Farm feed processing and handling

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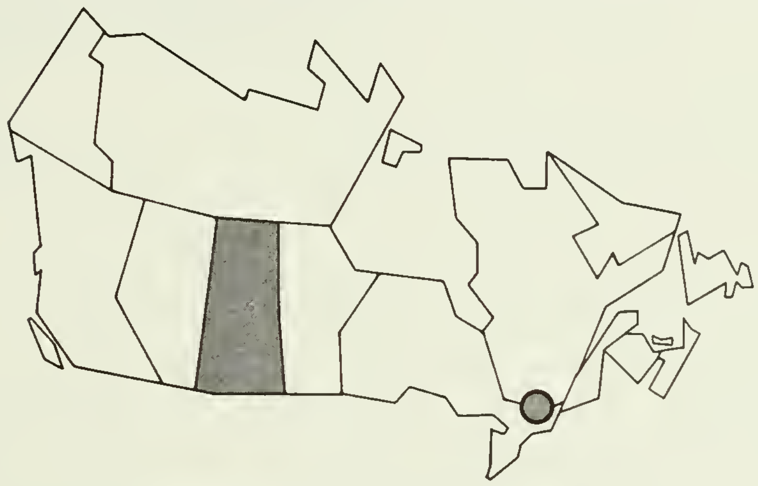

CANADA/SASKATCHEWAN

FARM FEED PROCESSING AND HANDLING

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CONTENTS

FARM FEED PROCESSING AND HANDLING

The continued diversification of farms to include some form of livestock production has increased the interest in feed processing and, in particular, feed processing on the farm. In livestock enterprises, feed costs account for about 65% of the total expense of raising livestock. Increased mechanization of the feed processing system reduces drudgery, eliminates undesirable tasks, frees labor for other purposes, reduces labor costs and may allow expansion without increasing labor requirements.

This publication attempts to bring together sufficient information to enable livestock producers, in cooperation with agricultural extension specialists, to plan a feed processing arrangement effectively and to choose the proper equipment for feed processing and delivery of processed feed to livestock.

PLANNING

In planning facilities for livestock operations, including cattle, swine, sheep and poultry, the feed processing and delivery system is often overlooked. Whether processed feed is to be prepared on the farm or purchased from a commercial plant and stored on the farm until needed, this important segment of the operation requires careful analysis. Sometimes existing facilities and equipment can be used as is or renovated; or new buildings and equipment may have to be designed and installed. Either way, decisions must be made on both immediate needs and possible future expansion.

When planning feed processing and delivery facilities, keep these five principles of handling materials in mind: (1) move materials as little as possible; (2) let the livestock help; (3) handle materials in bulk or in some form suitable for mechanical handling; (4) provide for continuous flow, eliminating unnecessary operations; and (5) mechanize operations so that they can be done efficiently and economically.

ANALYZE EXISTING SITUATION

The first step is to prepare a scale drawing of the proposed site, showing all existing buildings, fences, water supplies, water and power lines, feeders, drainage patterns, and so on. On a separate sheet, list the types and condition of existing buildings.

Prepare a summary listing the various kinds of feed handling and processing equipment, feeding equipment and storage facilities for raw and processed feeds. Consider the type of power available (single or three phase), the labor situation (both present supply and future source), and your current capital and credit position.

EVALUATE LONG-TERM PROGRAM

Give careful attention to future requirements of the feed processing center. If your plan is based entirely on present needs, it will likely be difficult to expand the operation later without considerable expense. Planning for the long term means leaving space for future facilities and equipment. Sometimes, it is necessary to change the location of present facilities to allow for future expansion.

SET PRODUCTION GOALS

Grain storage requirements, for both raw and processed grain, and capacity of feed processing equipment are determined by the production goals you set. These goals should be realistic so the feed processing plant and equipment chosen can perform the job efficiently and economically.

Some of the questions that need to be answered to determine production goals are: What kind and class of livestock will be produced? Will replacements be purchased each year? How many will be handled at one time? How will the livestock be housed?

ESTIMATE STORAGE REQUIREMENTS

Use Table 1 to estimate feed storage requirements for a livestock enterprise. The table gives daily and yearly feed requirements for various numbers and kinds of livestock. With this data, you can calculate storage requirements for raw products and for processed feed if feed is not prepared every day.

The various classes of livestock require different textures of feed to enable them to use the feed to best advantage. Grinding feed finer than necessary adds to the cost, decreases equipment capacity, increases power requirements and may be wasteful if wind blows fine material from feed bunks. Table 2 gives general grinding recommendations.

INVESTIGATE ALTERNATIVES

No single system fits all conditions, so evaluate every alternative before deciding. Your local agricultural representative may be able to provide names of producers with feed processing centers. Before visiting these facilities, phone and make an appointment. During your visit, find out what changes the owner would make to the system if he were rebuilding. Also, ask about the equipment used, its availability, and the availability of repair parts and reliable service personnel. Then, investigate the following alternatives.

Purchasing Services or Prepared Rations

Feed dealers Commercial feed dealers provide you with some or all of the following services: purchasing and handling of feed ingredients, formulation and mixing of rations, certain financial services, and advice on feeding and production. Cost is included in the price of premixed rations. If you need a special product, such as pelleted poultry feed, a commercial mill can provide it. Pellet mills are very expensive and purchase cannot be justified except for a large livestock enterprise.

TABLE 1 – FEED REQUIREMENTS OF LIVESTOCK

Type of livestock	Feed req'd kg/d		Feed processed t/annum			
CATTLE						
No. animals	1		**25**	**50**	**75**	**100**
Beef (maintenance)						
Cows and heifers	Hay[1]	11	100	200	300	400
	Silage[2]	35	–	–	–	–
225 kg calves	Hay	5.5	50	100	150	200
	Silage	15	–	–	–	–
Beef (finishing)						
Yearlings	Grain[3]	8	73	146	219	292
	Hay	1.5	14	28	42	56
225 kg calves	Grain	7	64	128	192	256
	Hay	1.5	14	28	42	56
Dairy						
Milking herd[4]	Hay	14	130	260	390	520
	Grain	7	64	128	192	256
	Silage	40	–	–	–	–
SHEEP						
No. animal	1		**25**	**50**	**75**	**100**
Ewes and rams	Hay	1.5	14	28	42	56
	Grain	9.25	2.3	4.6	6.9	9.2
Feeder lambs	Hay	0.25	2.3	4.6	6.9	9.2
	Grain	0.5	4.6	9.2	13.8	18.4
SWINE						
No. animals	1		**25**	**50**	**75**	**100**
Sows (maintenance)	Grain	3	27	54	81	108
(Pregnant)	Grain	2	18	36	54	72
(Lactating)	Grain	6	54	108	162	216
No. animals	1		**400**	**800**	**1 200**	**1 600**
10-day weaners (to 23 kg)	Grain	1.2	175	350	525	700
Feeders (23-80 kg)	Grain	2.5	365	730	1 095	1 460
CHICKENS						
No. birds	1		**500**	**2 500**	**5 000**	**10 000**
Laying hens	Grain	0.15	27	135	270	540
Replacement pullets	Grain	0.05	9	45	90	180
No. birds	1		**2 000**	**5 000**	**12 000**	**20 000**
Broilers	Grain	0.08	58	145	348	580
Roasters	Grain	0.12	87	218	522	180
TURKEYS						
No. birds	1		**500**	**1 200**	**1 500**	**2 000**
Breeding stock	Grain	0.25	46	110	138	184
No. birds	1		**1 000**	**2 500**	**5 000**	**10 000**
Growing turkeys	Grain	0.20	73	183	365	730

1
2 3 kg silage is equivalent to 1 kg hay.
3 Silage does not require processing.
4 Grain includes all concentrates and supplements used in ration.
Allow 50% additional storage for rest of herd.

TABLE 2 – GRAIN GRINDING RECOMMENDATIONS FOR LIVESTOCK

Grain	Beef cattle	Dairy cattle	Swine	Sheep	Poultry
Shelled corn	Coarse[1]	Medium	Medium	Whole	Cracked
Oats	Medium	Medium	Fine[2]	Whole	Medium fine
Barley	Coarse	Medium coarse	Fine[2]	Coarse or whole	Medium fine

[1] Whole grain to 12 months old, then coarsely cracked.
[2] As fine as possible without excessive dust.

Hauling grain to a commercial feed mill Feed is milled and mixed with purchased premixes and concentrates. Consider the services provided by feed dealers against these disadvantages of hauling your grain to a feed mill: transportation costs, extra labor in loading raw products and unloading the feed, time spent at the feed mill waiting for processing, and the possibility of inclement weather preventing you from getting to the mill when required.

Custom mobile mill A mobile mill processes your feed, can add supplements and concentrates as required, and places the mixed feed in storage bins on the farm. With custom service, you have no capital investment or maintenance costs and there is little or no labor. A well-proportioned, well-mixed feed depends on the mill operator's skill. If the custom operator is not able to call as often as you wish or at a convenient time, this type of feed preparation may not be satisfactory.

Processing Feed on the Farm

Power takeoff (PTO) portable grinder-mixer This equipment combines feed grinding, mixing and transporting. You can use it to service widely separated storage and feeding areas, and to fill self-feeders or feed bunks. It is especially suitable for a tenant farmer, as it can be moved from farm to farm. You can use existing tractor power, unless other farm requirements make it necessary to purchase a tractor for full-time use on the grinder-mixer. A disadvantage is that the breakdown of one component can stop the entire processing-distributing system. Also, the equipment requires proper bin unloading facilities and good service roads for solid footing in bad weather.

Electric blender-grinder A blender-grinder measures, grinds and mixes ingredients simultaneously and continuously. Milling and distribution of feed can be automated electronically. This type of mill can easily be adapted to a mechanized system for moving ingredients from storage to livestock, but is unable to handle roughage. Its installation may require additional electrical services and, if storage or feeding areas are scattered, you need extra mobile equipment.

Electric batch mill With this system, each ingredient processed must be weighed and each is ground separately. Using a batch mill is more time-consuming than using an electric blender-grinder, but it gives you more accurate rations and good feed records. Although you can use any type of grinder, if a roller mill is used you may have to adjust it before processing each ingredient. Batch milling is expensive and time-consuming and requires careful planning to avoid bottlenecks. Electrical service requirements are likely to be greater than for a blender-grinder. And if more than one ingredient is used, you also need a blender.

Economic Evaluation of Alternatives

To make a proper economic analysis, you require information on capital investment and annual fixed and variable costs covering installation and operation of the various systems. Cost estimates are available from manufacturing firms, salesmen and distributors, contractors who have recently installed comparable systems, and provincial agricultural extension specialists. To obtain estimates, provide each of these sources with a set of specifications showing the amount and kind of storage required, required rate of processing, required level of control and automation, number of ingredients in the ration, and how it is to be prepared and delivered to the livestock. Using the same set of specifications in all estimates simplifies comparison and helps you to select the most suitable feed processing equipment.

Annual fixed costs These vary only slightly. Estimate as follows:

- Depreciation = 10% of original value for equipment and 5% of original value for buildings.
- Repairs = 3% of original value for both buildings and equipment.
- Investment cost (interest on investment) = about half the original cost multiplied by the current interest rate.
- Insurance = 1% of original investment for buildings and 0.2% of original investment for equipment.

Operating or variable costs Labor, electrical power, fuel and lubrication costs vary directly with the use and efficiency of the system.

- Labor – include all preparation, travel and clean-up time. Estimate requirements as closely as possible in man-hours and calculate cost at prevailing local rates.

- Electrical power for processing and handling each tonne of feed. Use these formulas to determine power cost:

  Estimated cost of electric power = 1.2 x motor kW x $/kWh = $/h
  Cost of processing = $/h ÷ t/h = $/t

- Fuel for tractor. Cost can be determined by estimating annual hours of use and knowing the fuel consumption and fuel cost. Use this formula to estimate a tractor's average gasoline consumption:

  Consumption = 0.56 L/(kW.h)

  A diesel tractor uses about 73% as much fuel as a gasoline tractor and a propane tractor uses 20% more fuel than a gasoline tractor.

- Lubrication (oil, grease and filters). Cost is about 15% of the fuel cost.

Processing costs Figure 1 shows how to calculate costs for three processing systems. Table 3 shows each system's costs per tonne of processed feed for various annual feed requirements and Figure 2 shows the same results on a graph.

System 1 uses a portable grinder-mixer and assumes the tractor used on the grinder-mixer also is used for other farm work about half the time. System 2 uses a stationary grinder for processing feed and assumes the mill is housed in an existing building not charged to the cost of feed processing. System 3 processes the feed with a custom mobile mill, which is capable of removing the raw product from storage and putting the finished product into storage. In these examples, it is assumed that grain storage already exists. Processed feed storage is not included in System 1, as it is assumed the feed is delivered daily.

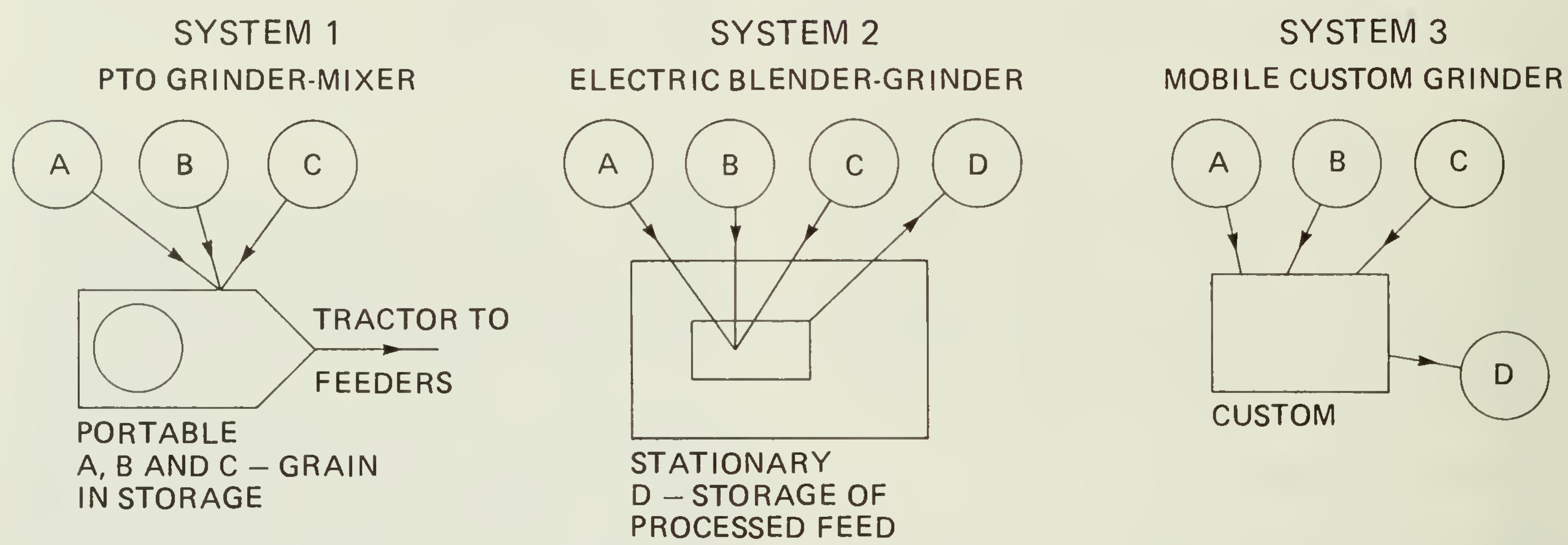


Figure 1 Economic analysis of three feed processing systems.

System 1

Capital investment	*Cost*
PTO grinder-mixer	$5500
3 augers and motors plus wiring	$1200
Total	$6700

Annual fixed costs	
Depreciation	$ 670
Repairs	$ 201
Interest 18%	$ 603
Insurance	$ 23
Total	$1497

Variable costs	
Capacity 2 t/h	
Horsepower used 45 kW	
Fuel costs/h	$ 4.12
Lubricant costs/h	.62
Fixed costs/h on tractor	$ 4.00
Labor costs/h	$ 6.00
Total variable costs/h	$14.74
Variable costs/t	$ 7.37

System 2

Capital investment	*Cost*
3.7 kW mix mill with motor	$3200
4 augers and motors	$ 800
Controls for automation	$ 400
Wiring	$1000
Processed feed bin (16t)	$2200
Total	$7600

Annual fixed costs	
Depreciation on equipment	$ 540
Depreciation on buildings	$ 110
Repairs	$ 228
Interest 18%	$ 684
Insurance on equipment	$ 11
Insurance on buildings	$ 22
Total	$1595

Variable costs	
Capacity 500 kg/h	
Electrical costs/t	$0.29
Labor costs/t	$3.00
Total variable costs/t	$3.29

System 3

Capital investment	
Processed feed bin (16t)	$2200

Annual fixed costs	
Depreciation	$110
Repairs	$ 66
Interest 18%	$198
Insurance	$ 22
Total	$396

Cost of Processing
$18.00/t

TABLE 3 – FEED PROCESSING COSTS PER TONNE ACCORDING TO ANNUAL FEED USAGE AND TYPE OF PROCESSING

t/a	50	100	200	300	500	1000
System 1	$37.31	$22.34	$14.86	$12.36	$10.36	$ 8.87
System 2	$35.19	$19.24	$11.27	$ 8.61	$ 6.48	$ 4.95
System 3	$25.92	$21.96	$19.98	$19.32	$18.79	$18.40

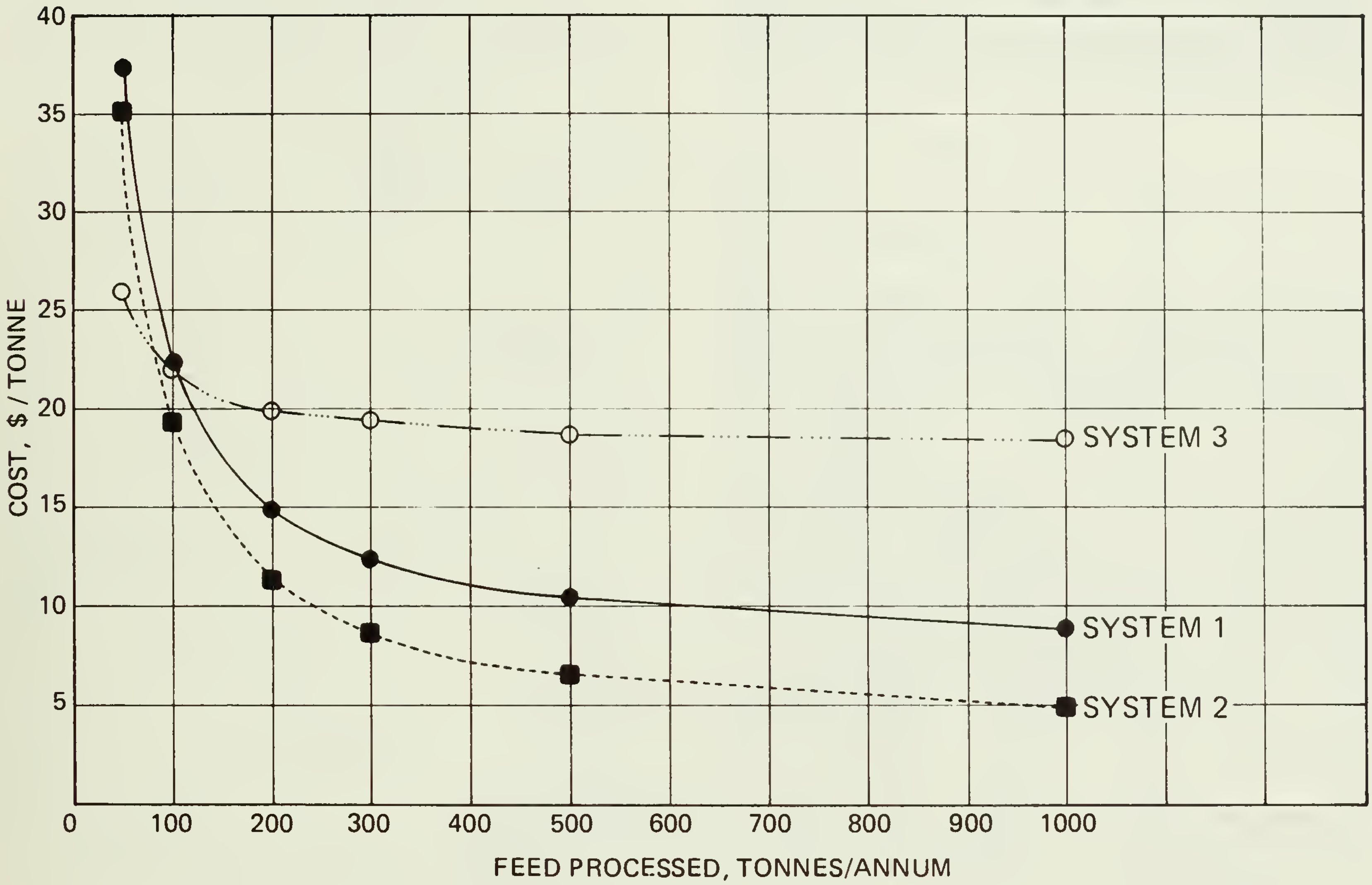


Figure 2 Comparison of feed processing costs.

Figure 1 indicates there is little difference in the annual fixed costs of owning a portable grinder-mixer or electric blender-grinder. The blender-grinder, however, has lower variable costs and less labor input per tonne of feed processed. This gives it an advantage over the portable grinder-mixer, especially at high levels of feed use. The custom mobile mill is competitive with Systems 1 and 2 if you use 90 t of feed or less. Above 90 t per year, it becomes economically advantageous to have your own equipment and process feed on the farm.

FINAL SELECTION

Although economic analysis is valuable in selecting the best system for your needs, consider the following as well before making your final selection:

- Availability of credit or capital for the investment and the effect it will have on the operating capital available to carry on your planned production program;
- Number of years your business will be in operation;
- Size of your livestock enterprise;
- Availability of reliable local commercial processing;
- Personal interests and desires, including the time available to operate the system and the availability and capability of hired labor;
- Quality of feed prepared by alternative systems and

its effects on your feeding program;

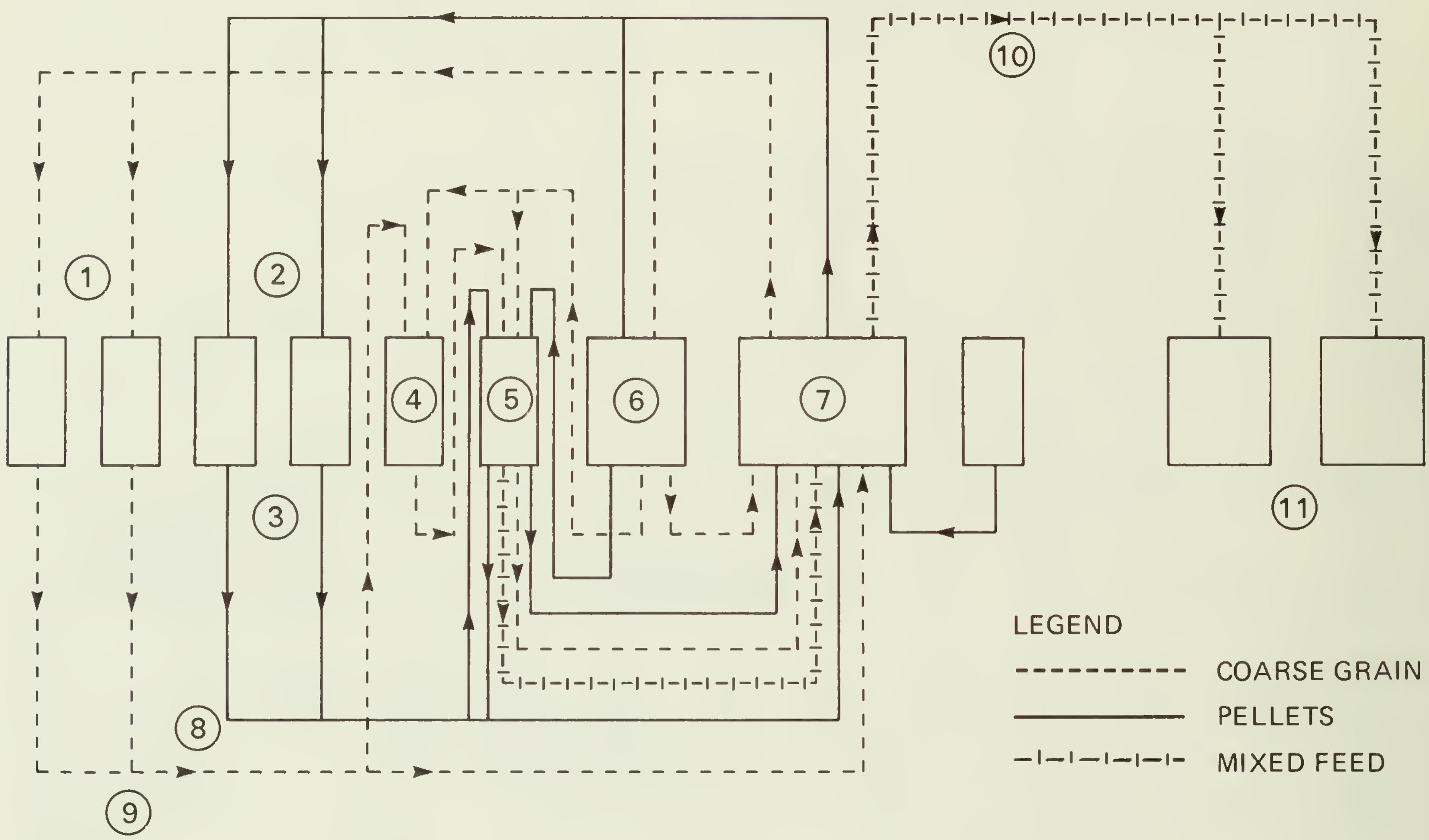
- Type of grain used — it's not possible to process high-moisture grain weekly in hot weather; and
- Availability of adequate power.

In selecting your feed processing system, think in terms of the complete livestock enterprise. Develop a complete flow pattern (using the flow diagram in Figure 3) for each ingredient entering or leaving the system. Select equipment with adequate capacity and make sure that the system's various components are compatible. Try to maintain maximum flexibility without reducing efficiency. Also, consider the effect expansion will have on the feed processing system.

PREPARE A DETAILED PLAN

Using a scale larger than the one used on your preliminary plan, lay out the feed handling and processing area. On this plan, locate all grain bins, silage storage and fodder storage to be used for raw and processed feed. Then, sketch in how various feeds will flow through the system (Figure 4). This plan should include the entire flow of feed from the time it is stored until it is fed.

Next, prepare a detailed plan to make sure the methods and equipment selected will suit your needs. This plan also provides a permanent record for further development if the system is built in stages. To prepare the plan,



1 BARLEY BINS
2 OVERHEAD BULK TANKS
3 CONCENTRATE
4 MILL
5 MIXER
6 WEIGH HOPPER
7 ELEVATOR LEG
8 PELLETS
9 COARSE GRAIN
10 MIXED FEED
11 OVERHEAD BULK FEED TANKS

Figure 3 Feed processing flow diagram.

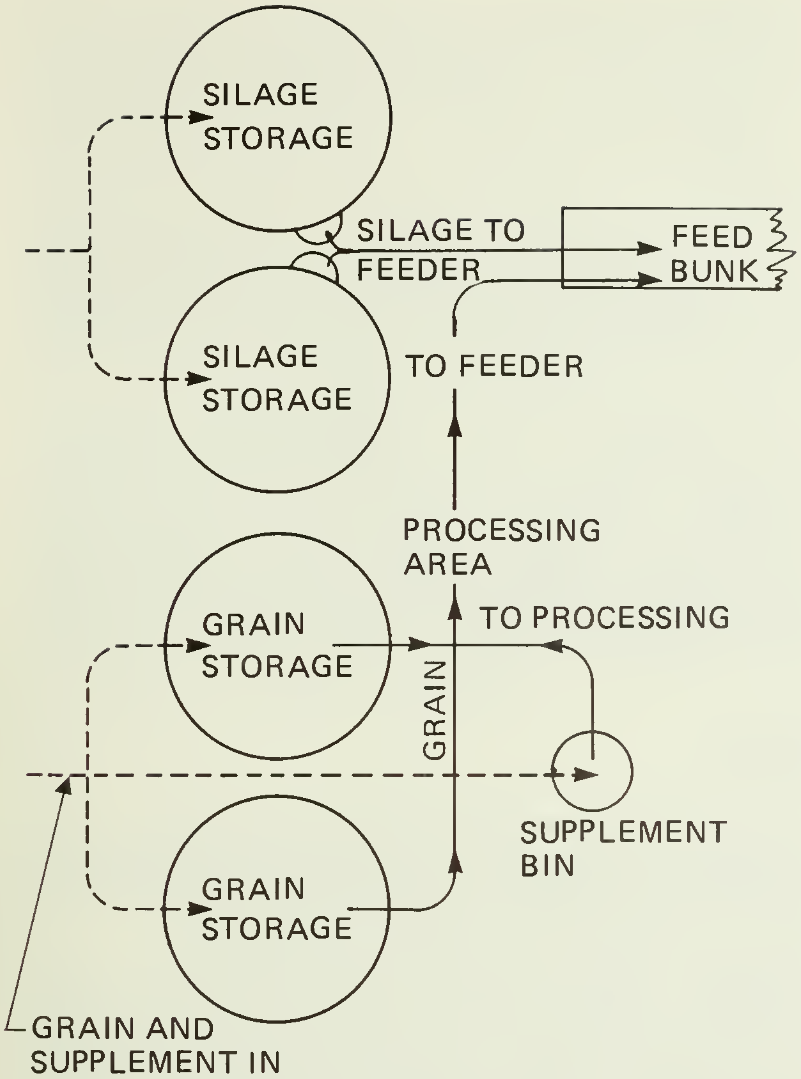


Figure 4 Plan of material flow pattern after feed processing.

place a sheet of tracing paper over your materials flow pattern (Figure 4) and locate all equipment and storage facilities on the plan (Figure 5). The use of tracing paper enables you to study several alternative arrangements by making additional overlays without destroying your original drawing.

FACILITIES AND EQUIPMENT

After your basic plan for handling materials has been developed and storage structures have been sized and located on a plan, you must select facilities and equipment for storing, processing and conveying the feed. There are many types and sizes of equipment for each of these tasks.

STORAGE

Grain and Processed Feed

Wooden storage Wooden bins can be rectangular, round or arch-roof structures. Rectangular bins may have frame or crib-wall construction. Unloading grain from a regular bin can only be mechanized to a small

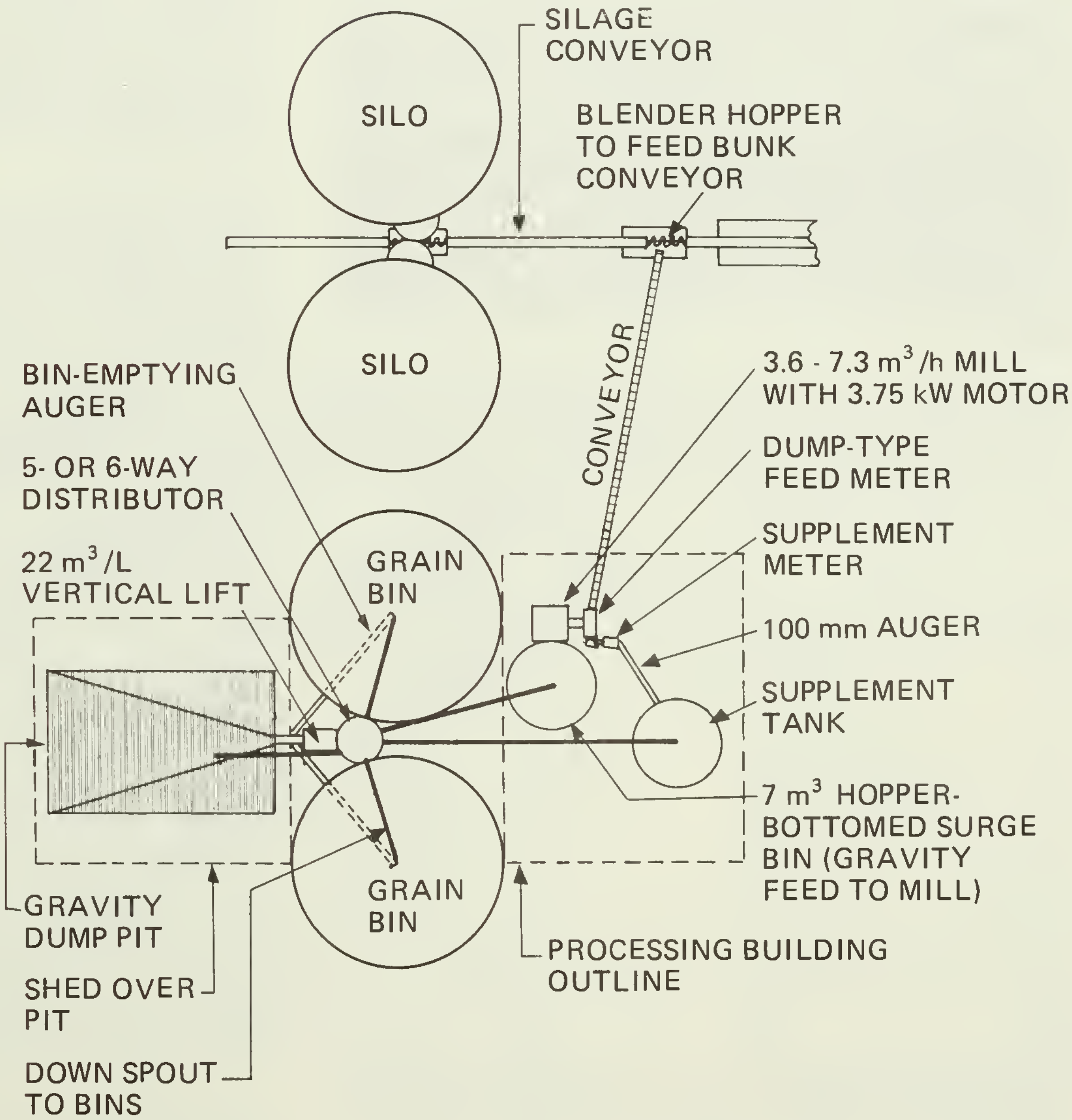


Figure 5 Plan showing equipment required to convey and process feed.

degree. Unloading of arch-roof structures can be mechanized, but it is not as convenient as unloading a circular bin. A frameless steel arch building can be used for machine storage when not required for grain.

Wooden bins have a shorter life and require more maintenance than steel bins. They are neither as fire resistant nor a easy to rodentproof as steel buildings.

Steel storage bins The popular circular steel grain bins range in capacity from 36 to 1500 m^3. They are fire resistant and rodentproof and can be built with very little difficulty. Unloading is easily mechanized and the bins are readily equipped with a perforated floor for in-bin drying. They must be properly anchored to prevent damage by wind, and must be filled and emptied from the center to prevent the walls buckling.

Frameless steel arch buildings, with their inward-sloping sidewalls, can usually be filled to the roof without tie rods or braces, but the vertical end walls require additional support. Straight-wall steel buildings can also be used for grain storage, but the walls have to be reinforced. Check with the manufacturer before filling with grain against the walls. Grain removal from both of these buildings can be mechanized, but it is not as convenient as unloading a circular bin. The structures can be used for other purposes when not required for grain storage.

Hopper-bottomed bins are very useful for storing materials before and after processing. Use bins with side draw-off hoppers for materials that tend to bridge, such as concentrates and ground feeds. Off-center unloading can cause denting at the sidewall, so side draw-off bulk feed tanks should not exceed 18 t. Steep side slopes of 60-70° allow these materials to flow freely. Center draw-off hoppers with side slopes of 45° are generally recommended only for whole grain. Figure 6 shows the difference between the two types of hopper-bottomed bins.

Steel grain bins used for storing acid-treated grain must be protected. You can either treat the interior walls and roof with a paint especially developed for this purpose or use a sealed plastic liner.

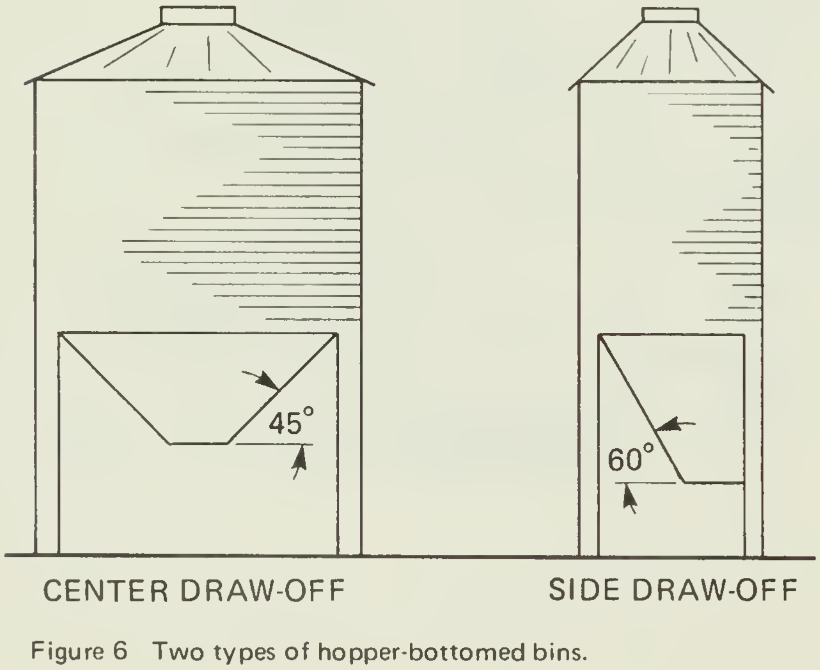


Figure 6 Two types of hopper-bottomed bins.

Overhead bins Small overhead bins are convenient to store processed feed or to supply ingredients to a processing unit by gravity flow. Their advantages may outweigh the extra cost. Often, small overhead bins are equipped with bin-level switches to control augers delivering grain from ground-level, outside storage. The bins hold just enough grain so that the auger motor doesn't have to start too often. (The overhead storage facilities provided with many 'farm feed factory' systems now being promoted are very costly and equivalent ground-level storage can be used just as satisfactorily.)

Regardless of the type of storage you choose, make sure it is weathertight. Always spread the grain going into storage so the fines are uniformly distributed. Check to ensure the grain is dry and, if necessary, install aeration equipment to control moisture migration within the bin. Stirring is also effective in reducing spoilage of damp grain. Arrange bins so that grain can be cooled by moving from bin to bin.

Silage

Silage can be stored in upright, sealed upright, or horizontal silos. The type you choose depends on how much you want to spend, how much silage will be fed each year and the degree of mechanization desired.

Upright or tower silos The most common type is concrete, either poured in place or a precast stave silo held together by steel hoops. Wood-stave upright silos, held together by steel hoops, are also available. With proper management, losses from concrete tower silos are about 10%.

When locating a tower silo, put it close to the feeding area to minimize conveyor costs, and leave sufficient space around it to facilitate unloading of wagons and trucks. As it is possible to completely mechanize the feeding of livestock from tower silos, arrange feed bunks and barns to take account of this advantage. If two or more tower silos are to be located side by side, separate them by at least one silo diameter to prevent overloading the soil under the foundations.

Sealed or airtight silos These silos have airtight walls, floors and roofs. Most are steel and glass-lined, and cost about 2½ times as much as upright concrete silos. Sealed concrete silos are available, but are not as common. Loss to spoilage can be kept to 4-8% with properly managed sealed silos. They should be located the same as suggested for upright silos.

Horizontal silos Horizontal silos are very popular because they are inexpensive in the larger sizes and require little additional equipment for filling or feeding. A silo can consist of either a trench cut into a hillside (trench silo) or two retaining walls (bunker silo) supported by concrete buttresses or pressure-treated posts. The walls of a bunker silo can be made of concrete panels or preservative-treated lumber or plywood. With proper management, losses from horizontal silos are 10-20%.

As feeding from a horizontal silo cannot be mechanized with conveyors, it is not as important to have it as close to the point of use as upright silos. However, travel time between the silo and the feed bunk or barns is reduced if the silo is close to the feeding area.

High-Moisture Grain

Recently, storage of high-moisture grain, particularly corn, has become popular. Storing high-moisture grain eliminates the cost and necessity of drying, but, since it must be processed and fed as it is removed from storage, daily processing is necessary. Livestock can be fed only as much as they will use each day, as high-moisture feeds mold when left in feeders.

High-moisture grain can be stored in either tower or horizontal silos. High-moisture ground corn (either shelled or ear corn) is usually stored in upright silos and whole shelled corn in sealed, bottom-unloading silos. A bottom unloader originally designed for silage has to be changed to handle high-moisture corn.

Hay

Most farms handle hay in bales, but new means of mechanization are making loose chopped and long hay more popular.

Stacks The loose-hay harvester used most often picks up hay from a windrow, shreds it and blows it into a stack former. When a stack has been formed, it is unloaded from the wagon and the process is repeated. Later, the stack is mechanically loaded onto the wagon and moved to final storage. Some of these machines are used to place hay in feed bunks.

Bales Pole-type hay shelters for storage of bales are very popular. If these structures are high enough (at least 4.8 m), self-unloading bale wagons can be used. Many shelters have bunk feeders along one or two sides, to reduce the amount of labor required to feed livestock, make sure that the hay shelter is easily accessible to portable feed processing equipment or close to stationary feed processing equipment so that a conveyor can be used.

Large round bales can be stored in a hay shelter, under a tarp or polyethelene cover. If not under cover, large round bales should be stored without touching each other until after the rainy season has passed. This will prevent moisture from entering into the forage, causing feed wastage.

Tub grinders can be used to chop large round bales. The strings should be removed before the bale is dropped into the tub grinder. The chopped forage from the tub grinder can be fed in feed bunk or in specially designed self-feeders.

Large round bales can be self fed using a daily electric wire feeding system (Figure 7). The electric wire is moved daily toward the feed. This limit feeding system encourages the cattle to clean up all the feed, reducing feed wastage. Then once the winter supply of forage is in place, no further movement is required during the feeding season.

An alternate system is to move the bales, with a tractor-mounted front-end loader adapted with prongs or a grapple fork, to feed bunks specially designed for feeding of large round bales.

Medium-moisture silage This is forage material, usually grass or legumes, field-wilted to 40-60% moisture for ensiling. It is handled like normal silage except that it can cause gumming in the forage blower; adding some water to the blower between loads helps to overcome the problem

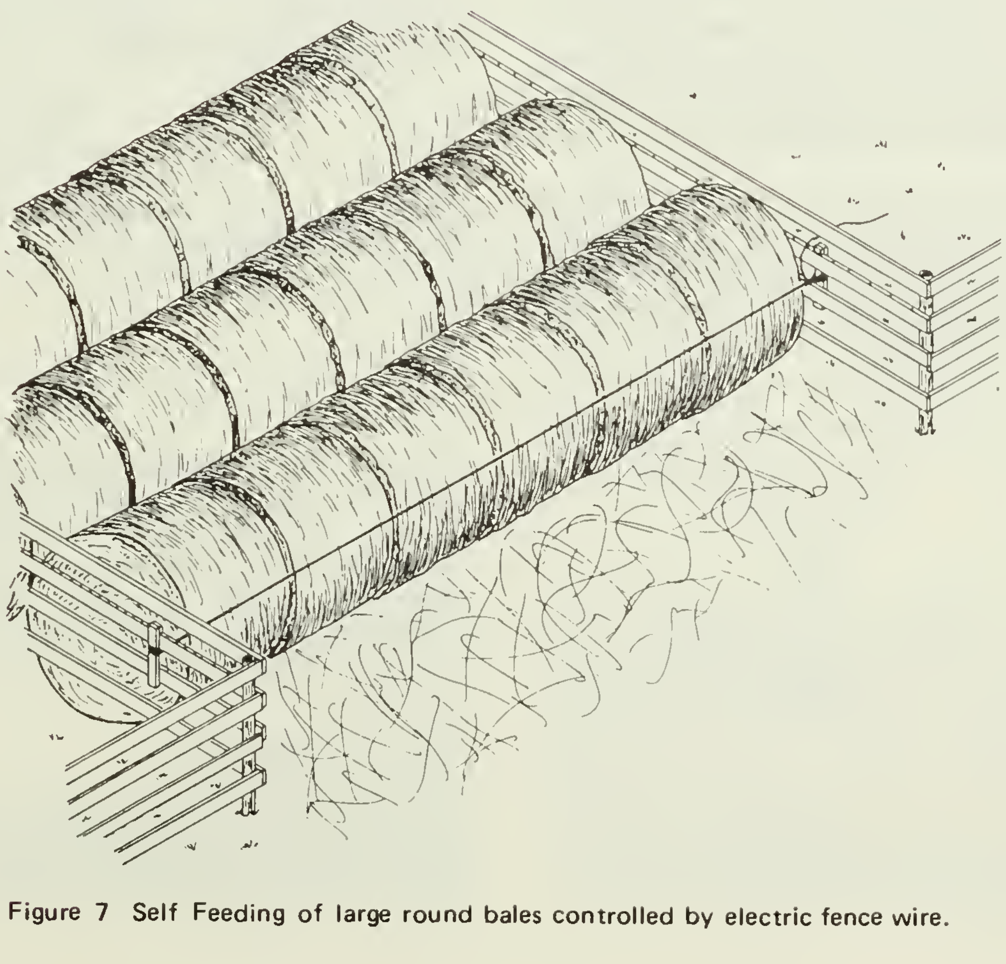


Figure 7 Self Feeding of large round bales controlled by electric fence wire.

Oxygen-limiting storages (sealed silos) have been widely accepted for medium-moisture silage. With these, 35-50% moisture (haylage) is recommended. The bottom-unloading feature permits refilling during the growing season without interrupting the feeding; this is economically essential.

Carefully sealed concrete tower silos at less than half the purchase price give storage losses only about 5% greater than sealed silos. For concrete silos, store at 50-60% for better compaction and sealing.

Horizontal silos have not been as popular as towers for medium-moisture silage. However, research indicates their performance can be improved by careful sealing with heavy plastic film secured tightly by roping, used tires or other easily removed materials.

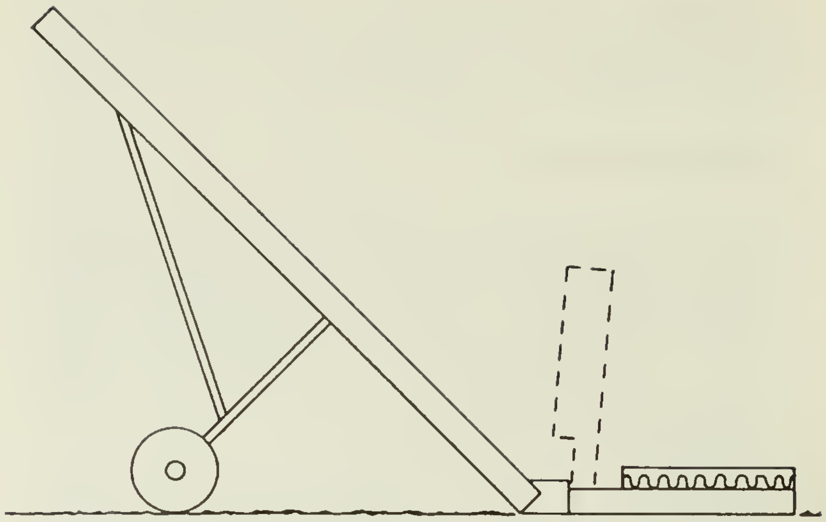


Figure 9 Tilt-up hopper with auger feeding inclined screw conveyor.

HANDLING AND CONVEYING

A wide variety of conveying equipment is available. Your choice depends on the distance feed is to be moved, power requirements, type of livestock and the weather protection available. Take care to select conveyors that can handle the quantities delivered to them by other conveyors in the system, as illustrated in Figure 8. This applies to all types of conveying equipment, not just augers. For efficient use of conveying equipment, it is important that bottlenecks not occur in receiving grain or removing processed feed.

Receiving Dump

The receiving dump may be either above or below ground. Many types of aboveground receiving hoppers are available, including the familiar tilting metal hopper (Figure 9) equipped with a screw converyor to deliver grain to an inclined auger. These hoppers do not require exclavation or concrete work, but neither do they provide drive-through convenience or the ability to 'dump and go.' Another type of aboveground receiving hopper is shown in Figure 10. It provides drive-through convenience, but requires extra construction.

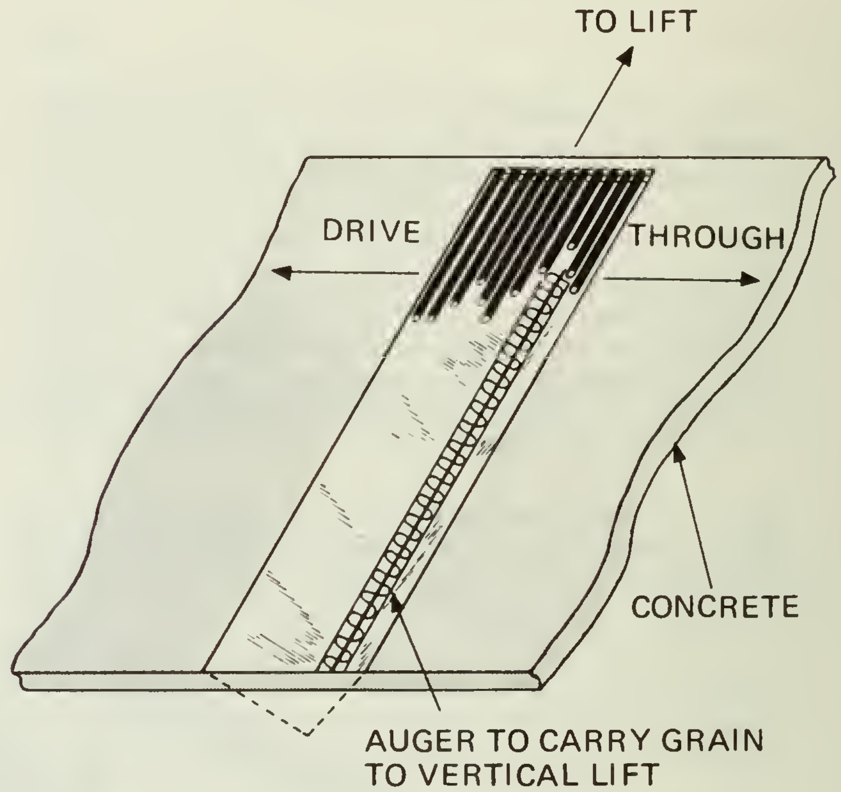


Figure 10 Concrete pad equipped with cross augers in shallow trench.

Belowground hoppers can hold either a few cubic metres (Figure 11) or a truckload (Figures 12 and 13). The larger pits allow you to unload the grain and continue on your way. Dump pits require 3-4.2 m excavations with sidewalls at a minimum slope of 45°. Reinforced concrete is required to make the pit. Where soil moisture causes a problem, some other method may have to be used. Dump pits should have an under-floor drain and a watertight cover. To drive the horizontal auger, the system in Figure 13 may require one more motor than the system in Figure 12.

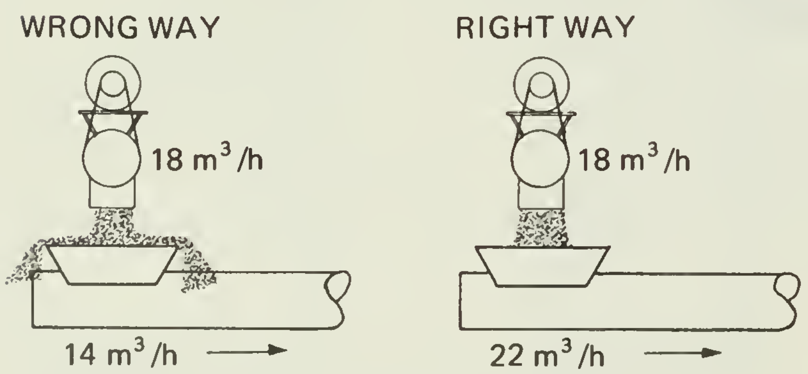


Figure 8 Proper conveyor selection prevents bottlenecks in the feed system.

Removal from Storage

On mechanized systems using a vertical lift, above-floor and under-floor augers (Figures 14 and 15) remove grain from storage and deliver it to cross conveyors, which move the material to a vertical lift for delivery to the

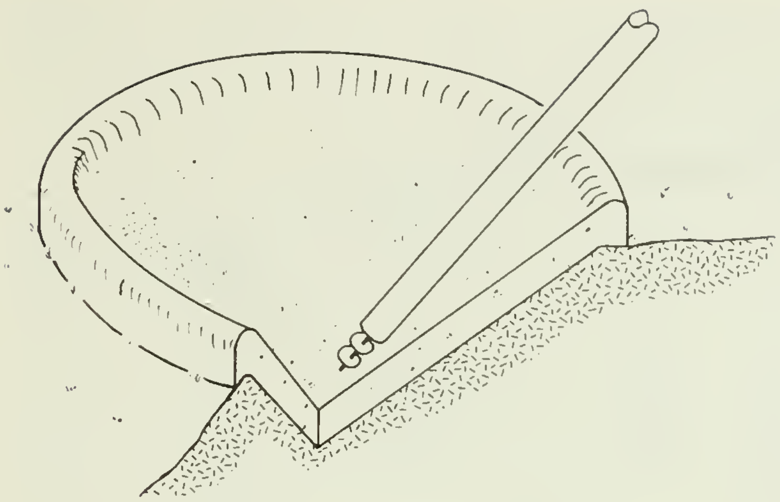


Figure 11 Concrete hopper.

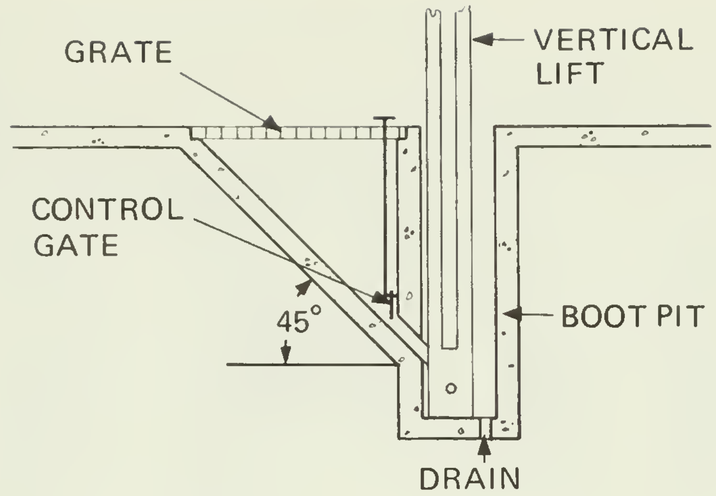
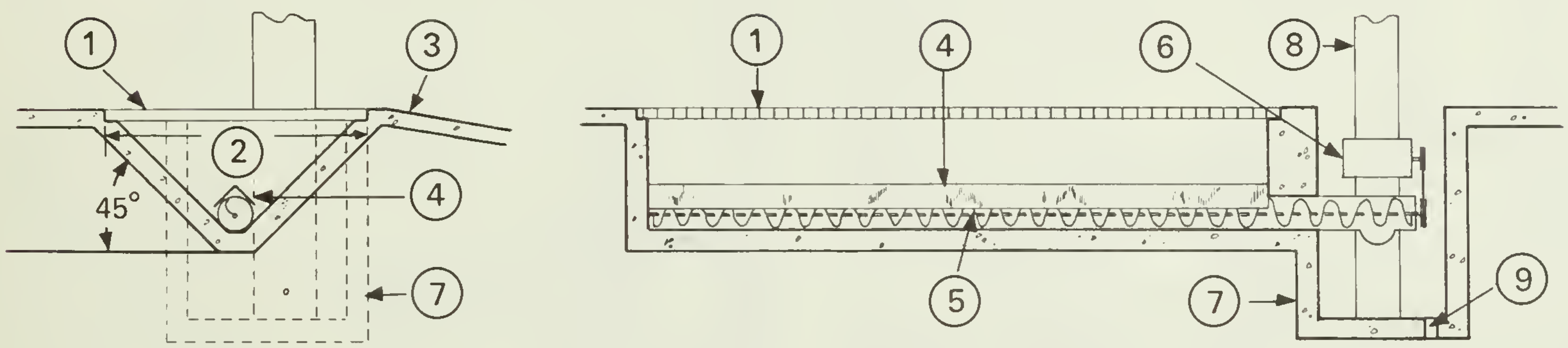


Figure 12 Gravity dump pit.



1 GRATE
2 1 m MINIMUM
3 CONCRETE
4 AUGER COVER
5 150 mm AUGER
6 DUMP AUGER DRIVE
7 BOOT PIT
8 VERTICAL LIFT
9 DRAIN

Figure 13 Auger dump pit.

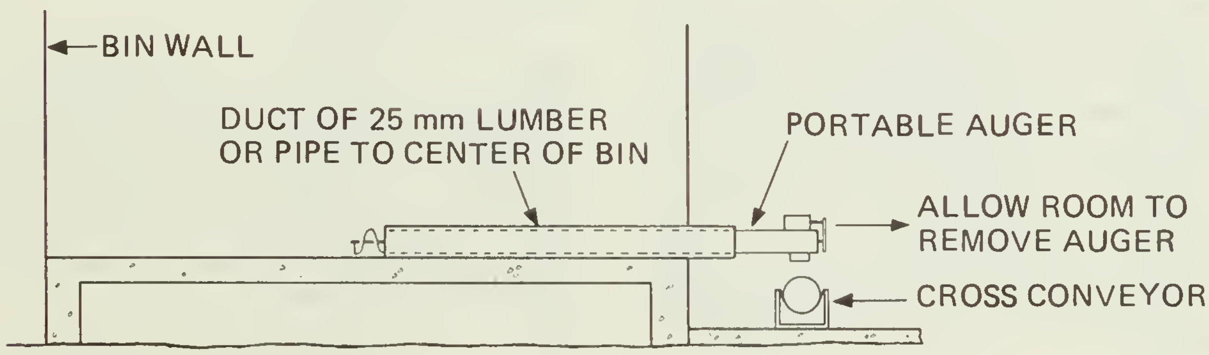


Figure 14 Above-floor unloading auger.

feed processing equipment or livestock. The augers in Figures 14 and 15 can be used with either rectangular or circular storage.

Figure 16 shows an under-floor auger and portable sweep for removing grain from circular bins. Figure 17 shows a below-grade hopper bottom installed under a circular bin. This method provides additional storage space, as well as unloading convenience, but soil moisture could cause a problem. Above-grade, hopper-bottomed bins, as discussed under Types of Storage, also facilitate grain removal.

Augers

If a central distribution system is not used, most grain is elevated into storage with an inclined auger. Inclined augers can be powered by gasoline engines or electric

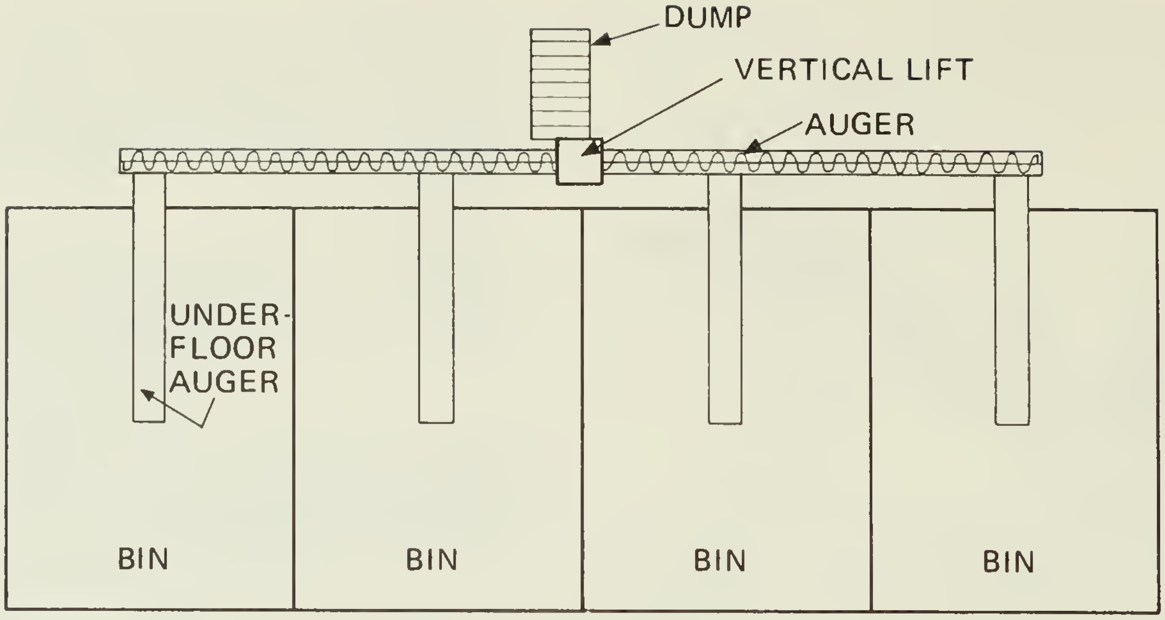


Figure 15 Under-floor unloading auger and cross conveyor.

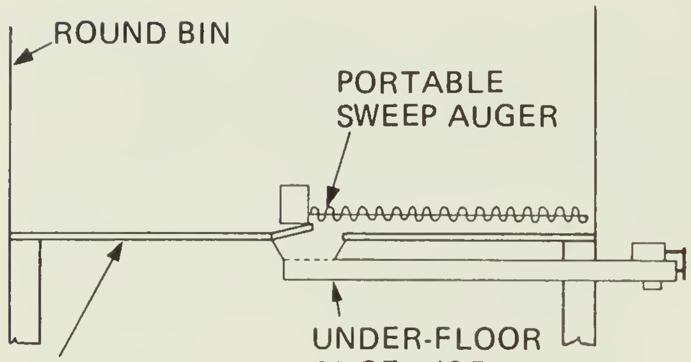


Figure 16 Portable sweep auger in circular bin.

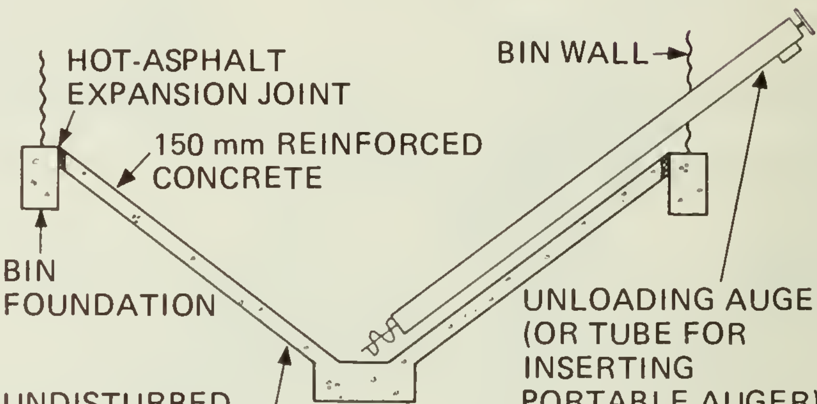


Figure 17 Below-grade hopper-bottomed bin.

motors, or driven by the tractor pto. An auger's capacity is affected by the materials being conveyed, auger size, auger speed, angle of operation, power available and flighting length exposed at the intake end. Capacity is reduced by 50% or more when grain moisture content increases from 10-12% to 20-30%. Speed should not exceed 1000 r/min as capacity does not increase but power requirements do. Power required for an auger increases in direct proportion to its length. Tables 4, 5, 6 and 7 give capacities and power requirements for various augers.

Vertical augers are most economical for low lifts at low capacities, but high power requirements limit their use for high lifts and high capacities. Foreign objects, such as sticks and stones, can damage an auger and most vertical augers are virtually impossible to repair without a crane to lift the flighting. Augers designed for vertical use usually have a short pitch helix and high requirements, and should not have intermediate bearings. Table 8 compares requirements of vertical augers and buck et elevators at various capacities.

Bucket Elevators

It is important to select bucket elevators for maximum capacity desired and material to be handled. Capacity change of a unit should not be attempted by increasing speed, as this changes discharge patterns, reduces capacity and causes excess wear at the head end. Make sure that installation for specific uses is done according to manufacturers' specifications.

TABLE 4 – CAPACITY 200 mm AUGER OPERATING AT 500 r/min ON 30° INCLINE

Grain	Capacity, m^3/h
Wheat	50
Oats	56
Barley	48

TABLE 5 – CAPACITY AND POWER REQUIREMENTS FOR 100 mm AND 150 mm AUGERS

Speed r/min	Angle from horizontal, °	100 mm auger: Approx.[2] power req'd kW/m	100 mm auger: Max. capacity, m^3/h[1] Wheat	Oats	Ground feed	150 mm auger: Approx.[2] power req'd kW/m	150 mm auger: Max. capacity, m^3/h[1] Wheat	Oats	Ground feed
	0	0.07	7.8	7.1	7.8	0.16	28.7	27.3	31.5
	30	0.09	6.0	5.7	8.1	0.17	21.1	20.2	27.6
300	45	0.09	5.0	5.0	6.7	0.20	17.4	16.6	21.2
	60	0.08	3.7	3.7	5.7	0.17	13.1	12.2	19.5
	90	0.07	2.1	1.4	1.4	0.15	8.1	8.1	17.7
	0	0.09	10.3	9.2	10.3	0.20	35.4	31.9	36.5
	30	0.11	7.6	7.1	8.3	0.23	25.1	23.0	31.2
400	45	0.11	6.7	6.0	9.6	0.23	20.5	18.8	23.7
	60	0.11	5.3	4.6	7.6	0.21	16.3	14.3	21.2
	90	0.09	2.8	2.1	6.0	0.18	11.7	9.6	19.8
	0	0.12	14.9	12.0	17.7	0.26	40.0	37.2	45.0
	30	0.15	10.6	9.6	18.6	0.28	30.1	25.8	34.0
600	45	0.15	8.9	7.8	13.8	0.30	24.4	21.2	29.0
	60	0.15	7.3	6.2	11.5	0.28	20.4	16.6	25.5
	90	0.14	5.0	3.2	8.5	0.26	15.9	12.0	23.0
	0	0.14	15.4	12.6	24.8	0.21	38.9	35.4	
	30	0.18	12.3	10.6	23.0	0.32	30.8	26.0	
800	45	0.20	10.6	9.4	17.7	0.34	25.3	21.2	
	60	0.19	8.7	7.3	7.3	0.34	21.0	17.0	
	90	0.14	5.8	4.1	10.3	0.33	16.5	12.6	

[1] Grain moisture at 10–20%.
[2] Power required at drive shaft. See Table 7 for recommended motor size.

TABLE 6 – CAPACITY AND POWER REQUIRED BY 100 mm AND 150 mm AUGERS HANDLING CORN

Speed, r/min	Angle from horizontal, °	100 mm auger: Approx.[1] power req'd kW/m	Capacity m^3/h	Ground feed	150 mm auger: Approx.[1] power req'd kW/m	Capacity, m^3/h	Ground feed
	0	0.04	5.3	–	0.12	20.9	–
200	45	0.05	4.3	–	0.14	17.7	–
	90	0.04	2.1	–	0.11	7.1	–
400	0	0.10	10.3	10.3	0.18	38.6	36.5
	45	0.10	7.8	9.7	0.29	30.1	23.7
	90	0.08	4.6	6.0	0.23	18.4	19.8
700	0	0.14	16.3	–	–	–	–
	45	0.17	12.4	–	–	–	–
	90	0.13	7.8	–	–	–	–
800	0	0.14	–	24.8	0.35	62.3	–
	45	0.20	–	17.7	0.53	48.5	–
	90	0.14	–	10.3	0.43	31.5	–

[1] Power required at drive shaft. See Table 7 for recommended motor size.

Bucket elevators have low power requirements, high efficiency, little noise and low maintenance cost. They cost more than augers initially, but operating costs are lower. Buckets for the elevator are fastened to either a belt or chain and are available in several sizes and shapes. For power requirements, see Table 8.

Pneumatic Conveyors

Pneumatic conveying of grain is relatively new on farms. The advantages of this type of system are its simple construction, ability to move grain around corners, easy control and location of all moving parts in one area. However, pneumatic conveyors have high power requirements and ground feed rations can be separated when blown through the pipe.

There are low-, medium- and high-pressure systems. Low-pressure systems operate with up to 3.7 kPa and low solid:air ratios (0.25 kg of material per 0.5 kg of air, or less). Medium-pressure systems operate at pressures of up to about 34 kPa. Air is usually supplied by a centrifugal blower or positive displacement pump. Because of higher pressures involved, an air-lock feeder such as a rotary valve or plugged auger is required. Material:air rates range from 0.5:1 to 6:1. High-pressure systems operate at pressures of up to 170 kPa. They require a positive displacement pump and operate on pressure only. Material:air weight ratios as high as 30:1 have been used.

Pneumatic conveyor systems may operate with positive or negative pressure. Positive pressure is generally used for conveying material from a single point to several points. With negative pressure, material is put into the system and conveyed to the suction side of the fan, providing cleaner operating conditions where dirty materials are being conveyed. This system is generally used for conveying from several points to a single point.

Horsepower requirements and capacities of pneumatic conveying systems depend on the length and diameter of pipe, the number of turns, the height to which material is lifted and the density of material being conveyed. Figure 18 illustrates an example of a pneumatic conveying system

Gravity Conveying

Gravity conveying provides a path for material to fall or slide from one location to another by its own weight, and largely depends on the flow characteristics of the

TABLE 7 — RECOMMENDED ELECTRIC MOTOR AND GASOLINE ENGINE SIZES

Conveyor power calculated from Tables 5 and 6 kW	Electric motor size recommended, kW	Gasoline engine size recommended, kW
Up to 0.20	0.19	0.37
0.21 to 0.26	0.25	0.50
0.27 to 0.41	0.37	0.75
0.42 to 0.60	0.56	1.10
0.61 to 0.82	0.75	1.50
0.83 to 1.20	1.10	2.25
1.21 to 1.57	1.50	3.00
1.58 to 2.39	2.25	3.75
3.40 to 3.92	3.75	6.00

TABLE 8 — APPROXIMATE POWER (kW) FOR VERTICAL AUGERS AND BUCKET ELEVATORS

Capacity, m^3/h		Lift, m						
		4.5	6	7.5	9	12	15	18
7	Bucket (75 x 100 mm)	0.25	0.25	0.37	0.37	0.37	0.56	0.75
	Auger (100 mm)	0.56	0.56	0.75	1.10	1.50	1.50	2.25
14	Bucket (100 x 125 mm)	0.37	0.37	0.56	0.56	0.75	1.10	1.10
	Auger (150 mm)	0.75	1.10	1.50	1.50	2.25	2.25	3.75
21	Buck (100 x 150 mm)	0.37	0.37	0.56	0.56	0.75	1.10	1.50
	Auger (150 mm force feed or 200 mm)	1.50	1.50	2.25	2.25	3.75	3.75	5.60
28	Buck (100 x 175 mm)	0.56	0.56	0.56	0.75	1.10	1.50	1.50
	Auger (200 mm)	1.50	1.50	1.50	2.25	3.75	5.60	7.50
35	Bucket (125 x 225 mm)	0.75	1.10	1.10	1.10	1.50	1.50	2.25
	Auger (200 mm force feed or 250 mm)	1.50	2.25	2.25	2.25	5.60	5.60	7.50
42	Bucket (125 x 225 mm)	0.75	1.10	1.10	1.10	1.50	1.50	2.25
	Auger (250 mm)	1.50	2.25	3.75	3.75	5.60	7.50	11.20

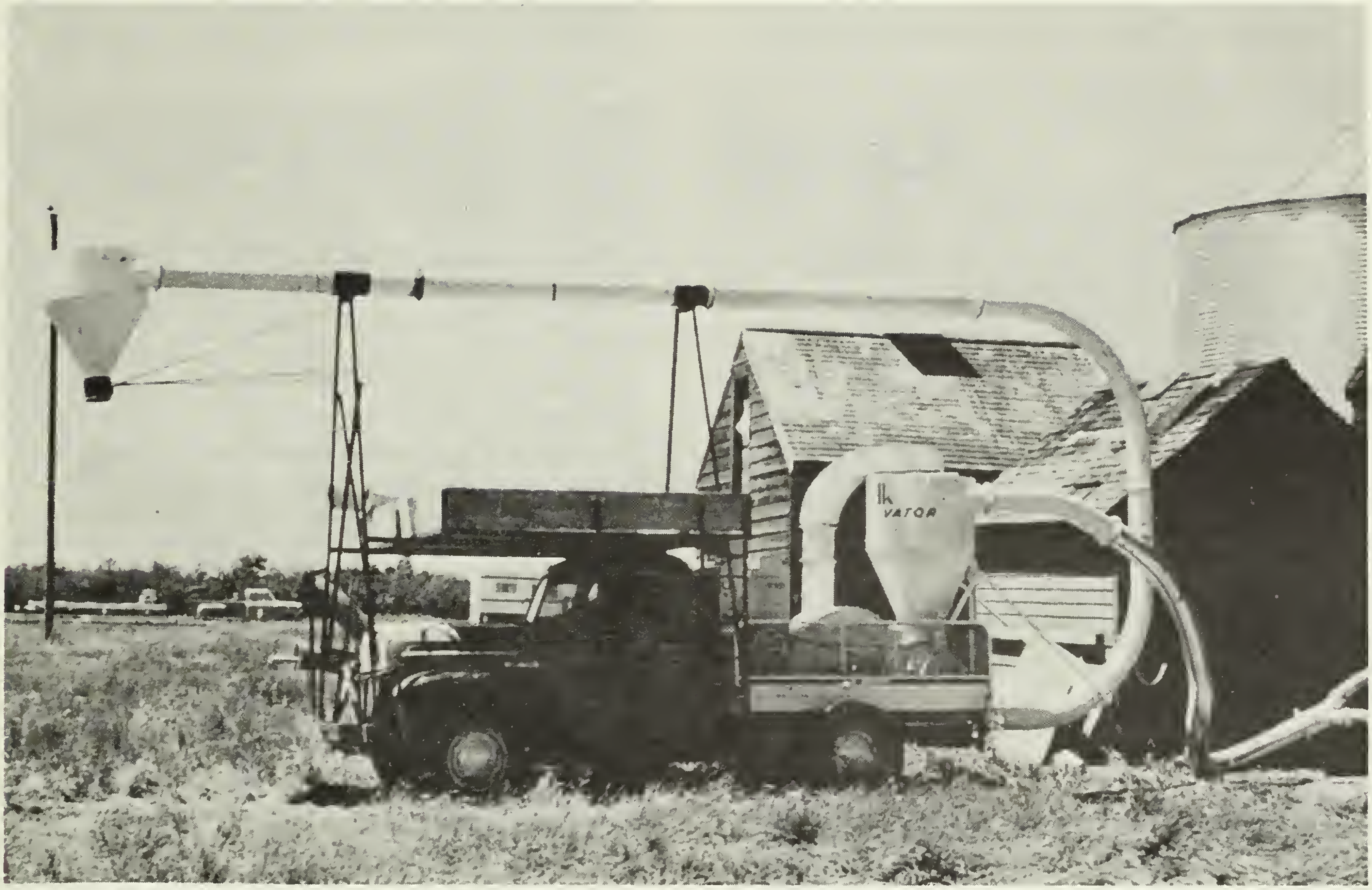


Figure 18 Pneumatic conveying system.

material The conveying path should be large enough and have sufficient slope to allow free movement of the material and should be free of projections or restrictions.

For livestock operations, gravity conveying is used when overhead bins situated above a feed mill supply raw grain to the mill or when overhead bins supply processed feed to a feed cart or conveyor before distribution. Gravity conveying is also used when grain, lifted vertically by a vertical screw conveyor, bucket elevator or pneumatic conveyor system, is distributed to storage bins. Figure 19 shows gravity spouting used to fill storage bins. The cushion box, or dead head, allows the grain to be dropped vertically into a bin for uniform loading.

The distributors shown in Figure 20 control the flow of grain. Grain distributors are available to control flow to as many as 12 points. Remember, when selecting a distributor, to choose one with extra openings to provide for possible expansion.

Vertical elevator height. The total height of the bucket elevator includes boot and hoppers, distributor or valves at the top, and head clearance at the top for the drive wheel (Figure 21). The effective elevator height is the distance between the hopper and the bottom of the distributor. Spouting height equals 1 m for each 1 m.

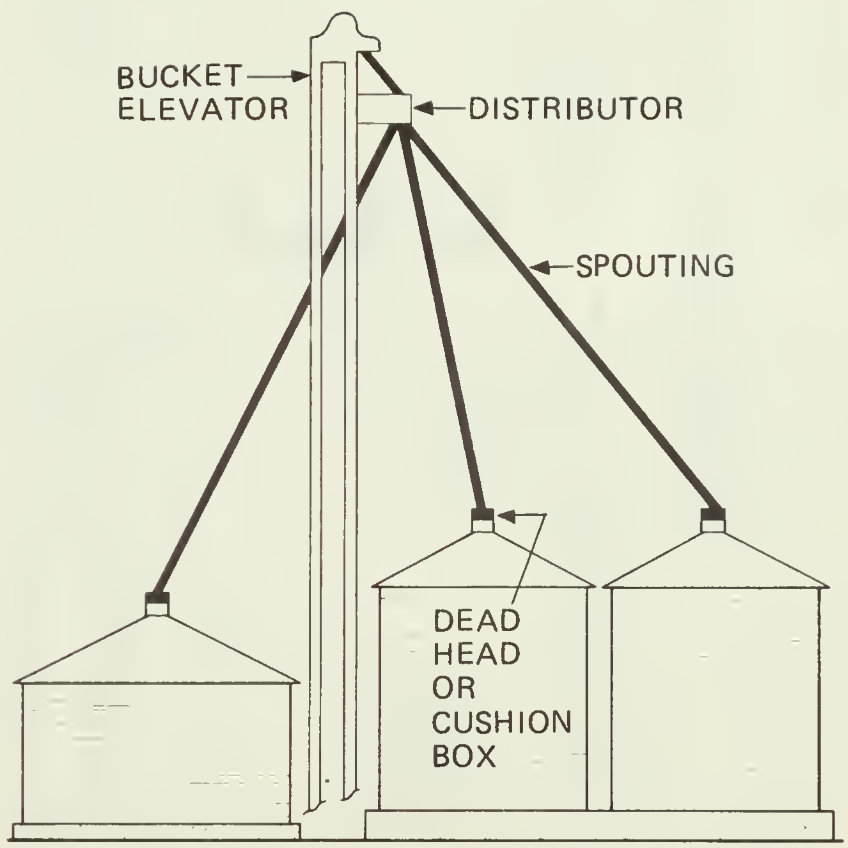


Figure 19 Gravity spouting to storage bins.

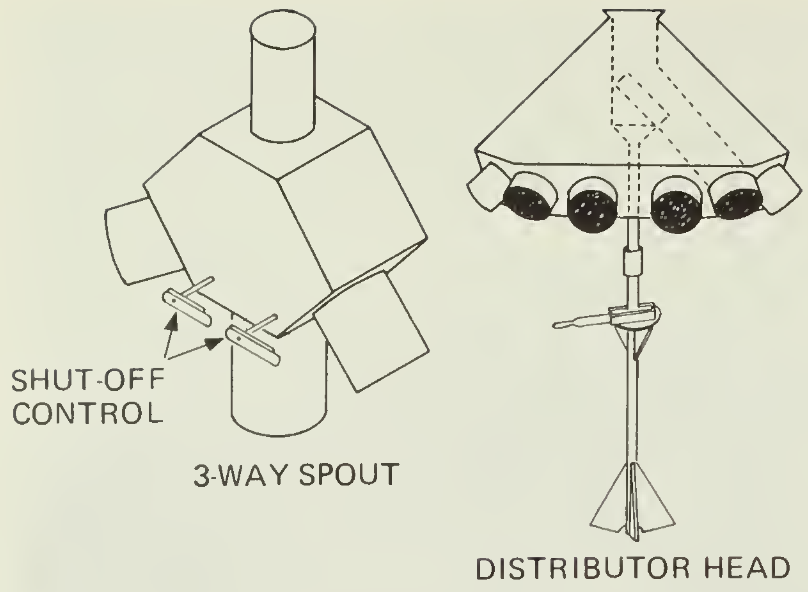


Figure 20 Two types of distributors.

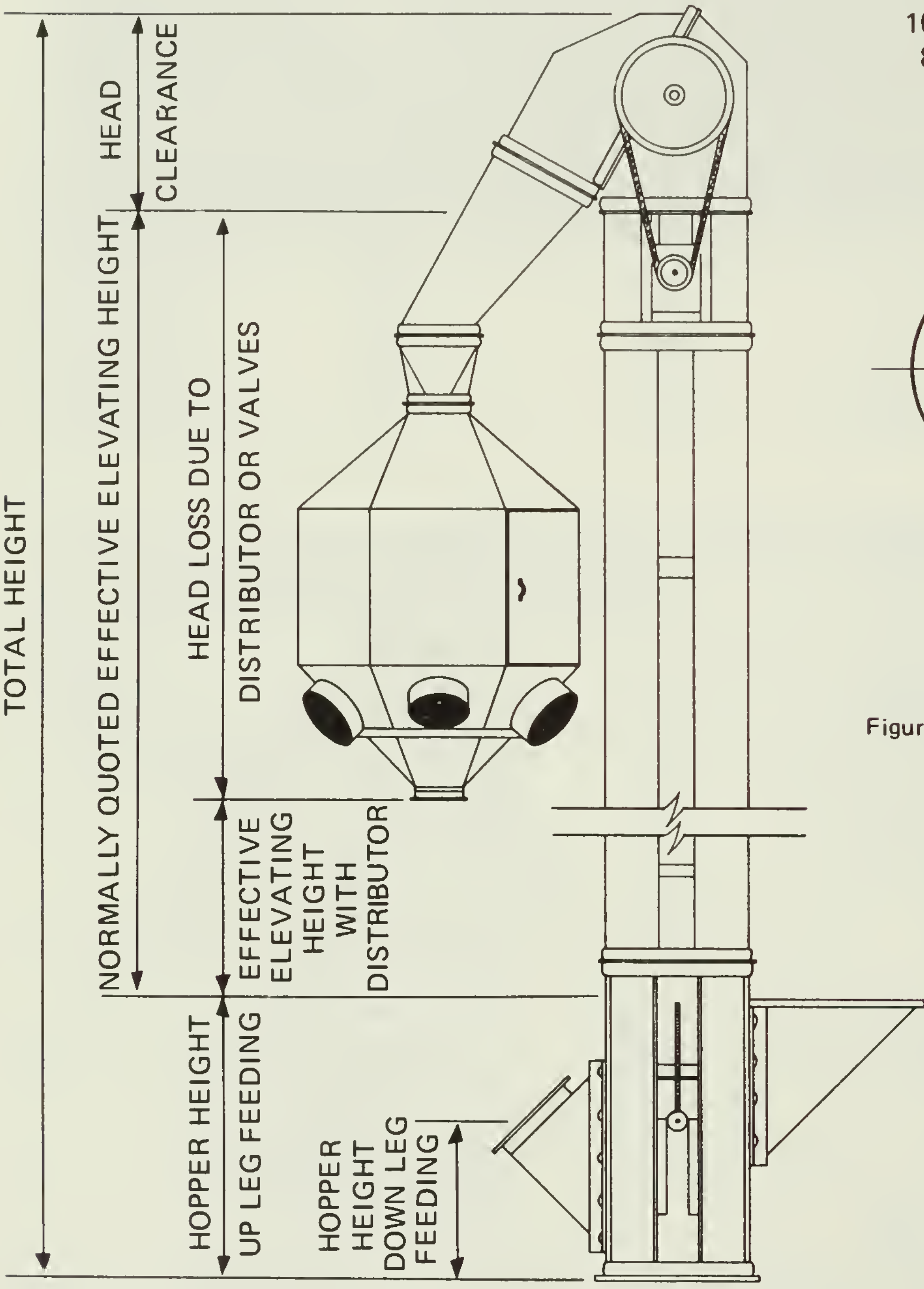


Figure 21 Leg dimensions showing hopper, distributor and overall height.

between leg and bin fill-point with a 45° slope; 0.75 m for each meter with a 37° slope; or 1.75 m for each meter with a 60° slope.

Example: If a bin fill-point is 10 m above grade, 45° spouting is to be used and the elevator is 8 m from the center of the bin, effective elevator height must be 10 m (bin) + (1 X 8) m (spout) = 18 m

Locating elevator between two bins A trial and error method can be used to locate a leg between two bins. As in Figure 22, for example, suppose you have a bin 10 m high for dry grain requiring a 37° spout, and a 8 m bin for wet grain, requiring a 45° spout. You could guess the leg to be 11 m from the dry bin and 7 m from the wet bin. But this would give unequal spouting heights:

10 m (dry bin) + (3/4 X 11) m = 18 m
8 m (wet bin) + (1 X 7) m = 15 m

Try moving the leg to a position 9 m from each bin. From this position, a 17 m leg should discharge into the middle to both bins:

10 m + (3/4 X 9) m = 17 m
8 m + (1 X 9) m = 17 m

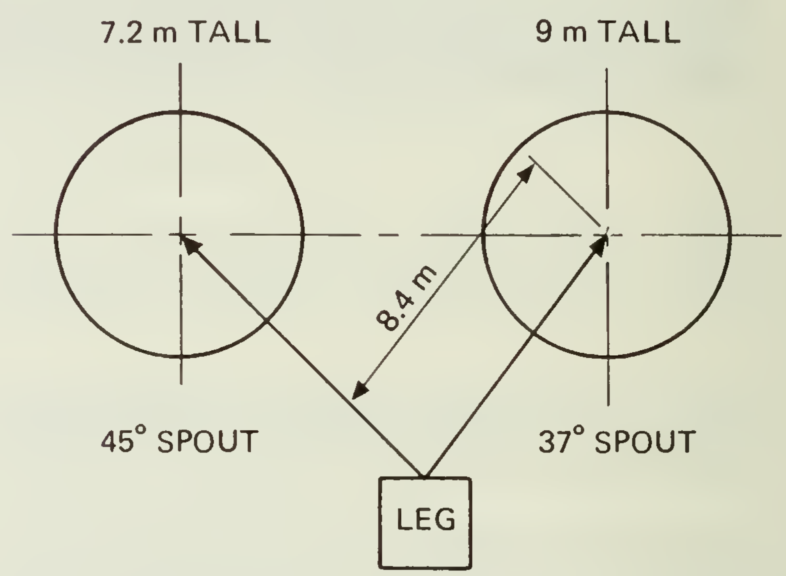


Figure 22 A 15.6 m leg located between two bin heights with different spout angle requirements.

Figure 23 and Table 9 indicate height differences between elevator discharge and spout discharge, and lengths of spouting required at 37°, 45° and 60° for various distances to bins.

Different materials require different spouting angles. Angles as low as 30° have been used successfully for dry grains, but are not recommended. Rusty pipe spouting may need to be scoured with dry hardgrain before bulky or damp grain can be handled satisfactorily. Varnishing or polishing wood and steel floors reduces friction and improves flow. Table 10 lists the recommended spout and floor slopes for gravity flow for various materials.

Belt Conveyors

As shown in Figure 24, belt conveyors are endless belts revolving around two pulleys. They are fairly efficient and are excellent conveyors for products that crack or are easily damaged. Initial cost is high, but power requirements are low. Belt incline is limited to about 15° for handling grain. Capacities of belt conveyors are compred in Table 11.

There are three types of belt conveyors, as shown in Figure 25. The troughed belt is used for granular or lumpy materials. The flat roller may be used as a return for a trough belt or, if side boards are provided, for bulky material. The sliding table can be used the same as the flat roller belt, but is limited to short runs and light loads. A smooth wooden or metal table minimizes friction and wear on the belt.

Chain Conveyors

Chain conveyors are used to move a wide range of agricultural products, from bales to small grains. They have a low initial cost but a high maintenance cost. Various types of chain are used, the type selected

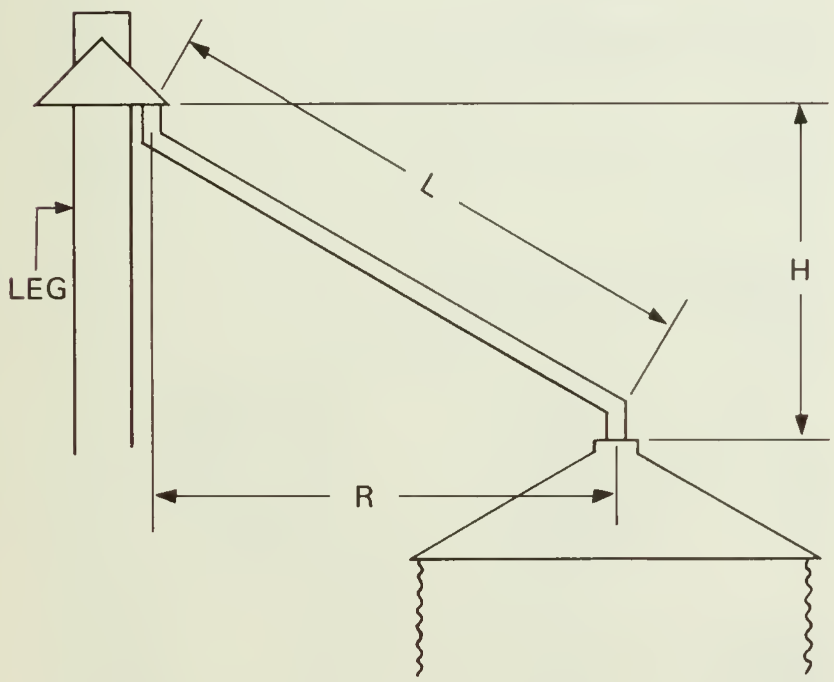


Figure 23 Indication of Run Length and Height for Table 9.

TABLE 9 – HEIGHT OF ELEVATOR DISCHARGE ABOVE SPOUT DISCHARGE AND LENGTH OF CONVEYOR FOR GRAVITY FLOW (FIGURE 23)

	Dry grain 37°		Wet grain 45°		Feed 60°	
Distance to bin (run) m	Length m	Height m	Length m	Height m	Length m	Height m
5	6.25	3.75	7.00	5	10	8.75
6	7.50	4.50	8.50	6	12	10.50
7	8.75	5.25	10.00	7	14	12.00
8	10.00	6 00	11.50	8	16	14.00
9	11.25	6.75	12.75	9	18	15.50
10	12.50	7.50	14.00	10	20	17.25
11	13.75	8.25	15.50	11	22	19.00
12	15.00	9.00	17.00	12	24	20.75
14	17.50	10 50	19.75	14	28	24.25
16	20.00	12.00	22.50	16	32	27.75
18	22.50	13.50	25.50	18	36	31.25
20	25.00	15.00	28.25	20	40	34.75

TABLE 10 – APPROXIMATE SPOUT ANGLES AND FLOOR SLOPES FOR GRAVITY FLOW

Material	Spout angle or floor slope,°	Slope equivalents, rise: run
Grains, dry	37	¾:1
Grains, wet or tough	45	1:1
Pellets	45	1:1
Meal	60	1:¾

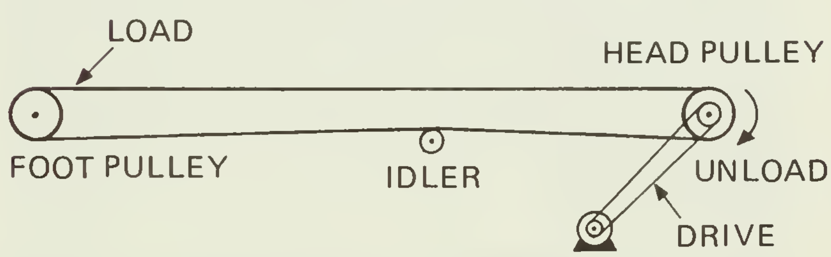


Figure 24 Belt conveyor showing various pulleys.

TABLE 11 – CAPACITY AND MAXIMUM SPEED OF UNIFORMLY LOADED BELT CONVEYORS RUNNING AT 30 m/min

Belt width, mm	Capacity, t/h: Troughed belts, 560 kg/m³ material	Capacity, t/h: Troughed belts, 800 kg/m³ material	Capacity, t/h: Flat belt, 800 kg/m³ material	Max speed, m/min: Fine grind	Max speed, m/min: Grain
300	7.4	10.4	5.2	90	105
350	10.7	14.3	6.4	90	120
400	13.3	19.1	8.6	90	135
450	16.5	23.5	10.5	120	135
500	21.3	30.3	13.6	120	150
600	31.2	44.5	20.0	150	180
750	50.2	71.5	32.2	165	210
875	70.2	100.0	45.4	180	240

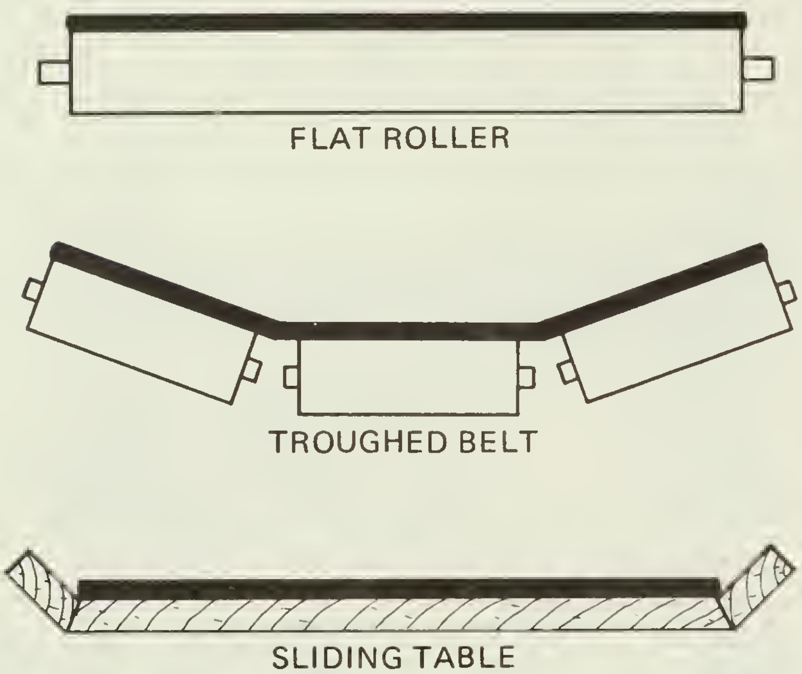


Figure 25 Types of belt conveyors.

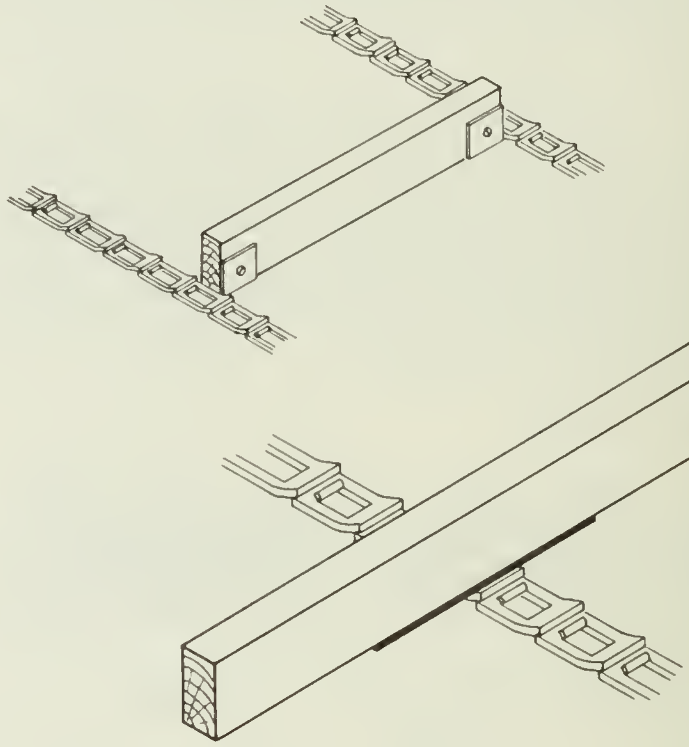


Figure 26 Chain and flight conveyors.

depending on the material being conveyed. Chain and flight conveyors (Figure 26) are the most common on farms. The simplest type is a single chain with steel or wooden flights operating in a steel trough. Flight conveyors do not operate efficiently on inclines greater than 40°. As shown in Figure 27, loose material cascades backwards unless the depth of the flighting is increased proportionately.

Table 12 gives capacities of horizontal flight conveyors where the flights are spaced at the same distance as their length. The capacity of a conveyor is reduced to 77% if it operates on a 20° incline, 55% at 30° and 33% at 40°.

Vibrating Oscillating Conveyors

An oscillating conveyor consists of a metal trough supported on coil or leaf springs or pivot arms and mounted to a rigid frame. Conveying occurs when the trough is moved back and forth by mechanical or

TABLE 12 – CAPACITY OF A HORIZONTAL CHAIN AND FLIGHT CONVEYOR

Flight size, mm	Capacity, m³/h, for conveyor speed of 30 m/min	Capacity, t/h, for conveyor speed of 30 m/min for two material densities of 416 kg/m³	Capacity, t/h, for conveyor speed of 30 m/min for two material densities of 720 kg/m³
125 x 50	13.6	5.7	9.8
200 x 75	32.3	13.4	23.2
250 x 100	54.4	22.7	39.2
300 x 125	81.6	33.9	58.9

electromagnetic means. These conveyors are self-cleaning, are often used for metering, have low power requirements and can handle several materials. They are limited to about a 7° incline, are not reversible, are fairly costly and may cause particle separation. Figure 28 shows the operating principle of a mechanical oscillating conveyor. Figure 29 shows a vibrator being used to meter material. A change in intensity of vibration changes the metering rate.

Pump and Pipe Conveyors

Pump and pipe conveyors have limited use for feed processing and distribution, although they could be used in liquid feeding systems for hogs. They are efficient conveyors, easy to control and require limited maintenance, but materials that can be moved are very limited and the pipes and pump must be protected from freezing.

Loading and Unloading Upright Silos

Most tower silos are filled by forage blowers, which should have enough capacity to fill the silo without delaying the harvesting operation. Blowers are relatively inefficient compared with mechanical elevators, but they provide a high-capacity method of filling tower silos with a low capital investment. Blower capacity depends on diameter of blower, power available, crop moisture and length of cut, and silo height. Most blowers have much less capacity when handling hay than when handling corn. The maximum capacity of a blower can be achieved only when an ample supply of power is available.

It is important that chopped material placed in the silo be distributed in a uniform pattern. Any of several types of rotary distributors or deflectors can be used for this purpose.

There are top unloaders and bottom unloaders for tower silos. Top unloaders are lowered onto the top of the silage and unload the silage by blowing it to the silo chute, where it falls onto a conveyor or into a cart. Another type of top unloader drops silage to a bottom unloader through a hole formed while the silo was being filled (Figure 30). Two types of unloaders are available: suspended and surface riding. The suspended top

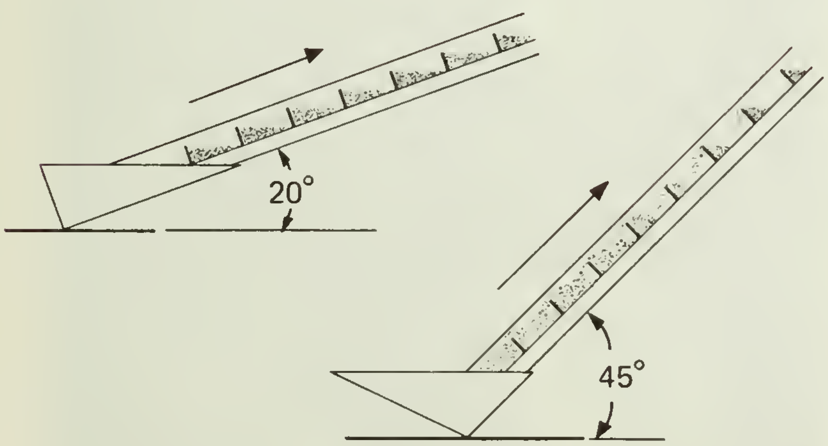


Figure 27 Loose material cascades backwards on chain and flight conveyors with inclines greater than 40°.

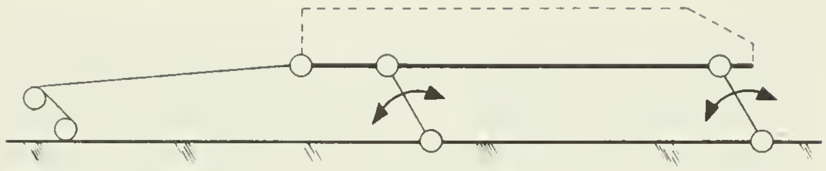


Figure 28 Mechanical oscillating conveyor.

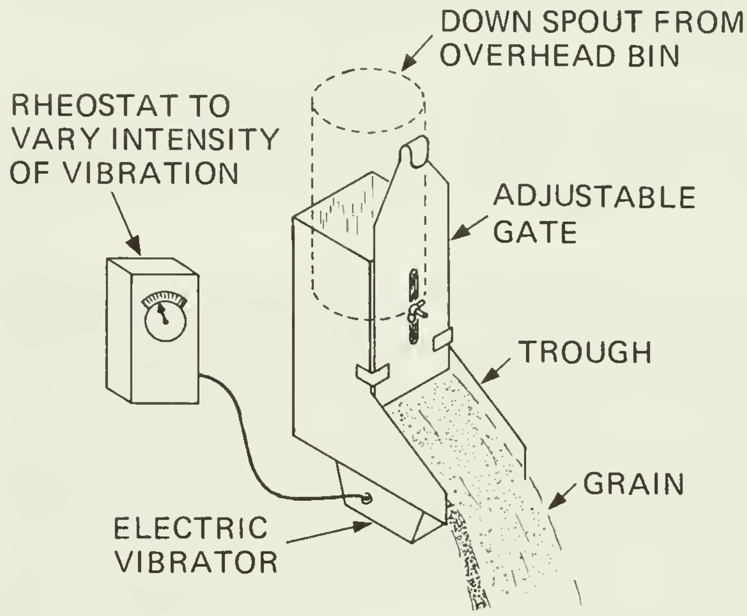


Figure 29 Vibrator meter.

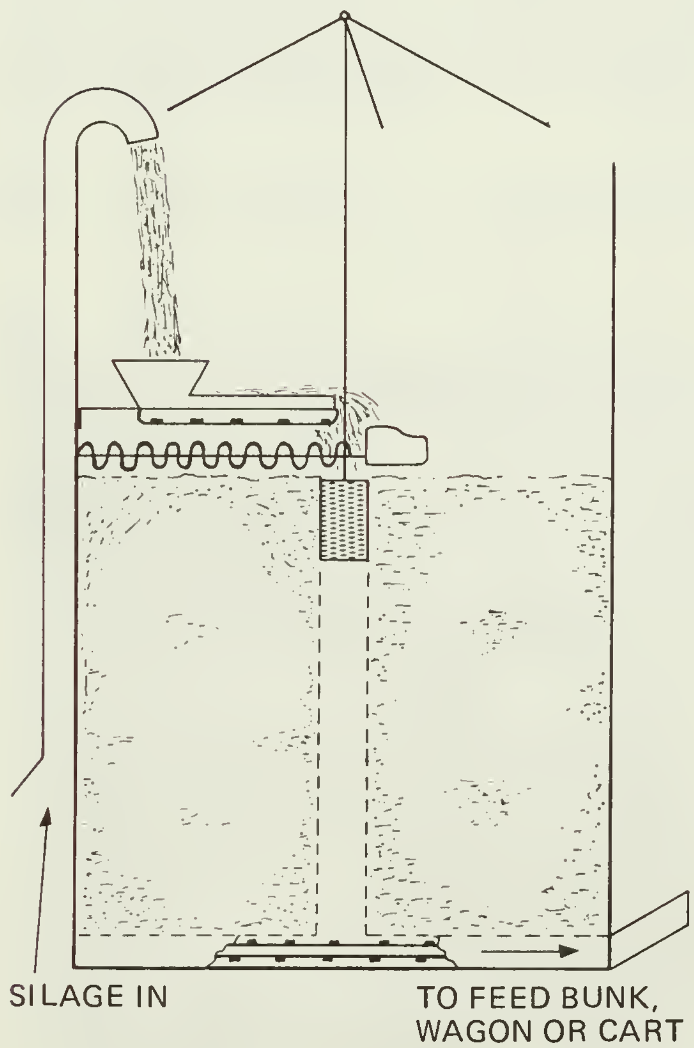


Figure 30 Combination distributor and top unloader for a tower silo.

unloader is supported by a cable and pulley arrangement attached to the top of the silo. The supporting cable is controlled by a winch at the bottom, which may be operated either manually or with an electric motor. This type of unloader requires fairly constant supervision. The surface-riding type is supported on wheels which can be set to control the depth of cut. Surface-riding types should be suspended when not in operation to prevent freezing into silage, as this causes start-up problems.

It is difficult to obtain a constant discharge rate from a top unloader. Frozen material around the silo perimeter, silage density, moisture content, length of cut, and type of silage all affect unloader capacity.

Bottom unloading from a silo offers several advantages: the motor and drive unit are at ground level outside the silo; the first silage into the silo is the first used; feeding can take place while new material is being added at the top; and it is not necessary to climb the silo to open chute doors. Bottom unloaders are more easily adapted to automatic feeding systems, but are more expensive than top unloaders and a special base must be prepared for them when the foundation is being poured. Also, repair work on bottom unloaders can be more difficult.

Unloading Horizontal Silos

Self-feeding of livestock from a horizontal silo eliminates the need for mechanical handling. Another method of removing silage from a horizontal silo is with a tractor and front-end loader. The front-end loader can fill either a feed bunk or a self-unloading wagon for distribution to a feed bunk.

Two types of commercial horizontal silo unloaders are available. One type shown in Figure 31 is tractor-mounted. Truck-mounted units are also available. This unit is fairly expensive and a large amount of silage must be fed to justify the capital investment. Another type of horizontal silo unloader, more commonly used, is the front-end loader (Figure 32). Both types of unloaders must be started every day during the feeding period and a reliable power unit is required.

Table 13 summarizes some of the information presented about various types of conveyors.

PROCESSING

Grinding and Mixing Equipment

Just as there are many types of conveyors with particular characteristics, the various kinds of grinding and mixing equipment each have advantages and disadvantages. In selecting grinding and mixing equipment, keep in mind the type of livestock to be fed and the type of ration required.

Hammer mills A hammer mill consists of rotating hammers spinning inside a heavy, concave, perforated screen (Figure 33). The hammers strike the material fed into the mill, as it rebounds from the screen again and again, and reduce it to a size small enough to pass through the screen. Hammer-tip speeds vary from 210 to 7500 m/min. Common tip speeds are 3600-4500 m/min. The slower the tip speed, the more uniform the grind.

Figure 31 Tractor-mounted horizontal silo unloader.

Figure 32 Front-end loader used as horizontal silo unloader.

TABLE 13 – SUMMARY OF CONVEYORS

Type of conveyor	Type of material	Capacity	Power req't	Cost	Advantages	Disadvantages
Screw (auger)	Ground, granular, chopped	Medium	Low to medium	Medium	Can be used as mixer or for uniform flow feeder, good for unloading bulk storage, wide range available	Size of material limited, single sections limited in length, medium to heavy wear
Chain	Most feed grains and farm products	Medium	Medium	Low to medium available	Inexpensive, multiple use, wide range	Noisy, heavy wear
Bucket	Ground, granular, lumpy	Medium to high	Low	Medium to high	Efficient, low maintenance, high capacity for vertical lift, low power requirement	Limited speed range, difficult to erect, expensive, should be equipped with automatic brake
Belt	Grain, packaged units	High	Low	High	Can be used for long distances, low power requirement	Limited in angle of elevation, expensive
Pneumatic	Grain, ground feed, chopped forage	Variable	High	Low to medium	Low first cost, low maintenance, flexibility of installation, excessive manpower may be needed to clean plugged pipes	High power requirement, creates dust, usually requires separation equipment, conditions of operation vary with type of material
Vibrator	Grain, ground feed	Low	Low	High	Can be used as meter, reliable, easy control	Limited capacity, cost
Oscillator	Grain, feed roughage	High	Low	Medium to high	Efficient, can handle large volumes, can handle several materials	Cost, must be solidly mounted, limited to lengths of about 30 m
Pump and pipe	Liquids, slurries	High	Low	Low to medium	Efficient, easy control low maintenance	Materials limited, subject to freezing

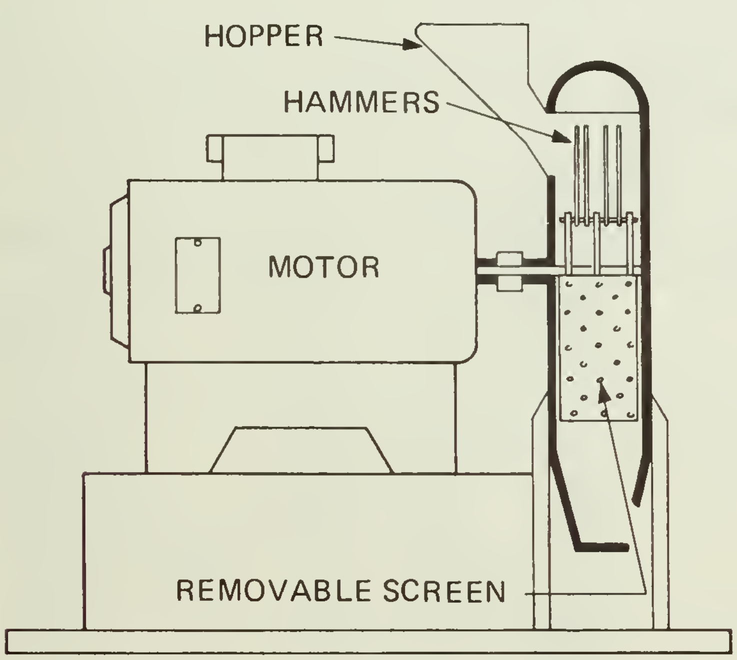


Figure 33 Hammer mill.

Fineness depends on screen size. As the screen size decreases, the fineness increases, but the mill capacity decreases and power requirements increase. Screens are available from 0.75-50 mm. The larger screens are used for processing roughage. Some hammer mills have a precutter ahead to reduce roughage.

Hammer mills are very versatile. They process several types of grain at one time, so are suitable for use with blending or grinding equipment. Also, they are not easily damaged by foreign objects, can run empty without damage and suffer no appreciable loss in efficiency due to hammer wear. A hammer mill does not produce a uniform grind and has high power requirements for high capacities. It can be powered by either an electric motor or a tractor.

The capacity of a hammer mill is reduced as moisture content of the grain increases. The meal produced from high-moisture grain is coarser than that produced from low-moisture grain.

Burr mills A burr mill consists of two roughened, cast-iron plates, one stationary and the other rotating (Figure 34). Material is reduced by the crushing and shearing action of the burrs. Fineness is controlled by the type of plates and plate spacing. Operating speeds range from 1200 to 3600 r/min. For best efficiency, coarse burrs should not be used for fine grinding as the power required increases rapidly and there is considerable wear. Burr mills have a low initial cost but require frequent replacement of the plates. They provide a more uniform product than hammer mills and are better adapted to coarse grinding, but require more power for fine grinding and are more suxceptible to damage by foreign objects in the grain. Excessive plate wear occurs when a mill operates empty. A burr mill requires more adjustment than other types of grinders, and will not handle high-moisture grain satisfactorily. Table 14 gives approximate grinding rates for burr mills and hammer mills.

Roller mills Roller milk, also called crushing or crimping mills, reduce material by crushing it between two corrupated rollers that turn in opposite directions (Figure 35). Roller mills can be powered by belt from stationary motors or by a tractor pto.

Roller mills can be supplied with rolls having corrugations spaced anywhere from 5 mm to 1.4 mm apart.

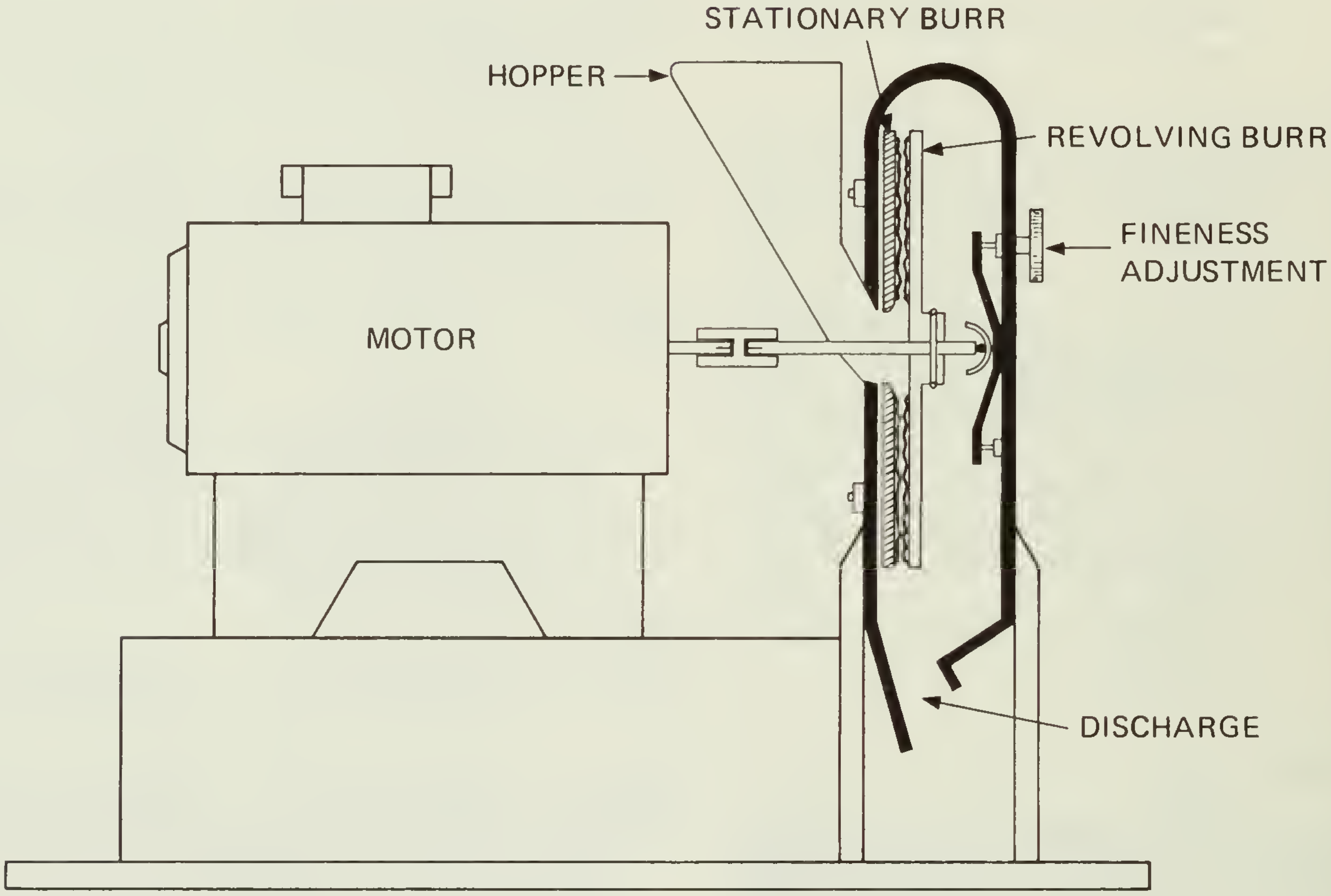


Figure 34 Burr mill.

TABLE 14 – APPROXIMATE GRINDING RATES FOR HAMMER AND BURR MILLS OF VARIOUS kW

Grain	Classification	Grinding rate, kg/h				
		0.75 kW	1.1 kW	1.5 kW	2.25 kW	3.75 kW
Barley	Coarse	140	230	270	410	640
	Fine	35	45	70	110	230
Oats	Coarse	140	200	270	450	680
	Fine	35	50	100	160	200
Wheat	Coarse	270	450	730	1100	1360
	Fine	90	100	270	390	450
Corn	Coarse	270	410	750	1150	1600
	Fine	110	140	280	410	450

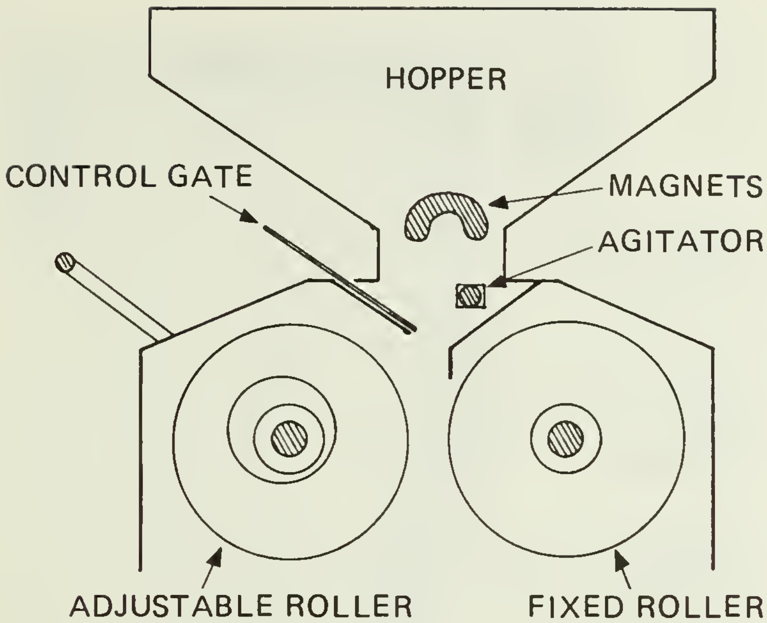


Figure 35 Roller mill.

TABLE 15 – TYPES OF ROLLERS FOR VARIOUS GRAINS

Corrugations/cm	Grains
2 or less	Corn
3-5	Wheat, barley, crimping oats
6 or more	Oats, barley wheat

TABLE 16 – ROLLER MILL CAPACITIES

	1.1 kW	2.25 kW	3.75 kW	5.6 kW
Capacity, kg/h	200	540	800	1600

Small-sized kernels require more corrugations to prevent uncracked grain from passing through. Table 15 is a general guide for rolling feed grains.

Rolls wear out and must be removed and regrooved, but, compared with other mills, roller mills have lower power requirements for high capacities and produce feed that is uniform with little fine or dusty material. They are not suitable for pulverizing feeds, such as chick starters, and can be damaged by foreign objects, so should be equipped with magnets to remove tramp metal. They also are not suitable for processing mixtures of different-sized grains. Table 16 provides information on approximate capacities. Roller mill capacities are considerably reduced when rolling high-moisture grain and are affected by roller speed, roller spacing and input power.

Table 17 compares roller, hammer and burr mills.

Portable grinder-mixers These usually are trailer-mounted, tractor-drawn and pto-powered. The grinding unit can be a hammer, roller or burr mill, but hammer mills are most common as they handle hay as well as grain. Mill selection depends on the class of livestock and kind of feed to be processed. Material is conveyed into the grinding unit either with augers or chain-slat conveyors. Chain-slat conveyors are used mainly with mills that can handle roughage. Mixer tank capacities vary from make to make and model to model, but most are rated by volume. Two types of mixing tanks, vertical and horizontal are available.

The power requirements of a horizontal mixer are usually higher than those of a vertical auger but the horizontal auger can handle liquid molasses and silage. About 30 kW is required to operate most portable grinder-mixers although some units may require up to 45 kW or more.

Options available on various grinder-mixers are a liquid-molasses attachment, scales, tramp metal magnets, extra inspection windows, unloading auger extensions, and a hopper for adding protein supplement or premixed rations to the mixer. Protein supplement or premixed rations should not be put through the grinder.

Roughage Processing

Many devices are available for handling roughage. Hay and straw can be handled with a forage harvester, stacking wagons, or in bales, large and small. Sometimes roughage can be self-fed, eliminating the need for

TABLE 17 – COMPARISON OF FEATURES OF HAMMER, ROLLER AND BURR MILLS

Feature	Hammer mill	Roller mill	Burr mill
Construction	Fixed or pivoted hammers	2 steel rollers	Rotating plate
Operation	Beats material	Crushes material	Shears and crushes material
Power needed	High	Low	Medium
Type of ground feed	Fine	Coarse	Medium coarse
Fineness control	Screen size	Roller spacing	Plate spacing
Operating speed	1500-4000 r/min	350-600 r/min	1200-8600 r/min

processing. However, some livestock producers prefer to process the roughage and feed it at the same time as the grain ration.

Hay mills Hay mills are available that shred solid bales of hay or straw and process it through a screen similar to that of a hammer mill. These machines have high power requirements and are expensive. They have a capacity of 5.4-18 t/h through a 25 mm screen and require from to 19-110 kW.

Tub grinders These machine for processing roughage are usually pto-powered, requiring a tractor with 56-75 kW. The large tub rotates slowly and feeds a constant supply of roughage to a hammer mill in the floor of the machine. After the roughage is processed through a screen, it can be conveyed to a pile on the ground or loaded into a wheeled vehicle for distribution to livestock. A tub grinder is usually fed with a front-end loader and has a capacity of about 9-11 t/h. The actual mass processed depends on the moisture content of the roughage, screen size used and power available.

Feed Mixers

The more complex the ration, the more thorough the job of mixing required. Both proper proportioning of ingredients and proper mixer operation are essential to ensure a desirable product. Also, rations must be carefully prepared because many of the feed additives, such as urea, can be highly toxic. Most feed mixers can be classified as horizontal batch type, vertical batch type or continuous mixing.

Vertical batch mixers The most common mixing device used on small to medium-sized feed processing systems is a steel tank in the shape of an inverted cone, with a central lift auger running vertically up the center (Figure 36). Vertical mixers are top or bottom loading, with bottom or side discharge. Capacities range from 0.45-7.1 t per batch. As only a small portion of the feed is being mixed at one time, power requirements are relatively low—2.5 kW for a 1 t mixer and 4-6 kW for a 2 t mixer. Mixing each batch takes 10-15 min

Be extremely cautious when mixing toxic feedstuffs; premix them with a carrier to reduce the risk of having large concentrations in one portion of the feed. Also, do not put wet feed into a vertical mixer, as damp material may cause blockages.

Vertical mixers are tall and cannot always be easily fitted into an existing building. Bottom-loading vertical mixers are not completely self-emptying. Access doors must be provided to allow cleanout between different rations.

Horizontal batch mixers This type consist of a u-shaped steel trough, in which mixing is accompliched by one or more agitators, paddles or spiral ribbons attached to a horizontal shaft revolving at 10-50 r/min (Figure 37). Horizontal mixers are used in large operations where high-capacity, thorough mixing is required; grain and roughage are being mixed; liquid feedstuffs or antibiotics are being added; rapid mixer unloading is required (mobile mixer installation for fence-line feeding, for

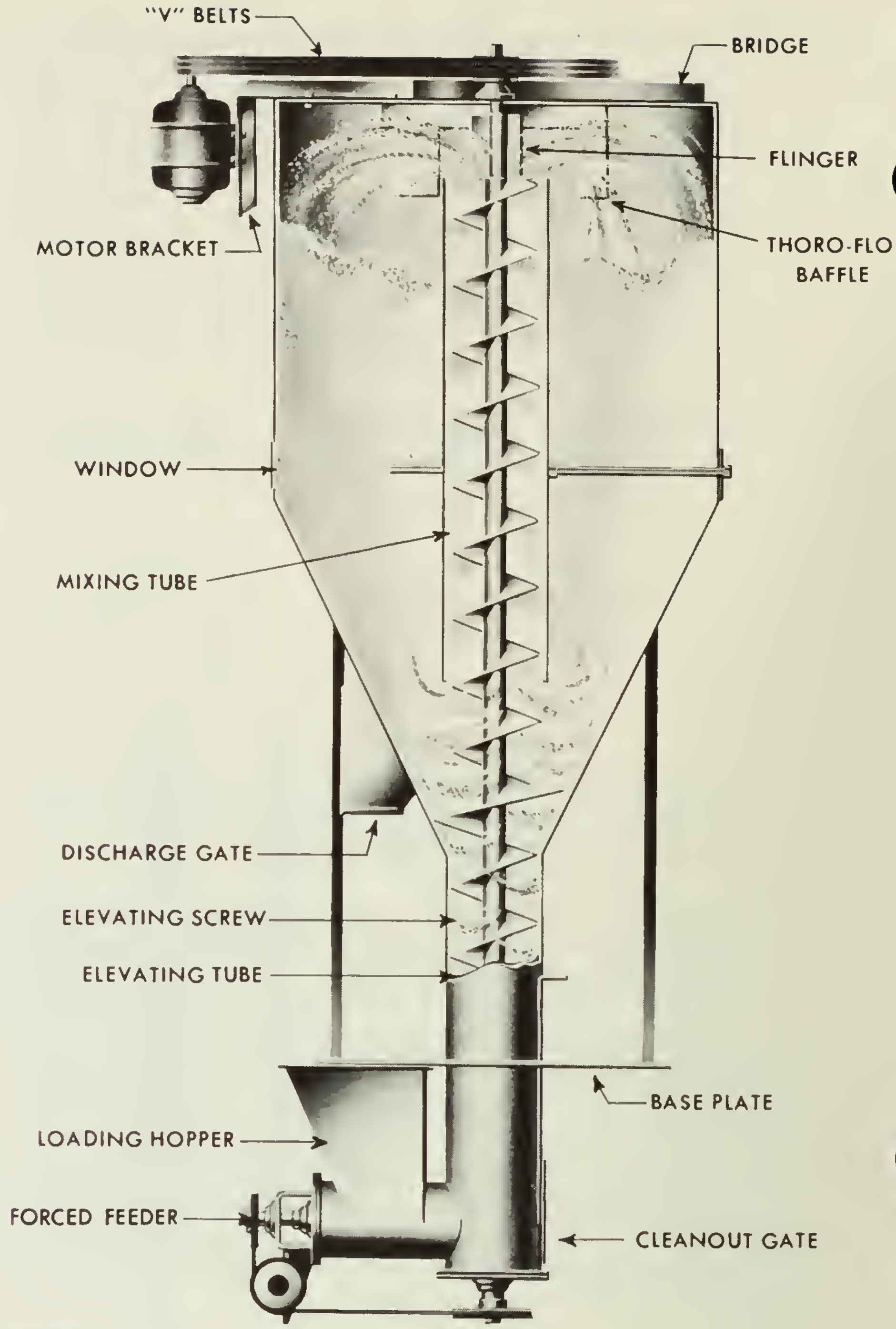


Figure 36 Vertical batch mixer.

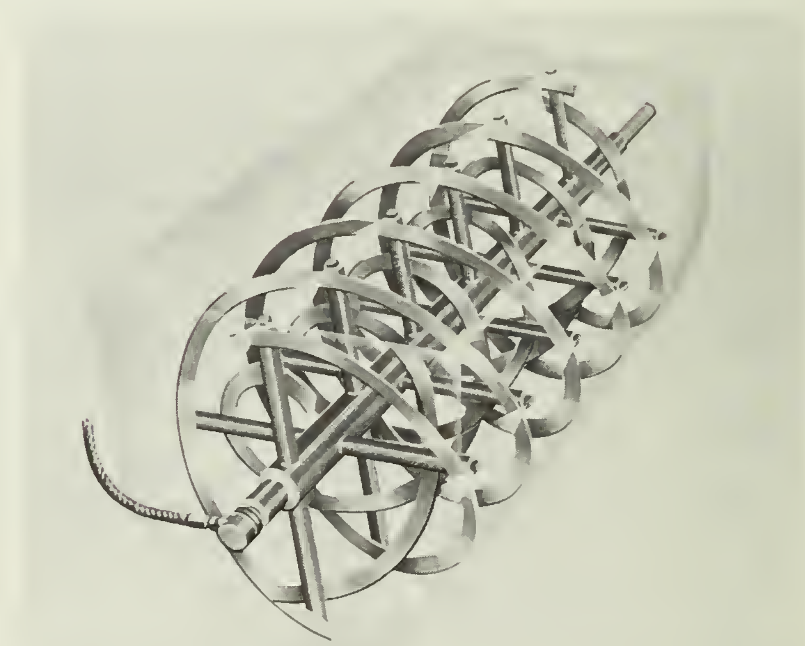


Figure 37 Horizontal batch mixer.

example); or high headroom in not available. They have high power requirements, 4-8 kW for a 0.5 t mixer, and high initial cost; and the mixing tank is difficult to empty completely, resulting in contamination of succeeding batches.

Continuous mixers Two or three ingredients may be metered onto a conveyor moving rations to a feed bunk or wagon. This method of mixing ingredients relies on constant flows and is not recommended where complex rations are required. More effective mixing can be achieved with a variety of cut-flight augers or paddles driven at high or low speed. Low-speed, cut-flight augers are used for continuous mixing of dry ingredients.

Proportioning devices are available to meter grains and supplements for mixing. These devices assist operators in formulating on-farm rations. Medicators, protein meters, and molasses and fat dispensers are used to add supplements at given amounts. They are useful when operators know the amount and rate at which feed is being distributed. Supplements are added to mixers or conveyors and are mixed as they are being conveyed to the feeding area.

Figure 38 Self-propelled poultry feed cart.

DISTRIBUTION AND FEEDING

After feed has been processed, it may be either delivered directly to the livestock or stored, preferably at the point of use. If feed is put into storage, one of the conveying methods discussed previously can be used. Feed removed from storage or fed directly after processing can be distributed to livestock by the following methods.

Feed Carts

Feed carts are usually used for hard feeding, but can be used to fill self-feeders with silage, chopped hay or ground ration. They may be loaded either by hand or by some type of conveyor, and are usually pushed to the place of distribution. Feed carts are mainly used for feeding dry and lactating sows, dairy cattle and poultry. They can be built in any particular size to suit the operation. Floors should be relatively smooth, to facilitate moving the carts. Figure 38 shows a self-propelled feed cart used to distribute feed to troughs on poultry cages. Figure 39 shows a push-type feed cart.

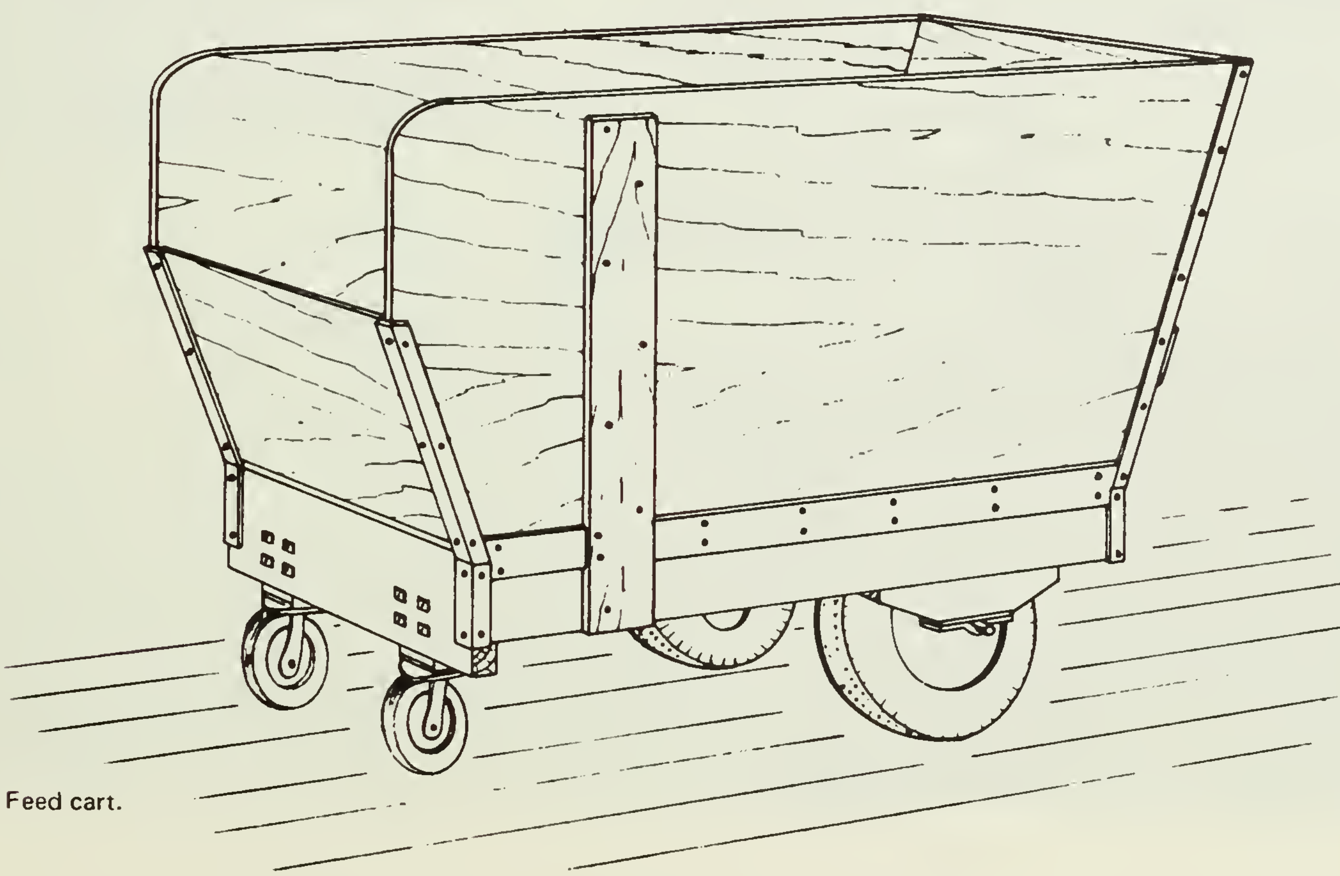


Figure 39 Feed cart.

Feed Carriers

Feed carriers are essentially feed carts suspended from an overhead rail, running on a track or on wheels, and with an unloading device for feed distribution. The feed carrier may be pushed (Figure 40), or powered by an endless cable. Unloading can be mechanical or by gravity flow. Feed carriers can be used to feed silage, dry chopped roughage or grain, depending on the unloading mechanism. As with feed carts, they can be filled by most types of conveyors. Feed carriers usually operate along or above feed bunks (Figure 41) and are used mainly for feeding cattle.

Bunk-Feeder Wagons

Bunk-feeder wagons, used mainly in beef feedlot operations, distribute feed to fence-line feed bunks. These units can be wagon-mounted, tractor-drawn or mounted on a truck (Figure 42). They are usually pto-driven.

Most bunk-feeder wagons can transport, mix and unload feed. A typical wagon has three main components: floor conveyor, mixing device and cross conveyor. The floor conveyor is usually a chain and slat conveyor running lengthwise in the wagon. The mixing device tears or shreds the load face as it is moved by the floor conveyor. Layers of grain and supplement are proportioned over roughage on the conveyor and are mixed by beaters, cylinders, augers or paddles, which are located either before or above the cross conveyor. Auger, belt or chain and slat conveyors collect material from the mixing device and discharge it into the feed bunk. The discharge point of the cross conveyor is important in choosing a bunk-feeder wagon to suit a particular type of feed bunk. Consider the unloading conveyor location, discharge height and discharge distance from the side of the wagon.

Many wagons are now equipped with electronic weigh scales to facilitate ration preparation. These wagons are often used to deliver silage and ground grain to cattle in pens. The silage can be loaded from a vertical or horizontal silo and the grain can be loaded either by gravity from overhead bins or by conveyor. Wagons are available with capacities of 2.8-28 m^3.

On some farms, forage wagons are used as bunk-feeders. They reduce investment capital because they are already available, but they have limited mixing capability. Portable grinder-mixers are also capable of unloading into feed bunks.

Automatic Bunk-Feeders

Automatic bunk-feed systems move feed in a continuous flow from the silo or storage bin of a feed mill to the livestock at the feed bunk. Two basic automatic bunk-feeders are the auger and chain or belt types. Auger-type

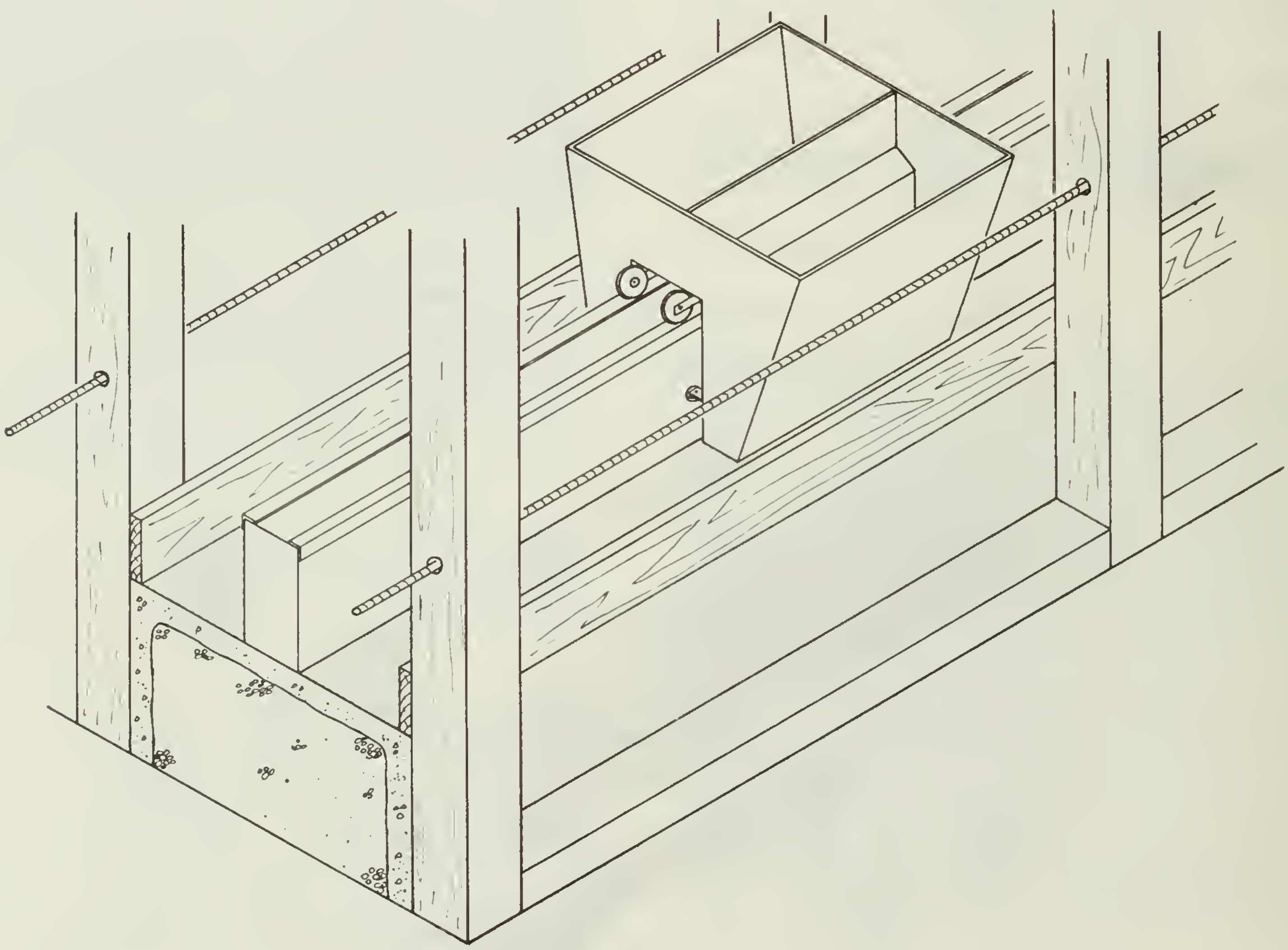


Figure 40 Feed carrier.

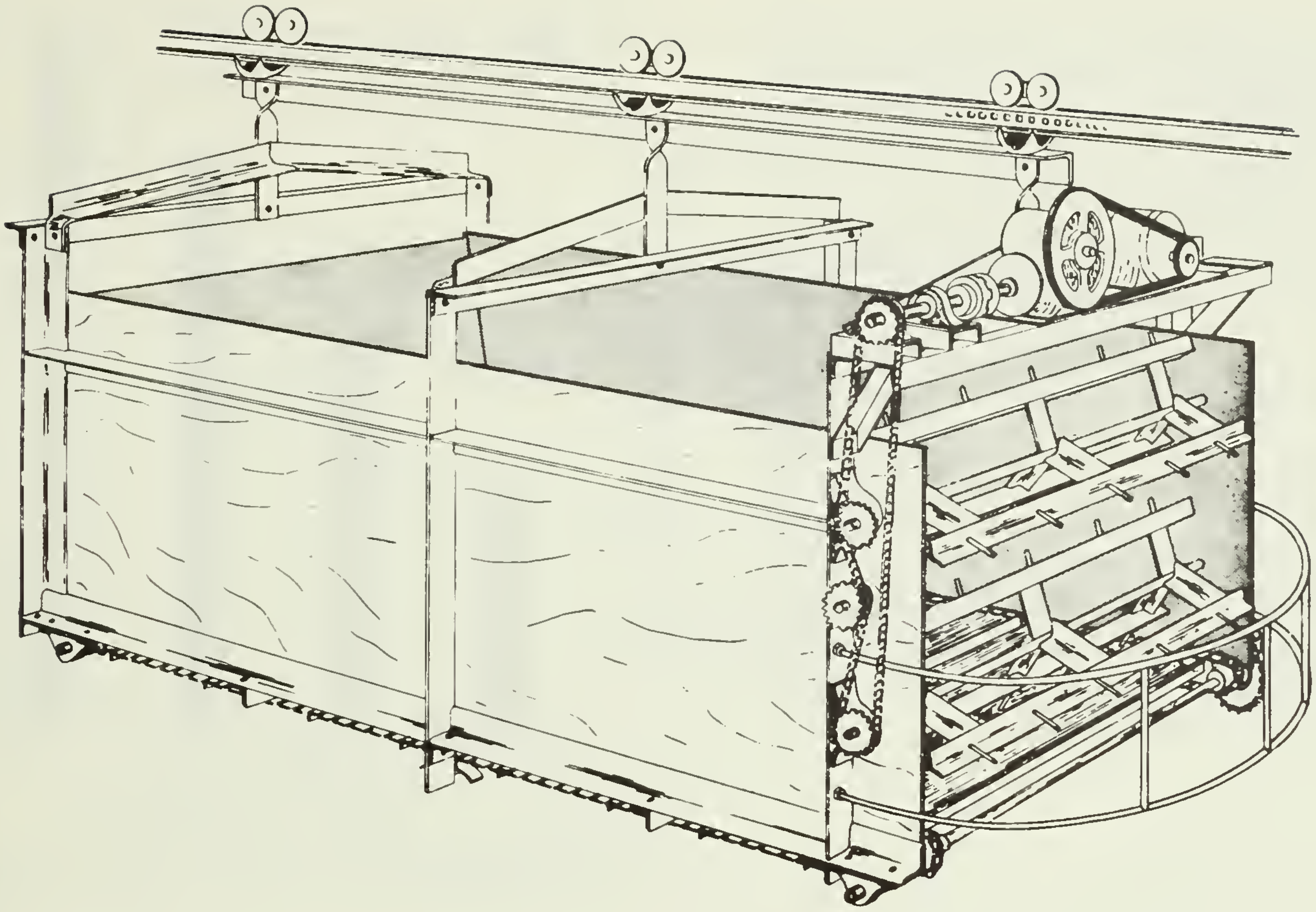


Figure 41 Feed carrier.

Figure 42 Truck-mounted bunk-feeder wagon.

bunk-feeders are simple, having only one moving part in the bunk, and do not tend to freeze during winter; but they have two main disadvantages — high power requirements and a tendency to separate coarse materials from fine and heavy particles from light ones. Chain or belt feeders have larger capacities than the auger type, can distribute feed faster, and can be used in longer feed bunks and to feed different rations to different lots of cattle. However, chain and slat conveyors tend to ride over granular feed materials, causing operating problems.

Most auger-type bunk-feeders operate at a fixed speed between 100 and 225 r/min. Table 18 shows and describes various types of auger bunk-feeders. Auger diameter, length and speed, kind of material handled (silage, roughage or grain), length and moisture content of material handled, all combine to determine the actual power requirements. Auger-type bunk-feeders need from four to five times more power for the same length of bunk as chain or belt feeders (Figure 43). With single-phase power, bunk length must be limited to about 45 m when an auger is used. Table 19 provides information on chain or belt bunk-feeders.

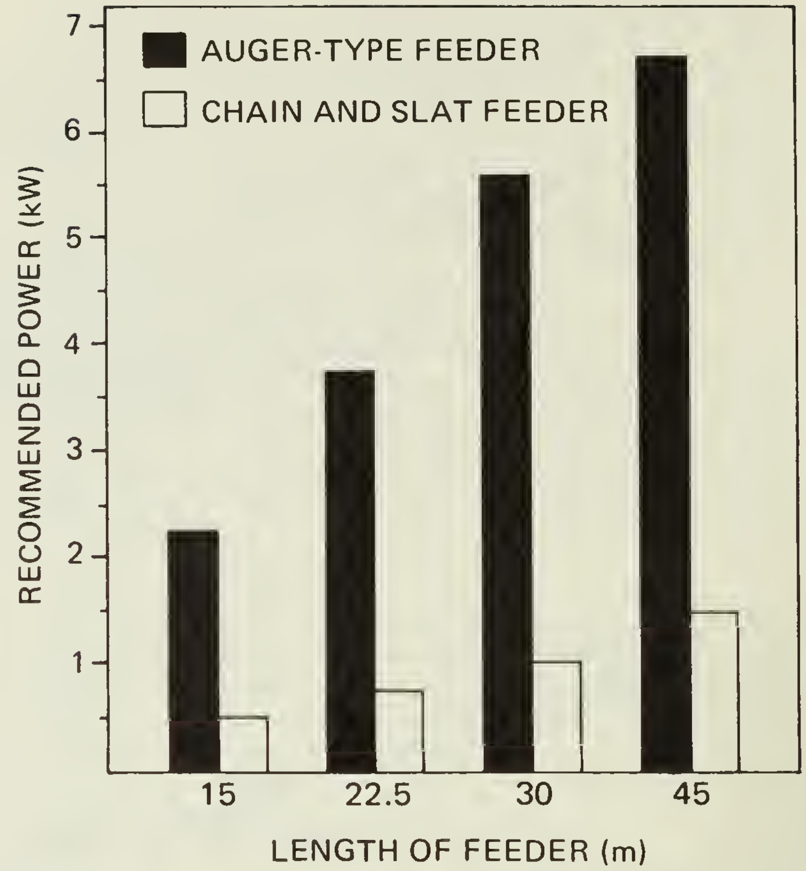
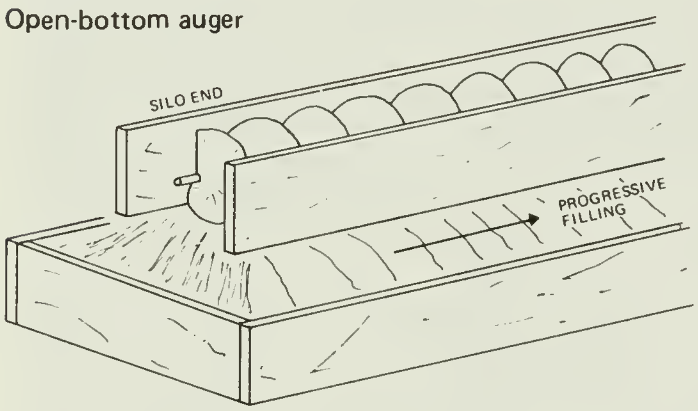
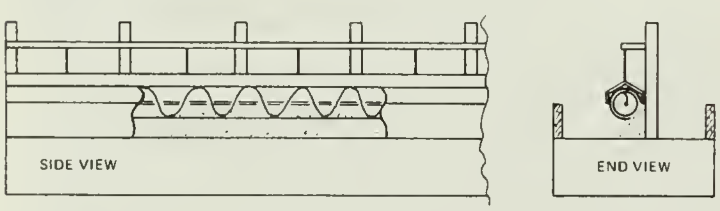
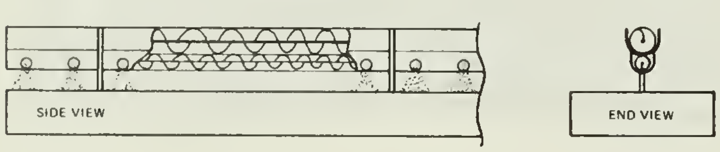


Figure 43 Power comparison for auger and chain bunk feeders.

TABLE 18 — VARIETIES OF AUGER-TYPE BUNK FEEDERS

Type of auger feeder	Comments	Approx kW for 30 m of bunk	No. pens normally serviced
Open-bottom auger 	Delivers more feed to first part of bunk than to last, unless vertical distance between bunk floor increases towards far end of bunk. Feed separation occurs along feed bunk when sillage and grain are fed together.	3.7-5.6	1
Cradle feeder 	Works much like an open-bottom auger unit, but uses less power. Amount of feed dropped each feeding can be regulated by adjusting height of the partly enclosed tube.	1.5-2.2	1
Auger-fill, auger-dump feeder 	Top auger fills a series of secondary hoppers. When far end of hopper unit is full, a switch starts lower auger, which discharges ration through fixed ports.	2.2-3.7	2+

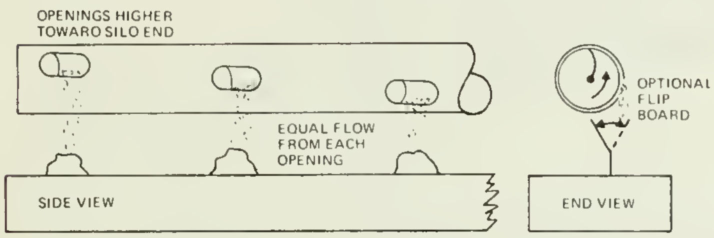
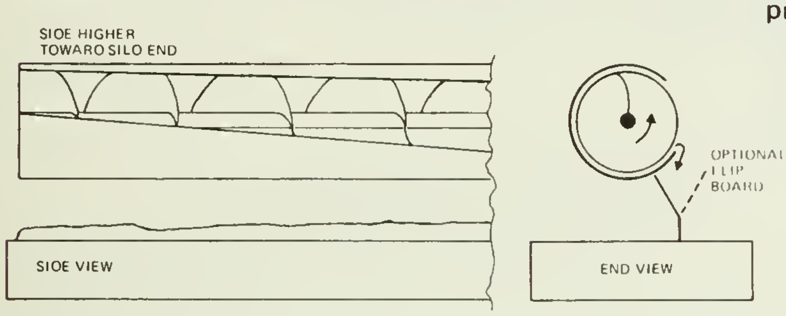
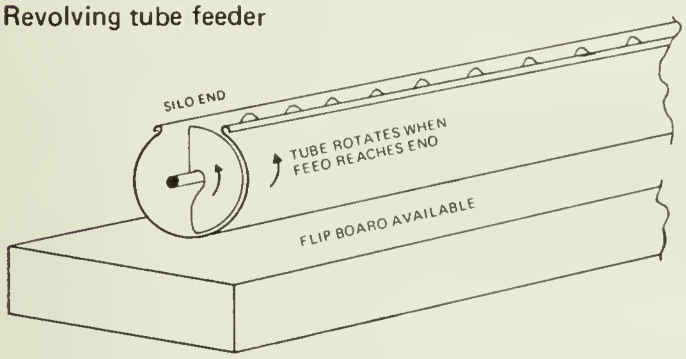
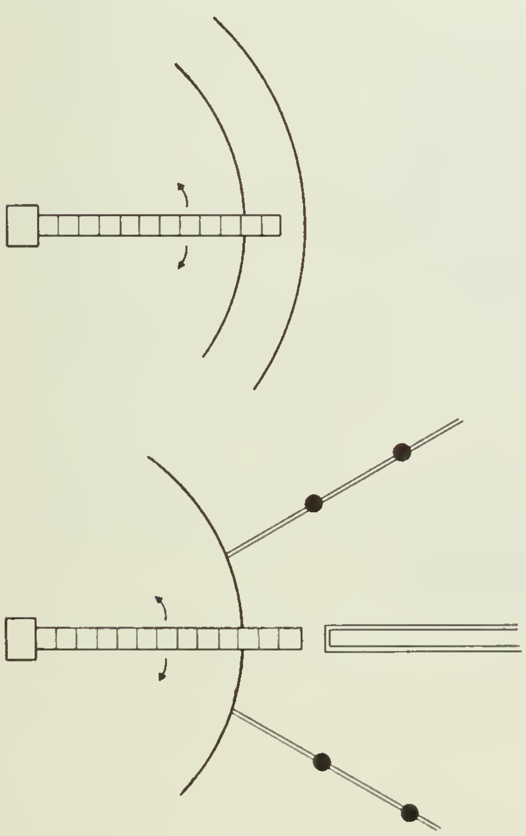
Type of auger feeder	Comments	Approx kW for 30 m of bunk	No. pens normally serviced
Perforated-tube proportional drop feeder 	When feed reaches its far end, unit fills entire length of bunk at once. Rotating so holes are on bottom and all material is removed from auger, this feeder causes considerable separation between coarse and fine particles.	2.2-3.7	2+
Tapered-side proportional drop feeder 	Operate as above, but separation is not a problem.	1.1-2.2	2
Revolving tube feeder 	When filled, trips a switch, dumps and returns to upright position for another cycle. Procedure is repeated until desired amount of feed is placed over full length of bunk.	2.2-3.7	2
Swinging overhead feeder 	Serves as a bunk feeder by traveling back and forth over a circular bunk. A chain-type conveyor can be used instead of the auger, lowering power requirements. Strong winds can be a problem with dry feeds, as all feed must drop several feet into the bunk. Another alternative shown is a swinging conveyor filling bunk feeders in several pens.	1.1-2.2	2+

TABLE 19 — VARIETIES OF CHAIN AND BELT BUNK FEEDERS

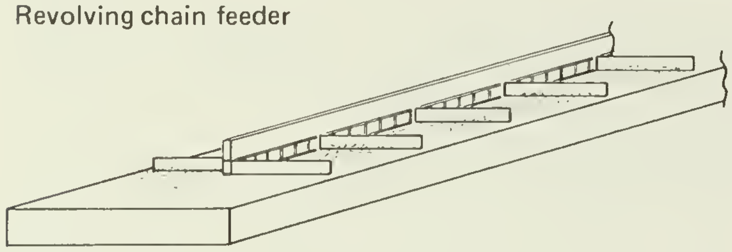
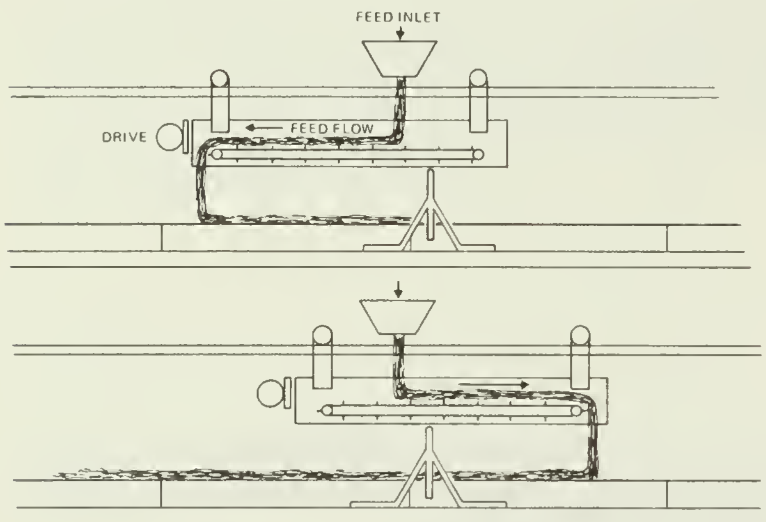
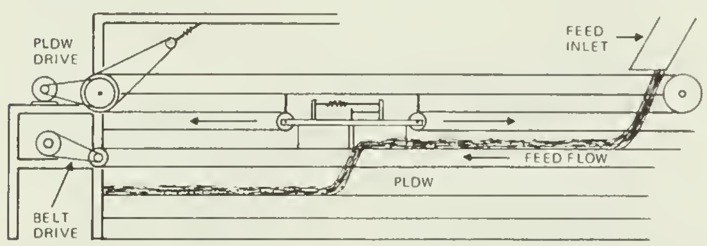
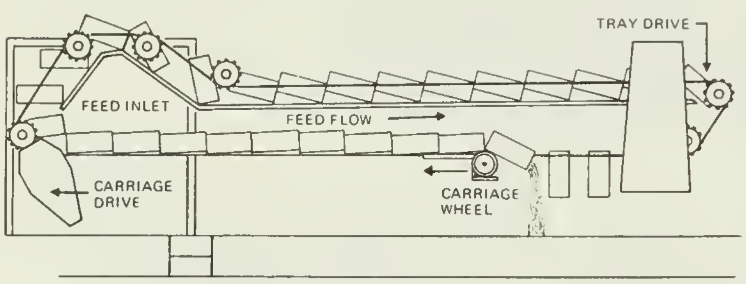
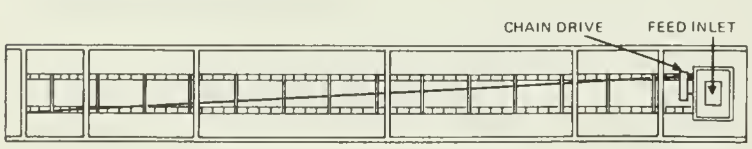
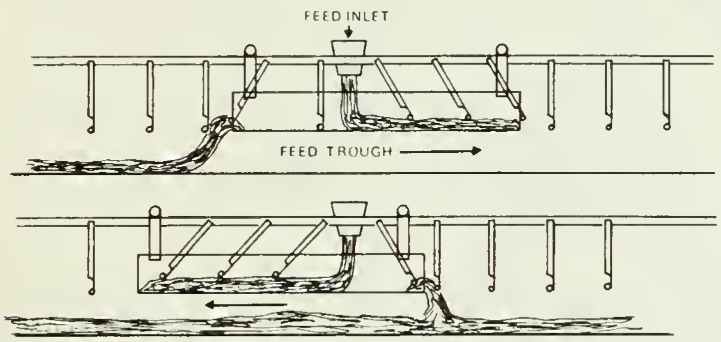
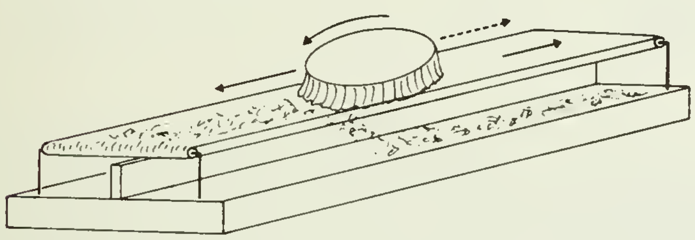
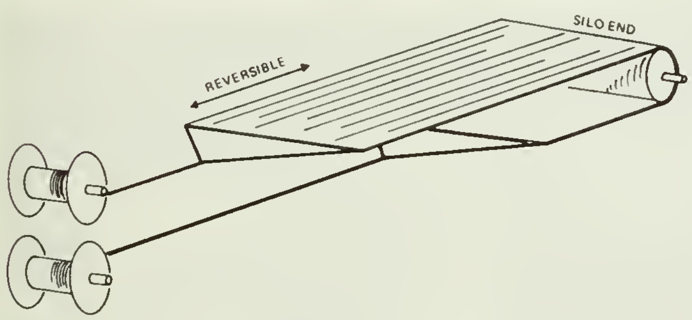
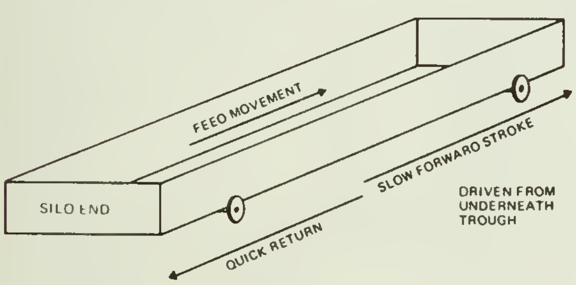
Type of feeder	Comments	Approx kW for 30 m of bunk	No. pens normally serviced
Revolving chain feeder 	Similar to a barn cleaner. Often filled from one end with a front-end loader. Can be used in circular bunks at base of silo or in rectangular bunks. Requires more power than most chain of belt bunk feeders.	1.1-2.2	2+
Reciprocating feeder 	Feeder is half the bunk length. Feed inlet is at the bunk's center. Conveyor travels about 15 m/min and frequently reverses direction to provide any desired amount of feed over entire bunk. For best performance, requires frequent oiling and adjustment of the chain.	0.6-0.75	2
Plow-type belt feeder 	An endless belt with a blade or plow that automatically reciprocates between ends of bunk. Belt travels at about 75 m/min and loaded side is always under tension. Plow travels at about 1/3 the belt speed.	0.75-1.1	2+
Tray-type feeder 	Designed so that exactly the same feed placed in each tray can be dropped in selected portions of the bunk. As trays are filled and move away, carriage wheel rides to a predetermined point with the full lead tray. When desired, the drive pulls the carriage wheel back, dumping each tray successively. Magnetic switches, placed at preselected points along the feeder supports, allow automatic filling of several sections with different rations.	1.1	2+
Taper-bed chain feeder 	Feed moves over a tapered board and is dropped off over the entire feed bunk length on a proportionate basis. With dry feed, wind may be a problem.	1.1	1

TABLE 19 – Continued

Type of feeder	Comments	Approx kW for 30 m of bunk	No. pens normally serviced
Baffle-type sweep feeder  	Similar to tray feeder, but has fewer mechanical parts and less flexibility.	0.7-1.1	2+
Belt feeder with brush 	Works like a plow-type belt feeder, but belt travels slightly faster. Feed is discharged by a rotating brush powered by an instantly reversing electric motor.	1.1-1.5	2+
Reversible belt feeder  	Belt, pulled by cables at the desired speed, is filled as it moves away from feed source. Cattle feed directly from the belt. On next feeding, drive is reversed and uneaten feed is dumped off the belt before refilling.	0.75	1
Shaker trough feeder  	Large metal trough oscillates, moving feed to far end of bunk on forward stroke. Trough is filled progressively and cattle eat from it. Fairly costly, as bunk plus drive and suspension mechanism must be purchased.	2.2	2

Self-Feeders

Self-feeding is popular for feeding beef cattle on full feed, swine in confinement, and poultry. In beef cattle feedlots, self-feeders can be filled with a system of horizontal augers, self-unloading wagons or portable, inclined augers. In hog and poultry barns, self-feeders can be filled by hand, by overhead auger (Figure 44) or by spool-and-chain conveyors.

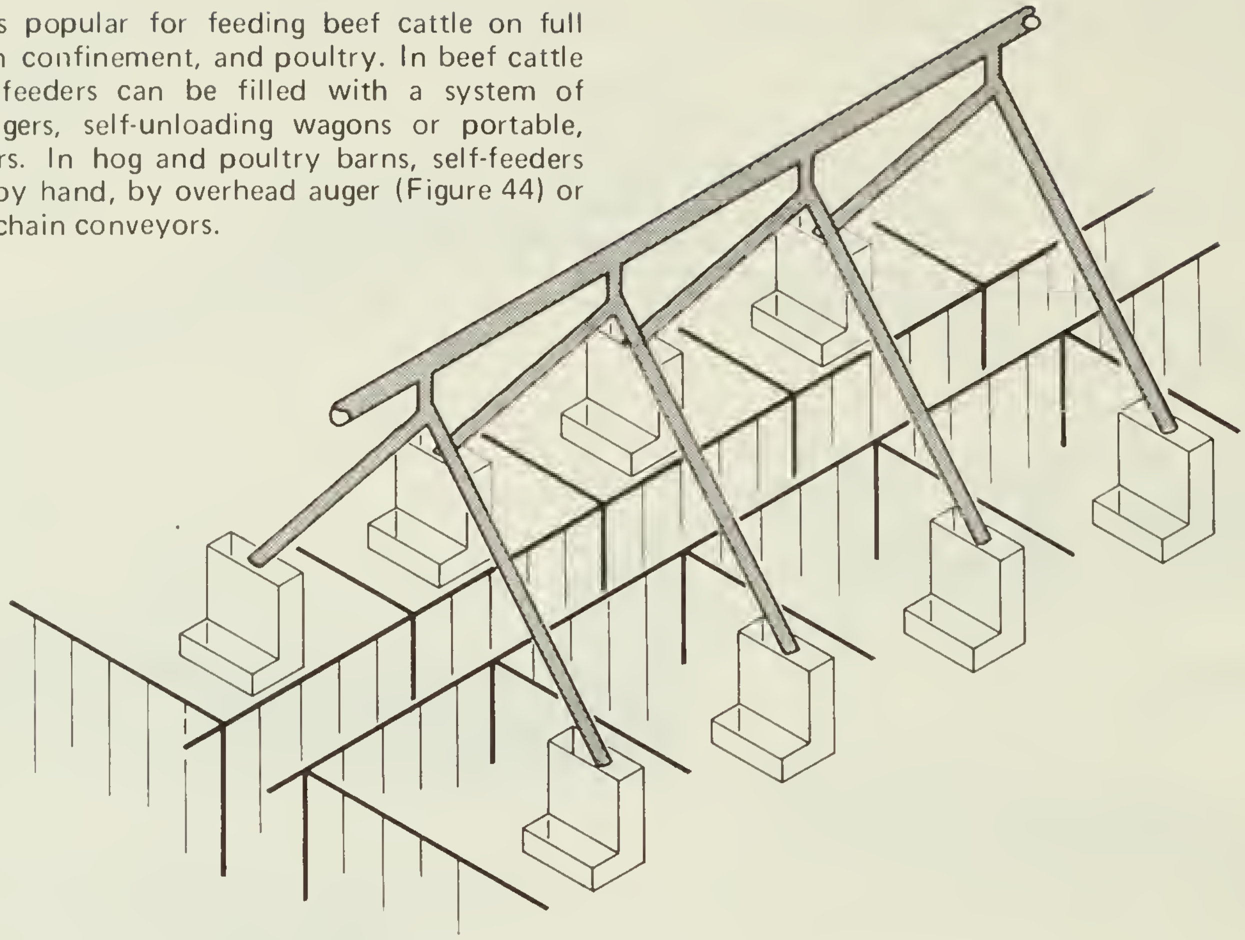


Figure 44 Overhead auger filling self-feeders in a hog barn.

Controls can be arranged for manual start and automatic stop. Use of self-feeders reduces the feeding space required per animal as feed is available at all times.

Limit-Feeding of Hogs and Poultry

Limit-feeding means feeding livestock only what they will eat at one feeding. A limit-feeding system comprises a series of feed drops or boxes above pens or feeders. A predetermined amount of feed is augered to the feed drops. At preset intervals, the feed drops are triggered and the feed falls down to the floor of the pens for hogs or into feeders for poultry (Figure 45). Limit-feeding systems require automatic equipment.

Figure 45 Limit-feeding pan for poultry.

Trough Feeders for Poultry

Poultry housed in cages are often fed from a trough in front of the cage, eating directly from the conveying device in the trough, which may be either an endless belt, chain or auger. These conveyors run at very slow speeds.

Liquid Feeding of Swine

Some hog producers use a liquid system for swine feeding (Figure 46). Feed used in a liquified system must be ground finer than dry feed. Before distribution, ground feed must be mixed with water and pumped through pipes to the feed troughs. Some of the advantages of liquid feed systems are less dust than with

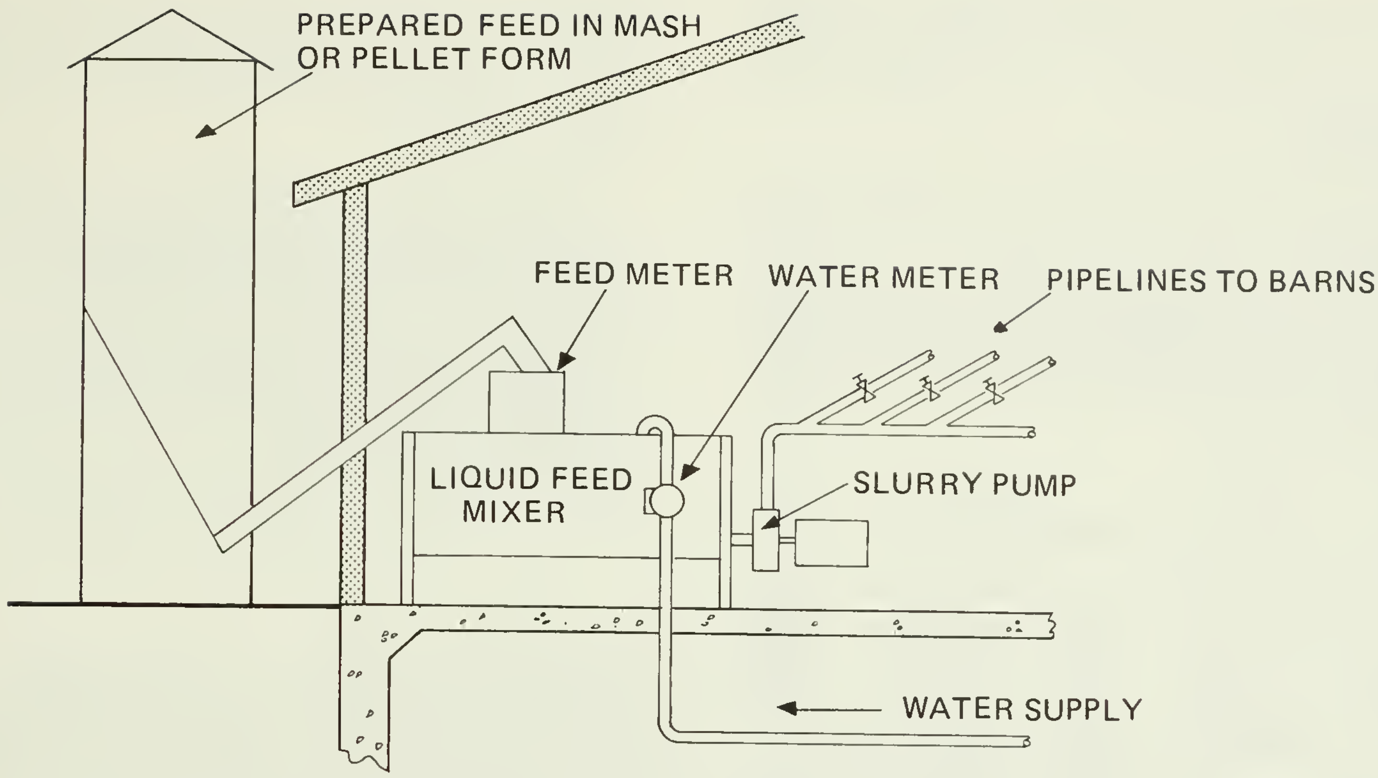


Figure 46 System for liquid feeding of hogs.

dry feeding systems, the feed trough can be used as a pen divider, there is a feeding station for each pig, and administration of antibiotics is simplified. Disadvantages include more equipment required, the system must be flushed with water at least once a day, the finer ground feed required takes more power and reduces mill capacity, and mineral supplement must be ground fine.

ELECTRICITY FOR FEED PROCESSING AND HANDLING

Most feed processing and handling equipment uses electric motors for convenience, safety and reliability. Constant-speed, instant-start electric motors yielding no hazardous fumes are available in varying power outputs, from 0.37 kW motor on a 3 m pencil auger to a 75 kW motor on a feedlot hammer mill. With automatic controls, constant supervision is not necessary and the motor can be allowed to operate over a much longer period than would be practical with engines. Large, expensive equipment considered essential with engines is not always necessary with electric power. Electric motors are limited by the availability of an adequate power supply and the loss of portability.

TYPES OF ELECTRIC SERVICE

Single-Phase Power

Most farms in Canada are served with 120/240 volt, 60 cycle, single-phase electric power. The capacity of this single-phase power supply depends on your transformer size, the primary conductor size and the distance from the power transmission lines. This capacity, or the size of electric motor connected to this single-phase line, is limited because of the voltage flicker to other power customers on the same line when the motor is started.

Follow these guidelines to the size of electric motors that can be installed on single-phase power systems:

- Any number of motors of fractional power can be connected;
- Several single-phase motors, up to 5.6 kW, provided the motors are not started simultaneously;
- Soft-start, single-phase motors up to 2.2 kW; and
- Phase convertors on three-phase motors up to 22 kW

Consult your local electrical utility representative if larger motors are considered.

Three-Phase Power

Three-phase power is available to farms that require a larger-capacity service. When several motors in the 5.6 kW size or larger are required, ask your local electrical utility representative about the availability and cost of a three-phase power supply The advantages of three-phase power include: more dependability and less maintenance than single-phase power, because of a simple motor design; large three-phase motors are considerably cheaper than single-phase motors; and the ability to run larger motors of 22, 37 and 75 kW. You need an overall plan for your electrical requirements, to avoid expensive rewiring and motor changeover.

ELECTRIC MOTORS

Electric motors come in various types, sizes and enclosures. The proper combination of type, size and enclosure is required to prevent unnecessary maintenance and premature failure.

Motor Selection

Most equipment in feed processing and handling may be operated unattended and may have to start under load. Therefore, select continuous-duty, totally enclosed, fan-cooled, capacity-start-type motors. Table 20 illustrates the most common types of motors for feed processing and handling, along with their characteristics and typical uses.

Enclosures

There are numerous motor enclosures, but these three are the most common:

- Open, drip-proof (Figure 47) – a general-purpose enclosure to be used in dry locations relatively free from splashing liquids and dust particles (for example, water pump or air compressor).
- Splash-proof (Figure 48) for use in relatively dust-free locations where splashing liquid may be directed onto the motor (for example, bulk milk tank or irrigation pump).

TABLE 20 – MOTOR CHARACTERISTICS

Motor type	kW range	Speed, r/min	Starting current	Starting torque	Characteristics	Typical uses
Capacitor start induction run	0.12-7.5	900 1200 1800 3600	Medium 3-6 times running current	High 350-400% running torque	Long service, low maintenance, versatile, most popular farm motor	Agitators, air compressors, augers, blowers, grinders, liquid manure pumps, milking machines, milk coolers, ventilating fans, water systems, silo unloaders, gutter cleaners, conveyors
Soft start single-phase	11-37	1800 3600	Low 2 times running current	Low 50% running torque	Available to handle larger power loads on single-phase power supply, requires an almost no-load start	Crop dryers, forage blowers, irrigation pumps, manure agitators, saws, hammer mills, roller mills
Three-phase squirrel cage	0.37-300 or more	450 900 1200 1800 3600	Low-medium 3-4 times running current	Medium 200-300% running torque	Very simple construction, dependable, service-free	Conveyors, dryers, elevators, hoists, lathes, manure pumps, mixers, irrigation pumps

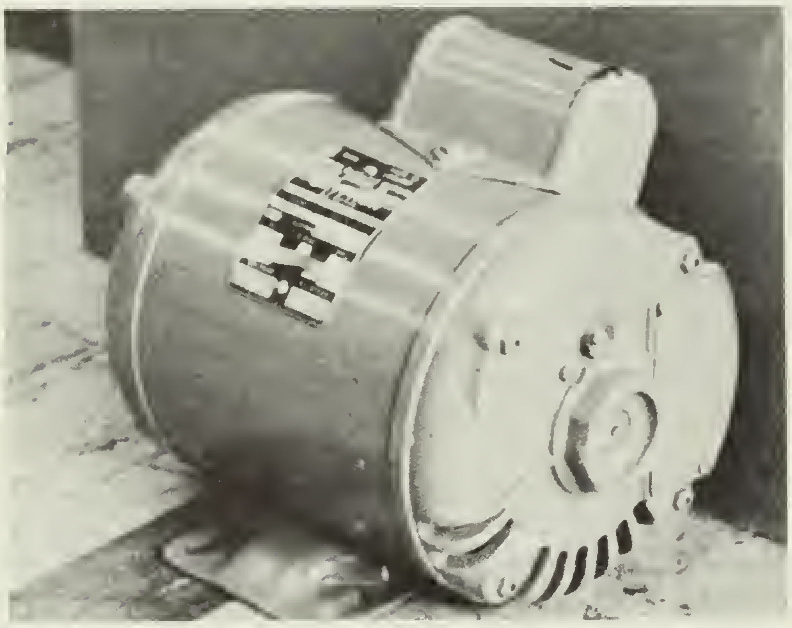


Figure 47 Open drip-proof motor.

Figure 48 Splash-proof motor.

- Totally enclosed, fan-cooled (TEFC) (Figure 49) – for use in dusty locations, indoors or out (for example, auger, elevator, roller mill or hammer mill).

Bearings

Make sure that motors for feed processing are equipped with ball bearings, either permanently lubricated of with special lubrication fittings. Motors requiring lubrication can be damaged as seriously from overlubrication as from underlubrication; follow manufacturers' instructions. Motors with sleeve bearings require oiling oftener than others and are not usually used in feed processing. They usually must be mounted in a horizontal position because they have no thrust bearings.

Size

Electric motors must be sized to operate the equipment satisfactorily. A 1 kW gasoline engine can be replaced by a 0.75 kW motor. A 2.25 kW motor should be adequate to replace a 3.75 kW engine. Table 21 indicates sizes of electric motors that can replace engines and lists electric motor sizes required for given load power requirements.

PHASE CONVERTORS

Phase convertors allow three-phase motors to be operated from a single-phase power supply and permit large motors on single-phase lines. Commercial phase convertors, both static and rotary, are available.

The static phase convertor includes a capacitor bank or an autotransformer to provide a partial three-phase output. Usually, one convertor is required for each motor, which must have wye-connected motor windings. The efficiency of these units varies from 70 to 90% ; that is, a 10 kW, three-phase motor operating with a phase convertor delivers only 7 kW. Static convertors however, are usually cheaper than a rotary convertor for one or two motor installations.

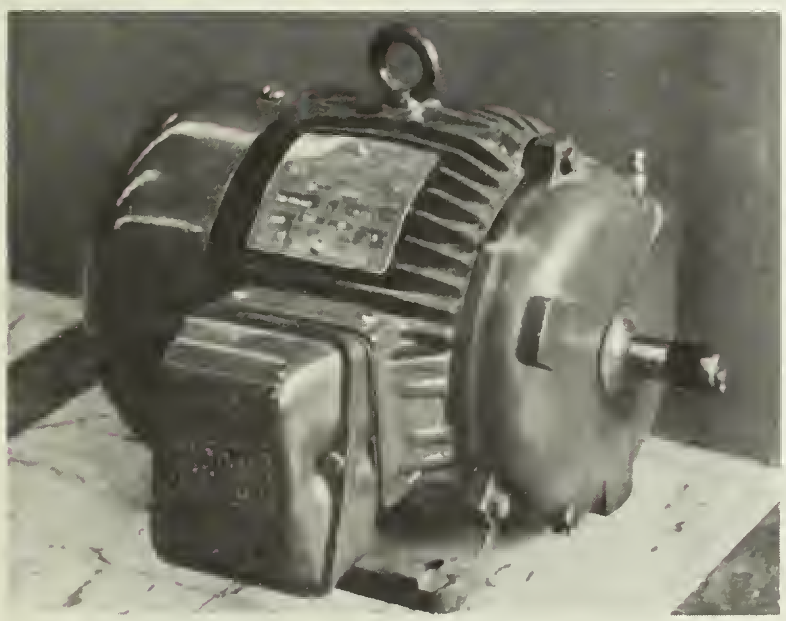


Figure 49 Totally enclosed fan-cooled motor.

TABLE 21 – SELECTING MOTOR AND ENGINE FOR VARIOUS LOADS

	kW rating required	
Load, kW	Electric	Internal combustion engine
7.5	7.5	10 – 11
10	10	13 – 15
15	15	20 – 23
20	20	27 – 30
30	30	40 – 45
40	40	53 – 60
50	50	65 – 75
60	60	80 – 90
75	75	100 – 113
100	100	133 – 150

Rotary phase convertors are more versatile. One rotary phase convertor can operate more than one motor at one time. With multimotor installations, a number of motors having a total rating up to three times the convertor rating may be used, providing no single motor is rated higher than the convertor. Three-phase motors, either wye or delta connected, can be used with no special wiring. These units are 90-95% efficient.

MOTOR PROTECTION

A motor circuit should consist of five components: (1) short-circuit protection of motor and branch circuit; (2) overload protection of motor; (3) means of disconnecting motor from power supply; (4) motor controller; and (5) motor.

Figure 50 shows a line sketch of devices used in motor protection. Often, these devices are mounted in the same enclosures and sold as a unit. Table 22 indicates the full load current, minimum conductor sizes, maximum overload and overcurrent protection for single-phase motors.

Short-Circuit Protection

This is usually provided by using a fuse rated 300% or a circuit breaker rated 250% of full-load nameplate reading.

Overload Protection

This is provided in two ways: (1) manual or automatic-reset thermal overload protection as an integral part of the motor (most motors of 0.75 kW or less have this type of protection); and (2) motor starting switch is comprised of a switch with a heater element. When the switch is closed, the circuit is completed to the motor. A heater element is in series with the switch. The element is located near a bimetallic strip or soldered switch control which, when overheated by excessive current flow, will open the circuit to the motor. Various-

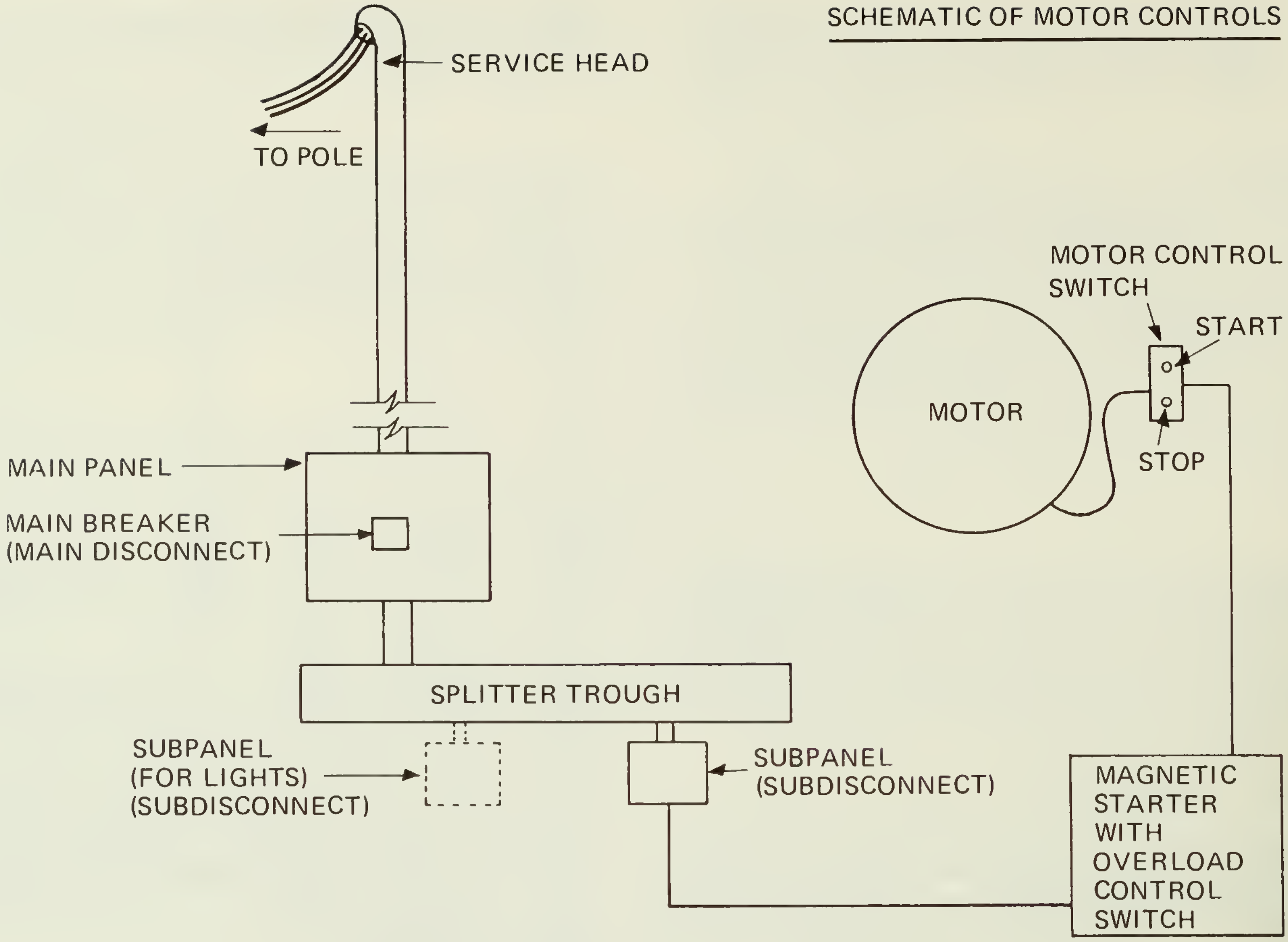


Figure 50 Recommended motor protection for large motor.

TABLE 22 – RECOMMENDED MOTOR PROTECTION SPECIFICATIONS

Motor kW	Full load current, A		Minimum copper conductor size A.W.G. #	Maximum overcurrent protection, A		Maximum overload protection, A
	120 V	240 V		Fuse	Breaker	
0.19	5.8		14	20	15	7.50
0.19		2.9	14	15	15	3.75
0.25	7.2		14	25	20	10.00
0.25		3.6	14	15	15	5.00
0.37	9.8		14	30	20	12.50
0.37		4.9	14	15	15	6.25
0.56	13.8		12	45	30	17.50
0.56		6.9	14	25	15	8.75
0.75		8	14	25	20	10.00
1.1		10	14	30	30	12.50
1.5		12	14	40	30	15.00
2.2		17	10	60	40	21.25
3.7		28	8	90	70	35.00
5.6		40	6	125	100	50.00

sized heaters are available and should be rated 1.15 to 1.25 times the full-load current of the motor.

Magnetic Starter

The magnetic motor starter is the best type of switch to be used with 0.75 kW motors and larger. It is comprised of an electric solenoid, which when energized by a start-stop switch or other motor controller (located either remotely or in the starter), closes heavy-duty contacts to transmit power to the motor. The electric solenoid requires only a low current flow. The wiring to the start-stop switch, therefore, can be much lighter and makes this unit very adaptable to remote control from one or more locations. An overcurrent heater controlling a bimetallic switch is in series with the current flow to the motor and will open the circuit to the solenoid, hereby cutting off power to the motor if overload occurs. Heaters should be rated 1.15 to 1.25 times the full-load current of the motor.

Disconnecting Motor from Power Supply

Motors under 0.4 kW may be disconnected by a plug cap on the end of the supply cord. For larger motors, check on local requirements for disconnect systems.

Motor Controller

A motor controller is any device used to control the motor. It may be a plug cap and receptacle or a motor starting switch. Also, when used in conjunction with a magnetic starter, it can be a pressure switch, float switch, time switch or start-stop switch.

WIRING REQUIREMENTS

All wiring requirements must be installed in accordance with the Canadian Electrical Code. Many provincial inspection authorities have supplements to the Canadian Code. Before wiring, contact appropriate inspection authorities for information. Small motors may be wired for 120-volt or 240-volt circuits; larger motors should be supplied by 240-volt power for best service. All motors must be grounded in accordance with the Canadian Electrical Code. Proper grounding minimizes risk of electrical accidents by equipment malfunction and drains off any stray currents.

Adequately sized wiring should allow not more than 2% voltage drop in conducting power from the distribution center to the electrical device. Inadequate wiring can easily cause faulty operation and high risk. Figure 51 gives wire sizes for farm motors.

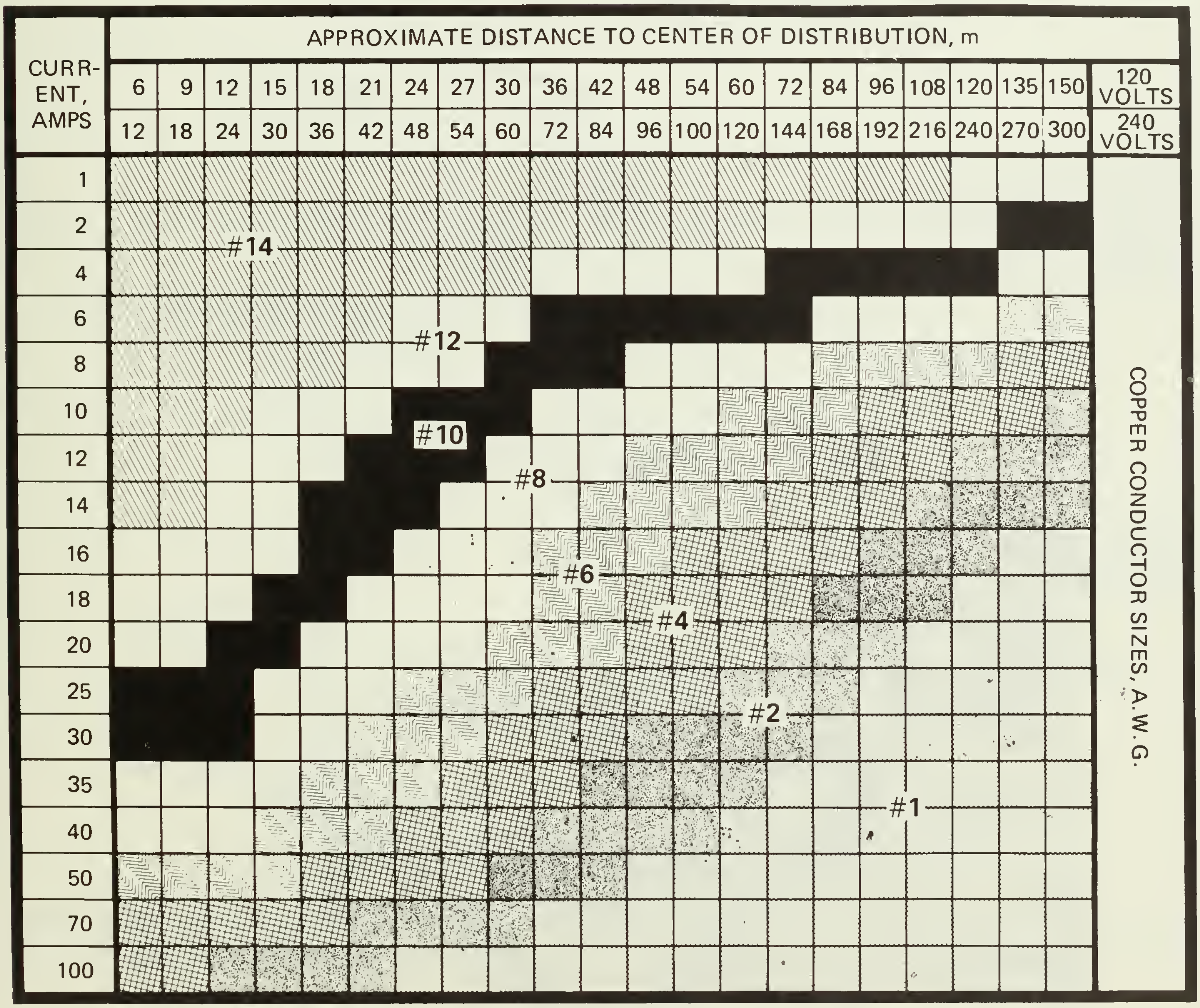


Figure 51 Recommended wire size for load current and distance (2% voltage drop).

Have electrical wiring installed by a qualified electrical contractor and inspected by a local authority. If this procedure is not followed, insurance claims may not be honored.

Locate all motor control switches near the operating equipment for safety protection in case of equipment malfunction or breakdown.

CONTROLS

Pressure Switches

Pressure switches are practical automatic start or stop devices for controlling feed processing and handling equipment. They are used, for example:

- To start and stop a supply auger in a surge bin;
- To indicate, by turning on lights, level of material in storage bin; or to shut down feed mill and supply augers; and
- To stop supply auger when required quantity of material has been conveyed.

A pressure switch consists of a rubber diaphragm that activates a microswitch (Figures 52 and 53). The microswitch usually handles only the current required to energize a magnetic contractor. Sometimes a microswitch handles the full-load current of a motor, but this reduces switch life and is not recommended.

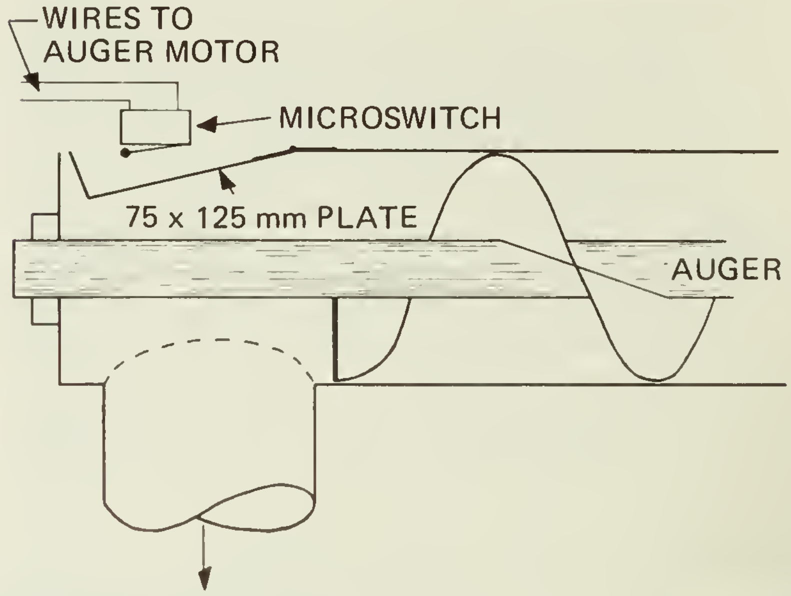


Figure 52 Microswitch to shut off auger motor for self-feeder.

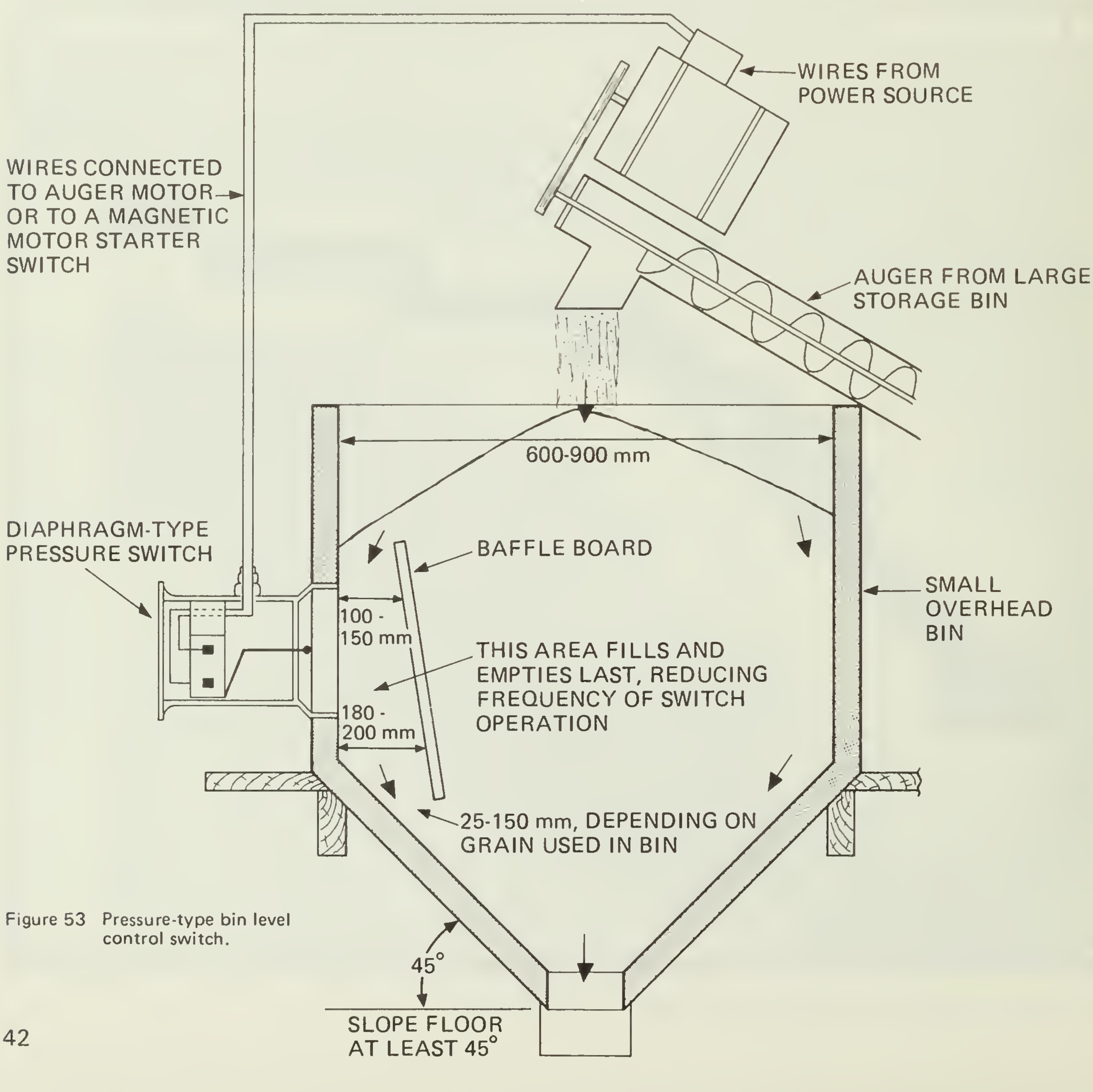


Figure 53 Pressure-type bin level control switch.

Mercury Switches

These are used much the same as pressure switches. A mercury switch (Figure 54) is made of a small glass tube partly filled with mercury and with two electrical contacts located in one end. As the tube is tipped on end, the mercury shifts, either opening or closing the circuit.

Time Switches

These are used to operate electrical equipment at specified times. A clock mechanism opens or closes a switch at a predetermined time.

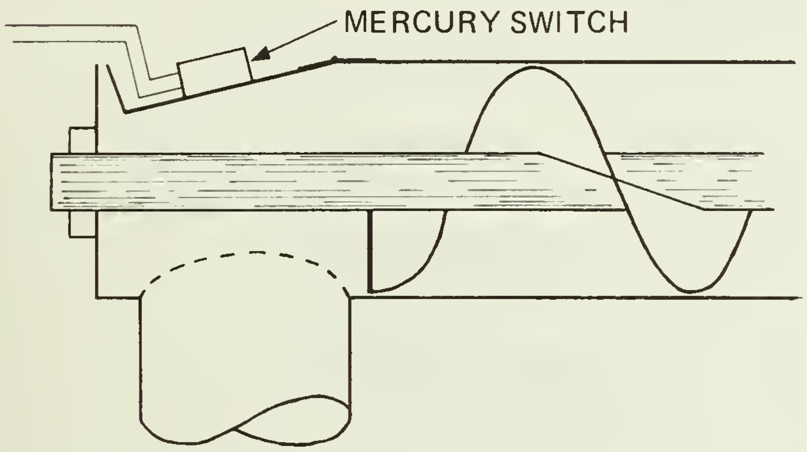


Figure 54 Mercury switch to shut off auger motor.

Time-Delay Devices

These are required in feed processing systems to start and stop augers and mills in proper sequence. For example, the starting of the supply auger to a roller mill must be delayed as the mill cannot be started under load. Time-delay relays, solid-state transistorized relays or time-delay magnetic motor starting switches can be used.

FEED PROCESSING CONTROL PANELS

Dustproof control panels housing breakers, thermal overload devices, time-delay devices, start-stop switches and system indicator lights are available from various manufacturers in Canada. These panels should be CSA approved and completely interlocked. They are available with automatic start-up and shut-down sequences as required for most feed processing systems.

It is usually more economical to purchase a complete control panel than to buy components.

Figures 55, 56 and 57 are examples of some alternative feed processing systems.

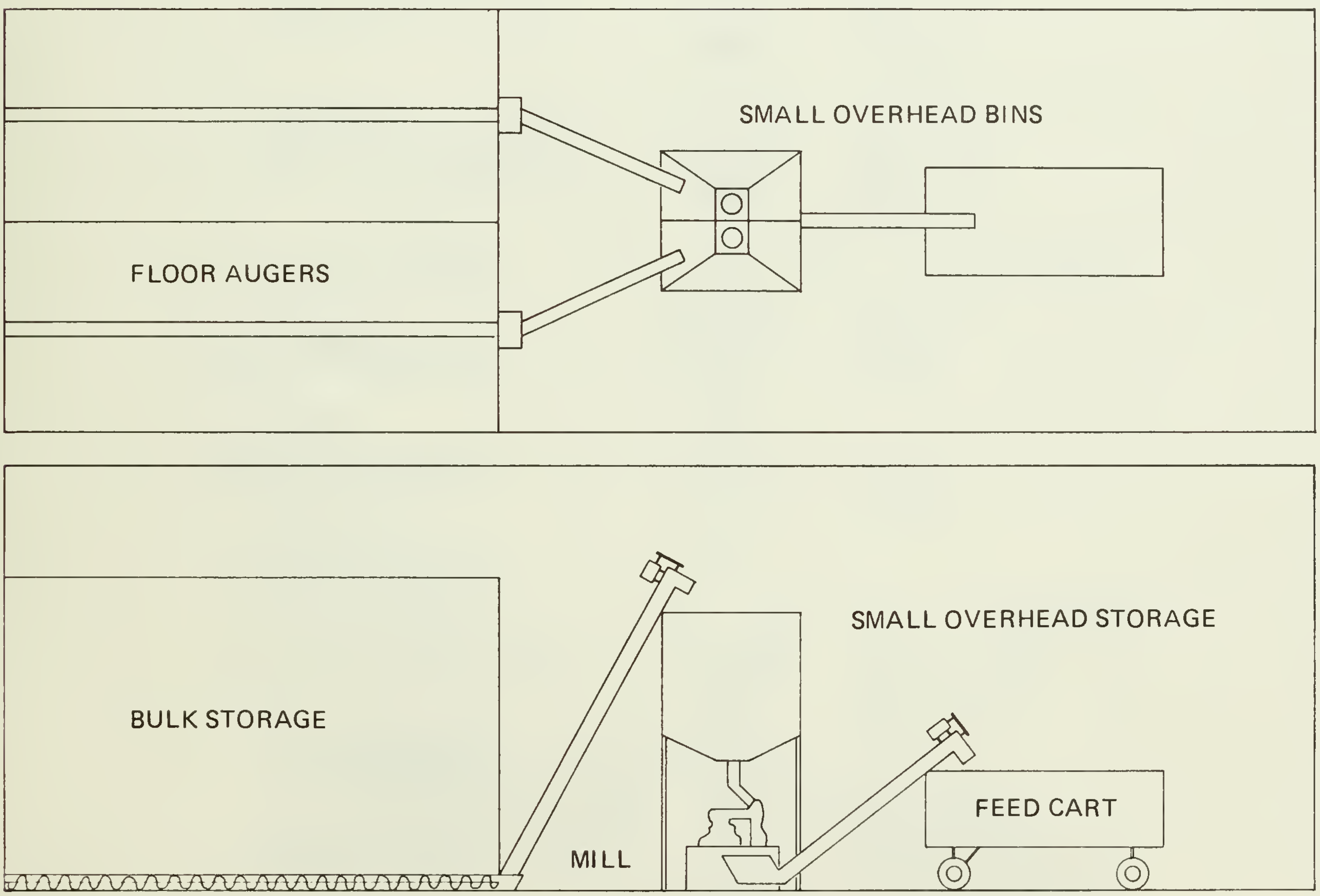


Figure 55 A simple feed processing center.

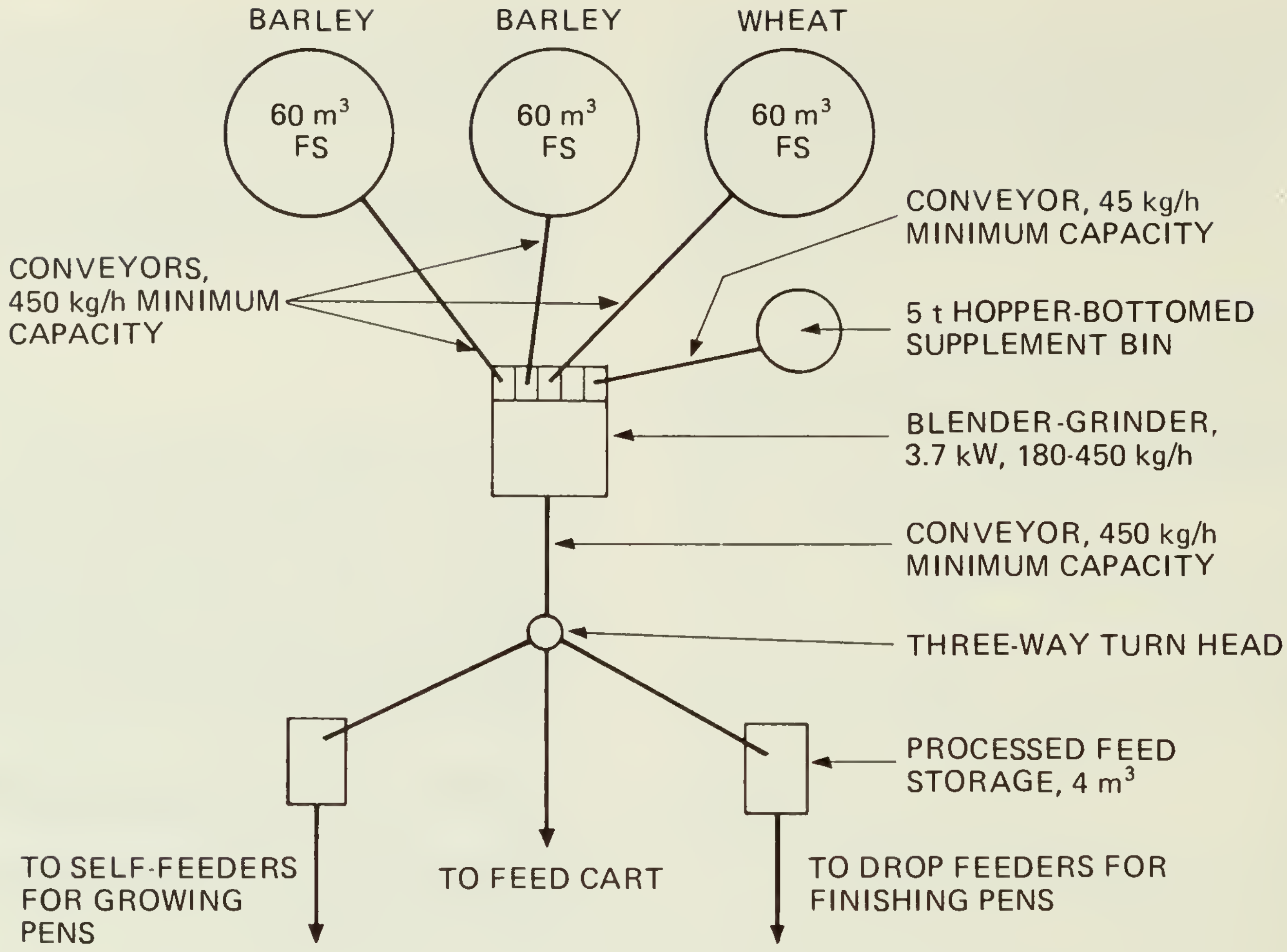


Figure 56 Flow diagram for a blender-grinder system.

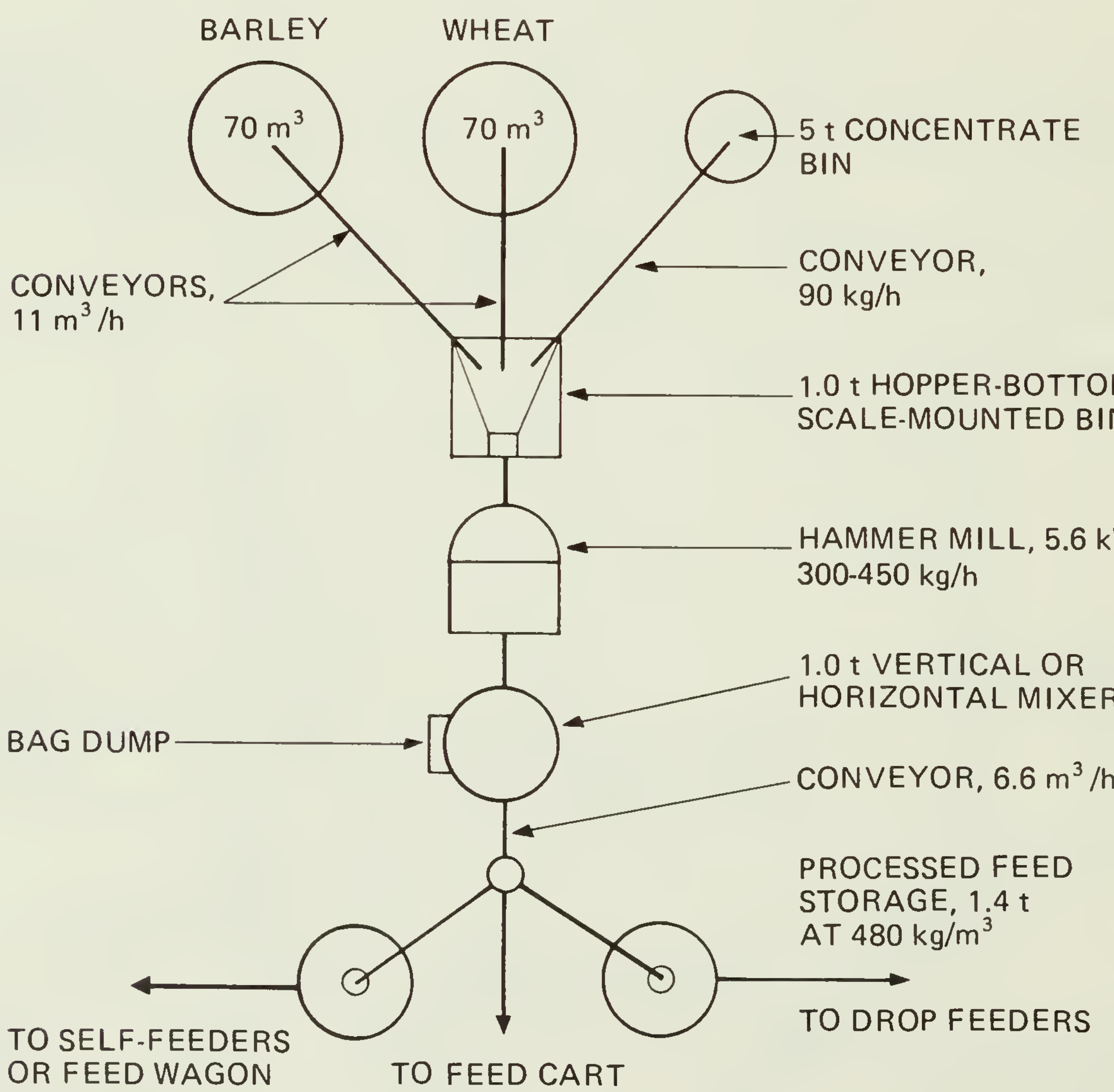


Figure 57 Flow diagram for a gravimetric batch system.

ACKNOWLEDGMENT

The information in this publication is derived from many sources and we wish to thank all who contributed.

Photo credits: KMN Modern Farm Equipment, Inc., Westwood, N.J. (Figure 31); Sprout-Waldron & Company, Inc., Muncy, Penn. (Figure 37); W. Murray Clark, Ltd., Caledonia, Ont. (Figures 38 and 45); B.J.M. Mtg. Co., Inc., Dodge City, Kan. (Figure 42); and B. Kennedy (Figure 18), F. Stroppa (Figure 32) and J.J. Matthews (Figures 47-49) of the Saskatchewan Department of Agriculture.

CONVERSION FACTORS

Metric units	Approximate conversion factors	Results in:
LINEAR		
millimetre (mm)	x 0.04	inch
centimetre (cm)	x 0.39	inch
metre (m)	x 3.28	feet
kilometre (km)	x 0.62	mile
AREA		
square centimetre (cm^2)	x 0.15	square inch
square metre (m^2)	x 1.2	square yard
square kilometre (km^2)	x 0.39	square mile
hectare (ha)	x 2.5	acres
VOLUME		
cubic centimetre (cm^3)	x 0.06	cubic inch
cubic metre (m^3)	x 35.31	cubic feet
	x 1.31	cubic yard
CAPACITY		
litre (L)	x 0.035	cubic feet
hectolitre (hL)	x 22	gallons
	x 2.5	bushels
WEIGHT		
gram (g)	x 0.04	oz avdp
kilogram (kg)	x 2.2	lb avdp
tonne (t)	x 1.1	short ton
AGRICULTURAL		
litres per hectare (L/ha)	x 0.089	gallons per acre
	x 0.357	quarts per acre
	x 0.71	pints per acre
millilitres per hectare (mL/ha)	x 0.014	fl. oz per acre
tonnes per hectare (t/ha)	x 0.45	tons per acre
kilograms per hectare (kg/ha)	x 0.89	lb per acre
grams per hectare (g/ha)	x 0.014	oz avdp per acre
plants per hectare (plants/ha)	x 0.405	plants per acre