2. The tuber shall be reasonably clean, healthy, and firm—with colour and shape distinct for variety.
3. 3% admixture of other varieties shall be permissible.
4. Mechanical damage, i.e cuts, bruises, injuries, and cracks shall be permissible only up to 5% level.
5. The following maximum percentage of diseases shall be permitted on the basis of visible symptoms: *Rhizoctonia*–2%, wart–none, brown rot–none, powdery scab–0.5%, common scab–2%, blackleg–1%, wet rot–1%, late blight–2%, *Fusarium* and *Verticillium* spp–2%.

PS	Pure seed	NWS	Noxious weed seed
IM	Inert matter	G	Germination
OCS	Other crop seed	MC	Moisture content
WS	Weed seed	NA	Not applicable

Source: Adapted from Ahmad (1989b).

6.7 Seed processing

Seed processing refers to a set of operations (drying, presorting, cleaning, size-grading, and treatment) undertaken to obtain pure and high-quality seed of different crop species.

6.7.1 Drying

Drying means lowering moisture content to levels safe for storage. Seeds have maximum viability and vigour at physiological and functional maturity, and if harvested at this stage have a moisture content ranging from 35 to 45%. Harvesting seed at such an unsafe moisture content will result in heating of the seed and rapid deterioration, particularly in storehouses. This makes drying to a moisture content level of 10–12% or less compulsory for safe seed storage. There are two methods of drying seed: (1) sun drying (natural drying), and (2) forced-air drying (artificial drying).

Sun drying. In dry climates, crops are harvested when they have fully dried in the field. After harvesting and threshing, the seed is spread out in the sun on a clean drying floor or roof of a building and turned frequently. In the rainy season, the seed is brought inside and spread out in a well-ventilated building, where it takes longer to dry. The advantage of this practice is that no additional expenditures or special installations are involved. The disadvantages include risk of weather damage and the possibility of admixture if several varieties are spread on the same threshing floor.

Forced-air drying. In recent years traditional methods of drying (sun drying) have become cumbersome, inefficient, and ineffective. This is due to the increased use of fertilizers, greater plant populations, improved crop varieties, and large acreages. Increased yields demand more efficient and effective seed drying methods which can provide temperature and air circulation to the storage area according to the requirements of the kind of seed stored. In setting up an artificial seed drying programme, one must consider the following things: (1) components of a drying system, (2) types of drying system. The components of a drying system include (a) physical space where seed will be located, (b) source of air supply, (c) source of heat loading and unloading mechanisms.

Drying systems are grouped into the following three types: (a) sack drying, (b) bin drying, (c) continuous-flow drying.

Sack drying. This process is very useful in countries where the seed of major food commodities like wheat, rice, maize, barley, sorghum, etc. are put in jute bags after threshing. The bags are placed on a perforated belt, and air is blown with a fan through the bags from beneath the belt. The bags can be turned over so that they are dried uniformly. Excellent airflow with minimum static pressure (resistance of the seeds to airflow) is possible because the drying bed is just one sack deep. If the surrounding air is moist, a heater can be installed. In this type of drying, the chance of contamination with other varieties is reduced, particularly when the seed lots are small and many varieties are handled. Construction is simple and inexpensive.

Bin drying. The bin drying system is useful and practical when larger quantities of seed are involved. The seed is received from the field and stored in round metal bins with perforated floors. A fan and heater are always installed to supply dry air to the perforated floor of the bin. Such bins of different dimensions can meet the needs of most seedsmen, and can usually be constructed at reasonable cost in most countries.

Continuous-flow or column dryers. This process is suited for drying large volumes of seed, such as rice and other small grains. The seeds are passed mechanically through a vertical column or tower while drying air is blown horizontally across them. Air is forced through the seed in such dryers with an approximate rate of 75–85 m^3 of air per minute per m^3 of seed. Three to four passes are usually enough to dry the seed to a safe moisture level. This system has limited application and is used by large seed concerns only.

6.7.2 Cleaning

This is the process in which undesirable materials such as inert matter, weed seeds, other crop seeds, light and chaffy seeds, and off-size, damaged, or deteriorated seeds are separated from the desirable material (good seeds). Separation of these materials is done on the basis of differences in their physical properties (size, shape, density, surface texture, colour, and electrical/magnetic conductivity).

Seed cleaning operations can be discussed under the two headings: (1) preconditioning and (2) basic seed cleaning.

Preconditioning. The term preconditioning is applied to operations that prepare or condition seed lots for basic cleaning. Preconditioning includes the following operations: (a) shelling (in maize), (b) precleaning (sifting with sieves), and (c) debearding (deawning).

Basic seed cleaning. This process is considered most essential in seed cleaning. It consists of removing materials differing widely in weight and gross size from the desired seeds. This is accomplished with an **air screen cleaner** which utilizes air streams for separation by weight, and a series of perforated screens (sieves) for separation by size. The size of an air screen cleaner varies from small (two-screen farm models) to large industrial cleaners with seven or eight screens, three to four air separators, and capacities up to 3000 kg per hour. In an air screen machine the following three cleaning operations are carried out.

a. Aspiration, in which light material is removed from the seed mass.
b. Scalping, in which good seeds are dropped through the openings of a screen, but larger material is carried over the screen into a separate spout.
c. Grading, in which good crop seed ride over screen openings while smaller particles drop through (Agrawal 1980).

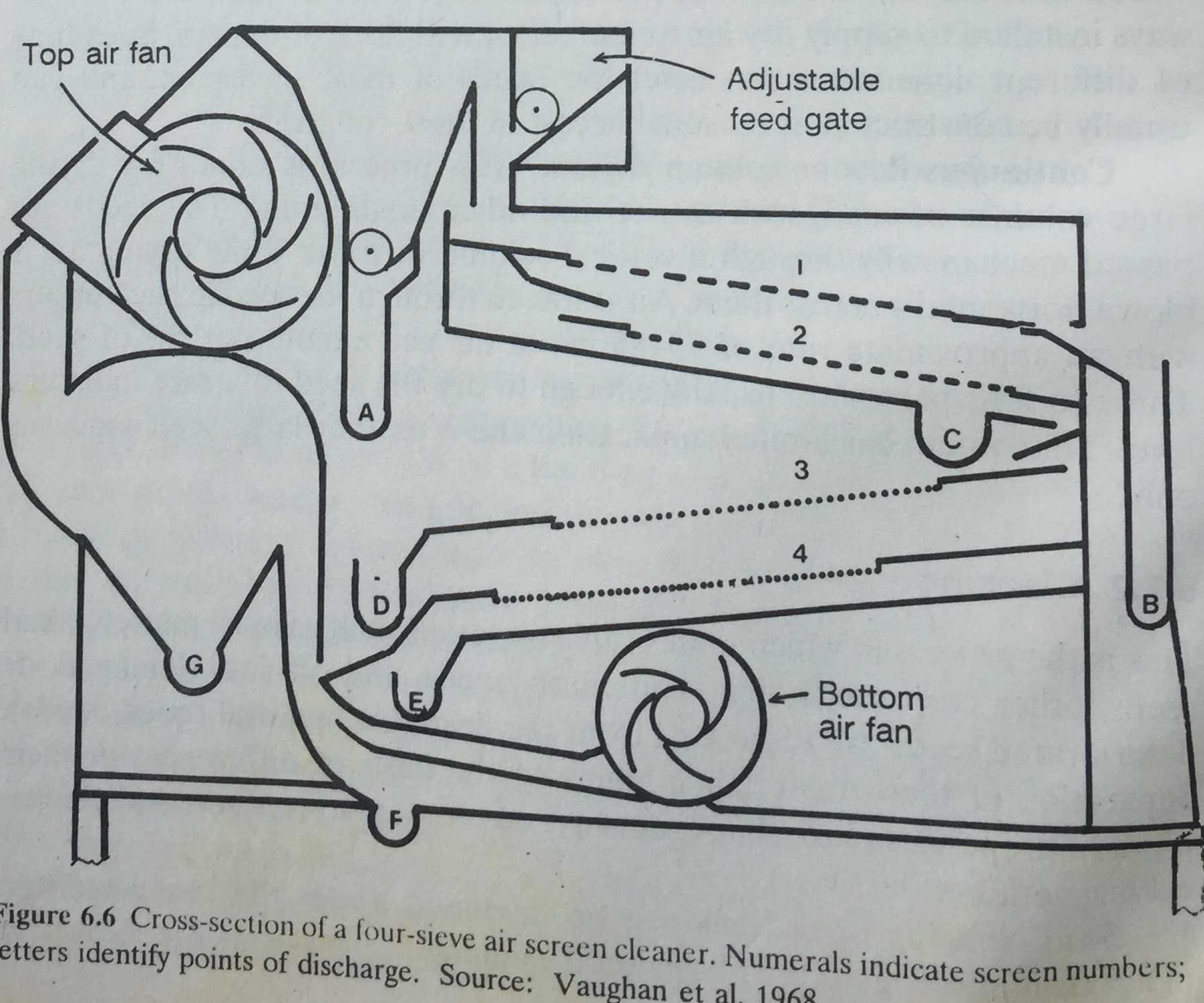

Figure 6.6 Cross-section of a four-sieve air screen cleaner. Numerals indicate screen numbers; letters identify points of discharge. Source: Vaughan et al. 1968.

The most important parts of an air screen cleaner are the feed hopper, shoes, screens, screen cleaning and drive mechanisms, and fans. In a four-sieve air screen cleaner, the following operations are performed (Fig. 6.6).

1. The seed is conveyed to the feed hopper, from where it flows by gravity into a feeding mechanism. Before falling on the top screen (scalping sieve–1), the rough seed is passed through an air stream. Here the light chaffy material is removed through A, and the remaining seed is distributed uniformly over the first scalping sieve. The top screen or scalping sieve is used for rough scalping. Its perforations are large enough to allow the seed to drop through, but small enough to trap foreign materials such as stems, leaves, chaff, dirt, trash, or bigger weed seeds on top of the screen, from where they are carried to the outlet B.

2. The second sieve grades or sizes the seed. Its perforations are small enough to retain the good seed but large enough to allow materials smaller than the seed to drop through and be removed through C.

3. The third sieve scalps the seed more closely. It allows the seed to drop through but checks the bigger materials and takes them to outlet D.

4. The fourth sieve performs a final grading. The finally graded seed is then passed through an air stream which further purifies it and blows out light seed, weed seed, and chaff into a trash container G while protecting the plump and heavy crop seed which moves out through F. The smaller unhealthy seeds drop through the fourth sieve and move out through E.

After a seed lot has gone through the various air screens, it may still contain contaminants similar in width, thickness, and weight to the crop seed. The indented cylinder and disc separator are machines commonly utilized to separate seed based on length differences. Screens of cylindrical, screen-type separators are available in a wide range of sizes because of the many uses of these machines. A combination of gravity and centrifugal force produce pressure which forces the seed into the perforations. This 'press-fit' action insures that particles smaller than the openings pass through (Figs. 6.7 and 6.8).

Separation by length. An **indented cylinder separator** consists of a rotating horizontal cylinder and an adjustable horizontal separating trough inside the cylinder. The inside surface of the cylinder has thousands of small, closely spaced, hemispherical indents (Fig. 6.8). The seed enters at one end and discharges at the other. As the cylinder rotates, the short seeds and other short material fit into the indents and are lifted out of the seed mass and discharged into the trough. The long, pure seeds not lifted by the indentations move towards the other end of the cylinder and are discharged in a

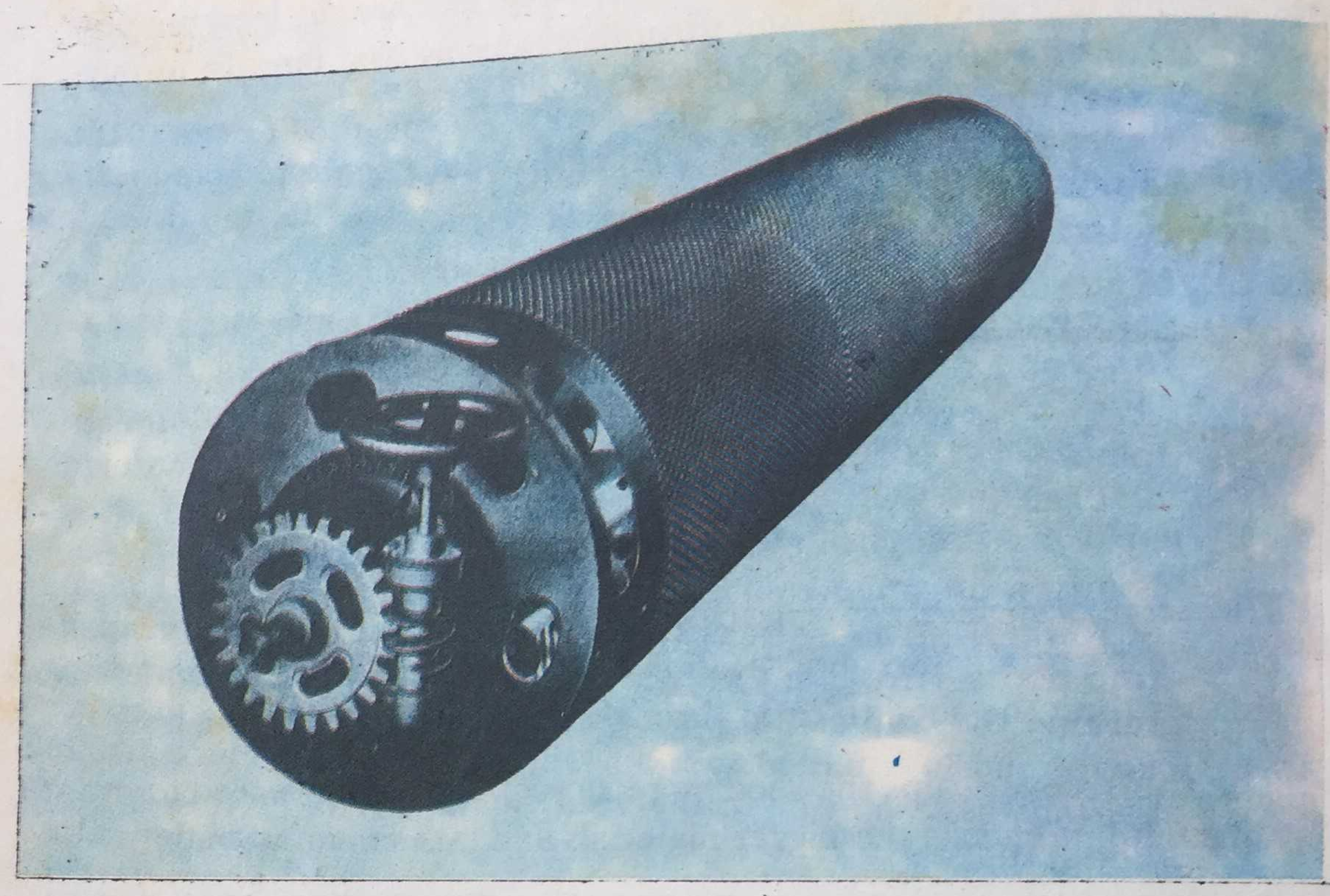

Figure 6.7 View of indented cylinder showing trough adjustment. Source: Vaughan et al. 1968.

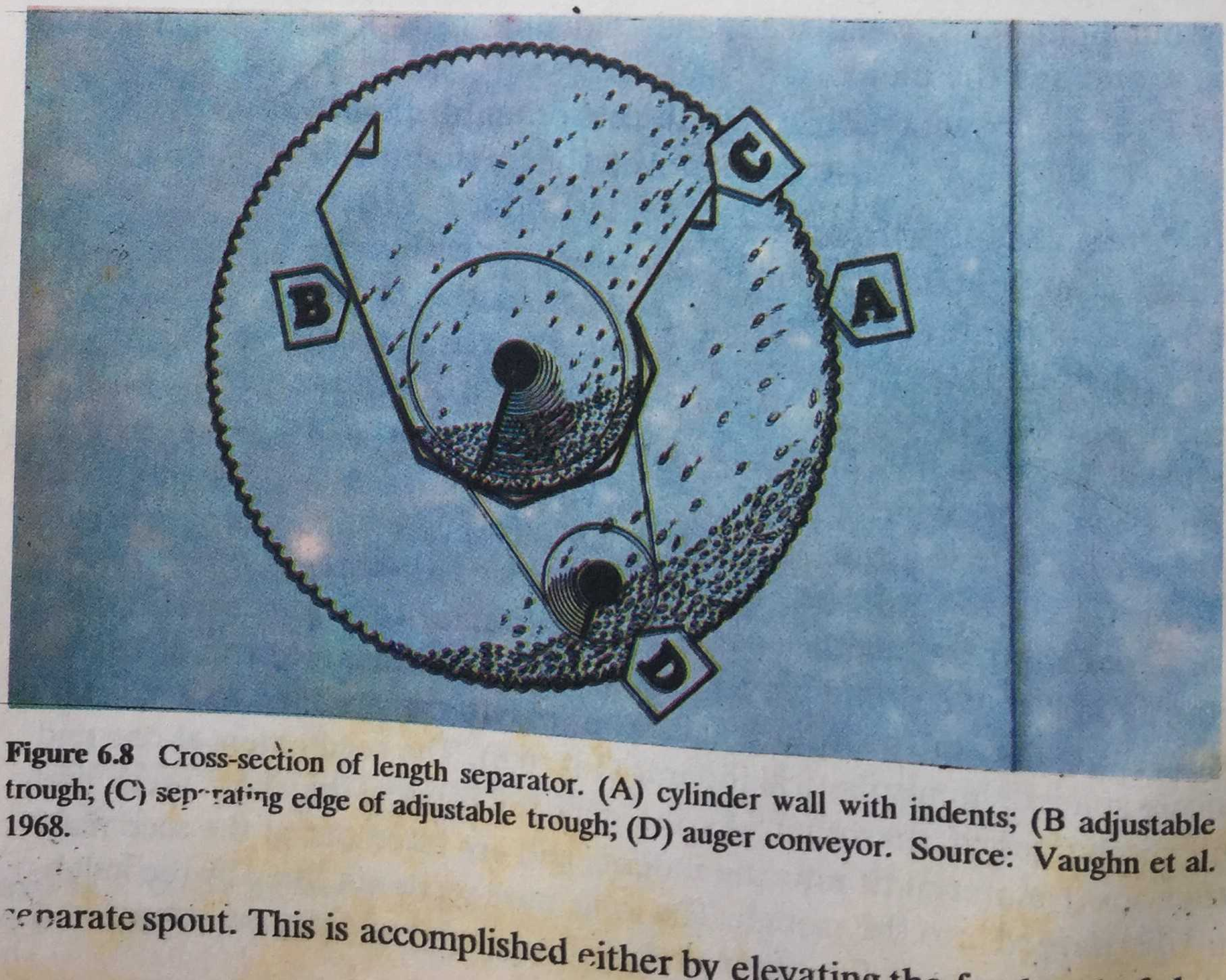

Figure 6.8 Cross-section of length separator. (A) cylinder wall with indents; (B adjustable trough; (C) separating edge of adjustable trough; (D) auger conveyor. Source: Vaughn et al. 1968.

separate spout. This is accomplished either by elevating the feed end of the machine to a point that allows the material to flow uniformly through the cylinder, or by a screw/auger conveyor or grain line blades.

A **disc separator** (auger) consists of a series of indented discs which revolve together on a horizontal shaft. Each disc contains hundreds of pockets on each side (Fig. 6.9). As the discs revolve, the seeds enter the in-

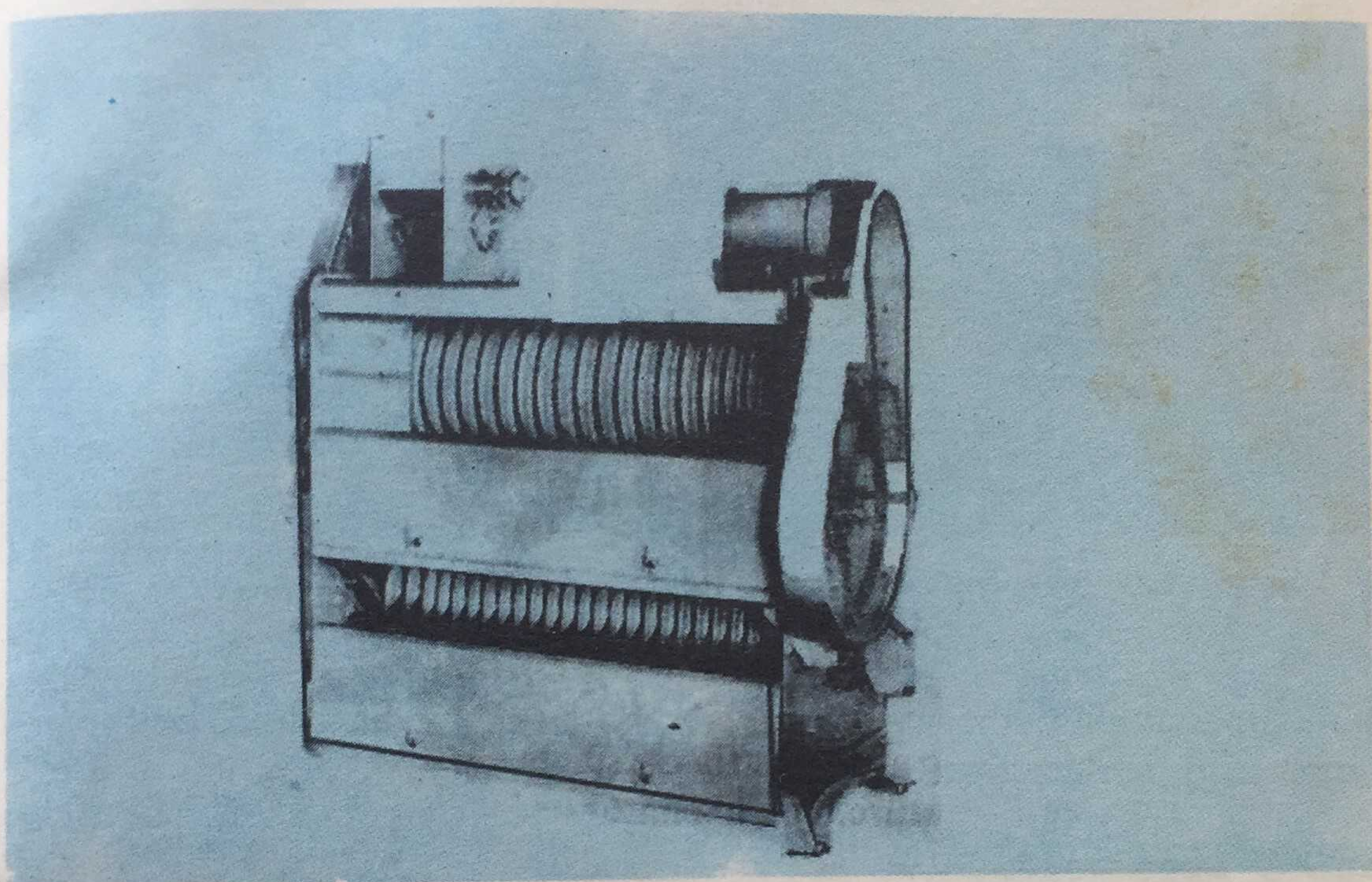

Figure 6.9 Disc separator, Model 1547. Source: Vaughan et al. 1968.

take end of the separator and move through the spokes of the disc towards the opposite end. The short materials fit into the disc pockets and are lifted out of the seed mass. The long seeds being rejected from the pockets move through the discs to the discharge end.

Width and thickness graders. In these graders, seeds are separated into grades of homogeneous width and thickness. Seeds from the feed hopper enter a cylindrical perforated screen. Oblong slots (perforations) are used to separate by thickness, producing 'flats' which go through the perforations and 'rounds' which stay inside the screens (Fig. 6.10).

Round perforations are used to separate by width, producing 'narrows' which go through the perforations and 'wides' that stay inside the cylindrical screen. These machines are extremely sensitive and precise, and perform separation of particles according to their width and thickness dimensions. They are modifications of air screen cleaners, but are more accurate than the air screen machines.

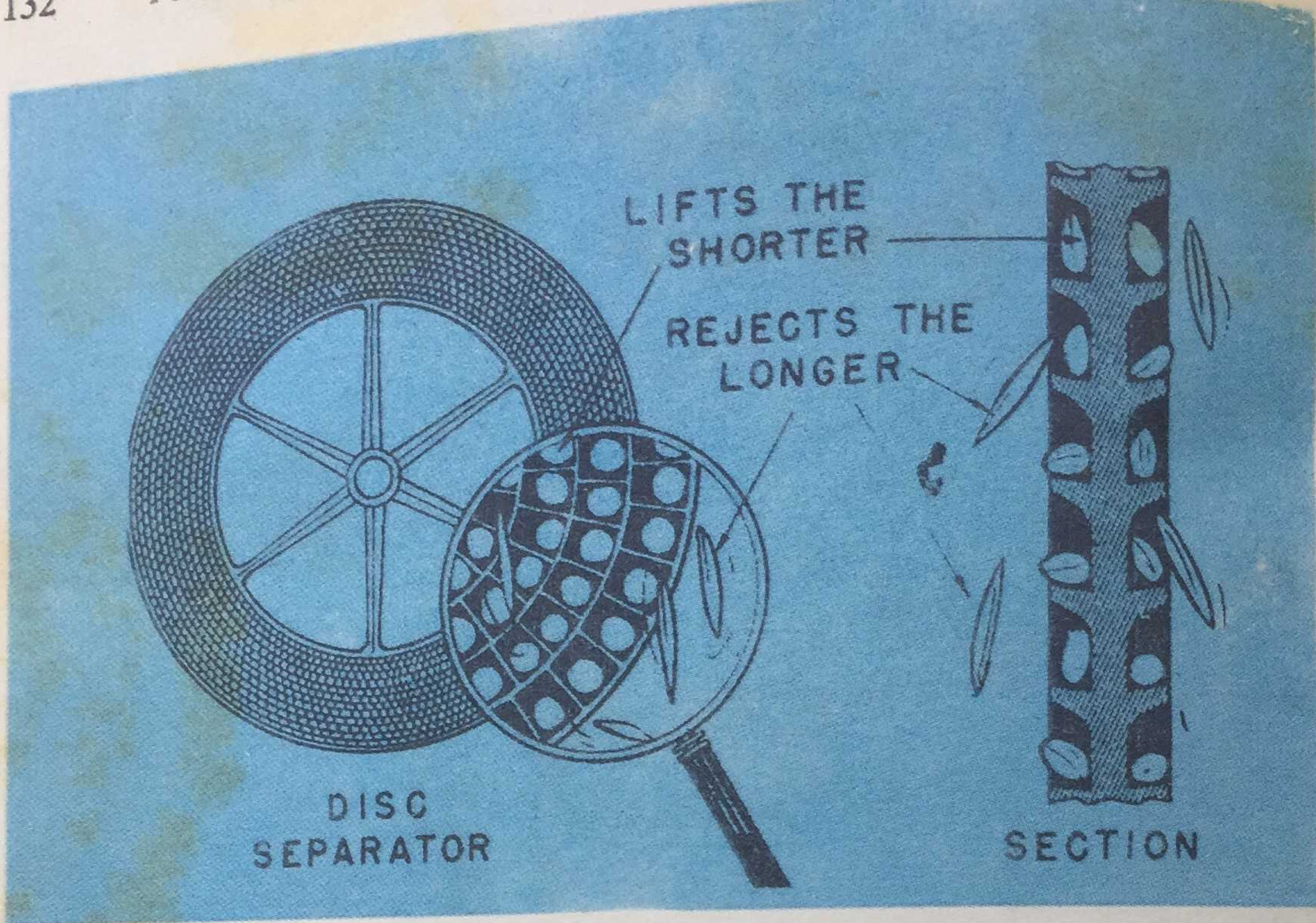

Figure 6.10 Face and cross-section of a single disc. Source: Vaughan et al. 1968.

In addition to the above methods, seeds can also be graded on the basis of density, surface texture, and chemical and electrical affinity.

6.7.3 Seed treatment

The operation of seed treatment is usually the last step in the processing of seed. Seeds are treated with fungicide and/or insecticide or any other material or technique to disinfect the seed and seedlings against seed and soil-borne diseases, organisms, and insects in storage and in the fields. The treated seed should be identified by giving the seed a contrasting colour or by labelling the container **'POISON'** and affixing a special tag showing the outline of a skull-and-crossbones.

Properties of disinfectants. An ideal seed-treatment chemical should possess the following qualities.

a. Highly effective against pathogens
b. Not harmful to humans and livestock even if misused
c. Stable and durable during seed storage
d. Easy to use and economically affordable
e. Non-toxic to plant life

Types of seed-treatment chemicals. Chemicals may be applied to disinfect, disinfest, or protect the seed and seedling formulated as: (a) slurry—a mixture of wettable powder and water, (b) dust, or (c) liquid.

Special equipment exists for applying these types of formulations, but if such equipment is not available the treatment may be done with a revolving metal drum or cement mixer. In agro-chemistry old products are continuously replaced by more effective ones. However, some of the commonly used seed treatment chemicals are listed in Table 6.3.

Table 6.3 Commonly used seed treatment chemicals

Name of chemical	Active ingredient (%)	Crop	Disease
Arasan 5 red	Thiram 50%	Maize, rice, sorghum, safflower, flax, millet, soybean, pea	Damping off, seed rot, blights
Agroson–GN	1% Dust	Tomato, okra, onion, squash, watermelon, cucumber, pumpkin	Loose and kernel smuts
Ceresan–wet	2.15%	Rice	Loose and kernel smuts
Captan–4 (flowable SPR)	Captan 39%	Alfalfa, clover, bean, beet, rice, barley, rye, wheat, maize, cotton, grasses, vegetables	Seed decay, damping off, seedling blight
Agrox 2-way	Captan Diazinon	Maize, soybean	
Agrox 3-way	Lindane Graphite	Bean, pea	

6.8 Seed storage

The purpose of storing seeds of cultivated plants is to preserve planting stocks from one season until the next. The basic reason behind various storage practices is the effort to maintain the physiological quality of seed throughout the storage period by minimizing the rate of deterioration.

6.8.1 Factors affecting seed quality

The following factors affect the storage life of seeds.

1. Humidity
2. Temperature
3. Air (oxygen and carbon dioxide content)
4. Direct sunlight
5. Kind of seed
6. Kind and number of fumigations
7. Effect of seed treatment
8. Attack by rodents, insects, and moulds