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MECHANIZATION AND AUTOMATION OF INDUSTRIAL FEEDSTUFF PRODUCTION PROCESSES 1/

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CONTENTS

Introduction

The increased demand for animal feeds is derived from the increased demand for products of animal origin as human food. Furthermore, the general pattern is such that demand rises in proportion to increases in income and population. Although there has been a rapid rise in the production of compound feeds in numerous countries in recent years, the potential market is much greater and there is a considerable room for expansion in this industrial sector, in the developing countries as well. The major question remains however the identification of appropriate technologies for the developing countries to adopt, if they are to secure the fastest rates of growth. The developed countries employ techniques which require extensive capital investment per worker. Since the developing countries have abundant labour resources, yet very little capital, they should - it is argued - develop intermediate technologies which have lower capital requirements and higher labour requirements per unit of output. However, it is mistaken to believe that the more primitive or less mechanized techniques which require less capital input per worker are more economic in capital terms per unit of output.

The response of labour to automation in developing countries has centred upon its immediate labour-displacing effects, whereas the response of management has centred up on the higher profits that can be earned through automation. These profits are higher when the equipment and its operation cost less than the requisite labour input. The automated or computerized process may incur both capital and labour savings. The productivity of capital may be increased without additional capital expenditure. Automation may raise profits and sales through better product quality and greater service variety. However, the real impact of these factors is contingent upon a correct pricing of labour, capital and foreign exchange.

The ultimate logic of automation lies in its efficiency in the mass production of materials, components and final products. Automation can be extended from an individual machine to an entire plant.

The entire processing line in an industrial feedstuff factory consists of the following main departments:

1) Storage of components and ingredients.
2) Cleaning, breaking, grinding and blending.
3) Mixing, pelleting, cooling.
4) Packaging, storage and transporting of product.

This paper attempts to deal with the principal factors relating to these four main departments and the problems associated with their automation and mechanization (see Fig.1).

I. Storage of components and ingredients

The first of these interrelated processes is the storage of components and ingredients. Numerous components and ingredients are used in feedstuff production; however, grain ranks first since it constitutes the most widely used feedstuff ingredient (60 per cent).

In view of the fact that a paper such as this cannot claim to be comprehensive, only certain problems, such as the mechanization and automation of grain store operations, will be considered. The main types of storage in feedstuff plants are:

1) grain elevators,
2) floor storage faculties.

Grain elevators ensure better sanitary and hygienic conditions and permit a more effective utilization of transport equipment upon reception of the grain and its transfer to the production area. The main operations in a grain elevator are: unloading; its cleaning and distribution throughout the silos; its storage and transmission to the production area. The handling equipment (track and rail dumps, track hoists), transport equipment (elevators, belt and drag conveyors) feeding mechanisms and grain distribution systems ensure the proper fulfilment of all these operations.

All this equipment is located on different floors and in different sectors of the elevator. The fact that the equipment is scattered throughout the building creates great difficulties in terms of rational operation. In a technological complex, all the machines and mechanisms are linked to form a chain or route. Owing to the fact that each electric motor is started individually "routing" grain requires considerable time thus extending the organizational stage of the operation. A large staff is required, machine idle time is excessive and the machine efficiency is low (0.2-0.3): furthermore, the output per energy unit consumed is low and the electrical equipment capacity is underutilized.

Efficiency and harmony in equipment operation can be achieved by installing a different control technique in a grain elevator to ensure one-man monitoring of the entire production process. Equipped with technical means of communication, signalling and control, an operator co-ordinates the operation of all the main plant units. By means of the control panel, automatic control of the production process is effected. The operator is kept informed of the production process through the automatic devices on the control panel (see fig. 2). As a rule, all the controls for the communication, signalling and control systems are located on the operator's console and vertical control panel. (see fig. 3). It allows the operator to watch the progress of any process and all the cycles in machine operation. Furthermore, only one operator is needed to control all the mechanisms as well as the elevator transport system. Sometimes grain upon entering the elvator has a high humidity content, sometimes as much as 20 - 30 per cent, and is not fit for storage. This surplus humidity in the grain is conducive to the growth of microorganisms and spontaneous ignition; furthermore, the rise in grain temperature accelerates degradation. The grain fit for storage should have a humidity content of not more than 14-16 per cent. Grain humidity may be reduced by passing it through special dryers. If, during grain storage, grain humidity and therefore its temperature are not too high, they can be reduced by transporting the grain by conveyor to an empty silo.

Grains of different humidity have their respective drying temperatures and rates. For better grain drying, it is necessary to automate the drying process. Automation assures the stabilization of the planned grain humidity, regulates the grain temperature in the dryer and provides an automatic blocking and control system. Using this system, better grain quality is reached and fuel costs are reduced.

Preservation of grain quality is achieved through timely technological operations which require constant measurement of grain temperature, usually by means of special electronic remote control systems. Such systems generally consist of monitors, secondary devices, control schemes and communication elements. Low-ohm thermo-resistors are used as monitors, ohmmeters being used as secondary devices. The thermo-resistors are built into special cables, which are suspended in the silos. The remote control system consists of a control panel and relay units and thermo-resistors (see fig. 4). Grain temperatures in the silos are measured in the following way: the required line of silo relay unit is selected and the appropriate thermo-resistant cable linked to the ohmmeter to obtain a reading.

In this way the operator can measure the grain temperature in different silos and at different levels therein. There are also remote control systems for measuring grain temperatures. However, these are more expensive and are normally used in large grain elevators for long periods of grain storage.

II. Cleaning, breaking, grinding and blending.

These are preparatory operations in the feedstuff production process of basic importance to the final product quality. The sifter sections ensure that the grain is free from any foreign matter in preparation for grinding, when the grain is passed through a series of machines combined in a technological complex. Magnetic separators, sieves, grain separators and aspirators are used to remove any foreign matter, including pieces of metal. For specific structural reasons these technological machines cannot be automatically controlled, although remote control of all electric powered units is possible and an emergency braking device is fitted to all feed systems (block systems). After the cleaning operation, the grain is ground using hammer or roller units.If the cake or corn-cobs are to be used in feedstuff production, a cakebreaker or crusher has to be used.

Firstly, the cake or corn-cobs are reduced to 20-40 mm splinters in the crusher, whence the splintered product is passed through a magnetic separator to a hammer or roller mill for further splintering.

The process consumes a great amount of electric power. Furthermore, crushing efficiency determines theefficiency of the subsequent mechanical stages in the technological process. Therefore, it is very important to ensure their optimal working by regulating the product feeds. This can be done by using automatically controlled loading systems; product feed regulation being based on a comparison of the crusher's actual power consumption with its optimum capacity. The application of this system ensures a rhythmic work flow and economical power consumption. The grain is reduced after passing through the crusher once. (see fig.5).

High-quality feedstuff production is a process entailing the accurate proportioning and blending of ingredients with different structures and specific weights. Inaccurate proportioning results in the wrong feedstuff structure and reduced efficiency; sometimes, it can even cause the animals' internal damage.

Different proportioning and blending methods are used. The method based on weight proportioning and on portioned blending as used in modern feedstuff plants is the most accurate. It has become increasingly popular since the introduction of vitamins, trace-elements, antibiotics and other microadditions to feedstuff production. There are two basic trends in the weight proportioning system: the use of separate scales for each ingredient or proportioning scales for several ingredients. The batch proportioning system which allows for both types of scales is widely used today, as the system can be more easily automated. The production process proceeds in accordance with a strictly calculated cycle which excludes the subjective mistakes, a typical example of a modern weight proportioning system is shown in figure 6). The system has two independent lines controlled from individual panels. In each line, six ingredients and two premixes are proportioned and transported by screw conveyor to one scale and the other twelve ingredients to the other one. The system works automatically except for the manual selection of the feedstuff composition. The operator merely sets the weight of each ingredient on the panel and presses the starter, whereafter proportioning and blending proceeds automatically for any number of cycles. The system can also include automatic selection by means of punch-cards.

III Mixing, pelleting and cooling.

Pelleted feed is the direct outcome of the increased demand for feedstuffs, which are to be more acceptable further to being convenient in terms of storage and transportation, as well as incurring little waste (dust and meal). Animals were observed to assimilate feedstuff pellets more easily owing to the good chewing factor. Feedstuff pellets stimulated the animals' appetite and did not irritate their mucous membranes.

Mixing, pelleting and cooling processes are combined in one technological system, such as the one illustrated in figure 9) (longitudinal section). The pelleting system comprises an automatic steamer, a boiler, a heater for molasses, and vegetable oil and molasses as well as vegetable oil tanks with pumps and ancillary equipment system. The pelleter completes both the mixing and pelleting operations, (see figure 7) the input being a pre-mixed uniformly proportioned meal. This feedstuff mixture is mixed with steam, water, molasses and other liquid ingredients before pelleting in the pelleting chamber, fitted with a ring-shaped matrix and pressing collars (see fig. 8). The pellets cutters being mounted on the outside of the matrix. Steam is sprayed throughout, the length of the mixer whereafter molasses is injected in spray form and mixed with the feedstuff meal. In the case of fishoil, compressed air is used as steam can damage the vitamins in the fish oil.

The pelleting process is controlled from a special panel, where the operator checks the ammeter to regulate feeder speeds. The molasses and steam pumps are set in motion by the feeder shaft and thus the molasses and oil feed rates are always in proportion to the shaft speed, and hence to the feedstuff feed to the matrix. Combined ground feedstuff and steam feed systems assure optimum pelleter operation with varying loads. Rotation speeds are adjusted to the main electric motor load. Steam quantities are regulated through electric-driven steam regulators activated by the thermo-resistors in the mixer and pelleting chamber. Product and steam feeds can be controlled both automatically and manually.

Pellets have a comparatively high temperature after pelleting, hence a cooler is always part of the pelleting complex. (see fig. 10). It reduces pellet temperatures and moisture content to levels necessary for storage. Pellets should be cooled gradually and uniformly so that they retain their properties and are not destroyed in any way.

A constant rate of pellet flow through the cooler is maintained by means of electric control mechanisms. Should the pellet level in the dump scoop drop owing to irregular pelleting, the unloading mechanism is automatically stopped by the level regulator fitted to the scoop. As soon as the necessary unloading level is reached, the mechanisms is re-activated and work continues.

Young chickens need 2.4 mm (3/3.2") diameter pellets. However, the most efficient output is obtained with 4.8 (3/16") pellets. Thus 4.8 mm pellets are usually manufactured for young chickens, the pellets being ground on a roller mill to the diameter required and 35 per cent of the product is re-directed to grinding or pelleting. Despite this apparent wastage, the output of the pelleting complex is some 80 per cent greater than that of a plant producing 2.4 mm pellets without grinding.

IV Packaging, storage and transporting of final product.

At present, feedstuffs are mainly stored in paper sacks in floor storages or in silos from which they are transported in specialized trucks. Pre-packed feedstuffs are more convenient because buyers do not need special dumps or storage bins. Feedstuffs are packed in a variety of ways depending on the volume. Manual packaging requires only little machinery. The filled sacks are weighed on platform scales before being tied or sewn by hand. Semi-automatic packaging is done on a packaging scale followed by hand s wing. Sometimes, it is combined with a [illegible] machine, the output being about five 50 kg [illegible], per hour. Automatic packers are used in large plants. Figure 11 illustrates an automatic packer, comprising an automatic portioning scale, packaging machine, conveyor and sewing machine. The output is about 360 sacks per hour, the whole operation requiring two workers. Feedstuffs are packed in jute, cotton or multi-layer (non-returnable) paper sacks. The paper sacks are strong for one-way usage only and the transfer of various diseases (microbial origin) is eliminated.

It is undesirable to store finished compound feeds for long periods owing to possible susceptibility to mould or damage through insects, and rodents. The feedstuff floor storage usually hold three or four days' output. The feedstuff floor storages are equipped with belt conveyors, gravity spouts and loaders (see fig. 12). In modern large-scale plants, mechanical bag loaders are used. Bag loading operations are usually carried out on trucks. Depending on output, the number of loading places varies. They are usually equipped with belt conveyors, and one loading area handles 100 tons a day. More recently there has been a trend towards storing feedstuffs unpacked in some countries, bins and silos being used instead.

Unpacked feedstuff is usually weighed on a trench scale, and the absence of packaging offers certain benefits in terms of transportation. Production and transport expenditures are reduced, manual loading is no longer necessary and an automatic animal feeding system can be set up.

Despite the economic advantages, the transportation of feedstuff in unpacked form is not widespread, the reason being the lack of mechanization on many small farms.

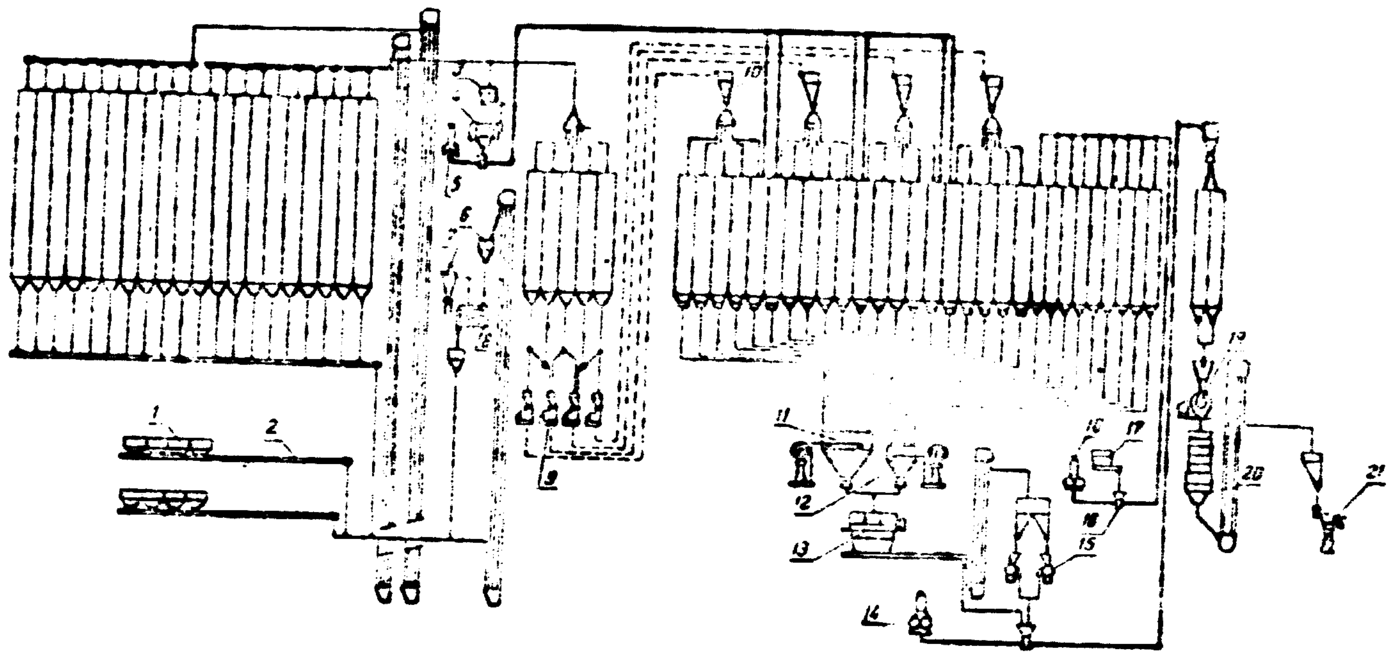
Conclusion

In this brief review, an attempt has been made to indicate some advantages and the efficiency of automated and mechanized feedstuff production processes and equipment. The automation and mechanization of feedstuff production processes are very important not only for developed countries, but also for the developing countries.

The introduction of mechanization and automation in feedstuff factories permits an increase in labour productivity. Cheap, high-quality products can be produced only in mechanized and automated factories. Power consumption is less with mechanization and automation. The mechanization of the raw material unloading and feedstuff loading processes accelerates them and thus reduces the number of vehicles required. The investment cost per ton of productive capacity in a feedstuff factory amounts to US$ 12,000 - 18,000 depending on total production capacity. The period of amortization for such a factory is about 4 - 6 years. Only by using highly mechanized and automated equipment can the developing countries lessen the gap between themselves and the developed countries, and improve their living standards.

In conclusion, it is necessary to stress the significance of a feedstuff factory's location. Raw materials amount to more than 80 per cent of operating costs. Therefore, it is very very important that feedstuff factories be linked with the suppliers of raw materials suppliers, such as wheat mills, oilseed crushing factories or sugar factories. However, the ideal solution is when a feedstuff factory is part of an agro-industrial complex. In this case, a feedstuff factory can use the by-products of other enterprises in the agro-industrial complex as well as agricultural products, thus ensuring a reduction in the cost of transporting raw materials and finished products as well as a proper utilization of the agro-industrial complex infrastructure. The establishment of agro-industrial complexes permits production of more competitive commodities not only for the local markets but also for export requirements.

Figure 1: Typical Technological scheme of feedstuff plant



1 unloading
2 conveyor
3 surger bin
4 sifter
5), 16) conditioners
6 automatic scale
7 cyclone
8 separator
9 crushers
10 cyclone
11), 12) scales for components
13 mixer
14 air compressor
15 mixer for molasses
17 live bottom bin
18 pneumatic dump
19 pelleter
20 cooler
21), 22) packing scales

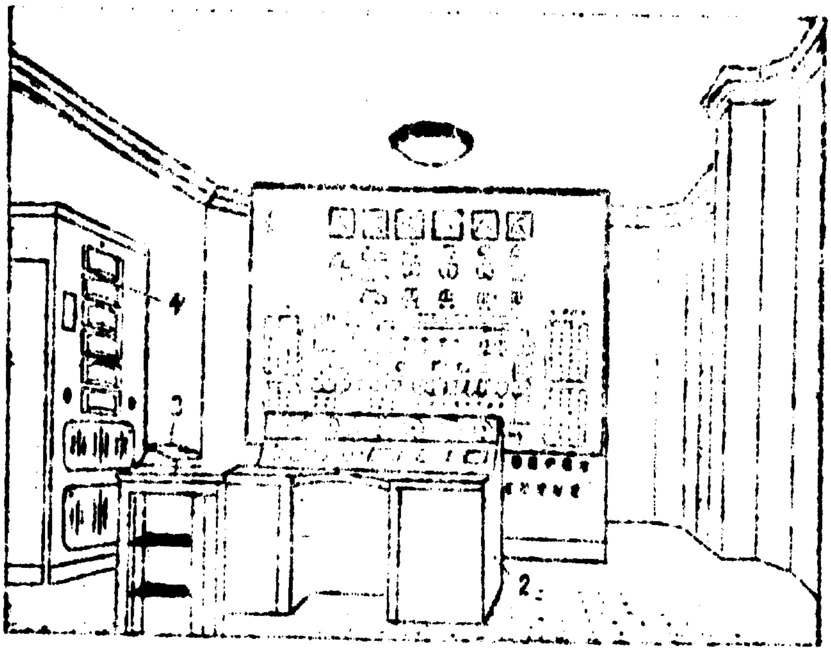


Figure 3 – Control room

1 control panel
2 controller's desk
3 telephone
4 temperature control panel

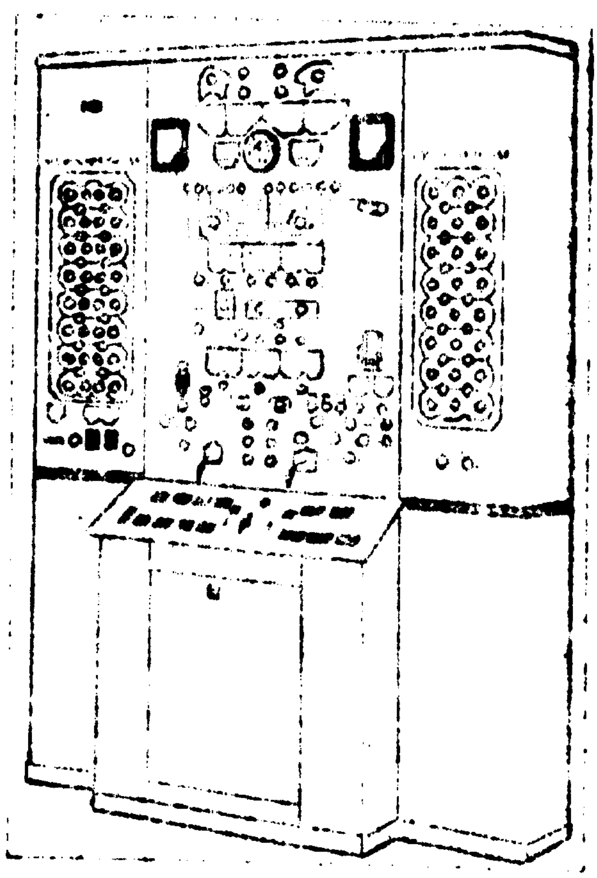


Figure 2 – Control panel

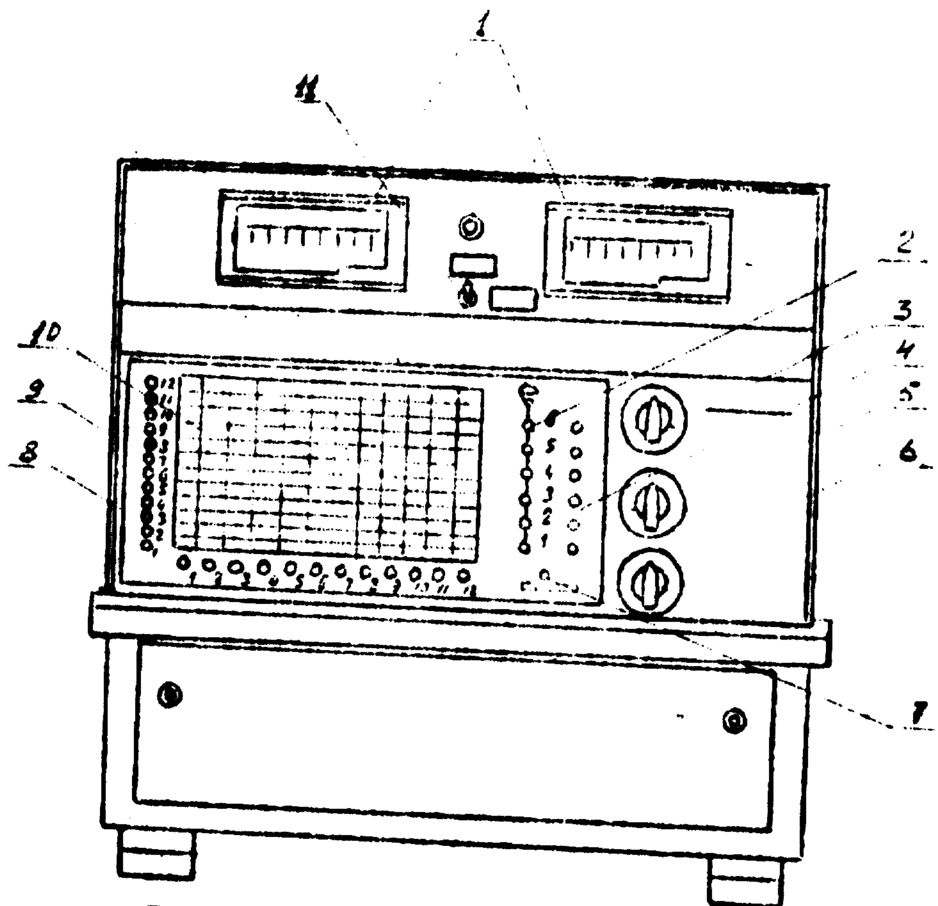
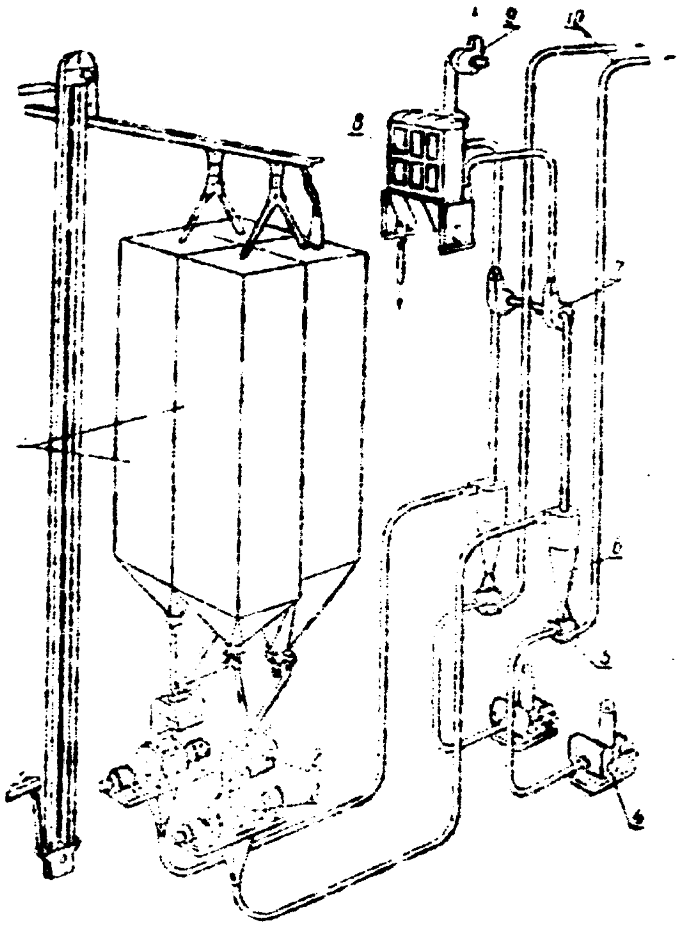


Figure 4 : Temperature control panel

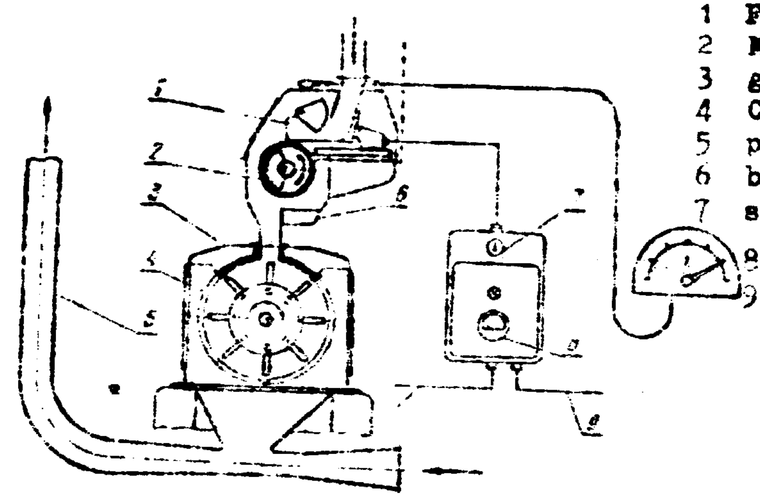
1 ohmmeter
2 thermorecistors signal lamps
3 selection of silo lines
4 selection of thermoresistors
5 selection of relay box
6 selection of silo
7 external air thermometer switch
8 silo signal lamps
9 relay box signal lamps
10 control screen
11 screen switch

Figure 5



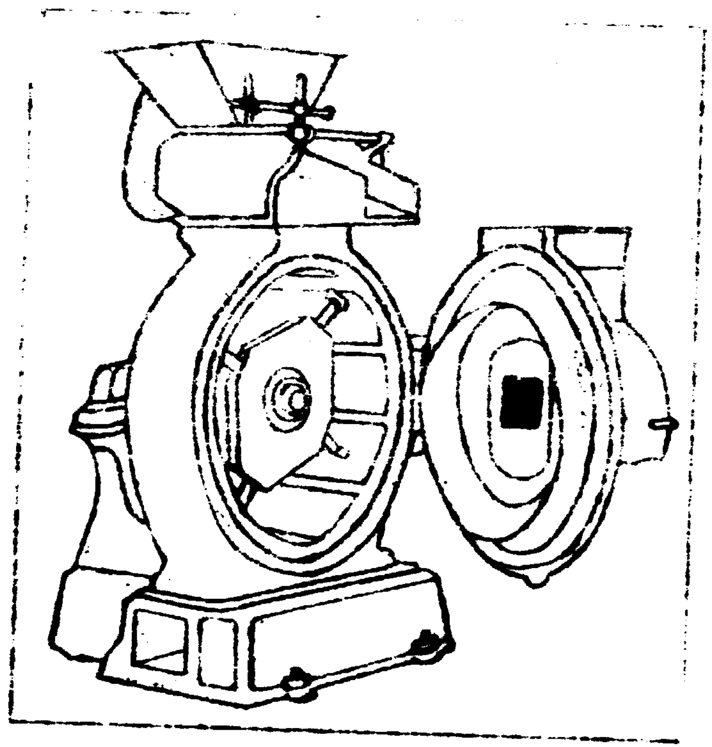
Typical grinding scheme

1 silos
2 feeder
3 crusher
4 aspirator
5 valve
6 cyclone
7) 9) filters
10 pneumatic conveyor
3 filter



Typical Crusher

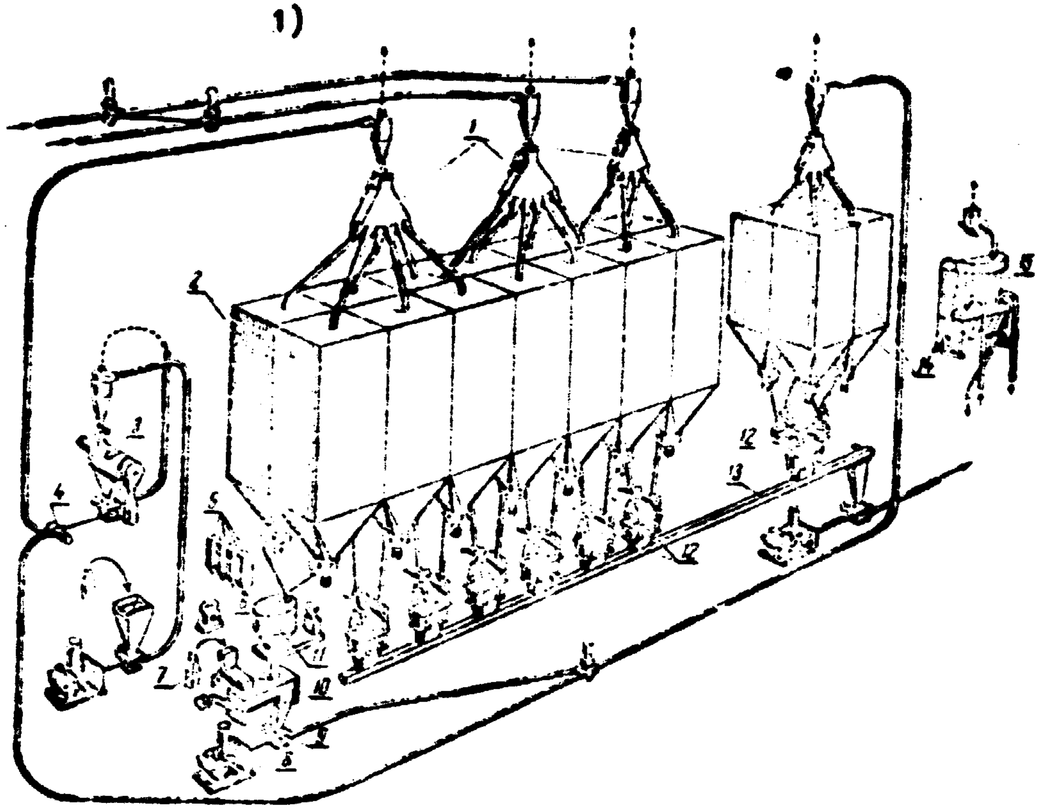
1 Feeder
2 Magnetic reel
3 grinding plate
4 Colter
5 pneumatic conveying
6 box for metal shavings
7 switch
8 ammeter
9 electric system



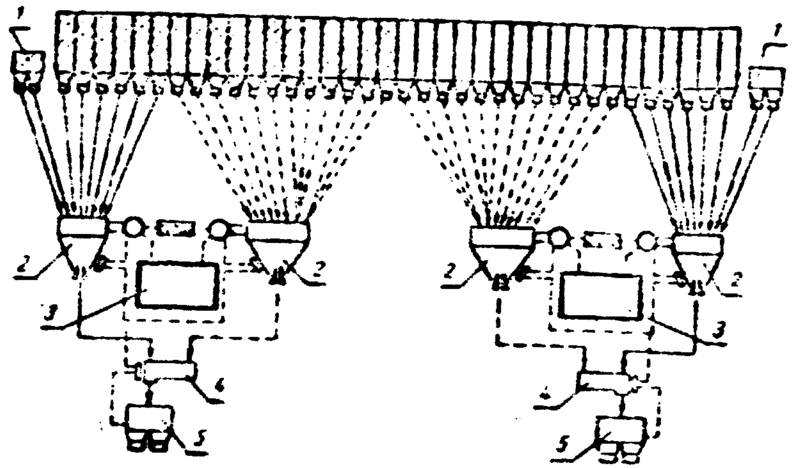
Typical crusher

Figure 6 - Schemes of Portioning

1)



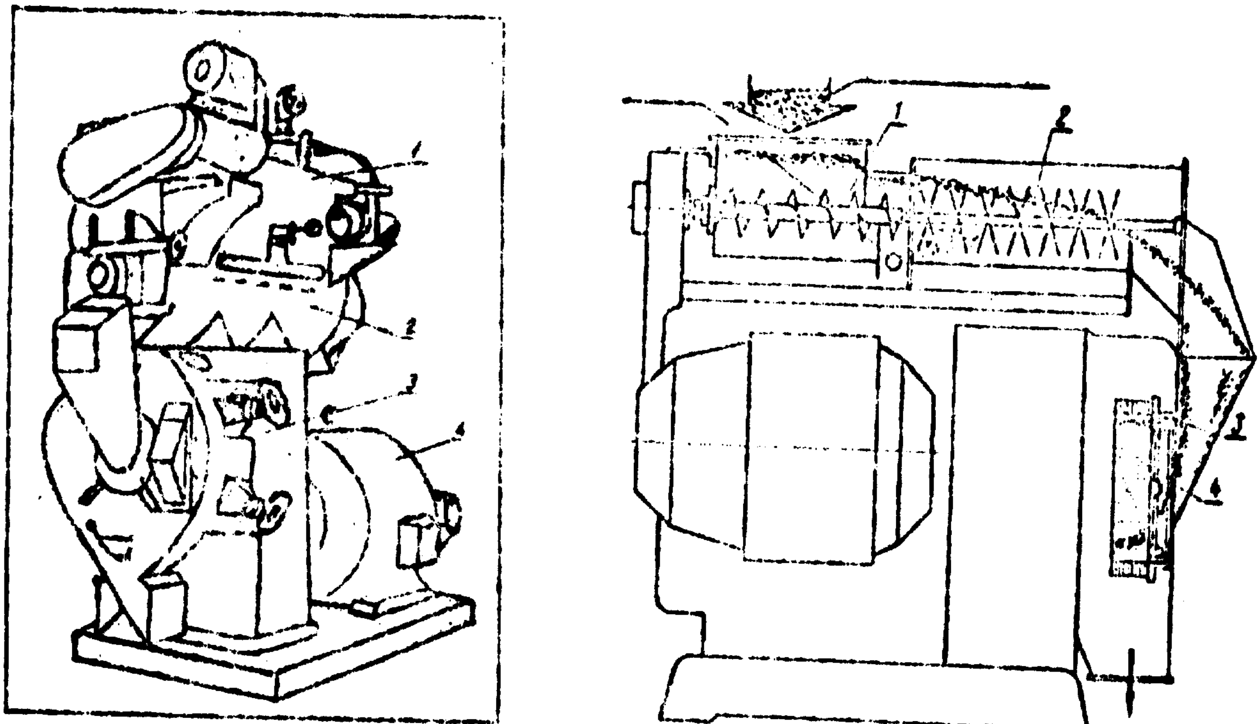
2)



1)
1. distributors
2. silos
3. sifter
4. two way valve
5. bins for ingredients
6. scales
7. feeder
8. air compressor
9. slide valve
10. mixer
11. surge bin
12. scales
13. drag conveyor
14. bins for premixes
15. air filter

2)
1. bins
2. scales
3. control panel
4. mixers
5. live bottom bins

1) 2)



typical

Figure 7 - Pelleter

1) 1 feeder
2 mixer
3 pelleting chamber
4 main electric motor

2) 1 feeder
2 mixer
3 pelleting rollers
4 feedstuff

1)

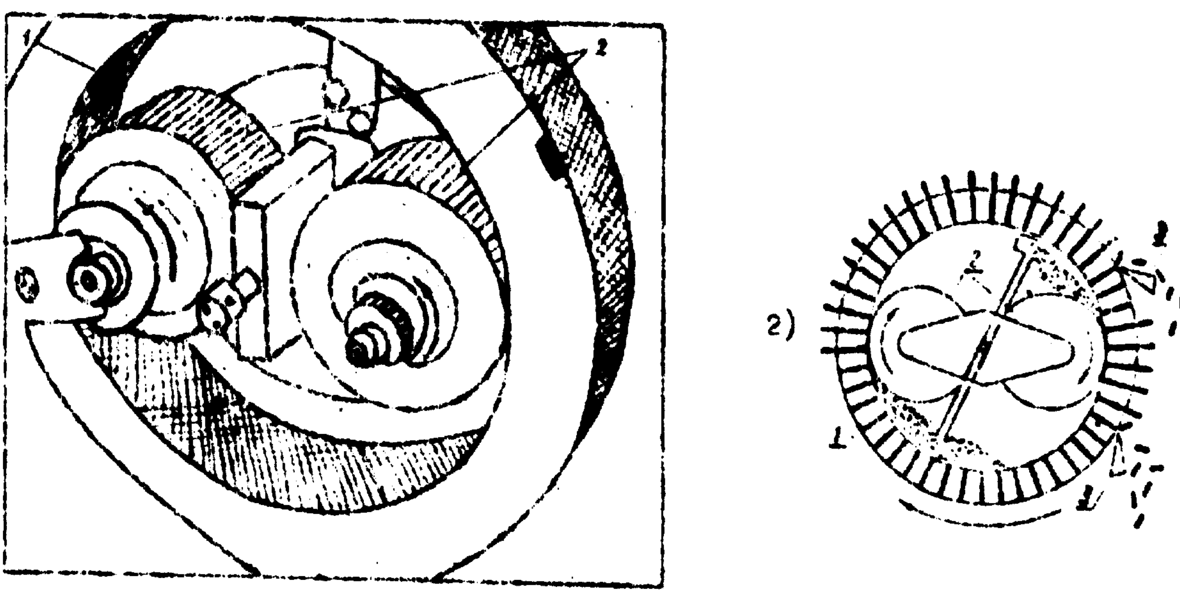


Figure 8 - Pelleting chamber

1) 1 pelleting rollers
2 matrix

2) 1 matrix
2 rollers
3 knives

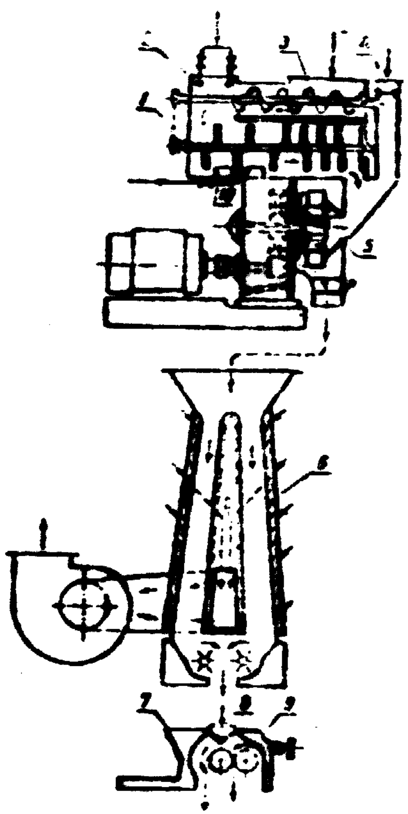


Figure 9 - Typical pelleter system

1 - mixer
2 - spray nozzles
3 - feeder
4 - product feeding
5 - pelleter
6 - cooler
7 - grinder
8 - two way valve
9 - rollers

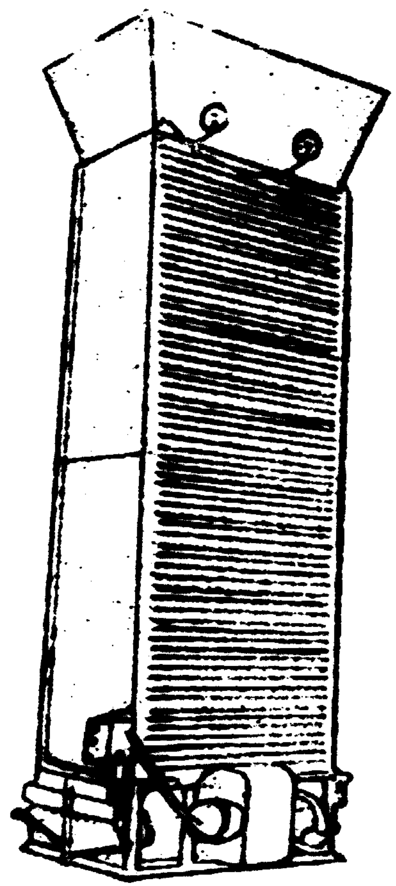
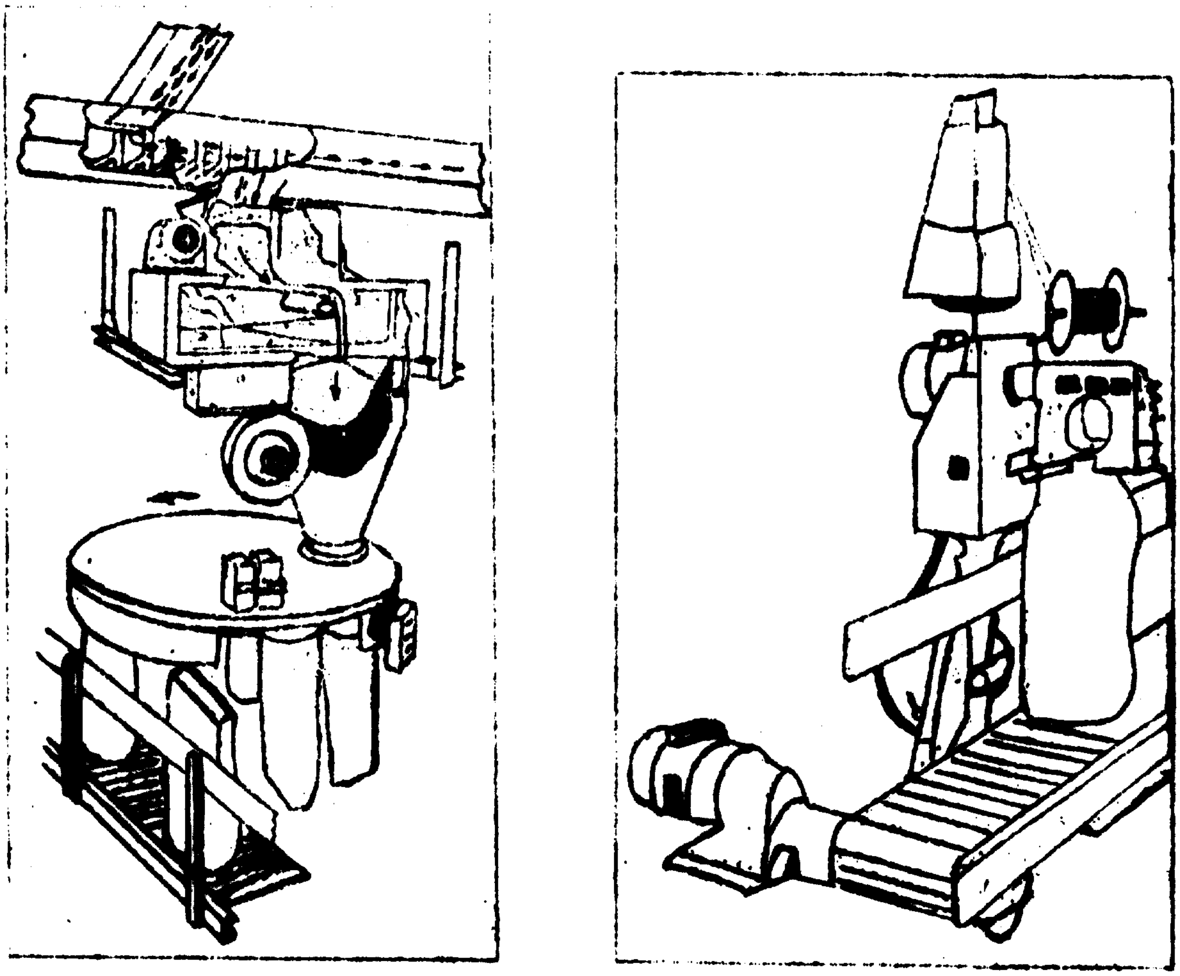


Figure 10 - Cooler (typical)



Automoter

Figure 11 - Packaging Scale and Sack Sewing Machine

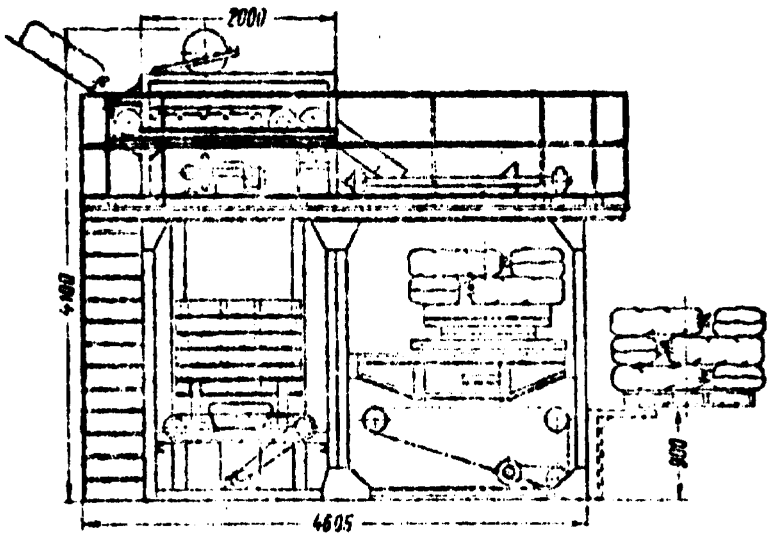


Figure 12 - Bag stacking machine

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