to be done before a complete understanding of the soil is possible. Soil is in a continual process of change. Man has to be able to influence this change and be able to adapt to future natural changes.

II. ADAPTATION TO SUBHUMID ENVIRONMENT

Early settlement. For the first half of the nineteenth century, and even until after the Civil War, there existed in the public mind a Great American Desert to the east of the Rocky Mountains. This concept grew out of the reports sent back by such men as Captain Meriwether Lewis and William Clark, Zebulan M. Pike, Major Stephen H. Long,
and Captain Randolph B. March. This idea was not overcome until settlers moved into the area and even then many years elapsed before the impression was proven false.

The transition from the forest to the prairies was not as extreme as the jump from the forest to the plains. Many settlers came directly from the East while the ones who came from the prairies in most cases had only been settled there a few years. Settlers were moving into the fringes of the area as early as the 1850's. The first major steps in winter wheat production in Kansas were taken between the years 1855 and 1860. Farmers soon began moving into the Northern Great Plains; by the Sixties, farmers in the Red River District were making notable progress. The early years were filled with such hardships as drought, insects, and the failure of many of the common farming practices inherited from the background of farming in humid areas. All these contributed to sporadic crop yields. The farmers soon realized that new methods would have to be developed.

The soft winter wheat boom in the upper Kansas Valley from about 1872-1882 witnessed many new or changed practices. "A new hard wheat had been introduced from Eastern Europe, new varieties of sorghums had been imported from Asia and

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38 Webb, op. cit., p. 21.
Africa, alfalfa had made its appearance, and new tillage, harvesting and milling machinery, was gaining widespread acceptance. Tillage implements were composed mainly of the walking and sulky moldboard plows, spiketooth harrow and the disk harrow. All the implements were pulled by horses and required many hours of hard labor. The moldboard soon converted into the gang moldboard which had from two to four bottoms. Figure 4 shows such an implement. This made it possible to cover a larger area more easily.

Malin considers the lister as the first significant new tillage tool introduced into the Prairie-Plains region. The lister was a double plow with a divided moldboard, splitting the slice and turning half each way. This implement was used first for corn and later for winter wheat. "The superiority of lister preparation of wheat ground lay first in the speed with which the operations could be performed." Lister type machines soon became used for tillage and seeding. One type that was developed for use with power machinery is shown in Figure 5.

The beginnings were hard and the toll was heavy. For those who stayed the future lay with the production of power machinery, high prices, and improvement in the rainfall pattern.

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42 Ibid., p. 245.
Figure 4. Two-bottom Gang Moldboard Plows Pulled by Four Horse Teams
Figure 5. Lister--Pulled by a "Big 4" Tractor
Dry-farming culture. In the Great Plains the ideas about soil culture and farm methods came to be known as the "Dry-Farming System." This system had many followers and encompassed many different ideas. Many farmers had been using the main concepts before they became popularized. The propaganda movement that went along with the formalization of the soil culture was aimed at spreading correct practices and also at getting settlers to move into the area.

Dry-farming in a broad sense is the profitable production of crops without irrigation on land where the natural rainfall is 20 inches or less. Dry-farming concepts seem to have developed independently in Utah, Washington, California, and the Great Plains. In the public mind Hardy Webster Campbell came to be identified with the dry-farming movement. In 1879 Campbell entered a homestead in Brown County, Dakota Territory. He experienced both good and poor crops. His crop failures induced him to investigate and see just what could be done. In 1895 Campbell's *Soil Culture and Farm Journal* was published. He went on to publish his *Soil Culture Manual* beginning in 1902. For his procedural theory Campbell relied on the works of E. W. Hilgard of the California Agricultural Experiment Station, and F. H. King,

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44 Hargreaves, op. cit., p. 85.
Willet M. Hays and Milton Whitney of the Minnesota Experiment Station.45

The essential features of the system changed as the ideas became more widespread and as more investigations were carried out. In 1907 Widstoe summarized the practices as follows:

The storage of water in the soil is imperative for the production of crops in dry years. This may be accomplished by proper tillage. Disk the land immediately after harvest; follow as soon as possible with the plow; follow the plow with the subsurface packer; and follow the packer with the smoothing harrow. Disk the land again as early as possible in the spring and stir the soil deeply and carefully after every rain. Sow thinly in the fall with a drill. If the grain is too thick in the spring, harrow it out. To make sure of a crop, the land should be "summer tilled," which means that clean summer fallow should be practiced every other year, or as often as may be necessary.46

The tillage measures were designed to store the moisture in the soil, until it was needed by the plants and to stop the evaporation of soil-moisture during the growing season. Soil moisture was drawn to the surface by capillary action. The moisture moved from particle to particle and the closer the particles the greater the number of points of contact. To stop this action a loose top layer of soil called a soil mulch was advocated. This was to break the points of contact with the top and subsoil.

46 Widtsoe, op. cit., p. 363.
Another type of mulch, a plant mulch, was mentioned as a possibility even though it was not practical on a large scale. This artificial mulching of the soil was not practical because of the large area and because tools were not available which would effectively carry out the operation. It was noted that plowing the straw into the soil caused it to decompose quite readily which was contrary to popular notion. Since the soil was now more porous much evaporation could be prevented. This practice was supposed to make the topsoil rich in organic matter and increase the fertility of the land. Widtsoe stated that it was better to scatter the straw over the land if it could not be fed than to burn it as was often done. Many farmers did not learn the value of this even after such implements as the "One-Way" and subsurface tools were developed. With the new tools it was faster, less expensive, and easier to incorporate the stubble into the soil than it was to burn the stubble and use the older tillage implements.

Campbell was more often criticized for the weak points of his system than praised for his constructive contributions. He emphasized the timeliness of tillage, the importance of weed destruction and the need for machinery that was adapted to the special requirements of his dry-farming culture.

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48 Widtsoe, op. cit., p. 156.
emphasis on excessive tillage which tended to break up the soil structure and entailed excessive costs was probably his weakest point.\(^{49}\) E. C. Chilcott of the South Dakota Experiment Station was a later writer and scientist who worked on the principles of dry-land agriculture. His main contribution came from his emphasis on lowering the cost of production. He wrote, "Lessening the cost of production without proportionally lessening yields should therefore be given first consideration. In other words, extensive rather than intensive systems of farming, should be followed."\(^{50}\) Malin believes that both men failed to recognize the disc plow as a factor in dry-land farming.\(^{51}\) The above ideas about dry-farming were held by the most progressive farmers at the time the "One-Way" disk was introduced.

Tillage implements—later developments. As new power units were made available to the Great Plains, tillage implements underwent changes in order to utilize the increased power. This power took the form of steam units such as shown in Figure 6 around 1900 and of large gas tractors

\(^{49}\)Malin, The Grassland of North America, Prolegomena to Its History with Addenda, op. cit., p. 250.


Figure 6. Two Sections of Disk Gang Plows—Pulled by a Steam Tractor
around 1910-1912. Figure 7 shows an early gas tractor. This new power was used by many farmers, but on the whole, power machinery did not become commonplace until the Twenties when more compact and better constructed gas tractors came into use.

For those who still used horses the riding gang moldboard was the most popular. A report on grain farming in North Dakota from 1912 to 1914 showed that most farmers used the moldboard plow of the riding type with two bottoms, pulled by four horses. The gang moldboard, shown in Figure 4, cut two furrows of 12 to 14 inches each; the most common gang was the twenty-eight inch. This gang plow drawn by five good horses could turn five to six acres in a day. A study of farm organization in central Kansas for the years 1920 to 1922 showed that the stubble land was practically all plowed or listed for wheat. An average of 82 per cent of the acreage on the farms included was plowed. The farms having the lowest man-labor requirements for plowing with horses used two-bottom gangs.

For those who were making use of the new power units' new plows were being developed utilizing the same principles.

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Figure 7. Five Sections of Two-bottom Moldboard Gang Plows—Pulled by a "Big 4" Tractor
Figure 8. Series of Small Tanden Disks--Pulled by a "Big 4" Tractor
as the horse drawn implements but on a much larger scale. The two bottom moldboards could be used by hooking several of them together as shown in Figure 6. Here five sections are being pulled by a Big Four tractor. This was not altogether satisfactory as the draft was so great that an efficient footage was not obtainable. The sections were hard to operate as a unit and the plows forced the power unit to operate at a speed no faster than horses would go. To overcome the clumsiness of the separate units, moldboard engine gangs were developed. The engine gang had all the plow bottoms attached to a main frame. With the advent of steam-lift machinery, plows were made with several gangs of four to six bottoms hung on a single frame. The average cut of moldboard plows in the Northwest was ascertained to be 11.18 feet with the theoretical daily capacity about 38 acres but with the average being 22.9 acres.  

In the Southwest the disk plow became popular for use with traction plowing. Ellis and Rumely estimated that four-fifths of the traction outfits included the disk engine gangs. Two different sizes are shown in Figure 7. It was possible to cover more ground with a given expenditure of time and power than with moldboard plows. Figure 7 shows plows of this type

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being pulled by a steam tractor. These plows contained anywhere from one to sixteen large disks which were connected to a single frame by individual arms. The disks were tilted as the purpose was to duplicate the action of the moldboard in turning over the furrow slice. The five to seven disk gangs proved the most successful. These plows had an average cut of 13.2 feet and theoretically could plow about 45 acres with the daily average being 25.7 acres.  

Plowing with power units and the enlarged gangs greatly increased the speed of tillage practices. Ellis and Rumely state, however, that the tractioneer should remember:

That the plows of today are designed to run at the speed a horse will maintain, namely, two miles an hour or less . . . . Until experience has proved that a higher speed is advantageous, and plowmakers have met the need with new plow shapes, the majority of tractors will be adapted to a plowing speed about equal to that of horses.  

Though the ideal engine gang plow had not yet been developed, these writers said that such a plow should be, "compact, strong, durable, simple, easily manipulated, cheap, light of draft, and above all efficient." The tractor's success was dependent on the development of more suitable machinery and on the progressiveness of manufacturers in other lines.

56 Ellis, op. cit., pp. 21-22.
57 Ellis and Rumely, op. cit., pp. 248-249.
58 Ibid., p. 167.
Edward A. Bumely, writing in 1910, believed that the plow of that day, perfect for the use of a single man, was no longer adequate.

We not only need ploughs that will break up rapidly and well the great fertile plains of the new Northwest and Southwest. There are the broad areas of the less productive lands that need not only efficient management and systematic organization, but cheaper ploughing than any yet known. 59

Summer fallowing was being practiced on a larger scale and machinery was needed that would destroy the weeds at a low cost. Also harvesting machinery had reached the stage where the harvesting of the crop was no longer the limiting factor in the number of acres that could be farmed effectively.

In effect harvesting has been speeded up till it is no longer the biggest job on the farm. The biggest job is now the preparation of the land for seeding and the operation of seeding. Plowing is now regarded by many farmers as an intolerably slow job. Hence the search for ways and means of accomplishing the plow's work without actually plowing. 60

The above discussion thus underlines the wide gulf between technology and power on the one hand, and tillage instruments and practice on the other. It will be seen that the "One-Way" disk plow went far towards closing this gap.

CHAPTER III

DEVELOPMENT OF THE DISK PLOW

I. INVENTORS OF DISK PLOW

The main use of the disk plow in the United States has been for specific tillage jobs for use in special areas. The disk concept has also been used very successfully for secondary tillage implements, such as the disk harrow. "The disc plow was produced through the efforts of inventors to reduce the draft due to the sliding friction on the moldboard." Early disk plows were designed to imitate the soil action of the moldboard plow. The disks were large and slanted so that the furrow slice would turn over. In 1907 Davidson said that there was nothing to be gained from the use of the disk plow in areas where the moldboard plow would do a good job. Disk plows were to be used where the soil was sticky or in ground that was hard and could not be worked with the moldboard plow.

According to R. C. Ingersoll, the first disk plow recorded in the United States Patent Office was in 1847. This


62 Ibid., p. 392.
was by George Page, Washington, D. C., who patented a revolving moldboard for the plow. "Page's idea seems to have been to utilize the principle of rolling friction to turn a furrow, the pressure of the earth causing the disk moldboard to revolve on its pivot and turn the soil." 63

In 1856 and 1858 B. C. Hoyt, of Wisconsin, patented a "rotary cultivator plow of the disk moldboard type but had another disk bolted to cutting disk with teeth, which would turn in the furrow and cause the moldboard disk to rotate." 64 J. S. Godfrey of Michigan, in 1868 made a gang plow of the concave type with revolving scrapers. These three patents cover the origin of the revolving disk moldboard type of plow.

The first patent on a purely disk plow was granted to M. A. and I. M. Cravath, of Bloomington, Illinois, in 1867. "The plow consisted of three discs cutting very narrow strips, . . . but did not have sufficient means of relieving the side pressure." 65 On June 11, 1872, E. T. Bussell, of Indianapolis, Indiana, received patent no. 127,677 for a "knifed-edged rim instead of a solid disk, which rim was supported by a hub with spokes . . . . It will there be noted that he did not

64 Ibid.
contemplate turning the soil completely as does the regular moldboard plow."  

The practical form of the disk plow began to take shape when John K. Underwood, of Sauk Centre, Minnesota, was issued patent number 169,499 on November 2, 1885. This was for a disk plow which now had two wheels to support the plow frame. He later modified this construction so that the follow wheel acted as a guide wheel in the previously cut furrow. Milton Hancock of Shreveport, Louisiana, received patent number 463,047 on November 10, 1891, for a rotary plow. This plow was similar to the improved Underwood but had a greater influence in stimulating the development of the disk plow. Underwood made one plow that he used in an experiment to test his idea that the disk should have an angle of 45 degrees and be set vertical. After being discarded for many years by Underwood, this plow was hunted out of the scrap pile and used by Deere and Company, the La Cross Plow Company and several others as evidence against the Hancock patents in the famous suit that occurred about 1893.  

With the advent of steam power the disk plow began to become more popular and take on the construction as shown in Figure 7. Patents issued later for improvements on the disk plow included one to E. C. Atkins and N. H. Roberts, patent  

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66 Ingersoll, op. cit., p. 172.  
67 Ibid., p. 172.  
68 Ibid., p. 172.
number 543,113, July 23, 1895, for a rotary plow. This plow had a three point frame with a slanted furrow wheel supporting four disks each mounted on individual arms. On April 4, 1905, C. R. Davis of South Bend, Indiana, an assignor for the Oliver Chilled Plow Works received patent number 786,427 for a disk plow. This plow had a three point frame and supported two disks each on individual arms. The land and furrow wheels each had an adjustable lever by which the frame could be raised or lowered. Another patent of the same type was obtained by W. G. Danielson of Logan, Utah, on July 25, 1905, patent number 795,430. Improvements from then on did not involve changes in basic design.

II. EARLY CONCEPTS OF "ONE-WAY" TYPE DISK PLOWS

Implements similar in structure to what Charlie J. Angell later called the "One-Way" disk plow probably started with E. T. Bussell who invented a plow that did not turn the soil as completely as the regular moldboard. On July 7, 1896 G. Spalding and J. S. Robbins of Stockton, California, received patent number 563,514 for a rotary disk plow. This plow had two wheels which supported a triangular frame. The frame was set at an angle to the line of draft. Connected to the frame by very short arms were 15 disks. The next change was made in Australia where the plow works of H. V. McKay made disk plows for use in plowing new lands not yet cleared of stumps, heavy roots, and other obstacles. These machines were called stump-jump plows. Each disk was attached to an
arm that would spring upwards if an object was hit. McKay's stump-jump moldboard plow was known as the "Sunprince." His stump-jump disk machine, built around 1906-1907 was called the "Sunrise." McKay constructed a disk cultivating plough in 1909 called the "Suntwin." This plow was closer in construction to the later "One-Ways" than were his stump-jump plows.

Another Australian, J. Grant, received a patent in the United States on May 14, 1907, patent number 853,510, for a disk cultivator. This machine had a three point frame with two adjustable levers. Connected to the frame was a shaft set at an angle to the line of draft on which were set 12 disks. The frame was of light construction as the machine was intended for use with horses. As far as is known, Grant's machine was never manufactured.

Newell Sanders of Chattanooga, Tennessee, a larger manufacturer of disk plows, received patent number 831,190 on September 18, 1906, for a disk plow. The plow had three wheels which supported the frame on which were attached 12 disks. Sanders never got away from the concept of turning the

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furrow over. Sanders relates a story of how the concept of setting the disk vertical, as was the case for earlier disk plows, was changed:

Many of the disk plows after the time of Underwood were fastened to a wooden frame and used in a practical way plowing Texas land. The wood would wear away due to the extreme pressure, which would allow the disk to slope back instead of standing vertical, which would prevent it from working properly. The farmer would drive wedges in the wood to bring it back to its normal position. Unintentionally one farmer drove the wedges in at an angle and it was found that the plow did much better work that way. A study of angles was then made and the present angles were developed.\textsuperscript{71}

There were probably many unrecorded or unpatented attempts to modify the disk plow. All over the semi-arid country farmers were experimenting with their equipment. Most of the experiments involved the rebuilding of older machines. One such attempt was made by Bradford Cox of Plainview, Texas. His efforts came out in the trial of the Angell patent. Cox modified a Sanders disk plow by making some structural changes and adding additional parts. The result was a machine that resembled the "One-Way" disk plow. This was done in the summer of 1921. The machine never did perform properly and was soon abandoned. It lay in a field on the Cox farm for five years until Cox's experiment came out in the patent trial. Many parts had been removed and there was much confusion as to what the original machine had been like.

\textsuperscript{71}Ingersoll, \textit{op. cit.}, p. 173.
Another experiment was the subject of an article that appeared in the *Kansas Farmer*, March 2, 1946. Here it was stated that Jerry D. Golliher of Plains, Kansas, designed and built the first one-way plow in the United States in 1922. This plow had a timber frame with 24 small disks. It also said that:

Mr. Golliher built only one plow but his neighbor, C. J. Angell, an aggressive master mechanic as well as a master wheat grower, saw great possibilities for its widespread adaptation. He arranged for its manufacture on his farm, where he erected a large shop and improved on the sturdiness and design of the machine . . . .

As stated before, the essential features of the one-way plow, which Golliher designed and Angell perfected, have not been changed.72

The main statements of this article were later reprinted in several Kansas newspapers.73 The source of information or the author of the article is not known but several statements of the story were proven to be in error. Mr. Golliher sent a letter to the *Kansas Farmer* which was printed in the May 4, 1946 issue. Mr. Golliher said:

I am sure the story about the "One-Way" plow in your March 2, 1946, issue leaves the wrong impression among farmers. The plow that I built had nothing to do with Mr. Angell's plow. He built his own plow and

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73 One such article appeared in *The Hutchinson News-Herald*, March 26, 1946. A later article relating much the same information was: Bill Bork, "One-Way Plow Born in Western Kansas," *The Hutchinson News-Herald*, May 21, 1950. This article was published after such statements were found to be in error and were corrected in *The Kansas Farmer*, May 4, 1946, p. 16.
it was he who gave it the name, "One-Way." That name is so well known that farmers call all plows of this type by that name, even though the letters on it say something else. And I am sure all farmers know that if Mr. Angell hadn't built several hundred of these plows we might not have any of them today.

Mr. Angell was one of the most progressive wheat farmers Kansas ever produced. He was using farming methods 30 years ago that we know now to be the best.

I would like you to find room to correct this wrong impression, for Mr. Angell was one of my best friends and I sure do not want any credit due him, after he has been dead almost 20 years.

J. D. Golliher, Plains

Also in the same issue was a letter by Francis Angell, son of Charlie J. Angell, of which the following extract is quoted:

... I am submitting to you the following article or statement which I have prepared which clears up the misstatements in the article appearing in your paper under date of March 2, 1946, in so far as my father is concerned....

It is implied in this article that my father, C. J. Angell, deceased, perfected a plow designed by Jerry Golliher. I feel that an injustice has been done my father in the minds of the readers, and I hope the following facts will clear this misunderstanding.

My father, C. J. Angell, was a man of genius and originality as well as a practical farmer, with an extensive knowledge of soils and their treatment.

Therefore, realizing the need for a new-type implement for preparing the seedbed and the idea which he had conceived from the Hapgood seeder, my father started work on the Angell "One-Way Disc" plow with a new principle consisting of placing a set of extra strong discs in an entirely new-type frame....

He drew up his own plans, made his own pattern for the castings, and proceeded to construct the plow from his original idea with no help or without borrowing any ideas from his neighbor, Jerry Golliher.

The name which my father gave to this plow which he invented was, Angell "One-Way Disc" Plow, which was also an original name and was later copyrighted . . . .

Therefore, I claim my father, C. J. Angell, invented, perfected and gave name to the first "One-Way Disc" plow.

Francis Angell, Plains

None of the above-mentioned machines, except for those of McKay and Angell, were ever manufactured and thus had no economic significance even though they were important from the standpoint of historical development. They never helped bring about a new production function for the raising of wheat. The real breakthrough came when Charlie J. Angell invented and constructed his plow. We shall see that Mr. Angell was not only an inventor but also an innovator. His tillage machine, which came into widespread use in Great Plains wheat production, was indeed an innovation of major significance.

III. ANGELL "ONE-WAY DISK PLOW

Charlie John Angell of Plains, Kansas, invented and constructed the Angell "One-Way" Disk Plow during 1923 and 1924. Mr. Angell developed his mechanical skill and


76Mr. Angell's given name was Charlie not Charles as it has appeared in some writings.
knowledge of wheat production from his many years of experience as a Kansas wheat producer. All through his lifetime Mr. Angell was known as a progressive farmer who was always experimenting with and making economical use of new production methods.

Mr. Angell, who was known either as C. J. or Charlie, moved to Missouri with his parents, Emily Jane and Americus Vespucius Angell, from Yadkin County, North Carolina, in the fall of 1884. Charlie was two years old at the time, his birth date being February 27, 1882. The journey was made by train and took three days and nights. The family lived on a rented farm in Jackson County, Missouri, for 18 months. The land on west seemed to offer better opportunities so the family set out in a covered wagon on March 15, 1886. Hutchinson, Kansas, was their goal. But upon reaching there the land in Meade County was said to be the best still available. They arrived in Meade County April 9, 1886, and paid $100 to a local real estate man for locating them on a claim. A pre-emption was entered on this quarter.

By the time Charlie was 16 he already showed promise of becoming a successful enterpriser.

77 I am indebted to Mrs. Christie Angell Linville, Salina, Kansas for the data of this early history which appeared in her paper, "The Angells of Meade County, Kansas," in 1935. She is the daughter of Charlie John Angell.
Like most of the pioneers he [Americus Vespucius Angell] depended for fuel upon the "chips" of the prairie, and all the fires were fed with this fuel until his son Charles [Charlie] attained the dignity of sixteen years and flatly refused to pick any more chips. After that the family depended upon other fuel, and that bit of rebellion on the part of the son has been a fact from which to date other items of history in the family career.\textsuperscript{78}

Soon after this Charlie insisted that the family obtain more land, give up cattle altogether and buy a second-hand threshing machine. Four hundred dollars was paid for such a machine. He and his father then turned to custom threshing. Charlie's mechanical ability contributed to the success of this venture. Charlie had always been interested in machinery and had his own workshop from the age of 12. "For his own amusement and to the worry of his mother, Charlie would take his mother's sewing machine apart, piece by piece, and then accurately replace every part with the result that the old machine ran like new after his overhauling."\textsuperscript{79} Charlie also became skilled in carpentry, making furniture such as a roll-top desk, and a radio cabinet.

In the fall of 1900 the family returned to North Carolina, for a short visit where Charlie met his future wife, Miss Mamie Davis. They were married May 25, 1901. Charlie


\textsuperscript{79}Christie Doris Angell Linville, "The Angells of Meade County, Kansas," Article written for the Native Daughters Chapter, Salina, Kansas (October 15, 1935), Typed, p. 5.
homesteaded land in Meade County in 1904. About the same time he and his father bought a steam engine and several disk gang plows. In 1912 Charlie and his brother, Eddie Meade Angell, bought a four-cylinder ("Big 4") gas tractor. The two brothers were also the local agents for this tractor. In one of their advertisements it was stated that the tractor plowed 100 acres at Minneola, Kansas, with a ten-bottom John Deere moldboard plow in 33 hours on 130 gallons of gasoline. That year the brothers farmed about 960 acres.

All through these years Charlie became quite skilled as a mechanic. "C. J. read almost everything he could get hold of to read; this varied from light fiction to the heaviest of technical treatises on scientific subjects." Charlie never completed high school. He was able to use an engineer's drawing set and draft his own blueprints. Hobbies such as cars and photography also interested him. The pictures contained in this thesis were all taken by him. Charlie's first car he bought second-hand soon after he was married and used it to drive prospective land buyers of the

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30 This engine and plows are shown in Figure 6.
31 This tractor is shown in Figure 7.
Charlie started work on the actual building of a new disk plow in the fall of 1923. The ideas for the plow were in the process of development for many years. His first idea may have come from an old Hapgood seeder he had seen which had a seeder box set on an arrangement of disks. These disks were on a shaft that was set at an angle to the line of draft. Charlie modified some old disk plows he had but never had any real success. He then decided to draw up the patterns and built a new plow of the type he was experimenting with. This was done and in the spring of 1924 the first machine, shown in Figure 9, was completed. Charlie made his own patterns for the castings and cut the steel for the frame to meet his specifications. The plow was tried out on ground that was still hard from the winter freezes. Not being satisfied with the performance of the plow, Charlie dismantled the machine and rebuilt it. This new machine with very few changes became the final model as pictured in Figure 10. This plow was named by Mr. Angell as the "Angell One-Way Disc Plow."

Charlie started using the plow successfully and soon built another one for his brother, Addie. In the fall of 1924, eight plows were made and sold to neighbors. The demand soon became so great that Mr. Angell established a
Figure 9. First Angell "One-Way" Disk Plow
Figure 10. Ten-Foot Angell "One-Way" Disk Plow
production line on his farm and hired several workers. During 1925 fifty-six "One-Way" plows were manufactured.

News of the successful performance of the Angell plow spread widely. In fact, several implement companies contacted Mr. Angell and came to Plains to see plowing demonstrations. In December, 1925 representatives of the Case Threshing Machine Company visited the Angell farm.

For a time it appeared that Dodge City, Kansas would get the Angell plow works. On January 23, 1926 an article entitled "New Industry for Dodge City" appeared in The Dodge City Daily Globe. The article told of plans to establish a plow factory there as well as information about Mr. Angell and the plow. This was largely propaganda on the part of the Dodge City interests, as Mr. Angell had no plans to move at this time. Mr. Angell did demonstrate his plow for the Southwest Tractor and Implement Company, who had a contract

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84 See Figures 11 and 12 for pictures of the Charlie Angell farm during manufacture of the plow. Figure 11 shows the steel frames while Figure 12 shows stacks of wheels and spools.

85 The Plains Journal, December 24, 1925.

86 The first known recorded reference to the Angell plow appeared in The Dodge City Daily Globe, June 15, 1925. Unfortunately the files of The Plains Journal from 1920 to July, 1925, are not known to be in existence. Other articles not mentioned in the text appeared in The Dodge City Daily Globe on July 24, 1926; February 25, 1927; August 1, 1927; August 2, 1927; August 4, 1927.

87 The Plains Journal, February 4, 1926.
Figure 11. The Angell Farm During Production of the Angell "One-Way" Disk Plow
Figure 12. The Angell Farm During Production of the Angell "One-Way" Disk Plow
to sell the Angell plow. One demonstration which attracted about 100 farmers was held on the farm of Hays Bealmear near Dodge City.

Meanwhile Mr. Angell continued his own manufacturing operations. By June 1, 1926, when he had sold 310 machines, The Hutchinson News recorded:

Angell's factory is mostly out in the open. A visitor today at the Angell farm would see heaps of steel rods, stacks of metal discs, piles of castings -- the rods shipped in from a steel works at Pueblo; the castings from a foundry at Hutchinson; the discs from a plant somewhere else. In the building between his large residence and barn is Angell's machine shop. There may be found lathes, punches, and machinery of every kind needed in turning, rolling, punching, and working up the steel rods and sheet steel into the finished product of his disc plow. All the millwork on the plows is done here in this shop.

Soon after this Mr. Angell leased his farm land and decided to move his plow works to Dodge City. Here he would find a better distribution center, and also be better located to receive iron and steel shipments from Colorado. The Plains Journal wrote: "It is to be regretted that this manufacturing establishment is to be moved from the vicinity of Plains, as it is one of the things that serves to keep it in the public eye."

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88 The Dodge City Daily Globe, February 11, 1926.
89 The Hutchinson News, June 1, 1926.
90 The Plains Journal, June 24, 1926. Charlie and his brother, Eddie, were featured in an article that appeared in The Kansas City Star, June 18, 1926. Their farming practices, acreage, and yields were mentioned but nothing about the plow.
Before the move to Dodge City could be carried out the Ohio Cultivator Company of Bellevue, Ohio, offered to buy the right to manufacture the plow. Other companies had made less attractive offers. The Ohio Cultivator Company offered to pay $25 for every plow manufactured up to a maximum of 3,000. This represented a total of $75,000. Furthermore, the Ohio Company offered a one per cent royalty payment on the wholesale price of all plows produced in excess of 3,000. Mr. Angell accepted this offer. With his son, Francis, he went to Bellevue, Ohio, and signed the contract on July 10, 1926. Mr. Angell agreed to cease production after unfilled orders were met. Altogether, 363 plows were manufactured in 1926, which brought the total, since the beginning of operations, to approximately 477.

Soon after this, other plow companies began manufacturing "One-Way" disk type plows. These implements were called by many different names since the Ohio Cultivator Company had received a copyright on the name "Angell" and "One-Way Disc." A few companies started to call their machine a "One-Way" disk but changed when the copyright was issued. A dealer for the La Crosse Plow Company, La Crosse, Wisconsin, had a plow advertised in September, 1926, called a one-way disc plow. The Sanders Plow Company of Chattanooga, Tennessee, announced that

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91 The Plains Journal, July 15, 1926.
92 The Dodge City Daily Globe, September 16, 1926.
they were going to make a disc-plow harrow.  

Mr. Angell and The Ohio Cultivator Company ran a series of advertisements in the *Kansas City Weekly Star* and 20 other Kansas farm papers warning farmers that these other machines were not the Angell plow and to beware of the other plows that were being offered as "Angell Plows" or "Just As Good."  


The Angell Plow was being advertised in many newspapers and also in *Dun's International Review*. An article about Mr. Angell appeared in the September, 1927 issue.

On June 15, 1927, Charlie J. Angell and The Ohio Cultivator Company filed a bill of complaint against Emanuel Milberger, a machinery dealer for the J. I. Case Threshing Machine Company, for damages and also to stop the Case Company from selling their Grand Detour Wheatland Disc Plow. The J. I. Case Threshing Machine Company assumed the defense for Emanuel Milberger.

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93 *The Plains Journal*, November 11, 1926.

94 This advertisement appeared in *The Plains Journal*, December 23, 1926.

95 *The Dodge City Daily Globe*, February 25, 1927.

96 The first advertisement appeared in the July, 1927 issue. Articles about "One-Way" disk plows appeared in the August, 1927; March, 1928; November, 1928; and December, 1928 issues of *Dun's International Review*. 
Between the time the complaints were filed and the case came up in court, Charlie J. Angell was electrocuted accidentally in the basement of his new home. This was a severe blow to the Angell family and to The Ohio Cultivator Company. Mr. Angell's testimony was going to be missed as he was the one most familiar with the workings of his plow and with all the transactions that had been carried on with the patent office and with the other machinery companies. The family and The Ohio Cultivator Company went ahead with the suit. The case was held in the District Court of the United States, for the District of Kansas, First Division, during May of 1928. The court was located in Topeka, Kansas.

The plaintiffs argued that Mr. Angell had invented a patentable machine. Moreover, it was argued that a valid patent had been issued by the patent commissioner, patent number 1,615,499. The patent was first filed for on March 29, 1924 and the patent was issued January 25, 1927, on an amended application filed May 11, 1926. The claims of the original application had to be amended as the patent office disallowed some of the claims on grounds of prior art. After the claims

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were amended the patent was issued. This patent covered the plow as a total machine; not just the individual parts. The plaintiffs stated that the machine as a whole was new and that the seedbed it produced could not be made by any other machine. They wrote:

Where as here, a machine produces a new product, a product which stands out boldly as something new and valuable, then a legal presumption arises that such a machine, having produced this new product, one no other machine ever produced, is necessarily a new machine.

The plaintiffs then argued that the J. I. Case Threshing Machine Company had infringed upon the rights of the Angell patent, held by the Angell family, and the rights to produce the plow, held by The Ohio Cultivator Company. The Case plow was said to include all the essential features of the Angell plow. The Case Company was also supposed to have begun manufacture of their "One-Way" disk plow after they had seen and copied the Angell plow.

The defendants did not argue that they had not infringed upon the rights of the Angell patent, because if the patent was valid that was clear, but that the Angell patent was not valid. Prior patents were presented to substantiate this point.

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98 Mr. Angell had received before this time several patents on certain features of the plow. He had one in particular on his end thrust bearing. A Canadian patent had also been received, February 16, 1926, on the plow as a whole. This was reported in The Plains Journal, March 11, 1926, where a letter from Mr. Angell’s patent attorney in Washington, D. C., Watson, E. Coleman, was reprinted.

99 "Brief and Digest of Evidence for the Plaintiffs," Toulmin and Toulmin, Jr., Counsel for Plaintiffs, p. 3.
The defendants stated that the state of the prior art was such that this machine was not patentable. The judge wrote in his statements of fact the basis on which the case would be judged:

If the patent is valid, the infringement of the defendant is clear. The Superintendent of the J. I. Case Threshing Machine Company testified that there was no essential difference between the plaintiff and defendant's plow... The infringement is aggravated by the fact that the Case Company, learning of the Angell plow, induced Mr. Angell to ship his plow to the Company plant in Illinois, there examined it and copied it, and then declined to enter into a license contract with him, and thereafter put the same plow on the market under another name. The only question in this action is whether the plaintiff has a valid patent.100

The judge said this about Mr. Angell and the plow:

The value and practicability of the plaintiff's plow is attested by sales of nearly a half million dollars in the 16 months preceding the trial; and by the number of imitators who followed it successfully in the market.101

Angell, probably without any actual knowledge of the art, struck upon the idea of making the old one-way disc-harrow or cultivator a little heavier, with larger discs, arranging the wheels to accommodate the greater swerving in heavier going, put in an end thrust bearing to take up the side-thrust of the discs, built a plow, tried it out, and it worked. He had a better seedbed than that made by the old method, because the surface was not pulverized and wouldn't blow away; there were no air-pockets in the soil; and the stubble could be prepared for seeding by going over the field once or twice with a plow of a ten-foot, instead of a 16-inch,


101 Ibid., p. 2.
cut. Since a moldboard plow must be followed by a disc or harrow, it really did away with the expense of plowing.102

After all the testimony was in, the opinion of the court was that the nature of the prior art was such that the Angell plow was not patentable. The Grant Cultivator patented by a citizen of Australia, was the main evidence used to defeat the Angell patent. The other two items of importance mentioned were the McKay disc cultivator and the Cox plow.

Even though the complaint was turned down, nothing was taken away from the fact that Mr. Angell made his implement, utilizing only his knowledge of the machines he had worked with and his originality. Mr. Angell's plow was not of crude construction but was a complete and finished implement that was basically different from any tillage implement that had ever been presented to the Great Plains' wheat producer. Mr. Angell, after making his plow, manufactured and sold it to farmers of the area. In this sense he was an entrepreneur, a bearer of the mechanism of change. The Case Company in their summary of the case did give Mr. Angell credit as being an entrepreneur. They wrote:

It is not and cannot be denied that the one-way disk plow as manufactured under the Angell patent and by several of the largest implement manufacturers in

102 "Memorandum Opinion on the Merits," In the District Court of the United States, First Division, In Equity No. 833-N, Signed by George T. McDermitt, U. S. Judge, pp. 2-3.
this country, has had a marked success in certain parts of the country and particularly in the wheat growing sections. Neither this fact, however, nor the fact that Angell may have been the first in this country to exploit and create a favorable demand for a one-way disk plow, can prove the patentable character of such a plow.

While, therefore, Angell may be entitled to much credit for creating familiarity with the advantages of the old one-way disk plow and for enlisting the interest of a large corporation in its exploitation, this cannot entitle him to monopolize a structure that was otherwise old.

Mr. Angell was able to lead the way to a new combination of the resources of production. This was done within the total structure of the economy. Improvements in a large number of fields were necessary before this innovation was possible. It also represented the many trials and failures of men in the past who attempted to make improvements in such machinery.

The death of Mr. Angell stopped him from completing a new grain drill that he had been constructing. His decision to sell the rights to manufacture the "One-Way" plow was influenced by his desire to perfect this drill. The drill was later completed by his son, Francis, and used by him for many years to drill wheat. The all-steel drill was V-shaped and has never been manufactured. It is probably not patentable since such patents on farm machinery often

have been defeated by large implement manufacturers. Mr. Angell acquired the skill of mechanical invention and was able to put this skill to work helping to solve the problems of wheat production in the Great Plains.
CHAPTER IV

"ONE-WAY" DISK PLOW—ECONOMIC ROLE

The "One-Way" disk plow was first sold in large numbers starting late in 1926. Farmers in the Great Plains were modernizing their farms at a fast pace during the 1920's. Many farmers were buying tractors for the first time. Harvesting equipment became more widespread and there was the need for a better and more efficient way to prepare a seedbed. The first "One-Ways" made by Mr. Angell were sold in western Kansas, Oklahoma, and Texas. When the "One-Way" was manufactured on a large scale it was available for use in all of the Great Plains states and even in the Canadian Prairies.

To have a significant economic impact the number of "One-Ways" used would have to be large enough so that they could be considered to be in widespread use. Table 1 shows that through 1930 there were approximately 57,460 "One-Way" disk plows manufactured in the United States; through 1940 there were 133,104 manufactured with 113,771 being shipped domestically and 17,044 shipped to foreign countries. Of the Canadian wheatlands one author writes:

In 1944 a survey indicated 85,000 one-way discs in the prairie provinces, and subsequent sales are estimated to have increased the total to some 135,000 or
### TABLE 1

**ONE-WAY DISK PLOWS MANUFACTURED IN THE UNITED STATES, NUMBER SHIPPED—DOMESTIC AND FOREIGN**

<table>
<thead>
<tr>
<th>Year Manufactured</th>
<th>Domestic Shipment</th>
<th>Foreign Shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1924(^a)</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>1925</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>1926</td>
<td>363</td>
<td>363</td>
</tr>
<tr>
<td>1927(^b)</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>1928(^c)</td>
<td>9,735</td>
<td>9,735?</td>
</tr>
<tr>
<td>1929</td>
<td>22,992</td>
<td>15,724</td>
</tr>
<tr>
<td>1930</td>
<td>21,306</td>
<td>14,541</td>
</tr>
<tr>
<td>1931</td>
<td>7,085</td>
<td>7,019</td>
</tr>
<tr>
<td>1932(^d)</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>1933</td>
<td>n.d.</td>
<td>2,440</td>
</tr>
<tr>
<td>1934</td>
<td>n.d.</td>
<td>4,700</td>
</tr>
<tr>
<td>1935</td>
<td>6,980</td>
<td>5,980</td>
</tr>
<tr>
<td>1936</td>
<td>9,651</td>
<td>8,814</td>
</tr>
<tr>
<td>1937</td>
<td>15,027</td>
<td>13,585</td>
</tr>
<tr>
<td>1938</td>
<td>13,245</td>
<td>9,962</td>
</tr>
<tr>
<td>1939</td>
<td>9,408</td>
<td>8,153</td>
</tr>
<tr>
<td>1940</td>
<td>14,148</td>
<td>11,721</td>
</tr>
<tr>
<td>1941</td>
<td>17,074</td>
<td>15,251</td>
</tr>
<tr>
<td>1942-1945</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>1946</td>
<td>11,572</td>
<td>9,772</td>
</tr>
<tr>
<td>1947</td>
<td>16,572</td>
<td>15,251</td>
</tr>
<tr>
<td>1948</td>
<td>27,713</td>
<td>24,340</td>
</tr>
<tr>
<td>1949</td>
<td>13,663</td>
<td>12,371</td>
</tr>
<tr>
<td>1950</td>
<td>14,642</td>
<td>10,399</td>
</tr>
</tbody>
</table>

\(^a\) 1924-1926 Charlie J. Angell

\(^b\) 1927 Ohio Cultivator Company


n.d. Data not available
equal to nearly 50 per cent of farms over 100 acres. Approximately one-third of the one-way discs in farms are equipped with seeding attachments, and there is every indication that the number of one-way discs in use will continue to increase.104

In a 1947 study by Scoville and Hodges of costs on wheat farms in Western Kansas, the principal tillage implements were moldboard plows, one-ways, and listers.105 Table 2 shows the frequency of use. In Lane County 90 per cent of the farms studied used the "One-Way" with other implements but without the moldboard plow or lister. In Thomas County 74 per cent used the "One-Way" and in Pawnee County, located on the edge of the wheatbelt, 11 per cent used the "One-Way" in the above manner. This was on summer-fallowed ground. On ground that was not summer fallowed, 94 per cent of Lane County, 96 per cent of Thomas County, and 46 per cent of Pawnee County farms used "One-Ways" without either the moldboard plow or the lister. Table 3 which is taken from the same study shows the typical operations in wheat production for the 1947 crop. The "One Way" was used at least twice for both continuous cropped and summer-fallow land in all three counties.


TABLE 2
FREQUENCY OF USE OF MAJOR TILLAGE IMPLEMENTS IN SEEDBED PREPARATION FOR WHEAT. CROP HARVESTED IN 1946

<table>
<thead>
<tr>
<th>Major Tillage Implement</th>
<th>Fields Reported</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fields</td>
<td>Pawnee</td>
<td>Lane</td>
<td>Thomas</td>
<td>Counties</td>
</tr>
<tr>
<td>Summer-fallowed fields:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moldboard plow (with other implements)</td>
<td>32 71</td>
<td>4 10</td>
<td>17 21</td>
<td>53 32</td>
<td></td>
</tr>
<tr>
<td>One-way disk (with other implements but without moldboard plow or lister)</td>
<td>5 11</td>
<td>35 90</td>
<td>59 74</td>
<td>99 60</td>
<td></td>
</tr>
<tr>
<td>Lister (with other implements)</td>
<td>6 13</td>
<td>-- --</td>
<td>-- --</td>
<td>6 4</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2 5</td>
<td>-- --</td>
<td>-4 5</td>
<td>6 4</td>
<td></td>
</tr>
<tr>
<td>TOTAL, all methods</td>
<td>45 100</td>
<td>39 100</td>
<td>80 100</td>
<td>164 100</td>
<td></td>
</tr>
<tr>
<td>Fields not planted on summer fallow:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moldboard plow (with other implements)</td>
<td>53 40</td>
<td>1 3</td>
<td>1 2</td>
<td>55 26</td>
<td></td>
</tr>
<tr>
<td>One-way disk (with other implements but without moldboard plow or lister)</td>
<td>61 46</td>
<td>32 94</td>
<td>44 96</td>
<td>137 64</td>
<td></td>
</tr>
<tr>
<td>Lister (with other implements)</td>
<td>10 7</td>
<td>-- --</td>
<td>-- --</td>
<td>10 5</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>10 7</td>
<td>1 3</td>
<td>1 2</td>
<td>12 5</td>
<td></td>
</tr>
<tr>
<td>TOTAL, all methods</td>
<td>134 100</td>
<td>34 100</td>
<td>46 100</td>
<td>214 100</td>
<td></td>
</tr>
</tbody>
</table>

*Medium-size commercial wheat farms.
+Summer-fallow operations included.

### TABLE 3

**TYPICAL OPERATIONS IN WHEAT PRODUCTION, 1947 CROP**

<table>
<thead>
<tr>
<th>County</th>
<th>Continuous Cropping</th>
<th>Fallow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pawnee</td>
<td>one-way, twice</td>
<td>moldboard plow</td>
</tr>
<tr>
<td></td>
<td>spike harrow</td>
<td>springtooth, twice</td>
</tr>
<tr>
<td></td>
<td>drill</td>
<td>one-way, twice</td>
</tr>
<tr>
<td></td>
<td>combine</td>
<td>drill</td>
</tr>
<tr>
<td></td>
<td>haul²</td>
<td>combine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>haul²</td>
</tr>
<tr>
<td>Lane</td>
<td>one-way, twice</td>
<td>one-way, four times</td>
</tr>
<tr>
<td></td>
<td>drill</td>
<td>springtooth</td>
</tr>
<tr>
<td></td>
<td>combine</td>
<td>drill</td>
</tr>
<tr>
<td></td>
<td>haul²</td>
<td>combine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>haul²</td>
</tr>
<tr>
<td>Thomas</td>
<td>one-way, twice</td>
<td>one-way, twice</td>
</tr>
<tr>
<td></td>
<td>drill</td>
<td>duckfoot, twice</td>
</tr>
<tr>
<td></td>
<td>combine</td>
<td>rodweed</td>
</tr>
<tr>
<td></td>
<td>haul²</td>
<td>drill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>combine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>haul²</td>
</tr>
</tbody>
</table>

*Order in which operations of seedbed preparation are listed does not indicate actual sequence, as this will vary with soil and weather conditions.

+Wheat was most commonly trucked from combine to a bin or pile on the farm, and hauled to market later.

**Source:** O. J. Scoville and J. A. Hodges, * Practices and Costs on Wheat Farms in Western Kansas, 1947, Agriculture Experiment Station, Kansas State College, Circular 268, Manhattan, December, 1950, p. 16.
Fenton found in his study of farm machinery costs that the "One-Way" disk was used to plow an average of 641 acres a year in Kansas. The next implement in terms of acreage use was the drag harrow which covered 263 acres per year followed by the tandem disk harrow which covered 208 acres. Chilcott in his article wrote,

It seems evident, therefore, that the one-way has a proper place in semiarid agriculture. It has been the means of advancing the efficiency of winter wheat raising more in recent years in this region than anything else except the combine and tractor.

These figures show that the "One-Way" disk plow was used by a large percentage of the Great Plains wheat farmers. This plow thus was able to have an impact on a large number of farms which were located all over the Great Plains.

I. COST REDUCING

One of the main features of the "One-Way" was said to be its effect in reducing the cost of seedbed preparation. This was possible since with the "One-Way" one could pull a wider width of plow. Mr. Angell states in his patent:

The advantage in the reduction of the amount of draft necessary provided by this rolling construction is very considerable, being approximately one-half in structures of the same size, so that a farmer owning

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a tractor capable of pulling a five-foot disk plow of the ordinary construction can use the same tractor in pulling a ten-foot plow of the construction herein-before referred to. 108

The fact that the disks are all on a square shaft and interlocked is a time-saving feature of some importance. This gives one disk or several disks the torque of movement of all other disks should one disk or a group of disks become clogged. In this way much clogging is avoided and the operator is thus saved the loss of time in getting down and removing the obstructing accumulation. The "One-Way" disk also does not ridge the soil or make the seedbed uneven. This eliminates the cost of having to harrow to level the seedbed and get it in a finished condition. These features allow the farmer to increase the efficiency of his labor, better utilize the capacity of his power equipment and decrease the number of tillage operations, all of which decrease the cost of seedbed preparation.

Increase in effective width. The principal advantages of higher-capacity machines are decreased labor required per unit of output and increased timeliness in the performance of critical farm operations. For most implements each unit of working width added results in a smaller saving of labor and a small increase in timeliness. For the conditions assumed in Table 4, adding the second row to a machine saves 0.50 hours

### TABLE 4

**EFFECT OF INCREASED IMPLEMENT WIDTH ON LABOR REQUIREMENTS AND TIMELINESS**

<table>
<thead>
<tr>
<th>Width of Machine</th>
<th>Man-hours Per Acre</th>
<th>Saving Over Next Size Smaller Hours</th>
<th>Percent</th>
<th>10-hour Days Required For 100 Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-row</td>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>10.0</td>
</tr>
<tr>
<td>2-row</td>
<td>0.50</td>
<td>0.50</td>
<td>50</td>
<td>5.0</td>
</tr>
<tr>
<td>3-row</td>
<td>0.33</td>
<td>.17</td>
<td>33</td>
<td>3.3</td>
</tr>
<tr>
<td>4-row</td>
<td>0.25</td>
<td>.08</td>
<td>25</td>
<td>2.5</td>
</tr>
<tr>
<td>5-row</td>
<td>0.20</td>
<td>.05</td>
<td>20</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*aHypothetical data assuming a row width and average speed which will result in working one acre per hour with 1-row machine and an equal effectiveness per unit of width for each longer size of machine.*

per acre, the third row 0.17, the fourth row 0.08 and the fifth row only 0.05 hours. This situation has a bearing particularly in small fields or where the soil is stony or the topography is rough. It has less bearing for the Great Plains area where the land lays flat, the farms are laid out in large fields, and the draft of the tillage implement is low.

Probably the simplest method of approximating the duty of a tractor or horse-drawn implement in acres covered per 10-hour day is to multiply the effective width of the implement in feet by the rate of travel in miles per hour. This relation is derived from the following equation:

\[ D = \frac{SW \times 5,280 (100-P)}{43,560 \times 100} \]

in which,

- \( D \) = duty in acres per day
- \( S \) = speed in miles per hour
- \( W \) = effective width in feet
- \( 5,280 \) = number of feet per mile
- \( P \) = per cent of time lost in turning and in servicing
- \( 10 \) = hours worked per day
- \( 43,560 \) = square feet per acre

When \( P = 17.5 \), the equation becomes \( D = SW \).

For larger farms like those found in the wheat belt, \( P \) may be less than 17.5. Increasing the speed or the effective width of an implement does not always increase its duty in the same proportion. The shape and size of fields, as well as the topography, draft of the plow, type of soil, and type of power used, also influence the duty of such
The "One-Way" disk was able to almost double the effective width with its new design and the conditions that exist in the wheat belt.

This increased effective width was able to increase the efficiency of labor. A study made by the Works Progress Administration using data collected in the National Research Project Farm Survey reported:

Since a given tractor will pull a wider vertical disk plow than either a moldboard plow or the older type of disk plow, the use of the vertical disk plow tends to reduce the labor required for a given acreage of small grain. This labor reduction is probably as much as 0.3 hours per acre, or at least one-half, in plowing. On the basis of this assumption and the additional assumptions, all conservative, of 60,000 tractor-operated vertical disk plows each plowing 250 acres yearly, the resulting decrease in labor needed may be estimated at 4.5 million man-hours.

The same study reported that labor used prior to harvest declined 60 per cent from 1909-1936 on the farm surveyed. "The tractor, one-way disk plow, and combine have drastically reduced labor requirements in wheat production in this section." In 1909, 6.1 hours of man-labor per acre were used while in 1936 only 2.2 hours were used in producing

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111 Ibid., p. 37.
wheat in the hard winter wheat section. In another study, still drawing data from the National Research Project Farm Survey, it was shown that the largest tractor-drawn moldboard plow required .47 man-hours per acre; the tractor-drawn disk plow of eight-feet or over required .30 man-hours per acre; while the tractor drawn vertical disk plow of ten feet required .25 man-hours per acre. The "One-Way" man-hour requirements may have been even smaller at the time of the above study since tractors were available that would pull at least 20-feet of "One-Way" disk plows. This width was obtained by hooking two ten-foot "One-Ways" together.

Table 8, taken from the study made by Scoville and Hodges of Western Kansas wheat farms, showed the average time and fuel requirements for different implements. Besides increasing the efficiency of labor, fuel requirements were reduced owing to an increased effective width and a less than proportionate increase in draft. A 15-foot "One-Way" consumed .63 gallons of fuel per acre, while the largest moldboard with five 14-foot bottoms required 1.60 gallons per acre. Table 9, taken from the same study, showed that a ten-foot "One-Way" required .29 man-hours per acre and .26 tractor-hours per acre.

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\[112\text{Ibid.}, \text{p. 37.}\]

\[113\text{Data shown in Table 5.}\]

\[114\text{Data shown in Table 6.}\]

\[115\text{Data shown in Table 7.}\]
TABLE 5

MOLDBOARD PLOWS: AVERAGE MAN-HOURS REQUIRED PER ACRE, BY AREA, 1936

<table>
<thead>
<tr>
<th>Motive power and Principal Size</th>
<th>Area (Small Grain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-bottom, total</td>
<td>0.47</td>
</tr>
<tr>
<td>4 x 14 in.</td>
<td>0.46</td>
</tr>
<tr>
<td>5-bottom, total</td>
<td>0.47</td>
</tr>
<tr>
<td>5 x 14 in.</td>
<td>0.47</td>
</tr>
</tbody>
</table>

aData obtained in MRP Farm Survey, 1936.

TABLE 6

DISK PLOWS (TRACTOR-DRAWN): AVERAGE MAN-HOURS REQUIRED PER ACRE IN THE SMALL GRAIN AREAS, 1936a

<table>
<thead>
<tr>
<th>Principal Size</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-ft.</td>
<td>0.72</td>
</tr>
<tr>
<td>5-ft.</td>
<td>0.58</td>
</tr>
<tr>
<td>6-ft.</td>
<td>0.52</td>
</tr>
<tr>
<td>8-ft. or over</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Excludes vertical-disk plows. Data obtained in NRP Farm Survey, 1936.

### TABLE 7

**VERTICAL-DISK PLOWS (TRACTOR- DRAWN): AVERAGE MAN-HOURS REQUIRED PER ACRE IN THE SMALL GRAIN AREAS, 1936**

<table>
<thead>
<tr>
<th>Principal Size</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-ft.</td>
<td>0.34</td>
</tr>
<tr>
<td>9-ft.</td>
<td>0.29</td>
</tr>
<tr>
<td>10-ft.</td>
<td>0.25</td>
</tr>
</tbody>
</table>

aData obtained in NEP Farm Survey, 1936.

<table>
<thead>
<tr>
<th>Implement</th>
<th>No. Cases Reported</th>
<th>Av. Size Tractor*</th>
<th>Acres Per Hour</th>
<th>Machine Hours Per Acre</th>
<th>Gals. Fuel Per Hour</th>
<th>Gals. Fuel Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-way disk:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-ft.</td>
<td>67</td>
<td>24</td>
<td>3.1</td>
<td>0.32</td>
<td>3.2</td>
<td>1.30</td>
</tr>
<tr>
<td>9-ft.</td>
<td>89</td>
<td>27</td>
<td>3.2</td>
<td>0.31</td>
<td>3.3</td>
<td>1.10</td>
</tr>
<tr>
<td>10-ft.</td>
<td>305</td>
<td>26</td>
<td>4.1</td>
<td>0.24</td>
<td>3.8</td>
<td>1.10</td>
</tr>
<tr>
<td>12-ft.</td>
<td>65</td>
<td>26</td>
<td>5.1</td>
<td>0.19</td>
<td>4.1</td>
<td>0.78</td>
</tr>
<tr>
<td>15-ft.</td>
<td>41</td>
<td>30</td>
<td>6.8</td>
<td>0.14</td>
<td>3.9</td>
<td>0.63</td>
</tr>
<tr>
<td>Moldboard plow:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-14&quot; bottoms</td>
<td>10</td>
<td>20</td>
<td>1.8</td>
<td>0.56</td>
<td>2.9</td>
<td>1.80</td>
</tr>
<tr>
<td>4-14&quot; bottoms</td>
<td>35</td>
<td>27</td>
<td>1.9</td>
<td>0.53</td>
<td>3.3</td>
<td>1.90</td>
</tr>
<tr>
<td>5-14&quot; bottoms</td>
<td>4</td>
<td>33</td>
<td>2.4</td>
<td>0.41</td>
<td>3.7</td>
<td>1.60</td>
</tr>
</tbody>
</table>

*Drawbar Horsepower

### TABLE 9
TYPICAL AMOUNTS OF LABOR, POWER, AND MACHINERY USED TO PRODUCE ONE ACRE OF WHEAT

<table>
<thead>
<tr>
<th>Operation</th>
<th>Size of Tractor Dbhp.</th>
<th>Size of Machine</th>
<th>No. of Times Over*</th>
<th>Hours per Acre</th>
<th>Percent of Acres Covered*</th>
<th>Average Hours Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preharvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous cropping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-way</td>
<td>26</td>
<td>10'</td>
<td>2.0</td>
<td>.29</td>
<td>.26</td>
<td>59</td>
</tr>
<tr>
<td>Drill</td>
<td>25</td>
<td>13 1/2'</td>
<td>1.0</td>
<td>.25</td>
<td>.23</td>
<td>59</td>
</tr>
<tr>
<td>Fallow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moldboard plow</td>
<td>27</td>
<td>4-14&quot;</td>
<td>1.0</td>
<td>.64</td>
<td>.53</td>
<td>3</td>
</tr>
<tr>
<td>Springtooth</td>
<td>27</td>
<td>16'</td>
<td>1.6</td>
<td>.25</td>
<td>.23</td>
<td>21</td>
</tr>
<tr>
<td>One-way</td>
<td>26</td>
<td>10'</td>
<td>2.5</td>
<td>.29</td>
<td>.26</td>
<td>39</td>
</tr>
<tr>
<td>Hawkfoot</td>
<td>31</td>
<td>12'</td>
<td>2.0</td>
<td>.25</td>
<td>.23</td>
<td>18</td>
</tr>
<tr>
<td>Rodweeder</td>
<td>27</td>
<td>12'</td>
<td>1.0</td>
<td>.19</td>
<td>.18</td>
<td>18</td>
</tr>
<tr>
<td>Drill</td>
<td>25</td>
<td>13 1/2'</td>
<td>1.0</td>
<td>.25</td>
<td>.23</td>
<td>41</td>
</tr>
<tr>
<td>Volunteer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-way</td>
<td>26</td>
<td>10'</td>
<td>1.0</td>
<td>.29</td>
<td>.26</td>
<td>104</td>
</tr>
<tr>
<td>Total Preharvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combine</td>
<td>27</td>
<td>12'</td>
<td>1.0</td>
<td>.74</td>
<td>.34*</td>
<td>100</td>
</tr>
<tr>
<td>Haul</td>
<td>1.0</td>
<td></td>
<td></td>
<td>.37</td>
<td>.34*</td>
<td>100</td>
</tr>
<tr>
<td>Total Harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Harvest and Pre-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>harvest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Typical implements used, and number of times over for each sample county weighted by 1947 wheat acreage in corresponding farming areas.

*Truck.

In addition to 0.34 hour truck.

while a four 14-foot moldboard plow required .64 man-hours and .58 tractor-hours per acre. The springtooth, duckfoot, and rodweeder shown in Table 9 are not primary tillage implements. When the "One-Way" disk plow is used as a secondary implement more footage is pulled and the plow is not set so deep. If the study had shown the "One-Way" as a secondary implement the man and tractor hour requirements for the "One-Way" would have been lower.

M. L. Wilson in his studies of large scale farming in Montana believed that the average farm family in the wheat growing areas of that state could manage from 600 to 1,000 acres of wheat, cropped once in two years. He attributed the increased acreage that one family could handle to: . . . the introduction of three machines especially adapted to Montana conditions, the one-way disk, the duckfoot cultivator, and the combined harvester thresher and to the big 'Hook-up.'"  
This big "Hook-Up" referred to the practice of pulling the drills right behind the final tillage implement, accomplishing both operations at once. In another article utilizing Wilson's data the above practice was called a new system for the tillage of the fallow ground. By this means a 50 per cent reduction in costs was found to be possible, or from $2.80 per acre to $1.40 per acre.  

Similar findings have been made by other investigators. They all point to the fact that the "One-Way," through its increase in effective width, has reduced the cost of seedbed preparation through fuel economy, reduced labor requirements per acre, and fewer tractor hours per acre.

Decrease in number of tillage operations. The decrease in the number of tillage operations resulted from the manner the "One-Way" prepared the soil. The disks moved the soil with a stirring action and thus did not ridge or leave the seedbed unlevel. Moreover, on the second and third tillage operations, the "One-Way" left the soil in a pulverized condition without large air spaces and with a level subsurface. Another advantage was that other implements were not needed unless the ground was extremely dry and emergency tillage was required to control soil blowing, or unless a light rain fell immediately before drilling. Mr. Angell wrote in his patent, "The seedbed which my plow produces needs no harrowing following the operation of this plow on the soil." The action of the disks was so effective in killing weeds that the additional tillage that was formerly required for this purpose was virtually eliminated.

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113 Other articles in which reference is made to the "One-Way" disk plow, J. Fergus Grant, "Implementing Agriculture," Canadian Geographic Journal, Vol. XVIII, No. 4 (April, 1928), p. 121-23.

G. A. Studensky, who wrote in 1929 about the technical revolution in farming, believed that as the result of improvements in harvesting and sowing, tilling was now considered the most critical farm operation. The forces of technical invention have thus been drawn in that direction. Important advances have been made in disk plows and harrows. Studensky wrote in this connection:

Very recently further improvements have taken place in the technique of the preparation of the soil, which considerably increased the efficiency of labor. Thus, the one-way disk plow, having a width of cut of 5 to 10 feet, combines plowing and harrowing in one operation. If one person can plow 14 acres a day with four plow-bottoms, tractor drawn, then with a 10-foot, one-way disk plow, he can prepare 25 to 40 acres a day. A 50-horsepower tractor can pull three 10-foot one-way disk plows, thus covering up to 9 acres per hour.120

The "One-Way" disk plow was a very significant economic force that was able to cut the cost of seedbed preparation. Through its widespread use farmers were able to produce wheat more efficiently. As the hours of farm labor were reduced, there was a displacement not only of wage workers but also of farm operators. The new technology made wheat farming at the same time more capital intensive and less labor intensive. The farmer himself was released from much heavy work, while his wife and children enjoyed more time for social, cultural, and educational pursuits.

II. OUTPUT INCREASING EFFECTS

Through the increase in effective width and the action of the disks on the soil, the "One-Way" disk plow contributed materially to the expansion of wheat production. The effective width allowed the farmer to handle a larger acreage and also increased the timeliness of his tillage operations. The action of the disks produced a homogeneous seedbed, and incorporated the plant residue into the soil structure. This action also allowed moisture to soak in better and helped in the control of soil blowing. The net effect was an increased productivity of the soil.

Production of a homogeneous seedbed. Seedbed preparation was one of the most difficult operations in the production of wheat. One has to balance the desire for a smooth, well pulverized, seedbed with the desire to keep the soil from blowing. The use of the stubble mulch performed this balance most effectively. The stubble was left on the soil through the winter and plowed in during the spring months. The land was left rough with stubble sticking through after the first spring plowing to help in the absorption of moisture and to help stop blowing. In later tillage operations the soil was worked into a finer condition.

In his patent Mr. Angell described the seedbed made by his machine as follows:

In my seedbed no air pockets or spaces are left or formed as the result of the action of the disks on the soil. To the contrary my seedbed is characterized by two essential qualities or conditions: (a) The mass
of soil, three to six inches in depth is without clods or lumps . . . which I best can describe by saying that the bed is homogeneous or of uniformity of structure . . . . (b) There are no air spaces or unoccupied places or pockets in the bed because my disks do not dig up the soil in the sense of scooping out and turning over large fragments or strips, which when mixed with the fine portions of the soil leave spaces, or air pockets forming chasms across which the wheat roots will not pass or project themselves, and will thus produce dwarfed wheat stems, or no wheat stems at all due to the perishing of the seed for want of sufficient plant food and sufficient root depth. 121

This result was accomplished by the fact that the disks stand practically vertical to the surface, and at an angle to the line of draft so that the work of each succeeding disk overlaps the path of soil treated by the preceding disk. E. F. Chilcott found that if the ground needed to be plowed soon after harvest, "The one-way is often the only soil implement that will dig into the baked surface of hard-land soils, destroy weeds, and open up the soil so that rains will penetrate it." 122 As the use of this machine spread it became in a true sense an economic force. It revolutionized tillage practices and at the same time economized on labor, time and fuel.

Incorporation of plant residues into the soil structure. The incorporation of plant residues into the soil structure has been shown to be of beneficial value to the


Great Plains farmers. Stubble, surface growth, and stalks should be mixed with the soil, not thrown to the bottom of the furrow and covered. This condition makes for a better humus structure in the soil. The plant material forms a mulch which helps rain to penetrate, stops evaporation, and reduces the washing and blowing of the soil. The Works Progress Administration reported:

This plow, may be described as half (one-gang) of a very heavy single disk harrow equipped with wheels to control depth and resist side thrust... was developed by Carles Angell during the early twenties in the wheat area where complete weed control and rough, shallow tillage are the usual requirements. Under most conditions the rough land surface and the partial coverage of stubble and other vegetative growth resulting from the use of the vertical disk plow tend to increase water absorption and to decrease both water and wind erosion, particularly the latter.123

The "One-Way" disk was the first implement used on a large scale that did not turn the furrow slice over and thus bury crop residue. Subsurface implements had been developed but never were used on a large scale as the effective width was small and the weeds were not completely destroyed. The "One-Way" has been used in areas other than the Great Plains to cultivate the soil. In the Eastern areas smaller plows were used. Arthur A. Collins writing about farm equipment in Iowa reported that the wheatland disk plow had been introduced with a resulting decrease in costs.

We find that it is very necessary to obtain a firm seedbed for wheat, free from air pockets. The work done by the wheatland plow is much superior in this respect.

123 Elwood and others, op. cit., p. 22.
to that obtained in the moldboard plow because there are no air pockets, because the straw is mixed throughout the soil so that it will not destroy capillarity, and enough straw and trash is left on the surface to prevent blowing and drifting of the soil.\textsuperscript{124}

During the Thirties the "One-Way" was considered by some as contributing to soil blowing. Soil blowing was the result of many factors. The practice of burning the stubble, which is so important to the soil structure, was practiced in many areas. The lack of moisture, with a resulting lack of plant residue, led to deteriorated soil structure. For farmers whose fields were highly pulverized and lacking in plant residue, emergency tillage measures which prelude the use of the "One-Way" may be necessary. The use of these measures depends on the area and the situation. The "One-Way" was not designed to ridge the soil or make the top soil cloddy, especially when there was no stubble. The lister and other tools are more effective as emergency tillage implements. They bring up large clods of soil and also ridge the soil. For those farmers who had been using the "One-Way" and had not been burning their stubble, the control of soil blowing was not an impossible task because they used emergency tillage implements immediately when the soil began to blow. In many areas the "One-Way" came into use because of the way it worked the soil. In Canada it was reported that, "The advent of

drought and widespread soil drifting in the early 1930's resulted in a large-scale shift to surface-tillage implements such as the one-way disc, field cultivator, and blade weeder, particularly in the open plains area.125

The surface sweep of the wind is destructive, especially in Southwestern Manitoba, Saskatchewan, and Southern Alberta, where this machine mixes the surface soils with the stubble and provides a resistant seedbed that holds together with greater tenacity than is possible through previous tillage methods.126

Excessive use of the implement on ground that was already loose and powdery was not recommended. Chilcott in a study of soil blowing on the Southern Great Plains wrote that during dry times:

... the one-way has frequently been used excessively and at times when it should not have been used. On many farms it is the only tillage implement, a fact that has led inevitably to its misuse and to the conviction on the part of some that it should not be used at all. On bare land that is already loose it is inclined to pulverize too much; a great deal of soil blowing can be fairly laid to its use under these conditions ... . However, as stated, it is the only practical implement that will break up heavy land when baked hard, the only implement that can be used in many cases in heavy stubble without clogging, and the best implement to destroy quickly a heavy growth of weeds. By alternation the one-way with other implements, except when there is too much stubble or litter on the ground to permit their use, it can be used safely ... .127

125 Jacks, Brind, and Smith, op. cit., p. 40.
127 Chilcott, op. cit., p. 4.
In a 1933 study of power and machinery in agriculture, Hurst and Church reported:

The most outstanding recent advance in the design of plows is probably the development of the wheatland or vertical disk plow, which is a combination disk plow and disk harrow. The soil is not turned over, as with the moldboard plow, but is moved to one side with a stirring action. Trash and stubble are mixed with the soil, which gives the field a ragged appearance, but the protruding stubble and trash tend to prevent blowing of the soil and to cause snow to lodge, thus conserving moisture. The vertical disk plow has made possible a reduction in power and labor requirements for seedbed preparations in the Great Plains States.128

Implements of all kinds were many times blamed for soil blowing when the fault lay with the farmer who prepared his soil at the wrong time or used his implements in the wrong way. He may have pulled the implement too fast, may not have adjusted it correctly, or may not have been using the implement that the specific condition called for. Factors contributing to soil blowing also include neglect by suitcase farmers, overcropping in times of war and high prices, and abandonment of wheat farms in periods of low prices and depression. During the 1930's blowing was almost impossible to stop on land that lay idle with no cover. Only rain and the return of plant growth corrected the situation.

Increase in timeliness of tillage operations. In agriculture as in other fields of production there are limiting factors. Because of the uncertainty of weather in

128 Hurst and Church, op. cit., p. 29.
in the Great Plains, tillage operations, drilling, and harvesting have to be completed within a limited time. The ability to perform these operations quickly and at the proper times is perhaps, the principal contribution of farm mechanization. Each new advancement in the unit of power, with the subsequent change in implements, makes faster operations possible. For wheat production harvesting used to be a limiting factor as it was really the slowest operation. Hail, hot winds, wet ground, or grasshoppers ruined wheat that was ready to be harvested. The combine, pulled by the new tractors, speeded harvesting considerably in the early 1920's. The new power and the larger grain drills also made possible the drilling of wheat at times when conditions were right. Seedbed preparation now became the operation that was considered the slowest. The adoption of the "One-Way," and the use of the new power changed this.

Summer fallowing, though recommended as one of the old dry-farming concepts, did not become effective until the Twenties when power equipment came into use. Summer fallow operations, in order to stop the weeds from using all the moisture, should be completed within a period of a week or ten days. The "One-Way" helped make this possible for the wheat farmer. Brown writes:

Through the development of that tool variously known as the disk tiller, gold digger, wheatland plow, cylinder plow, one-way disk, the answer to the seedbed preparation problem of the wheat farmer appears to have been solved. It has speeded up
seedbed preparation through the wheat belt so that large acreages may be prepared in a very short time after harvest, thus saving moisture and enabling individual farmers to keep their seedbed preparations up to the same relative speed as their planting and harvesting methods.129

Farmers in the Great Plains were now better able to adapt to the conditions imposed upon them by nature, though many did not take advantage of these new developments until they found out what severe conditions could be imposed upon them by nature with the drought of the Thirties. They could now wait longer for nature to provide them with the right conditions because they could get their operations finished before climatic conditions changed again.

**Utilization of larger acreage.** Another economic result of the adoption of the "One-Way" disk plow, in conjunction with the other new implements and sources of power, was that many acres that were not being cropped could now be farmed efficiently. Moreover, the individual farmer could handle a larger acreage. The new developments not only speeded up operations to the point where the old acreage could be farmed better, but they also made it possible to manage larger farms effectively. The "One-Way" was one of several advancements within the total structure of development. Total output was now increased without any not

increase in input. Great Plains' farmers who failed to keep up with the new advances or went too deeply into debt soon found themselves moving into new occupations. A balance had to be reached so that one could achieve the optimum combination of investment and timeliness. Successful farmers found that the investment per acre must be kept as low as possible while at the same time enough equipment must be available to allow for timely operation. The tendency in the Great Plains was towards adjusting the land unit to the available equipment, which depended on the resources and managerial ability of the individual farmer.
CHAPTER V

SUMMARY AND CONCLUSIONS

Dry-farming methods in the Great Plains have undergone many changes since the first settlers moved into this area. Settlers found farming conditions quite different from those previously experienced. If farming was to become stabilized, the techniques of production would have to be adapted to the special conditions imposed by the Plains region. Every change, whether good or bad, was an attempt to insure the possibility of successful farming. A permanent, non-destructive type of agriculture had to be developed.

The Great Plains were settled in a time when many advances had already been made in agriculture. A backlog of technology also existed that had not yet been applied to agricultural production techniques. Horse power and certain basic pieces of machinery were used almost from the first. It was not long before the existing technology expanded and was able to supply the farmer with many new technological innovations. Farmers in this semi-arid country were also at work inventing new techniques and selecting the best features of the old culture to improve their farming practices. Special attention has been given to the dry-farming movement since it represented an early, but largely unsuccessful,
The development of new mechanical implements and power units, steam and then gasoline tractors, stands as probably the most important force which altered the production techniques for small grains. Mechanical innovations cut the cost of production and brought about the larger farm unit. Tillage, drilling and harvesting operations could now be carried out with greater speed and efficiency. This was particularly important as the environment placed narrow limits upon the time one had to complete the necessary operations.

New tillage implements needed to be invented. The older units neither met the soil conditions found in the Plains area or utilized the new power units that came into widespread use. The technological lag that existed in the early 1920's has been shown above. Tillage advances had not kept pace with the new drilling and harvesting methods.

The "One-Way disk plow was introduced into this expanding mechanical revolution to meet the problem of soil tillage. Other tillage implements were developed and used from time to time but none of these had as great an economic impact as the "One-Way" disk plow. This implement was invented and manufactured by a man who had gained a wide knowledge of mechanical principles and a keen insight into the problems of wheat growing in the Great Plains. The
experiments of many were realized when C. J. Angell of Plains, Kansas, made his successful innovation. We have seen that many individuals contributed to the development of the disk plow, however, the contribution of Mr. Angell was unique in that his modifications were adapted to the special needs of the Great Plains wheat industry. By combining a gift for mechanical invention with the practice of large-scale wheat farming, Mr. Angell was in an unique position to perfect his implement.

A better seedbed was now possible at a reduced cost per acre. C. J. Angell was able to demonstrate the merits of his plow to wheat farmers and implement companies. This was done through the manufacture and sale of the "Angell One-Way Disc Plow." Mr. Angell introduced this implement successfully to Great Plains wheat producers and was thus an entrepreneur, the bearer of the mechanism of change.

The "One-Way," as shown above, came into widespread use in this area. It was able to become an economic force contributing to the advancement of wheat production. The fertility of the soil could now be better maintained through the conservation of plant residue, provided stubble burning was discontinued. Stubble burning was cut to a minimum in most areas as farmers learned that a new implement was available to work the stubble into the soil. Moisture could now be conserved through the enlarged practice of summer fallowing. Weeds left to grow on summer fallow ground would
use up all the conserved moisture within four to six days. Weeds could now be controlled efficiently. Also additional tillage that was formerly required for this purpose was virtually eliminated. The reduced draft of the "One-Way" per unit of width meant that a wider width could be pulled. This was possible since the "One-Way" did not turn the furrow slice but only stirred or cultivated the soil. The soil of the Plains did not require a turning action. This increase in effective width reduced man-hours, fuel costs, and tractor hours per acre.

The "One-Way" disk plow as an economic force contributed to the expansion of efficient wheat production. It helped bring about a new production function which meant a new combination of the factors of production. This implement was not a final answer to tillage problems or a final breakthrough. Man's adaptation to any natural region necessitated the invention and adoption of new productive techniques. The "One-Way" was an innovation that allowed a particular productive process to be better adapted, during a certain historical period, to the conditions imposed by a natural region. Man's future advancement will depend upon the speed with which new cultural and technological processes are developed and utilized. These new processes for agriculture must be adapted to the natural regions of the world.
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