The development of a trailer mounted corn picker

August Stephen Paydon
Iowa State College

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THE DEVELOPMENT OF A TRAILER MOUNTED CORN PICKER

by

A. Stephen Paydon

A Thesis Submitted to the Graduate Faculty for the Degree of

MASTER OF SCIENCE

Major Subject Agricultural Engineering

(Agricultural Machines)

Signatures have been redacted for privacy

Iowa State College
1941
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INTRODUCTION

With the ever increasing mechanization of the farming industry, corn production practices have been rapidly changing. By methods employed less than a century ago, one man could successfully handle only five acres of corn. Today, with modern equipment and management he can handle more than twenty times that acreage.

As might be expected, the various processes involved in corn production have not progressed uniformly. Seed bed preparation has been greatly improved; planting machinery has been made to accomplish much more accurate work; cultivation speeds have been scientifically increased—but harvesting practices go on with little advancement.

A large percentage of corn in Iowa and throughout the corn belt is being harvested as it was a century ago—by hand. In some sections there has been extensive use of mechanical pickers—machines very similar to those introduced more than thirty years ago.

Suggested reasons for the lack of popularity of mechanical methods are numerous. However, the excessive initial cost and the need for two men to efficiently operate the machine are two of the most ardent objections.

Research in corn harvesting machinery has, therefore, been directed towards lighter and more simplified pickers, to be operated by a one man crew.
An attempt to remove the main objections without losing the advantages of present day machines has led to the development of the trailer mounted corn picker.
CORN HARVESTING MACHINERY

Importance of Corn Harvesting Machinery

With an average corn crop of well over two billion bushels (12), nearly two hundred fifty million man hours would be required for harvesting alone, were it done entirely by hand. In 1933 nearly ninety percent was husked by hand, or an equivalent of some two hundred twenty-five million man hours.

Corn yielding seventy bushels per acre requires about nine man hours per acre to harvest by hand, while all other production processes together require only four and one-half man hours per acre (11). Recent reports with mechanical pickers show them capable of doing the same work for less than one man hour per acre. The cost of corn production could thus be greatly reduced by decreasing the amount of labor involved in the harvesting process.

Use of Corn Harvesting Machinery

Advantages of mechanical corn pickers

Decreased labor requirements. Agricultural Experiment Stations throughout the corn belt states report data in agreement with that furnished by the Illinois station (5). The relationship between yield and the labor requirements for hand picking corn in Illinois is shown
in Table I.

Table I. Labor Requirements for Hand Picking Corn in Illinois

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<thead>
<tr>
<th>Yield per Acre</th>
<th>Man Hours per Acre</th>
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<tr>
<td>30</td>
<td>4.00</td>
</tr>
<tr>
<td>40</td>
<td>4.60</td>
</tr>
<tr>
<td>50</td>
<td>5.38</td>
</tr>
<tr>
<td>60</td>
<td>5.72</td>
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<tr>
<td>70</td>
<td>6.23</td>
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The complete mechanization of this country's corn harvest would realize a saving of as much labor as is now used in producing the entire crop, exclusive of harvest. This would mean a forty percent reduction in corn production labor requirements.

**Lower harvesting costs.** Studies made by K. H. Myers (7) show that harvesting costs are definitely reduced by mechanization. Table II shows the relative costs of the three most popular methods of corn harvesting.

Reports from East Central Illinois give even lower cost figures on mechanized harvesting methods (4).

**Husking is accomplished in season.** Since winter and spring husking are undesirable from the standpoints of both corn losses and labor comfort, speed has become an important factor in corn harvesting. The
Table II. Cost of Corn Harvesting by Various Methods

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<thead>
<tr>
<th>Items</th>
<th>Hand</th>
<th>Single Row</th>
<th>Double Row</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres Husked per Farm</td>
<td>98</td>
<td>105</td>
<td>159</td>
</tr>
<tr>
<td>Yield per Acre</td>
<td>48.8</td>
<td>43.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Cost per Acre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Hired Labor</td>
<td>$1.88</td>
<td>$0.34</td>
<td>$0.26</td>
</tr>
<tr>
<td>2. Operator's Labor</td>
<td>.61</td>
<td>.75</td>
<td>.63</td>
</tr>
<tr>
<td>3. Horse Labor</td>
<td>1.43</td>
<td>.46</td>
<td>.40</td>
</tr>
<tr>
<td>4. Tractor</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td>.48</td>
<td>.39</td>
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<tr>
<td>Interest</td>
<td></td>
<td>.25</td>
<td>.21</td>
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<td>Fuel and Oil</td>
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<td>5. Picker</td>
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<tr>
<td>Depreciation</td>
<td></td>
<td>.45</td>
<td>.44</td>
</tr>
<tr>
<td>Interest</td>
<td></td>
<td>.15</td>
<td>.13</td>
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<tr>
<td>Repairs</td>
<td></td>
<td>.09</td>
<td>.01</td>
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<tr>
<td>Shelter</td>
<td></td>
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<td>.02</td>
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<td>6. Wagon Use</td>
<td>.10</td>
<td>.06</td>
<td>.04</td>
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<tr>
<td>7. Elevator Use</td>
<td>.24</td>
<td>.21</td>
<td>.23</td>
</tr>
<tr>
<td>8. Extra Elevator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td>.05</td>
<td>.09</td>
</tr>
<tr>
<td>Total Cost per Acre</td>
<td>$4.46</td>
<td>$3.74</td>
<td>$3.14</td>
</tr>
<tr>
<td>Total Cost per Bushel</td>
<td>.091</td>
<td>.087</td>
<td>.070</td>
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The mechanical picker can be used as soon as the corn is ready to crib. Since a two row picker in fifty bushel corn is capable of husking from five to six times as fast as an identical crew of hand pickers, it is evident that the length of actual husking time is greatly reduced. This allows the husking to be completed before bad weather sets in during the fall.
Labor comfort. Most farmers agree that the type of work connected with mechanized husking is both easier and more pleasant than is that involved in hand husking.

Labor efficiency is increased. A larger acreage of corn can be successfully handled with the same labor that is necessarily kept for other purposes.

Disadvantages of mechanical corn pickers

Although individual models have their distinctive drawbacks, there are many disadvantages common to all of the present types of machines.

Excessive initial cost. A corn picker is a relatively complicated piece of machinery with many moving parts. This requires a large number of bearings and other accurately machined parts. The cost, based on weight, is, therefore, rather high. Most pickers will vary from twenty to twenty-five cents per pound.

Thus, to the farmer with only a few acres to harvest, the cost is prohibitive. According to H. H. Reed (9), a single row picker is uneconomical unless the operator has at least fifty acres to husk each year. Sixty-five acres will make the double row machine more economical to operate.

Weather limitations. Weather conditions usually limit the use of mechanical pickers to only a few weeks in early fall. Because of their excessive weight, they can be used only to a limited extent in mud.
The pull type picker becomes useless because of the occurrence of excessive side draft. Lack of sufficient traction for steering as well as forward motion is usually the limiting factor.

Mounted pickers, because of the weight added to the tractor, usually have sufficient traction but are much more subject to miring down. Thus, during the fall rains and early freezes these machines are of little use.

Field losses. Both ear corn and shelled corn losses are often significantly large. This is especially important to those farmers who do not have livestock. It has been conclusively shown that these losses rapidly increase as the husking season progresses (10). Mechanical features of the picker and corn varieties grown have a great deal to do with the extent of these losses.

Corn spacing limitations. With the ever increasing popularity of reduced corn row spacings (1), difficulty is encountered in obtaining sufficient clearances. Most pickers are limited to row spacings of more than thirty inches.

Excessive weight. Besides being a problem in bad weather conditions, the weight is often great enough to cause excessive ground packing. Popular makes on the market at present weigh as high as thirty nine hundred pounds—almost two tons. Upkeep, cost of operation and initial costs are all directly related to machinery weights.

Tractor useless for other jobs. This is primarily a disadvantage
of the mounted type picker. However, wagon hitches on pull type pickers often complicate the unhitching possibilities. Since many of the units require most of a day to mount, and a similar time to dismount, the power unit is practically useless for any other purposes during the husking season.

**Accident hazards.** The great number of moving parts, often in reach of the operator, make the corn picker especially dangerous. In the case of tractor mounted pickers the operator is often entirely surrounded by moving parts.

**Ineffective husking.** When unfavorable husking conditions prevail a considerable number of husks are often left on the ears. This seems to be a disadvantage only in so far as storage space is concerned—it having little or no effect on the spoilage that may occur.

**Justification for Study**

In view of the disadvantages mentioned above, there is definitely room for improvements to be made. Those items of major importance which would justify further research are:

1. Reduction of initial picker costs.
2. Further increase of labor efficiency in corn harvesting.
3. Reduction of shelled corn and ear corn losses.
4. Reduction of weather limitations.
5. Reduction of accident hazards.
EXPERIMENTAL

Scope and Purpose of the Project

Introduction

In an attempt to develop a simplified corn harvesting machine with low labor requirements, the hauling unit presents itself as the logical basis for picker mounting. Instead of the picker carrying a large amount of corn as has been attempted in the elevated bin type of machine, the process has been reversed—the hauling unit now carrying the picker. This has led to simplified machinery as well as a large reduction in equipment necessary for one man operation. One large trailer, without the necessity of time consuming hitching and unhitching, does the work formerly requiring two or three wagons.

Because of simplicity in design and compactness of the unit, one side of a Kuhiman tractor mounted machine has been selected as the basic picking unit. This part of the machine consists of a combination set of rollers and the necessary gathering shields and chains.

One cast iron roller working against a soft rubber roller furnishes both snapping and husking facilities. The lower portions of the rollers are designed to snap the ears while the upper portions complete the husking process. This entirely eliminates the need for the common husking bed. Elevating chains keep the ears moving uniformly over the
rollers at all times, eliminating clogging and piling of the ears.
Shelled corn losses are thus considerably reduced.

The unit is especially adapted to remounting. Its weight is less
than six hundred pounds and all moving parts are operated from a
single cross shaft.

Figures 1 and 2 show the unit as removed from the Kuhlman picker.
Shields have been removed to show gathering and elevating chains.

Features of the machine to be constructed

The following items have been listed as a guidance in the essen-
tials to be included in the machine—hereafter referred to as the
trailer mounted corn picker.

1. The trailer shall be of the two wheeled type. This will
facilitate the use of the wheels as auxiliary drive wheels under un-
favorable picking conditions.

2. The capacity of the trailer shall be about one hundred bushels.

3. The trailer box shall be pivoted on the axle so that a light
mechanical dump may be employed for unloading.

4. The entire picker shall be mounted on the trailer in order that
the tractor may remain free for other use when needed.

5. Weight shall be held to a minimum.

6. A transmission shall be included in the power system so that
variable speeds may be obtained from the trailer wheel drive.

7. The over-all width of the entire unit shall not exceed nine
feet. This will allow reasonable clearance in an eleven foot crib
driveway.
Figure 1. Kuhlman Corn Picking Unit—Shields Removed to Show Gathering Chains

Figure 2. Kuhlman Corn Picking Unit—Shields Removed to Show Gathering and Elevating Chains
8. The picking unit shall be mounted so that any corn row spacing may be successfully harvested.

9. Construction shall be as simple and straightforward as possible and practical.

Accomplishments expected from the machine

The following accomplishments are expected from the trailer mounted corn picker:

1. Reduction of labor costs in corn harvesting through an increase of labor efficiency.

2. Reduction of machinery costs in corn harvesting. The initial cost of the entire unit should be low and the trailer should be of great value in other farming operations.

3. Weather conditions will not hinder operation to any great extent. The combination tractor-trailer drive should operate under most any conditions.

4. Picking speeds may be increased under favorable conditions by driving the picking unit from the trailer wheels.

5. The machine should be capable of harvesting corn of any spacing down to about sixteen inch rows.

6. The simplicity of the machine should effectively reduce the upkeep, repair and storage costs of corn harvesting machinery.
Introduction

In the designing of any machinery, whether it be agricultural or commercial, there are certain basic requirements which must be given consideration. These four are of major importance: (6) (8)

1. Strength and stiffness.
2. Simplicity.
3. Adaptability.
4. Appearance.

It is impossible to list these in order of their importance since individualities of the machine being designed vary extensively with the service in which it is to be placed.

Machine design methods

The designing of machine parts may be approached by either of the following methods: (6)

1. Where strength alone is the basis of design; that is, the parts must be made strong enough to resist the stresses developed in them. So long as rupture does not occur the parts successfully fulfill their purpose. By first selecting the materials to be used, an analysis of forces present will make possible a determination of the necessary dimensions.

2. Where stiffness as well as strength is taken into consideration. Besides being strong enough to prevent failure, it is often necessary
that a part be rigid.

In the design of many kinds of machinery, especially the greater part of agricultural machinery, it is very difficult and often impossible to determine the forces acting on many of the parts. In such cases, estimations based on the designer's experience is the only solution.

**Design of agricultural machines**

"Agricultural machinery is in many respects the most difficult class of machinery to design."** (2)

Besides being of the proper strength and stiffness, the parts of an agricultural machine must be simple. Operators require it. Simplicity, in most cases, is also the key to weight and cost reductions.

When the many parts are assembled into a machine it must be kept in mind that the assembled units should be simple and must function to a high degree of accuracy under most adverse conditions. The accomplishment of the desired result in the most practical manner is of utmost importance; that is, the machine must be adapted to its work.

Even though all other requirements are satisfied, a machine will never be successful without a pleasing finished appearance.

**Design and Construction of Trailer Unit**

**General considerations**

Simplicity of design and economy in construction have been maintained as most important in the development of the first trailer mounted corn

*Davidson, J. B. Agricultural Machinery.*
picker. Insofar as has been possible, second hand materials of various sorts have been used. Standard repair parts of several companies have been used where it seemed inadvisable to machine such parts in the department shops. In this way considerable time and labor has been saved in actual construction.

Welding has been used throughout as the most economical and practical method for joining used materials. The greater portion has been of the electric arc type, although considerable brazing and gas welding has been used on the smaller and more intricate parts. The acetylene cutting torch has been indispensable as a means for preparation of most of the construction materials.

Little or nothing is known concerning the actual stresses present in most of the machine parts. Therefore, very few actual calculations have been carried out. The practice has been to estimate as nearly as possible, using similar parts of other machinery as a basis for estimation. In general, it has been the practice to under estimate the strength of parts in order to be on the safe side.

Wood has been used in the construction of the box because of its light weight and relatively low cost.

**Wheels and Axle**

**Requirements.** Provisions must be made for power operation of the trailer wheels. The wheel and axle assembly must be strong enough to carry the load of the entire machine as well as the pay load through all kinds of conditions. Provisions must be made for the pivoting of the
box on the axle in order to facilitate unloading.

**Description and operation.** The rear axles and housing of a light truck fulfilled all of the above requirements. A Model A-A Ford rear end was selected for two reasons; first, it was easy to obtain, and secondly, the unit has provisions for the pivoting of the box. Few changes were required to make a suitable pivot where the springs were originally mounted.

This unit contained a strong and durable differential which is required for driving the trailer under adverse conditions. The differential, rear axle and drive shaft were not altered in any way.

The direction of the tractor power take off is opposite to that normally found in an automotive motor. It was, therefore, necessary to turn the entire rear end unit upside down. The emergency brakes and rod assemblies were removed in order to further reduce the weight. However, the main brake bands and arms were left in place for future connection, should they seem necessary. The dual type wheels gave possibilities of width adjustment so that corn of any spacing could be husked without running a wheel on the row at any time. For twenty-one and forty-two inch row spacings, both wheels should be in their outer position. For thirty or thirty-six inch spacings, both wheels should be in their inner positions.

The hollow rear "wishbone" type braces were cut off at about eight inch lengths and were bent slightly outward so as to make suitable stubs to weld to the frame. No other changes were made in the rear end assembly.

Figures 3 and 4 show the assembly as used.
Frame

Requirements. The frame must be strong and rigid enough to carry the weight of the box, the husking unit and the load of one hundred bushels or more. At the same time it must necessarily be simple so as not to interfere with the transmission of power to the picking unit.

Description and design. A triangular type of construction gives the strongest framework with the least material. The main members were cut from the channels of a car chassis. The channels selected were as straight as could be found, with not too large a variation in depth.

The back ends of the channels were securely welded to the stub braces on the rear axle housing. The front ends were brought together and welded around a short section of three inch pipe. This section of pipe serves as the forward sleeve for the tongue mounting. The original cross bracing was all removed, except for the main center brace. A section was removed from the center of this brace so that the two stubs could be welded together without removing them from the side channels.

Thus, with one main cross brace, the final frame is of the "A" type, made entirely from a discarded car chassis.

Figures 3 and 4 show the frame construction.

Hitch

Requirements. Since the trailer is to be power driven, it must be fastened rather rigidly to the tractor drawbar. At the same time it must have ample movement in all three planes of motion. This flexibility would allow for turning, for gully crossing and for uneven roughness and
Figure 3. Frame and Rear Axle Construction
Figure 4. Trailer Unit Power Transmission System—Box Frame in Raised Position
side hills without undue strain on any part of the trailer or tractor.

**Description and design.** Motion in two directions has been taken care of in the hitch proper while a full floating tongue provides the other necessary flexibility.

The hitch itself, allowing necessary motion for turning and for going through gullies, is of very compact construction. It consists of a heavy universal joint made from pipe sections, piston pins and flat sideplates. It is pivoted in two planes on hardened piston pins to give easy motion under heavy loads. The connection to the tractor drawbar is by one three-quarter inch bolt, insuring quick and easy disconnection.

The tongue is of the full floating type made from a section of extra heavy two and one-half inch pipe. It is mounted through two sleeves and has provisions for adjustment in length. The force is transmitted from the tongue to the trailer through a set of collars which are pinned to the tongue. In this way, should one wheel of the trailer be raised higher than the other, the frame of the trailer simply pivots around the tongue, the sleeves sliding against the collar in contact.

Figures 3 and 4 show the hitch construction and the mounting of the tongue in the frame.

**Details of the hitch.** Details of the hitch construction may be found in an assembly drawing, Figure 5.

**Power take off mechanism**

**Requirements.** The power take off must furnish power to drive the trailer as well as additional power to operate the picking and elevating
units. The trailer must have variable forward speeds so that it may be used to advantage both in the field and on the road. The system must be so arranged that when desirable the picker unit may be operated directly from the trailer wheels.

Description and operation. A track transmission mounted in the main drive system furnishes the trailer with four forward speeds of its own. These speeds are approximately as follows:

<table>
<thead>
<tr>
<th>Speed</th>
<th>Speed (in mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super-low</td>
<td>1.7</td>
</tr>
<tr>
<td>Low</td>
<td>3.4</td>
</tr>
<tr>
<td>Second</td>
<td>8.3</td>
</tr>
<tr>
<td>High</td>
<td>11.2</td>
</tr>
</tbody>
</table>

The transmission has been mounted on its original cross-mounting. This cross member was reversed and welded on top of the main frame channels near the front of the box. The arrangement is shown in Figures 3 and 4. Besides holding the transmission, this cross member serves as rests for the two main box joists.

The drive shaft and transmission are joined by a special short coupled universal joint. Splines on both the drive and transmission shafts make for simple assembly. The original extended universal joint housing was cut to the necessary length, rewelded, and bolted to the back side of the transmission, making the drive shaft assembly oil tight.

A heavy enclosed roller bearing for power transmission purposes was installed well ahead of the transmission. Its purpose is to support one of the two universal joints used in connecting the tractor power take off to the transmission shaft. The forward universal is clamped directly to
the splined tractor power take off stub. A double acting extension shaft has been included between these joints for turning flexibility.

The splined extension takes care of small variations while under load.

The square bar extension which operates with considerably more friction comes into action only when the other reaches its limits.

The square bar extending shaft allows for immediate disconnection by simply driving the tractor away.

Figures 6 and 7 show the power take off coupling and the extension shaft.

Box

Requirements. The capacity shall be at least one hundred bushels of ear corn. An over-all width of nine feet limits the box width to seven feet, outside measurements. Length is limited mainly by the ability of the elevating unit to properly distribute the corn. The length of available frame channels and the slope required of the box for dumping are other limitations. A twelve foot box was chosen as most desirable.

Description. The main members which support the box are a pair of two by tens, twelve feet in length. They not only give the required strength, but are necessary in obtaining the necessary floor clearance. These main sills have been re-enforced by mounting on heavy angles cut from car chassis channels. These angles are four feet long, completely spanning the center box section. Figure 3 shows their installation.

The four secondary cross joists are of two by six construction. They are mounted just above the main sills on light steel angles. Special bearing plates have been used so that the joint will remain firm.
Figure 6. Power Take Off Extension Shaft Parts

Figure 7. Power Take Off Extension Shaft Assembly
As can be seen in Figure 3, the two center cross joists are directly tied to the main sill support.

In order to stiffen the box, a pipe of large diameter has been welded between the main sill supports to act as a torsion member. Figure 3 shows this construction.

The box has further been stiffened by the use of glue in both floor and side construction. The floor, made from end grain fir, has been both glued and nailed. The sides, of six inch material, have been riveted to the side braces. The welded construction of these braces is indicated in Figure 15. These braces occur above each cross joist and are two feet in height.

The ends of the box have been made from heavy plywood. They are held in place by small angle irons welded to the front and rear side braces. In order that the desired capacity of one hundred bushels be obtained, removable side boards must be added above this permanent box.

Unloading mechanism

Requirements. Some lifting mechanism is required to pivot the box on the rear axle. It should be strong enough to lift the picking unit as well as the load. The unit weighs approximately five hundred pounds and is suspended from a point five feet ahead of the trailer axle. The lift should also have provisions for holding the box from dumping too rapidly if the load is concentrated near the back.

Description. Possibilities of operating either a hydraulic or mechanical lift from the power take off were originally considered.
Because of the expense involved in order to obtain the necessary speed reduction, a hand lift seemed more practical.

The original lift consisted of a worm and gear, a torque tube and a set of folding arms. The ratio of the worm shaft to the gear shaft was sixteen to one. The torque tube, made from heavy pipe, was mounted between the main box joists as near the front as was possible. The folding arms were fastened to the torque tube and to the transmission cross mount. As the torque tube was rotated by the worm gear, the arms were unfolded, raising the front of the box. Figures 3 and 4 show the construction and installation of the unit.

During the field trials this lift failed. For a description of the mechanism that was used to replace it, see the details of the Third Field Trial.

Design and Construction of Picker Unit Mounting

Picks

**Introduction.** As mounted on the tractor, the picking unit was supported in only two places. These mountings will hereafter be referred to as the upper (forward) and lower (rear) mountings. The upper mounting consisted of the lifting mechanism and was of the suspended chain link type. The lower mounting provided for the pivoting of the unit around its own cross shaft. This mounting consisted of bolting the bearing holders to the tractor rear axle. In normal positions the weight of the unit is practically all carried by the upper support. When the nose
is on the ground considerably more weight is held by the lower mount. Lateral motion was prevented by a set of bumpers which worked against the tractor frame.

Requirements. Provisions must be supplied for the two main mountings as well as some method to brace the unit from lateral motion. These mounting brackets must be of sufficient strength and stiffness to prevent undue distortion when used under rough field and road conditions.

Description and design. In order to obtain the necessary stiffness and to aid in the prevention of lateral motion, the lower mount was of frame channel construction. A piece of light chassis channel was clamped against the front side of the second cross joist so that it could be easily removed. Lugs were welded to the face of the channel so that the original mounting brackets could be used. The construction and installation of this lower mounting channel is shown in Figures 6 and 9.

The overhanging or upper support was made to extend to the right front corner of the box. It was cut from a Model T chassis channel. A small angle was welded to the left side to ride on the edge of the box. It was found necessary to weld a small triangular plate between the channel and the box riding angle to prevent undue twisting of the channel while traveling over rough ground. The picking unit was hung from the ends of this channel by means of chain links.

Lateral motion was further prevented by bracing the nose of the picker to the inside end of the lower mounting by means of a small pipe.
Power Supply

Introduction. The tractor power take off is the source of power for operating the picking unit. If desired, the trailer wheels themselves may be made to furnish this power. Insofar as possible, used parts have been employed throughout the power system.

Requirements. Power of sufficient quantity must be supplied to the main picker unit sprocket. This sprocket is located near the end of the second cross joint and is limited to thirteen teeth because of small clearances. The chain required for operation is a standard roller chain of one inch pitch. The location of this sprocket is shown in Figure 9.

Description and design. The main power system was tapped by the use of a truck power take off on the trailer transmission. In order to arrive at the picking unit with power in the correct plane, a miter gear box was installed in the system. This gear box was mounted on the right main box joint just above and ahead of the trailer axle, as shown in Figure 4. A pair of universal joints was installed between the transmission power take off and the miter gear box. In order that the box might be raised, a square bar extension shaft was used between these joints.

Power from the gear box is transmitted to the main drive sprocket through a second set of universals. An extension shaft between these joints allows for the adjustment of the center distance between the main driver and picker unit sprockets. This allows for changes in sprocket sizes should other speeds seem desirable. In order that the shaft may remain in line, both roller bearing supports are adjustable. Figures 4.
and 8 show this bearing and shaft installation.

In determining the drive sprocket size the assumption has been made that the gathering chains should travel at such a speed as to have no relative motion with the ground. After correcting the forward speed for error due to inclination of the gathering chains, a sprocket of twenty-three teeth seemed most desirable. Since a twenty-two tooth sprocket was available, it was installed for trial operations.

A schematic diagram of the power system is shown in Figure 10. Photographs of the unit show the power transmission shafts in Figures 3, 4 and 28.

Height adjustment

Introduction. Parts from the original machine were used insofar as possible in constructing the height adjustment and lifting mechanism. These parts include the following: the lifting lever and lever lock, the quadrant, the lifting yoke and the auxiliary lifting springs.

Requirements. The lifting unit must give ample adjustment for field use and sufficient lift for clearance while on the road. It should be operated from the tractor seat and should be well balanced for easy operation in either direction.

Description. The lifting yoke was mounted at the outer end of the picker supporting channel. The lever and quadrant were mounted on the same channel near the right side of the box. In this position the picking unit is raised by moving the lever towards the operator in a horizontal plane of motion. The original lever is not of sufficient length to permit easy operation from the tractor seat. The auxiliary
Figure 8. Front View of Picking Unit Lower Mounting Channel

Figure 9. Picker Unit Lower Mounting Brackets
springs were attached so as to balance the unit when it is about half raised.

The height of the picking unit relative to the lifting lever can be adjusted by shortening the length of the hanger chain. An adjusting nut is provided for this variation. Both spring tensions are also adjustable.

Figures 11 and 14 indicate the construction, installation and operation of the lifting unit.

Shields

Description. The two gathering points are the original outer noses from the tractor mounted picker. The outside shield is also standard equipment. The inner shield was made from a sheet of eighteen gauge galvanized iron. A small curved section has been used to fill in the sharp corner left in the bending process. The shields are both removable without tools; yet they are securely locked in place. They are shown in position and removed in Figures 14 and 2.

Design and Construction of the Elevator

Elevating unit

Introduction. In the selection of an elevator for the type of service required it seemed certain that the conventional flight elevator would be entirely unsatisfactory. The elevating angle of this type requires more space than was available.
Figure 11. Picking Unit Upper Bracket and Lifting Yoke
In the designing of a new elevator the bucket type presented the greatest possibilities. Both lengthwise and crosswise buckets of both low and high speeds were considered. A high speed elevator with lengthwise buckets was selected as the most satisfactory possibility. A construction of this type would necessitate no change in direction of the corn ears—always allowing them to remain parallel to the direction of motion.

**Requirements of the unit.** The main factors entering into the design of the elevating unit are as follows:

1. Corn must be successfully elevated without clogging.
2. The unit should throw the corn far enough into the trailer box to permit the gathering of a large load without stopping to level the corn at any time.
3. The unit must be less than two feet wide. This will be necessary in order to hold the over-all width of the entire machine to nine feet.
4. Rigid, strong, and yet simple construction is desired.
5. There should be as few moving parts as possible.
6. Corn delivery will be between the chains. This will not permit the use of sprockets at the bottom of the elevator.
7. The elevator must depend on centrifugal force for unloading of the buckets. This will require special bucket design.
8. Corn shelling during elevation should be kept at a minimum.
9. The elevator must be able to handle stalks and husks which may come through with the corn under adverse conditions.
10. The mounting and drive should allow for quick attachment and
removal.

**Description and operation.** The body of the elevator, made from sixteen gauge sheet iron, is entirely of welded construction. Although special clamps were used, considerable difficulty was encountered due to the extensive warpage during the welding process. Both the front and the back sections required considerable straightening before the final assembly was welded together. The main backing sheet was welded last, joining the completed ends to make the finished elevator body.

In the selection of chains to operate the buckets, manufacturers' recommendations have been followed. According to one manufacturer—# (3) 

"Conveyor chains should be chosen for given operating conditions on the basis of the maximum working loads that will be encountered. For various speeds, in feet per minute, the maximum working loads should not exceed the following:

<table>
<thead>
<tr>
<th>Speed Range</th>
<th>Maximum Working Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 50 f.p.m.</td>
<td>1/6 of chain strength</td>
</tr>
<tr>
<td>50 to 100 f.p.m.</td>
<td>1/7 of chain strength</td>
</tr>
<tr>
<td>100 to 200 f.p.m.</td>
<td>1/8 of chain strength</td>
</tr>
<tr>
<td>200 to 300 f.p.m.</td>
<td>1/10 of chain strength</td>
</tr>
<tr>
<td>300 to 400 f.p.m.</td>
<td>1/12 of chain strength</td>
</tr>
<tr>
<td>400 to 600 f.p.m.</td>
<td>1/15 of chain strength</td>
</tr>
</tbody>
</table>

"Chains selected on this basis will give satisfactory performance if loads are smooth and if the chains are lubricated."

Since the increase in the speed of the periphery of the buckets as they turn around a small sprocket is depended upon for the unloading of the buckets, rather high speeds are desirable. By operating the elevator shaft at the same speed as the transmission power takes off, a chain speed of 545 feet per minute is obtained. This is sufficient to throw the corn

#Diamond Chain and Manufacturing Company.
the desired distance and yet stay within the limits set by manufacturers of conveyor chains. The tensile strength of the one and one-quarter inch pitch chain selected is 6000 pounds. This extra strength makes allowance for the fact that the chain will be operating under dirty conditions with little or no lubrication.

The chain rollers, whenever the buckets are loaded, will roll on a small quarter inch chain track. In this manner smooth operation can be obtained with a minimum of chain wear.

Special sideplates on the links fastened to buckets have provisions for rivets. Later trials indicated that permanent fastening required welding for speeds as high as those encountered.

Eight buckets were built in the original elevator unit. Later field trials indicated three were sufficient. In order that the buckets operate properly, the chains must be tight enough to eliminate tilting of the buckets, thus causing them to lose part of their loads.

The back of the elevator has been left open in order that stalks could pass straight through the machine. Only enough has been enclosed at the bottom to prevent ears from being thrown over. The entire unit has been mounted on four hangers for easy removal.

Figures 14, 15, 16 and 26 show various views of the elevator in mounted position.

Details of design. Details of the elevator parts are shown as follows:

1. Body details . . . . . . Figure 17
2. Shaft and bearings . . . . Figure 18
Power supply

The power is supplied to the elevator drive shaft by means of a long "V" belt. This belt is driven by a pulley mounted on the end of the main miter gear box shaft. The belt runs with a twist in order to obtain motion in the proper direction.

A schematic diagram showing the entire power system is shown in Figure 22.

Laboratory Trials

Introduction

The purpose of the laboratory trials was to obtain some indication of the mechanical operation of the machine before it was subjected to actual operating conditions. Smoothness of operation and rigidity of the various mountings was of primary interest.

Power take off system

The trial test of the power take off system was to determine the picking unit's reactions under the various speeds and drive methods. These tests were made in the street and cinder area north and west of the laboratory. At the time of testing the machine was not complete,
Figure 15. Elevator Unit—Back View
Figure 16. Elevator Unit—Inside View
ELEVATOR BEARING DETAILS

FOR
TRAILER MOUNTED CORN PICKER
AGRICULTURAL ENGINEERING SECTION
IOWA STATE COLLEGE

DRAWN BY:
TRACED BY:
APPROVED DATE:

Figure 18: Elevator Bearing and Shaft Details.
Figure 19. Elevator Chain, Sprocket and Counterweight Details.
Figure 20. Elevator Bucket Details and Assembly.
Figure 21. Elevator Idler and Miscellaneous Details.
Figure 22. Schematic Diagram of Elevator Belt Drive System.
the elevator and lifting mechanism not having been finished.

Discussion. The following trials were conducted. Because the machine was not fully lubricated, the trials were short unless some trouble developed.

1. The picking unit operated from the tractor power take off. Both tractor and trailer transmissions in neutral positions.

2. The trailer unit was driven through its own wheels in the four possible forward gears. The picking unit was not in operation. The tractor transmission was in neutral position.

3. The picker unit operating from the trailer wheels. All forward speeds of the tractor were used.

Results and changes made. All bearing, gear box and picker mountings seemed to have the required rigidity. It was necessary to tighten the main drive chain of the picking unit in order that it run smoothly and not climb the teeth occasionally.

The trailer worked equally well in all speeds. The approximate possible speeds obtainable are shown in Table III. (John Deere Model B tractor used—power take off speed of 553 r.p.m.)

This arrangement gives a very good spread of speed as well as an almost perfect matching of the working gear for use under adverse conditions. A slippage of only one percent is necessary for operation in these matched gears.

No changes in design seemed necessary before field tests were started.
Table III. Trailer Mounted Corn Picker Speed Combinations

<table>
<thead>
<tr>
<th>Tractor transmission</th>
<th>Trailer transmission</th>
<th>Speed - m.p.h.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>Super-low</td>
<td>1.70</td>
</tr>
<tr>
<td>Low</td>
<td>Neutral</td>
<td>2.47</td>
</tr>
<tr>
<td>Second</td>
<td>Neutral</td>
<td>3.38</td>
</tr>
<tr>
<td>Neutral</td>
<td>Low</td>
<td>3.41</td>
</tr>
<tr>
<td>Third</td>
<td>Neutral</td>
<td>5.01</td>
</tr>
<tr>
<td>Fourth</td>
<td>Neutral</td>
<td>6.59</td>
</tr>
<tr>
<td>Neutral</td>
<td>Second</td>
<td>8.29</td>
</tr>
<tr>
<td>Neutral</td>
<td>High</td>
<td>11.20</td>
</tr>
</tbody>
</table>

Unloading mechanism

The unloading mechanism, operated by a worm and gear, was designed to tilt the box when loaded or empty. Due to the moving of the center of gravity of the load upon being tilted back, the greatest load should always occur when the box is first lifted from its normal position. Thus, it should be very little harder to dump a full load than to lift the box when empty, the picking unit being attached.

Results and changes. Trials were made both before and after mounting the picking unit. Although the lift worked much harder with the unit mounted, there were no indications of any failure.

During field trials this lift did fail. For a report of this failure and the resulting changes see the Second and Third Field Trials.
Height adjustment

The height adjustment was operated in the laboratory and was found to need an auxiliary spring to aid in lifting the picking unit. This spring was installed and the tension on the two springs adjusted for easy operation.

Elevating unit

Being of entirely new design, the elevating unit required considerable testing before and after installation.

Discussion. As soon as one bucket was completed it was assembled, so that the elevating unit might be tested. The unit was operated by a "V" belt driven by a gasoline engine. After running long enough to loosen the chains no changes seemed necessary before construction of the remaining buckets was completed. As soon as all buckets were assembled it was again loosened by brisk operation. The edges of several of the buckets required dressing before there was sufficient clearance for it to run freely.

After mounting on the trailer the unit was operated considerably in order to check the working parts of the elevator and its drive.

Changes. No changes, other than those mentioned above, were made before field tests were begun.
Field Trials

Introduction

Two acres of corn were left standing through the winter in order that field tests might be run on this machine. As might be expected, the condition of the corn was not equivalent to that harvested in the fall. However, the corn was of a hybrid variety which stood very well. The condition of the corn is clearly shown in Figures 23 and 24. Only two or three localized spots were down badly.

The corn had been seeded to sweet clover which at the time of the tests had reached a height of from eight to sixteen inches. The stand was thin and in no way interfered with the husking trials.

The stalks were weathered and brittle, thus making husking conditions in many ways much less satisfactory than fall harvesting. The ears snapped easily and were very readily broken and shelled. Thus, the corn losses were exceedingly high.

First field trial – conducted May 12, 1941

Procedure. In order that two acres might last to give the machine a rather thorough test, only as much was husked each time as was necessary to definitely indicate that some changes must be made.

The machine was first tried in each of its operating speeds. It was found difficult to keep the picker well on the row above about four miles per hour. This was partly due to the excessive erosion that had
occurred during the spring rains. Only a very small amount of husking was necessary to indicate that some definite changes were required.

Results. The pin which fastened one of the universals to the drive shaft was sheared off. Since the shaft was short in length and could be easily removed, the joint was welded securely to the shaft to prevent further trouble.

A small but steady stream of oil flowed from the front bearing cover of the transmission whenever the power take off was operating. This indicated that the transmission was either too full or that the oil retainer was not functioning properly.

Stalks which went into the elevator either clogged the unit or, in traveling on through, became entangled in the belt. This indicated two things. First, some arrangement for a slip clutch must be included in the elevator power system in order to save the belt; secondly, the belt must be shielded from stalks.

The elevator seemed to be speeded correctly. At normal speeds the corn was thrown against the removable side boards. Occasionally an ear would go over the four foot side. At reduced speeds the elevator successfully emptied the corn into the trailer without clogging.

The constant churning of the corn after it entered the elevator indicated that too many buckets were present for the ears to be successfully picked up.

Changes made before the second test. The following changes were made before the second trial run:

1. The front bearing cover of the transmission was removed and
found to have a thread type oil retainer sleeve. Since the direction of
the power shaft had been reversed, this served as a pump instead of a
retainer. This sleeve was set up in the lathe and the threads removed.
The recess was then filled with bronze with the acetylene torch and braz-
ing rod. The sleeve was recentered in the lathe and bored to the correct
diameter. Left handed threads were then cut so as to form a new oil
retainer. No trouble was encountered thereafter.

2. A slip clutch assembly from an Allis Chalmers No. 60 combine
was installed in the elevator drive system.

3. An idling pulley and shield were installed in order that the
drive belt might be shielded from corn stalks which come straight
through the machine.

4. Every other bucket was removed, leaving only four.

Second field trial - conducted May 20, 1941

After making the changes mentioned above, a second field trial was
conducted under very favorable conditions. The tractor hitch was moved
slightly to the left so that the front wheels would not run so close to
the row. This would make steering easier at increased speeds.

Procedure. A great deal more corn was husked during this trial.
A load of seventy-five bushels was husked before trouble of any serious
nature resulted.

Results. The elevator slip clutch worked very well after the
proper spring tension was obtained.

The belt shield and idling pulley fulfilled their purpose, keeping
all stalks from becoming entangled in the belt.

Ears gave considerable trouble in becoming lodged between the buckets and the elevator drive shaft just as the bucket reached the top. The clearance was not sufficient to allow the bucket to go on around and the slip clutch worked before the ears were cut or broken. The rivets which held the buckets to the chain sideplates were soon jerked loose in this manner.

A small piece of cob would occasionally become caught under the chain at the sprocket, causing the slip clutch to operate.

The failure which ended the test was slightly more serious. The left wheel of the trailer came off. In turning the rear axle over to get the correct direction of travel, the use of left and right handed wheel bolts was overlooked. The wheel nuts thus worked themselves loose until only one remained. As the trailer struck a small gully that nut was pulled through the wheel.

Upon unloading at the crib, the lift failed completely. As the load was raised, the corn in the back end of the trailer rolled out, leaving a great deal more weight on the lifting mechanism. Consequently, four teeth were broken from the worm gear.

Changes made before the third trial. The wheel and buckets were repaired immediately. Since a heavy rain occurred that night, no other changes were made, it being desired to run the third and final trial under rather adverse field conditions.

Third field trial - conducted May 21, 1941

Although the rain had been rather heavy, the corn was in good
husking condition. The ground was rather muddy and slippery and the
sweet clover was very wet.

Results. The results obtained continued to indicate that clearance
between the buckets and the drive shaft was insufficient. Three buckets
seemed to be sufficient to elevate a heavy yield of corn.

The matched gears were used in this mud and were found to operate
very successfully. It was found necessary to use them in climbing a
slippery grade on the way to the buildings, after completion of the
trial.

Changes made after this final field test. The rear hubs were re-
versed so that wheel bolts would again be in their correct position.

An offset shaft, shown in Figures 25 and 26, was installed in the
elevating unit in order to increase the clearance between the buckets
and the drive shaft. In order to do this, two links were removed from
each elevator chain so that the three buckets might be timed with the
offset shaft. With thirteen teeth in the sprockets and seventy-eight
links in the chains, three buckets can be timed.

A rod climbing type of jack was substituted as the lifting mechanism.
Figures 28 and 29 show this jack in a closeup and as installed. In order
that the box might not lift faster than the jack, an extra set of locking
dogs has been installed at the base of the jack, as can be seen in
Figure 28.

Small angle irons were welded to the ends of each of the buckets
to serve as chain stops. This allowed the elevator chains to be run
much looser without excessive tilting of the buckets.
Although field trials could not be carried on after these changes had been made, laboratory trials indicated that they would prove successful.
Figure 23. Scene During Second Field Trial of Trailer Mounted Corn Picker

Figure 24. Scene During Second Field Trial of Trailer Mounted Corn Picker
Figure 25. Offset Drive Shaft and Bearings for Elevator Unit

Figure 26. Installation and Timing of Offset Elevator Drive Shaft
Figure 27. Elevator Moving Parts—Buckets, Chains, Sprockets and Shaft

Figure 28. Replacement Box Lifting Mechanism—Rod Climbing Jack
Figure 29. Installation of Replacement Lifting Mechanism

Figure 30. Operation of Replacement Box Lifting Mechanism
Figure 31: Elevator Drive Slip Clutch Assembly.
Figure 32. Installation of Elevator Drive Slip Clutch Assembly

Figure 33. Elevator Unit in Action
Figure 34. A Seventy-Five Bushel Load—Corn Has Not Been Leveled
DISCUSSION

Limitations of the Study

The trailer mounted corn picker is still in its development stage. Only the first machine has been constructed—and that in a piece by piece manner. Considering the entire machine as a unit, the results of these early trials have been very encouraging. However, its actions under harvesting conditions during the normal husking season can only be predicted. Fall operation alone will show the differences between the tough, damp ears of the regular season and the thoroughly dried ears and stalks of late spring.

A few short field trials have been insufficient to indicate the structural defects of the machine. The use of second hand materials has resulted in compromises. The size and shape of the material at hand has too often determined the design. In this manner, many of the parts have been made much heavier than is required. At the same time, further trials will no doubt indicate the presence of weak and flimsy construction.

Appearance has been of secondary importance. Parts machined in the department shops have been very rough—machined to fit the work they are to do. Again, the use of scrap and second hand materials somewhat limits the possibilities of a "finished" machine.

The design of the elevator has been a radical departure from
conventional practice. The object was to obtain a unit that would successfully elevate the corn under the operating limitations. This has been done. However, many details of design will call for alterations as soon as more exhaustive trial studies can be made.

Suggestions for Future Work

A great number of improvements for this machine have already presented themselves. The revision of this original machine, or the construction of a second unit, calls for several changes.

The elevator probably offers the greatest possibilities for future study. Little is known concerning the proper chain speeds. The optimum bucket width is not known. Some study of the lower chain radius, the size of the drive sprockets and the angle of elevation should prove worth while. All of these parts may have a great deal to do with the power required for elevation. A change in design may also allow for successful elevation at lower bucket speeds, resulting in less shelled and damaged corn and less wear on the elevator chains.

A more suitable picker mounting should be designed. A more satisfactory lifting device, with controls easily operated from the tractor seat, would add much to the machine.

A study should be made of the optimum size of trailer to fit the power unit at hand. Perhaps a slightly smaller or larger unit would be more suitable to the average farmer.

The development of a light power operated dump would add a great deal to the value of the machine. This perhaps could be either mechanical
or hydraulic, a double acting lift being most suitable.

Time studies should be conducted with the machine in actual picking conditions. Comparison with other corn harvesting methods will then give some indication as to the economic value of the machine in corn harvesting.

The possibilities of making this type trailer the nucleus of harvesting machinery seem feasible. The development of a small combine, all-crop harvester, and other harvesting equipment to mount on the trailer seems well within the realm of possibility.
CONCLUSIONS

1. The trailer mounted corn picker is definitely a one man machine. It makes possible an increase in labor efficiency which is comparable to that obtained by a two or three man crew operating a two-row machine.

2. Weather will no longer be so important a factor in corn harvesting. The combination tractor-trailer drive system will facilitate husking under previously impossible conditions.

3. The initial cost of the trailer and picker combined will be no more than the cost of an ordinary mounted single-row machine. The weights of the two are about equal, but the use of wood in the box construction will reduce the cost per pound.

4. Picking speeds may be increased during favorable conditions. By driving the picking unit directly from the trailer wheels, the relationship between the machine speed and the forward motion is not altered.

5. The tractor is free for other use when needed during the husking season. Only one bolt need be removed to disconnect the tractor from the trailer.

6. Corn of any practical row spacing can be harvested successfully with this machine.

7. A large load may be quickly and easily dumped. The pivoting box allows a light lift to dump a load of one hundred bushels or more.

8. The corn harvesting machinery will be very easily stored. All
of the parts, including the picking unit, the elevating unit and the two mounting brackets, are small enough to be easily handled. Only a small amount of floor space will be required for the storage of these parts.

9. The simplicity of the machine will reduce both initial and upkeep costs. A reduction in the number of moving parts will greatly reduce the repair costs of corn harvesting machinery.

10. The trailer, with the picking unit removed—which can be readily done—will be a very useful hauling unit on any farm.

11. The trailer offers excellent possibilities for the mounting of other power equipment. Combine, all-crop harvester and manure spreader attachments would result in very practical combinations.
The trend in corn harvesting machinery is towards lighter and more simplified pickers to be operated by a one man crew.

A comparison of the advantages and the disadvantages of present day corn harvesting equipment indicated that there is need for such improvement.

In an attempt to develop a simplified corn harvesting machine with low labor requirements, the hauling unit was selected as the basis for picker mounting. The features of such a machine and the accomplishments expected from it were listed as a basis from which to work.

The first trailer mounted corn picker was built and tested, both in the laboratory and in the field. Simplicity of design and economy of construction were maintained as most important throughout the machine.

A power driven trailer of large capacity served as the hauling unit.

A standard light weight commercial unit was used for the actual picking process. A new type of bucket elevator was designed to give positive, lasting and economical service.

Tests indicated that the use of such a machine will materially reduce the costs encountered in corn harvesting.
LITERATURE CITED


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