THE 4-H TRACTOR CARE AND SAFETY PROJECTS

FIRST YEAR — TRACTOR PROJECT

Units

1. Learning How to Be Safe
2. What Makes an Engine Run
3. Nuts, Bolts, Screws and Rivets
4. The Instrument Panel
5. Controls for Your Tractor
6. Daily Maintenance and Safety Check
7. Starting and Stopping Your Tractor
8. Clean Air for Your Engine
9. Periodic Lubrication and Maintenance

SECOND YEAR — TRACTOR PROJECT

Units

1. Tractor Safety on the Farm
2. Oil for the Engine
3. Mixing Fuel and Air
4. Battery Service and Spark Plugs
5. Cooling Systems for Engines
6. Care of Tires
7. General Lubrication
8. Tractor Records and Operating Costs

THIRD YEAR — TRACTOR PROJECT

Units

1. Tractor Safety on the Highway
2. Engine Ignition Systems
3. Hitches, PTO and Hydraulic Controls
4. Steering, Brakes and Front Wheels
5. Valves and Valve Service
6. Power Transmissions
7. Winter Care and Troubleshooting
8. Tractor Records and Ownership Costs

FOURTH AND ADVANCED YEARS — MACHINERY PROJECTS

Units

1. Safe Use of Farm Machinery
2. Transmitting Power
3. Tools For Breaking The Soil
4. Applicators For Chemicals
5. Servicing Seed Planters
6. Cutters for Crops
7. Grain Harvesting
8. Farm Machinery Management

ACKNOWLEDGEMENTS

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4-H TRACTOR PROGRAM
FOURTH AND ADVANCED YEARS
FARM MACHINERY CARE AND SAFETY PROJECT

This is the fourth and last book in the 4-H tractor project. In the first three projects you learned about tractor care and safety. Now you can continue your enrollment in the project by learning about the care, operation and safe use of the machinery on your farm.

It is not intended for you to try to complete the entire Fourth Book in one project year. Divide it into two or more years of activity according to the machines on your farm. Take your time and do the jobs thoroughly.

You will find some challenging jobs waiting for you in this phase of the program. At the same time, you can continue keeping records on your tractor.

It is expected that you will select one or more machines on your farm when you do each job outlined in the lessons. For instance, if you do the unit on transmitting power, you may need several different implements to represent all of the ways that power is transmitted. If you learn how to adjust and take care of chains, belts, gears, slip clutches, etc. on one machine, you will then know how to take care of these parts on other machines. If you learn how to check the rate of planting on one machine, you should then be able to apply what you learned to other seed planters on your farm. If you have several implements to work on, you may want to repeat a lesson and work on more machines.

Equally important with care and safety of your equipment is the 4-H goal of helping you to become a better citizen in your community. Your 4-H training will be beneficial throughout your life.

WHAT TO DO

Take time to read the information in this unit. Go through the work sheets and complete the demonstrations and jobs outlined. The greater your interest and effort, the more you will learn. Remember, safety is always important!

Ask your leader about Unit 8 on record keeping and farm machinery management. He may want you to start on this unit right away.

Read each paragraph carefully. Study your Operator's Manual and put into practice what you learn by actually working with a tractor.

At the end of each unit, record the jobs that you have finished. There are also some questions to answer. Answer only those that apply to your tractor. Use the check-up sheets to see how much you have learned. All you have to do is put the letter for the correct answer at the right of the page.

Your keys to success are: Keep records up to date as you complete each work unit . . . Give demonstrations and talks on tractor care and safety . . . Take part in local and county tractor operators' contests . . . Encourage other boys to enroll in the club . . . Become a junior leader and help your leader to assist other young members . . . Practice what you learn on your tractor at home. Remember, you should know the "why" as well as "how" . . . Submit records needed for project completion . . . Ask your leader for information about the opportunities for awards and recognition.
MEMBER'S SUMMARY
FOURTH AND ADVANCED YEARS
FARM MACHINERY CARE AND SAFETY PROJECT

Name ____________________________________________ Age ________ Years in 4-H ____________________________

Address ________________________________________ County ________ State ______________________________

Name of Club ______________________________________ Name of Leader _______________________________

<table>
<thead>
<tr>
<th>Date and Place of Meetings</th>
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Date meeting held

Did you attend?

Date work unit completed

Date check-up sheet completed

DEMONSTRATIONS: Where? When? Topic?

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

TRACTOR OPERATING CONTESTS: Date? Where? Placing?

__________________________________________________________________________________________

__________________________________________________________________________________________

OTHER EVENTS: Exhibits, Tours, etc.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________
SAFE USE OF FARM MACHINERY

Farming is considered a dangerous occupation. In fact, agriculture has the third highest worker death rate of all industries in the United States. This may seem strange when some of the machines used in factories are more dangerous than farm machines. It is the condition under which they are used that makes the difference. A factory worker uses the same machine every day and follows a standard routine that includes all necessary precautions. Farming methods and machines are constantly changing. Other than the tractor, each of the machines may be used only a few days a year. The operator never gets a chance to establish a routine that lets him work with his machine with complete safety. As an operator of farm machines, you have to make up for these shortcomings with your ability to reason. You will have to establish some hard and fast rules for being safe - and then follow them completely at all times.

THE FACTS

A report by the United States Department of Agriculture tells us that each year about 1 out of every 5 of our farm population has an accident serious enough to cause time loss from the job. One person in 33 suffers a serious accident resulting in a disabling injury. One in 1,600 ends up a fatality. In each of these groups, accidents with farm machinery account for about one-third of the total, making the most frequent cause of accidents involving our farm population.

WHAT CAUSES ACCIDENTS?

Many different surveys have been made to find out why accidents happen. In nearly every case, the results are similar to the following summary:

<table>
<thead>
<tr>
<th>Cause of Accident</th>
<th>Percent of total</th>
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</thead>
<tbody>
<tr>
<td>Unavoidable (lightning, or other forces of nature)</td>
<td>2-4</td>
</tr>
<tr>
<td>Use of faulty equipment</td>
<td>10</td>
</tr>
<tr>
<td>Carelessness (includes all human factors)</td>
<td>86-88</td>
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</tbody>
</table>

As you can see, there really isn't much excuse for an accident.

YOU ARE NO MATCH FOR A MACHINE

Any moving part of any machine, whether it be a pulley, blade, sprocket, belt, shaft, gear, chain, knife or hammer, is faster and more powerful than you are. The high-speed blade of a power lawn mower is capable of cutting off your toes even though it is powered by a very small engine. And a shaft that appears to be turning slowly can grab your clothes and wrap you up before you can make a simple move to avoid the accident.

SHUT IT OFF!

This is the most important rule of all. Whether a machine is simple or complex, and regardless of its size, speed or power - always shut it off before working on it. It is the only sure way you can avoid trouble with a machine.
With a PTO driven machine you need to be alert to the possibility that the machine will coast for a while after you have disengaged the power shaft. This is particularly true with a baler or foarge chopper. Always allow time for the machine to come to a complete stop before you open a cover or attempt to work on it.

**KEEP SHIELDS IN PLACE**

Shields are intended to be used on moving parts of machines to protect the operator. Sometimes it is tempting to leave off a shield to make it easier to adjust or repair the machine. But this is a dangerous practice that can lead to an accident. Give your machine a careful inspection and see where shields are missing. Replace all missing shields if they are available. If you don’t have the shield or can’t get one from your dealer, perhaps you can make one.

**DRESS PROPERLY**

An almost unbelievable number of accidents happen because of loose or improperly fitted clothing. It only takes a small string caught in a gear or shaft to cause a serious accident. Be especially careful of gloves, sleeves and pant legs.

**AVOID FATIGUE**

If you work when you are overly tired, you are inviting an accident. You will do things that you would normally never do if you were properly rested. There are a few things that can be done to avoid fatigue even when you know that you will have to work long hours. Eat a balanced diet. Take along, or have someone bring you, a snack to eat between meals, in the middle of the morning and afternoon. If possible, let someone else operate the machine, even for a short time, to give you a rest. Fatigue is listed as a major cause of accidents.

**OTHER GOOD SAFETY RULES**

Here are some good safety rules that apply to many different machines. As you read this list, think of others that apply to your machines at home. There is a place in the work sheet to add to this list.

1. Set tractor wheels out - this is important in helping to prevent tipping accidents.
2. Always set the brakes - before leaving the tractor seat. This may prevent an implement from running over you.
3. Don’t use a stick or other object to unplug a machine - unless you have first shut off the machine.
4. Keep equipment adjusted - well-adjusted equipment will cool hot temps and prevent accidents.
5. Watch out for others - always make sure other people, especially children, are kept away from the area where machinery is working.

**NOW IT’S UP TO YOU**

Throughout your 4-H tractor projects, you have had a chance to learn how accidents are caused and how to prevent them. Remember that an accident can happen: When you commit an unsafe act, or when you allow an unsafe condition to exist. Your farm is only as safe as you make it - as safe as you think and act. Put what you know into practice. Start right now - pledge yourself to safe operation on your farm machinery.
SAFE USE OF FARM MACHINERY

Select one of the larger power driven machines on your farm for this unit. A cotton picker, beet harvester, potato digger, corn picker, combine, forage chopper or baler would be a good one to use. You will need your Operator’s Manual to help you with this unit. Eliminate all hazards.

1. Check all shafts that require a shield. How many are needed? ________________________________
   How many were missing? ______ which ones? ____________________________________________
   Could any of the missing shields have caused an accident? ________________________________
   Why? ______________________________________

2. Now check all places where guards are needed to cover gears, sprockets, pulleys, belts, chains, etc. How many are needed? ________________ How many missing? ________________________________
   Which ones? ____________________________________________
   Could any of the missing guards have caused an accident? ________________________________
   Why? ______________________________________

3. List any places on the machine that are not normally covered with a shield or guard but might cause an accident (the cutter bar of a combine, for example) ____________________________________________
   How can you make sure none of these places will cause an accident? ____________________________

4. Is it necessary to wear close-fitting clothes when operating this machine? ____________________________
   Why? ______________________________________

5. Make a list of accidents that you think can happen while operating this machine. How can such an accident be prevented?

<table>
<thead>
<tr>
<th>Possible accident</th>
<th>How it can be prevented</th>
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</table>

6. If this machine becomes plugged during operation, how could you safely correct the trouble? ___________

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
Place the letter for the correct answer at the right of the page.

1. Farm machinery is involved in (A—10) (B—20) (C—35) percent of the accidents involving the _______ farm population.

2. It has been estimated that (A—50) (B—30) (C—over 80) percent of accidents are due to plain _______ carelessness.

3. Your first reaction in the case of an emergency (A—may require as long as 1 second or more) _______ (B—is usually less than 1/2 second) (C—is to do nothing).

4. On the basis of the accident rate per man-hour, it is safer to (A—work in a factory) (B—work on _______ a farm).

5. A tractor with a wide front end is (A—more) (B—less) likely to tip than a tricycle type tractor. _______

6. Accidents happen to approximately (A—20) (B—10) (C—40) percent of our farm population each _______ year.

7. Many accidents with farm machinery happen when (A—the machine reaches out and grabs the _______ operator) (B—the operator starts tinkering with the machine while it is running.)

8. It is estimated that faulty equipment is a factor in (A—2) (B—24) (C—10) percent of the _______ accidents with farm machinery.

9. When getting ready to operate power-driven equipment, the first step is to (A—start it up and _______ see if it still runs) (B—be sure all of the shields and guards are in place) (C—check the speed of the PTO).

10. Safe operation of farm machinery is (A—impossible) (B—a matter of pure chance) (C—a matter _______ of making up your mind to be a safe operator).

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members, the more you learn.
Machines need power to turn shafts, fans, cylinders and many other moving parts. We get power to operate machines from the tractor power-takeoff and from the belt pulley. We get power from engines mounted on implements. We may also get power from drive wheels that run on the ground.

Power is transmitted by flat belts, V-belts, chains, gears, clutches, shafts and also by hydraulic pressure. If we need a great deal of turning force (or torque), we don’t change the power - we cut down on the speed of the driven part. We do so by using small gears, sprockets or pulleys. If we want less torque at higher speeds we use larger gears, sprockets or pulleys to drive smaller ones. There is always some friction loss when power is transmitted through gears and belts.

**PROPER SPEED FOR EFFICIENCY**

One of the first things to understand when working with a machine is how to make sure that it is running at the proper speed. You will sometimes want to change the size of sprocket wheels or gears. If you do, remember to count the number of driving teeth and compare this figure with the number of driven teeth.

When power is transmitted by belts it is often necessary to change pulleys to obtain the proper speed. Some pulleys for V-belts are adjustable for speed changes. You can change the diameter of the pulley by moving one half of the sheave in or out with respect to the other. This is done by inserting or removing spacer disks between the two halves, or by special levers, or by moving one half of the sheave toward or away from the other half.

**MEASURING A PULLEY**

Working with pulleys for flat belts, you can determine the speed by measuring either the diameter of the pulley or the distance around it. Because pulley size usually is given in diameter, we measure the diameter of a pulley when checking the speed of the machine. To measure the diameter of a pulley, lay two straight pieces of wood or metal across the highest part or crown of the pulley, measuring the distance between the pieces. The speed of the driving pulley times its diameter is equal to the speed of the driven pulley times its diameter. Here is an example: The speed of a pulley 14 inches in diameter is 800 rpm. This pulley is driving another pulley 8 inches in diameter. How fast will the smaller pulley turn?

\[
800 \times 14 = ? \times 8
\]

\[
\frac{800 \times 14}{8} = 1,400 \text{ rpm}
\]

Fig. 7. This V-belt pulley can be adjusted.

Fig. 8 Measuring a pulley.
When determining the pulley ratio for V-belts, measure the outside diameter of each pulley and subtract the thickness of the belt. The ratio of these two numbers gives you the speed ratio. (This works only when the belt is running nearly flush with the top of the pulley.) For example: The speed ratio between a 3-inch pulley and an 8-inch pulley using a 1/2-inch belt is 1/m.

\[
\begin{align*}
8" &- 1/2" = 7-1/2" \\
3" &- 1/2" = 2-1/2"
\end{align*}
\]

\[
\text{ratio} = \frac{7-1/2}{2-1/2} = 3
\]

In other words, the speed of the smaller pulley is just three times the speed of the larger.

POWER-TAKE-OFF HITCHES

When implements are pulled by a tractor and, at the same time, are being driven by the power-take-off shaft, proper and safe hitching is more difficult. Sometimes operators connect machines and tractors not built to work together. These makeshift arrangements are often dangerous. Tractors and PTO shafts have been standardized in two sizes (1-3/8 inch and 1-3/4 inch) and two speeds (540 and 1000 rpm). The desired dimensions for the four types of shafts are shown in the following table.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>NO. OF TEETH</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td>540 rpm, 1-3/8&quot;</td>
<td>6</td>
<td>14&quot;</td>
<td>6-12&quot;</td>
<td>13-17&quot;</td>
</tr>
<tr>
<td>540 rpm, 1-3/4&quot;</td>
<td>27</td>
<td>14&quot;</td>
<td>6-12&quot;</td>
<td>13-17&quot;</td>
</tr>
<tr>
<td>1000 rpm, 1-3/8&quot;</td>
<td>21</td>
<td>16&quot;</td>
<td>6-12&quot;</td>
<td>15&quot;</td>
</tr>
<tr>
<td>1000 rpm, 1-3/4&quot;</td>
<td>20</td>
<td>20&quot;</td>
<td>8-10&quot;</td>
<td>19&quot;</td>
</tr>
</tbody>
</table>

Follow these recommendations. If you buy a used combine or tractor different from the one formerly used, check the hitch and power-take-off to make sure they are the proper length. Have the proper size of coupling. See that safety shields can be attached.

---

Fig. 9 Older tractors have two power connections - PTO and belt pulley.

Fig. 10 There are two standard PTO speeds.

Fig. 11 How to hitch your PTO (shows what happens when you turn).

Fig. 12 How to hitch your PTO (shows what happens when you turn).

Fig. 13 Standardized hitch with PTO.
CHECKING SPEED

Suppose you wanted to find out how fast the cylinder on your combine turns. You will need a pocket watch with a second hand.

1. Turn the combine cylinder by hand and count the number of turns required to turn the wheel once or a straw walker arm to make one shake.

2. Run the combine at governed speed and count the turns the reel or straw walker makes in one minute.

Suppose the combine cylinder turned 30 times for one turn of the reel. You find the wheel turns 35 times in a minute. Now $30 \times 35 = 1,050$ turns or 1,050 rpm for the cylinder.

V-BELTS

V-belts cause much less trouble than flat ones in transmitting power. Since V-belts contact the sides of the sheave grooves, they provide more belt pressure with less pull on the shaft bearing and have greater contact area per unit of belt width than a flat belt. V-belts also can be used with adjustable pulleys for speed changes.

There is no simple way of estimating the power a V-belt will deliver. However, the manufacturers have tables for selecting belts to fit power requirements. Remember that power is a result of speed and torque. Even the smaller belts on large-diameter pulleys running at high speeds will transmit a lot of power. Some of the larger drives are made of many matched belts running side by side. Because of the way V-belts are manufactured, it is important to have new belts matched to the same length when they work together. Otherwise the shorter belts are over-worked, easily worn and eventually cause trouble.

V-belts should also be kept clean. As they wear and ride deep in the groove of the pulleys they should be replaced. On some pulleys the sheave can be adjusted. In general a V-belt should be flush with the top of the pulley.

When you need to replace a V-belt, make sure you have plenty of slack. Don't force a V-belt over a pulley. Remove the pulley, put on the belt and then slide the pulley onto the shaft.
CHAINS

Chains have the advantage of providing a positive drive. If there is danger of breakage because of machine jam, the drive usually will have a slip clutch or shear pin.

Detachable chains are commonly found on farm machinery and are well adapted to light loads and slow speeds. For higher speeds and loads, roller chains are often used. There also are chains with special lugs or flanges for attaching flights or cleats. Chains with lugs are commonly used on machines such as the corn picker for guiding stalks into the snapping rolls.

Chains are made in many different sizes and are numbered. The smaller the number the lighter the chain. A number 45 and number 55 detachable chain have the same pitch diameter; but the number 55 chain is made from much heavier material.

There are several things to watch in maintaining long chain life. The sprockets should be in line. If a sprocket becomes worn it must be replaced. Whenever you put on a new sprocket, always use a new chain. A badly worn sprocket will cause the chain to wear rapidly. A new sprocket and old chain is also undesirable.

It is usually best to run detachable chains with the link hook or barrel forward (the link slot is always to the outside). This distributes wear more evenly between chain and sprockets. On conveyor or elevator chains where you have a long chain and ample means for taking up slack, the chain is often run with the closed ends of the links forward. Since detachable link chains may run in either direction, it is well to examine your machine and note which way the chains run.
**LUBRICATION**

All chains need to be lubricated. Usually SAE 30 or 40 grade motor oil is recommended for the chains. Clean the chains before oiling them. Take them off and wash them in a pan of solvent or diesel fuel before you start the machine. Then dip them in oil. Hang them up to let the excess oil drain off. If the chain is to be used under dusty conditions, soak it in oil and wipe it off. Dirt will be held by the oil. Chains will rust if not protected in storage. Therefore, take them off, then clean and protect them with oil. You may even leave them in oil during the storage season. Be sure to keep chains out of dirt. Don’t throw them in a heap in the shed or drag them across the yard.

**GEARS**

Gears are used for changing shaft direction and for changing speeds. Three kinds of gears are commonly used, the spur or straight cut gear, the bevel gear and the worm gear. The worm gear is used to make big reductions in the gear ratio. Gears require less space than chains or belts but are more expensive. After bevel gears have been used for a long time, they become worn and need to be adjusted by moving them closer together. This can be done by inserting washers, or by loosening a set screw. Be sure you move each one of a pair of bevel gears the same distance so they will continue to mesh properly.

On most equipment, gears are enclosed in a gear case and run in oil. If the case is tight, a straight gear lubricant of 80 or 90 grade or a heavy motor oil is recommended. If there is a problem of leakage, grease is often used. When grease is used, it is better to use a highly stable grease, such as wheel bearing grease or lithium soap grease. In servicing gears, be sure to use a lubricant that will flow at the prevailing temperature. Gear lubricants should be changed at least once a year to get rid of dirt and contaminants. However, where highly stable grease is used in the gear box it may be left longer than a year without changing.

**CLUTCHES**

Clutches on farm machines (not the friction clutches used in the tractor) resemble gears. They have teeth to mesh with each other in driving from one shaft to another or from a sprocket or gear running on a shaft. Some clutches will have square jaws to drive in either direction. Others will have saw-teeth jaws to drive in one direction only. (You should always stop your engine before engaging square or saw-tooth clutches.) Others may have flattened teeth held together by light springs and are used only as safety clutches. If the machinery jams, the clutch will slip, preventing breakage.
Another type of clutch is used as a ratchet. It drives in only one direction. On lawn mowers, it drives the cutter blades alternately with one wheel and then the other, whichever wheel is traveling the longest path. And, of course, it is used for the same purpose on trailed mowers and other ground-driven machines.

Most clutches are used in dirty places where oiling helps collect more dirt. Therefore, it is necessary to clean them with a solvent occasionally and to keep the metal covered so it will not rust. Otherwise, clutches are simple power transmission units that work with little attention.

Whenever you get ready to start a machine, put a little solvent or diesel fuel on the slip clutch and turn the machine by hand to make sure the clutch will slip. It may even be necessary to loosen the adjustment. The main thing is to make sure this protective device will work.

Before throwing a machine in gear, it is always a good practice to turn it by hand and to make sure all parts are free. You should do this when using drills and planters equipped with fertilizer attachments. These can get stuck overnight in damp weather.

**BEARINGS ON MACHINES**

All types of bearings are used on farm machines. There are plain bearings made from babbitt, bronze, wood and other materials. Machines also use many roller bearings, ball bearings and tapered roller bearings. Keep all bearings in proper adjustment and well lubricated. Most machinery bearings are equipped with a grease gun fitting for lubrication. Regular pressure gun grease is usually recommended for these bearings. If some of the bearings are located where they pick up heat, a special heat-resistant grease such as wheel bearing or lithium soap grease may be more satisfactory. Always wipe off the fitting before applying the grease gun.

On some machines, a special sealed bearing is sometimes used. This bearing usually contains enough grease for a season or more. Sealed bearings are widely used on farm machinery. These bearings are lubricated for life and are replaced as a unit (lubricants, seals and all) when they wear out.

Other bearings are sealed within a separate housing. In these bearings, the seals and bearings are repacked and replaced as required.
Select any machine and tractor combination or self-propelled machine you like and learn about transmitting power. Be sure you use your Operator's Manual in learning how to operate and adjust your machine.

1. What power and machine combination did you select? 

2. What is the rated crankshaft speed of the power unit? 

3. How is the machine driven? PTO? V-Belt? Chain? 

4. What kind of clutch or safety release device is used between the power unit and the machine?
   Explain 

   Did you check and adjust the slip clutch? How? 

5. Check the speed of some of the parts of the machine. Example: The beater speed on a combine. List the parts you checked and their speed 

   If these speeds were not the same as recommended in the Operator's Manual, would the machine work properly?
   Why? 

6. Adjust all of the chains and belts on the machine. Tell how you adjust each of the following:
   Roller chain 
   Steel link chain 
   V-Belt 

7. Check all of the safety shields on your power unit and machine. What did you find? Were any missing?
   Bent? 

   Before going on, be sure all of the shields on the machine are in the right place.

8. Does the machine have a gear case? What kind of lubricant is used?
   How often should it be serviced? 

9. How do you lubricate roller chain? 
   Steel link chain? Bevel gears? 

10. Try this problem. A pulley with a diameter of 6-inches runs at a speed of 900 revolutions per minute. It drives another pulley with a diameter of 9-inches. The two pulleys are connected by a 1/2-inch V-Belt. What is the speed of the second pulley?

11. Trace out at least one major operation in the machine. Start with the power source and continue until you reach an important part of the machine, such as the cylinder on a combine. Draw a sketch of the path of the power and indicate the speed of the different devices that are used to transmit power.

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
MEMBERS’ CHECK-UP

Fourth Book Unit 2

TRANSMITTING POWER

* Place the letter for the correct answer at the right of the page.

1. Power: (A—is increased through gears) (B—is not changed through gears except for friction loss).

2. Speed changes may be made by means of: (A—gears only) (B—belt drives, chain drives and gears) (C—clutch).

3. An idler should run on the (A—tight side) (B—loose side) of a V-belt.

4. V-belts are easier on bearings because they: (A—have more surface contact with their pulleys) (B—are narrower and cool better) (C—use the wedge principle and grip the pulleys).

5. Chains waste less power than flat belts but: (A—they are more expensive and need safety clutches) (B—they break easily and are always jumping off sprockets).

6. Like belts, chains can have idlers also. An idler should be on the: (A—tight) (B—loose) side of the chain.

7. Gears: (A—are better than chain drives because of compactness and because less power is lost in distance between machine parts) (B—allow more compactness in design but make the machine more costly).

8. Slip clutches connect one part of a machine to another to transmit power. (A—These clutches should not slip because they will burn out) (B—Slip clutches are made so they will slip for safety to the machine).

9. A ratchet is a clutch that allows the shaft to turn independently on a wheel or pulley that normally drives it. Such a drive: (A—is automatic and should not be lubricated) (B—needs attention to keep it clean and working free).

10. When storing a machine the chains should be: (A—left on) (B—removed, cleaned and protected by oil) (C—tightened and oiled).

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members, the more you learn.
TILLAGE

In preparing a field for seeding, some type of tillage is usually done. The tool used and the number of trips made over the field vary according to the soil type, rainfall, crop and other factors. Generally, tillage is done to accomplish one of the following goals:

1. Prepare the soil for seeding
2. Control weeds
3. Break up compacted soil layers
4. Incorporate crop residue to speed up decay
5. Incorporate chemicals
6. Reduce erosion

In the past, "clean tillage" has been practiced in all areas of the nation. Clean tillage is the practice of covering nearly all weeds and crop residue with soil, and it is usually done with a moldboard plow. The primary disadvantage of clean tillage is that it leaves a bare soil surface exposed to erosion. One way to reduce wind and water erosion is to retain some of the trash-stalks and straw from the previous year's crop on the surface of the soil.

There are several types of tools available that allow the farmer to till the soil without burying all of the protective soil cover. For example, a chisel plow covers only 25% of the surface residue, while an offset disk covers about 50%. Wise use of these tools can produce a compromise that will protect the soil from erosion while still preparing an excellent seedbed.

SAVE FUEL

Not only can soil be conserved, but fuel can be saved by using a chisel plow or offset disk instead of a moldboard plow. The approximate amounts of fuel needed to work an acre under normal conditions is shown for several tillage tools in the following table:

<table>
<thead>
<tr>
<th>TOOL</th>
<th>GAL. DIESEL/ACRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moldboard plow</td>
<td>1.68</td>
</tr>
<tr>
<td>Offset disk</td>
<td>.95</td>
</tr>
<tr>
<td>Med. Wt. tandem disk</td>
<td>.55</td>
</tr>
<tr>
<td>Chisel</td>
<td>1.10</td>
</tr>
<tr>
<td>Springtooth cultivator</td>
<td>.40</td>
</tr>
</tbody>
</table>

There are many other types of tillage tools that are not discussed here. Experienced farmers in your area can show you how these operate. Your County Extension Agent can advise you about special problems on your farm.
MOLDBOARD PLOWS
The moldboard plow has historically been the single most common tillage tool on American farms. It is designed to cut a strip of soil, break it up and turn it over so that crop residues are covered.

A plow may have from 1 to 12 bottoms, with each of the bottoms cutting from 14 to 20 inches. Some plows are built so that the width of cut of the entire plow can be hydraulically adjusted as the plow moves through the field. Each plow bottom has a share, a moldboard, a landslide and a frog to hold the component parts together. The shin is sometimes made as a separate replacement part of the moldboard.

TYPES OF PLOW BOTTOMS
Several different types of plow bottoms are available. How much a plow bottom pulverizes the soil depends on the shape of the bottom. A long, gradually curving moldboard turns the furrow gently and does not break up the soil unduly. Short, sharply curved moldboards twist and shear the soil and pulverize it. Between these two extremes are many types of bottoms for general use. They are called stubble, general purpose, high speed, moldboard and blackland bottoms.

The breaker bottom is used in tough sod where you may want to turn the furrow slice completely so that the crop (or weeds) will not continue to grow. (For example, plowing alfalfa under as a green manure crop.) Stubble bottoms are especially adapted for plowing old ground where good pulverization is needed. Most general purpose or high speed bottoms are used at speeds from 3 to 6 miles per hour. These bottoms meet the general demands of most farmers and will do a good job in stubble, old ground and a variety of other conditions. They are considered to be the best for general farm use.

The slat moldboard is favored for use in tight, sticky soils where it is difficult to get the moldboard to scour. The slats give a higher pressure between the soil and the moldboard and will scour better. A special blackland bottom is often used for plowing gumbo and buckshot soils where scouring is a primary problem.

PLOW STYLES
Plows may be purchased in one of three styles - mounted, semi-mounted and trailed. Mounted plows are lifted by the hitch system (usually 3-point) of the tractor. Semi-mounted plows carry the rear of the plow on a tail wheel which lifts part of the plow’s weight by means of a hydraulic cylinder. The front weight of a semi-mounted plow is carried by the lower lift arms of the tractor.

A trailed plow is carried by wheels that are independent of the tractor. Trailed plows are usually lifted by hydraulic cylinders.
OFFSET DISKS
The offset disk is popular for primary and secondary tillage. Offset disks have two gangs that operate at opposite angles. The front gang throws the soil to the right and the rear gang throws the soil back to the left. The two passes through the soil do a thorough job of killing weeds while chopping and mixing stalks and other residue. The offset disk is one of the best tools for incorporating chemicals into the soil. Most offset units are heavily constructed and use disks from 22 to 28 inches in diameter.

TANDEM DISKS
Tandem disks are similar to offset, except that they have four sererate gangs of disks compared to the two gangs for the offset. Tandem disk gangs are arranged so that the side forces balance each other and the hitch is located in the center of the width cut. Disk diameters are typically between 20 and 26 inches. Since the forces on a tandem disk are balanced, the draft of the disk will be less than that of an offset operated under the same conditions.

In past years, the offset disk was capable of deeper, more aggressive tillage than the tandem, due to its heavier construction and greater strength. New tandem disks are available with heavier construction that provide much the same capabilities as the offset.

CHISELS
These are moderate to deep tillage tools with shanks that are usually spaced about 12-inches apart. The shanks may be arranged in two, three or four rows with more rows giving greater trash clearance between shanks. There are two common sizes of shanks offering 22 or 26 inches of clearance from the end of the shank to the main frame of the chisel. Special high clearance shanks are also available.

Many different types of chisel points are available. Straight, narrow spike points are used for deep tillage of hard, dry soil. Twisted points can be used to allow the chisel to work through heavier residue better than one with straight points. The twisted points stir the soil more thoroughly, so they also cover more surface residue and create more draft. Where controlling weeds is the primary objective, sweeps are often used. Sweeps are available ranging from 6 to 24 inches.
FIELD FINISHING TOOLS
Final preparation of the seedbed is often done by a relatively shallow tillage operation, such as a springtooth harrow or field cultivator. These tools are usually built so that the teeth of the tools penetrate the soil every 4 to 8 inches. These tools are most effective in controlling small weeds. The teeth may be situated in 2, 3, 4 or even 5 rows, with more rows giving better trash clearance. Since they are relatively light draft tools, they are usually wide and hinged to follow the ground contours. The units also fold for moving from field to field.

Most springtooth harrows are mounted on wheels, with the wheels usually located in front of the teeth. For this reason, level adjustments are important. A small change in the depth setting may make a large difference in the depth of the rear teeth.

HITCHING A TRACTOR TO AN IMPLEMENT
In doing this job right, there is more to hitching to an implement than just dropping a pin in place. If the hitch is not correct, it can result in poor soil tillage, wasted fuel and a rapid wear on the tillage tool.

You will need to know three things to properly hitch any trailed implement behind a tractor:
1. The location of the center of tractor pull
2. The location of the center of draft
3. The location of the line of draft between the implement and the tractor.

CENTER OF PULL
On farm tractors, the center of pull can be figured as a point midway between the rear wheels in line with the axle. Actually, the

![Diagram](https://via.placeholder.com/150)

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*Fig. 12* A wheeled springtooth is a popular choice for final seedbed preparation. This model folds to the rear for road transport.

*Fig. 13* A field cultivator equipped with a tine tooth attachment to level the soil and evenly distribute residue.

*Fig. 14* A one-way plow.

*Fig. 16* Centers of resistance and lines of draft — one-bottom, two-bottom and three-bottom plows.
TILLAGE

point is ahead of the axle, but this is not too important when adjusting
hitches. Where the tractor has a swinging drawbar, take the hinge pin
at the front end as the location of the center of pull.

CENTER OF LOAD

For moldboard plows, you might think of the center of load as a
point on a plow bottom where, if you attached a chain and pulled the
plow with the chain, the plow bottom would run level and cut its proper
width and depth. Center of the load on a single bottom plow is a point
about three inches to the right of the shin and about where the share
and moldboard meet. For a two-bottom plow, the center of load would be
halfway between the center of load points of two single bottoms. For a
three-bottom plow, the center of load is located at the point of center
resistance of the middle bottom.

The object is to set the drawbar on the plow and tractor so that you will
have a straight line from the center of load of the plow to the center of
tractor pull.

For an offset disk, the center of load is located in the center of the
width of cut, roughly midway between the front and rear gangs, and
about halfway down through the depth of tillage.

For chisels and most other tillage tools, the center of load is practically
in the center of the teeth. That is, the center of load is halfway across
the width of cut, halfway between the front and rear rows of teeth, and
halfway down through the depth of tillage.

LOCATE LINE OF DRAFT

Once you have located the center of pull for the tractor and the
center of load for the implement, you can locate the line of draft.
Stretch a cord from the center of pull to the center of draft. The hitch
pin should lie on this straight line. It may be necessary to raise or lower
the tractor drawbar or readjust the implement hitch to obtain proper
alignment.

ADJUSTING A MOLDBOARD PLOW

Before going to the field, check the plow for overall condition. If you
hit a rock or turn too sharply with a plow while it is in the ground, it
may have a sprung beam. Before checking for a sprung beam or "frog",
be sure that the shares are in good condition. The share should be tight
and firmly in place. To make the check, measure from a point 1-inch back from the tip of the plowshare to the underside of the plow beam directly above each bottom. There should not be over 1/4-inch difference in these measurements.

Plows having more than two bottoms can be checked for alignment by measuring distance between corresponding points on the bottoms. Measure from the point where the side of the share attaches or meets the moldboard. This measurement should not be more than 1/2-inch in variation. If you find much variation in width or height, it means that the beam or frog of the plow is bent and should be repaired. Uneven furrow slices or ridging of the ground are common indications of a sprung bottom or beam.

**ROLLING COLTERS**

Rolling colters on plows are used to cut trash and to help keep the plow from clogging. In general, the colter should be set about 2-inches shallower than the depth of plowing and it should never be set deeper than 4-inches. If the colter is set too deep, it is likely to collect trash and cause plugging in front of the colter. Notched colters are sometimes used to help keep the colter turning when cutting heavy trash. To obtain a neat furrow wall, the colter is usually set 1/2 to 3/4 of an inch outside of the land side of the plow.

When hitching a plow to a tractor, locate the line of draft, then try to arrange the hitch so that the hitch point lies on that line. It may be necessary to raise or lower the tractor hitch or to readjust the tractor wheel in order to get the correct hitch.

**MOUNTED PLOW ADJUSTMENT**

The mounted moldboard plow has become more popular in the last several years. It is easier to maneuver and more convenient to transport than a trailing plow. It is also well suited to hydraulic controls.

There are many different types of mounted plows, but their adjustments are quite similar. The most common type is mounted to the tractor with a three-point hitch. Most of the adjustments for these plows are obtained with the controls on the three-point hitch.

The upper link is used with the control, which raises and lowers the hitch to give the proper plowing depth and downsuck. Shortening the top link, for example, gives the plow more downsuck and makes it try to run deeper. The plow can be leveled by a control on the lower links. Sometimes a crank is used. On others, a turnbuckle arrangement is used.
TILLAGE

The proper width of cut can be obtained in different ways on different makes of plows. On some, the only way to change the width of cut is to change the rear wheel spacing of the tractor. On most mounted plows, there is an adjustment on the plow for this purpose.

It is important to use the proper procedure for adjusting mounted plows. Always follow the outline given in your Operator's Manual when adjusting mounted plows.

ADJUSTING TANDEM DISKS

Each gang on a tandem disk is individually adjustable for angle. The angles should be the same from side to side, but not necessarily from front to rear. Steeper gang angle produces deeper penetration and more aggressive tilling action. The depth of the tillage should be the same for the front and rear gangs. This adjustment is usually located on a linkage that controls tongue height.

ADJUSTING OFFSET DISKS

The name "offset disk" comes from the fact that the hitch point is not usually located in the center of the disk, but is offset somewhere to the left of the center. This is done to counterbalance the unbalanced forces normally produced by the two gangs of disks. The front gang tends to push the gangs to the left, while the rear gang tends to push the disk to the right. If the main disk frame does not run straight in the field, excessive ridging will result.

The angle of the individual gangs is important. Assuming a constant amount of weight on the disk, increasing the angle of the disks will enable them to penetrate deeper. The greater angle will also work the soil more vigorously, creating more draft and covering more residue.

A second adjustment on an offset disk is the lateral position of the individual disks on the main frame. The gangs can be shifted back and forth so that the rear gang gathers the soil thrown by the front gang and returns the soil to its original position. If the gangs are not positioned properly, ridges will be left in the field.
The third basic adjustment on an offset disk is the relative depth of the front and rear gangs. For normal conditions, both gangs should run at the same depth. This is best determined by walking beside the disk as it operates in the field and observing the main frame. Ordinarily, the frame should be level, but in extremely hard soil conditions, it may be necessary to operate the back gang slightly deeper in order to make the disk pull straight. There is usually an adjustment on a linkage that controls tongue height and the relative depth of the front and rear gangs.

**ADJUSTING CHISELS**

Chisels are relatively simple tools. The important point is that the chisel runs level. If the chisel does not run level, one row of shanks will run deeper than the others. On trailed chisels, the height of the drawbar clevice determines the position of the main frame.

Raising the tongue of the chisel lowers the back row of shanks. On a mounted chisel, lengthening the top link of the three-point hitch, lowers the back row of shanks.

---

Fig. 29 A mounted plow adjustment is provided by controls for three-point hitch.
Any tillage tool for breaking the soil may be used for this unit.

1. Tool Selected __________________ Size ______________ Is the tool mounted or trailed? ______________

2. Make a list of the lubrication requirements of this tool.

<table>
<thead>
<tr>
<th>Place</th>
<th>Type of lubricant</th>
<th>How often serviced</th>
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3. How do you keep the surfaces that contact the soil from rusting? __________________________________________________________________________

4. How deep do you normally run this tool? ______________ inches. How is the tool adjusted to obtain a given depth? __________________________________________________________________________

5. Does the tool have a tail wheel? ________ How should it be adjusted? __________________________________________________________________________

6. What attachments does this tool have for trash coverage? __________________________________________________________________________

7. List some possible causes of excessive draft for the tool you selected _______________________________________________________________________

8. With the aid of your Operator's Manual, locate all of the adjustments on your tool and list what each adjustment is intended to accomplish. If you do not have an Operator's Manual, see if your implement dealer can get one for you.

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>Purpose of adjustment</th>
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Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
Place the letter for the correct answer at the right of the page.

1. The center of pull on any tractor is (A—midway) (B—slightly to the right of center) (C—midway between the rear wheels and just ahead of the rear axle).

2. The ideal way to attach an implement is to have its center of pull fall (A—directly behind) (B—slightly to right of) (C—slightly to the left of) the center of the tractor.

3. Side draft means (A—adding weight to one side or the other of the tractor to keep it from slipping) (B—that there is some side pressure on the tractor wheels or that the implement hitched pushes to one side).

4. Important facts to know when hitching a plow to a tractor are: (A—location of the center of friction) (B—length of the figure 4) (C—location of center of tractor pull) (D—location of the center of load) (E—location of line of draft). Mark three answers.

5. A chisel requires (A—more) (B—less) (C—about the same) fuel per acre as a moldboard plow.

6. An offset disk covers (A—more) (B—less) (C—about the same) surface residue as a chisel.

7. A chisel can be used with (A—one) (B—two) (C—many) types of points.

8. A plowshare should be kept sharp to (A—make the plow scour) (B—make the plow go into the ground better) (C—make the plow do a better job of covering trash).

9. A moldboard plow covers (A—nearly 100%) (B—about 75%) (C—about 50%) of the surface residue.

10. If a plow does not throw even furrows look for (A—a dull share) (B—a sprung beam or frog) (C—the spring lift set too tight).

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members the more you learn.
Some form of chemical application for control of crop or livestock pests can be found on nearly every farm. Most of these applications need to be made with precision to make sure that control of the pest will be obtained without wasting the chemical or causing damage. Sometimes the pesticide comes in a form to be applied as a liquid, and sometimes it is to be applied as a dry, granular material.

THE SPRAYER

A sprayer applies a chemical that has been mixed with water or oil. The main parts of a sprayer include:
1. A pump to supply pressure.
2. Nozzles to distribute and apply the spray material.
3. A pressure regulator to control spraying pressure.
4. Screens to remove sediment and keep nozzles from plugging.
5. A supply tank.

PUMPS

Several different kinds of pumps are used on sprayers. The most common types for low-pressure spraying include a gear pump and one that uses nylon rollers. A piston pump that works like the piston in your tractor engine is used for high-pressure spraying. In order to make pumps last a long time, make sure the water you use for the spray mixture contains no gritty material. As a rule of thumb, use only water that is clean enough to drink.

When you remove a pump for storage, flush it out with water and fill it with light oil, to prevent rust and corrosion. (Unless, of course, the pump has rubber rollers.)

NOZZLES

There are nozzles for all of the different spraying jobs you might have on your farm. The most common type of nozzle is designed for spraying a liquid and is normally used for applying a pesticide to field crops. This nozzle usually works under low pressures (from 15 to 100 psi) and is designed for working close to the object being sprayed.

A second kind of nozzle uses air under pressure as well as the liquid and produces a mist that can be sprayed a considerable distance. It is well suited for orchard work where it may be necessary to spray to the top of a tree.
There are three common types of nozzles used for ordinary spray work. The flat fan nozzle is the most popular for weed control work where it is necessary to place droplets on the leaf surface of the weeds. These nozzles have a flat, fan-shaped pattern and because of their tapered edge they must be overlapped slightly to give even distribution. The hollow-cone nozzle has a flat disc and whirl plate. This gives a circular spray pattern that is hollow in the middle. These nozzles are often used for insect control work where the cone-shaped pattern helps to assure coverage in hard-to-reach areas of the plants. A solid-cone nozzle has a solid circular pattern and is well suited for such jobs as spotting weeds in lawns with a hand sprayer.

**SPRAY BOOMS**

Spray booms enable the nozzles to be located as needed for a specific purpose. If, for example, you want to broadcast-spray a weed killer in a barnlot, place all of the nozzles in the boom and direct the spray downward so that it overlaps and gives uniform coverage of the weeds. If you want to spray a row crop for insect control and need to apply a liquid spray material directly to the plants you can use three nozzles per row. One nozzle can be used directly over the row and one can be used on the end of a drop, on each side of the row. Sometimes the outlet over the row is plugged and the plant is covered with the two nozzles from the sides.

A typical use for a sprayer is to spray weeds between the rows of a growing crop. In this case the nozzle outlet over the row is plugged and two nozzles are used on a drop to spray the middle of the row.

**PRESSURE REGULATOR**

Precise application of a spray material is based on accurate control of the spraying pressure. This is accomplished with a spring-loaded valve. Changing the spring pressure regulates the amount of material that is allowed to flow through to the nozzles.

**STRAINERS**

You will find several different strainers on your sprayer. The purpose of strainers is to prevent solid particles from entering into the pump, hoses, boom and nozzles. It doesn’t take much dirt to quickly wear out a pump or plug a nozzle. You should use a strainer at the end of the suction hose. This can be a rather coarse strainer, say 40 mesh. A 40-mesh strainer has 40 holes per linear inch, or 1,600 openings per square inch.

There should also be strainers in the line between the pump and the nozzles and each nozzle should contain a strainer.
BAND SPRAYERS

There are many times when a chemical for weed control is band-sprayed on the surface of the row where a crop is planted. The chemical controls the weeds in the row, while weeds between the rows can be removed with cultivation. Application is usually made with an attachment on the planter, but sometimes it is made as a separate trip with a sprayer.

SPRAYER CALIBRATION

In application of chemicals it is very important to see that the material goes on at the exact rate recommended on the label. The amount of material applied by a sprayer depends on:
1. The ground speed of the applicator.
2. The area covered by each nozzle.
3. The rate of flow through each nozzle.

The rate of flow of a spray material through a nozzle depends on the size of the opening and the pressure. The rate of flow does not vary directly with pressure. If you quadrupled the pressure, the rate of flow would be doubled.

The following formula can be used to help select a nozzle and calibrate your sprayer:

\[
\text{GPM} = \frac{\text{GPA} \times W \times \text{MPH}}{5940}
\]

- GPM = gallons per minute of flow through the nozzle
- GPA = application rate in gallons per acre
- W = width of the area sprayed by each nozzle
- MPH = ground speed, miles per hour

Suppose we wanted to make a broadcast application at the rate of 10 gallons per acre at the speed of 5 miles per hour. The nozzles on the sprayer are spaced 20 inches apart (each nozzle sprays a 20-inch swath). How large a nozzle would be needed?

\[
\text{GPM} = \frac{10 \times 20 \times 5 = 1000}{5940} = 0.168 \text{ gallons per min.}
\]

one gallon = 128 ounces, thus 0.168 gallons per minute = 21.5 oz. per min.

We would want to select a nozzle that would have a flow rate of 0.168 gallons per minute at the spraying pressure needed for the situation. This information is needed to select a nozzle from the manufacturer’s nozzle chart. Once the nozzles are selected, you can adjust the pressure regulator until you get 21.5 ounces per minute from each nozzle. Use a measuring cup or jar to make this check. As a final check before you mix in the chemical and start spraying, you can make a field check with a tankful of water.

CHECKING GROUND SPEED

If your tractor does not have a speed indicator, you can check the speed if you use a watch with a sweep second hand. Measure the time in seconds that it takes to drive between markers 88 feet apart. Dividing 60 by the time in seconds gives the speed of your tractor in miles per hour. If it takes 15 seconds to drive the distance, the speed would be 60 divided by 15, or 4 miles per hour. Be sure to check the speed with a running start.
GRANULAR APPLICATORS

Granular chemicals for weed or insect control must be applied with precision. This is particularly true of pre-emergence herbicides or soil insecticides. To meet these rigid requirements, you must calibrate the application equipment carefully.

In most cases the granular chemicals are usually applied as a band or row application at the same time the crop is planted.

FACTORS AFFECTING APPLICATION RATE

Most granular applicators use gravity flow with a rotating agitator for metering the granules through a variable orifice. It is difficult to design a granular applicator that is relatively inexpensive and yet capable of accurately applying many different chemicals over a wide range of field conditions. Several factors can cause a variation in the application rate, including the following:

1. Area of the metering orifices.
2. Speed of the agitator.
3. Ground speed of the applicator.
5. Roughness of the field.
6. Humidity.
7. Temperature.

VARIATION IN GRANULES

All granules seem to look alike at first glance, but there is wide variation in the size and density of the particles and the nature of the inert carrier for the chemicals. For these reasons, a different applicator setting may be necessary for each chemical applied.

CHECK AND MAINTAIN GROUND SPEED

Except for the orifice setting, ground speed is the most significant factor affecting the application rate. Speed should be maintained carefully once the applicator has been properly adjusted. You can use the method given earlier in this unit for checking speed.

CALIBRATION OF GRANULAR APPLICATOR

A granular applicator must be calibrated for each different chemical that you apply. Any method of calibration is suitable as long as you end up with the applicator applying the correct application rate. The following method is suggested for most applicators:

1. Read the chemical container label to determine the application rate and particle size of the granules.
2. Check the Operator's Manual to determine the correct orifice setting for the recommended application rate and particle size.
3. Make a field check. This can be done in one of two ways. One way is to operate the applicator for a short distance in a field and collect all of the chemicals in a paper sack or cloth bag fastened on the hoppers. If, for example, you collect 1/2 pound from all of the hoppers while covering 1/20 of an acre, the application rate would be 10 pounds per acre. Another method that is less accurate but still useful is to proceed with the field application but check the amount used by each hopper while covering a known acreage.
Select a sprayer or granular applicator for this unit. You will need the Operator's Manual to help you answer the questions and calibrate the applicator.

1. What unit did you select? _______________ Size? _______________

2. List the chemicals used on your farm and what pests they are used to control _______________

3. How do you obtain a given application rate with the unit you selected? _______________

4. How would the application rate be affected if the field speed were changed while traveling across the field? _______________

If you have a sprayer, answer the following questions. If you are using a granular applicator go on to the next section, starting with Number 10.

5. Is the sprayer used for weed control, insect control or both? _______________

6. What kind of pump does the sprayer have? _______________

7. How many screens or strainers are used on your sprayer? _______________
   Where are they located? _______________

8. What kind of nozzles are used? _______________ For what application rate were the nozzles intended? _______________ How can you tell? _______________

9. Calibrate your sprayer, using only water in the tank. (Remember that: 43,560 square feet = 1 acre and 128 ounces = 1 gallon.) Desired application rate _______ gal/acre. Desired speed _______ MPH. Width sprayed by each nozzle _______ inches.
   Desired flow rate from each nozzle _______ gal/min. = _______ ounces/min.

Answer the following questions if you have a granular applicator.

10. Describe the applicator _______________

11. For what purpose is this applicator used on your farm? _______________

12. What is the recommended application rate? _______________ pounds per acre.

13. How far would you have to travel with your applicator to cover 1/10 of an acre?
   (Hint - divide 43,560 by width of the applicator: _______ feet.

14. How much of the chemical should be applied while traveling the distance needed to cover 1/10 of an acre?
   _______ pounds _______ ounces.

15. What speed is used while making application? _______ MPH.

16. Where should the rate dial on the applicator be set to apply the recommended rate?

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
Place the letter for the correct answer at the right of the page.

1. In applying chemicals it is important to (A—calibrate the applicator carefully) (B—guess at the proper rate and get the job done quickly).___

2. (A—Piston pumps) (B—Gear pumps) are used for high pressure.___

3. A flat fan nozzle has a (A—round pattern with a hole in the center) (B—rectangular pattern) (C—flat, oval-shaped pattern).___

4. Strainers are used in sprayers to (A—keep the spray material properly mixed) (B—remove dirt and foreign particles).___

5. A 40-mesh strainer has (A—1,600) (B—40) (C—80) holes per linear inch.___

6. Increasing speed while spraying (A—increases) (B—decreases) the application rate.___

7. Increasing pressure (A—increases) (B—decreases) the application rate of a sprayer.___

8. Once you have a granular applicator adjusted for the proper rate you (A—never) (B—may) have to change the rate setting if you move to another field.___

9. (A—Speed) (B—Time of day) (C—Temperature) is the most important factor once you have a granular applicator properly adjusted.___

10. A careful field calibration is a good idea for (A—all chemical applicators) (B—only sprayers) (C—only granular applicators).___

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members, the more you learn.
SERVICING SEED PLANTERS

Modern farming calls for careful drilling and planting of crops. To get big yields you must plant the right amount of seed. Drills and low-down seeders are used for smaller seeds and do a much more accurate job than broadcast seeders. Planters are used for larger seeds. A planter will space single seeds in a drill row, or groups of seeds in a check-row or hill.

All drills and planters work on similar principles. First there must be a furrow opener. There must be a hopper for carrying the seed. There must be a mechanism to select and drop the seed. The planting mechanism is where most drills and planters differ in the way the job is done.

Low-down and broadcast seeders place the seed on the surface of a prepared seedbed. The seed is covered by a light disking, by dragging or by rolling.

GRAIN DRILL REQUIREMENTS

A drill needs to open furrows to a uniform depth. The seed must be dropped uniformly without injury. To complete the job the seed should be covered and the soil firmed over it. Adjusting levers control the depth of planting. Small seeds are usually planted very shallow, whereas large seeds are planted deeper. If small seeds are planted too deep, seedling plants use up all the food stored in the seed cells and die before reaching the soil surface.

THERE ARE SEVERAL KINDS OF DRILLS

Drills equipped for seeding small grain or beans are called plain drills. When fertilizer or grass-seeding attachments are used, they are called fertilizer grain drills or combination drills.

A seed drill equipped with a fertilizer attachment spreads fertilizer evenly beside the row. On some drills the fertilizer flows down the seed tube. On the newer drills the seeds and fertilizer are deposited in separate rows.

FURROW OPENERS DEPEND ON SOIL CONDITIONS

Three types of openers have been used — hoe, shoe and disk. Sometimes various disks and corrugated sectional rollers are used for soil openers in sowing small seeds. Furrow openers are commonly spaced 6, 7 or 8 inches apart. In some areas where it is very dry, deep furrow openers are used. These are often spaced much wider than 8 inches. Hoe openers with spring releases are especially suited for stony or root-infested fields. Shoe openers work well in poor or trashy soils.
Where considerable plant debris or trash mulches are used, disk furrow openers are favored. Single-disk openers ridge the seedbed. This helps prevent soil blowing. On contoured fields the ridges hold the rain. The seed delivery boots are designed to allow the moist soil from underneath to be the first to fall on the dropped seed. The heavy trashy cover is left on top.

Double disk openers are intended for even more accurate placing of seed in the soil. They are available in either straight or curved blades. The disks are fitted with scrapers to keep them clean.

Disk bearings must be kept lubricated and dust free. This is difficult to do because the bearings are working so close to the soil. It is important to watch the bearing seals. Make sure they are tight. Lubricate the bearings frequently. Before putting a drill into use, examine the disk bearings. They may need to be removed and cleaned. Make sure the bearings are taking grease. Follow your Operator’s Manual very closely in caring for drills.

Good sturdy seed hoppers are used on drills and seeders. Keep all bolts and connections tight. Make sure the hopper does not leak. Be sure to clean out the seedbox and fertilizer hopper before you store the drill. The grain drill hopper is fitted with either of two feeds, the “fluted force-feed wheel” or the “double-run feed.” Both feeds are driven by the ground wheels which carry the weight of the drill.

**FLUTED WHEEL FEED**

The fluted wheel is driven by a square shaft. Fluted wheels can be shifted on the shaft so as to expose more or less of the gear. This changes the rate of seeding. On some drills that use a fluted wheel feed, the speed of the shaft can also be changed. Be sure to use your Operator’s Manual when learning how to change the seeding rate. There is also an adjustable gate to fit the size of the seed.

**DOUBLE-RUN FEED**

The internal double-run feed has a double-faced wheel; one face has a larger opening for large seeds and the other face or side has a smaller opening for use with smaller seeds. A flapper gate in the bottom of the box is used to control the opening not in use. If you want to sow small seeds you flip all the flapper gates over to cover the large opening. When planting extremely small seeds you can put a heavy curved wire into the opening. This cuts down on the size of the opening and reduces the amount of seed planted. The rate of seeding with the double-run feed is controlled by changing the speed of the internal seed wheels. The speed is changed by shifting a small drive gear so that it will mesh with a greater or smaller number of teeth on the driven gear.
Most seed-metering mechanisms are automatically shut off when the furrow openers are raised out of the soil.

**SEEDING GRASSES AND LEGUMES**

A grass-seeding attachment is often used on a grain drill. This attachment usually has a fluted feed for metering out the seed. Small flexible tubes carry the seed to the ground. The tubes can be set to put the seed either ahead or behind the furrow opener. Drag chains are used to pull a light covering of soil over the small seeds. Small seeds are seldom directed into the grain tube because the furrow opener would plant them too deeply. When the grass-seeding attachment is not in use, it is a good idea to remove it from the drill and give it a good cleaning. Cover the working parts with oil or anti-rust material before you store the seeding attachment.

**TAKE CARE OF YOUR TIRES**

Most drills are mounted on rubber tires. This keeps the drill from being jarred unnecessarily on rough fields, and you can pull it faster going to the field or when planting. Be sure to keep tires inflated to the recommended pressure. Low pressures reduce the “rolling radius” at the wheel. This can cause inaccurate seeding because grain drills are ground-driven from the wheels.

Press-wheels behind the openers are rubber in many cases also. Damp soil does not ball up on rubber as it does on metal wheels. However, covering and firming the soil over seeds can be accomplished in a number of ways. Chains, drags and rollers of many kinds can be used.

**POWER LIFTS MAKE DRILL OPERATION EASIER**

The furrow openers can be lifted in one of three ways. The smaller drills have hand-lever lifts. Some tractor-drawn drills have power lifts like those on a plow. Newer drills are fitted with hydraulic cylinders for lifting furrow openers. The hydraulic cylinder may also control the depth of the furrow openers.

On some disk drills the disks are held in the ground by spring tension. On these drills you can often change the tension on the springs to suit the hardness of the ground. You may want to increase the spring pressure on those disks that follow the wheel tracks of the tractor.

**PROPER HITCH HEIGHT IS IMPORTANT TOO**

Adjust the hitch on your drill so that the grain box is level. If you hitch too low the furrow openers will not run deep enough. A slight backward tilt may cause the drill to go through trash better. When the hitch is too high the furrow opener may run too deep. A high hitch may improve penetration but it may cause the seed tube to plug with dirt.
In a planter with ribbon-type seed tube, used for vegetables or close-growing row crops, it takes considerable time for the seed to bounce down the tube. In the so-called precision and later model planters this ribbon tube has been replaced with a short, smooth tube, or housing, and the valve mechanism has been improved or eliminated in some instances. Such a planter then becomes a very accurate machine. It will plant coated and other seeds with precision and can be used in a number of ways with a variety of seeds.

HERE'S HOW YOU CAN CHECK YOUR PLANTER

When you are getting ready to plant, it will pay to first set the planter on a concrete slab or smooth floor and inspect it carefully. Block up the wheels and the hitch so that shoe openers or runners will be in planting position. On tractor-mounted planters, block up the tractor wheel equal to depth of planting. See that all moving parts work freely and are not fouled by rust or dirt. Worn bearings will sometimes allow teeth to drop out of mesh. Check drive chains and sprockets for wear and looseness. Check the clutch and variable drop gears. Chains that are too loose will cause slippage on sprockets, waste power and can be broken. Inspect chains to run with link hooks forward and link slot to the outside. Chains should run loose and yet not climb sprockets. Worn furrow openers or runners will cause scattering of seeds. Check the tightness of bolts and those that are worn. See that all parts are in alignment and that the frame is not sprung. You will want to put some of your planting seed through the planter to check it for accuracy of drop and plate size. Do this before going to the field, and then field-check it also. Don't wait for the crop to see if your planter has done a good job.

HILL SPACING CAN BE ADJUSTED

Most planters can be set to plant 2, 3 or 4 kernels per hill. When drilling, a wide range of spacing can be obtained by using plates with varying numbers of seed cells. Adjusting the variable drop setting and using the drive chain on the large, medium or small sprockets will change the spacing. See your Operator's Manual.

DON'T TRY TO MAKE "ANY OLD PLATE" WORK

Cracked seeds will not germinate. You should plant certified seed. The seed house will recommend plate sizes for the seed they furnish, but you need to check their recommendations under your conditions. Plate openings that are either too small or too large will cause seed cracking. Binding of rusty or dirty moving parts will cause cracking troubles, as will badly worn knockouts. Plate holders put in upside down can also cause cracking. Heavy oiling or greasing of exposed parts is not recommended. Light oiling is needed for many parts to "limber up."

CHECK PLANTING RATES

Accurate planting is necessary for high yields. Use a seed corn test stand to select the proper plates for your seed. Make sure the plates are matched to the seed for the speed you want to drive. You can also check your planter by driving down a lane or roadway at planting speed and checking the average kernel spacing. Leave the runners up, but lock the valves open and engage the seed plate drive. Count the total number of kernels dropped in a given distance and figure the average kernel spacing. If you use 40-inch rows, divide 156,800 by the average kernel spacing and you will get the number of kernels planted per acre. If you find your planter drops 36 kernels in a distance of 30 feet, that's an average of 1 seed every 10 inches. When 156,800 is divided by 10 it gives a planting rate of 15,680 per acre. For 36-inch rows use 174,000; for 38-inch rows use 165,000; for 42-inch rows use 149,000.
Select a drill or planter for this unit or add another sheet and work on both machines.

1. Machine selected __________________ Make __________________ Model __________________ Size ____________

2. What crops are planted or seeded on your farm? ______________________________________________________

3. Trace the flow of power from the drive wheel to the point where the seed is metered from the hopper. For each ten turns of the drive wheel, how many turns does the metering mechanism make? ____________________________

4. What kind of furrow openers are used? ______________________________________________________________

5. How is the depth of the openers controlled? __________________________________________________________

6. How is the seed taken from the hopper? ______________________________________________________________

7. How is the furrow closed after the seed is dropped? ____________________________________________________

8. What devices are used by the machine for making a good seedbed, both before and after the seed is dropped? _________________________________________________________________

9. How is the seeding rate changed? Be sure you list all the different methods you can find on the machine. ____________________________________________________________

10. Calibrate the machine and report your findings. Report the type of seed you calibrated, the seeding rate you wanted, the seeding rate you obtained and explain how you could be sure the machine was calibrated properly. _________________________________________________________________

11. If your machine has a fertilizer attachment, explain how it can be adjusted to apply the correct amount.

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
Place the letter for the correct answer at the right of the page.

1. Rubber tires are used on drills: (A—so as not to pack the seed too tightly) (B—because damp ______ soil will not stick so readily and the rubber mounting is easier on the machine being carried).

2. A double-run feed: (A—drills twice as fast as a fluted-wheel feed) (B—has two sides of ______ different sized pockets for large or small seed) (C—exposes more of the gear for increasing the rate of seeding).

3. Planters work very much like drills: (A—except for the selection of seed from the hopper and ______ dropping it into the seed tube) (B—except that planting is all done in hills and the crop must be cross cultivated).

4. Planters should be cleaned after use: (A—because the valves might stick overnight and cause ______ trouble) (B—particularly after fertilizer has been used in them).

5. A planter seed mechanism: (A—should be lubricated sparingly) (B—should be oiled and greased ______ liberally every day).

6. A planter is said to be an edge drop: (A—when the seed is dropped on edge in the soil) (B—when ______ the seed is held on edge by the plate in the bottom of the hopper) (C—when all the seeds accumulate in one cell).

7. A "knock-out" is used: (A—to kick the seed out of the hopper) (B—to clear each hole in the ______ plate ready for the next seed to be selected) (C—to make chains easy to unhook).

8. A precision-type planter uses a straight, short seed tube because: (A—the ribbon tube breaks ______ seeds) (B—otherwise the seed is delayed in bouncing down the ribbon tube).

9. A corn planter with a 40-inch row spacing drops an average of 1 kernel every 10 inches. The ______ number of kernels planted per acre is (A—14,900) (B—156,800) (C—15,680).

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members, the more you learn.
CUTTERS FOR CROPS

Cutting a crop on time is important. Much of it can be lost if the work is delayed by a machine breakdown. Sharp cutters are necessary for fast, easy cutting; yet sharp cutters can be hazardous. Therefore be careful when working around mowers or cutters of any kind. Be sure the cutters are out of gear whenever you work on them. Be especially careful when sharpening them. Use goggles when working with a grinding machine. Be sure all shields for gears, shafts and cutting parts are in place.

WHY CUT CROPS

We know the livestock we feed is well equipped by nature to grind and chew most forage crops. If livestock doesn’t need the crops chopped, then why do we cut and chop the material? The answer to this question is that we do this to save labor, to save storage space, to aid in curing and to keep the crop from spoiling while in storage.

We mow hay so it will wilt and cure to a safe moisture content for storing. We windrow small grain so that the crop will cure evenly. If the crop is weedy, windrowing causes the weeds to dry. This makes it easier to separate the grain when the crop is picked up with the combine. But why do we chop hay? One of the main reasons is to make it easier to handle with mechanical equipment. Another reason is that chopped hay can be put in storage with a higher moisture content, especially when put into the silo or dried with an artificial drier.

Hay loses some of its feeding value when it dries in the field. Chopping and storing the hay shortly after it has been cut eliminates some of the feeding-value loss. Chopped hay is easy to feed and the livestock may waste less of the chopped hay.

Now, why chop corn or sorghum or green hay for silage? There are several reasons. We can handle the chopped materials by labor-saving mechanical methods. The shorter the length of cut, the easier the silage is to pack. Air is excluded and the silage keeps better.
SHEARS ARE CUTTERS

Most farm machines with cutting elements use a shear cut. Metal knives, sliding over a square-edged shear bar, like a pair of scissors, do the cutting. Scissors or grass shears are common examples. They work best when the two blades are sharp and are adjusted close to each other. For your first demonstration, show that you know how to sharpen a pair of scissors, a pair of tin snips, pruning shears or a pair of grass shears. A grinder, a file or an oilstone can be used to put a fine edge on the blades. Tighten the blades, but be sure they are free to work against each other without dragging. Put the handle of the file in a vise. Gently pass the edges and inside surfaces of the blades across the file. Don't try to sharpen the bearing inside the blade where the blades are fastened together. If you do so you will ruin the shears. Be careful to keep a straight cutting edge. Oil the bearing surfaces to make them slide over each other better.

Good hard steel will hold a sharp edge better than poor or soft steel. It will take more work to sharpen a good tool but the edge will last longer. Use oil to smooth the close-fitting joints and prevent rusting.

You should learn from this demonstration the importance of keeping the cutting edge sharp. The cutting edges must also be held close together. This principle is the same for all cutting tools: a sharp knife that passes close to another knife or shear plate.

LAWN MOWERS ARE CUTTERS

It's important for you to understand the lawn mower because many farm machines use the same idea for crop cutters. Most ensilage and forage harvesters have cutter heads resembling that of a lawn mower. They cut by shear and impact. We'll talk more about kinds of cutting later. Without a special sharpening tool it is difficult to get a true sharpened edge on lawn-mower cutter knives. They have curved blades that are fastened in a spiral form in a round frame. Fortunately, almost any sharpening job is better than none at all. Therefore, when you have a mower that just won't cut, try sharpening it yourself. Use a mill file and work from behind the blades with forward strokes. After you get the proper feel, you will discover the knack of working lengthwise on the blades.

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**Fig. 6** Sharpening shears.

**Fig. 7** This is a cylinder cutter used in a forage harvester — looks like a lawn mower.

**Fig. 9** Sickle on a mower.
After the blades are sharp, sharpen the shear bar. At each end of the shear bar are adjusting screws. Tip the shear bar toward the revolving blade by adjusting the screws so that all the blades just touch the bar. The blades should touch for their full length. If one blade drags more than the others or if you find high places on a blade which cause heavy drag, correct this trouble by more filing.

A little sharpening, adjusting and oiling of an old lawn mower will make it cut like new. This is one job where you can get first-hand information on how much easier a sharp, properly adjusted and properly lubricated machine will run. Now let's check to see how many implements you have on your farm that have cutters and need your help.

TYPES OF CUTTING PARTS ON MACHINES

You will find that there is a large number of common farm machines that have cutting parts. These cutting parts include sickles on mowers, binders, combines, forage harvesters and the like. The sickle is the most commonly used cutting machine. It has a double-edged cutting action. The sickle is a metal bar on which are mounted triangular-shaped sections. The edges of the sections are sharpened. Mowers and haying tools that are used to cut the heavy, coarser crops use larger sections which you may grind to sharpen.

The sickles on the combine, windrower and grain binder use corrugated edge sections. The length of stroke is often longer and sometimes the section passes over two guards on one stroke. The sickle edge is rough or serrated to help keep the straw from slipping while it is being cut. The serrated sections can't always be sharpened. They may need to be replaced when they become dull.

To obtain a good cut, the knife holder must fit down snugly on the knife. Such a fit holds the knife close to the guard plate. A tight fit is also needed to keep from breaking the sickle head. A badly worn wear plate or a loose knife holder may allow the sickle to bend. This is a common cause of the sickle head's breaking at the point where it attaches to the bar. Later when we discuss mowers we will tell you how to adjust the cutter bar.

CYLINDER CUTTERS

The cylinder cutter is in common use. The cutting edges are spiral shaped, and are bolted onto a revolving frame. The cylinder looks something like the reel-type of lawn mower. Cylinder cutting blades or knives can be sharpened by use of special attachments without being removed. Sharpening without first removing them is a timesaver for the farmer.
Take care, when sharpening any knife with a grinder, that the knife edge does not get overheated and lose its hardness. Also, be careful to grind the bevel of the edge to the same angle it originally had.

Most field forage harvesters use the cylinder type of cutter. You will find them on some stationary ensilage cutters and even on some roughage grinders.

The length of cut can be varied and depends upon how much of the crop is fed under the knives between cuts. Changing the speed of the feed roll is the most common method of changing the length of cut.

**FLYWHEEL CUTTERS**

The flywheel cutter has knives mounted radially on the blower fan of the machine. It is used on field forage harvesters and ensilage cutters. To obtain a clean cut the knives must operate close to the shear plate. They can be adjusted for clearance. The length of cut can be changed by: (1) changing the speed of the feed rolls; (2) changing cutterhead speed; (3) varying the number of knives used. The knives should be removed for sharpening. Be sure to grind at the same bevel as when the knives were new. Other cutting elements you will find on farm machines are rotating knives. Sometimes these knives rotate in the vertical plane. You will find them on sugarbeet toppers, stalk cutters and, in one instance, on a field forage harvester.

Cutting knives that rotate parallel to the ground are used to chop corn stalks, cotton stalks and the like. They are used to destroy brush, weeds and other heavy plant growth which cannot be cut with a conventional mower. Horizontal rotating blades are used as grass and weed cutters as well as for topping sugarbeets and cutting up cotton and corn stalks or other heavy plant growths before plowing the land for another crop. On some of these machines the blades are sharp, while on others they are left dull and depend upon impact or battering for the cutting action. A mower section may be mounted on the end of a bar to provide the cutting action.

**MOWERS**

Having worked on cutting shears, you already know what to look for in adjusting a sickle bar. First you want sharp sickle sections. Next you want the sickle bar to slide easily. And finally you want the sickle
sections to be held in place so they work close to the ledger plates fastened to the mower guards.

**MOWER ADJUSTMENTS**

The sickle sections cut first in one direction then in the other. As the pitman arm moves the sickle back and forth, the center of the sickle section usually stops at the center of the guard on each stroke. This is called register. On many mowers the cutter bar can be moved or adjusted to give proper register.

On some of the later model, high-speed, tractor-mounted mowers, a short length of stroke is used to give better balance. These mowers do not have register such as found on earlier models.

On most mowers the outer end of the cutter bar is carried a little ahead of the inner end. This is done so that as the mower bar is pulled through the crop, the outer end will align with the inner end. This is called "lead" and gives better cutting. The sickle and pitman arm will then run in a straight line. On some of the later model tractor mowers the driving mechanism is mounted on the inner end of the cutter bar. With this mower, lead is of less importance.

As the mower bar wears, the lead may need to be checked and adjusted. To measure the lead on the cutter bar, first get the mower into proper cutting position. Tie a heavy cord to a point on the pitman box. Stretch the cord to the outer end of the cutter bar and sight it in with the pitman. The cord should be parallel with the pitman arm. Pull back on the outer end of the cutter bar and see how it lines up. A good rule is to have the outer end of the cutter bar leading the inner end by about 1/4 inch for each foot of cutter bar length. (Check your Operator's Manual for details.)

There is a grass board on the outer end of the mower which causes the cut crop to fall toward the cut swath. The angle of the board can be changed for different crops. Proper setting of the board will help keep the cutter bar from plugging.

**REPAIRING YOUR MOWER**

It is easy to replace most of the wearing parts on a sickle used on a mower, combine, binder and the like. The rivets holding the sickle sections can be sheared by hitting the back side of the section a sharp blow with a hammer. The rivets can then be punched out and new sections riveted in place. The guards on a mower are held in place with one bolt for each guard. On a combine or binder, two or more guards are made in one piece. They can be removed for straightening and replacement. A special metal block for holding the guard is a big help when straightening the mower guard or replacing the ledger plates.

If badly worn, the knife holder and wearing plates can be unbolted and replaced. If the knife holders are high they can be bent down by hitting them with a hammer. Before you do this, remove the sickle. If the knife binds when the sickle is replaced, it can be bent up by giving it a light, sharp tap in the center section with a hammer. Leave the sickle in place when bending the knife holder up.

The points of the guards should be kept in alignment so that the ledger plates will be at the same level. If a guard is bent you may be able to straighten it by slipping a short piece of pipe over the end of the guard, then bending the guard up or down. When cutting grain or grass you may need to put lifter guards of some kind on the cutter bar to keep the cut crop from collecting on the cutter bar.
The clutch shifter lever can usually be adjusted for wear. See that it engages all the way. Keep it free of dirt. See that all driving parts as well as the cutting parts of the mower are regularly cleaned and lubricated. Change the lubricant in the gear box regularly. (See your Operator's Manual.)

Most tractor-mounted mowers have a safety slip clutch. You should inspect the clutch to make sure that it is working. It also has a shielded power line back to the pitman crank. Another safety spring release allows the cutter bar to swing back if it hits an obstruction. These need to be checked as does the lubrication. The system of cutting is the same as on a drawn mower or grass shears.

**CORN HARVESTERS**

The corn binder and field forage harvester with row-crop attachment have the same kind of cutter found on a mower. Only one section is used on the sickle. Two side-cutting knives assist the cutting action. The side-cutting knives must be sharpened often because they operate in dirt. The beveled edges are placed downward. The sickle head can be adjusted for wear. If you have an ensilage harvester, it's well to keep a spare sickle section on hand. You will get good experience by sharpening the sickle and knives on your corn-harvesting implements. See that all chains are properly adjusted. Lubricate the machine. Study your Operator's Manual.

**FIELD FORAGE HARVESTERS**

Your ensilage and hay cutters may have either the lawn-mower type of blades or radial knives working against a shear bar. In either case, you should see how they work and what is needed to sharpen and adjust them.

On the lawn-mower type of cutter, the shear bar is usually adjustable, just as it is on a lawn mower. In the radial type of cutter for silage or hay, the straight blades can usually be adjusted closer to the shear bar. On many of these cutters, the shear bar can be turned over when one edge becomes rounded from wear.

Again, like scissors, the blades need to be sharp. They need to be adjusted up to the stationary shear bar. They need to be driven at the right speed (see your Operator's Manual) and the machine needs to be lubricated and protected from rust and careless use.

You may have other machines that have a cutting mechanism. On some hay balers a knife is used to cut the hay as it enters the compression chamber. Your Operator's Manual will tell you how to adjust and care for the hay baler.
MOWING MACHINE

For this work unit you may use a mowing machine or forage harvester or both.

1. What type of mower did you observe? Width or cut? 

2. Tell how power is transmitted to the sickle 

3. Describe or diagram how register is adjusted.

4. How is knife head guide to knife head clearance adjusted? 

Why is this adjustment important to the conventional pitman mower? 

5. Describe or diagram any safety device in the power line.

FORAGE MACHINE

1. What type of forage harvester did you observe? 

2. What is the dimension of the throat opening? height? 

   width? area, square inches (height x width) = sq. in. 

3. List the parts through which power is transmitted between tractor and PTO or engine and cutter head. 

   Between engine or PTO and feeding mechanism. 

4. Tell what lengths of cut can be obtained. 

5. For what length of cut is the machine now adjusted? 

   How was this determined? 

6. Does the pickup cylinder reverse when the feeding mechanism is reversed? 

7. How are the knives sharpened? 

8. What is the bevel angle of the cutting edge of the new knife? 

9. How is each knife adjusted to the shear bar? 

   What should the clearance be? 

10. What changes or adjustments can be made to the shear bar or stationary knife? 

11. What is the maximum and minimum cutter head speed in revolutions per minute? 

   Maximum rpm. Minimum rpm. 

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
Place the letter for the correct answer at the right of the page.

1. On some of the high-speed, tractor-mounted mowers a (A—shorter) (B—longer) length of stroke is used to give better balance.

2. When adjusting a cutting mechanism: (A—the shear bar should have 1/8 inch clearance) (B—the shear bar should be set close to the knife) (C—the back side of the shear bar should be ground).

3. The hammers in a hammermill cut by: (A—shear) (B—slice) (C—impact).

4. Crops are cut fine so that: (A—animals can do a better job of chewing) (B—so that the crop can be easily handled with power equipment) (C—so that the weeds will be mixed better).

5. When sharpening shears: (A—the blades should be ground square) (B—the blades should be rounded) (C—the blades should be ground at a slight angle).

6. A crop cutter is: (A—safe when it is properly guarded) (B—never completely safe) (C—safe when someone else is around).

7. The lifting spring on the cutter bar: (A—helps to hold it down) (B—helps to make the bar and sickle register) (C—helps in lifting and takes weight and wear off the outer shoe).

8. By lead we mean that: (A—the outer end of the cutter bar is slightly ahead of the inner end) (B—the sickle sections stop in the center of the guard) (C—the sickle passes close to the ledger plates).

9. A spring release is used to: (A—allow the cutter bar to swing back when striking an object) (B—allow the mower to be thrown into gear without stopping) (C—brush trash off the cutter bar).

10. On a rotary cutter: (A—the blade should be kept sharp and operated at high speed) (B—the blade should be kept sharp so it can be operated at slow speed) (C—the shield should be removed so that crops will feed in better).

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members, the more you learn.
In this unit we shall point out some of the things you should know about seed separation machines. Our discussion will be general. To learn the details of how to adjust and operate your machine, you should study your Operator’s Manual. If you have trouble understanding how to adjust or operate the machine, ask your father, your leader or implement dealer to help you.

Seeds must be separated from the stalks on which they grow. Sometimes these seeds are used for planting another crop, such as alfalfa or cabbage. In most cases the seeds, such as corn, wheat, rice, cotton, peanuts, beans, etc., are collected for food or for the oil that can be obtained from them.

The modern method of harvesting most of these seeds is with some type of “combine” harvester. The machine is called a combine because it does many jobs at one time. It combines jobs. When we use a combine the crop is allowed to ripen in the field. If the field is weedy the crop is often cut so that the weeds will dry; then the cut grain is picked up and put through the machine. Even though you try to harvest when the grain is dry and ripe, it is sometimes damp and needs to be dried in the bin before being stored to keep it from spoiling.

SAVE ALL YOUR SEED CROP

After the seeds are ripened, your next problem is to adjust and operate your machine efficiently so as to cut down harvesting losses. Yields of experimental plots are often much higher than the yield of the same seed in the field. The reason these plots show the highest yield is because all the seeds are saved. The grain is carefully harvested by hand; therefore, there are no losses. In the field we have losses but much field loss can be prevented by proper operation and adjustment of the machine.

MACHINES FOR SMALL GRAIN

Let us look at a combine for small grains. If you could see farmers of a century ago harvesting and threshing grain, you would know what takes place in a modern combine. For centuries, farmers have known that the grain must be held while being cut. We hold the grain upright with the guards on our modern machine. The farmer of long ago laid the grain in a pile so that he could bind it into a bundle. On our modern machines, the grain is pushed off the sickle with a reel. The reel forces the grain back to the draper canvas or to an auger as it is cut. The farmers who cut by hand had to collect the grain and bring it to a threshing floor. In our modern machine the auger or draper canvas carries the cut plants to the cylinder where threshing begins.
The farmer of the last century, after allowing the grain crop to dry in the sun and air, placed it on a threshing floor. Here he walked oxen on it or beat it with flails to thresh out the grain. Our modern machine does the same thing in a slightly different way. The ripened grain is carried to a cylinder where it is threshed. The cylinder contains bars to give the grain a rubbing motion. Located below the cylinder is another set of bars; we call this part of the machine the concave. The rotation cylinder strips the seed or rubs it from the straw as it is drawn over the fingers or bars on the concave. The cylinder works like the oxens' hooves in crushing the heads past each other and in crushing the straw to loosen the heads from the straw and from the chaff holding the kernels.

Next the straw passes the beater, which beats the heads of the grain as they come from the cylinder. This action keeps the grain from going around with the cylinder. In addition it helps further to loosen the grain in the head, so that it will fall out. Some combines have a number of beaters in different parts of the machine.

Next comes the straw rack. The farmer of many years ago used a pitchfork to lift the straw, shaking it to cause the grain to fall on the threshing floor. In our modern machines we use a rack which shakes up and down to move the straw and to fluff it up so that the grain will shake through it, falling to a screen below it.

It used to be necessary to have a windy day for hand-threshing grain. As the straw and chaff were thrown into the air the lighter chaff and unfilled heads were blown away. In our modern machine we have a power-driven fan that furnishes the air for cleaning the grain. Nowadays it is not necessary to schedule such an operation only on a windy day. In the machine, the air is directed under screens so that all the light material is removed from the heavier grain. If more air is needed, the size of air intake opening is increased.

The screens allow the grain to fall through to the conveyor auger. The auger moves the grain to a bucket elevator, which dumps the grain into a bulk tank on the combine, ready to be hauled away by truck. In some combines the grain may be run into a sacking attachment and placed in sacks and tied.

Fig. 6 Hand threshing was a slow, laborious process in the old days.

Fig. 7 Here's how the cylinder, concave and beater operate inside the combine.

Fig. 8 Cut-away view of combine showing — left, rear beater; center, cylinder; right, feeder beater.

Fig. 10 This combine has three screens to separate grain from straw and chaff.
It is easy to understand what takes place in the hand threshing of grain. Similarly you can understand how a combine operates like a hand thrasher at work. Now, you need to examine one for yourself. Later you can see what takes place in other seed-separating and cleaning machines. Certain machines may not do the job expected of them. If you know what is needed, you can readily determine where adjustments are needed to make the combine work properly. To thresh the many different kinds of grain grown on a farm, it is necessary to have several machines; or one machine may be so equipped that the sieves can be changed, the space between the cylinder and concave can be changed and other adjustments made.

**PEANUT HARVESTERS**

An example of a specialized machine is the combine used for the harvesting of peanuts. Peanuts, which grow underground, are lifted from the earth much like potatoes and are left to dry in the sun. The old method was to pick them off the stems by hand. If they are run through a machine such as a grain combine, the cylinder shatters some of the nuts from the pods. A special machine, a peanut picker, works more effectively. As the vines are dragged over a set of screens, the peanuts drop through and are pulled away from the stems. One of these machines, which can do the work of 25 hand pickers, is a time and labor saver.

**GRAIN HARVESTING PROBLEMS**

Small grains, such as oats, wheat, barley and rye, form in heads. Each individual kernel is protected by a chaffy covering or coat. Each kernel must be knocked from its protective cover and torn from the straw. Such crops require a vigorous threshing action. The best way to tell how well a combine is working is by observing the straw as it comes through the combine. If there are unthreshed kernels in the straw or seed pods, the threshing action isn’t vigorous enough.
There are several ways to make the cylinder do a better threshing job. Check the Operator’s Manual to see if you are running the cylinder fast enough. However, one precaution to guard against is over-speeding the cylinder. Over-speeding will cause cracking of grain. You can reduce the space or clearance between the cylinder bars and the concave bar and you can even put in more concave bars if the cylinder is not knocking the grain from the head. If the cylinder concave bars are worn, they won’t do a good job. Make sure also that the cylinder is parallel with the concave bars. On some machines the ends of the cylinder can be raised or lowered to permit adjustment.

A good demonstration is to show how to check the cylinder speed on a machine. Here is all you need to do: Determine how many times you need to turn the cylinder to make the reel go around once or to make the straw-walker complete one shake. When you have determined the reduction ratio between the cylinder and the slow-moving part, count the revolutions of the slow-moving part for 1 minute and then multiply by the reduction ratio. The result will give you the speed of the fast-moving part. Crops such as clovers, alfalfa and grasses are hard to thresh. They must really be whacked hard. Tests show that you could still get red clover seeds from the straw by re-threshing up to five times. The old clover huller had two threshing cylinders — one behind the other. When threshing seeds of this nature use high cylinder speeds and have the cylinder set close to the concave.

**SOME SEEDS REQUIRE GENTLE HANDLING**

Seeds such as soybeans can easily be damaged if the combine is not well adjusted. To thresh soybeans you need to cut down the cylinder speed to about one-half that used for small grains. You may also need to remove some of the concave bars. Consult your Operator’s Manual to learn how this is done. In other words, what you are doing is reducing the threshing action and allowing more space for the seeds to get past the cylinder and concave so that they will not be cracked.

For lima and castor beans, a cylinder covered with rubber works against a concave or holding surface to rub the husks or pods off the beans. The rest of the cleaning takes place as it would in any other combine.

**STRAW, CHAFF AND DIRT SEPARATION**

You don’t need to wait for a windy day to clean your threshed grain if you own a combine. But you do need to be careful or you’ll blow away some of the crop and lose it. Grain separation is just like separating gravel of varying sizes with a series of screens. The coarse screen is comparable to the straw rack — it removes the coarse material. The medium screen is like the chaffer — it removes the smaller material. The grain screen is much finer — it removes the hulls and separates the grain into more uniform parts.

In the combine, if all the seeds are not removed at the end of the sieve they are returned to the cylinder and threshed again. This action makes use of what is known as the return elevator. In general when combining, as little material as possible should be returned for re-threshing. If too much material is returned it may result in extensive cracking of the grain.

The straw racks must be run at the right speed for proper shaking of the grain so that some of the grain will not ride over on top of the straw.
GRAIN HARVESTING

Your Operator's Manual will tell you how fast the straw rack should be operated. In general, it should operate around 170 to 270 shakes per minute.

CORN SHELLERS
How does a corn sheller work? One type is called the cylinder sheller. Ears of corn enter at one end and kernels are rubbed off between the teeth on the cylinder and bars or holes in the concave. They fall through the concave. Cobs pass out the other end between the cylinder and the concave. Sieves and a fan are used to clean the broken pieces of cob, chaff, shucks and silks from the corn. Chaff, silks and shucks are blown into a pile. The corn cobs are elevated into a separate pile.

CORN PICKER
The job of the corn picker is to strip the ears from the standing stalk of corn and leave the stalk in the field. This could be done with a pair of straight bars like two fingers. They could strip small ears from a corn plant, but they could do it better if each one revolved. That is just what the “picker rolls” or “snapping rolls” on a corn picker do. They have spiral ridges that bump the ears, first one way, then the other, as the machine moves forward. The ear soon gives up and is on its way up the rolls and into the machine.

The picker also has husking rolls. These are smoother than the picking rolls. The ears are too large to go through; but the rolls will catch the corn shucks and tear them from the ears. Husking rolls are made of metal, wood or rubber. Mating rollers of unlike materials, such as rubber and metal, help to give better grip on the husks. Moving along these rolls, the ears fall at the other end into an elevator for a trip to the trailer wagon. Sometimes the ears are put through a sheller, like the one we described earlier, before they leave the machine. We call this machine a corn combine or picker sheller. There are other kinds of corn shellers. It will be helpful to you if you will find one and see how it works.

COTTON HARVESTERS ARE BIG LABOR SAVERS
The cotton picker is also a labor-saving machine and it increases cotton production. A mechanical picker can do the work of 40 hand pickers. Again, the way it works is simple. You can demonstrate it to your club by placing a roughened rod in an electric hand-drill. Wet the rod if you want it to work better because cotton clings to it more readily if the rod is wet. The revolving rod or “spindle” picks up the cotton and winds it up much as you would wind a piece of string. The spindle then moves back into the machine on its carrier and a “doffer” strips the cotton from the spindle, in about the same way you would remove cotton from the roughened rod with your fingers. The cotton is then blown up into the basket on the machine. The spindle next passes through a “wiper” where it is cleaned and wetted for picking more cotton. Another type of cotton harvester is the stripper, which removes both burr and lint.

COTTON GINS
Cotton fibers, called lint, grow on cottonseed. These fibers must be separated from the seeds before either can be used in the manufacture of the many products that are made from these raw materials. The process of separating cottonseeds from fibers is called ginning. Before
the invention of the cotton gin it took many man-hours to do this job of seed and fiber separating by hand. It is said that Eli Whitney got his idea for the cotton gin from watching a cat claw feathers from a hen through the bars of a coop. When cotton is harvested it often contains much trash and moisture that must be removed before ginning. The trash is removed by passing the seed cotton through one or more cleaners. The excess moisture is removed by driers. Seeds with cotton fibers hanging to them move alongside bars or "ribs" through which seeds cannot pass. Saws with many small teeth extend through the ribs and pull the fibers from the seeds. The cotton fibers are then blown or brushed off the teeth. The cotton fiber is now ready for additional cleaning (if needed) and baling. When all usable fibers have been removed, the seeds drop between the saws and fall onto a conveyor which carries them to a storage bin.

**COTTON HANDLING**

Air moves cotton most of the way from the trailer through the gin and to the bale. Because cotton is light and bulky it moves easily with air. It is also easy to separate from the air stream by mesh screens through which the air can penetrate, leaving the cotton behind. Cotton goes through a number of cleaners.

So from combines to cotton pickers, simple methods are used in machines that seem almost magical. You can find out how any of them work. The thrasher is a mechanical flail. The corn picker is a two-bar stripper. The cotton picker is a rolling rattail file. The cotton gin is a cat's paw, clawing cotton instead of feathers. What you don't see the first time, you will understand when you look again. Keep trying. Power farming makes it possible for you to have the time to study labor- and time-saving methods.

**CHECK FIELD LOSSES**

By checking field losses and adjusting your harvesting machines you can learn how to get more grain into the grain tank — where it belongs.

Here's how to check field losses behind combines and corn pickers.

**Combines:** You can check field losses behind a combine by counting the seeds left on the ground. Make a wooden frame 1 foot on each side. Place the frame on the ground immediately behind the combine. Count all of the seeds you find inside the frame. Repeat the process several times until you are certain that you have enough counts for a good average. Vary the location across the width of cut of the combine so that you will average the shatter loss from the sickle and the losses that come from the rack and cleaning shoe. Use the table in Fig. 24 to determine your loss in bushels per acre. With a little time and patience you can learn how to adjust your combine to get the least amount of grain left on the ground.

**Corn-harvesting equipment:** Most cornfields are planted in 40-inch rows. Measure off a square 40 inches on a side around the corn hill, or 40 inches of row in drilled or listed corn. Count the number of kernels in the square. Twenty kernels per 40" square equals 1 bushel per acre of shelled corn loss. If you found 60 kernels inside the frame the loss would be 3 bushels per acre. To get the ear corn loss, figure each good-sized ear you find in 133 feet of row as 1 bushel per acre loss. Added shelled loss and ear loss for total loss. Maybe your club could check on the field losses of several of your neighbors. They would be glad to find out how their machines are working.
Select a harvesting machine for this work unit. Use your Operator's Manual to help you learn how to service the machine and adjust it properly. If possible, spend some time checking field losses. Maybe you can even find a way to adjust the machine to reduce losses.

To make it easier for you to study your machine, divide it into sections according to the jobs performed. For each section, describe the adjustments that can be made, maintenance needed and then add some safety pointers. Any time that you find that speed is important, add it to the list and indicate the proper speed at which the part should run.

Machine selected _______________________________________

1. Cutting; stripping; snapping; gathering.
   a. Adjustments _______________________________________
   b. Maintenance _______________________________________
   c. Safety pointers ____________________________________

2. Feeding; elevating.
   a. Adjustments _______________________________________
   b. Maintenance _______________________________________
   c. Safety pointers ____________________________________

3. Separation; threshing.
   a. Adjustments _______________________________________
   b. Maintenance _______________________________________
   c. Safety pointers ____________________________________

4. Cleaning.
   a. Adjustments _______________________________________
   b. Maintenance _______________________________________
   c. Safety pointers ____________________________________

5. Conveying to wagon, truck or hopper.
   a. Adjustments _______________________________________
   b. Maintenance _______________________________________
   c. Safety pointers ____________________________________

6. Others.
   a. Adjustments _______________________________________
   b. Maintenance _______________________________________
   c. Safety pointers ____________________________________

7. Check field losses. Tell how you checked the losses, how much they were and whether you were able to adjust the machine to reduce the losses. _______________________________________
   _______________________________________
   _______________________________________

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.
Place the letter for the correct answer at the right of the page.

1. Seeds are usually collected: (A—so we can have the straw) (B—for seed, food and other uses) (C—to get the crop out of the field).

2. An important feature to watch when using a combine is: (A—to make sure the machine is operated at a high speed) (B—to make sure the grain is ripe and dry enough for storage) (C—to make sure the beater turns in the opposite direction from the cylinder).

3. In a combine the cylinder: (A—cuts the standing grain) (B—separates the grain from the chaff) (C—strips or rubs the grain out of the head).

4. On a combine the beater is located: (A—in front of the cylinder) (B—under the straw rack) (C—just back of and above the cylinder).

5. The fan on a combine is used to: (A—remove green weeds) (B—cool the cylinder) (C—furnish air for cleaning the grain).

6. When threshing large grains such as beans, the cylinder speed is: (A—usually slowed down) (B—increased) (C—left the same as for small seeds).

7. A cotton picker uses: (A—knives) (B—sections) (C—spindles) to gather the cotton from the boll.

8. In a corn picker the husks are removed by: (A—the snapping rolls) (B—the husking rolls) (C—a strong air blast).

9. Grain scattered evenly over the field indicates: (A—the cylinder is losing grain) (B—too much air on the separating sieves) (C—the grain is shattering in the field).

10. If the reduction ratio between cylinder and reel is 30 to 1, how fast will the cylinder turn when the reel makes 35 revolutions per minute: (A—900 rpm) (B—1,200 rpm) (C—1,050 rpm).

Note: This Check-Up Sheet is intended to test what you have learned and to stimulate discussion with the other members. The more you discuss these questions with your leader and the other members, the more you learn.
Farm machinery costs represent a large portion of the total expenses on your farm, and as such are quite important from the standpoint of management. Machinery costs often account for 25 to 60 percent of the total annual expenses. On some farms they are the largest single expense item except for interest on the investment in the land.

In this unit you will learn how to determine costs for some of the machinery on your farm. You will also study some of the important factors related to the ownership of farm machinery. But first, it is important that you continue with the service and cost records for your tractor. The first three pages of the work unit are provided for that purpose.

**MEANING OF MACHINERY MANAGEMENT**

As you take on the job of running a farm you will have to make several decisions regarding the ownership and use of machinery to run your farm. You will have to select suitable types and sizes to match the needs of your farm. You may make decisions as to the economy of owning a machine compared with having a custom operator do the work.

Once you have purchased a machine it’s up to you to take care of it and use it properly. We hope your experience with the 4-H tractor project will be of benefit to you. The more you can cut operating and repair expenses the greater will be your profits. You can’t have any “loafers” on your farm. Each machine must pay its own way.

**MACHINE CAPACITY**

In selecting equipment and planning field work it is sometimes desirable to know the capacity — or rate of performance — of a given machine. In the use of any machine there is a certain amount of lost time in idle travel, in turning at the ends, and in adjusting, lubricating, and servicing. The percent of time lost by each machine varies considerably, but you can make a quick estimate with the following formula (a time loss if 17.5 percent is assumed):

\[
\text{Acres per hour} = \frac{\text{machine width in feet} \times \text{speed in miles per hour}}{10}
\]

Example: if you cut hay with a 7-foot mower traveling 4 miles per hour the capacity would be \(7 \times 4 = 2.8\) acres per hour.

\(\frac{10}{10}\)

The following table shows capacities of various sizes of machines, as determined by this formula: Capacity, acres per hour = \(\frac{\text{width} \times \text{speed}}{10}\)

<table>
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FIXED COSTS

In the Third Year tractor project you learned how to determine the costs of owning a tractor. These costs are sometimes called fixed costs because they are affected very little by the amount a machine or tractor is used. To refresh your memory we will review these costs briefly: (1) Depreciation or loss of value as you continue to own a machine; (2) interest on money invested in a machine; (3) insurance; (4) taxes; (5) housing costs. These costs will vary from one year to the next, but their average values can be estimated as a given percent of the purchase price. The following average annual values are commonly used in estimating fixed costs for a tractor or machine: (1) Depreciation — 6 to 9 percent of the purchase price, depending on its useful life; (2) interest — 3 percent of the purchase price; (3) insurance — 0.25 percent of the purchase price; (4) taxes — 1 percent of the purchase price; (5) housing — 1 percent of the purchase price.

REPAIR COSTS

When the amount of annual use of a tractor or machine is known, repair costs are often included along with fixed costs and figured on the basis of the purchase price of the machine. Such is the case with the figures shown on page 3. A little later on we will show you how to use the table on page 3. Repair costs will vary with the amount of time a machine is used. Notice that the table on page 3 contains a column showing repair costs for a machine as a certain percent of the purchase price. The table shows, for example, that 30 percent of the purchase price of a disk harrow will be spent for repairs during its life of 15 years. That’s an average of 2 percent a year. If the disk cost $1,000 when new, then a total of $300 would be spent for repairs during its useful life of 15 years. As an average, 2 percent of $1,000, or $20, would be spent each year.

OPERATING COSTS

Of all the various costs, operating costs are the easiest to determine. You can use the records you have been keeping as part of the 4-H tractor project to help you estimate operating costs for a given tractor or machine. Suppose you found that it takes 6 gallons of diesel fuel per hour for plowing. If diesel fuel costs 40 cents per gallon that would be a total of $2.40 per hour. You may even have records to show how much is spent for oil and grease. If not, you can estimate these costs as 15 percent of fuel costs. In the previous example the oil and grease costs would be about 15 percent of $2.40 or 36 cents per hour. Total costs for fuel, oil and grease would then be $2.76 per hour.

ESTIMATING COSTS

The table on page 3 can be used to estimate costs for various machines, including depreciation, interest, insurance, taxes, housing and repairs. Notice that the table gives the cost per hour of use for each $100 new cost. In order to show you how to use this table let’s work some sample problems.

(1) What is the cost per hour of use for a tractor that was purchased new for $24,000 and is used 500 hours a year? On the line for a tractor and under the column showing an annual use of 500 hours a year we find a cost of $.032 per hour for each $100 new cost.

\[
\frac{24,000}{100} = 240 \times 0.032 \text{ or } 7.68 \text{ an hour}
\]

Note: This does not include fuel, oil and grease costs.

(2) What is the cost per hour for a $40,000 combine that is used 200 hours a year? There is no 200-hour column on the table so we have to do a little estimating. Under the 150-hour column we find a value of $.088. In order to use 200 hours (that’s half way between 150 and 250), let’s use $.102, which is about half way between $.088 and $.117.

\[
\frac{40,000}{100} = 400 \times 0.102 \text{ or } 40.80 \text{ an hour}
\]

If the combine could cut 6 acres an hour, that would be a cost of $6.80 an acre, not counting fuel, oil and grease. The charge for fuel, oil and grease can be easily estimated from your own records.
COST OF USE OF CROP MACHINES

The following table may be used for estimating costs for owning and using a machine or tractor. Cost per hour of use per $100 new cost includes depreciation, interest, insurance, taxes, housing and repairs. The figures do not include cost of labor, fuel, oil, grease, wire, twine or other such operating costs.

*COST PER HOUR OF USING FARM MACHINES
(Per $100 of new cost)

<table>
<thead>
<tr>
<th>Machine</th>
<th>Years until obsolete</th>
<th>Hours to wear out</th>
<th>Total repair cost in percent of new cost</th>
<th>20 hr. per yr.</th>
<th>40 hr. per yr.</th>
<th>60 hr. per yr.</th>
<th>100 hr. per yr.</th>
<th>150 hr. per yr.</th>
<th>250 hr. per yr.</th>
<th>350 hr. per yr.</th>
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<td>$3.19</td>
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<td>.093</td>
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<td>.076</td>
</tr>
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<td>1500</td>
<td>15</td>
<td>.568</td>
<td>.289</td>
<td>.195</td>
<td>.122</td>
<td>.107</td>
<td>.095</td>
<td>.090</td>
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60 hr per yr 150 hr per yr 300 hr per yr 500 hr per yr 750 hr per yr 1000 hr per yr 1500 hr per yr

Wagon gear and box 15 5000 50 .196 .084 .047 .039 .036 .015 .013
Tractor 15 12000 120 .196 .084 .047 .032 .026 .025 .023 .021

*From American Society of Agricultural Engineer's Handbook.
On the last page of the work unit you will find a form for estimating costs for one tractor and one machine that is used on your farm. You will need to use some of the records you have been keeping to help you determine these costs. You will also need to use some of the information we have given on pages 2 and 3 of this unit. It will be easier for you to complete the cost estimates in the work unit if you will first try your hand at the following problems.

Problem 1. How many acres an hour could you plow, if the plow cuts an 80-inch width at 5 miles an hour?

Problem 2. How many acres an hour would a 20-foot combine harvest at 3-1/2 miles an hour?

Problem 3. How fast would you have to travel to mow 6 acres an hour with a mower-conditioner cutting a 10-foot swath?

Problem 4. What is the cost per hour for an $18,000 tractor that is used 750 hours per year? (Do not figure fuel, oil and grease costs.)

Problem 5. What is the cost per hour for a $2,000 field sprayer that is used 100 hours per year?

Problem 6. What is the cost per hour for a tractor plow costing $4,000 that is used 80 hours a year?
**RECORD of HOURS and TYPES of SERVICES PERFORMED**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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<tr>
<td>A</td>
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<td>B</td>
<td>Hrs.</td>
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<td>C</td>
<td>Hrs.</td>
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<tr>
<td>D</td>
<td>Hrs.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>E</td>
<td>Hrs.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>F</td>
<td>Hrs.</td>
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</table>

- 50 HRS.
- 100 HRS.
- 150 HRS.
- 200 HRS.
- 250 HRS.
- 300 HRS.
- 350 HRS.
- 400 HRS.
- 450 HRS.
- 500 HRS.
# RECORD of FUEL, OIL, and REPAIRS

<table>
<thead>
<tr>
<th>DATE</th>
<th>TYPE of WORK</th>
<th>FUEL USED</th>
<th>OIL USED</th>
<th>HOURS</th>
<th>NOTES on other LUBRICATION COSTS, REPAIRS, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>GAUGE AT START</td>
<td>GAUGE AT STOP</td>
<td>Gallons Used</td>
<td>Quarts</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Use the records you have been keeping, and the information given earlier in the main body of this unit to estimate the cost for some of the equipment on your farm. We are asking that you use the blanks below for one tractor and one machine for which you have accurate records for at least one month's use. If you want to figure costs for other machines or tractors, submit those on a separate sheet.

1. Tractor: Make ____________________ Model ____________________ New cost ____________________

   Number of hours used each year ____________________

   a) Cost per hour for each $100 new cost: (from table on page 57) ____________________

   b) Cost per hour for tractor: (new cost) ____________ X ____________ (factor from table on page 57) ____________ 100

   Answer: ____________ cost per hour

   c) What is the estimated cost for depreciation, interest, insurance, taxes, housing, and repairs for your tractor for each year.

      Cost per hour (from b) ____________ X ____________ hours of use each year

      Total cost per year ____________________

   d) What is your estimate of the fuel, oil, and grease cost for your tractor for the year?

      Fuel ____________ Oil and Grease ____________ Total ____________________

   e) What is the average cost per hour for your tractor? Add the cost for depreciation, interest, etc. from (c) to the fuel, oil, and grease cost from (d) and divide by the number of hours the tractor is used each year.

      Answer ____________ an hour

2. Machine: ____________ Make ____________________ Model ____________________ Size ____________ New cost ____________

   a) What is the capacity of the machine in acres per hour? ____________ acres per hour

   b) Number of hours machine is used each year? ____________ hours of use each year

   c) Cost per hour per $100 new cost. (from page 3) ____________________

   d) Total cost per hour for machine: (new cost) ____________ X (c) ____________ 100

      Answer: ____________ cost per hour

   e) What is the total annual cost for depreciation, interest, insurance, taxes, housing, and repairs for the machine for each year?

      (hours of use per year) ____________ X (cost per hour) ____________________

      Answer: ____________ per year

   f) What is the average cost per acre? ____________________

Note: Fill out this work unit, using your own machinery at home. Be ready to discuss your experiences with other 4-H members at your next club meeting.