mechanical & automatic feeding systems for livestock farms

F. W. ANDREW
This circular will help the livestock farmer to plan an automatic or mechanical feeding system and show him how he can expect to use mechanized equipment that will profitably bring his feeding operation up to date. Mechanical feeding systems will vary from farm to farm and one may be as good as another. Each farmer will have to select the feeding system that best fits his particular needs. The general principles stated in this circular can be modified to suit any kind of farm layout or size, and any type of livestock operation.

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This circular was prepared by F. W. Andrew, Associate Professor of Agricultural Engineering.
MECHANICAL FEEDING SYSTEMS are becoming increasingly important in livestock farming. For a long time farmers have enjoyed the use of low-cost power and machinery in crop production, but until very recent years livestock feeding has been an unmechanized and inefficient operation. The present availability and convenience of electric power at low cost makes it possible for every farmer to eliminate shovel and basket feeding in favor of electrical and mechanical feeding systems. Such developments not only increase the individual farmer's output per man hour, but change his role from that of a manual laborer to that of a business manager.

A mechanical feeding system uses the energy of a machine to do work that was formerly done by human muscle power. An automatic feeding system supplies controls to machines so that they may function by themselves. A mechanical feeding system, to be ideal, should indeed be completely automatic, that is, it should be set up so as to enable feed and supplements to move from storages to feed bunk without any manual attention from the livestock operator. Such an ideal system — where grinders, blenders, conveyors, and distributors are perfectly coordinated so that no manual attention is necessary — is sometimes unattainable, but should always be considered the goal when planning mechanical systems.

Before good use can be made of electrical energy for increased efficiency of production, machines must be selected and facilities for their operation arranged. On many farms the facilities have been constructed and located without planning for convenience or efficiency. In some instances the facilities remain as first laid out for livestock production when the land was settled. It should be kept in mind when planning a system for livestock production that there must be a well organized and harmoniously synchronized arrangement of the elements of the system. This means of course not only the purely mechanical elements of the system, but every factor involved in livestock management. A farmer must know, for example, how large a feeding area his animals will need both under present and expected future conditions. He must give thought to arranging storage facilities, to maintaining proper drainage conditions, to ensuring safety, and numerous other details that crop up in the process of planning a completely mechanized system.

Every farm will have problems peculiar to itself. Before proceeding with plans, the farmer who has little experience with these problems should consult his county farm adviser, his electric power supplier, or his farm equipment dealer or distributor. They will have valuable suggestions to make, and will be able to direct him to other sources of help. They may be able to arrange visits to other farms with successful installations.

With these considerations in mind we are ready to discuss in some detail the mechanical feeding system. The five parts of the system are often said to be storages, blenders, grinders, conveyors, and distributors. Electric power and electric controls make these parts perform together effectively and under the best of conditions can give the farmer a wholly automated livestock feeding system.
STORAGE SYSTEM

Overhead Bins as Storage Units

Storages for the essential feed ingredients should be grouped together. Often this is impossible to accomplish when one is attempting to make good use of existing buildings and facilities. Many of the older storage arrangements can be conveniently integrated into the system although others may need to be abandoned. If storages are grouped together and close to the point of use, if a good driveway makes them easily accessible, and if there is adequate space for modern filling equipment, older facilities may certainly be used.

A good example of an existing storage set-up that might fit well into a mechanical or automatic system is the familiar double crib with an inside elevator (Fig. 1). In this case the elevator can be used for moving wet corn to storage for drying, for elevating dry grain to storage, or for filling overhead working bins with grains and supplements that are gravity fed to the blenders and grinders. One elevator does all the work, although gravity allows easy filling of numerous different storage units. Thus we have a well-planned processing center which is set up to move material from any location in the building to any other location.

Whenever possible it is wise to make use of existing overhead bins in your feeding system. Gravity flow, when available, is a very satisfactory method of supplying ingredients for feed processing (Fig. 2). Gravity of course is not free (since overhead construction is costly) and equipment now on the market makes ground level and flat-bottom storage more economical for newly planned systems. Nevertheless, overhead bins found in older farm structures may fit quite well and simply into a modern system. Fig. 3 shows a convenient structure in which “working bins” hold about a month’s supply of ingredients for the ration. These bins may be filled by a portable DUST COLLECTOR

Fig. 1. A conventional double crib with overhead bins is readily adapted to a gravity-fed grinding system. Drying equipment and additional dry grain storage may also be added.
Fig. 2. This mill, equipped with a blower, can elevate ground feed for overhead storage where it may be gravity-fed to a feed wagon in the driveway, or fill the self-feeder directly.

Fig. 3. A gravity-fed mill is low in cost and can be easily adapted to automatic operation if overhead storage is available.
outside elevator, or, as shown here, by the same vertical conveyor that is handling ground feed from the mill. In the latter case, a motor with a two-speed drive is desirable.

The bins shown in Fig. 3 are not hoppered. The material itself forms the hopper and at the same time gives some reserve supply which can be manually piled over the drop pipes if necessary. Note the placement of the bins over the mill. The dry shelled corn is located farthest to one side because of its free-flowing characteristics. Supplement needs to be as nearly directly over the mill as possible. Gravity spouts and hoppered bins should have slopes of 30° for shelled corn, 45° for oats, and 60° for supplement and ground feed.

On the market today there are many types of storage bins and silos that are designed to be an integral part of an automatic feeding system. The farmer who wants to invest in new bins and silos will need to take his own particular problems into consideration, but the following general principles should be kept in mind.

A bin should not only hold the raw ingredients for feeding, but, as far as possible, fit into the system by being self-unloading. A hoppered center-drawoff bin is the common storage for free-flowing materials such as oats, barley, wheat, shelled corn or pelleted supplement (Fig. 4). Round, flat-bottomed bins may also be used for storage of free-flowing materials and unloaded by auger and conveyor from the door or center. The material at the bottom of the bin may be removed with a flat-bottom bin unloader such as a motor-driven sweep arm of either chain or auger type.

Materials that are less free-flowing, such as many of the meal types of supplement, would better be stored in a tapered side-draw-off bin (Fig. 5). Some materials such as corn-and-cob meal, or supplements containing molasses, will not flow from any tapered storage. They will need to be pulled out of storage by a movable mat in the floor (Fig. 6).

In recent years, newly developed silos have become very popular for storage of grains as well as forages (Fig. 7). The farmer who is expanding and improving his business may want to consider installing one or more modern silos. The most versatile of these is the vertical glass-lined air-tight structure with an undercutting type of “bottom” unloader (Fig. 8). This can be used for all types of short chopped silage including wilted hay put up at about 50 percent moisture. It also provides storage for dry grains under certain conditions as well as for grains with moisture above 22 percent. A plastic bag and relief valve are provided to allow the gasses within the storage to expand and contract with the daily change in temperature without becoming mixed with outside air. This particular storage requires a minimum of climbing, removal of doors, or adjustment of the unloader position during filling and emptying operations.

The “tub” or “jumbo” silo with a diameter nearly equal to its height is coming into common use. In these silos a vertical discharge hole is formed through the center of the silage by pulling up a plug during filling.

The farmer who is planning a completely automatic system must remember that silos can be labor-consuming structures if not carefully designed.
Fig. 4. Material is augered from beneath these hoppered bins. Each bin is equipped with a slide-valve shut-off.

Fig. 5. In this storage set up forage is in the silo and supplement is in sacks within the feeding room. Dry shelled corn is metered by auger from the side-draw-off hoppered tank into the feeding room for blending with the supplement and silage before distribution in the bunk feeder.

Fig. 6. A movable mat similar to that used in some self-unloading wagon boxes will remove materials that tend to bridge. The rate the material is removed depends upon the speed of the mat and the size of gate opening.

Fig. 7. Modern silos are used for storing dry grain. One of these hoppered bins holds wet grain for the automatic drier, the other holds a supply of dry grain for the automatic mill inside the processing shed.

Fig. 8. Air-tight glass-lined structures are used in this system for the storage of high-moisture shelled corn and low-moisture silage.
is important to have a good method of silage distribution which will save the labor of “tramping” and insure a more uniform product through the elimination of air spaces and the thorough mixing of coarse and fine materials. One of the outstanding features of many of the modern silos is the unloader which also acts as a distributor during filling.

In making a long-range survey of his storage handling system, the livestock farmer must keep in mind the feed requirements of his animals. The following is a summary guide to these requirements which will help to determine the amount of storage space that a particular feeding operation needs.

<table>
<thead>
<tr>
<th>Beef:</th>
<th>Corn (bushels)</th>
<th>Supplement (pounds)</th>
<th>Corn silage (tons)</th>
<th>Hay* (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steer calves (425 pounds)</td>
<td>55</td>
<td>380</td>
<td>1.2</td>
<td>1/3</td>
</tr>
<tr>
<td>To gain 600 pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heifer calves (400 pounds)</td>
<td>40</td>
<td>280</td>
<td>1.0</td>
<td>1/4</td>
</tr>
<tr>
<td>To gain 400 pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearling steers (700 pounds)</td>
<td>40</td>
<td>220</td>
<td>1.5</td>
<td>1/4</td>
</tr>
<tr>
<td>To gain 400 pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearling heifers (550 pounds)</td>
<td>25</td>
<td>150</td>
<td>.75</td>
<td>1/4</td>
</tr>
<tr>
<td>To gain 250 pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-year-old steers (800 pounds)</td>
<td>15</td>
<td>150</td>
<td>2.5</td>
<td>1/4</td>
</tr>
<tr>
<td>To gain 250 pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hogs (for each 100-pound gain after weaning): 8 bushels of corn, 40 pounds of concentrates.

Dairy (for 10,000 pounds of milk): 2500 pounds of farm grains, 650 of protein and mineral supplements, 3 tons of hay, 3 tons of silage, 160 days of pasture.

Poultry (for 100 5-pound birds laying 180 eggs per year): 75 bushels of corn, 50 of oats, 20 of wheat, 2000 pounds of concentrates.

Sheep (Western lamb in drylot 20-30 pound gain): 2 bushels of corn, 1 bushel of oats, 150 pounds of legume hay.

* If hay is left out of the ration, corn silage needs to be increased by about .8 ton.

A blender consists of two or more feed meters that are operated simultaneously so that feeds are put together in the correct proportion for a ration. A feed meter is a method or device for measuring the amount of a particular feed grain. In its simplest form feed is metered by hand from a bucket. In a mechanical or automatic system there are various kinds of feed meters used for various kinds of blending operations.

A feed meter, for example, may be used to add granular material to silage in a mechanical bunk feeder (Fig. 9). The open-auger bunk feeder (Fig. 10) is also a form of meter. The amount of feed per foot of length is determined by the height adjustment of the auger, or in the case of a tube feeder, by the position of the discharge openings. Other factors to be con-
sidered of course in calculating the delivery rate are speed, angle of elevation, diameter, and the type of material being handled.

Hoppered-bottom bins, too, may be unloaded with an auger in such a way that the material is brought out at a controlled and steady rate. Changing the speed of the auger by means of a variable-pitch pulley is a common method of accomplishing this.

A series of augers in individual hoppers fed by gravity comprise the blender used on a popular electric hammermill (Fig. 11). The delivery rate of each ingredient is determined by the relative speed of rotation of each auger. Each is controlled by a dial which adjusts the effective length of a ratchet rotating the auger in the blender.

Supplement may be added to silage by the auger meter or by a vibrator meter. Vibrator meters (Fig. 12) are generally used for free-flowing materials such as shelled corn, small grain, or pelleted supplement. The amount of material metered out of a given unit will depend upon the setting of the opening and the intensity of the vibration. For example, if a silo unloader delivers forage fast enough to feed 100 head in ten minutes, and it is desired to feed about one pound of supplement per head, the vibrator meter is so adjusted that supplement is metered on at about 10 pounds per minute.

Belt blenders also are used most successfully. These may be fed by gravity spouts (Figs. 13 and 14). The proportion of each ingredient is determined by the height of the spout above the belt. The total amount delivered may be adjusted by changing the belt speed.

In many modern feeding systems, it should be added, blenders are not truly gravity-fed at all, but so arranged with small hoppers and pressure switches that they are supplied material by conveyor from ground level storage. Gravity-fed blenders of course are common on farms in which

Fig. 9. A 2-inch diameter auger in this hopper meters supplement onto silage. The silage guide swings to one side when it is necessary to climb the silo chute.

Fig. 10. A 9-inch diameter open auger will convey forage effectively. Note how the material is carried up and along one side.
Fig. 11. This disassembled display shows how dial-adjusted auger meters regulate the proportioning of free-flowing ingredients into a 2-horsepower hammermill.

Fig. 12. Three vibrator meters deliver three different ingredients from overhead bins at measured rates. The hoppers are mounted on the auger conveyor which can deliver the materials to the grinder or on to the silage conveyor.

Fig. 13. This diagram shows how a single belt may be used to meter the ingredients of a ration. Such a unit can be a very effective blender.

Fig. 14. The height of discharge tubes can be adjusted to change the amount of each ingredient metered by a belt blender. The total amount can also be changed by the speed of the belt.
older facilities are being utilized, but in building newer facilities it is often thought better to save the expense involved in constructing tall structures and build instead ground-level storages which require a conveyor to feed the mill. In this case the feed is usually metered into a hopper above the mill, but the main storage itself is not above the mill.

The use of feed meters to blend materials before or as they go into a grinder eliminates the need for any additional mixing. This is the principle of grinding mixed grain rather than mixing ground grain. In some cases the ration may require that the ingredients be ground through different screens, but the majority of livestock feeds can be processed simultaneously through a single hammermill with satisfactory results.

The increasingly widespread use of feed additives which are dispensed in small amounts has brought about a need for a completely mixed feed. Only by completely mixing the feed may one be assured that each animal receives the desired ration. Forage is often fed separately but it too may be mixed with small grains and supplements for a completely mixed ration. But whether forage is mixed with the rest of the ration or not, grinding of the various grains and supplements is a very important part of the blending process in most mechanical feeding systems. If one follows the principle of grinding mixed grains, it is clear that the grinding is the final and essential part of the blending process.

Grinding machinery must be carefully selected in accordance with available power and individual need. The use of low-power electric mills has proven satisfactory now that automatic controls are available. By using auto-

Grinders

Fig. 15. Downspouts from overhead bins supply various grains and supplement to the dial adjusted auger meters on this 2-horsepower automatic mill. A safety switch in each ingredient hopper stops the mill in case the supply runs out.
matic controls farm wiring need not necessarily be overhauled and a large
number of livestock may be fed from one small and relatively inexpensive
mill. Very large farming operations may of course make use of larger grind­
ers which perform the grinding in a short period of time but which have much
greater and more expensive power requirements. For the great majority of
farms, however, it is recommended that a low-power mill be selected and that
this mill be operated continuously for a number of hours. Such a set-up can
inexpensively feed a fairly large number of animals and lends itself to a
system of controls that is completely automatic.

The hammermill (Fig. 15) is a very successful type of grinder now being
used in livestock farming. A two-horsepower hammermill has an output of
1,000 to 2,000 pounds per hour. Such a machine must obviously be used in
an automatic system for it is too slow to justify the labor of hand feeding
and the manual removal of the feed. One of these small units, running con­
tinuously, can easily grind ten tons of feed per ten-hour day, which is enough
for 500 cattle and 3,000 hogs.

A hammermill consists of a series of hammers rotating at about 1,500 to
4,000 r.p.m., and a heavy perforated screen through which the crushed mate­
rial passes. The fineness of the material is determined by the size of the holes
in the screen. It has the advantage of being simple in construction, reasonably
inexpensive to keep up, and low in power requirements. Since the vast ma­
jority of livestock farmers planning a mechanical feeding system will find it
most efficient and least costly to install a “continuous” rather than a “batch”
processing center, the hammermill is one of the most prominent and useful
grinders being installed today.

In addition to hammermills, some farmers have made use of burr mills,
roller mills, and cutter mills for the purpose of grinding. These also do a
satisfactory job of grinding most livestock feeds, but at present are not as
readily adaptable to continuous automatic feeding operations.

Even on the most perfectly organized farm, processed feed will have to be
conveyed to the point of use. The job of conveying and distributing feed can
be carried out in several ways. Depending on the distance involved and type
of equipment available, one may use a batch or continuous operation. When
distances are very great, trucks or self-unloading wagons may be needed.
Ideally, in a completely automatic system, the farm will be so arranged that
blowers, augers, or chain conveyors can do the work of distributing the feed
to the animals. With continuous flow equipment, feed does not need to be
brought to the point of use in batches, and is easily regulated by switches and
other controls. Don’t forget that gravity flow may make a satisfactory con­
vveying method when available.

Blower conveyors (Fig. 16) are quite satisfactory for conveying ground
feed. They are particularly adaptable for use on poultry farms and for feeding
situations where ground grain alone is used, although they have been
employed in every type of livestock operation. With a 4-inch irrigation pipe
and a five-horsepower motor it is possible to blow 3,000 pounds of ground
Fig. 16. A blower conveyor is used for blowing ground feed from the processing center in the ear corn crib (left) to a barn which has been converted to a three story poultry house.

Auger Conveyors

feed per hour up to 300 feet. At other diameters the maximum conveying rate is as follows:

- 5-inch pipe — 4,500 pounds per hour
- 6-inch pipe — 5,500 pounds per hour

Naturally the horsepower of the fan must be increased with the pipe size. An air velocity of 4,000 feet per minute is necessary for satisfactory operation. The horsepower needed to give this velocity is as follows:

- 4-inch pipe — 1 horsepower for each 100 feet
- 5-inch pipe — 1½ horsepower for each 100 feet
- 6-inch pipe — 1½ horsepower for each 100 feet
  plus ½ horsepower for each 1,000 pounds of grain delivered per hour.

Because of the amount of air used to move the feed, a dust collector must be installed. In calculating horsepower requirements it should be considered that the dust collector is equal to 25 feet of pipe.

Blower conveyors are suggested for feeding operations where feed must be conveyed to several different locations. They cannot of course be used as the sole conveying method when roughage is included in the ration. In this case some other method, such as the auger conveyor or self-unloading wagon, must be used. The advantages of the blower conveyor are simple construction (there is only one moving part), low initial cost, simple maintenance, and flexibility. The dealer who supplies the blower is in the best position to explain the possibilities and limitations of this kind of conveying system in a given farm situation.

A four-inch, 100-foot-long horizontal or 30-foot-long vertical auger can be driven at 300 r.p.m. by a ½ horsepower motor and convey 2,000 pounds per hour. This is greater than the output from a 2-horsepower automatic mill. If distances are more than 100 feet, the first auger may be cascaded into a second and so on as far as necessary. Distances greater than 500 feet probably require an unloading wagon, although in usual farmstead organization such distances are not often encountered.

[13]
Table 1. — Power Requirements per 10 Feet for a 4-Inch Nominal Diameter Auger Delivering 1 Ton per Hour of Ground Feed, Shelled Corn or Oats at Various Angles of Elevation and Various Revolutions per Minute

<table>
<thead>
<tr>
<th>Auger speed r.p.m.</th>
<th>0°</th>
<th>45°</th>
<th>90°</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>.018</td>
<td>.060</td>
<td>Will not deliver 1 ton per hour</td>
</tr>
<tr>
<td>300</td>
<td>.025</td>
<td>.074</td>
<td>.093</td>
</tr>
<tr>
<td>400</td>
<td>.035</td>
<td>.092</td>
<td>.118</td>
</tr>
</tbody>
</table>

Table 2. — Capacity and Power Requirements per 10 Feet of a 6-Inch Nominal Diameter Auger Delivering Either 14 or 25 Percent Moisture Shelled Corn at 0°, 45°, and 90° Angle of Elevation and at 200, 400, and 600 Revolutions per Minute

<table>
<thead>
<tr>
<th>Auger speed r.p.m.</th>
<th>Corn moisture Percent</th>
<th>0°</th>
<th>horse-bushels per minute</th>
<th>45°</th>
<th>horse-bushels per minute</th>
<th>90°</th>
<th>horse-bushels per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>14</td>
<td>9.9</td>
<td>.28</td>
<td>5.3</td>
<td>.44</td>
<td>4.6</td>
<td>.32</td>
</tr>
<tr>
<td>200</td>
<td>25</td>
<td>6.2</td>
<td>1.37</td>
<td>4.7</td>
<td>1.31</td>
<td>2.6</td>
<td>.32</td>
</tr>
<tr>
<td>400</td>
<td>14</td>
<td>18.1</td>
<td>.56</td>
<td>14.2</td>
<td>.88</td>
<td>8.6</td>
<td>.70</td>
</tr>
<tr>
<td>400</td>
<td>25</td>
<td>11.6</td>
<td>1.84</td>
<td>8.5</td>
<td>1.78</td>
<td>5.0</td>
<td>.70</td>
</tr>
<tr>
<td>600</td>
<td>14</td>
<td>25.2</td>
<td>.84</td>
<td>19.4</td>
<td>1.28</td>
<td>12.4</td>
<td>1.05</td>
</tr>
<tr>
<td>600</td>
<td>25</td>
<td>15.8</td>
<td>3.32</td>
<td>11.3</td>
<td>2.27</td>
<td>6.8</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Combinations of speed, angle, and capacity for auger conveyors can be calculated with the aid of Tables 1 and 2.

Distributors

In systems where the place of feeding is adjacent to storage or the mill, it is often possible for the conveyor to act as distributor. In other systems the feed is brought to a hopper by the conveyor and is distributed to the animals by another means.

Of the numerous types of distributors, self-feeders are among the more obvious. These may be used with all types of livestock, are inexpensive to install, and have the advantage of keeping feed always available to the animals. The major disadvantage of self-feeding is the difficulty of regulating feed intake and determining consumption.

There are several types of mechanical feeding lines which are alternatives to self-feeding and which are more highly recommended for present-day livestock farming. Chain drag conveyors have been used for this purpose. They provide a “clean plate” for the animals because the slats of the conveyor move along the feed bunk and drag out the material remaining from the previous feeding. The same advantage is had with the shuttle-stroke type of feeder. In both instances there is the objection that the material must be metered into the distributor at the rate it is to be placed before the livestock. This means also that no fresh feed can be added without discarding what was left from previous feeding.

An open auger with plank sides is a simple distributor for silage (Fig. 17). The amount of feed per foot of bunk length is regulated by the height of the auger above the feed bunk. Bearings need to be located on the side carrying the least amount of feed. Both forages and concentrates can be distributed by an auger enclosed in a tube with adjustable holes, or with holes designed at grad-
Fig. 17. An open auger with plank sides first fills the bunk nearest the sources of supply. Height adjustment regulates the amount of feed in the bunk.

Fig. 18. Tube-type feeders are designed to distribute some feed their entire length. The amount of feed per foot of length is determined by the amount of time it operates.

ually changing levels about every two feet (Fig. 18). There is a tendency for the finest material to be deposited at the openings nearest the intake end and coarsest materials to be carried to the opposite end of the distributor. This is not a serious disadvantage.

In planning the means of distribution, one must give careful consideration to the problem of feed and water space for the animals. At the present time, most mechanical feeding systems use the kind of self-feeders in which the feed is actually held in the main bins or silos until it is prepared and conveyed to the feeder. For mechanical self-feeding of hogs and beef, the same space requirements apply as for older forms of self-feeding. For the constantly replenished feeder these are about 2 inches per hog and 6 inches per steer. If frequent limited feeding is planned there must be enough space for all the animals to eat at one time; the requirements are 1 foot for hogs and 2 feet for steers.

Using these figures one may determine the space needs of any number of feeding animals. A 10-door feeder with 1 foot per door is satisfactory for 60 hogs on self-feed. If frequent limited feeding is to be practiced, 1 foot of feeder space per pig is necessary. Cattle of 500 pounds or larger each require 2 feet of space at the feed bunk when fed on a limited feeding basis. A 100-foot bunk accessible from both sides has room for 100 head if they are all to eat at one time. However, cattle have been brought to full grain feed by starting them on silage full fed, and then, over a period of several weeks, adding increasing quantities of grain while decreasing the silage mechanically. When this kind of self-feeder is used, 6 inches of space per steer is sufficient and a 25-foot-long feed bunk will feed 100 head (such feed bunks must be at least 58 inches wide and 10 inches deep).

A two-door hog waterer, located so as to be accessible from all sides, is satisfactory for 75 market weight animals. Two hundred cattle can be accommodated with a two-door waterer which should be located in the open so that there is no crowding at any time against a fence or shed (Fig. 19).
In taking space requirements into consideration, resting space for the animals must not be forgotten. These may be estimated as follows:

- Beef — 30 square feet in shed unpaved, plus 30 square feet paved outside shed.
- Hogs — 10 square feet on concrete in shed.
- Dairy — 30 square feet in shed, unpaved, plus 30 square feet paved and 35 feet drylot.

Fig. 19. This convenient small tank filled automatically from a pressure water system and kept ice-free by thermostat control can supply 200 head of cattle in a lot.

Farmers who have planned and built automatic feeding systems have had to face the problem of matching unloading rates with conveying and distributing equipment. In many cases the delivery rate of the unloader may exceed that of the conveyor. This is usually due to the fact that most silo unloaders require some manual attention, and there is a tendency to operate them at their highest capacity to get the job done in the shortest time. For example, if the bottom unloader delivers 500 pounds of high-moisture corn per minute, the meter for supplement may need to deliver as much as 50 pounds per minute if the correct ration is to be attained.

Proper ration or blend, of course, is one of the keys to success in any livestock operation. In calibrating equipment the farmer will naturally need to know in detail the feed requirements of his animals. (The table included in the section on storage will help you to determine what the feed requirements are.) For example, calves under 500 pounds will consume about 7 pounds of high-moisture shelled corn, 1 pound of soybean meal, and 8 pounds of corn silage daily, together with about 2 pounds of hand-fed hay. Thus to feed 100 animals in ten minutes the unloader will be required to deliver 80 pounds of silage, and 70 pounds of high-moisture shelled corn per minute, blended with supplement at the rate of 10 pounds per minute. Whatever the feed requirement, variable rates of delivery will need to be worked out for the equipment. This is usually accomplished by the use of variable-speed pulleys, transmissions, or other means which speed up the output of the supplement and decrease the grain output.

Correct calibration of the blending operation is important if the accuracy of the ration is to be maintained. This may be checked by running each piece of unloading equipment separately for one minute and weighing the outputs. (Repeat the procedure at least three times to be sure of the results.) The same method may be used for checking the output of blending equipment such as the belt or auger blender. Simply turn off all ingredients except one and weigh its output for one minute. It may be impossible to catch the output from the blender except at the discharge of the grinder. This method, however, is quite satisfactory.
The output of a silo unloader will vary so greatly with different kinds of materials and situations that its calibration on a time basis gives only an indication of capacity. On the other hand, the delivery of a bunk distributor per foot of length is fairly uniform for a given setting of the distributor. It may be calibrated by filling ten feet of the bunk with silage, scooping it up, and weighing it.

The farmer, in short, will have to experiment with his equipment until it delivers precisely the ration that is desired. Some trial and error experiences are occasionally necessary, but the metering rate is important and must be determined. Proper calibration of equipment is every bit as important, for example, as checking to see that a corn planter is putting out the right number of seeds.

Electric power is the ingredient that makes today’s automatic feeding system possible. No other source of power is so readily adaptable to farm needs and at the same time so widely available. The farmer’s electric power supplier is in a position to evaluate the power requirements of a proposed feeding operation; he should always be called upon to lend advice when new equipment is being purchased and installed.

One of the questions the farmer needs to have answered is whether his wiring system is adequate for present and expected future needs. The power supplier can usually answer this question and see to it that the farm’s transformer is adequate to provide the desired capacity. A singular advantage of the automatic grinding system recommended in this circular is that farm wiring set-ups may not need to be overhauled in the process of installing the mechanical system. But no matter what system is chosen, every farmer should know a few essential facts about power equipment and maintenance so that he and his power supplier can plan together effectively.

For automatic feeding systems one should choose a heavy-duty motor capable of starting heavy loads with a low starting current. It is a good idea to install a totally enclosed motor since the atmosphere is likely to be dust-filled. Time-duty interval is also an important consideration. In “batch” feeding operations, motors with time-duty intervals of 5, 15, 30, or 60 minutes are often satisfactory. Most feeding systems, however, especially those set up for an hour or more of continuous operation, will require a motor with a continuous duty rating.

Most farms do not have three-phase power so that single-phase motors must be used. Since one should start a heavy load with a low starting current, it is suggested that motors with either capacitor or repulsion start be selected. Where three-phase power is available, three-phase motors can be used to great advantage. These are low in cost and require little maintenance.

It is a good thing to remember that since the feeding operation is dependent upon the continuance of electric power, some kind of provision needs to be made for power failure. Even though power stoppages are not frequent and seldom long-lasting, it is advisable to have on hand a generator capable of supplying at least some power in case of an emergency.
Mechanical feeding systems may be controlled in a number of different ways. The simple on-off switch that opens and closes an electric circuit is one that immediately suggests itself. When using very large mills which do all the grinding in a short period of time, it is sensible to let the operator do the controlling with just such a manually operated switch. When continuous operation is used, some kind of automatic switching is necessary. These switches may be activated by timers or by sensing elements such as devices to measure temperature, material level in a bin, pressure, etc. (Fig. 21).

In order to be a satisfactory part of an automatic feeding system, sensing elements and similar small current-carrying devices must be used with heavy current-carrying relays, such as magnetic motor starters. In other words, a relay on a control panel is necessary to start a large motor from a small electrical signal. The pressure switch, for example, is a simple method of using the pressure of feed or grain to close or open an electrical circuit. When larger than fractional-horsepower motors are used, a magnetic starter-circuit is needed to handle the current. A small signal current through the pressure switch causes the solenoid or magnet to close contacts on the magnetic starter so that a large motor can be operated. This same magnetic starter may have auxiliary switches which will either open or close other control circuits to other magnetic starters. By this means, circuits are interlocked or interconnected. This interlocking is very important and necessary in an automatic system where there are several motors that must work in harmony, and where a sequence of operations requires overload protection for each motor.

In planning a control set-up for an automatic feeding system, one must carefully consider the problem of adjusting starting and stopping sequences.
Fig. 22. Ground feed is distributed automatically for a milking parlor. The amount for each animal is manually metered.

Fig. 23. A typical arrangement for automatic preparation of hog feed, using a premix supplement.

to the available power and the needs of the equipment. A bunk distributor, conveyor, and silo unloader, for example, need to be started one at a time and in that order so as to avoid a heavy current surge.

In the case of the roller mill shown in the accompanying diagram (Fig. 23), sequence starting is absolutely necessary since it is difficult to start the mill with any grain in the hopper. If the central panel is equipped with magnetic starters and 10 to 30 second time-delay relays, it will be able to do the following: (1) simultaneously start conveyor motors $M_3$, $M_4$, and the mill motor $M_1$, then, (2) 10 seconds later, the conveyor motor $M_2$ for the shelled corn, and meter $M_3$ for the supplement. A stop button, a time clock, or a feed pressure switch will shut the system down in the reverse order, i.e., the shelled corn conveyor motor $M_2$, and vibrator meter $M_5$, and 30 seconds later the mill motor $M_1$, and conveyor motors $M_4$ and $M_5$. The circuit diagram for this system shows two-wire control for the shelled corn conveyor motor and vibrator meter. Three-wire control is shown for the mill motor and conveyor with interlocked overloads (Fig. 24).
Remote Feed Valve Control. A single ration may be conveyed to several different locations by using a series of augers. In the distribution system shown in Fig. 25, motors $M_1$, $M_2$, and $M_3$ could be switched on manually at the control box in order to fill feeder #2. Feeder #1 would thus be by-passed because motor $M_2$ would not be running. This method of distribution naturally also makes it possible to control the distribution of different rations to different locations by simply energizing the proper conveyor motors and the distributor motor for that particular location.

It should be noted that if feeders in several different locations are to be kept filled automatically, a pressure switch must be put in the circuit for each feeder. The circuit diagram for such a system is shown in Fig. 26. The feed pressure switch will fill the feeders one at a time as required.

Push-button automatic feeding equipment presents some very definite physical hazards to the operator and his family. This is a relatively new use of electric power on the farm and great care must be taken to build a system that is safe as well as efficient. All electrical equipment must be grounded and weather protected. The wiring should be of U.F. (Underground Feeder) type to resist the deterioration of moisture. It must also be kept in mind that automatic equipment which is operated by switch or time clock may start unexpectedly. If equipment is being serviced without the power being disconnected, injuries may result.