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AGRICULTURAL MATERIALS HANDLING MANUAL

PART 3 PROCESSING EQUIPMENT

SECTION 3.3

WEIGHING AND METERING

Agriculture Canada

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WEIGHING AND METERING

The Agricultural Materials Handling Manual is produced in several parts as a guide to designers of materials handling systems for farms and associated industries. Sections deal with selection and design of specific types of equipment for materials handling and processing. Items may be required to function independently or as components of a system. The design of a complete system may require information from several sections of the manual.

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SECTION 3.3. WEIGHING AND METERING

3.3.1 General

3.3.1.1 Historical

The determination of weights and measures can be traced back to prehistoric times. It is generally believed that weight and length measurements were probably the first developed. Kernels of grain and shells were probably the first weight standards while length measurements were based on dimensions of the human body, i.e. the foot, palm of the hand etc. With the passage of time many systems of measurement have evolved, the most recent being the British system and the International Systems of Units (SI).

The importance of commercial transactions has required governmental regulations to establish uniform standards on permissible tolerances for weighing devices. Generally, weigh scales should be accurate to ± 0.2% of full scale for commercial transactions. Scales used in commerce are regularly checked by government inspectors and the seal indicates the date of latest approval.

3.3.1.2 Weight

Matter is characterized by its gravitation property which is called weight while mass is a measure of the quantity of matter and is independent of gravitational forces. The ratio of mass to a unit volume of a substance is referred to as density, i.e. kilogram per cubic meter. Weight is then a measure of the force exerted on a body of material by the earth's gravity. Since this gravitational force varies inversely as the square of the distance from the center of the earth, the "weight" of a given quantity of material would be less on a mountain top than at sea level. Thus devices that depend on the extension of a spring or electrical voltage changes from a load cell are weight determinations while devices that use a counterbalance principle give mass determinations, since the object being measured and the counterweights are both subjected to the same gravitational attraction. From a practical standpoint all weight and hence mass determinations depend on gravitational attraction and the same terms, kilograms, pounds etc. are applied to both. If a force is applied to 1 kg mass, such that it is accelerated at the rate of 1 m/s^2 this force is referred to as a Newton (N). Under the attraction of standard gravity a mass of 1 kg produces a force of 9.806 N. Recently non-gravimetric (nuclear devices) are being used by some industries to measure mass but the agricultural industry will likely continue to use simpler, well established, gravimetric devices.

TABLE 3.3.1 Relationship of Metric and Imperial Units of Mass

Unit	Abbreviation	Kilogram
1 avoirdupois ounce	oz	0.0283
1 avoirdupois pound	lb	0.4536
1 short hundred weight	cwt	45.36
1 short ton	ton	907.18
1 kilogram	kg	1
1 tonne	t	1000

3.3.1.3 Volume

Units of volume are derived units, defined in terms of linear units; the validity of volume measurements depends on calibration or reference to linear standards. Thus in SI units the cubic meter is the basic volume, or for smaller units, the cubic centimeter (or millilitre). Test weights of grain will be measured in kg/hectolitre (kg/hL) while liquids will be measured in litres (L) which is 0.001 m^3. To obtain grain density (in kg/m^3) from grain test weight (in kg/hL), multiply the test weight by 10.

3.3.2 SELECTION OF METERING AND WEIGHING SYSTEM

There are four important operations to a weighing and metering system:

1. Storage: Withdrawal of free-flowing material from a storage presents no major problems but non-free-flowing materials require careful consideration. Materials must flow in a uniform and consistent stream for volumetric metering devices but flow rate is not as critical for most

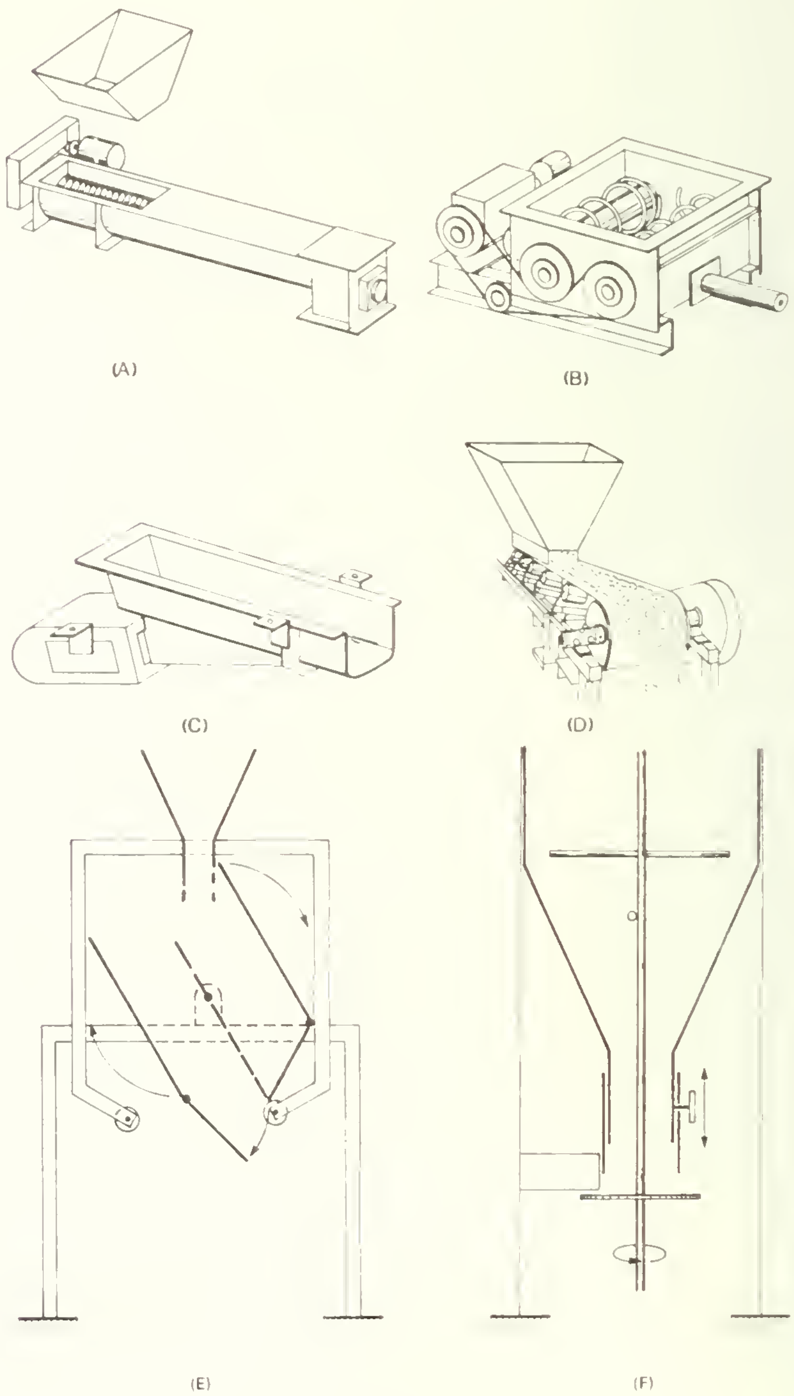

Figure 3.3 1 Mechanical feeders

gravimetric systems. Non-free-flowing material forms an arch or bridge across the hopper or discharge opening in a bin. Flow can be improved by using two adjacent sloping sides (not less than 70°) and two adjacent vertical sides to form a hopper. The outlet should be large. Discharge can be further assisted by external vibrators, belts, chains or augers at the bottom of the bin, or by internal mechanical agitators. See Section 6 for additional information on storage design.

2. Feeding: Various feeding devices are illustrated in Figure 3.3.1. Screw or auger feeders (A) are generally suited to free-flowing and ground material such as grain, cereal products and minerals. Live bottom feeders (B) are mulitple augers in a bin bottom; the auger may be either flight auger or coil spring type depending on the cohesiveness of the material handled. Vibratory feeders (C) are best for lumpy materials. Belt and chain flight feeders (D) are suited for semi-free-flowing and fibrous materials. A forage wagon-box without running gear is an example of a chain flight feeder (see Section 2.4, Figure 2.4.30).

3. Weighing: Examples of weighing devices are hopper scales, with gravity or power feed, and either manual or automatic stop-start action. Continuous weighing is provided by belt weighing equipment.

4. Readout of Weight Data: Examples are mechanical dials with either manual or mechanical printout of weights, and electronic devices which permit optical or weight printers at locations remote from the scale.

Factors influencing the selection of equipment for weighing and volumetric metering are summarized in Table 3.3.2. Characteristics of agricultural materials can be found in Section 7.1.

TABLE 3.3.2 Factors Affecting Selection of Weighing and Metering Equipment

Factor	Influences
Flow characterists of material (% moisture, free or non-free-flowing, partical size, hygroscopic)	Storage bin design, feeder selection, weigh hopper design, electrical enclosures
Other characteristics of material (abrasiveness, corrosiveness, flammability)	Storage bin materials, feeder material, weigh hopper material and their design
Accuracy required	Selection of weigher
Output rate	Operating speed, weigh hopper size, belt width and speed on continuous weighers
Weight sensing method	Cost and choice of readout devices
Readout information	Cost, choice of readout device and type of weigher

3.3.2.1 **Batch Versus Continuous Weighing**

There are many recent improvements in the accuracy and reliability of continuous weighing equipment. Where large tonnages are involved continous weighing has some advantages but batch weighing will likely be the more popular choice for agricultural installations. Batch weighing is more accurate and is officially recognized as legal weighing for commerce. By incorporating automatic controls (Section 5) approximations to continuous weighing can be achieved. For example, assume 100 kg/min are required; on a continuous weigher scale only 1 kg may be on the scale at one time; for an accuracy of 0.5% this means a sensitivity of 5 g which is difficult to achieve in practice. On the other hand, the same flow handled in batch form by discharging every 6 seconds would mean 10 kg batches at 0.5% accuracy or 50 g sensitivity which is much easier to achieve. Therefore only processing systems that are about 10 times larger than this example are likely to be suitable for continuous weighing.

3.3.3 GRAVITATIONAL SYSTEMS

There are four basic methods of gravimetric weight measurements; eachemploys a different type of opposing force (see Figure 3.3.2).

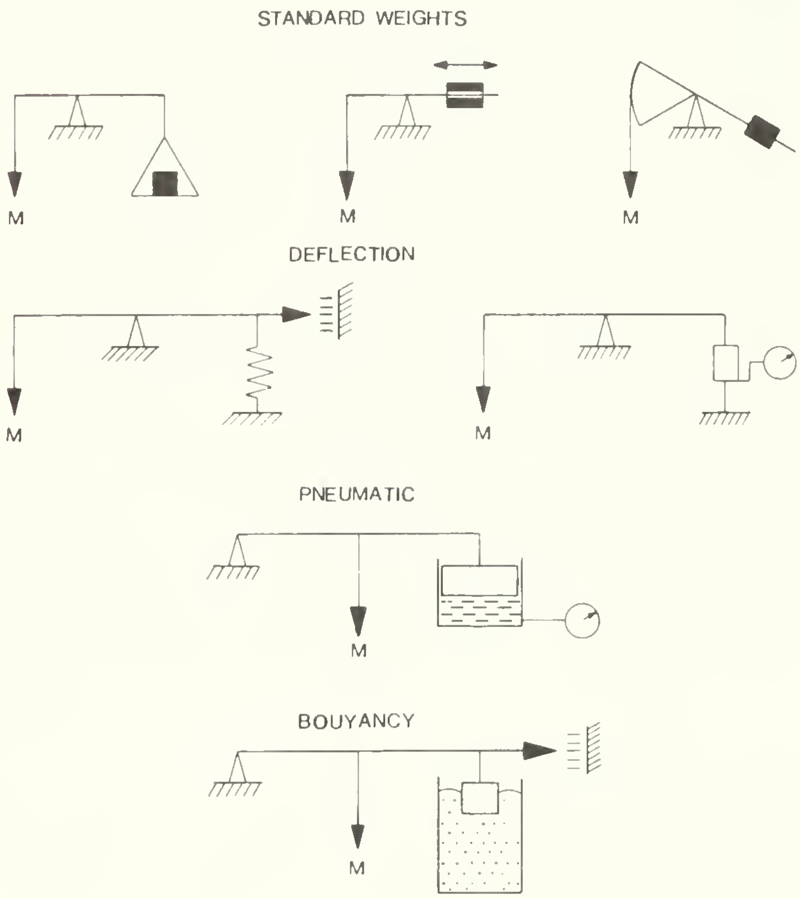

Figure 3.3.2 Gravitational weighing systems.

1. Standard Mass Counterbalances: These employ a known weight to counterbalance the applied load either directly or through a lever system. These systems are independent of variations in gravitational force and hence are really comparing an unknown mass to a standard or known mass.

2. Deflection or Spring Counterbalances: These use elastic elements, such as springs in tension or compression which deflect within their elastic limits to a condition of equilibrium. Strain-gauge load cells and load rings with a linear variable differential transformer (LVDT) also fall into this category. The output of these units is linear within their elastic limits and must be calibrated with a known mass. A variation in gravitational force

would cause a variation in output even though the mass did not change.

3. Pneumatic or Hydraulic Force Counterbalances: These generate pressure in a fluid that can be measured with bourdon tubes or diaphragms. These units are best used where vibrations occur to help overcome friction at the diaphragm or bourdon tube.

4. Magnetic and Buoyancy Systems: Magnetic and buoyancy forces may be used to counterbalance the applied load. Buoyancy systems involve the displacement of an equivalent mass of liquid depending on the ratio of the moment arm to the applied load and to the float.

3.3.4 WEIGH HOPPERS AND AUTOMATIC BATCHING

Magnetic force can be applied to counteract the clockwise rotational effect of the applied load shown in the buoyancy schematic of Figure 3.3.2, to return the pointer to the no-load condition. The amperage delivered to an electromagnet to counterbalance the applied load is measured and the ammeter is calibrated in terms of the applied load. The scale is linear but the reading is dependent on the magnitude of the gravitational force. Except for very accurate mass measurements the variation over the earth of the gravitational force is not sufficient to be of concern to agricultural materials handling systems. Most weighing systems in use in agriculture involve gravitational force and a system of moment arms or levers. An exception to this is the simple spring scale where the line of gravitational force and the center line of the scale are colinear. The use of levers greatly expand the range of the load that can be weighed with relatively small counterweights.

To achieve accuracy in batch weighing it is very important to provide a material supply stream of uniform density. The greater the throughput of the system, the more ingredients that will be in space between the supply discharge and the weigh hoppers. Hence a uniform stream permits one to anticipate the extra weight added after the stop switch has been activated.

3.3.4.1 Manual Control

Manual control is the simplest type of system where an operator opens or closes a valve from overhead storage or presses a button to start and stop a conveyor delivering material into a weigh hopper. Each ingredient of the ration or process requires a separate feeder and stop-start switch (or bin and control valve). This system is low in first cost and best only up to four or five ingredients since the system is entirely dependent on the skill and mental concentration of the operator. Control of gravity flow by valve from overhead supply bins may be by lever, rack and pinion, or by pneumatic cylinder if remote from the operator.

3.3.4.2 Semi-automatic Control

The addition of dial-type cut-off controls permits pre-setting to weigh cumulatively for a given ration or process. The feeder automatically stops when the present weight of each ingredient has been added. The operator presses the start button for the next ingredient and so on. Output will be greater per unit time since the operator does not have to "jog" the last few pounds of each ingredient. Increased accuracy and greater throughput should amortize the system costs provided it has a high usage factor.

3.3.4.3 Control Components

Basic cycle control
Power on/off selector switch
Power on pilot light
Fuse for circuit protection
Relays for motor and circuit protection (one required for each feeder)
Cycle start button
Emergency stop button
Feed indicator light
Automatic/manual switch
Manual feed pushbotton

3.3.4.4 Recorder-printer Control

This can be used to automatically actuate a printer or to give totals at the end of each weighing.

3.3.4.5 Manual discharge

This allows manual emptying of the scale when the special discharge button is pressed. Releasing the discharge button closes the discharge gate.

3.3.4.6 Automatic Discharge

This allows automatic discharge of weigh hopper after filling to a preset weight.

3.3.4.7 Fully Automatic Control

When these controls are turned ON, the scales automatically fill and discharge, repeating the cycle until turned OFF.

3.3.4.8 Time Function

This control permits a timing dial to be set for timing mixing or other processes.

3.3.4.9 Batch Stop Counter

This control shuts off the filling of weigh scales when a preset number of scale discharges have been completed. This is used with fully automatic control.

3.3.4.10 Ingredient Selector Switch

Where several bins may be available for each ingredient this control permits the manual selection of the appropriate "in" bin.

3.3.4.11 Batch Counter

This is an electrical or mechanical counter used to indicate the number of batches completed.

3.3.4.12 Alarm

This gives an audible or visual alarm for some fault condition, i.e. empty supply bin. The choice and number of alarms needed will depend on a thorough analysis of the individual installation.

3.3.5 DESIGN CRITERIA OF BATCH SYSTEMS

Many choices exist in the type of weighing and metering equipment to be used for a specific installation. System manufacturers can offer expert help. The following points should be used as a check list of criteria necessary for making informed selection of equipment and performance specifications.

3.3.5.1 Ingredients

Tabulate all the ingredients to be formulated or used. List their flow characteristics, bulk density and other mechanical or physical properties as given in Section 7.1. These characteristics will influence bin design as given in Section 6 and feeder selection as given in Section 2.1 to 2.3 inclusive. They also determine which precautions should be taken against contamination, dirt, dust and explosion. Additional considerations are summarized in Table 3.3.3 and 3.3.4.

3.3.5.2 Formulation Arrangement

The number of formulas and ingredients likely to be used (such as in a livestock ration) should be established. This will help define the metering or proportioning system. For example, an ingredient used only occasionally should be added manually.

TABLE 3.3.3 Characteristics of Volumetric Feed Meters[1]

Basic Type	Power Required	Materials Handled	Approximate Capacity Range[2]	Capacity Varied With	Relative Cost (1965)[3]
Auger (small)	124 and 15 W	Medicines, Antibiotics	2.8 to 370 g/min	Auger size and speed	E
Auger, 2 in	124 and 15 W	Supplements	0.6 to 1.1 kg/min	Auger speed and gear ratio change	E
Auger, 3 in	50 W	Supplements	1.4 to 10 kg/min	Sliding gate	A
Fluted wheel	(Home built)	Grain and Supplements	Not available	Sliding gate	A
Auger, 5 in	560 W	Grains, ground feed, high moisture corn	9 to 91 kg/min	Auger speed (V-belt sheaves)	F
Auger, 6 in	Used on PTO Unloading wagons	Ground feed and grain	0 to 270 kg/min	Intake opening, auger flight and pitch	A
Shaker		Ground feed, supplements	0 to 140 kg/min	Feeder cycling rate and gate height	A
Vibrator	30 W	Free-flowing meals-grain	0 to 4 kg/min	Frequency change	D
Vibrator	15 W	Free-flowing meals-grain	0 to 30 kg/min	Frequency change and hopper height	B
Vibrator	90 W	Free-flowing meals-grain	0.9 to 15 kg/min	Voltage change and hopper height	A
Rotary disk	90 W	Grains and supplements	1.8 to 18 kg/min	Spout height over table	A
Reciprocating gate valve	187 W	Free-flowing meals-grain	1.4 to 113 kg/min	Change in stroke of valve	C
Reciprocating gate valve	187 W	High-moisture corn	14 to 500 kg/min	Change valve stroke	D
Tumbler-agitator	187 W	Ground feed, supplements	4.5 to 36 kg/min	Change slide gate	A
Weighing	Gravity power	Grain	0.4 to 1.5 m^3/h	Auger capacity	A
Weighing	Gravity power	Free-flowing	Up to 33 m^3/h	Auger capacity	B

[1] From Gilbertson, C.B. 1966. *Aids for planning mechanized feeding*. Circular AE-75. Extension Service, North Dakota State University. Fargo N.D.

[2] Capacity range stated by manufacturer.

[3] A=$50-100; B=100-150; C=$150-200; D=$200-250; E=$300-350; F=$350-400.

3.3.5.3 Programming Methods

The frequency of formula change will determine the formula programming method since the risk of human error is increased each time a procedure is changed. Possible formulation methods are:

1. Individual mass selection using mass selection dials.
2. Preset formula package mass selection such as formula capsule.
3. Preset formula package using a punched card and formula board.

3.3.5.4 Output and Batch Size

Where batch delivery every 5 to 10 minutes is adequate then cumulative batching with a common weigh hopper would be adequate, but with some sacrifice in accuracy since the scale capacity must be high compared to some individual ingredient weights. Where batch deliveries must be every minute or so, simultaneous weighing and batching should be considered. Accuracy will be greater since individual scales can be matched more closely to the amount of ingredient in each batch. Costs will be materially higher since hopper and weigh scales are required for each ingredient.

3.3.5.5 Batching System Accuracy

Unnecessarily close tolerances on weighing will increase the cost of the system. As the size of the weighing is increased relative accuracy is improved. For example, if 0.25% accuracy is required then for 1000 kg this amounts to 2.5 kg, while for 100 kg it is 0.25 kg. Such accuracy is more difficult to achieve for the smaller amount. System accuracy depends on mass sensing and especially on good materials handling that moves a consistent and uniform mass flow of material into the scale.

TABLE 3.3.4 Material Classification Code Chart[1]

Major Class	Material Characteristics		Code Designation
Density	Bulk Density, Loose		Actual lb/ft³
Size	Very Fine	No. 200 sieve (0.0029 in.) and under	A_{200}
		No. 100 sieve (0.0059 in.) and under	A_{100}
		No. 40 sieve (0.016 in.) and under	A_{40}
	Fine	No. 6 sieve (0.132 in.) and under	B_6
	Granular	½ in. and under	$C_{1/2}$
	Lumpy	3 in. and under	D_3
		7 in. and under	D_7
		16 in. and under	D_{16}
	Irregular stringy, fibrous, cylindical, slabs, etc.		E
Flowability	Very free-flowing - flow function > 10		1
	Free-flowing — 4 < flow function < 10		2
	Average flowability — 2 < flow function < 4		3
	Sluggish — flow function < 2		4
Abrasiveness	Mildly abrasive — Index 1-17		5
	Moderately abrasive — Index 18-67		6
	Extremely abrasive — Index 68-416		7
Miscellaneous Properties or Hazards	Builds up and hardens		F
	Generates static electricity		G
	Decomposes — deteriorates in storage		H
	Flammability		J
	Becomes plastic or tends to soften		K
	Very dusty		L
	Aerates and becomes fluid		M
	Explosiveness		N
	Stickiness-adhesion		O
	Contaminable, affecting use		P
	Degradable, affecting use		Q
	Gives off harmful or toxic gas or fumes		R
	Highly corrosive		S
	Mildly corrosive		T
	Hygroscopic		U
	Interlocks, mats or agglomerates		V
	Oils present		W
	Packs under pressure		X
	Very light and fluffy — may be windswept		Y
	Elevated temperature		Z

[1] From Conveyor Equipment Manufacturers Association, 1970

3.3.5.6 Scope of System Control

The control panel design should include all events that are affected by the batching operation. Typical functions that can be included are bin level indicators, bin loading controls, mixer controls, loading and unloading conveyor controls, liquid meter injection and various indicating lights used to show equipment operation. Section 5 of this Manual discusses control systems in more detail.

3.3.5.7 Weigh Sensing Arrangements

Depending on the requirements of the installation and the physical limitations involved the weigh hopper can be "weigh-sensed" in several ways.

1. Overhead suspension levers and mechanical dial levers: Attached to the weigh hopper, this assembly is suspended by rods from a floor or support structure above. A lever system as shown in Figure 3.3.3 divides the force from the added mass of material accumulating in the weigh hopper to a range appropriate to the connected indicator (dial, etc.)

2. Tank-type levers and mechanical dial: Similar to the previous arrangement except the weigh hopper sits on the lever system rather than suspended from it, and is usually mounted on the floor.

3. Balance beam readout: The principle of the balance beam can be used to provide automatic weighing of dry free-flowing materials. Many variations are available but the essential features are illustrated in Figure 3.3.4. For farm applications a bucket is made to hold from 5 to 20 kg. When the bucket has filled to overbalance the adjustable counterweight, the vertical motion is sufficient to trip the discharge gate. The discharge gate and feed gate on the feed supply hopper may be interconnected so that feed does not flow into the bucket while feed is discharged. A mechanical counter can be actuated each time the bucket discharges its load hence the total mass of material can be determined by multiplying the number on the counter by the set mass at the point of balance. Units are available that automatically weight 20-25 tonnes per hour.

4. Lever system with electronic load cell output: Instead of the extension lever being attached to a mechanical dial as in Section 3.3.5.9, an electronic load cell is substituted.

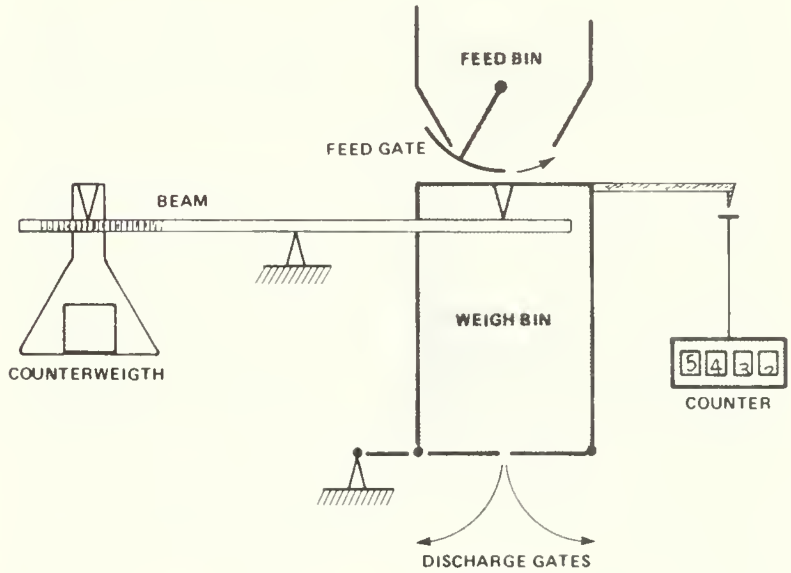

Figure 3.3.4 Schematic of balance beam readout.

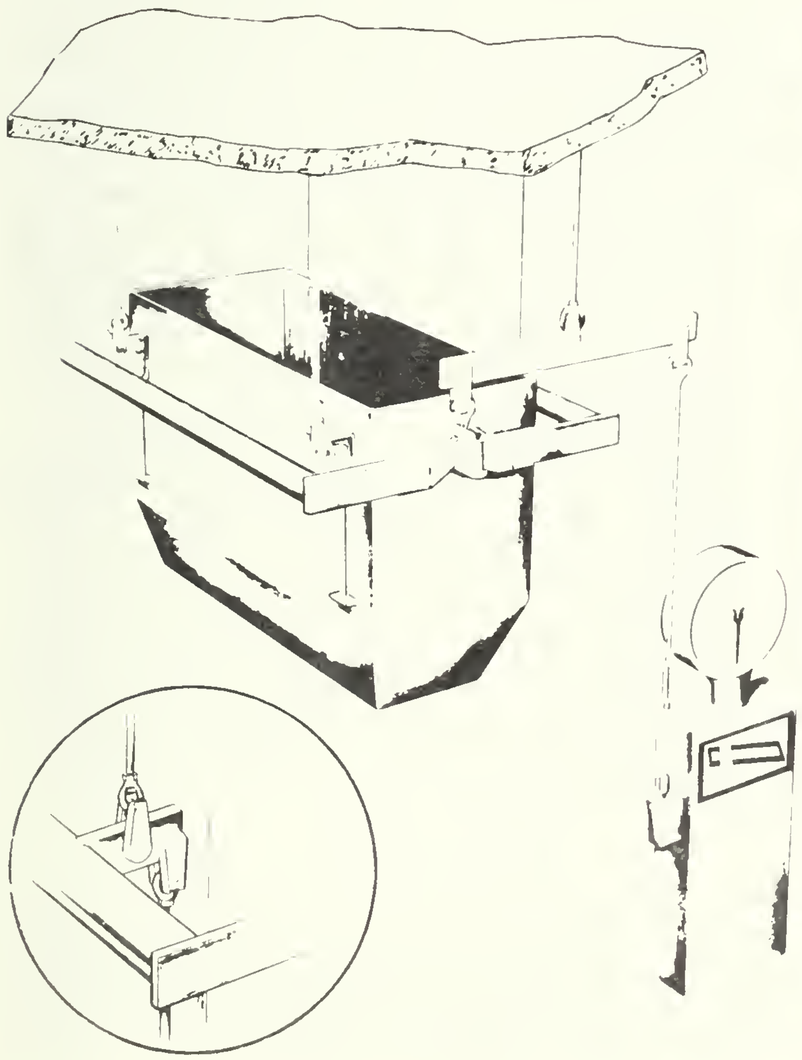

Figure 3.3.3 Suspended weigh sensing arrangement. Courtesy: H. Colijn.

Figure 3.3.5 Commercial application of balance beam readout. Courtesy: Burrows Equipment Company, Evanston, Illinois.

The voltage output of the load cell is proportional to the applied load. This output signal can be used to actuate an electronic dial indicator, a digital indicator, a printer or a calculator. All these devices can be located remote from the weighing site. Since the load cell supports only a fraction of the weighed mass it will be less expensive than the following system.

5. Full load cell electronic indication: The weigh hopper is either suspended from or set directly on load cells. The load cells are interconnected for totaling the output and the result is transmitted to readout devices as in the previous example.

6. Multi-range dials and load cell indicators: If a wide range of weights is to be accommodated then an extended range dial should be considered since this gives greater accuracy than a single range dial. For example, a 500 kg scale might have graduations of 0.5 kg; an extended scale with five 100 kg ranges, each with 0.1 kg graduations, also has a total capacity of 500 kg, but measures to 0.1 kg.

Multi-range units can be obtained which automatically add counterweights as required to match the required mass. Load cell systems can have extended ranges by adding resistance to one arm of the control circuit wheatstone bridge to balance out a single dial range.

7. Digital load cell indicators: Many scale manufacturers now offer digital load cell indicators rather than analog units. The resolution of these units is from 1/10,000 to 1/20,000.

Advantages of these units over analog units are:
1. All displays are absolute, no interpretation is required by the observer.
2. The units can provide computer-compatible outputs.
3. The units are smaller in size than analog units.
4. Solid state circuits assure long life and minimum maintenance.

3.3.6 BELT SCALES

In situations where the discontinuities of batch weighing are not acceptable then belt scales are a viable alternative. Most manufacturers claim accuracy of 0.5% over the full range of the scale but this may not be realized in practice, depending on the operating conditions and the maintenance provided.

The sensitivity and resolution of belt scales must be high since only a small fraction of the material to be handled is on the belt at any one time. Therefore great care must be taken in the selection of all components and in the way in which the belt scale is installed into the system. The primary advantages of belt scales are low headroom and high material throughput.

Several designs are available; three of the more common types are shown schematically in Figure 3.3.6. The essential components of a belt scale are a suspension system to direct the load to a load sensing device, a device to measure the belt speed and an intergrater (mechanical, electrical or a combination) to total the load and provide a readout.

For accurate weighing the belt must be uniformly loaded as near capacity as possible and the suspension system kept clear of accumulated debris.

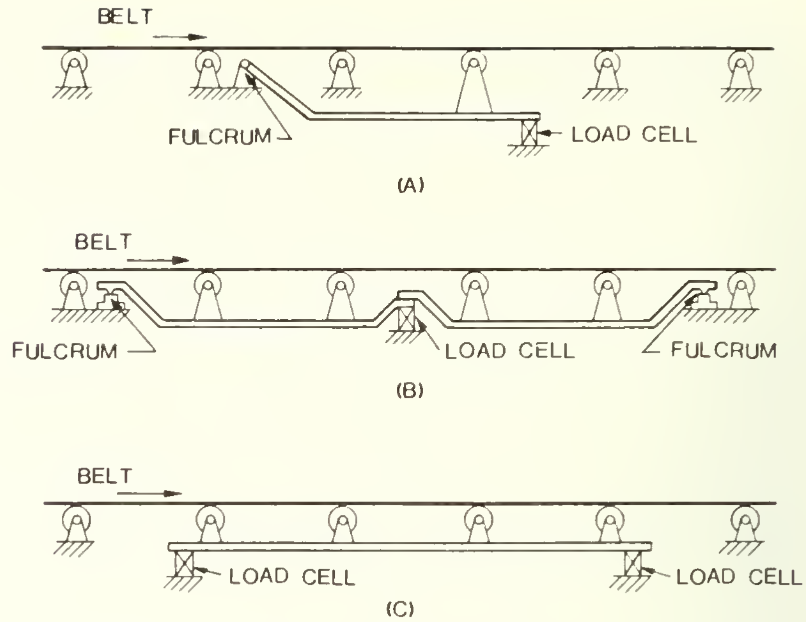

Figure 3.3.6 Belt scale suspensions.
Courtesy: H. Colijn.

3.3.7 Weigh Feeders

3.3.7.1 General

Weigh feeders are a special application of belt scales that are integrated into an overall system. Weigh feeders must:
1. withdraw material from a hopper outlet.
2. provide volumetric regulation of flow by a preset or variable gate opening.
3. sense weight to provide a feedback signal for adjusting the flow rate of material, by changing belt speed or gate position.
4. discharge the material onto another conveyor or into another container.

The weight feeder, the hopper outlet and the hopper work as one system and changing one will affect the performance of the whole system. The material must move onto the belt in a uniform manner with constant density. This means the material should flow out of the hopper as a mass-flow. Bin selection for mass-flow is discussed in Section 6.1.

To assist in the proper selection of equipment for handling bulk solids, the Conveyor Equipment Manufacturers Association established a classification code for bulk materials in 1970. This code is reproduced in Table 3.3.4. Based on this table the material code for wheat would be 48 B_6 1 5 PQ. This means that: the bulk density is 48 lb/ft^3; B_6- under 0.132 in size; 1- very free-flowing; 5- mildly abrasive; P- material can be contaminated affecting its final use; and Q- material can be degraded affecting its final use. Based on this system, equipment suppliers can more effectively provide the best equipment for handling the material in question.

3.3.7.2 Belt Feeders

A slotted discharge opening in a bin combined with a belt feeder is an economical means of removing material in a uniform manner from the whole width of the bin. This arrangement is illustrated in Figure 3.3.7. Belt feeders range from 0.15 to 1.8m in width and 0.9 to 9m in length. The capacity is a function of belt width and speed. Most range from 7.5 kg/s and up. Belt speeds of 0.26 m/s are generally recommended. Power requirements vary upward from 375 W. Most of the power is required for start-up to overcome the high torque needed to initially shear the material.

3.3.7.3 Screw Feeders

For fine material that may have a tendency to flood, (smooth grains etc.) screw feeders can be a useful method of unloading bins. To avoid drawing material from the back of a bin it is necessary that the feeder have increased capacity in the direction of flow. Figure 3.3.8 compares the effect of a constant pitch and diameter auger to one with variable pitch. Parallel multiple augers placed in the bottom of a storage bin provide a "live bottom bin" which can successfully handle chopped hay, hay cubes or combinations of the two. For metering powders or other finely ground materials that may adhere to regular flights, spiral wound wire augers can be used. Four types of feeder designs are shown in Figure 3.3.1.

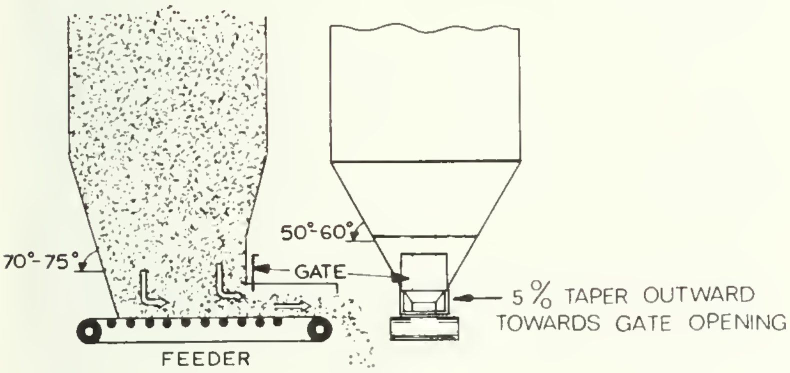

Figure 3.3.7 Belt feeder.
Courtesy: H. Colijn.

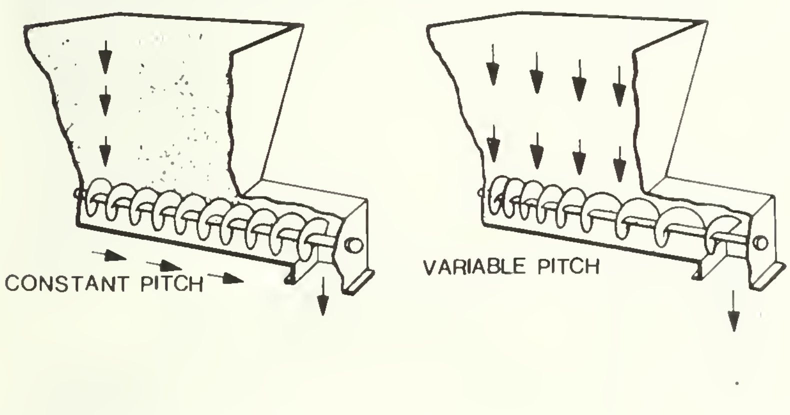

Figure 3.3.8 Screw feeder comparison
Courtesy: H. Colijn.

3.3.8 MECHANICAL WEIGH SCALES

Hopper type feed scales can be mounted on tracks to weigh feed and discharge it directly into feed bunks. The hopper scale shown in Figure 3.3.9 can also be used to weigh pellet-sized fertilizer and hay cubes. Manually operated discharge gates are available as hinged doors or sliders. Capacity is up to 680 kg. Blenders can be scale mounted as illustrated in Figure 3.3.10. This arrangement allows accurate control over feed rations. Capacities range from 34 to 6350 kg batches. These units can also be equipped with electronic load cells as discussed in Section 3.3.9.

For free-flowing materials a tipping bucket can be provided as a weighing unit. The unit shown in Figure 3.3.1.E can be combined with rolling and metering in one machine. The balanced weigher operates by gravity, dumping one side while filling the other. A totalling counter can be provided to record grain weighed and to stop the unit when a predetermined weight of grain has been processed. Auger type metering is discussed further in Section 3.3.10 and blender grinders are covered in more detail in Section 3.2.4.

3.3.9 ELECTRONIC SCALES

Lower cost durable electronic systems utilizing various transducers are now feasible for on-farm application.

3.3.9.1 Electronic Strain-gauge Load Cells

For the larger farm operator, replacing the mechanical weighing system with electronic load cells may be justified. Electronic strain-gauge load cells can be located at the four corners of stationary or portable mixers and truck bodies. Figures 3.3.11 to 13 inclusive illustrate the components of such a system. Either a digital or dial type readout indicator can be used to indicate the mass of each ingredient added to a mixer or the mass of feed fed out to bunk feeders. Alarm systems such as buzzers and flashing lights can be provided to indicate when the desired amount of material has been added or discharged from the scale. For general use the accuracy is 0.25% of full load (2.5 kg/t).

For record keeping a manual or self-balancing electronic scale (Figure 3.3.14) can be provided. The mass is indicated digitally as well as providing an alarm. A ticket printer attachment records the mass for later bookkeeping. Units accurate to 0.25% or even 0.10% are available. For legal trade, 0.1% is required.

3.3.9.2 Electronic Load Cell Controllers

A recent development tried by Townsend (2) involves a force gauge in the form of a U-shaped bar. As the load is applied to the open ends of the U, adjustable microswitches can be "stepped" to open at specified increments of load. Up to 4 microswitches can be used to control ingredient supply (overhead augers, rolling mill etc.) that drops into a hopper in a mixer tank suspended from the force gauge.

3.3.10 PROPORTIONING BLENDERS

Farm blenders are discussed in more detail in Section 3.2. These blenders generally use short augers to meter each grain and supplement to subsequent grinding (see Figure 3.3.15). The effective auger speed can be varied to handle different volumes of each input ingredient and can be adjusted by varying the stroke length of the pawl-and-ratchet mechanism driving each auger shaft. A separate variable speed motor drives the whole metering system to permit adjusting total throughput to match the motor power and grinding capacity of the unit. A volumetric accuracy of 98% is claimed for metering augers.

While small speed-controlled augers are the most accurate mechanical method of metering grains and other

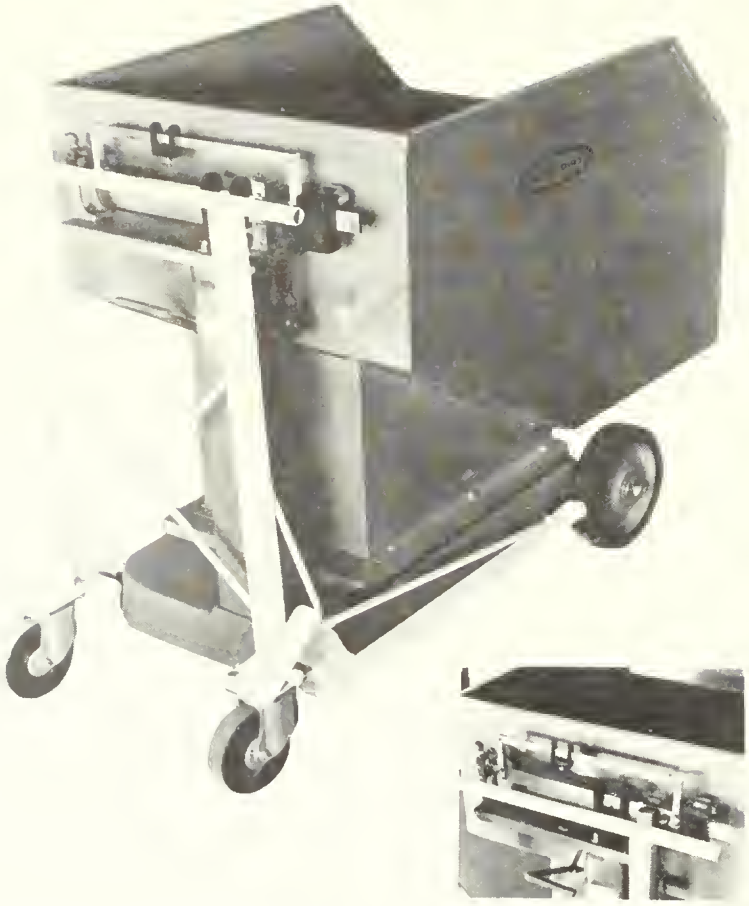

Figure 3.3.9 Hopper-type scale.
Courtesy: Burrows Equipment Company, Evanston, Illinois.

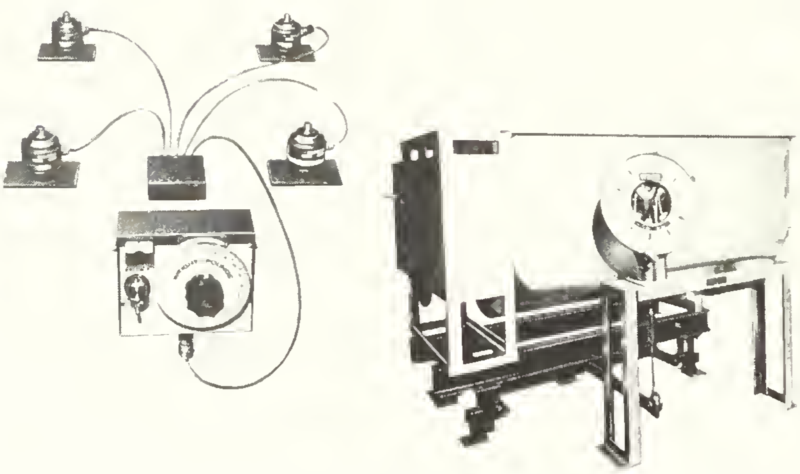

Figure 3.3.10 Blender on mechanical scales or alternatively on electronic load cells.
Courtesy: H.C. Davis Sons Manufacturing Co., Inc., Bonner Springs, Kansas.

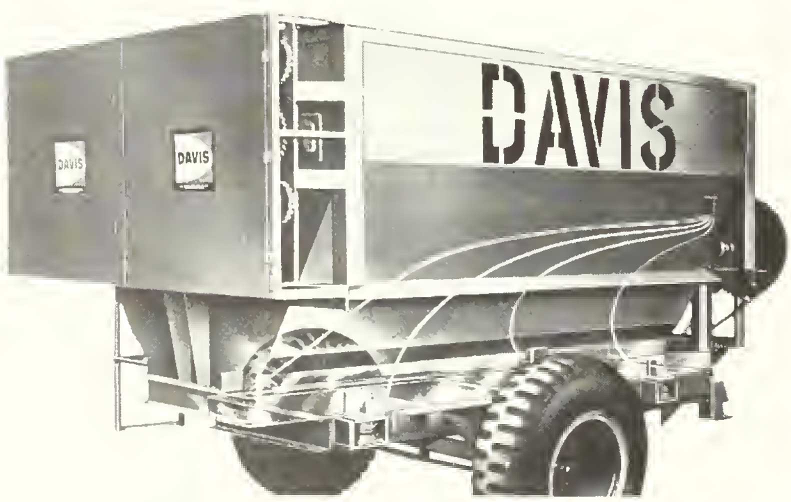

Figure 3.3.11 Electronic Load cells, weigh truck or blender contents. Courtesy: H.C. Davis Sons Manufacturing Co., Inc.

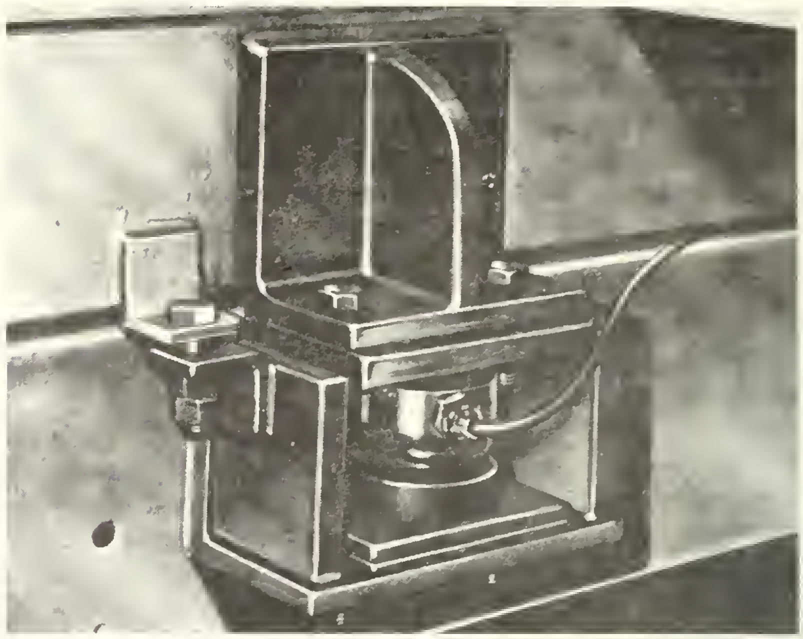

Figure 3.3.12 Electronic load cell.
Courtesy: H.C. Davis Sons Manufacturing Co., Inc.

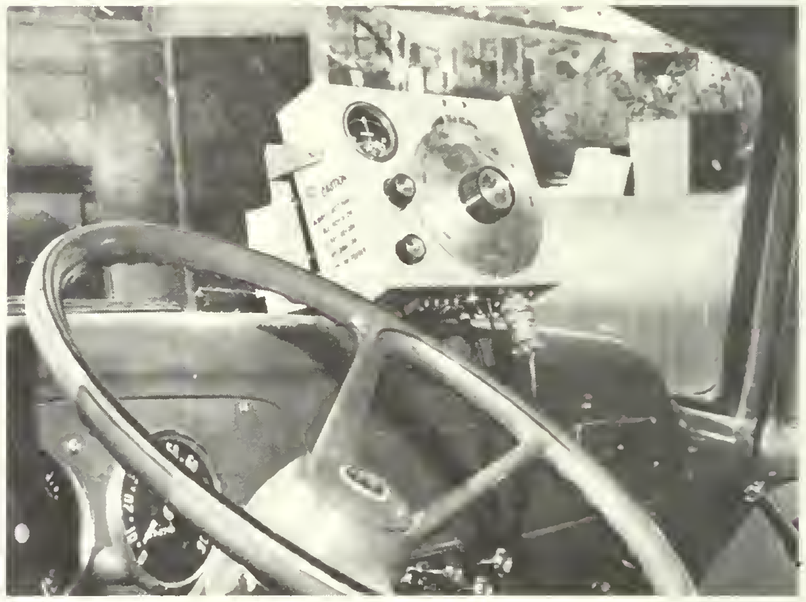

Figure 3.3.13 Dial-type read out.
Courtesy: H.C. Davis Sons Manufacturing Co., Inc.

Figure 3.3.14 Self-balancing electronic read out and printer.

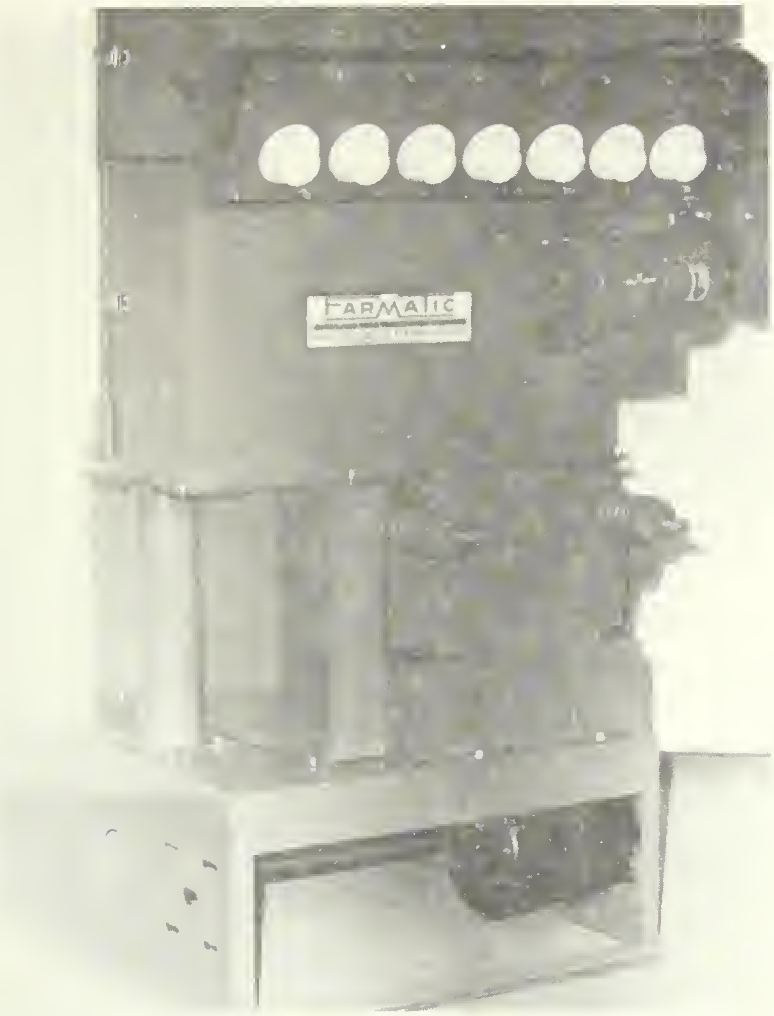

Figure 3.3.15 Metering augers on blender grinder. Courtesy: Farm Automatic Feeding Ltd. Gorrie, Ont.

particulate material used in feed rations, it must be remembered, as pointed out in Section 3.3.7 and 6.1, that the bin design and the unloading method are equally important for satisfactory results. For accurate metering, materials must be relatively free-flowing. For example, whole grain high-moisture corn can be metered by speed-controlled augers, but pre-ground high-moisture corn cannot.

The addition of automatic blenders over hammer mills, grinders or roller mills will release labor for other tasks. After setting the controls for the required ratios and quantity and turning the unit on, no further labor input is required.

3.3.11 REFERENCES

1. Colijn, H. 1975. Weighing and proportioning of bulk solids. Trans. Tech. Publications, 1975.
2. Townsend, J.S. 1977. A novel farm weighing device for feed ration ingredient proportioning. CSAE paper no. 77-317, Can. Soc. of Agr. Eng. ann. mtg., Guelph, Can. Aug.