Farm Machinery
Its Purchase, Care, Operation, and Adjustment

By R. I. Shawl

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No attempt has been made in this circular to cover all the different pieces of farm machinery, or all the different makes of any one piece. An effort has been made to select the most important machines, and those which most frequently cause trouble, and to offer in a general way practical suggestions for getting better service and a longer period of usefulness, and for saving time in operation.

An index will be found on page 56.
Farm Machinery—Its Purchase, Care, Operation, and Adjustment

By R. I. Shawl, Assistant Chief in Farm Mechanics

Farm machinery represents a large investment in Illinois. The value of farm implements and machinery as given by the 1920 Census was $222,619,605, showing an increase of 202 percent over the figures for 1910, which were $73,724,074. The average investment per farm for machinery in 1910 was $293, while in 1920 it was $939. However, the coming of the tractor and changing implement prices were responsible to a considerable extent for the increased investment in 1920. If Census figures were available for 1925, it is doubtful whether they would show much of an increase over those for 1920, but even on the 1920 basis the average farmer has $939 invested in machinery and wants to get the best possible returns from his money.

Large losses frequently result from the improper care and use of different implements and machines, and it is hoped that the suggestions offered in this circular will help to cut down materially such losses.

SELECTING NEW MACHINERY

A machine should be purchased only after due consideration as to its usefulness to the purchaser. A little thinking before buying will save time, worry, and expense later, for once it has been used, a machine cannot be economically disposed of. In selecting a machine some of the following points should be kept in mind:

Future Needs. When buying a tractor, the purchaser should be sure that it has sufficient power to operate the sizes and combinations of field machines and belt-driven machines that he will want in the future. He should work out a scheme of purchasing machinery which will fit in with the future development of his farm, as well as with present conditions.

Value Compared with Cost. The cost of a machine as a rule is given too much consideration at purchasing time, often at the sacrifice of desirable features or of greater durability. The saving of a few dollars at the time of purchase causes the buyer to lose sight of the fact that the higher priced machine usually carries the extra value in better material and workmanship, or in having adjustments which enable it to do better work.

A machine must be efficient in order to make its use economical. By efficiency is meant the quantity and quality of work done by the
machine, as compared with the energy put into it. Because of its construction one machine may give better and longer service than another. The use of roller bearings in a binder, for example, will decrease its draft, allowing the machine to be operated with less power and probably at a greater speed. All implements should work at the speeds for which they were designed, if the greatest possible efficiency is to be secured. Much deviation from this rule will mean either a poor quality of work or a shortening of the life of the machine, or both. This means that there must always be sufficient power available to operate the machine, or combinations of machines.

Construction. Strong and durable construction is essential to long life and low repair costs. The purchaser should study the vital parts carefully; they should be so constructed that if any piece or part gives way it can readily be replaced without the purchase of adjacent parts.

Ease of Manipulation. Adjusting levers should work easily. If they are hard to work, the operator may not use them at all, and thus will sacrifice the quality of work done. This is especially true when hired help is used. If the machine must be stopped to make adjustments to meet changing conditions, the amount of work done is lessened. For example, if on a side hill the plow, with a fixed tongue, does not cut full width, ordinarily the operator will not stop to change the adjustment which turns the front furrow wheel in more towards the land. A landing lever such as is shown in Fig. 5 allows the operator to make this adjustment while the plow is in motion.

Simplicity in design and construction also is desirable. The necessary adjustments must be provided, but extra devices should be studied carefully to see if they have any real value.

Accessibility of Parts. If parts cannot be readily inspected, and if the greasing and oiling places are out of sight, they are apt to be neglected. Parts that require frequent inspection and adjustment must be within easy reach and sight.

Quick Repair Service. Repairing machinery on the farm is in all too many cases put off until the machine breaks down in the field. If quick repair service is not available, costly delays usually result. Buying machines of standard makes whenever possible means more prompt repair service, especially in the case of the renter. If there is not a great deal of difference between several makes of machines, it is best to purchase the one sold by the local dealer, provided he carries a full stock of repairs. In replacing old, worn-out machines with new ones of the same make, the old machines should be kept, so that repair parts can be used from them, either permanently or until new parts can be secured.

It is an excellent plan to tag the worn or broken parts when the machine is brought from the field, and order the needed repairs at
once. Much has already been written about making repairs during the slack periods of the year, and the writer can only emphasize the importance of following that program.

**Possibility of Cooperative Purchase.** Cooperative buying is often desirable when the purchase is to be a high-priced machine or some minor piece of equipment which has a limited use on any one farm. A silo filler, corn picker, or threshing machine may be purchased by several farmers in an immediate neighborhood. This plan enables the farmer to have the use of a machine which he could not afford to buy independently. The greater the variety or amount of work that a machine can handle, the better the investment.

**METALS USED IN MACHINE CONSTRUCTION SHOULD BE OBSERVED CLOSELY**

The kind and quality of metals used in the construction of machinery affect its strength and durability. Malleable iron castings, steel plates, and pressed steel parts are big factors in obtaining greater strength and reducing the weight of many farm machines. Careful observation of the materials used will often be a valuable aid in selecting different types of farm machinery.

**Cast Iron.** Cast iron, commonly known as grey iron, is made by combining pig iron with a certain amount of scrap iron. The amounts combined depend upon the use to which the casting is to be put. This material is quite brittle, and the castings have to be heavily constructed to withstand strain. When broken, the better grades of grey cast iron have a fine, crystalline, whitish appearance. Grey cast iron is often used in the construction of such parts as cylinders, pistons, piston rings, and the flywheel of an engine.

**Malleable Iron.** Malleable iron is made from a special pig iron. In order to get malleable castings, those made from the special analysis pig iron are baked in an oven at high temperature for several days. This annealing process removes part of the carbon and makes the castings tough, so that slight bending does not cause them to break. Because malleable castings possess greater strength and can be made lighter than those made from grey cast iron, they are replacing the cast iron type in the construction of many farm machines.

**Chilled Cast Iron.** This type of iron is made by pouring the hot metal into molds, the outside of which can be very quickly cooled, thus producing a hard, tough, close-grained material, which is used in the construction of plow moldboards and shares. Plow bottoms made from this material are of uniform texture, and can be used until they wear thin enough to break. The process of chilling the iron next to the polished surface places the grain so that the dirt, in passing over the surface of the plow bottom, rubs against the ends of the grain.
Steel. Steel is made by removing most of the impurities from cast iron. It varies in hardness in proportion to the amount of carbon which it carries. Low-carbon steel is softer and less brittle than high-carbon steel. Steel possesses unusual strength and is used to construct frames of machines, and also for shafts and gears.

Soft-Center Steel. This special type is used in the construction of plow bottoms. It consists of a layer of soft steel on both sides of which is fused a thin layer of very hard, high quality steel. Fig. 1 shows its construction. The top and bottom layers are the high-carbon steel.

Case-Hardened Steel. Case-hardened steel (Fig. 2) is made by heating mild steel to a high temperature in the presence of carbon-forming material. The carbon penetrates the pores of the steel, giving it a very hard outer surface which resists wear. It is used for making pins used in chains and hinges. Sometimes plow bottoms are made

from case-hardened steel (often called imitation soft-center steel) and put on the market as soft-center steel. The big objection to imitation soft-center steel is that the hardened surface is not of uniform thickness, and that thin spots wear thru on the plow bottom, making it necessary to discard that part of the implement.
Bronze. Bronze is an alloy of copper and tin. It is harder than brass, and is used in places where great pressure is exerted, such as the piston pin bushing in a gas engine or at either end of the crank shaft on a mower. Bronze will stand up under a beating motion when softer metals would be pounded out of shape.

Phosphor bronze is the same as ordinary bronze, with the exception that some phosphorus is added to make the bearing harder and tougher.

Babbitt Metal. Babbitt metal, as found in the better grades, is an alloy of copper, tin, and antimony. It is a soft metal, and when used in bearings will melt out if the bearings become hot, thus preventing injury to the shaft. New bearings can be poured and easily fitted to the shaft.

BEARINGS REDUCE DRAFT AND LENGTHEN LIFE OF MACHINERY

The types of bearings used in farm machinery have been changed greatly in the last few years, making a study of the bearings important in the selection of a machine. Machines should be constructed so that the larger bearings, which are subject to much wear and are difficult to replace, can be adjusted so as to take up the wear. Some types of bearings used in machinery construction are shown in Fig. 3.

Plain Bearings. These bearings are used chiefly in places where the shaft runs at slow speed. When wear occurs in a plain bearing it is necessary to rebabbitt or to replace the bearing.

Roller Bearings. Roller bearings are being used in many places in farm machinery, because they reduce the total friction and the draft by changing the sliding friction into rolling friction. This type of bearing is greased by means of compression cups, and does not require as frequent attention as the plain bearing. Some roller bearings are not equipped with a cage to hold the rollers in place and properly spaced; this type is not very desirable.

Roller or ball bearings used on shafts rotating at high speeds or carrying heavy loads, give a smoother running, longer-lived machine than if plain bearings are used. Roller bearings usually carry only the load supported by the shaft. However, the adjustable combination radial load and thrust bearing shown in Fig. 3 also takes care of the end thrust of the shaft.

Ball Bearings. Ball bearings are used to carry the rotating load of the shaft and to take care of the end thrust. They usually take up less space than roller bearings, and so can be used to best advantage where space is limited. Usually a special thrust ball bearing (Fig. 3) is used to take the end thrust of a shaft.
Self-Aligning Bearings. This type of bearing is used on shafts extending across the flexible framework of certain machines, where the shafts are subjected to strains or twisting out of line. The bearing is held in a frame so that it can pivot, and always be in line with the shaft, thus preventing excessive wear and springing of the shaft. The ends of the beater shaft on a manure spreader, and the counter shaft which receives the power from the bull wheel on the binder, are good examples of self-aligning bearings.

Bronze Bearings. Bronze bearings are usually constructed solid. They do not wear out rapidly, and when they do become worn, the old bearing can be removed and a new one put in its place.

LACK OF LUBRICATION CHIEF CAUSE FOR MACHINERY WEARING OUT

Improper and insufficient lubrication is probably the chief cause for machinery wearing out. The instruction book sent with each machine should be read carefully, so that no oiling places will be overlooked. If oil holes are located where they become clogged with dirt, they must be cleaned thoroughly with a wire or nail before oiling. It is not a good practice to put a great deal of oil in an open bearing and then let it go for several hours, because the oil soon runs out, and poor lubrication, wear, and a waste of oil result.
In the open type bearings use less oil and apply it more frequently. Bearings with grease cups do not need such frequent attention. If a machine has been standing from one season to the next, use kerosene first in the bearings to cut the grease, and then put in fresh lubricants.

Always select a good grade of oil and grease. Cheap lubricants are often the most costly, because they may contain acids or other substances which destroy the surfaces of the bearings. Never allow oil or grease cans to remain uncovered, for they collect dirt and grit. In bearings that carry heavy loads, an oil must be used that will not squeeze out and allow the shaft to touch the bearing. Remember that the purpose of lubrication is to reduce friction and wear of the parts; therefore an oil film must be present between the moving parts at all times.

**IDLE MACHINERY REQUIRES CARE**

The watchword of the farmer in regard to his machinery should be, "Good machinery, properly oiled, repaired, adjusted, and well housed."

When a machine is left standing for a short period, the working parts that are likely to be damaged by rust should be greased or covered. At the end of the season, whether a machine is to be housed or not, it should be thoroughly cleaned and all the bearings and bright surfaces oiled or greased.

Before putting a machine away, go over it carefully for broken or badly worn parts, tag them, and order the new parts at once.

Machinery to be properly housed must be placed on a floor or on boards in a closed, dry shed to which stock does not have access. Unfortunately, housing often means merely putting machinery in an open, leaky shed with a dirt floor, where it serves as a chicken roost. It would be just as well off standing out in the open. Some machinery, however, can be stored outside if properly cared for. Corn cultivators, discs, drag harrows, and even plows can be left outside if the polished parts that can be taken off are removed and put in a dry place, the other polished parts greased, and the rest of the machine given a coat of paint when it is needed.

Investigations from several states indicate that the life of farm machinery is practically doubled by proper housing. Attention to this point alone would mean a tremendous saving to the farmers of the state, and in addition would increase the ease with which a machine is adjusted and the quality of work it does.

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PLOWS

The plow is universally recognized as the fundamental and most important implement used in the preparation of soil for the seed bed. Authorities have estimated that the power used annually for plowing amounts to more than enough to run all the factories of the world. Each farmer can cut down the power required to do his plowing by knowing which type of plow bottom to use in various soils, and by having a clear understanding of the troubles which cause heavy draft, and the adjustments which make for greater efficiency.

Plowing produces a mellow seed bed, adds humus to the soil, covers trash and prevents the growth of weeds, modifies the soil texture by exposing it to the action of the seasons, and leaves a surface which will absorb and retain moisture.

Types of Plow Bottoms. Three types are in general use; the stubble, the sod, and the general-purpose. The general-purpose bottom is probably the most popular, since it will handle all the plowing on most farms, and does away with the necessity of having two sets of bottoms. The types of soils vary so much from one section of the country to another that the manufacturer has to carry in stock several hundred different designs of plow bottoms, many of which are slight modifications of the three general types mentioned. Manufacturers have classified the different soil sections, and have determined which design of bottom works best in a given section, and which kind of metal to use in its construction.

Chilled cast-iron bottoms are made by chilling the iron next to the polished surface, which places the grain of the metal so that the dirt rubs the ends of the grain in passing over the moldboard. The back of the moldboard is tougher, thus giving strength to the whole plow bottom. Chilled cast iron is very tough, quite porous, and possesses extreme hardness. Plow shares of chilled cast iron are commonly used in rocky and gravelly sections; they can be used until they wear thin enough to break. On account of the cheapness of chilled cast iron it is best to purchase new shares as the older ones become dull and worn. The shares can be sharpened by grinding.

Solid steel bottoms are made from Bessemer, or crucible, steel of uniform construction, and are used on light clay and sandy loams. The steel bottom is not so tough as the chilled bottom, but is finer grained and takes on a higher polish. It is not advisable to use a steel bottom in rocky or gravelly soil. Steel shares are sharpened by filing or cold hammering.

Soft-center steel bottoms (Fig. 1) are used in tight, sticky, or fine-textured soils, free from sand and gravel, where scouring of the bottom is hard to secure. This metal is extremely hard, very close-textured, and takes on a very high polish. If soft-center steel bottoms
are used in gravelly soil, the polished surface will be scratched and the bottoms will be unfit for soil where scouring is difficult to obtain. Soft-center steel shares can be sharpened only by heating and drawing out with a hammer.

**Suction in Plow Share.** In Fig. 4 it will be noticed that the point of the plow dips down below the underside of the share. This dipping down of the point, which causes the plow to be pulled into the ground, is called suction, or "share suck." When a straight edge is placed on the underside of the bottom, from the point of the share to the heel of the landside, there is a space between the share and the straight edge. This space should be measured at its greatest width, which will be about \( \frac{3}{16} \) inch for a walking plow. Too much suction causes the plow to "bob" instead of running smoothly. The suction may be as much as \( \frac{3}{8} \) inch under special conditions where penetration is difficult. On riding plows and tractor gangs there may be no suction in the share. If this is the case in the riding plow, the suction is taken care of by the set of the plow bottom on the frame or the beam, by the collar which holds the frame on the rear furrow wheel standard, or by the set of some of the other parts.

The suction of the new share should be measured so that proper instructions can be given the blacksmith when repainting and sharpening. Obviously if a share constructed without suction is given \( \frac{1}{8} \) inch suction when repainting, "digging in" of the plow bottom and heavy draft will result. In case there is no suction in the share, the suction of the bottom can be measured as shown in Fig. 5.

**Land Suction of the Plow Bottom.** The point of the share turns in towards the unplowed land, when a straight edge is placed along the side of the plow bottom from the point of the share to the back of the landside (Fig. 4). The space shown is called the land, or land suction, of the plow bottom. Measured at its greatest width this space will vary
from \( \frac{1}{16} \) to \( \frac{3}{16} \) inch on various bottoms. Land, or land suction, is necessary to keep the plow bottom cutting into the land to its full width. The land should be measured in a new bottom, so that the proper amount can be given when sharpening the share.

**Wing Bearing.** In a walking plow, in order to support the weight at the rear of the share, it is necessary to flatten out the share at this point to produce a bearing surface, which is called the wing bearing.

![Diagram of Wing Bearing](image)

**Fig. 5.—Measuring the Total Suction of the Bottom**

Level up the plow frame with the land wheel on a 6-inch block, and lower the plow bottom until the point of the share touches the floor. Measure the distance from the heel of the landside to the floor. This distance can be used for checking the suction in case the adjusting collar on the rear furrow wheel slips or is changed.

While wing bearing is very necessary on a walking plow in order to support the bottom and keep it running level, it is of minor importance on the riding plow, because the thrust on the plow bottom is carried by the wheels.

**Set of Coulter.** The coulter is a very important part of the plow, and must be properly set and sharpened to secure a good job of plowing. It cuts the furrow slice loose vertically, leaves a clean furrow bank, and cuts the trash, thus making good trash covering possible. Professor F. H. King of the University of Wisconsin found that in plowing two-year-old clover sod with a sod bottom, the rolling coulter diminished the draft about 20 percent under favorable conditions for plowing. The proper setting of the coulter varies with the condition and kind of soil and surface trash. The following directions are for average settings:

*For general plowing* set the bearing of the coulter as nearly as possible over the point of the share.
In stubble ground set the blade of the rolling coulter to cut \( \frac{5}{8} \) inch "to land" (that is, to cut \( \frac{5}{8} \) inch farther into the land than the shin of the plow), and \( \frac{1}{2} \) to \( \frac{2}{3} \) the depth of the furrow.

In sod ground set the blade of the coulter \( \frac{1}{2} \) inch to land, and lower it to cut the entire depth of the roots. Running the entire depth of the roots, the coulter cuts all the roots instead of the share breaking them off.

In stony ground set the coulter the full depth of the furrow with the bearing over the point of the share if possible, or set the coulter somewhat wide, and high enough to let the stones pass between its edge and the edge of the share.

In dry trash good results can often be obtained by setting the coulter well forward and a little high, so that it mounts the trash and cuts it, instead of pushing it ahead.

In wet trash or when a dull coulter is used, best results are often gained by setting the coulter back and higher so that it will mount the trash, carrying it down and cutting it against the shin of the plow bottom.

Many plows, especially tractor plows, are equipped with a combination coulter and jointer. The jointer is a miniature plow which turns over a ribbon-like slice from the inside of the furrow. This slice doubles the weeds or trash under, and, when the jointer is properly set, gives a good job of covering up the trash. Set the point of the jointer close enough to the coulter to prevent trash being raked up, and allow the inside edge of the jointer to slope gradually away from the coulter. Set the point of the jointer to run about \( 1\frac{1}{2} \) inches deep on smooth surfaces, or 2 inches deep in uneven ground. In loose surface trash the jointer sometimes causes a bunching up of the trash, and has to be removed. The jointer should scour in order to turn over a neat slice and to prevent clogging.

Width of Cut. If the front bottom cuts more or less than its width, the furrow crowns will be uneven and a poor job of covering trash may result. Fig. 6 shows how to measure the width of the cut of the front bottom. If the width of cut is not correct, it can be remedied by moving the wheel out or in on its axle, or by moving the casting (where the front wheel standard is joined to the frame) to the right or left.
Landside Friction. In a riding plow the landside should have very little pressure against the furrow bank, since heavy pressure causes heavy draft. The rear furrow wheel should run in the angle of the furrow, and hold the landside of the plow away from the furrow bank. Various methods are provided for moving the rear furrow wheel towards or away from the furrow bank, which in turn relieves or increases the pressure on the landside. One method is shown in Fig. 7, where by means of set screws the adjustment is made.

Set of Furrow Wheels. The furrow wheels must be set to carry the plow straight, and to overcome a tendency of the plow to twist around and move ahead at an angle to the direction of motion. The back end of the plow tends to swing into the furrow bank, so the rear furrow wheel must be set to lead out at an angle from the bank. The angle of the rear furrow wheel may be changed by lengthening or shortening the rod which joins it to the front wheel. The front of the plow tends to swing away from the furrow bank, so the front furrow wheel must be set to lead in slightly towards the furrow bank. The angle of the front wheel can be changed by the slot in the casting to which the tongue is attached, or by the landing lever (Fig. 5) over the front furrow wheel standard. The landing lever makes possible the quick changing of the angle of the front furrow wheel, which is desirable when plowing on hilly land or when finishing up lands.

The wheels should be provided with dust-proof axle bearings in order to insure long life. Frequent greasing will be necessary to prevent excessive wear.

Draft of Plows. Heavy draft in many cases limits the amount of work that can be accomplished, because there is insufficient power to operate the plow, and the rate of travel slows down. It is of utmost importance, then, that the farmer have a clear understanding of the factors which increase or decrease the draft, such as the character of
the soil, whether the area is level or rolling, the condition of the surface, sharpness of share, conditions for scouring, special adjustments, and the proper hitch (see page 16 for discussion of hitches).

A number of tests have been made in various parts of the United States and Canada to determine the amount of draft in different types of soil. Results of these tests follow:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Draft per Square Inch of Furrow Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy soil</td>
<td>3</td>
</tr>
<tr>
<td>Sandy loam, moist</td>
<td>3-4</td>
</tr>
<tr>
<td>Sandy loam, dry</td>
<td>4-6</td>
</tr>
<tr>
<td>Sandy clay loam, moist</td>
<td>5-6</td>
</tr>
<tr>
<td>Sandy clay loam, dry</td>
<td>6-7</td>
</tr>
<tr>
<td>Clay loam, moist</td>
<td>6-7</td>
</tr>
<tr>
<td>Clay loam, dry</td>
<td>7-8</td>
</tr>
<tr>
<td>Heavy clay, dry</td>
<td>9-10</td>
</tr>
<tr>
<td>Heavy clay, sod</td>
<td>10-11</td>
</tr>
<tr>
<td>Virgin prairie land—clay, moist</td>
<td>12-13</td>
</tr>
<tr>
<td>Virgin prairie land—clay, dry</td>
<td>14-15</td>
</tr>
<tr>
<td>Gumbo, moist</td>
<td>16-18</td>
</tr>
<tr>
<td>Gumbo, dry</td>
<td>16-20</td>
</tr>
<tr>
<td>Dry adobe</td>
<td>20-25</td>
</tr>
</tbody>
</table>

In figuring the draft per square inch of furrow slice, the total draft of the plow as measured by a spring scale is divided by the number of square inches in a cross-section of the furrow slice. Thus a 14-inch bottom, plowing 6 inches deep, would turn over a furrow slice measuring 6 by 14 inches, or 84 square inches; and if the total draft of the plow were 336 pounds, the draft per square inch would be 336 ÷ 84, or 4 pounds a square inch. It is estimated that a horse can pull \( \frac{1}{10} \) to \( \frac{1}{8} \) of its weight continuously, and \( \frac{1}{4} \) to \( \frac{1}{2} \) its weight for short periods. A 1200-pound horse then can exert continually a pull of 120 to 150 pounds. It can be seen readily that when plowing hilly ground or extra hard ground, one or two extra horses must be added. In almost all cases, using five or even six horses to the gang plow, rather than four, will increase the speed of plowing sufficiently to make it an economical practice.

At the Utica Plow Trials conducted by the New York Agricultural Society it was found that about 55 percent of the total draft of the plow is caused by cutting loose the furrow slice, about 10 percent is due to raising and turning the slice, and about 35 percent is caused by the friction of the soil on the plow parts. If 55 percent of the draft of the plow is consumed in cutting the furrow slice loose, it is evident that the share, which does most of the cutting, must be sharp and properly pointed. Ellis and Rumley in "Power and the Plow" make the following statement:

\(^{1}\) Kranich, F. N. G. Farm Equipment. Macmillan. 1923.
"At the Winnipeg Motor Competition in 1909 two six-bottom engine gangs of the same make, supposed to be cutting the same depth and width, showed a difference in draft of 45 percent. Most of this can be attributed to the fact that one was a new plow, just from the factory, especially ground for the occasion, while the other had been used for several months for plowing in stony ground, with only ordinary attention."

The clogging up of the moldboard, or its failure to scour, greatly increases the draft of the plow. When the moldboard becomes filled with dirt which sticks to its surface, the furrow slice, instead of slipping easily over the moldboard, tends to bunch up and stick, causing the plow to clog. (See the discussion of scouring on page 21.)

Excessive draft of the plow and the quality of work done are largely dependent on the operator's skill. If he knows how to adjust the hitch and the coulters properly and how to overcome failure to scour, he can do much towards lessening the draft.

**Proper Hitches Reduce Draft.** The proper hitching of the horses or tractor to the plow is one of the ways by which the farmer can materially decrease the draft. If a bucket of water is to be lifted by the bail, the bail must be grasped at the center, or if a box is to be pulled straight along the sides parallel to the direction of motion, it must be pulled from the front at the center. This is called pulling from the center of resistance. If a plow is to be moved straight ahead, it must be drawn from its center of resistance, which is estimated as nearly as possible to be at point C in Figs. 8 and 12. Point C is located about 3 inches up from the bottom of the landside, and 2 inches inside the shin on the plow bottom. The line CXH, which extends down the center of the beam in a forward direction, is what is commonly known as the true line of draft (T.L.D.) of the plow. In a two-bottom gang plow this point will fall halfway between the centers of the two beams, and in a three-bottom plow on the center of the center beam. To pull the plow with the least draft, so far as the hitch is concerned, the eveners must be attached at the T.L.D.

When two horses are used, the true line of pull (T.L.P.) is located halfway between the ends of the long evener to which the horses are hitched. In the standard 4-wheel tractor the T.L.P. is at the center, between the two wheels at the rear. To get the most effective working
conditions, the point of the true line of draft of the plow must coincide with the true line of pull of the horses or tractor. In other words, the true line of pull must be attached directly in front of the true line of draft of the implement.

Side draft must be eliminated in order to decrease the draft. It is shown in Fig. 8 that when the line of pull is hitched to X, the plow moves straight ahead. If we attempt to use three horses on this plow, we find that in order to allow one horse to walk in the furrow the center of pull on the evener must fall at point Y. The plow would then tend to twist, so that the center of resistance C would line up back of Y. This would cause the plow to move to the right and cut too narrow a furrow or none at all. In order to keep the plow cutting its full width, the operator would have to guide the plow straight by means of the handles, and hold it there.

In a gang plow, if the point of hitch is at Y (Fig. 8), the front end of the plow will tend to twist away from the furrow bank, and the back end to move into it. This is another instance of the center of resistance of the plow trying to line up behind the point of attachment of the hitch. To overcome this and keep the plow running straight, the front furrow wheel should be set to lead into the furrow bank, and the rear furrow wheel to lead away from it. This tendency of the plow to twist sidewise because the point of attachment of the hitch is to one side of the true line of draft, adds to the total draft of the plow by the amount of the extra force required to keep the plow running straight, and is known as side draft.

Hitching four horses abreast to a two-bottom 14-inch gang probably gives the worst side-draft conditions possible. In Fig. 9 from the center of the furrow to the true line of draft of the plow is 26 inches, and from the center of the furrow to the true line of pull of the evener 45 inches, or a difference of 19 inches, which is side draft.

How much does side draft increase the pull? Some tests made by the Illinois Experiment Station with a two-bottom 14-inch gang,
plowing 7.64 inches deep in prairie land, show the increase in total draft due to side draft.

**INCREASE IN PULL DUE TO SIDE DRAFT**

<table>
<thead>
<tr>
<th>Distance of hitch attachment to plow</th>
<th>From true line of draft, or number of inches of side draft</th>
<th>Amount of draft</th>
</tr>
</thead>
<tbody>
<tr>
<td>From center of furrow</td>
<td></td>
<td>Pounds</td>
</tr>
<tr>
<td>26 inches</td>
<td>none</td>
<td>1 217</td>
</tr>
<tr>
<td>21 inches</td>
<td>5 inches</td>
<td>1 226</td>
</tr>
<tr>
<td>42 inches</td>
<td>16 inches</td>
<td>1 412</td>
</tr>
<tr>
<td>47 inches</td>
<td>28 inches</td>
<td>1 475</td>
</tr>
</tbody>
</table>

With the hitch giving 16 inches of side draft, the total draft was increased 195 pounds, or 16 percent more than the hitch with no side draft. What this means is indicated by the fact already pointed out that in most cases a 1200- to 1500-pound horse is able to pull only 120 to 150 pounds continuously, so that this increase in pull would practically offset the pull of one horse.

To determine the length of eveners and single-trees, the center of the furrow is usually taken as a starting place, because one horse walks in the furrow. On a 16-inch sulky plow (Fig. 10) the evener is 1 1/2 widths of the plow bottom less 2 inches from the center of the furrow to the true line of draft of the plow, or 22 inches. If a 3-horse evener is used with 26 1/2-inch single-trees (Fig. 10), the T.L.P. and T.L.D. are 4 inches apart and, as the term is used, there is 4 inches side draft. In most cases 26-inch single-trees are too small, and if a 30-inch single-tree were used, there would be 30—22, or 8 inches side draft, which is too much. Under these conditions, not more than 4 inches side draft is advisable.

The use of the tandem hitch allows more horses to be used without the objectionable feature of side draft. The tandem hitch\(^1\) allows the operator to hitch the true line of pull over the true line of draft, making them coincide and thus conserving energy. The use of more horses on the same plow by means of the tandem hitch greatly increases the amount of work which can be done in a day. Not only is this an economical practice, but it provides better working conditions for the horses by preventing crowding and overheating.

**Tractor Gang Plows.** Small tractor gang plows are a comparatively recent development in the machinery field. They offer some problems that differ from the horse-drawn plow. There are a great many makes of tractor plows on the market. The chief factors to look

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\(^1\)Directions for constructing various tandem hitches are included in Circular 283, "Hitching Horses to Get More Work Done," which is available on request at this Station.
for at purchasing time are strength of construction, simplicity, and ease of adjustment, along with the proper size and shape of bottom. The unit-lift gang, in which all the bottoms are lifted together, is most popular, and is manufactured in sizes up to five or six bottoms.

In the tractor gang the furrow wheels as a rule do not run in the angle of the furrow, because the plow is held in its proper position, and the landside friction is taken care of by the hitch. The front furrow wheel runs straight ahead, and usually about two inches away from the furrow bank.

![Diagram of furrow wheels and moldboards](image)

**Fig. 10.—Length of Evener and Single-Tree for a 16-Inch Sulky Plow with Three Horses Abreast**

In this case the evener is 39 inches long and the single-tree 26 inches, leaving 4 inches side draft. A four-horse tandem hitch would eliminate side draft and allow the use of much longer single-trees.

The rear furrow wheel is usually run straight ahead, and may be built to run anywhere from the center of the furrow to the furrow bank. Its chief functions are to support the weight of the plow, to give suction to the bottoms, and to control the depth to which the plow operates.

The suction of a tractor gang in the three-wheel types is obtained in much the same way as in riding plows. Various methods are provided for changing the suction if conditions require it. If the set screw at the back of the plow (Fig. 11) is turned to draw the rear furrow wheel in under the frame, it raises the back of the moldboards and dips the point of the plow down, increasing the suction. If the screw is turned to allow the wheel to drop back and the rear of the bottoms to be lowered, the suction is decreased. The suction in a new plow, when there is no suck in the share, should be measured as suggested in Fig. 11.

In the two-wheel tractor gang plows, the suction is increased in most cases by lowering the plow hitch at the point of its attach-
ment to the tractor hitch, and is decreased by raising the point of the plow hitch on the tractor hitch.

**Break Pin.** The break pin is necessary to prevent damage to the plow when it strikes an obstruction in the ground which is too great for the plow to overcome. The break pin, which is constructed of hard wood, is used in holding the hitch parts together in such a way that if the pull is too great, the wooden pin will shear off and disconnect the plow from the tractor. Never replace the break pin with an iron bolt, because the bolt will not break, and much damage may be done to the plow. Special spring devices or open end slotted pieces bolted together, which will separate when the plow strikes an obstruction, are often used in place of the break pin.

**Horse and Tractor Plow Troubles.** A good job of plowing depends largely upon correct plow adjustment. A little extra time spent in setting the plow to do good work will save much time later in the preparation of the seed bed. The following discussion may assist the operator in remedying his special conditions.

*Be sure the shares are sharp,* and that the plow bottom has the right amount of suction, because too much suction causes the plow to dig in too deep, thus throwing extra strain on the implement and increasing the draft. Other causes for heavy draft which should be eliminated are excessive landside friction in horse-drawn plows and too much side draft. In tractor gangs the landside friction is taken care of largely by the hitch. Usually too much side draft will twist the plow, causing landside friction. To even up side draft adjust the

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**Fig. 11.—Changing and Measuring the Suction of a Tractor Gang Plow**

One way of regulating the suction in a plow of this type is by means of a set screw at the back of the plow. The proper method of measuring the total suction is similar to that for measuring the suction in a horse-drawn plow. The plow frame is levelled up with the land wheel on a 6-inch block, and the plow bottoms are lowered until the points of the shares touch the floor.
Hitch so that part of the side draft is thrown in the plow and part in
the tractor.

**Furrow bank breaking.** Side draft and improper setting of the
coulters are the chief causes for furrow bank breaking.

**Failure to scour** is one of the most serious difficulties, and in some
cases it cannot be remedied for the particular plow and soil combi-
nation. In order to get satisfactory scouring, the moldboard should
carry a high polish at all times. It should be greased when left stand-
ing out, even overnight, for a rain may stop the plowing for several
days, and if the plow is not protected it will rust.

If there is insufficient power to pull the plow at the proper speed,
the soil does not move over the moldboard fast enough. In this case
more horses should be added, or if a tractor is being used, one bottom
should be removed or the depth of plowing decreased.

Side draft often causes non-scouring, the plow being twisted at
an angle to the direction of motion, which reduces the pressure of
the furrow slice on the moldboard. This reduction of pressure allows
dirt to collect on the surface of the moldboard, which soon becomes
clogged. In engine gangs more side draft will have to be transferred to
the tractor. Increasing the suction of the bottoms often gives enough
increased pressure on the moldboard to cause the plow to scour.

Coulters frequently can be adjusted to give better scouring con-
ditions. Any loose, fine dirt which rolls in under the slice on the mold-
board will lift the furrow slice enough to break the suction between
it and the moldboard. This condition soon allows soil to collect on the
plow bottom. If the coulter is set too close to the shin, fine dirt may
be thrown in under the furrow slice. In this case the coulter should
be set ahead on the beam. Sometimes setting the coulters out from
the shin tends to force a wider slice upon the moldboard, thus in-
creasing the pressure sufficiently to keep the moldboard clean.

Hitching too high or too low causes shifting of pressure on the
moldboard. In Fig. 12 and Fig. 13 line CEH shows the proper line
of hitch for horse-drawn and tractor-drawn plows.

Attaching the hitch at point A lifts the front bottom up, causing
shallow plowing, and makes the rear bottom dig in slightly deeper.
This condition may prevent scouring, especially on the front bottom.

**Uneven furrow crowns.** To have alternate furrows standing higher
than the others makes a bad job of plowing, and also makes it difficult to get the field leveled down properly. This trouble usually
is due to poor adjustment of the plow, which causes one bottom to
cut deeper or wider than the other. To avoid the trouble, see that
the front bottom cuts the proper width (Fig. 6), that the plow frame
is run level, that the coulters are all set to cut the same width, and
that the hitch is attached at the proper place on the plow.
Failure to penetrate. If, even tho the shares and coulters are sharp, the plow fails to penetrate, the trouble may be due to the hitch being attached too low on the vertical clevis, so that the points of the shares tilt up. Setting the hitch a little high, or increasing the suction, may give better penetration. Care should be taken, however, not to increase the suction too much, because that may also increase the draft. When the suction is increased too much, the bottoms tend to jump along.

Engine gang fails to lift out of ground. This trouble often results from the hitch being too low on the vertical clevis, in which case the pull of the tractor lifts the front end of the plow and prevents the lifting wheel from getting a firm footing on the ground. This may be overcome easily by raising the hitch on the vertical clevis.

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**Fig. 12.—Proper Line of Hitch for a Horse-Drawn Plow**

The proper line of hitch is shown by the line $CEH$. It should extend from the horse's shoulders or the tractor drawbar back to the point $C$, which represents the center of draft of the plow bottom. The point $E$, where this straight line cuts the vertical clevis of the plow, is the proper point of attachment of the hitch to the plow. If the hitch is attached at point $A$, the front bottom will be lifted up, which will cause shallow plowing, and may prevent scouring, especially on the front bottom. If attached at $B$, the front bottom will run too deep.

**Fig. 13.—Proper Line of Hitch for a Machine-Drawn Plow**

The line $CEH$ indicates the proper line of hitch. Care should be taken to avoid hitching too high or too low, which causes shifting of pressure on the moldboard.
General suggestions on plowing may be of assistance in securing the best results possible. The following quotation is taken from "Better Farming" by W. E. Taylor:

"Careful, judicious plowing is the most important operation in the preparation of a seed bed. It is the basis of all further operation, and if poorly done no amount of subsequent surface tillage will correct the mistake. Here is one secret of success in farming. The texture of the soil is nearly always more important than mere richness. The maintenance and improvement of soil texture is more dependent upon plowing than any other tillage operation. It will add neither humus nor richness, but if properly done it will maintain a good condition of tilth and make plant food available. Good plowing pulverizes and mellows the soil. A finely divided, mellow soil is more productive than a hard, lumpy one of the same chemical composition, because it affords more feeding ground and more favorable environment for plant roots, absorbs and retains more moisture, has better aeration and less variable extremes of temperature. Further, it promotes nitrification and the development of available plant food by giving favorable conditions for the development of soil bacteria and also for the decomposition and solution of soil minerals.

"In order to secure the ideal condition for seed germination and plant growth, a seed bed for planting all small seeds should not be too deep and mellow; rather the soil should be mellow but well pulverized only about as deep as the seed is planted. Below the depth at which the seed is planted the soil should be firm and well settled, making a good connection with the subsoil, so that the water stored therein may be drawn up into the surface soil. The firm soil below the seed, well connected with the subsoil, supplies the moisture of the seed, while the mellow soil above it allows sufficient circulation of air to supply oxygen, and favors warming of the soil by gathering the heat of sunshine during the day and acting as a blanket to conserve the soil heat, maintaining a more uniform temperature of the soil during the night. The mellow soil above the seed conserves the soil moisture, acting as a mulch to keep the water from reaching the surface, where it would be rapidly lost by evaporation. The same condition favors the upward growth of the young shoots into the air and sunshine. The too mellow, deep seed bed is almost wholly dependent upon rains for sufficient moisture to germinate the seed and start the young plants. If the crop starts, it is very apt to be injured by short periods of dry weather, because of the rapid drying out of the loose surface soil. In such a seed bed the crop is not only more apt to 'burn up' in summer but it is also more apt to 'freeze out' in winter than a crop grown in the 'ideal' seed bed described above."

The handling of heavy soils, such as clay, offers some difficulties. Clay is very plastic and if plowed too wet, it will become packed or puddled. If this happens, it takes several seasons for the soil to regain its normal granular condition. If clay soil has to be plowed when wet, it is best to use a general-purpose or sod moldboard and to plow shallow. This allows the soil to be turned over with very little pressure while on the moldboard. If the clay soil is to be plowed when too dry, a stubble moldboard with its sharp curves will exert extreme pressure. This will break up and pulverize the soil, but will cause a big increase in draft.
DRAG OR SPIKE-TOOTH HARROW

Next to the plow, the drag and disc harrows are the most important tools in seed-bed preparation. These two implements are probably the most neglected of all machines. It is not uncommon to see a spike-tooth or a disc harrow left standing in the field, partly buried in the soil, for many months. Such treatment not only causes the machine to rust and weaken, thus making repairing difficult, but impairs the efficiency of its work, as the rusty parts do not scour. A little care will keep the drag or spike-tooth harrow in good shape. One of the most essential points is to keep the frame, levers, and draft attachments tight and properly adjusted.

Teeth Must Be Kept Sharp. The function of the teeth is to penetrate the soil, stirring it thoroughly, and at the same time to cut and crush the clods and level the surface. In order to penetrate well and pulverize the soil, the teeth must have sharp points and edges. When the teeth become worn on the front edge, turn each tooth, bringing the next sharp edge to the front. This can be repeated until all the edges have been used. The points of the teeth must not be worn off blunt. Remove the teeth when they become dull, and resharpen by forging and retempering, or by grinding them down carefully. In replacing the teeth, the frame should be supported so that the teeth will all be set at a uniform depth. In transporting the harrow section over pavement or stony ground, it should be put on a drag or wagon, if runners are not provided.

Storage. The harrow should be stored in a dry place. Set it up on edge on boards, or if it is laid down flat be sure that the teeth do not sink into the ground.

DISC HARROW HAS MANY USES

During the last few years the double-disc gang has become quite popular. This gang pulverizes and levels the ground in one operation, the front gang throwing the soil out and the rear gang throwing it back in. In the use of the disc gang, the soil is handled by the rear gang while it is still moist and is easily broken up. It not only does a better job of pulverizing than the single disc but conserves the moisture.

Bearings. The bearings in a disc harrow work in the dirt most of the time, and require frequent attention. They should be washed out once a year with kerosene and repacked with oil before being assembled. In using the grease cups, screw the cup down until the grease is forced out of the edges of the bearing. This shows that the bearing is filled, and it also forces out part of the dirt which works into the bearing. Many disc bearings used on out-throw discs are made of wood, because there is no end thrust and wood does not cut
out so quickly as metal (Fig. 3). These wooden bearings cost but little, and a few extra ones should always be kept on hand. Metal bearings are often used on the rear tier or in-throw discs, because they take care of the end thrust.

**Disc Blades.** Good penetration and cutting of trash cannot be secured if the disc is dull. A sharp disc will do the work without being weighted down heavily. Get the disc sharpened early so as to avoid the spring rush on the blacksmith. Small disc sharpeners are made which can be used on the farm. Keep the original angle at the edge of the disc when sharpening.

**Scrapers.** Scrapers are necessary to keep the disc blades clean so that they can do good work. They must be adjusted just close enough to clean the disc. If set too close, they cause friction and wear.

**Snubbing Irons.** The out-throw disc tends to sag down at the outer ends and push up at the center when in operation. The center of the discs are held to the proper depth by the snubbing irons, which are mounted above the angling or draft bars to the inside of the disc sections. See that the snubbing irons are adjusted either up or down, to keep the sections cutting the same depth at both ends. The rear gang is an in-throw, and the center ends tend to dig down and the outer ends to be raised up. Snubbing irons are provided to keep both sides of this gang level.

**Special Adjustments.** When the operator is allowing the disc to lap over on the previously disced ground, the part of the disc working on this part of the ground should be set at a slightly greater angle, in order to make the disc pull straight ahead. In discing on side hills, the end of the disc on the uphill side should be set at a greater angle to keep the disc from working downhill. Always be sure that the bumper irons touch each other.

**Transporting.** Pulling the disc over hard and stony surfaces dulls the edges of the blades. If the disc is to be transported far, it should be loaded on a wagon or drag. For short distances transport trucks are very desirable.

**Storing.** In storing, see that the disc is run up on boards to prevent its sinking into the ground. A little time spent in removing the dirt from the disc blades and putting on a coat of grease, will well repay the operator for his trouble.

**GRAIN DRILLS**

For oats, wheat, and soybeans, which should be planted evenly and at a certain depth, the modern force-feed grain drill with furrow openers is widely used. Broadcasting large seed is a cheap method, but the grain drill is a surer one. Experiments have shown that in bad
years drilling increases the oats yield 2 to 8 bushels an. acre. A good grain drill must be strongly built and should have a positive force feed.

**Fluted Force Feed.** This type of force feed consists of a fluted wheel resembling a gear wheel, which extends into a casting opening into the seed box (Fig. 14). There is a fluted wheel for each furrow opener. All the wheels are mounted on a shaft which extends the

![Fluted Force Feed for Grain Drill](image)

**Fig. 14.—Fluted Force Feed for Grain Drill**

The quantity of seed sown can be quickly changed by moving the lever which shifts the flutes. Some old models of this type are best adapted to small grain, while later models have the throats of the flutes made deeper in order not to crack beans or cowpeas.

length of the seed box and turns at constant speed. In order to increase the quantity of seed sown, the rim of the flute is pulled into the chamber where, in rotating, it pushes more of the grain out of the casting into the lead down to the furrow opener. It will be noticed that a blank gear is attached to the fluted wheel, and when the fluted wheel is clear out of the seed chamber, or only part way in, this blank gear takes up the extra space in the chamber.

In some old models of machines the throats do not have enough clearance to permit large seed such as soybeans or cowpeas to pass thru without cracking. Later models have the throats of the flutes made deeper, so that they handle beans and peas successfully.

**Internal or Double-Run Force Feed.** This type of feed (Fig. 15) consists of a double-edged wheel with teeth on the inside edges of the
rim. The side on which the teeth are fairly close together is used for small grains such as wheat. The other side has the teeth farther apart, and is used for oats, beans, and peas. This wheel is mounted in a shaft and turns in a casting mounted on the bottom of the seed box into which the seed runs. A plate is hinged over the wheel and covers up the side of the wheel not in use.

On the counter shaft, driving the double-run feeds, is a sliding gear which works on the large multiple drive gear. Running the sliding gear at the center of the large gear gives the slowest movement of the double-run feed, and running it at the outside edge gives the fastest. This type of feed is somewhat complicated and has more parts to wear out than the fluted feed.

**Furrow Openers.** The various types of furrow openers and their advantages and disadvantages are given below:

*The single-disc furrow opener* is most popular where the operator encounters hard soil, difficult to penetrate, where there is heavy trash to cut, or where pulverization of the soil is required. Because of the work which it does, it gives the heaviest draft. It tends to ridge the soil slightly and has a disc bearing to care for.

*The double-disc furrow opener* gives better results on side-hill work because it seems to cover the seed better. It also gives excellent results in wet soil, where the more effective scraper system keeps the
soil from rolling up with the disc. This type of furrow opener is lighter in draft than the single-disc, and in a well-prepared seed bed, free from trash, it gives excellent satisfaction, altho it has two disc bearings to care for.

The shoe furrow opener finds its chief use in well-prepared seed beds free from trash. It does not penetrate hard ground, and rides over trash instead of cutting it, which results in a varying depth of planting. It is of simple construction and has light draft.

The hoe furrow opener, the oldest type, does not penetrate well, works poorly in trash, and does not pulverize the soil. It works well only in the mellow, well-prepared seed bed.

The furrow openers on most drills are forced into the ground by the lowering lever, which works against a spring on the furrow-opener shank. If the lowering lever is exerting its full pressure on the spring, greater pressure can be secured by releasing the lever and pushing the spring up on the shank and setting the washer and cotter-key up against it. Holes are provided for this purpose in the shank of the furrow opener. Keep the furrow openers sharp.

Grain Tubes and Sight Feed. Spiral steel ribbon is considered the best type of tube for carrying the grain down into the shoe. It is flexible and does not get out of shape easily. Rubber tubing becomes bent and rotted after use, and does not let the seed down freely.

The force feed should be constructed so that the operator can see the seed as it drops down into the lead to the furrow opener. Oftentimes the drill will become clogged at one or two openings, and the sight-feed construction will enable the operator to locate these places immediately.

Quite often a blank space of 6 or 7 feet is noticed at the end of a field where the operator has turned and started back on another trip. This is the result of the operator starting the team before the drill is thrown in gear, which is usually done by lowering the furrow openers, and it takes some time for the seed to get down to the furrow opener. Always be sure that the furrow openers are down and the drill in gear before starting.

Wear in driving chains and sprocket wheels will cause the force feed to start slowly. The ratchets may be worn or clogged, and the pawl may be broken or worn. These should be examined before using the drill. Do not grease the ratchets and paws.

In the disc furrow openers, heavy pressure must be exerted on the discs in order to get penetration. This throws strain on the disc bearings, which must be oiled frequently or great wear will result. The bearings must be examined before using to see that they are tight.

If the drill is not calibrated for the seed for which it is desired to use it, it can easily be calibrated as follows: Measure the diameter of the wheel; multiply this by 3.1416, which gives the distance the
wheel travels in one revolution, or measure the circumference of the wheel direct. If the wheel travels 15 feet in one revolution and the drill sows a strip of 8 feet, multiply 8 by 15, which equals 120 square feet. An acre has 43,560 square feet; dividing 43,560 by 120 gives 363 revolutions of the drive wheels necessary to sow an acre. To get the amount of seed sown, either fill the hopper and measure the amount of seed the drill drops in 363 revolutions, or put in a certain amount of grain and count the revolutions of the wheel to run it all out. By adjusting the "quantity of seed sown" lever and making a few trials, the exact amount to be sown per acre can readily be determined.

CORN PLANTERS

Good corn-planter operation requires great skill on the part of the operator, in order that accuracy of drop and check may be secured.

Accuracy of Drop. The placing of the same number of kernels in each hill is very desirable in all cases. The number of kernels which should be dropped in each hill depends upon the fertility of the soil; some soils can stand three kernels, while others give better results with two. If the land will support two kernels to a hill, the planter should not drop one kernel in one hill and three or four in the next. Even planting will give greater returns per acre than uneven planting. Accuracy of drop depends largely upon two factors—the grading of the seed corn and the use of the proper seed plates.

Seed corn must be graded. No planter can handle kernels of varying sizes and drop an accurate number in each hill. The inaccuracy caused by leaving the butts and tips in the seed is shown in the data from a series of tests in which three-kernel hills were dropped, sorted and unsorted corn being used in combination with the different kinds of drop. Hand-tipped and butted corn and machine-sorted corn give about the same accuracy of drop.

Comparison of Different Types of Plates for Securing Accuracy of Drop with Sorted and Unsorted Corn

<table>
<thead>
<tr>
<th>Variety of corn</th>
<th>Grade</th>
<th>Edge drop</th>
<th>Flat drop</th>
<th>Hill drop</th>
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<tr>
<td></td>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
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<tr>
<td>C. W. P.</td>
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<td>85.90</td>
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<td>80.06</td>
<td>85.50</td>
<td>66.20</td>
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*These figures are the results of a long series of tests run by C. O. Reed, a former member of the staff of the Department of Farm Mechanics.
Plates with the proper sized openings must be selected in order to get accuracy of drop, as is shown by the tables below. Seed varies from year to year, so that the plates must always be tested and the proper sized opening found before going to the field. To check the accuracy of drop of the planter, set it in some convenient place and put a block under the frame so that the drive wheel can be turned. Two men should be available, one to turn the wheel and one to check the number of kernels dropped in each hill, checking one side at a time.

Tests run at the University of Illinois have shown how the accuracy of drop may be affected by the grade of the seed, and by the selection of the seed plate. Using sorted corn with the proper seed plates, a 93-percent perfect drop was secured. When the same corn was used with plates in which cells were the next size larger, the drop was 60 percent perfect, and when unsorted corn was used with the proper seed plates, the drop was 77 percent perfect.

In making the check, the operator should use an average sample of the seed corn to be planted, run the planter at field speed, use at least sixty hills for each test, and not stop until the proper seed plate has been found.

Check arms must be correctly shaped. If they become spread apart, inaccuracy of drop may result. The button on the wire will leave the check arm before it has pulled it back the full distance. As a result the valves are not forced to open wide enough to allow the corn to pass out freely, or the seed plate is not turned far enough. Bend the arms back so the sides are parallel, being sure that the wire does not bind in them.

Accumulative and Hill-Drop Planters. Two general types of planters are in use. One is the hill drop, which contains all the kernels in a hill in one hole of the plate, and drops them as the hole passes over the shoe. The accumulative drop carries one kernel in each hole of the plate, and if three kernels are to be dropped, three holes of the plate must pass over the opening leading into the shoe. The accumulative drop plates are of two kinds—the flat drop which receives the kernels lying flat, and the edge drop which receives the kernels on edge.

Accuracy in Checking. Accuracy in checking the hills of corn, especially crosswise of the field, is of greatest importance in saving time during the cultivating season. Two-row cultivators cannot be used effectively for crossing corn if the check is poor. It is impossible to stretch a check wire across an 80-rod field and take all the slack out of it, and as the planter moves across the field the slack of the wire is pushed ahead. The distance this wire "travels" across the field has been found to be about 3 inches.

The corn planter is so constructed that when the front frame is run level, the hill is dropped 1 1/2 inches back of the button, or half the distance that the wire travels. If the planter drops the hill behind the button a distance equal to half the wire travel on the trip across
the field, and the same distance on the return trip, the wire travel will be neutralized, and an accurate check with the rows planted before will result. The check at the ends of the field will not be quite so accurate as in the middle, because the wire has its maximum travel as the planter nears the end of the field. Naturally then, the place to begin checking the accuracy of drop is a few rods back from the end of the field.

If the wire is always stretched to the same tightness, better checking will result. The travel of a loose wire is greater than that of a tight wire, so the hill will have to be dropped farther back of the button when the wire is loose. It is not necessary to stretch the check wire very tight for accurate work.

The front frame of the planter should be run as nearly level as possible. If the operator finds that the hills are not checking at the center of the field, he will have to change the drop of the hill with respect to the button. By lowering the front end of the frame of the planter, by the adjustment provided on the front part of the tongue where the planter is attached to it, the shoes will be allowed to drop back with respect to the button, and the hill will be dropped farther back of the button. Such adjustments are to be found on all planters, but if the adjustment is at the rear end of the tongue, conditions will be reversed, and the back end of the frame will have to be raised.

Using teams of different heights also will cause the back of the shoe to change its position with respect to the button. Planting deeper if the distance is materially changed will require readjustment of the tongue. Every operator knows that by shortening or lengthening the straps of the neck yoke, the hill can be dropped closer or farther from the button. If the planting is done in a hilly field, the wire should be pulled tighter at the high stake.

**Cracking of Seed.** This trouble is usually due to putting the plates in wrong, or in some cases to the plate holder being upside down.

**Stringing of Hills.** Close cultivation is difficult where the hills are strung out, and cross cultivation is almost impossible without
plowing out some of the corn. In order to plant the kernels close together in the hill, the shoe is constructed with valves, one at the bottom and one at the top as shown in Fig. 16.

If the check arm does not work freely or is spread apart the valves may not open properly and the hill will be strung out. If the team backs up, dirt may be pushed against the valves, holding them open; in other cases the valves may become clogged when the shoe is forced into the soft ground.

**Blank Hills.** This trouble usually occurs when the stop is made at the ends of the field. If the team stops just as the button is forcing the check arm back, the hills in both valves will fall to the ground; when the check arm is again tripped, there will not be a hill of corn in either valve, so the trip will have to be worked until the corn gets down to the lower valve. If the operator sees that the valves have been emptied, he should trip the planter by hand until the valves are filled again.

**Timing the Plate Drive Rims.** It sometimes becomes necessary, because of breakage, to remove the rim which drives the plate. In some planters this rim is “timed” with the gear that drives it, and must be replaced correctly timed. The gears and the teeth must be marked by punch marks, so that they can be assembled properly timed.

**Clutch Troubles.** Accumulative drop planters have clutches which sometimes become worn or gummed up. Accuracy of planting cannot be expected if the action of the clutch is not quick and positive. The clutch should be cleaned with kerosene, and inspected for worn parts which must be replaced.

**Gage Shoes.** This attachment gives more uniform depth of planting in soft and uneven ground. It is often desirable to float the runners under such conditions, in order that the gage runner may help to secure more even depth of planting.

**Soybean and Fertilizer Attachments.** If the operator wishes to fertilize each hill of corn or to plant soybeans in the hill with the corn, he can purchase such attachments from the manufacturers.

**CORN CULTIVATORS**

The main purpose of cultivating the corn crop, a job which consumes a great deal of labor, is to kill the weeds. A secondary object is to produce a dust mulch which checks the evaporation of moisture from the ground. The weeds should be killed or covered during the first two cultivations, while they are small. Considerable skill is required to do a good job of cultivating.

**Shovel and Surface Cultivators.** The shovel cultivator is used chiefly in cultivating corn in clay soils, or soils that are hard or sticky and difficult to penetrate. It is also used where the weeds or grass have gained considerable growth. The shovel gives deep penetration
but does considerable damage to the corn roots. Some special shovels called “sweeps” or “hoof shovels,” designed for doing shallow work, are now being used on shovel cultivators. These sweeps give good penetration and shallow cultivation at the same time.

The surface cultivator is an excellent machine in mellow soils. It kills the weeds, and leaves the soil smooth and even. It has much lighter draft than the shovel cultivator, and, due to its ability to do shallow cultivation, it does not damage the corn roots. It will not work well in wet or hard soils which are difficult to penetrate.

**Two-Row Cultivator.** This cultivator allows one man to do practically twice the work that he can do with a single row machine. Careful attention is required at the first cultivation to operate a two-row machine, and special care must be used in securing a good cross check of the rows at planting time.

**Adjustment of Surface Cultivator.** Cultivator adjustments will vary with the type and condition of the soil, the weather, and the advancement of the crop. The surface cultivator presents some special problems in its adjustments, with which the operator must be familiar in order to do first class work in cultivating.

To secure sufficient cultivation, the inside blades of the cultivator should be set at a depth of 1½ inches, and the outside blades at 2½ inches.

If there is a difference in the knives used, be sure that they are assembled on the proper shanks. In many cases the inside blades taper off at the back, as shown in Fig. 17. Set the shanks so the inside blades are 1 inch higher than the outside blades. The cutting edges of the inside blades should lie in the same plane. In other words, if the outside blades were removed and the arch and rigs were let down on a level floor, the cutting edges of both inside blades would touch the floor for their entire length.

The outside blades are set 1 inch deeper than the inside blades. The cutting edge of the outside blades should be parallel to the cutting edge of the inside blades, so that all the blades will form the same angle with the row. Care must be taken that the blades are set to cover all the ground out to the front points of the outside blades.

The average operator will make the cultivator adjustments in the field just before starting to cultivate. With the gangs out of the
ground, sight from the back to see that the blades in each gang are parallel to each other, and that the blades on each side form the same angle with the row. Sight underneath to see that all the blades are in the same horizontal plane. Hold a straight board across the underside of the outside blades, and see that the inside blades are an inch higher. Lower the gangs to the ground and set the blades at a 45-degree angle to the ground. If the sides are not set the same, there will be a tendency for the rigs to settle to one side. The blades should run parallel to the surface of the ground.

If the blades are sharp and properly set, they will usually penetrate. If they fail to penetrate, set the front ends down \( \frac{1}{8} \) to \( \frac{1}{4} \) inch lower than the heels. The soil should move back freely over the blades; too much suction prevents penetration. The blades must be run at a sufficient depth, since running shallow will cause ridging and scraping of the soil.

**Fig. 18.—Proper Setting of the Blades of the Surface Cultivator**

The cutting edge of both the inside blades should form the same angle with the row. Set the blades so that the back of the blade forms an angle of 45 degrees with the surface. If the blades are set too flat they do not penetrate well, and if set too straight they cause unevenness of the soil.

degree angle to the surface. The rakes should press the ground hard enough to draw out the weeds that have been cut off, and to level the dirt, especially towards the hill, where it will cover up the small weeds.

If the blades do not scour, better penetration can be secured by setting them up a little straighter.

In old surface cultivators the raising lever tongue may not hold on to the teeth of the quadrant. The hole at the bottom of the lever handle in some cultivators is slotted, so by loosening the bolt at this point and pushing the lever down, the tongue may be pushed far enough into the teeth to hold it.

**Adjustment of Shovel Cultivator.** The shovel cultivator can be used under a greater variety of conditions than the surface cultivator, but it is a heavier draft machine.

Proper suction is necessary to make the shovels penetrate, and it is obtained by setting the blade to run flatter with respect to the surface. Setting the shovel too flat, however, will decrease its penetrating ability. Too much suction causes heavy draft. On the other
hand, if the shovels are set too straight, they must be forced into the ground, and this will cause heavy draft. Shovels should be kept sharpened, which is usually done by heating and drawing out the edges.

The condition of the soil should determine the set of the shovels. Setting the gangs down so that the shovels run deep may give better pulverizing, but may leave undesirable ridges. Setting the shovels flatter often makes a smoother job. Failure to scour can often be remedied by setting the shovels straighter. Shovels which are cut straight across the top usually throw the soil both ways, while those which slant across the top usually throw the soil to the high point.

In order to keep the same suction in all the shovels, the rig of gangs must be run level. The gangs can be levelled by lowering or raising the front of the gang in the cultivator frame.

To do good work, the gangs should run parallel or as nearly so as possible. If they are not parallel, the ground between the shovels will not be entirely covered.

It is difficult to give exact rules for setting the fenders or shields. They should be set just high enough to allow the fine dirt to work in around the hills, but low enough to prevent the clods from rolling on the young plants. Try to have the shields stand vertically, a little higher and wider at the front than at the back.

**Excessive Neck Weight.** Most cultivators carry a balancing adjustment, so that the cultivator can be balanced with the operator on the machine, thus relieving the neck weight. Sometimes the balancing is done automatically as the gangs are raised or lowered, and again by a special lever or adjustment for that purpose.

**BINDERS**

The binder is one of the most complicated machines that the farmer uses, and is also one of the least understood and in many cases the most neglected machine on the farm. Many adjustments are provided, some for taking up wear between parts, thus increasing the life of the machine, and others for regulating the machine in order to do better and more efficient work. The wheat and oat crops in most cases must be harvested in a comparatively short period. This is especially true during late years on account of the ravages of insects, rust, and diseases which weaken the straw, causing it to fall to the ground, where it is difficult to pick up with the binder. It can be seen readily that the profit from a season’s work on these two crops is often dependent upon a perfectly working binder; yet some binders are left standing out in the open several months a year, or housed under sheds where they serve as chicken roosts, and are given no attention as to the condition of repair.

**Starting a New Binder.** A new binder must be limbered up before using it in the grain field. Refer to the instruction book for oiling
places, and put a plentiful supply of kerosene in all the oil holes, in order to cut the paint. Run the binder for ten to fifteen minutes on the road or in the pasture to limber it up. Then supply fresh machine oil to all working parts. Cut half a swath with the machine the first round or, if compelled to cut a full swath, cut the grain high. The knotter bills and twine disc should be thoroly cleaned before going to the field. If the machine misses a few bundles at the start, do not worry; it will usually adjust itself. Never make any adjustments on the binder head until positive that they are necessary.

**FIG. 19.—THIS METHOD OF HITCHING FOUR HORES ABOREAST MAKES QUICK CHANGING POSSIBLE**

This method of line arrangement is often used, and requires very little time to adjust. If the operator wishes to drive only the center horses, the outside guide line can be removed, and the outside horses tied back to the inside horses.

If the binder fails to start when thrown in gear, remove the elevator chain, throw binder in gear, and test the sickle. Replace the elevator chain, remove the reel chain, and test the elevators. Test the reel by hand while the chain is off. In this way the trouble can be found quickly without any breakage.

**Storing Binder.** Remove all the straw and dust collections possible. Grease the knotter bills and twine disc, put a fresh supply of oil in all the oil holes, and turn the binder a few times with the crank. This oiling will prevent the bearings and parts from rusting. Inspect the machine for broken or worn parts and label them with shipping tags, so that they will not be overlooked. Store the binder in a dry place away from the stock.
Hitch Should Permit Quick Changes. To do good work, a binder must be run at a more constant speed than most other field machinery. This practice is hard on the horses and requires that they be changed frequently. The hitch shown in Fig. 19 makes quick changing possible. In case the operator wishes to drive only the center team, the outside horses will have to be tied back to the inside horses to keep them from crowding ahead.

Binder Should Cut Full Swath. If it is necessary to walk the inside horse in the grain in order to cut a full swath, set the wheels of the tongue truck to lead into the grain slightly, or if the binder tends to run into the grain too much, set the truck wheels to lead away from the grain. This adjustment can be made under the tongue where it fastens to the truck, or on the braces holding the wheels in position.

Side Draft. To prevent side draft the binder platform must be run high enough so that it will not drag. Also, the sickle must be properly adjusted, and the grain wheel must turn freely. The front side of the grain wheel should be set to lead into the binder, in order to reduce the draft and make guiding easier.

Heavy Draft. Heavy draft is due largely to side draft and insufficient lubrication. See that sprockets and gears line up, and that chains are put on correctly and run as loose as possible. Sometimes in setting up the machines the bull wheel is not started squarely in the quadrants.

Chains. Chains should be run as loose as possible, with the hooks out and leading as the chain passes over the driving sprocket. Tight chains wear rapidly and result in very heavy draft. They also cause rapid wear on sprockets and bearings. The sprocket wheels must be in line. Oil or grease should not be used on chains where there is dust or sand.

Bearings. Bearings, especially those on a new machine, should be tested occasionally in order to guard against heating. This may
be done simply by feeling the bearing. If the bearing fits tightly or is not in line with the shaft, extreme wear and heating will result. Where a shaft is mounted on a flexible frame, a self-aligning bearing is used (Fig. 3) to prevent wear and heating.

**Gears.** Gears must be properly meshed to prevent wear and the possibility of slipping. This fact is especially true of the large bevel gears at the back of the binder which are driven from the bull wheel and deliver all the power required to operate the binder. When gears are properly meshed, the teeth fit into each other as far as possible without binding. If the gear teeth slip past each other, one of the gears will usually break. In this case, it usually is best to replace both gears.

![Diagram showing adjustment for taking up wear in bevel gears on binder](image)

**Fig. 21.—Adjustment for Taking Up Wear in Bevel Gears on Binder**

When the gears are properly meshed, the teeth fit into each other as far as possible without binding. If the gear teeth slip past each other, one of the gears will usually break. In this case, it usually is best to replace both gears.
Canvas Trouble. Both the lower and upper elevators must be square. In testing for squareness, see that both diagonals are the same (Fig. 22). In making the diagonals align properly, they can be changed for the lower elevator by the adjustments on the brace rod to the frame, and for the upper elevator by the adjustments on the diagonal brace, or the attachment of the elevator to the goose-neck at the back. The upper elevator should be the same height above the lower elevator at the front and back. This adjustment can be made at the attachment to the goose-neck.

Creeping of the canvas is caused by the elevators not being square, or the canvas being loose on one side. The canvas should have the same tension at both sides. Test the tension by lifting with the finger. If one side of the canvas travels faster than the other, the slats go over the roller crooked, and break. If the slats on a new canvas are too long, they will bind and break. All canvases should be slackened when they are not in use.

Roller Troubles. If a roller binds at one end, examine the box to see that it is fitted properly. Binding at both ends is usually caused by the frame being pulled together too tightly by the tie rods. Loosen the tie rods until the roller moves freely.

Often the lower elevator roller at the front will wrap with short pieces of straw or green stuff. Wrapping with short straw is caused by one end of the platform being lower than the other, thus cutting off part of the stubble from the round before. The platform should be run level from end to end. If the roller wraps with green material, raise the platform or tilt up the front edge.

Adjustment of Sickle Bar Parts. See discussion on page 51.

Manipulation of Reel. The proper manipulation of the reel is essential to the making of good bundles. The reel slats should hit the grain 2 to 3 inches below the heads, and must be adjusted to suit the changing height of the grain. In this position the reel lays the straw back evenly on the platform. If the reel is too low, it throws the straw too far back or the reel slats carry it up. The reel slats should
be run parallel to the platform. Most binders have the reel mounted so the inner end of the slat travels ahead of the outside end. The reel slat is placed in this position for the purpose of throwing the heads of grain out and away from the elevators, thus counteracting their tendency to go in head first.

**Adjustments for Making Bundles.** One of the chief difficulties in making good bundles is the failure of the operator to use freely and intelligently the adjustments provided for that purpose.

The operator who secures the best possible results from the binder will see that the reel is manipulated properly. The butter should always be run as nearly at right angles to the elevator rollers as possible, in order to make a square butt. The binder head is made so that it can be shifted back and forth, giving a tying range of about 15 inches. With the butter stationary, the head must be shifted back and forth as the length of grain changes, in order to tie the bundle at the proper place. The binder-head roller should be well oiled in order to slide and make shifting easy. The header board should be adjusted to suit the length of the grain. In extra heavy long grain it can be laid down flat. The grain checks should be just tight enough to prevent the straw from working under and past them. The head end of the straw tends to travel faster than the butt end, and goes up the elevators first; this results in poorly formed bundles. This trouble can usually be overcome by fastening a steel strip to the outer end of the platform, allowing it to lie on top the canvas, where the heads fall on it. In more severe cases crimp the half of this steel strip so that it will offer more resistance. In extreme cases take the rope with which the twine was wrapped, and let it drag on the platform canvas. Sometimes it will be necessary to tie knots in the rope to retard the heads.

To get down grain that leans away from the binder, tilt the platform down and run the reel forward and down, so as to pick up the straw and lay it on the platform.

To get down grain that leans toward the binder, tilt the machine down, and run the reel as low as possible and back on the platform. This carries the straw away from the sickle.

It is difficult to make a good bundle in very short grain. In order to adjust the binder to short grain, run the platform level or tilt the front end up if possible. Use the methods described above for retarding the heads. Throw the binder head forward as far as possible. It may be necessary to bring the butter back, in order to tie the bundle in the proper place.

In long, tangled grain loosen the grain checks slightly, so as to allow the ends of the bundle to slip out when discharged, and adjust the head so that it will tie a looser bundle.

The cover of the deck is made adjustable so that it can be raised or lowered. In case of heavy or tangled grain the cover can be raised
to give more room. With light, fluffy grain the straw tends to pile up just as it comes on the deck, and the packers cannot reach it. Lowering the deck cover will help to prevent this.

**Twine Tension.** The purpose of the twine tension is to take up the slack as the needle pulls the twine from the box in its advance to tie the bundle; the tension is not for the purpose of making a tighter bundle. Tight twine tension causes wearing of the needle eye, breaking of the twine, and failure to tie bundles.

**Binder-Head Troubles.** The binding attachment contains many parts that are most troublesome. Failure to realize that its mechanism must be accurately timed is a source of much trouble. In the following discussion the binder head will be considered the entire binding attachment with the exception of the knotter head, which will be discussed separately.

The binder head is driven from one end by the continually revolving packer shaft, which receives its power from the elevator chain. At the other end of the shaft is fastened a casting called the binder-head drive, or dog driver (Fig. 23), which carries either two small rollers or a number of notches on its inside edge. Between the binder-head drive and the countershaft, which drives the cam wheel of the tier shaft, is a clutch consisting of a bevel gear and the dog. The latter part is attached by means of a bolt to one side of the bevel gear. The dog has a shoulder against which the binder head drive pushes when the dog spring forces the dog out in its path. When the binder head is at rest, the stop arm drops down in the path of the dog and

![Fig. 23.—Driving Parts for Binder Head](image)
pushes the dog back toward the center of the gear, so that its shoulder does not come into contact with the drive.

**Timing the binder head.** If the addition of new parts requires the removal of some of the timing mechanism, the binder head can be retimed as follows:

Remove from the packer shaft the binder head drive, or dog driver, and the bevel gear to which the dog is fastened. Turn the discharge arms in the direction of rotation until they are in a locked or "resting" position. Now replace the bevel gear with the dog, pulling the dog back close to the center of the gear, and mesh the gears, with the dog held back in the above position by the stop arm. Replace the dog driver and be sure it does not strike the dog when the packer shaft turns, unless the binder head is tripped. If it strikes the dog, take up the play by the binder-head lock or stop (Fig. 24), or by the adjustment in the end of the stop arm.

*When the discharge arms fail to start, or when they revolve but part way when the binder head is tripped, the trouble is caused:*
(1) Either by a weak dog spring, which fails to throw the dog out into the path of the binder-head drive and hold it there, or by a missing spring, in which case the dog will not move at all. The remedy is to supply a new spring of the proper strength. (2) The faces of the dog and dog driver may be so worn that they slip past each other. New parts usually are needed to correct this trouble, but filing the faces to their original shape may help.

*When the discharge arms revolve continually,* the trouble is caused in one of two ways: (1) The faces of the dog and the stop arm may be so worn that they slip past each other. To correct the trouble, file the faces off square and take up the play by means of the adjusting screw in the stop arm, or in the binder-head lock (Figs. 24 and 25). If this cannot be done, supply new parts. (2) The binder head may be out of time. To correct this trouble, check the timing (see page 42).

*The casting of very small bundles* may be due: (1) to the binder head being out of time or the stop arm not stopping the dog; or (2) to tangled grain which causes the weight of the bundle to trip the binder.
head. This trouble can be relieved some by manipulating the binder head to cast a cleaner bundle or to trip small, loose bundles.

When the discharge arms are not set tight, the dog driver will strike the dog. This condition allows them to jar down and to throw the dog out, so that the dog driver strikes it and slips past. This causes rapid wear, and soon the parts will fail to hold at all. This trouble may be due to extreme wear in the gears in old machines, or to the binder-head lock coming loose. Set the discharge arms tight by means of the binder-head lock (the adjustment at the end of the stop arm), setting the dog bevel gear ahead one tooth if worn sufficiently, or supplying new parts.

Tight or loose bundles are made by adjusting the trip spring (Figs. 24 and 25); this is the only adjustment used for this purpose. The pressure of the straw against this spring trips the binder head. If a tighter or looser bundle is desired, adjust the tension on the trip

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**FIG. 26A.—PARTS OF THE KNOTTER HEAD OF A WIDELY USED MAKE OF BINDER**

In this type of knotter head a stripper arm is used to strip the knot from the bills. If this arm becomes bent or its roller badly worn, it may fail to strip the knot from the bills, and the band will be broken when the bundle is cast out.
spring, which is always found in the mechanism which trips the stop arm, altho it may differ in shape and exact location.

*Large or small bundles* are made by moving the compressor arm (Figs. 24 and 25) forward or backward by means of an adjustment provided at the bottom of the arm. If the size of the bundle is increased very much, the extra weight of the straw will trip the binder head too soon; the tension on the trip spring must therefore be increased slightly. In smaller bundles, this tension must be loosened.

**Knotter-Head Troubles.** Troubles with the knotter head need not be perplexing to the average operator, since in most cases they may be located quickly.

If poor twine is used, trouble is certain to occur. Twine not fairly uniform in thickness will cause both disc and knotter troubles.

The knotter-bills pinion and twine-disc pinion each have a flat side which must fit close to the track on the knotter-head cam wheel.
In order to keep the bills and twine disc in their proper relation. An adjustment is usually provided on the end of the tier shaft to hold the knotter head in place. If such an adjustment is not provided, washers can be used to force the knotter head towards the cam wheel. Care must be taken that these parts do not bind.

The knife cuts many hundreds of bands during a season and must be kept sharp. Otherwise difficulties in tying knots will result.

![Knotter Head and Parts](image)

**Fig. 27.—Another Type of Knotter Head and Parts**

In this type of knotter head the discharge arms strip the band from the knotter bills. The twine disc and disc drive can be removed easily for retiming or replacing new parts.

Since the knotter head is very sensitive to adjustments, the nut or screw should be given not more than a quarter of a turn at a time. Failure to observe this rule will soon get the parts out of adjustment and mean considerable loss of time.

If the binder misses enough bundles to indicate serious trouble, the machine should be stopped and the band examined. The condition of the band and the place where it is found are good indications of the accuracy of knotter-head adjustments; they are used here in a suggested system for locating troubles. Most binders resemble each other closely in their respective parts so that the principles discussed will
apply to all types. The bands shown in Fig. 28 illustrate the results of the most common tying troubles.

1. The band may be found clinging to the bills (Fig. 28, 1) with both ends cut off square by the knife. This condition results when the twine tension is too tight and the disc tension too loose. As the needle advances to carry the twine to the disc, the twine is pulled out of the loose disc instead of from the can. As the knotter bills turn to tie the knot, they catch only the single twine brought up by the needle, and tie a single knot in it. The bundle is forced out by the discharge arms, leaving the band on the bills. To remedy the difficulty, try loosening the twine tension, and if this does prove effective, tighten the disc spring slightly.

2. The band may be cast with the bundle with the ends cut off square. It looks like No. 1 but is found with the bundle.

This difficulty is most commonly the result of the tension on the disc being too loose. In this case, however, the twine tension is perfect but the disc itself is too loose. Both ends of the twine extend across the knotter bills and are held in the disc. As the bills rotate to tie the knot, they must pull the twine tighter around the bundle in order to get twine for tying the knot. Because the disc is too loose, the disc end of the twine is pulled out of the disc, and as the bills come around they grasp only the needle end of the twine which is in the disc. This means that a simple knot (slip knot) is tied around one strand of twine. When the bundle is cast out, the expanding bundle pulls the end of the twine out of the slip knot, and the bundle spreads out. Sometimes the end does not slip out until the shocker picks up the bundle. The remedy is to tighten the disc spring so that it will hold both ends of the twine until the knot is tied.

In old binders this difficulty may result from worn parts. If tightening the disc spring does not remedy the difficulty, the trouble may be due to one of four other causes:

(a) The disc may be badly worn. If one notch in the disc is worn, a bundle will be missed every time the notch comes around. To remedy this trouble a new disc should be supplied.

(b) There may be wear under the bills pinion which allows the bills to drop down some. This means that the roller that opens the upper bill is lowered away from its cam track, and as a result the bills are not opened wide. As they rotate to tie the knot, the upper bill, not being open wide, will nose in between the strands of twine, catching only the lower one and tying a slip knot the same as in the illustration. File a washer thin and put under the bills pinion, raising the pin, or better yet, supply new parts. A worn roller on the upper bill will add to this trouble.

(c) The twine disc may be out of time. When the twine disc comes to rest, the notch in the disc should be set up to the tongue so
Fig. 28.—Different Types of Troubles Which May Occur With the Band When the Knotter Head Fails to Tie the Bundle Properly
that a lead pencil will just slip into the notch. In this position the twine will always be placed in the notch. If the notch goes on past this point, both strands of twine will not be placed in the same notch, and the bills will grasp only one end.

(d) The twine tension may allow the twine to lie so loosely on the bills that only one strand is grasped. In this case the twine tension should be tightened slightly.

3. The band may be found on the bills. This band is different from that shown in No. 1, in that one end is crushed. This trouble comes from too tight a tension on the disc, which crushes and weakens the twine, and from too tight a twine tension. As the needle advances to tie the bundle, the twine, instead of coming from the twine can, is broken off at the disc, and as a result a simple knot is tied in one end of the band as in No. 1. Loosen the twine tension and disc-spring tension slightly.

4. This band is the same as that shown in No. 3, but is found with the bundle. The twine tension is perfect but the disc spring is too tight, and as the knot is being tied the twine breaks at the disc instead of pulling out. See the discussion under the first part of No. 2.

5. The band may be found with the bundle and with both ends crushed. The cause for this is too tight a twine-disc tension. As the twine is carried into the disc, it is crushed, so that when the bills start to tie the knot both ends of the twine break off at the disc. This trouble is usually the result of the operator's tightening the disc too rapidly.

6. This band has been cast with the bundle. The appearance of the ends shows that the twine was wrapped around the bills but that the ends were not pulled thru the loop to complete the knot. This situation results from one of two causes:

(a) The knotter-bills spring may be loose, resulting in a failure of the bills to hold and pull the ends of the twine thru the loop completing the knot. Tighten the bills spring.

(b) The bills hump or bills cam roller may be worn. The same things happen as in (a). A hump can be filed on the underside of the bills in some cases, but it is best to get new bills and bills shaft.

7. On binders that have a stripper arm this kind of band may appear. When the knot is tied, the stripper arm advances to strip the knot from the bills. If the bills are too tight or the bundle is too loose, the twine will draw up around the bundle and not be stripped from the bills, the result being that when the bundle is cast, the twine is broken. Loosen the tension on the bills, or adjust the head to tie a tighter bundle. Sometimes the stripper arm may be bent, and the stripper does not advance far enough to remove the knot from the bills.

8. This kind of difficulty, which results when the needle does not place the twine in the disc, is caused in five different ways:
(a) A slow needle. The needle must carry the twine forward and down so that it is placed in the disc notch. A slow needle does not come up far enough to do this. The trouble can be remedied by shortening the needle pitman. Be sure that the needle does not strike the breast plate.

(b) A badly worn needle eye. This usually results from too tight a twine tension. If a new eye cannot be supplied, the wear can be repaired by welding, shortening the needle pitman rod, or supplying a new needle.

(c) A bent needle. Straighten the needle by slipping a piece of gas pipe over the end. The needle moves in a perfect circle. In order to check its straightness, make a mark on the deck where the needle comes thru, and see that all parts of the needle check on the mark as the needle advances.

(d) Trash being carried up by the needle and obstructing the disc. This is not a frequent cause of failure to tie but in case it is troublesome, cut the grain higher to get away from trash and heavy green stuff.

(c) The disc being out of time.

9. The band illustrated here is a perfect band as tied by one make of binder. Some operators believe that the extra loop is a waste of twine, but in other binders the end which is looped thru the knot is cut off and falls to the ground.

Miscellaneous Suggestions. When the twine tension is broken or missing, the slack twine may wind around the bills and give trouble. In order to locate the tying trouble from the band, in case it continues to miss tying, it is necessary to stop the machine as soon as a bundle is cast. If several bands are wound on the bills, it is impossible to locate the trouble from the band.

MOWERS

A lack of knowledge as to the care and repair of mowers has resulted in many of these machines being discarded several years too soon. A number of adjustments are provided on mowers which, if properly made, will lengthen the life and increase the efficiency of the machine and prevent breakage.

Heavy Draft. Heavy draft is most often caused by lack of lubrication, and a dull sickle. Other causes for heavy draft are non-alignment of the pitman and cutter bar, and improper adjustment of the cutter-bar parts.

Non-Alignment. This trouble is usually caused by wear in the hinge between the cutter bar and the yoke, which allows the outer end of the cutter bar to drop back. In this position the power delivered from the pitman to the sickle must be delivered at an angle, which
causes excessive wear and heavy draft. To check the cutter bar for alignment, a string stretched down the center of the pitman rod (Fig. 29) and out to the end of the cutter bar, must touch the same parts of the cutter bar all along its length. Non-alignment usually does not occur in mowers until they have been used for several seasons. Fig. 29 shows a cutter bar properly in line with the pitman.

Many of the mowers are so constructed that the outer end of the cutter bar is from 1 to 1 1/2 inches ahead of the inside end. This is not especially objectionable, because the mower can be used for a number of years without the cutter bar being badly out of line at any time. Not many mowers carry aligning devices. Supplying new pins at the yoke will often help to line up the cutter bar properly. If a mower has an aligning device, it accomplishes alignment by changing the angle at the yoke where it joins the drag bar or push bar. Shortening the drag bar or lengthening the push bar will not in most cases give alignment.

Function of Cutter-Bar Parts. The cutting action of the mower is the same as that of a pair of shears. The sickle acts as one of the blades and the ledger plate in the guard (Fig. 30) as the other. These two cutting surfaces are held together by the clip, which serves the same function as the screw in the shears. The fact that the sickle cuts at an angle causes a backward pressure, which is taken care of by the wearing plate that fits in under the sections and up against the sickle rib. The wearing plates hold the sickle in a straight line thru its entire length. Each plate has slotted holes so that it can be pushed forward when wear occurs on its face.

Sickle Sections Must Center. When the pitman rod is on either the outer dead center or the inner dead center, the sections on the sickle should exactly center in the guards. In other words, the sickle must be centered at each end of its stroke (Fig. 31). This rule does not hold true for grain binders because the sickle moves thru two guards, instead of from one guard to the next, as in the mower.
Uneven Stubble. Sometimes the stubble is ragged and not cut even, which causes side draft. This is due to the cutter-bar parts being out of adjustment in one of the following ways:

*Guards bent out of line.* A guard may be bent down, carrying the ledger plate away from the sickle; which results in the grass dragging in and being pulled out or crushed at this point instead of being cut. If a guard is bent up, it lifts the sickle up off the ledger plate of the guard on either side of it, and thus prevents the sickle from cutting at two places. In either case the stubble will be ragged, and side draft will result. Check the guards by sighting down the cutter bar about 2 inches back from the point of the guard. Any guards bent up or down can be straightened into place by a sharp blow of a hammer on the thick portion of the guard. The wing of the guard must never be bent down.

*Clips worn.* Often the underside of the clip and the place where it rubs on the sickle are worn enough to allow the grass to wedge in between the sickle and the ledger plate, and be chewed off or pulled out. This of course gives excessive side draft. A dull sickle will augment this trouble. Bend the clips down by striking them lightly on top with a hammer. After each blow test the sickle by hand to see that it can be moved back and forth without binding. The clips must hold the sickle sections close to the ledger plates, thereby obtaining a good shearing effect.

*Wearing plates not adjusted.* The sickle rib, rubbing along the edge of the wearing plate, keeps the sickle working in a straight line. From time to time the clip must be loosened, and the wearing plate...
pushed forward up against the sickle rib. If the top of the clip wears off so that it does not hold the point of the section down on the ledger plate, it is best to supply new clips. On some mowers the wearing plate is not placed on top the cutter bar but at the back of the guard as shown in Fig. 30.

**Ledger plates dull or nicked.** The ledger plates should be in perfect condition. Dull or nicked plates should be sharpened if possible or new ones supplied. Remove the guard to grind the plate. If a new plate is to be supplied, punch out the rivet that holds the ledger plate and rivet in the new one. If the new ledger plate is higher than the others, it can be lowered by placing a strip of tin between the guard and the underside of the cutter bar.

A loose section in the sickle will give uneven stubble, and can be detected easily by an examination of the place that is clogging.

**Non-centering** of the sickle in guards. See discussion on page 51.

**Sickle Breaking.** This is a trouble which is very irritating to the operator. The break usually occurs somewhere along the reinforcement at the sickle head and usually thru a rivet hole. It often happens in light cutting, which would indicate that it is a result of some improper adjustment. The breaking is caused by wear on the underside of the clips and guides which hold the sickle head down. This allows the sickle to be bent down on the out stroke and to bend up on the back stroke. Usually the wearing plates and clips at the sickle head (Figs. 29, 30) can be lowered by removing some of the shims that are placed under them. If this does not take up the play, new clips and wearing plates will be needed and possibly a new sickle head. Non-alignment does not cause breaking of the sickle, but it does cause more rapid wear at the sickle head.

**Other Troubles.** When the outer stubble is shorter than the inner stubble, it is usually due to the outside shoe-runner being set up too close, so that the cutter bar is lower at the outer end.

Clogging at one point of the cutter bar is due to improper adjustment of the cutter-bar parts. See discussion under "uneven stubble."

Clips worn at the center of the cutter bar are caused by the bar humping up at the center as a result of the lifting spring being too tight.
Knife parts become gummed up if oil is used on the sickle parts when juicy grass is being cut. The oil and juice combine to form a sticky gum, which causes heavy draft and poor cutter-bar work. Run the sickle dry, but see to it that the sickle head is oiled.

**Care of the Sickle.** The sickle should be kept sharp at all times and special care should be exercised in grinding it. Try to keep the cutting angle as near the angle of a new section as possible. Usually too much grinding is done at the point, and not enough at the base of the section. Sections which have been ground off short at the point should not be allowed to remain in the sickle. It is always a good plan to have an extra sickle sharpened and ready for immediate use. In removing the sections do not punch out the rivets, as the holes become enlarged and the sickle rib weakened. Cut the rivet heads off with a cold chisel. Round off the tops of the new rivets after putting them in, and be sure that the sections are all tight.

**Joints at End of Pitman Rod.** These joints should be kept tight. If play is allowed to occur on either joint at the ends of the pitman where it joins the balance wheel, or the sickle head, the constant beating will cause rapid wear and soon new parts will have to be supplied.

**Drive Wheel Ratchets and Pawls.** If the sickle does not move as soon as the wheels start, the trouble may be due to worn gears, but more often to the pawls and ratchets of the drive wheel being worn or clogged (Fig. 32). In taking the drive wheel apart to locate the trouble, care should be exercised in the removal of the hub face so as to avoid breakage. A spring may be broken, the ratchets clogged or worn, or the face of the pawls badly worn. When assembling the parts of the drive wheel after repairing or cleaning it, the ratchets should not be oiled. Several pawls are placed in a wheel, but only one of them does the driving. They are so placed that the wheels move only a very short distance before one of the pawls will engage.

**Bevel Gears.** An adjustment for keeping the bevel gears properly meshed, similar to that in binders, is usually provided at the end of the shaft carrying the large bevel gear. If a means of adjustment is not provided at the end of the shaft, the bevel gears may be forced together by putting washers back of the large gear.
Causes of Side Draft. Side draft is caused by non-centering of the sickle sections in the guards, and by improper adjustments of the cutter-bar parts which cause a dragging of the stems. A dull sickle will not cause side draft if it is held down against the ledger plates so that the grass cannot pull under it. It is often thought that 7- or 8-foot cutter bars give side draft. If the cutting parts of the bar are kept properly adjusted, there is no more side draft than with shorter bars.
INDEX

BINDERS .................................. 35
Bearings .................................. 37
Binder-head
Timing of .................................. 42
Troubles .................................. 41
Bundles, adjustments for making ....... 40
Canvas trouble ................................ 39
Chains ..................................... 37
Cutting full swath ........................ 37
Draft, heavy and side ..................... 37
Gears ...................................... 38
Hitch ...................................... 37
Knotter-head troubles ..................... 45
Reel, manipulation of ..................... 39
Roller troubles ............................ 39
Sickle-bar parts, adjustment of ......... 39
Starting .................................... 35
Storing ..................................... 36
Twine tension ................................ 41

CORN CULTIVATORS ......................... 32
Excessive neck weight ..................... 35
Shovel cultivator .......................... 32
Adjustment of ............................ 34
Surface cultivator ........................ 32
Adjustment of ............................ 33
Two-row cultivator ........................ 33

CORN PLANTERS ............................ 29
Accumulative planters ..................... 30
Accuracy in checking ...................... 30
Accuracy of drop .......................... 29-30
Blank hills ................................ 32
Clutch troubles ............................ 32
Cracking of seed .......................... 31
Fertilizer attachments ..................... 32
Gage shoes ................................ 32
Hill-drop planters ........................ 30
Soybean attachments ....................... 32
Stringing of hills ........................ 31
Timing plate drive rims .................... 32

HARROWS
Disc ....................................... 24
Bearings .................................. 24
Blades .................................... 25
Scrapers .................................. 25
Snubbing irons ............................ 25
Special adjustments ....................... 25
Storing .................................... 25
Transporting ............................... 25
Drag or spike-tooth ........................ 24
Sharp teeth ................................ 24
Storage .................................... 24

GRAIN DRILLS .............................. 25
Double-run, or internal, force feed .... 26
Fluted force feed .......................... 26

Furrow openers ............................ 27
Double-disc ............................... 27
Hoe ....................................... 28
Shoe ...................................... 28
Single-disc ................................ 27
Grain tubes ............................... 28
Sight feed .................................. 28

MACHINERY ................................ 3
Bearings, types of ........................ 7-8
Care when idle ............................. 9
Lubrication ................................ 8
Metals used in construction of .......... 5-7
Selecting new ............................. 3-4

MOWERS .................................... 50
Bevel gears ............................... 54
Cutter-bar parts, function of .......... 51
Draft ..................................... 50
Heavy ..................................... 50
Side ....................................... 55
Non-alignment ............................. 50
Paws, drive wheel ........................ 54
Pitman rod, joints at end of .......... 54
Ratchets, drive wheel ........................ 54
Sickle ..................................... 53
Breaking .................................. 53
Care of .................................... 54
Centering of sections ..................... 51
Uneven stubble, causes of ............ 32-53

PLOWS .................................... 10
Bottoms, types of ........................ 10
Chilled cast iron .......................... 10
Soft-center steel .......................... 10
Solid steel ............................... 10
Break pin .................................. 20
Coulter, set of ............................ 12-13
Cut, width of ............................. 13
Draft ..................................... 14
Reduction by proper hitches ............. 16
Eveners .................................... 18
Furrow wheels, set of ................. 14
Landside friction .......................... 14
Side draft ................................ 17
Single-trees ................................ 18
Suction
In share .................................. 11
Land ....................................... 11
Tractor gang plows ........................ 18
Troubles, horse and tractor plow ....... 20
Engine gang ............................... 22
Furrow bank ............................... 21
Furrow crowns, uneven .................... 21
Heavy soils ................................ 23
Penetration ............................... 22
Scouring ................................. 21
Wing bearing ............................. 12