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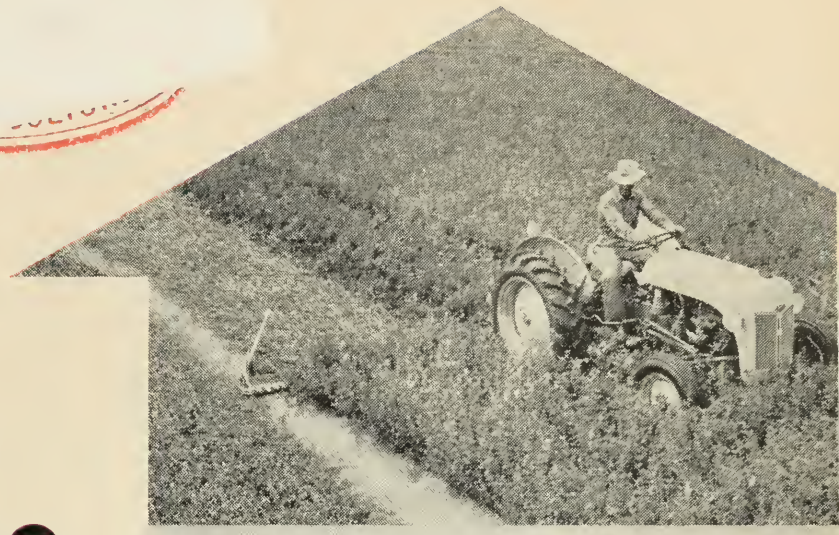
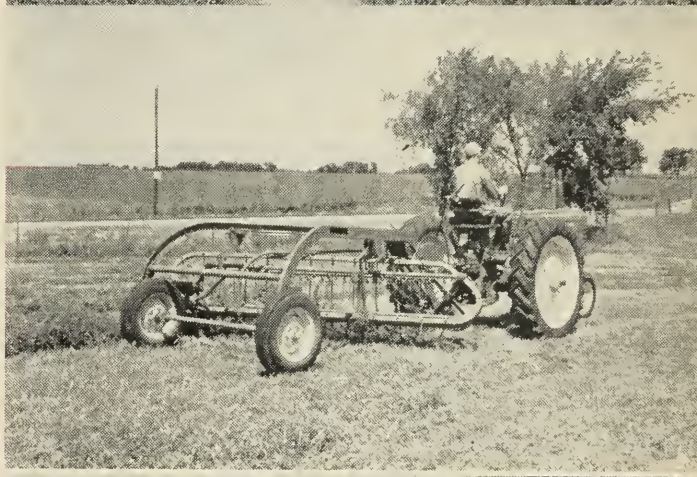
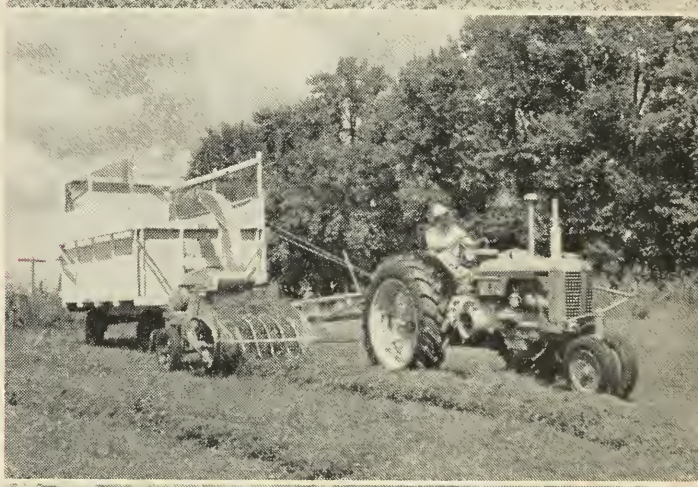


HARVESTING MACHINERY

FOR HAY AND SILAGE

A. I. Magee





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HARVESTING MACHINERY FOR HAY AND SILAGE

A. I. Magee*

INTRODUCTION

The methods used to harvest hay or silage depend on the amount of crop to be handled, weather conditions, availability of labor, location and type of fields, and many other factors. Cutting and raking operations usually present fewer problems than gathering and storing the crop. Hand loading involves manual labor and willing workers, but the equipment costs are very low. Harvesting equipment increases the investment in machinery but the labor required per ton is reduced. Efficient use of labor and equipment is very important. Some farmers can harvest twice as much crop as others with the same crew and method. If not properly maintained and efficiently used, equipment may only partly demonstrate its value and may increase the cost of harvesting.

"Man hours per ton" is a measure of the amount of labor required to perform an operation. For instance, if 6 men work 2 hours to harvest 4 tons of hay this is 12 man hours for 4 tons of hay or 3 man hours per ton.

The labor required, value of machinery, and cost of operation for the various harvesting methods are included in a table on page 30. These figures are averages and are only a guide in estimating the cost of operation. To arrive at a cost for a particular case, the various costs and rates of operation should be adjusted to conform with local conditions.

CUTTING HAY

Cutting or mowing normally presents fewer problems than does storage of hay. Usually the crop is cut more quickly than it can be stored, and the equipment and labor required for cutting per acre or per ton is relatively low.

Equipment

Mowers are built in four general types: (1) horse drawn traction mowers, (2) tractor trailer power driven mowers, (3) semi-mounted power driven mowers, and (4) fully mounted power tractor mowers. Trailer mowers can be attached to any make of tractor but as they are a trailed type of machine they cannot be manoeuvred so easily as the other types. Semi-mounted mowers are attached directly to a plate on the drawbar and are carried on one or two castor wheels. This style of machine can be attached to any make of tractor, can be manoeuvred readily and can be removed quickly so that the tractor can be used for other work. Fully-mounted mowers carried directly on the tractor are very flexible in operation, but some models are not so easily attached to the tractors as semi-mounted machines. Moreover, when these mowers are attached to the rear of tractors, the drawbar cannot normally be used for hauling other equipment. However, with the center or mid-mounted models the cutter bar is under the direct view of the operator, the drawbar is free for hauling other machines, and the unit is suitable for extensive or high speed operations.

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Power operated hydraulic or mechanical devices for lifting the cutter bar are available for tractor mowers and make it possible to lift the cutter bar with a minimum of effort.

Semi-mounted mowers can be attached to practically any type and make of tractor. With a power-take-off driven cutter bar, the mower can operate at a higher speed and in heavy crops.

A few mowers now on the market use a hydraulic motor that is operated from the hydraulic system of the tractor and drives the reciprocating knife.

Mowers with cutter bars that will cut at various angles with the horizontal are also available. These units are useful for cutting along road banks, ditches, or terraces and can be used also for regular operations in cutting field crops.

A curved divider rod fitted on the front of the outside shoe to hold down the crop will permit the knife to make a cleaner cut. The divider board can then separate the swath from the standing crop. When cutting a heavy, tangled crop of hay a good divider on the mower is essential.

Windrow attachments, which consist of a series of parallel metal straps fastened to the cutter bar, are sometimes used to windrow the crop as it is being cut. The attachments operate satisfactorily on tractor mowers at speeds above 3 miles per hour, but they tend to hinder operations when turning corners or manœuvring the mower. Windrowers are suitable for use when cutting hay for silage or when cutting very light crops of dry hay. Heavy crops dry more rapidly if they are left in the swath and windrowed some hours later. Hay mowers can be obtained with cutter bars 4 to 8 feet long. The length of bar used depends on the power available to draw the mower and on the method

used in harvesting the crop. In heavy crops balers and forage harvesters with narrow throats can only handle a windrow from a 5-foot mower. Wide throat balers and large capacity harvesters will operate on larger windrows.

Side-mounted tractor mowers permit a clear view of the cutter bar. Hand or power operated devices are available for lifting cutter bars on tractor mowers.

The number of acres of hay that can be cut per hour will depend on the land surface, kind of crop involved, condition of the equipment, type of mower used, size of field and other related factors. It is important, therefore, that fields be clear of obstructions, and that machines be in good condition. Valuable time is often lost by making unnecessary loops at the corners of fields.

TABLE I.—CUTTING HAY WITH HAY MOWERS

Rate of operation and man hours per ton—assumed yield, $1\frac{1}{2}$ tons per acre

Machine or method	Crew size	Acres per hour		Man hours per ton
		Range	Av.	
Tractor power mower 5′ bar	1	.....	1.7	0.39
Tractor power mower 6′ to 7′ bar	1	1.5 to 3.5	2.0	0.33
Horse mower with 5′ to 7′ bar	1	0.7 to 1.2	0.9	0.74
Tractor and horse mower	2	0.8 to 1.7	1.2	1.11

Some operators may cut $1\frac{1}{4}$ acres per hour with a team and mower while others may take over an hour to cut one acre. Theoretically, a mower with a 6-foot bar should cut more than a 5-foot machine but this is not necessarily the case because of the many other factors involved. Tractor type mowers when in good mechanical condition and when operated efficiently can cut a larger area per day than horse drawn mowers. Where it is necessary to reduce the time required for cutting hay, a tractor mower can be used to advantage.

Roller-Crusher

A crusher is a machine with two heavy steel rollers about 5 feet long that partially crush the hay as it is picked up from the swath. The object is to bruise the plant and crack the stems to make them dry more rapidly. Under field tests, when the weather was favorable for drying, the crusher reduced the time for drying a 2-ton crop of grass and legumes from 3 days to 2 days, or 30 per cent. With a lighter crop, and under good drying conditions, the curing time might be reduced by 50 per cent but under unfavorable conditions the saving in time would be negligible or only up to 10 per cent.

RAKING, COCKING, AND TRIPODING

After a crop is cut for dry hay it is desirable to wilt, cure, or dry it as rapidly as possible to a point where it is suitable for storage. The equipment and methods used vary considerably with climatic conditions and the method of gathering the hay after it has cured. During field wilting or curing one or more of the following operations might be used: raking, tedding, coiling or cocking, or roller-crushing of the crop. Following cutting, however, the crop is normally left in the swath where it undergoes the first stage of curing, when the upper layer of the swath dries considerably. The subsequent operations of raking or coiling, et cetera, are performed to aid in curing or to facilitate other operations in harvesting the crop.

Before the swath is raked it should be partially cured but not excessively dry. If the swath is dry and crisp 20 to 50 per cent of the leaves, representing 10 to 25 per cent of the crop, may be lost. The side rake should travel in the

This is a roller-bar side delivery rake fitted with hydraulic lift. Since roller-bar rakes move the hay a shorter distance they tend to reduce leaf loss.

same direction as the mower to place the greener stalks on the outside of the windrow for drying. A crop for silage may be harvested direct from the stand or cut and raked as required for subsequent operations.

Equipment for Raking Operations

Three types of rakes, the dump rake, side rake, and wheel rake, are commonly used in haying operations. Dump rakes 10 to 14 feet wide are relatively low in initial cost and are adaptable to operations on many small farms. Moreover, they may be used for raking rather rough pasture land. Rakes of this type are available as horse drawn or tractor mounted machines. Large trailer type tractor dump rakes are 21 to 36 feet wide. These rakes are commonly used in raking range land where large areas must be covered. Dump rakes are frequently equipped with fast acting teeth lifting devices and rubber tires, while wide units are constructed in flexible sections for uneven terrain.

Side delivery rakes are frequently used in conjunction with hay loaders, narrow throat balers, and forage harvesters because they form a tight, narrow windrow. These rakes are made in three types, cylinder, roller-bar, and wheel. The cylinder type is the conventional side delivery rake which has been in use for many years. The cylinders of these machines are driven from wheels or from a power-take-off but there is little or no difference in their utility.

Roller-bar rakes are similar to conventional side delivery rakes but have the spiders that carry the tooth bar set at about right-angles to the direction the machine travels. When raking a seven-foot windrow this machine moves the hay about 10 feet while the ordinary side rake moves it about 18 to 20 feet. If the hay is in reasonably good condition and the speed of operation is moderate, roller-bar rakes should reduce leaf loss.

Wheel rakes consist of one to five wheels about 60 inches in diameter with wire teeth attached to the rim of each wheel. When set diagonally across the swath the teeth touch the soil and hay causing the wheels to rotate and roll the hay into a windrow. Wheel rakes move the hay a shorter distance, and more gently than conventional side rakes, and thus reduce leaf loss.

TABLE 2.—RAKING, TEDDING, COCKING, AND TRIPODING HAY

Rate of operation and man hours per ton

Method or equipment	Crew Size	Rate per hour for crew in acres		Man hours per ton
		Range	Av.	Av.
Tractor and tractor side rake 5′ to 7′	1	1.5 to 4.0	2.5	0.27
Horses and side rake 5′ to 7′	1	1.2 to 2.4	1.6	0.42
Tractor and tractor dump rake 10′ to 12′	1	2.0 to 4.0	2.5	0.27
Tractor and tractor dump rake 21′	1	5.0 to 9.0	7.0	0.10
Horses and dump rake 10′ to 12′	1	1.4 to 2.4	1.8	0.37
Hand turning hay	1	0.3 to 1.0	0.4	1.67
Hand cocking hay*	1	0.3 to 1.3	0.6	1.11
Tripoding hay and setting tripods**	1	.....	0.3	2.22

* Approximately 60 lb. to 90 lb. of hay per coil or cock. Cocking from windrow.
** Approximately 650 lb. of hay per tripod.

Cocking and Tripoding Hay

When the climatic conditions are not favorable for ordinary field curing, the hay is sometimes placed in cocks or on tripods after it is raked. Hay coils or cocks will shed a certain amount of water and only the outside layer will bleach to any extent. By tripoding, a good quality of hay can usually be obtained even under severe weather conditions. Under adverse weather conditions, and where the volume of hay involved will justify the use of equipment, the crop might be stored in a silo as an alternative to tripoding.

Tripods are made from three poles, each 8 feet long, wired together at the top, and three lighter poles about 7 feet long wired to these legs in a horizontal position near the bottom of the tripod. Holes ¼-inch in diameter are drilled in the legs at the top so that the legs may be fastened together with a piece of wire. Holes are drilled in the legs about 20 inches from the bottom for attaching the lighter horizontal poles. For tripoding, the hay is usually wilted in the swath, gathered in bunches with a dump rake or sweep rake and then forked on the tripod. Five to ten tripods may be required per acre. When building the tripod a forkful of hay is first placed on the projecting corners and then three or four forkfuls are placed directly on top of each pole between the legs. After building the hay to the top of the tripod, the sides are combed down to aid in shedding water. Some 500 to 1,000 pounds of hay may be placed on each tripod. Hay cured on tripods is usually moved to the barn in wagons or with sweep rakes.

METHODS OF COLLECTING, HAULING, AND STORING HAY AND SILAGE

In moving the crop from the windrow into storage numerous methods are used and these vary with the conditions on each individual farm. The value of equipment involved may range from $200 to $8,000 depending on the method employed and on the volume of hay being harvested. Where the work is primarily done by hand it may require four man hours per ton to harvest the crop while only one man hour might be used with power equipment.

Hand Loading Method

The hand loading method is used on many farms where the volume of hay handled is relatively small. With this method the amount of labor required is high and the work is strenuous but the cost of equipment is low. In cases where only a few tons of hay are harvested, where fields are small, irregular, stony or rough, the hand method may be the most suitable and economical means of collecting the crop. Hay equipment may consist of a wagon, rack, and barn hay track to unload the hay wagon.

Hay Loader Method

The hay loader method is one of the most common methods of harvesting hay. It involves a modest investment in equipment and a medium amount of labor. A wagon can be loaded in about three-quarters of the time needed to load with a hand fork. Although the method is flexible and adaptable to a wide range of conditions a considerable amount of heavy labor is involved in loading and in storing the hay. The hay loader method for harvesting green material for silage involves considerable manual labor. In harvesting a crop for silage consideration should be given to the sweep rake and forage harvester.

Equipment

Hay loaders are made in two general types, the slat style which is suitable only for dry hay and the push bar style which is a heavy duty machine suitable for dry hay or green forage for silage. When using a loader, straight even windrows facilitate operations.

Hauling Hay and Size of Loads

The average rate of speed to and from the field is, for horses and wagon, 2.5 miles per hour; tractor and wagon, 5 miles per hour; and motor truck, 5 to 15 miles per hour. On the basis of a ¼-mile haul from the field to the barn, a complete trip and return requires approximately the following times, horses and wagon 10 to 15 minutes, and tractor and wagon 6 to 10 minutes.

Normal loads of long hay range from 1,500 to 2,500 lb., baled hay from 2,000 to 4,000 lb., while chopped hay may vary from 1,000 to 2,000 lb. Where the hauling distance is long it is desirable to carry large loads. A larger load is usually carried when low wheeled, rubber tired wagons are used.

Sweep Rake Method for Dry Hay

This method of gathering hay is often used where the hauling distance is less than one-half mile, where the amount of hay harvested is 60 tons or less and where the fields are reasonably smooth and firm. If fields contain very sandy soils, muck, dead furrows, or other such obstructions the teeth of the rake are often broken as they penetrate the soil or hit obstructions. Although a tractor is required for this method of collecting hay the investment in the actual haying device, or rake is relatively low, as wagons or loaders are not required. Moreover, the man labor involved is reasonably low ranging from 1.2 to 2.5 man hours per ton with an average of 1.8 man hours for gathering and storing the crop. Where the sweep can be used it is often an efficient and economical method.

Equipment

Both commercially built and homemade sweeps have been successfully used. When mounted on tractors, sweeps are usually placed on the front to obtain a loading speed of 5 to 7 miles per hour. Power driven hydraulic lifting devices are essential for raising the rake teeth and are a standard feature of commercial rakes. Homemade rakes can be constructed for use on the front of tractors or on the rear of old car chassis, but considerable work is involved and the purchase of a commercial unit is often desirable.

Sweeps for hay are normally 11 feet wide with teeth 12 feet long, spaced at 11-inch centers. Each tooth, of fir or hardwood, is 3 by 3 inches at the butt and 2 by 2 inches at the point. Tips of the teeth should be tapered at the end from both the top and bottom, not just from the bottom, and fitted with metal sweep rake points.

Both commercially made and homemade sweep rakes are used in harvesting. The sweep rake, where it can be satisfactorily used, eliminates heavy manual labor in gathering hay.

Operational Details

Hay may be picked up from either the swath or the windrow with a sweep, but most operators prefer the windrow as the raking often facilitates curing of the crop and the gathering of a larger load on the sweep. By putting a half load on the sweep and then unloading, a second load can be gathered and deposited on top of the first, thus making it possible to pick up a double load for hauling.

In gathering hay from the swath, two 6-foot swaths should be collected simultaneously and the rake should follow the direction the mower has travelled. If the hay is cut in the same direction as the field was plowed there will be fewer depressions to cross, and it will be easier to gather the hay.

Loads vary from 500 to 700 lb. depending on the design of the sweep rake, the method of loading, and on the type of hay involved. The rake should be operated at a speed of 5 to 7 miles per hour. At the barn the hay can be elevated by means of a blower, cutter box with blower, or with slings. When using slings at the stack or barn, two forkfuls of hay are spread out on the ground, the slings are laid on top of the hay and the sweep load is then deposited on the slings. The hay under the slings aids in unloading the sweep rake. On farms where tractor sweep rakes are used, the amount of hay harvested averages 30 to 50 tons. For short hay extra ropes are added to the slings. Well-constructed heavy duty sweeps are sometimes used to gather sheaves at threshing time. Refer also to the section dealing with combination sweep stackers and sweeps for silage.

Sweep Rake Method for Silage

When a crop does not have to be moved more than one-half mile to storage, a silage sweep can be used effectively in conjunction with trench silos or stacks. With this method the long or uncut material is picked up from the swath with the sweep and deposited directly into the silo or stack.

Silage sweep rakes carry loads of 400 to 700 pounds and can be used economically on a hauling distance of ½ mile or less. Smooth fields and good roads from the fields to the trench silo facilitate operations.

Equipment

In general, silage sweeps resemble hay sweeps. They are 9 or 11 feet wide and are fitted with steel teeth 5 feet long spaced 8 inches apart. Some types are designed for mounting on the rear of tractors while similar units

can be mounted on the front or attached to the arms of a tractor manure loader. With all types, the rake can be raised with a hydraulic power lift. The cost of a sweep may range from $150 to $250.

Operational Details

To use a sweep, the field should be cut in the same direction as it is plowed or cultivated so that the sweep can be loaded easily without crossing dead furrows. When loading the rake, two 5-foot swaths are gathered simultaneously with a 9-foot rake and the best results are obtained by travelling in the same direction as the mowers. The load normally carried on a sweep ranges from 400 to 700 lb. with an average of 550 lb. In a good crop this load can be gathered in 2 minutes at 3 miles per hour. When carrying the load from the field, the tractor should straddle a swath so that silage falling from the rake will drop on adjoining swaths to be picked up later without extra sweeping.

To unload, the tractor may be driven through the silo or backed into the silo as required. When the wheels of the tractor are on a mound of silage and the teeth of the sweep dropped as low as possible, the silage will usually slide off. If a load remains on the sweep, a hand fork may be driven through the load to hold it while the sweep is pulled out by the tractor. In effect, the silage is placed in the silo in sloped, lapped layers with the loads lying like shingles on a roof. The most suitable width of silo for a 9-foot rake is 11 feet or 20 feet. Hand spreading of material in a silo can be practically eliminated by a skillful tractor operator.

TABLE 3.—COLLECTING AND STORING HAY AND SILAGE

Rate of operation and man hours per ton from windrow to storage

Method or equipment	Haul miles	Crew size	Rate per hour for the crew in tons		Man hours per ton
			Range	Av.	Av.
Hand loading, dry hay	½	3	0.7 to 1.5	0.9	3.5
Sweep rake, dry hay	⅓	2	0.8 to 1.7	1.1	1.8
Sweep rake, dry hay	⅓	3	1.2 to 2.0	1.4	2.1
Sweep rake, silage	⅓	1	1.5 to 2.2	2.0	0.5
Sweep rake, silage	⅓	2	.....	2.0	1.0
Sweep rake, silage	½	1	1.2 to 1.7	1.5	0.7
Hay loader, dry hay	½	2	.....	0.9	2.2
Hay loader, dry hay	½	3	1.0 to 2.5	1.2	2.5
Baler, dry hay	¾	5	2.0 to 3.5	2.5	2.0
Forage harvester, dry hay	¾	4	1.5 to 4.0	3.0	1.3
Forage harvester, silage (grass)	¾	5	3.0 to 7.5	5.0	1.0
Forage harvester, silage (corn)	¾	6	5.0 to 10.0	7.5	0.8

The Baler Method

In the harvesting of hay, balers form the hay into bundles that can usually be moved more readily than loose long hay. The baler method will, therefore, be used to the greatest advantage under the following conditions (a) where the crop is being shipped some appreciable distance by truck or train, (b) where the storage space is limited, (c) where during feeding operations the hay is moved from one building to another or into a feed lot, and (d) where it is convenient to temporarily divide the harvesting operations by hiring a custom operator to assist with the harvest work by baling the crop, or to quickly package the hay so that it will withstand some rain and thus allow more time for hauling and storing operations. Baling, however, involves

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another machine operation and also the cost of twine or wire for the bales. Although baled hay will shed some water and dry off when the weather is favorable, baling does not overcome all of the weather hazards as the hay must be properly cured before baling. Unless the hay is as dry as or slightly drier than ordinary long hay when ready for storage, the bales will mold in the center. Though bales may be more convenient to move than long hay the total time required to move baled hay from the windrow into storage may be about equal to the time used in moving loose hay by the loader method.

Field balers may be operated from the tractor power-take-off shaft or from a separate engine mounted on the baler. Machines with auxiliary engines cost more than power-take-off units but balers with engines are more suitable for uneven windrows and they can be drawn by a small tractor. In general, engine driven balers are preferred by custom operators who wish to bale a large tonnage per day from windrows that might be too large or irregular for convenient operation with power-take-off machines. With round bale machines the forward motion of the baler is stopped while the bale is wrapped and discharged. For this type of baler a tractor with a continuous power-take-off drive is definitely advantageous as it is only necessary to push in the tractor clutch while the bale is put through the machine.

Operational Details

To prevent clogging of the machine it is important that windrows be the proper size. For balers with a broad throat, such as the round bale units, a double windrow can be used, while with narrow throat machines, a 5-foot swath

Broad throat, round bale machines can operate on a heavy windrow. As the baler is stopped to discharge each bale, a tractor with a continuous power-take-off is usually used with this baler.

is quite sufficient in a 2-ton crop. Both types of baler, however, may have the same tonnage capacity per day. Straight, even windrows are desirable as a poorly cured bunch of hay may spoil when packed in a bale.

Under the most favorable conditions and without loss of time it is possible to bale 5 to 7 tons per hour with automatic field balers but the average daily capacity is usually about 4 tons per hour with a seasonal capacity of $2\frac{1}{2}$ to $3\frac{1}{4}$ tons per hour. On reasonably level land a two-plow tractor will haul an engine driven baler. For a power-take-off baler at least a two-three plow tractor is

needed and a three-four plow tractor is normally used on rolling land or where a loaded wagon is hauled behind a baler. As balers and forage crop harvesters have numerous moving parts it is extremely important to have a thorough knowledge of these machines in order to operate them at their maximum capacity and efficiency. Only by keeping these machines in good repair and properly adjusted can they be successfully and profitably operated. When bales are to be handled or moved several times, it is advisable to set the machine for small bales, as large bales frequently warp and fall apart. For information on bale loaders see the section on auxiliary equipment.

Forage Crop Harvester Method

With a forage crop harvester, the amount of manual labor required to gather and store a crop is reduced to a minimum while the investment in equipment is relatively large in comparison with some other methods. By using

Automatic twine tying balers may be used to bale straw, hay, and similar materials. Balers with auxiliary engine are often preferred for custom work.

a harvester, an unloader and blower, grass silage, corn for silage and dry chopped hay can be placed in storage without manually handling the crop. However, to economically utilize this method it is necessary to move a reasonably large tonnage per year in order to keep the equipment investment charges within reasonable limits. Forage crop harvesters range in price from about $750 to $3,000 depending on the type and size of the machine and whether power-take-off or engine driven.

Two general types of forage harvesters are available (a) the chopper type and (b) the flail type. Each of these types is discussed below.

Chopper Type of Forage Harvester

The chopper harvester consists of three sections, a cutter or pick-up or corn attachment, a chopper unit which cuts the material into lengths ranging from ½ inch to 4 inches, and a blower or conveyor for delivering the crop into

a wagon or truck. With a cutter bar attachment the crop can be harvested directly from the stand. With a pick-up unit dry hay or green hay is lifted into the machine from the windrow. With a corn head attachment, the standing corn is cut off near the ground and conveyed into the main body of the machine. Wagons may be trailed behind the harvester or can be hauled at the side with a separate tractor. To keep power requirements at a minimum the cutter knives should be sharpened after each five hours of operation. To obtain a clean cut, knives should also be properly adjusted.

With one form of forage crop harvester, the blower of the machine can be used to place hay in the barn or green material in the silo. As a result a regular forage blower is not required. When using the machine, the entire harvesting equipment consisting of tractor, harvester, and wagon is drawn to the barn or silo. The crop material is then forked into the harvester through the suction attachment and the crop is blown into storage.

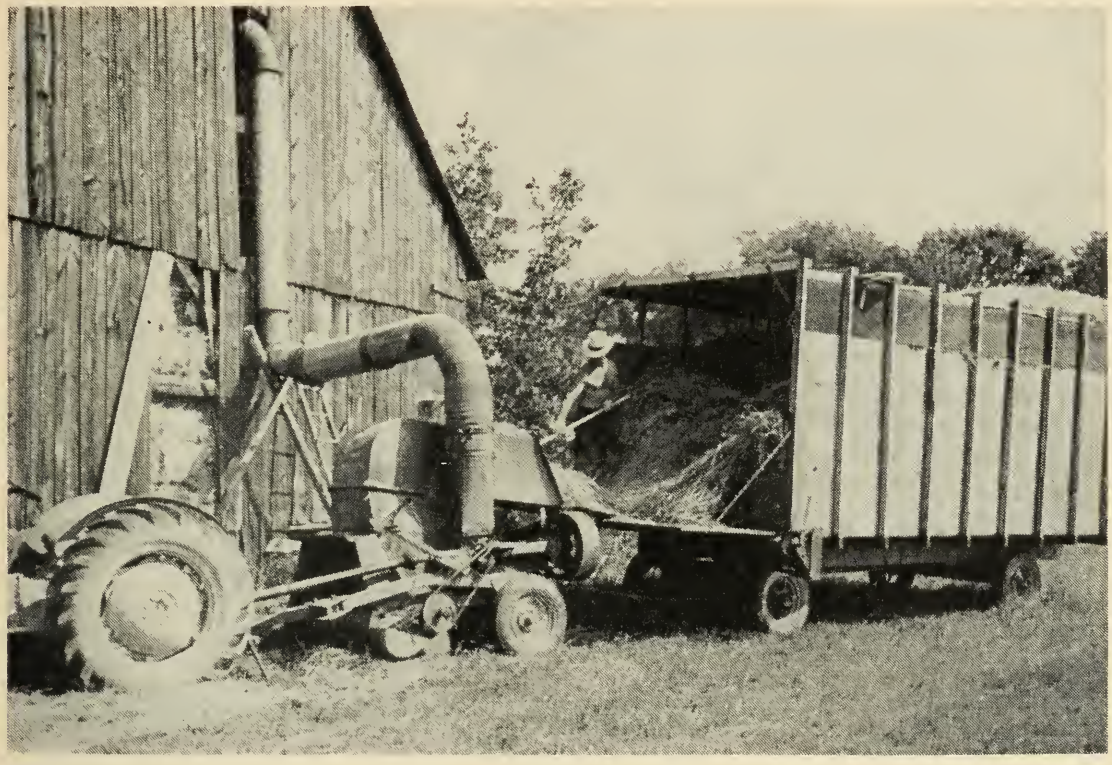
Another recent development in forage harvesters is a unit consisting of a pick-up that elevates the crop to a chopper consisting of two rollers. One roller is equipped with blades while the other has a rubber surface, and the crop is chopped as it is drawn between the rollers. This unit may be mounted on a

This is a new type of forage harvester. The crop is chopped as it passes between a rubber roller and knife drum and a fan blows the material into the wagon.

truck chassis as a self-propelled unit or it may be drawn behind a tractor similar to a conventional harvester. The power required to drive the unit is claimed to be very low and the length of cut is six inches. The machine should be well adapted to handling dry hay, since the material is not finely chopped.

In conjunction with a harvester, a blower is required for elevating the crop into a silo, barn, or stack. These units consist of a cross conveyor or feeder, and

a fan. If power-driven wagon unloaders are to be used the feeder should be long enough to extend across the entire width of a 7½-foot wagon box. Moreover, a feeder which can be raised to allow a wagon to pass and which can be lowered behind the wagon eliminates the necessity of backing the wagon up to the blower. For large-scale operations a blower should have a silage capacity of 12 tons per hour and a dry hay capacity for 4-inch hay of at least 5 tons per hour. Some blowers can be fitted with an attachment for driving wagon unloaders. For details on unloaders see page 23.



Windrowed hay may be loaded into the wagon in the field with this machine and then blown into the mow with the same equipment.

Power Requirements and Capacity

A two-three plow tractor at full throttle will operate a power-take-off chopper harvester on level firm land and haul a wagon when picking up a light windrow of dry hay or silage. If an engine-driven harvester is used a two-plow tractor will draw a harvester and wagon under reasonably favorable conditions. A three-plow tractor is more suitable for a power-take-off harvester and will draw and power the machine in corn yielding up to 15 tons per acre. For heavier corn crops a four-plow tractor or an engine-driven harvester is desirable. Where a tractor has difficulty hauling both the harvester and a wagon, the wagon can be hauled at the side of the harvester with a separate tractor. Harvesters with wheel-type cutters have throats measuring 12 to 18 inches. Machines with 12- to 15-inch throats are normally used on smaller individual farms, machines with 14- to 16-inch throats are common on medium sized farms or for some custom work, while 15- to 18-inch machines are for large farms or extensive custom work.

The capacity of forage crop harvesters varies according to the size of the machine, the power supplied, the crop involved and the conditions of operation. Medium sized units have a capacity of 3 to 4 tons of chopped hay per hour, 5 to 10 tons of grass silage per hour, and 7 to 15 tons of corn per hour. The output of the machine depends primarily on the yield of the crop.

Operational Details for Dry Hay

When using a power-take-off driven chopper harvester it is important to adjust the size of the windrow to the capacity of the machine. Relatively small windrows are desirable to prevent plugging the machine. In a crop yielding 2 tons per acre, a 5-foot mower is most suitable while in a 1-ton crop a 7-foot cut is suitable when using a medium sized harvester. To prevent intermittent loading of the machine it is also important that the windrows be straight and even. When using harvesters with engines or when using a tractor with a continuous power-take-off, the speed of the tractor can be adjusted for variations in the size of windrows.

Straight, even windrows are desirable when using forage harvesters or balers. Harvesters operated with an auxiliary engine are frequently used by custom operators and on farms with relatively large quantities of hay and silage.

Stones will often severely damage forage crop harvesters. Care should therefore be taken when raking to set the teeth as high as possible to avoid dragging stones into the windrow. In addition the pick-up head should be set as high as possible to avoid lifting stones into the harvesters. In operating any machine with a large number of moving parts the unit should be properly greased and maintained. Precautions should also be taken to prevent accidents that may injure anyone working with the machine.

Hay chopped with a machine setting of 4 inches or longer can be stored at the same moisture content as ordinary long hay. A 4-inch cut will require about 450 cubic feet of storage space per ton. Chopped hay that is blown into a mow or stack should not be tramped or walked on. The pipe nozzle of the blower pipe should be adjusted frequently to obtain even distribution. Hay chopped in $2\frac{1}{2}$-inch lengths must be very dry (below 20 per cent) for storage and in this condition it shatters appreciably in the machine. The storage space required is 250 to 300 cubic feet per ton.

Operational Details for Grass Silage

Silage may be harvested directly from the standing crop with a cutter bar attachment or lifted from the windrow with a pick-up attachment. The method chosen may depend on the nature or condition of the crop. Chopped silage may be placed in tower silos or trench silos as desired.

Green material can be windrowed with a windrow attachment fitted to the mower. These attachments are more satisfactory on tractor mowers at speeds over 3 miles per hour than on horse-drawn mowers. Teeth of a rake should be set as high as possible to avoid dragging stones and soil into the windrow. When using large capacity engine-driven harvesters, swather-mowers 10 to 12 feet wide can be used to cut and windrow the silage material. Swather-mowers resemble grain swathers but can cut closer to the ground. They form a larger windrow than a standard 7-foot mower. Stone hazards are also reduced because the swather eliminates the need for a side delivery rake. Regardless of the method, uniform windrows are the aim.

Direct cutting is probably suitable when a crop contains more than 50 per cent of grass or when the crop is rather mature and not particularly wet. Succulent crops should be windrowed and allowed to wilt before being harvested.

The length of chop or cut required may depend on the type of silo used, maturity of the crop, moisture content, and other unknown factors. In general it appears that chopped grass legume crops to be put in tower or surface silos should be cut in lengths of 3 to 4 inches (1) when the crop is cut prior to the bloom stage, (2) when the crop is rather moist or succulent, (3) when the crop contains over 50 per cent grasses in the grass legume mixture or, (4) when silos have a large capacity possibly exceeding 200 tons. A shorter cut of $\frac{3}{8}$ to $\frac{3}{4}$ inch appears suitable when the crop is not so moist (60 to 70 per cent moisture), when the crop is more mature, or when the silo is relatively small. A very short cut also seems desirable for the top third of a tower silo.

Operational Details for Corn

When harvesting a heavy crop of corn (over 20 tons per acre) adequate power is required for driving the chopper harvester. In a heavy crop or on rolling land the wagon can be hauled beside the harvester with a separate tractor. The load on the tractor pulling the harvester is materially reduced when a wagon is not being trailed at the rear. A reversing gear on the harvester also facilitates operations in heavy crops. With this device the entire feeder mechanism can be reversed to clean out the throat if the harvester plugs or blocks. Where there are stones in the field the corn should be cut at least 6 inches from the ground to avoid picking them up. The length of cut for corn normally ranges from $\frac{3}{4}$ to 1 inch.

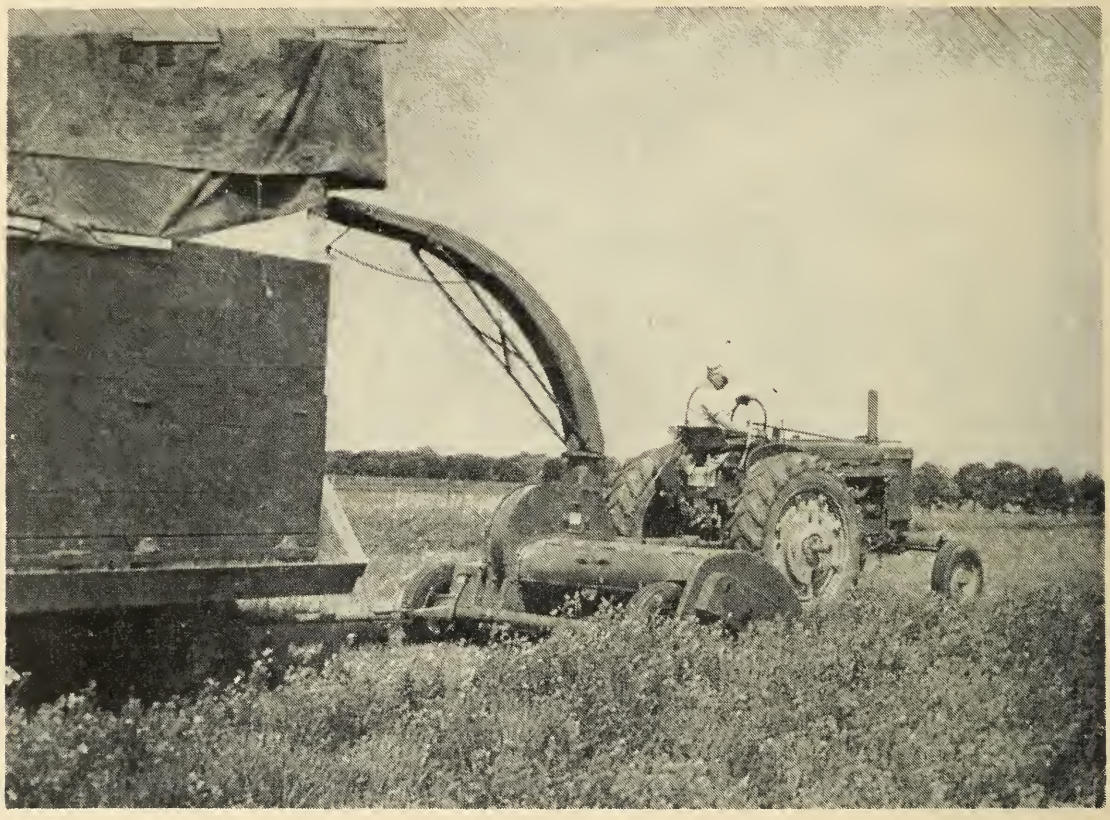
Flail Type of Forage Harvester

The flail type of harvester resembles a crop shredder with the addition of either a hood or a blower assembly to deliver the crop to a wagon. The models with a blower assembly usually have an auger to carry the shredded material from the flails or blades to the blower. Units without a blower have specially designed flails that create sufficient air blast to blow the material through a duct into the wagon without the use of an auxiliary blower.

Practically all shredder harvesters are driven by the power-take-off of the tractor and do not have pick-up or cutter bar attachments as is usual with chopper forage harvesters. However, a few models are available with special attachments for harvesting corn. Early models of shredder harvesters were drawn behind the tractor. This sometimes resulted in unsatisfactory cutting because the crop was trampled by the tractor wheels. To prevent trampling the uncut crop, offset machines have been introduced that permit the tractor to drive alongside the crop being cut. Shredder harvesters are available in

cutting widths from 5 feet to 8 feet and priced from $750 to $1,500. In general, the harvesters with the blower attachment are more expensive than the models with special flails to blow the crop into the wagon.

Flail-type harvesters are well suited to operations where direct cut forage is to be stored in a horizontal or surface silo or when the crop is to be fed



Flail harvesters shred the crop and deliver it to a wagon. This unit has an auger and blower to convey the crop from the shredder to the wagon.

directly to the cattle. As the material is cut in 2- to 6-inch lengths the blower should have ample clearance and the material should be uniformly fed into the machine to prevent plugging.

Operational Details for Dry Hay

Windrowed and swathed crops may be handled with a shredder harvester, but, since large portions of the swath are usually pulled into the machine at one time, a large tractor is necessary for efficient operation.

When dry hay is picked up with a flail type machine many of the leaves may be separated from the stems by the shredding action of the flails. The length of cut may range up to 6 inches or more with an average of 4 to 5 inches. To conserve the leaves covered wagons should be used for hauling, and the material should be spread carefully in the mow by adjusting the deflector hood and pipe of the blower. The chopped hay should not be tramped in the mow.

Power Requirements and Capacity

A tractor of at least three-plow size is recommended to satisfactorily operate a power-take-off shredder harvester and draw a wagon. With a 7-foot machine a four-plow tractor may be necessary especially in heavy crops or on hilly land. Often a three-plow tractor will operate a machine satisfactorily, but a four-plow tractor would increase the capacity. A two-three plow tractor is not recommended unless an engine driven shredder harvester is available. A tractor of this size might operate a 5-foot machine in light crops with skillfull handling, but the capacity would be low.

The capacity of a shredder harvester is approximately the same as a chopper harvester. With ample power the rate would vary from 4 to 12 tons of green material per hour. In general, a 5-foot machine with a three-plow tractor would cut 4 to 8 tons of green crops per hour while a four-plow tractor and 7-foot machine would handle 6 to 12 tons per hour. The output depends primarily on the crop yield and the size of the tractor.

Operational Details with Grass for Silage or Green Feed

Flail type harvesters are well suited for cutting standing crops of grass, cereals or forage. Mechanical grazing—that is cutting the grass and placing it in bunks to feed cattle—is becoming more practical because the flail harvester has a low initial cost and is a reliable direct-cut machine when compared with the conventional forage harvester.

The shredded material from a flail harvester may be stored in any practical type of silo. While the length of cut may range from 2 to as much as 6 inches, the shredding bruises the grass and it will pack uniformly in the silo. However, the long material should be carefully fed into a forage blower to avoid blocking the machine.

Windrowed crops may be harvested with the flail harvester, but because loose windrows are often pulled into the machine in bunches a three-four plow tractor is recommended to prevent plugging the cutter. The machine, however, does give best results when used on a standing crop.

Rocks and large stones may damage the shredder harvester. This damage is usually confined to the cutting knives, and repairs may be made in the field by the operator but valuable time may be lost. It is wise to cut the crop at a height of 4 to 6 inches and avoid the obstacles and subsequent repairs.

Operational Details for Corn

The shredder harvester will gather corn stalks from a field of standing corn and in some cases very few stalks and cobs will remain in the field. Light

By off-setting the harvester, the standing crop is untrampled by the tractor wheels. This harvester uses a flail shredder that cuts and elevates the crop in one operation.

crops of short corn may be satisfactorily harvested. With a crop yielding 10 to 25 tons of corn silage per acre the harvester becomes less efficient as the yield increases. The harvester pushes the stalks forward and the flails are unable to gather all the cobs and stalks. Machines are available with specially designed attachments that may increase the efficiency in harvesting corn.

Corn harvested with a shredder harvester ranges in length of cut from 2 to 8 inches with a few sections of cobs 3 to 4 inches long. Since the corn is well shredded it should result in satisfactory silage although some operators object to the long cut. Silage blowers require careful attention when handling the long material from a shredder harvester to prevent blocking the equipment.

AUXILIARY EQUIPMENT

Numerous auxiliary devices that are used with different methods of harvesting crops are worthy of consideration. Hay slings, sliding racks, quick coupling wagon hitches, hay hoists, and various other pieces of equipment, might be included in this category. Before purchasing equipment of this type, each of the detailed operations in gathering and storing the crop should be carefully studied to discover the time-consuming jobs that might be improved. Sometimes a small and inexpensive device will materially improve a certain operation. All such equipment should be sturdily constructed and properly installed to obtain efficient operation during the harvest season.

Hay Carts

Where a small tonnage of hay is loaded by hand, the work in loading can be reduced by using a very low hay cart or wagon. Such a cart may consist of an 8- by 14-foot platform supported by a cross axle located at the rear and a set of dolly wheels at the front. The frame of this wagon may consist of two stringers, 6 inches by 6 inches by 13 feet, spaced 5 feet apart at the rear and fastened together at the front where the dolly wheels are attached. With wheels 2 feet in diameter the platform is about 1½ feet above the ground. Many variations of this type of cart or wagon have been used for hauling hay.

Preservative Application Equipment

When a preservative such as molasses is added to grass or legume silage it is occasionally applied with a garden sprinkling can, but there are much better ways of adding preservatives to the silage. For silage cutters and for silage blowers most manufacturers can supply a molasses pump attachment which consists of a pump and an automatic regulating valve. With this equipment, molasses is drawn from a barrel by the pump, flows through a regulator valve set according to the quantity of molasses required, then through a control valve which is operated from the feed roll on the cutter in such a manner that the molasses is shut off when no material is being fed into the machine.

Chemicals in dry form are being used to improve the quality of silage and hay. These chemicals may be added to the crop either at the time the crop is being placed in storage with a cutter or blower, or in the field when a forage harvester or baler is used to gather the crop. A dispenser is attached to the machine that is handling the crop, and the conditioner is applied during the normal operation of the machine.

Several devices are available to meter the powder into a baler, forage harvester, or blower. A satisfactory device may be constructed by using a fertilizer hopper from a corn planter or drill. The hopper is mounted on the machine to deliver the chemical on the crop as it enters the machine. A sprocket and chain arranged to drive the hopper shaft at 10 r.p.m. is suitable for average operating conditions.

Grapple Forks, Slings, and Harpoon Forks

In general the harpoon fork is a suitable tool for unloading long hay from wagons and it is very efficient in this operation. The grapple fork is, however, sometimes preferred for hay from a second cut or a poor crop when the hay is rather short. In addition some types of adjustable grapple forks can be used in hoisting baled hay and they usually lift eight bales per load. Slings can satisfactorily lift larger loads of loose hay than forks but the slings must be taken to the field and placed in the load as the load is being formed. If 600 to 800 pounds are lifted on slings a sturdy hay hoist rope and hay track are required. Slings are very suitable for hoisting hay hauled with a sweep rake.

Carriage or One-Man Racks

A carriage unit can be built and used on any sturdy flat top hay rack. The carriage consists of a platform 8 by 8 feet mounted on two axles with four 5-inch steel rope pulleys as wheels. These wheels run on two tracks consisting of two pieces of $\frac{3}{4}$-inch pipe or $\frac{3}{4}$-inch angle iron each 16 feet long which are fitted on top of the main rack and spaced $4\frac{1}{2}$ feet apart. Two front end standards 2 inches by 3 inches by 6 feet are placed on the front of the carriage. At the top of these standards is fitted a roller and crank with a piece of rope to crank the carriage from the rear to the front of the main rack when it is loaded. Suitable pins should be used to lock the carriage in the rear or forward positions so that it will not roll free and hit the ends of the main deck when going up or down hill. In operation, the carriage is placed at the rear of the wagon and loaded from a hay loader and then it is cranked ahead to the front of the wagon whereupon the rear section of the main rack is loaded with hay. Some farmers consider that the carriage saves much work in loading operations. When loading green hay that is to be used as silage it eliminates some of the heavy work in moving the green material to the front of the rack.

Bale Loaders and Elevators

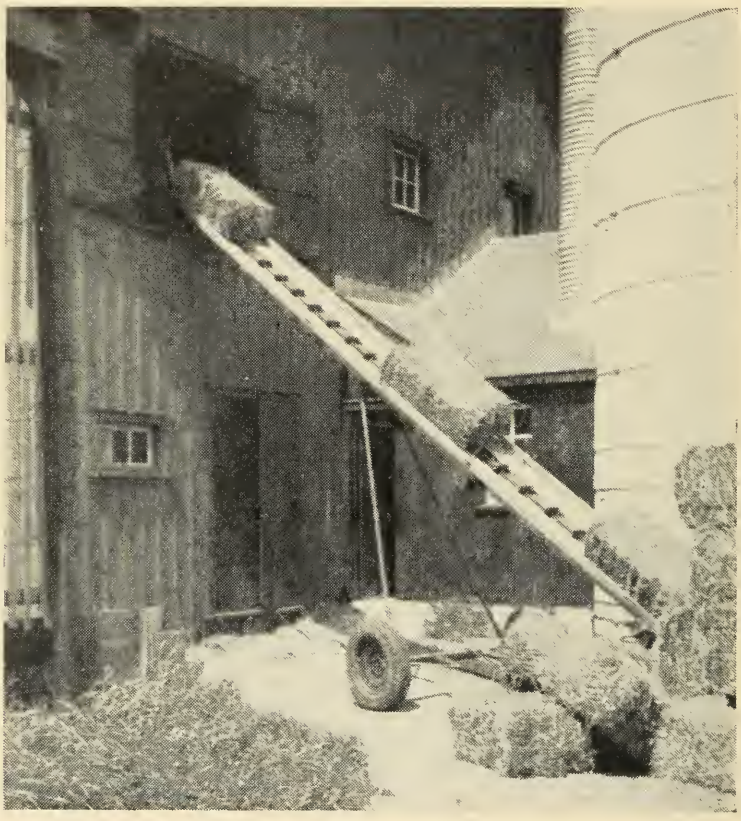
Loaders have been devised that will pick up bales that are lying in the field and lift them to a convenient height that one man can load a wagon or truck. These units are drawn alongside the wagon and may be traction or engine driven. Some loaders are combination units which are used for field loading and also for elevating bales into a hay mow. Under favorable conditions a loader will lift four tons of hay per hour and may average about two tons per hour. A two-man crew can hand load a wagon at the same rate.

Conveyor attachments that can be fitted to balers to carry hay from the baler to a wagon are available. The wagon is trailed directly behind the baler and the conveyor attachment guides the baled hay to the front of the wagon. With this attachment one man can load the wagon as the hay is being baled in the field. Balers are available with an attachment to toss each bale back into the wagon. A wagon fitted with a box may be loaded without manual labor.

Stacking the bales in a mow or in a field stack is a time-consuming operation connected with the baler method of harvesting hay. Bale elevators may be used to elevate the hay to the mow or onto a stack but the bales must be manually handled at both the top and bottom of the conveyor.

Regular hay slings or grapple forks can also be used in conjunction with a hay track for elevating bales into a mow. Where space is not limited the bales can be dropped at random in the mow from the slings to eliminate hand piling. This saves labor but 25 to 50 per cent of the first bales will be broken when dropped to the floor. After the floor is covered with hay, however, fewer bales are broken. When using an adjustable four-prong grapple fork to unload

bales it is necessary to systematically load a wagon so that eight bales can be conveniently picked up at one time with the fork. Tractor mounted sweep stackers can also be used for lifting bales to the top of a stack or to the door of a hay mow.



Bale elevators can be used to advantage when placing bales in a mow or when stacking baled hay in the field. However, considerable manual labor is necessary to operate the elevator and store the bales. Elevators can be powered either by a gasoline engine or an electric motor.

Bale Bunchers and Stookers

A steel bale buncher consisting of a frame with ½-inch rods in the bottom may be used to collect the bales from the baler. The operator unloads the unit by releasing a rear end gate. This provides large windrows of bales and reduces the time required to gather the bales in the field.

Drag platforms can also be obtained for use with balers. Such a platform is 6 feet wide and resembles a sweep rake with teeth or slats 7 feet long made of 1- by 6-inch hardwood. This slatted platform is dragged behind the baler after the manner of a stoneboat. Ten to fifteen bales may be piled on the platform as they are discharged from the baler. To unload the platform two light crowbars are driven into the soil between the slats in front of the bales. As the platform moves forward, the bales slide to the ground.

A stooker is a sleigh-like device that is drawn behind the baler and on which an operator piles 6 bales in the form of a stook. These bales are then lowered to the ground and remain in a stook that provides partial protection from light rainstorms.

The stooks are gathered with a special attachment for a front-end loader that picks up the six bales in one load. They can be easily deposited on a wagon or truck. In operations where bales are to remain in the field for a short period, this stooker and power loader should reduce the labor required to handle the crop.

Wagon Unloaders for Hay and Silage

Unloading Silage into a Forage Blower

Commercial devices are now available that will move a load from a wagon into a blower in a very satisfactory manner. One type of unloader consists of a conveyor chain with slats similar to that used in a manure spreader. In another type a canvas placed in the box and rolled onto a shaft at the rear of the wagon carries off the load. In a third type a movable false front end gate pulled back by cables drags off the load. Motor trucks with dump bodies are also being used. Another type of unloader consists of a hoist that lifts the front wheels of the wagon. With either the dump truck or hoist the load slides

A wagon with a flat top rack, high slatted side sections, a canvas hood to retain chopped material, a hinged end gate, and a power unloader is suitable for use with forage harvesters.

off too rapidly for the blower, and, therefore, it is necessary to check the movement of the silage with a tail gate and feed the silage into the blower with a hand rake. The chain slat, false front end gate, and canvas unloaders are driven by a ½-horsepower electric motor, or gas engine and a gear reduction box. Speed reduction boxes cost from $100 to $175, motors about $60, and conveyor devices approximately $40 to $100 per wagon. Silage blowers with attached gear reduction boxes for operating wagon unloaders are available with this attachment, a separate electric motor or engine is not required.

For canvas unloaders, some farmers have purchased gear reduction boxes to drive the unloader and have purchased or constructed their own canvas conveyor for each wagon. The gear reduction box is needed to reduce motor speed from 1,800 r.p.m. to 2 r.p.m. for the canvas roller shaft. To construct a

canvas conveyor for a 7- by 14-foot wagon the following materials are required: a suitable gear box; eight pieces of No. 6 18-ounce water-proofed canvas, 30 by 78 inches, sewn together with a double seam to form a $6\frac{1}{2}$- by 20-foot sheet; one 2-inch heavy duty pipe $7\frac{1}{2}$ feet long fitted with a square steel shaft at one end; and two brackets fitted onto the back of the rack to support the pipe roller. Standard tractor power-take-off shafts and universal joints can be

This is a bale stooker with a typical stook of bales. The bales are piled on the pipe platform by hand. An attachment for a tractor loader is available to load the stook on a wagon.

used to connect the pipe roller to the gear box. This style of unloader has very satisfactorily unloaded chopped silage from wagons carrying $2\frac{1}{4}$ tons as fast as it can be taken by a heavy duty blower. When using this type of unloader the canvas should be given a lap or fold 2 feet wide each time it is laid on the bottom of the rack to distribute the movement of the load and reduce the strain on the canvas.

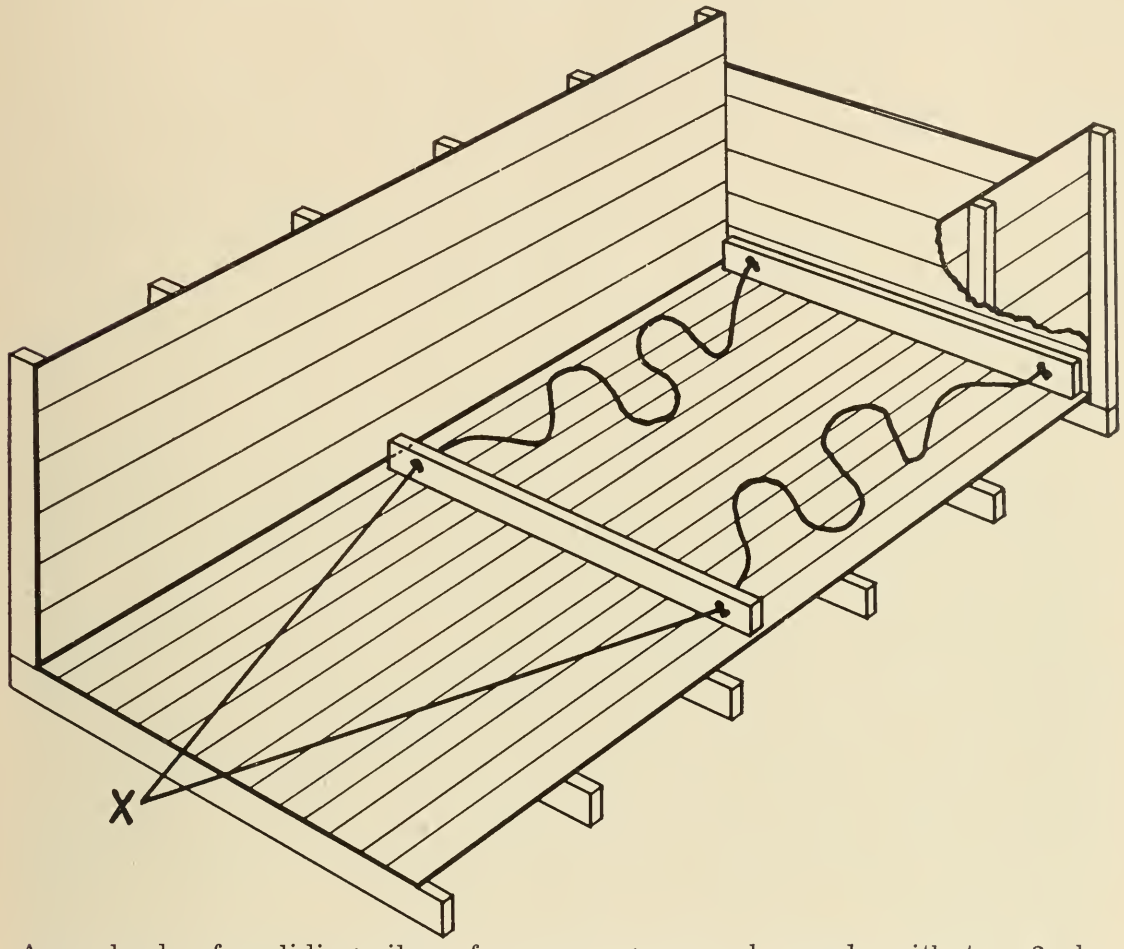
Front end gate unloaders consist of a movable gate or frame, two chains and a power driven roller that pulls the gate from the front of the wagon to the rear for unloading hay or silage. The false end gate is built on two $\frac{3}{16}$-inch by 1-inch strap iron frames and two 2- by 4-inch battens. Each chain is made of $\frac{5}{16}$-inch material 16 feet long. The roller is similar to that for canvas unloaders. End gate unloaders can be homemade or obtained as commercial units.

Another type of wagon unloader, in which a 10-inch pipe is used, conveys the material to a suction blower that blows the crop into the storage. Wagons may be unloaded by moving the suction pipe around the wagon rack to pick up the material. At least 30 horsepower is required for efficient operation of the unloader.

Unloading Silage in a Trench Silo

Where chopped grass or corn silage is being placed in a trench silo several methods may be used to unload the silage from the wagon.

One method is to use rope and plank pull-type slings. In constructing these slings a plank is placed at each end of the wagon box with ropes threaded through the planks. Before loading, the plank at the rear of the box is moved to the center of the wagon. The load is removed with a team or tractor hitched to the ropes of the sling at "X", the rear half being removed first.



An unloader for sliding silage from a wagon can be made with two 2- by 6-inch planks 6 feet long, and two $\frac{3}{4}$-inch ropes 22 feet long.

Swather-Mowers

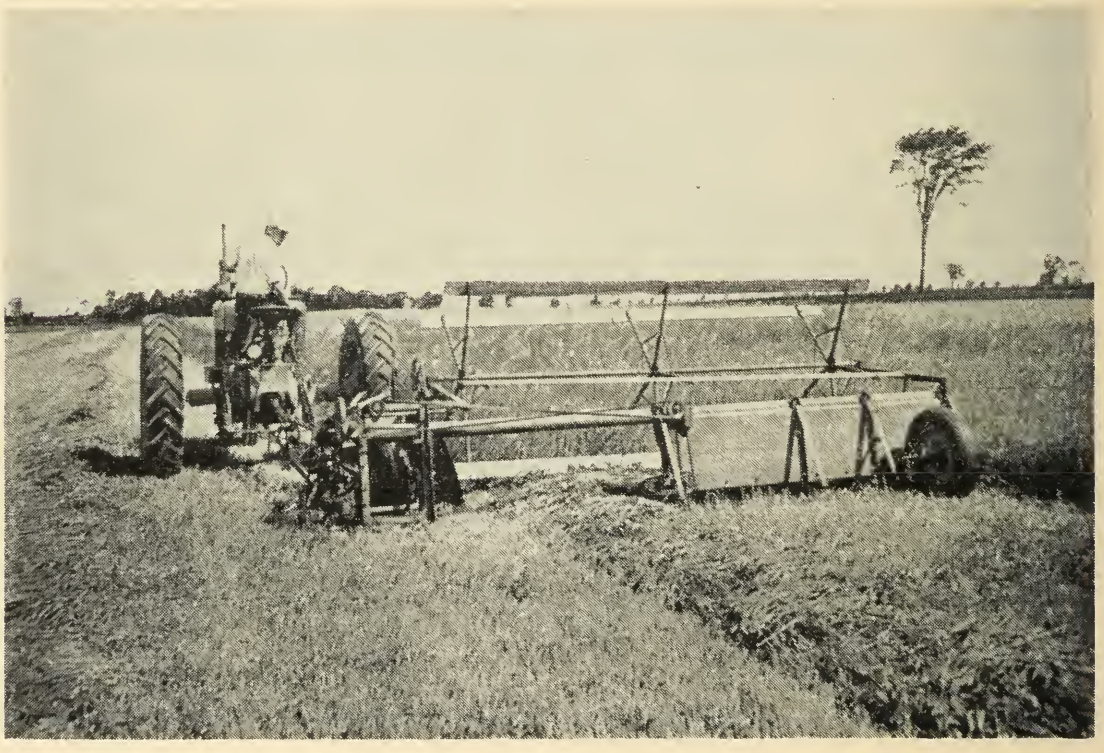
Swather-mowers are very similar to grain swathers but are modified to cut somewhat closer to the ground for hay and silage operations. When 10- or 12-foot swathers are used for cutting a crop for silage they have a greater capacity than standard 7-foot mowers and are therefore operated in conjunction with large engine driven forage harvesters. Swathers also reduce stone hazards as they have a higher cut and carry the crop to the windrow on a canvas belt thus eliminating the use of a side delivery rake.

Hay Stackers

The hay crop can be stored in buildings or in stacks. Although hay is stacked in all sections of the country, stacks are more commonly used in the Prairie Provinces where the climatic conditions for stacking are more favorable than in areas of higher rainfall. The amount of hay that is stacked depends to some extent on the type of farming followed and on the methods of feeding. The success with which hay can be field stacked often depends on the art of building stacks to shed rain. Where hay is placed in stacks in the field it is not fully protected from the weather, but this method of operation eliminates the necessity of hauling the hay any distance during the harvesting operations

and also eliminates or reduces the cost of storage buildings. Very often hay that has been stacked can be moved to the livestock building when there is more time available than in the harvest season. In some instances hay can be fed to livestock directly from the stack.

Although low stacks of hay can be built by hand by forking hay from a wagon, there are numerous types of devices used to aid in stacking operations. Very often the stacker used is determined by personal preference of the farmer as there are several styles which give equal results in speed of operation and in manual labor requirements. The general types used include overshot, boom and derrick, cable and combination sweep stackers. Combination units for



Swathers or windrowers form a uniform windrow for forage harvesters and other harvesting equipment. A wide swath may increase the capacity of the harvesting equipment.

sweeping hay and elevating it onto the stack normally operate with tractors while the other types are operated with either tractors or horses. Overshot, some types of boom, and combination stackers are suitable only where sweeps are used to gather hay in the field.

Overshot stackers are used in conjunction with sweep rakes as the hay on the sweep can be readily deposited on a similar set of teeth that forms part of the overshot stacker. Stacks about 16 feet wide and of any length can be formed with an overshot unit. Some 12 to 20 tons of hay may be added to the stack at each setting of the stacker. Depending on length of the stacker arms, stacks are built to a height of 16 to 24 feet. From 500 to 900 pounds is elevated to the stack each time the stacker arms are pulled up by means of a rope drawn by a team or tractor. Overshot stackers are built on skids and can be moved readily from place to place with a tractor. Occasionally movable frames or forms are used in conjunction with stackers as an aid in building or forming the stack. These units consist of a slatted wall or frame placed in a vertical position on either side of the stack.

Mast and boom, derrick and boom, and cable stackers are usually used to lift the hay to the stack with a harpoon fork or slings. Where slings are used, hay can be taken from a wagon or from a sweep rake but when forks are used

the hay is unloaded from wagons. With these stackers, as with the overshot stacker a tractor or team is used to hoist the loaded fork or slings. Mast and boom stackers require guy wires for bracing the mast and when using this unit a nest of four stacks about 16 feet square and 16 feet high are built with one setting of the stacker. Derrick and boom stackers are self supporting and can be moved more readily than mast stackers. The cable on a cable stacker supports the carriage as does a hay track in a barn. The cable is anchored at each end and supported in an elevated position over the stacking area with a pair of poles that hold the cable about 18 feet above the ground.

Combination sweep stackers are constructed in various forms, with some types being fully mounted on a tractor while other types are mounted on two wheels and are pushed in front of the tractor. The unit consists of a regular hay sweep fitted to a pair of arms or other mechanism with which the sweep can be lifted about 12 to 16 feet by traction lift, hydraulic hoist, or similar type of device. A combination stacker may be the only piece of equipment used in the hay harvesting operation, or it may be used in conjunction with one or two ordinary sweep rakes which gather the hay while the combination unit lifts the bunches of hay to the top of the stack. Tractor mounted sweep stackers can be used for gathering and transporting the hay only where the land is firm and smooth. Loads on sweeps usually range from 500 to 800 pounds of loose hay. With a short haul, favorable conditions for using a sweep, and an experienced crew, hay can be gathered and stacked at 0.75 to 1.5 man hours per ton when using a combination stacker and a crew of 2 or 3 men.

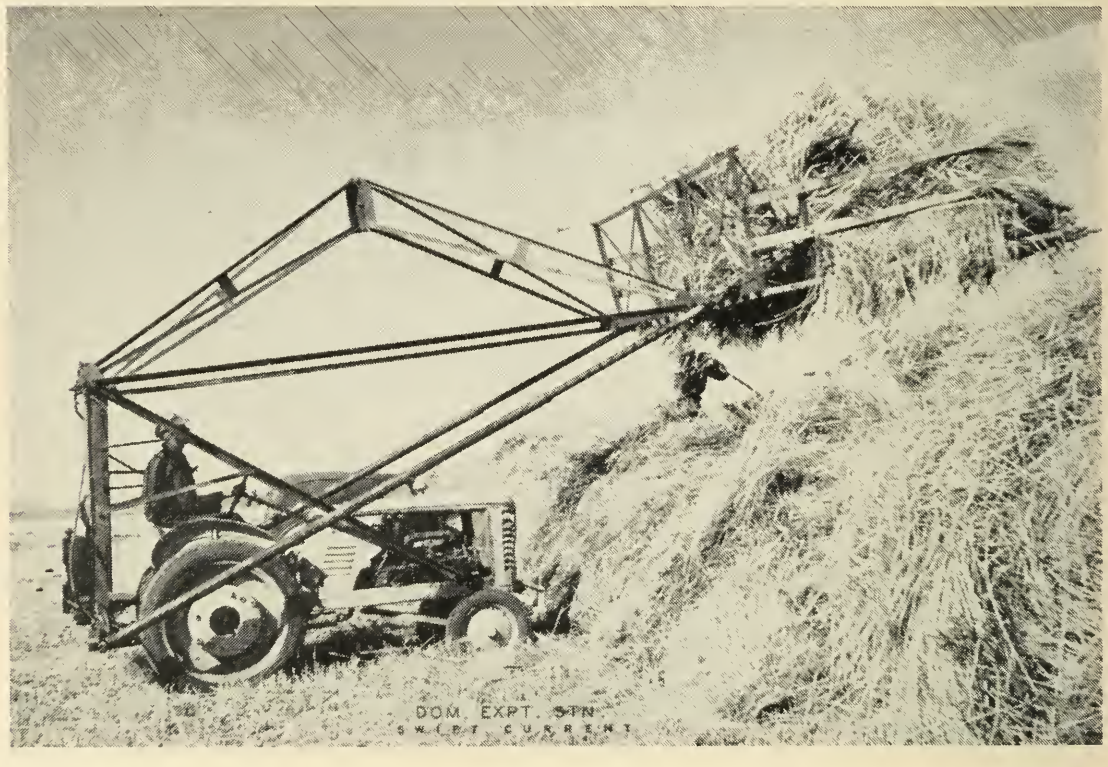
With the mast and boom stacker four stacks can be built at each setting of the stacker.

Stacking Hay

To successfully store hay in the field, it is necessary to construct stacks that will bind together and shed rain. In making a stack, material should be carefully spread over the entire area to keep the working surface relatively level. When placing hay around the edges of the stack it should be laid with the stems almost at right angles to the edge and layers should overlap for

binding the stack together. The surface should be uniformly packed and tramped. To reduce top spoilage, high, relatively narrow stacks are better than wide low stacks. Walls on the lower 6 feet of a good stack are practically vertical. In the next 10 to 15 feet the stack is widened about 2 feet and is then topped with a relatively high center or crown. Hay placed on the top of the stacks should be combed to give a thatched effect for shedding rain.

Canvas stack covers will keep rain out of the stack, but if allowed to remain on a stack while the hay is curing they restrict ventilation, and the hay often molds at the top, just under the canvas. Although some means of ventilation should be provided, raising the canvas at the top of the stack often subjects the canvas to wind damage. In some districts the tops of small stacks are protected with a light cottage roof frame which is supported by four poles placed at the corners of the stack and which can be raised with ropes and pulleys attached to the corners of the movable roof as the stack is being built. With overshot stackers and other stackers that handle loose hay the stack must be built in a direction dictated by the wind and thus stacks sometimes have the shape of an "L" or a "T" because of changes in the direction of the wind. In using sweep stackers the hay must be elevated against the wind or it will be blown off the sweeper.



Combination tractor sweep stackers are used to gather hay from the windrow and deposit it on a stack. By field stacking hay, storage building costs are reduced.

Stacking Baled and Chopped Hay

Baled hay can be stacked by hand or with a conveyor or boom stacker fitted with slings. When properly field cured, baled hay can be as successfully stacked as long hay. A stack of baled hay can be kept from spreading or breaking open by using boards and baling wire. When the four bottom layers of bales are in place, two 1- by 6-inch boards are laid flat on top of the bales, at opposite sides of the stack and about 1 foot from the edge, and are connected with several strands of baling wire stretched across the stack. Four more

layers of bales are then added to the stack, and another set of boards placed at opposite sides, with connecting wires between. Boards and wires used in this manner on every fourth layer of bales will blind the stack together.

Stacks are usually square or rectangular with a pyramid form on top. Sometimes a stack is formed which is flat on top in which case long loose hay is placed on the bales to form a circular crown. This hay is held on top of the bales by laying strands of wire across the stack that are connected to wood poles at the sides of the stack. Chopped hay has been successfully stored in stacks but as yet there is no detailed information on the best method of stacking. As chopped hay can not be moved readily, it is stacked only where it can be fed from the stack. Round stacks, about 18 feet in diameter, have been made with rather high conical tops by using two rounds of snow fence to form the stacks. Long hay is frequently used to cover or top these stacks. This hay should be placed in rings around the cone or top of the stacks in the same manner as used when shingling or thatching a roof. A hand fork is then used to comb down the long hay so that it will shed rain.

ESTIMATED COSTS OF HARVESTING OPERATIONS

Operation	Crew Men	Annual use Tons/year	Investment		Rate of operation Tons/hour	Man hours per ton	Cost per ton			
			Power	Equipment			Power	Machine	Labor	Total
Mower—6-foot, horse-drawn	1	50	200	200	1.4	.74	.40	.45	.50	1.35
" 6-foot tractor p.t.o.	1	150	2,000	250	3.0	.33	.30	.30	.25	.85
Roller Crusher	1	175	2,000	1,000	3.0	.33	.25	1.00	.25	1.50
Rake—dump—Horse-drawn	1	60	200	150	2.7	.37	.25	.20	.30	.75
" —side —Horse-drawn	1	120	200	350	2.4	.42	.25	.25	.30	.80
" — " —Tractor p.t.o.	1	120	2,000	500	3.7	.27	.18	.40	.20	.78
" — " —Tractor p.t.o.	1	250	2,000	500	3.7	.27	.18	.25	.20	.63
" — " —1 plow tractor	1	120	1,500	500	3.7	.27	.13	.40	.20	.73
" — " —3 plow tractor	1	120	3,000	500	3.7	.27	.25	.40	.20	.85
Hand Loading and Storing	3	50	200	150	.9	3.5	.65	.05	2.60	3.30
Hay Loader and Storing	2	60	200	450	.9	2.2	.65	.65	1.75	3.05
Sweep Rake Hay	3	50	2,000	450	1.4	2.1	.45	1.00	1.50	2.95
Sweep Rake Silage	2	100	2,000	200	2.0	1.0	.30	.30	.75	1.35
Baler tractor p.t.o.	1	120	2,500	1,800	2.5	.4	.35	1.25	.30	1.90
(with twine 3.5 lb. at 20 cents per lb.)								.70	.....	2.60
Baling and Storing	5	120	4,000	2,000	2.5	2.0	.65	2.25	1.50	4.40
Forage Harvester tractor p.t.o. (Chopper type)										
Hay	1	60 ($\frac{1}{3}$ of use)	2,500	2,000	3.0	.33	.30	1.50	.25	2.05
Grass Silage	1	100 ($\frac{1}{3}$ of use)	2,500	2,000	5.0	.20	.20	.90	.15	1.25
Corn Silage	1	150 ($\frac{1}{3}$ of use)	2,500	2,000	7.5	.13	.13	.60	.10	.83
Forage Harvester tractor p.t.o. (Flail type) Grass	1	200	3,000	1,000	5.0	.20	.25	.65	.15	1.05

Harvesting and Storing										
Hay—										
Forage Harvester tractor p.t.o. (Chopper type)	1	60 ($\frac{1}{3}$ of use)	2,500	2,000	3.0	.33	.30	1.50	.25	2.05
Tractor 2-wagon	1	60	1,500	750	3.0	.33	.15	.05	.25	.45
Tractor and Blower	2	60 ($\frac{1}{3}$ of use)	2,000	500	3.0	.66	.25	.30	.50	1.05
Total Costs	4	60	5,700	3,250	3.0	1.32	.70	1.85	1.00	3.55
Grass Silage—										
Forage Harvester tractor p.t.o. (Chopper type)	1	100 ($\frac{1}{3}$ of use)	2,500	2,000	5.0	.20	.20	.90	.15	1.25
Tractor 2-wagon	1	100	1,500	750	5.0	.20	.10	.04	.15	.29
Tractor and Blower	3	100 ($\frac{1}{3}$ of use)	2,000	500	5.0	.60	.15	.18	.45	.78
Total Costs	5	100	5,700	3,250	5.0	1.0	.45	1.12	.75	2.22
Corn Silage—										
Forage Harvester (Chopper type)	1	150 ($\frac{1}{3}$ of use)	2,500	2,000	7.5	.13	.13	.60	.10	.83
Tractor 2-wagon	1	150	1,500	750	7.5	.13	.07	.03	.10	.20
Tractor and Blower	3	150 ($\frac{1}{3}$ of use)	2,000	500	7.5	.39	.10	.12	.30	.52
Total Costs	5	150	5,700	3,250	7.5	.65	.30	.75	.50	1.55
Grass Silage..										
Forage Harvester (Flail type)	1	200	3,000	1,000	5.0	.17	.25	.65	.15	1.05
Tractor 2-wagon	1	200	1,500	750	5.0	.17	.10	.04	.15	.29
Tractor Packing horizontal silo	2	200	2,000	.....	5.0	.33	.15	.....	.30	.45
Total Costs	4	200	6,500	1,750	5.0	.67	.50	.69	.60	1.74

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