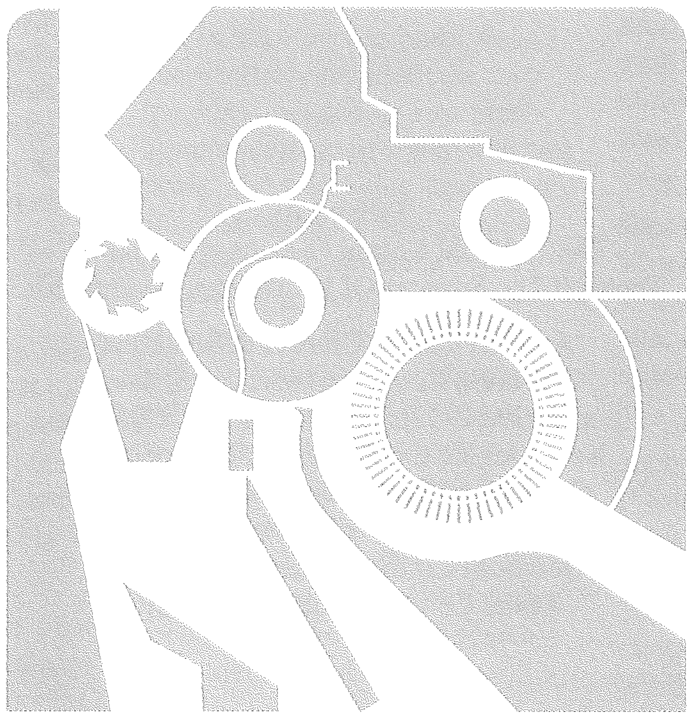
INTRODUCTION TO A

COTTON GIN



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Gin Safety

Every employer has the responsibility of providing a safe working environment. Providing safe, comfortable working conditions is a good business investment when considering the costs of accidents and health problems. A general safety program should be developed for each gin, including the education of employees on unsafe conditions, practices, and behavior. Basic gin safety materials to create a gin safety program are available from your state/regional ginners association or from National Cotton Ginners Association, P.O. Box 820285, Memphis, Tennessee 38182.

INTRODUCTION TO A COTTON GIN

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Cotton fibers must be separated from the seed (ginned) before they can be used to manufacture textile goods. The first machine to gin cotton was the "Churka" gin. The "Churka" gin was most efficient when handling naked seeded varieties with loosely attached fibers. Early American settlers found that the fuzzy seeded varieties that yielded best in this country were difficult to gin on a roller gin. Consequently, the fiber was generally pulled from the seed (ginned) by hand until Eli Whitney patented his gin in 1794.

Whitney's gin used spikes on a hand-driven cylinder to remove fibers from the seed. The spikes pulled lint through slots that were too narrow for the seeds to pass. A revolving brush then removed the lint from the spikes. Whitney's gin could process as much cotton as 100 people could gin by hand. This invention enabled cotton growers to rapidly expand production, and marked the beginning of the modern cotton industry.

Henry Ogden Holmes received a patent in 1796 for an improved gin that used saws rather than spikes to remove the fibers from the seed. The saws were spaced on a shaft to provide openings that allowed the clean seed to drop out the bottom. Holmes' invention made ginning a continuous rather than a batch process, and greatly increased capacity. The basic principles developed by Whitney and Holmes are used in modern gin stands, but there have been many improvements.

When cotton was hand picked and carefully handled, the only machines needed in a ginning system were a gin stand, a baling press, and conveying equipment. Rougher hand harvesting methods and mechanical harvesters caused more moisture and foreign material (trash) to be mixed with the seed cotton. Thus, seed cotton cleaning and drying equipment and lint cleaners were developed to compensate for the trashier harvesting methods. Currently, about three-fourths of the U.S. crop is harvested with spindle pickers and one-fourth with mechanical strippers.

There is a major difference in the trash content of the spindle picked and stripper harvested seed cotton. On the average, about 2,200 pounds of stripped seed cotton containing about 800 pounds of trash are required for a 480-pound bale of lint. About 1,500 pounds of spindle picked seed cotton, containing about 120 pounds of trash would be required for a bale.

Storing Seed Cotton

Seed cotton can be safely stored in modules or trailers if its moisture content is kept at 12 percent or less. Wet cotton or cotton containing green plant material will heat during storage and quickly deteriorate. Cotton damaged in this manner produces low grades and poor quality seed. Fresh modules should be checked daily. If the temperature inside a seed cotton module exceeds 110°F, it should be ginned immediately to prevent further deterioration.

Modules of dry seed cotton should be carefully formed so water will run off the top and sides, placed on a well-drained site, and covered with good quality tarpaulins.

Cotton rope should be used to anchor the module coverings. Plastic twine should not be used to tie down covers since pieces of this material can get into the cotton and become a serious contamination problem at the textile mill.

Machinery in the Saw Ginning System

Quality preservation during ginning requires the proper selection and operation of each machine in a ginning system.

Automatic Feed Control

Gin machinery operates more efficiently when the cotton flow rate is constant. In early gins the flow rate was often erratic because of the variable work rate of the man operating the unloading system. The automatic feed control was developed to solve this problem by providing an even flow of cotton to the gin's cleaning and drying system. A mechanical module feeder also performs a similar function and may be used to feed seed cotton directly from a module.

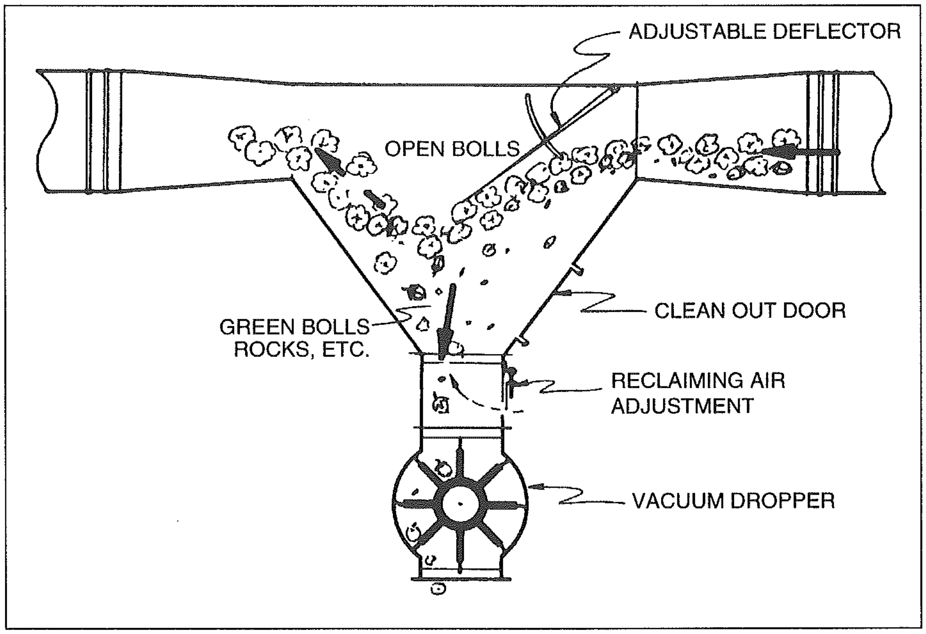

Figure 1: The green boll trap removes heavy objects such as green bolls and rocks from the seed cotton.

Green Boll Trap

The green boll trap is important for removing green bolls, rocks, and other heavy foreign matter from rough cotton. These large, heavy materials should be removed early in the ginning system to prevent damage to machinery and to preserve fiber quality. Green boll traps use sudden changes in flow direction and/or reduced air velocities to separate heavy foreign materials from seed cotton. A typical green boll trap is shown in Figure 1.

Driers

The most important factor in preserving quality during ginning is the fiber moisture content. At higher moistures, cotton fibers are stronger, but trash is harder to remove and cleaning machinery is less efficient. Consequently, selecting a ginning moisture content is a compromise between good trash removal and quality preservation. For most conditions, cotton should be ginned at 6 to 7 1/2 percent lint moisture.

The tower drier is the most widely used gin drier. Tower driers commonly have 16 to 24 shelves arranged so cotton must slow down while making turns through the machinery (Fig. 2). Heated air conveys the cotton through the shelves in 10 to 15 seconds. Practically all of the approximately 1,600 gins in the United States are equipped with at least one stage of seed cotton drying, and most ginning systems have two stages.

The temperature of the conveying air is regulated to control the amount of drying. To prevent fiber damage, the maximum temperature in the drying system should be kept below 350 °F. The temperature control sensor should be located near the entrance to the drier and a maximum temperature limit switch should be located between the burner and the mix point to keep the temperature below 350°F. If the temperature control sensor in your gin is located near the bottom of the drier, the reading may be 200-240 degrees lower than the temperature at the mixpoint.

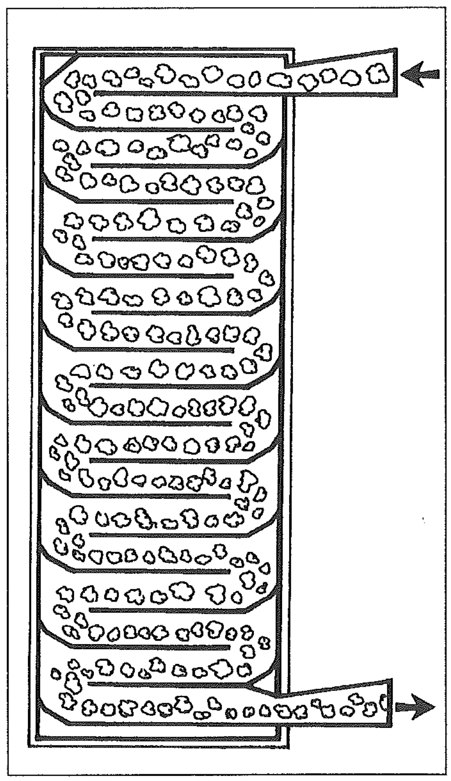

Figure 2: The tower drier reduces the seed cotton moisture content for smooth ginning.

Seed Cotton Cleaners

Seed cotton cleaners (cylinder cleaners) consist of six or seven revolving spiked cylinders that turn about 400 r.p.m. (Fig. 3). These cylinders convey the cotton over a series of grid rods or screens, agitate the cotton, and allow fine foreign materials such as leaf trash and dirt to fall through openings for disposal. In many gins, two cleaners are installed in parallel (split stream), with each one cleaning half the seed cotton.

Seed cotton cleaners break up large wads and generally get the cotton open and in good condition for additional cleaning and drying. Cylinder cleaners may also be used to remove seed cotton from the hot air line as it comes from the drier. They may be used in either a horizontal position or inclined at an angle of about 30 degrees (inclined cleaners).

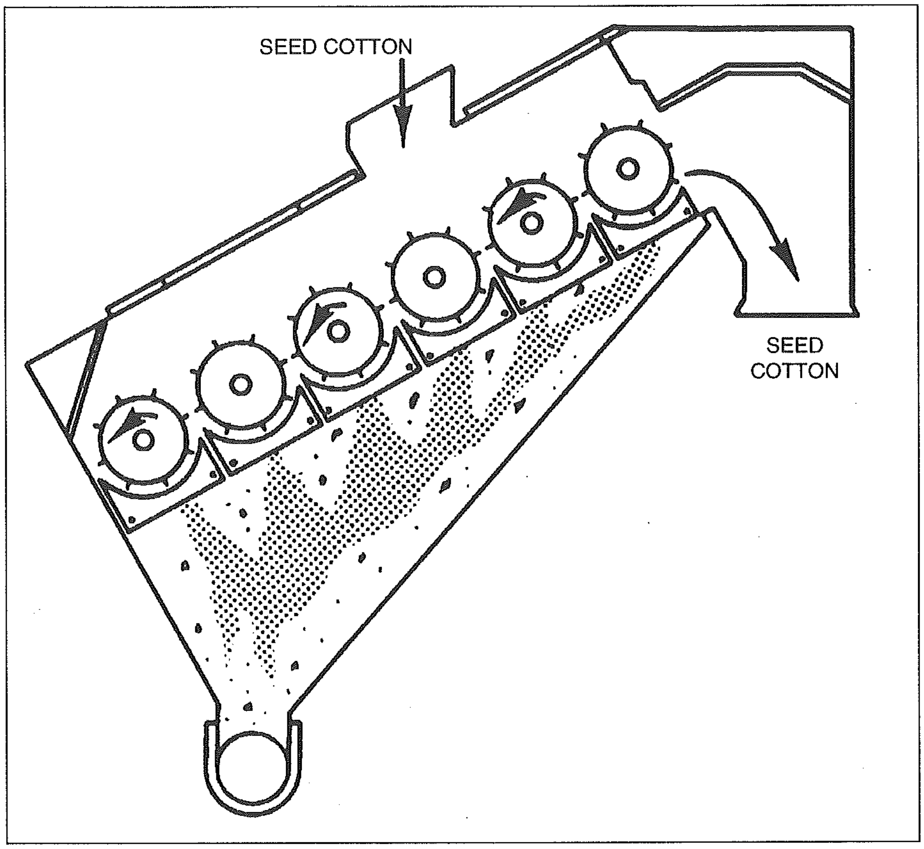

Figure 3: The cylinder cleaner breaks up seed cotton wads for improved drying and removes small foreign matter.

Stick Machines

The stick machine (stick and green leaf machine) was developed to remove the extra foreign matter taken from the plant by mechanical harvesters (Fig. 4). Stick machines use the centrifugal force created by high-speed saw cylinders to sling off foreign material while the fiber is held by the saw.

Inside a stick machine, seed cotton is wiped onto the sling-off saw teeth by stationary wire brushes. Grid bars or stationary wire brushes are located around the saw cylinder to reduce the amount of seed cotton that is thrown off the cylinder. Some models have two sling-off cylinders while others use only one.

The seed cotton which is thrown off with the foreign matter is picked up by reclaimer saws and put back into the seed cotton stream. Reclaimer saw cylinders are similar to main sling-off cylinders, but usually run slower and have more grid bars. The foreign matter that is slung off the reclaimer feeds into the trash handling system.

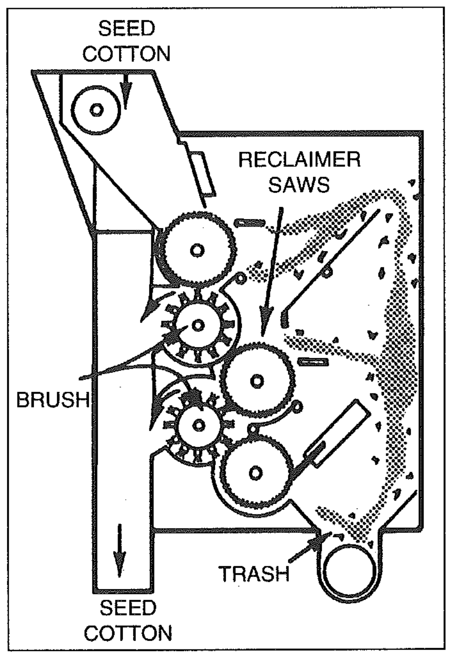

Figure 4: The stick machine primarily removes plant parts 1-4 inches long.

Extractor-Feeders

The primary function of an extractor-feeder is to feed seed cotton uniformly to the gin stand at controllable rates (Fig. 5). Seed cotton cleaning is a secondary function. Feed rollers, located at the top of the extractor-feeder and directly under the distributor hopper, control the feed rate of seed cotton to the gin stand. These feed rollers are powered by variable-speed motors controlled manually or automatically by various interlocking systems with the gin stand.

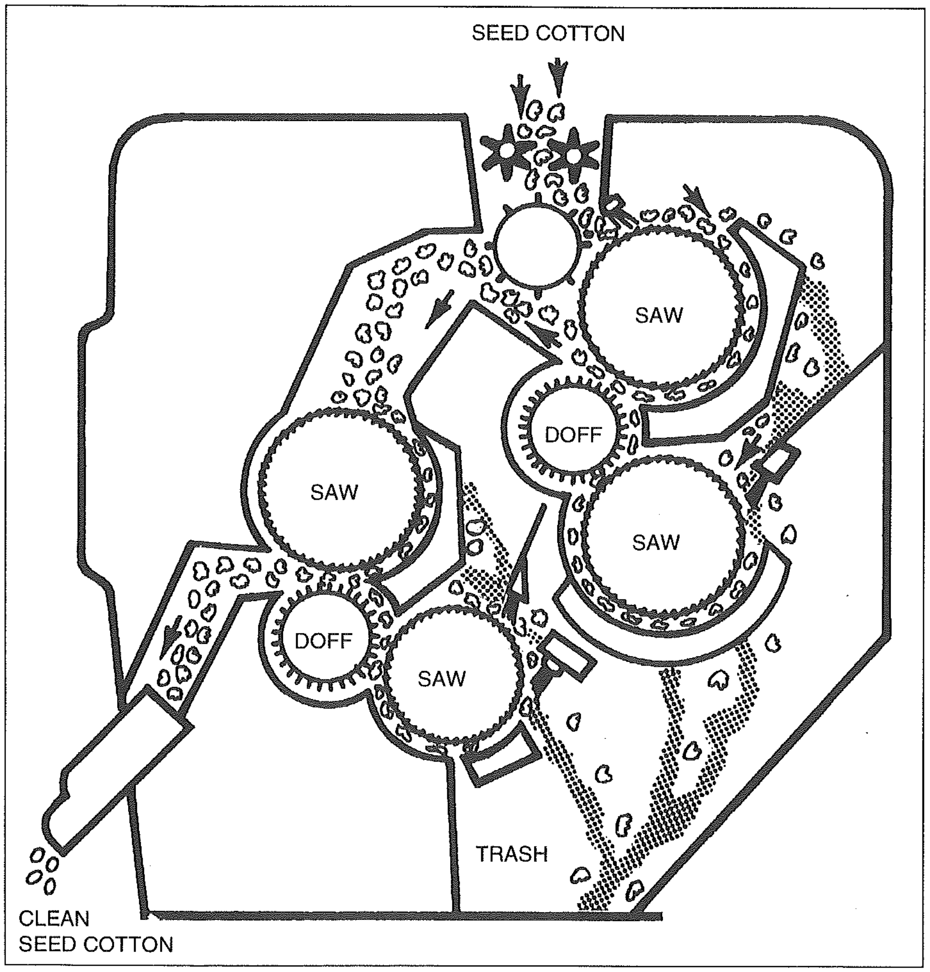

Figure 5: The extractor-feeder, the final stage of seed cotton cleaning, delivers seed cotton uniformly to the gin stand.

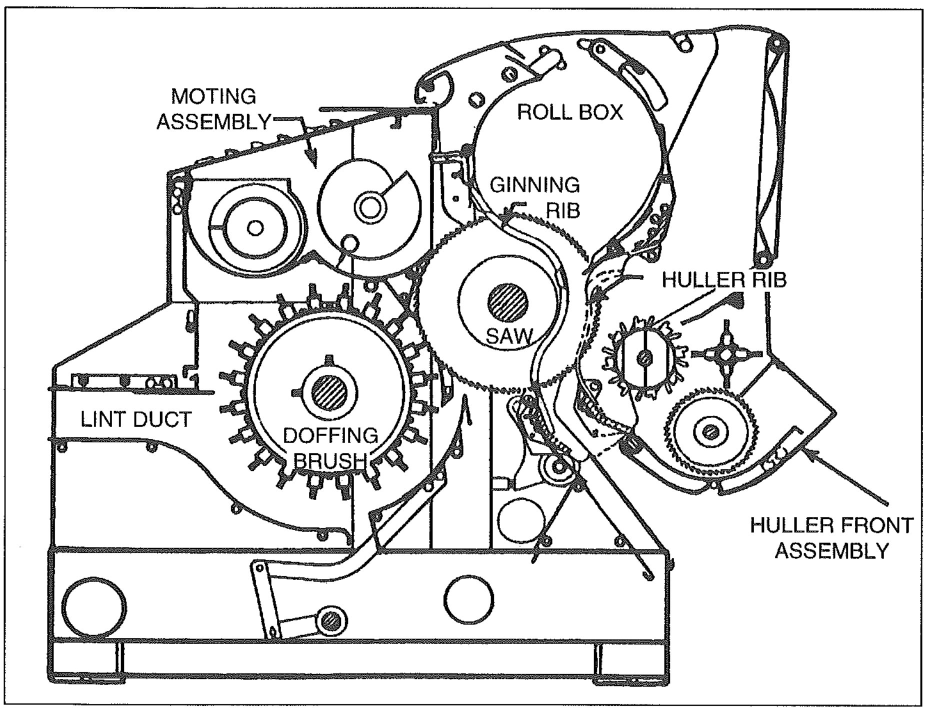

Figure 7: Traditional brush-doffed gin stand with huller front which actually gins cotton (separates the seed from the fiber).

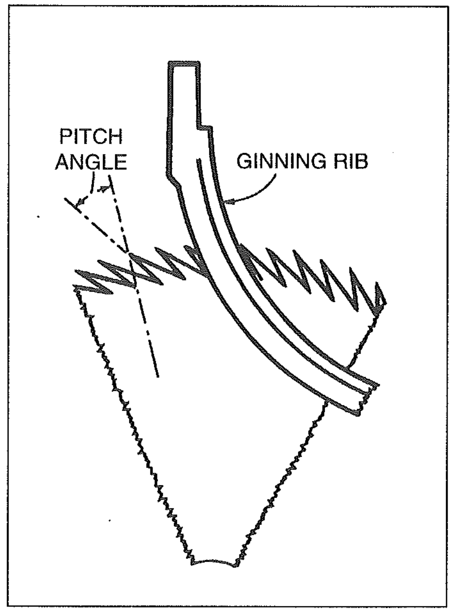

Figure 6: During ginning, the fibers are carried through a slot between the ribs by the saw tooth at right angles to the face of the rib, avoiding a scissors action which would cut the fiber.

Gin Stand

The gin stand consists of a set of saws rotating between ginning ribs (Fig. 6). The saw teeth pass between the ribs at the ginning point. Here the leading edge of the teeth is approximately parallel to the rib to pull the fibers from the seed rather than cutting them.

On traditional gin stands, cotton enters the stand through a huller front (Fig. 7). The saws grasp the cotton and draw it (in locks) through a widely spaced set of ribs known as "huller ribs". This causes hulls and sticks to fall out of the machine. The locks of cotton are drawn into the bottom of the roll box through the huller ribs.

Newer gin stand designs have eliminated the huller fronts, dropping the seed cotton directly into the roll box from the feeder apron (Fig. 8). This change increases stand capacity, but obviously eliminates the final stage of seed cotton cleaning.

The actual ginning process (separation of lint and seed) takes place in the roll box of the gin stand. When all the long fibers are removed, the seeds slide down the face of the ginning rib between the saws and fall onto a conveyor under the stand. Lint is removed from the saw by a rotating brush or by an air blast. It is then conveyed to the next machine in the ginning system, usually a lint cleaner.

Saw-Type Lint Cleaner

In the lint cleaning process, a condenser removes the fiber from the conveying air stream and forms it into a batt (Fig. 9). The batt is introduced to the lint cleaner saw cylinder which normally rotates at approximately 1,000 revolutions per minute. The saws carry cotton over grid bars which, aided by centrifugal force, remove immature seeds (motes) and foreign matter. The cleaned lint is removed from the saw by a rotating brush which also provides air to convey it to the next machine.

Lint cleaners can improve the grade of cotton by removing foreign matter if the cotton has the necessary color and preparation characteristics. Lint cleaners may also blend light spotted cotton so that it becomes a white grade. But fiber length and several other important quality factors can be damaged by excessive lint cleaning, especially when the cotton is too dry.

For average machine-picked cotton, the first stage of lint cleaning will remove 20-30 pounds of lint and foreign matter from each bale. The second lint cleaner would be expected to

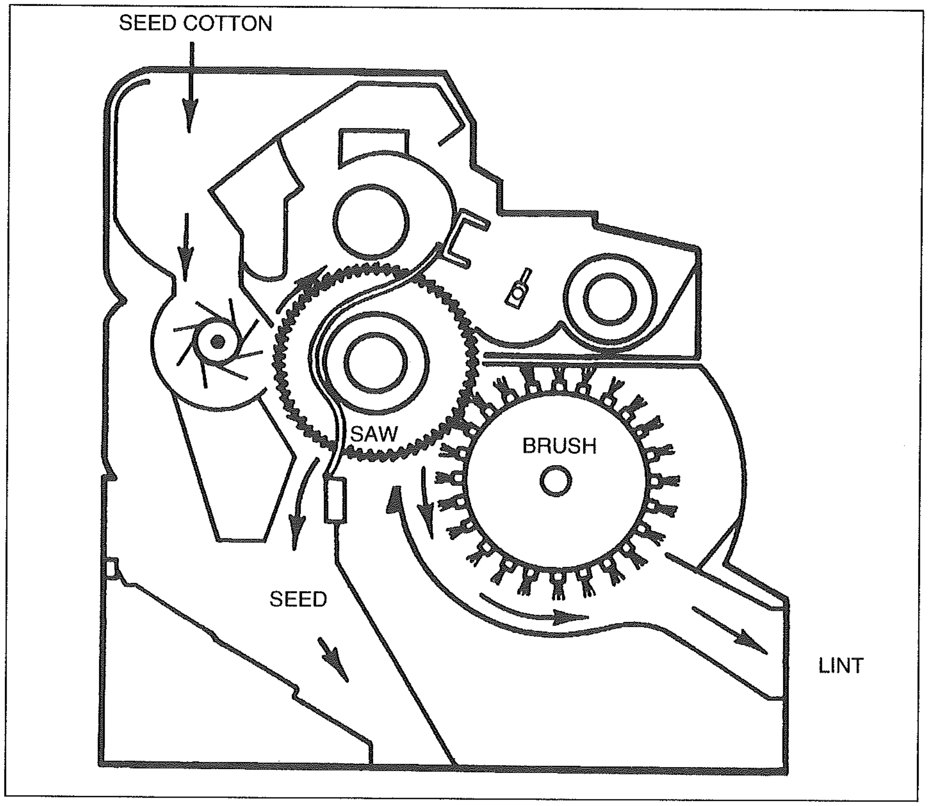

Figure 8: A modern, high capacity gin stand without a huller front.

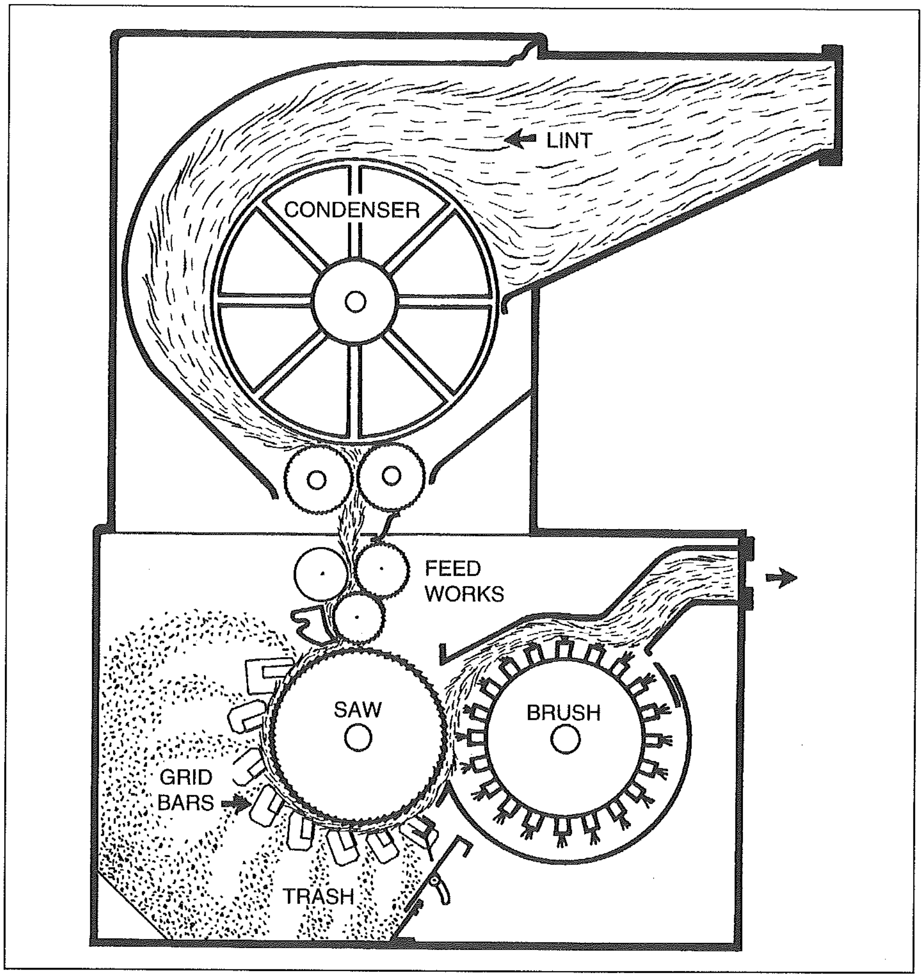

Figure 9: A typical saw-type lint cleaner which removes trash and blends and combs the fiber.

remove an additional 10-12 pounds and the third stage about 6 pounds.

Determining the number of lint cleaners that gives maximum bale value is a compromise between increased grade and reduced length, turnout, and other fiber quality factors important to textile manufacturers. The price differentials for grade and staple length have a great influence on this decision. Under most circumstances, one or two saw-type lint cleaners will give the best economic returns. Consequently, ginning systems should be designed so that all saw-type lint cleaners after the first stage can be by-passed.

Bale Press

Cotton must be baled and packaged to protect it from contamination during transportation and storage. The U.S. cotton industry has adopted the universal density bale with a nominal density of 28 pounds per cubic foot. Universal density bales may be produced at a compress from modified flat bales, or they may be produced at the gin with a universal density (U-D) press. In 1990, approximately 85 percent of the U.S. crop was packaged in U-D bales at the gin.

Bale coverings and ties should meet the specifications developed by the Joint Cotton Industry Bale Packaging Committee. Detailed specifications are available from your county Agricultural Stabilization and Conservation Service office or from the National Cotton Council.

Moisture

Moisture is the most important single factor affecting fiber quality during ginning. When ginning at higher moisture contents, the average length of cotton fibers will be greater than if the same cotton was ginned at low moisture contents. However, trash is easier to remove from drier cotton. Consequently, determining a ginning moisture content is a compromise between good trash removal with some fiber length damage and length preservation with less lint cleaning.

The ideal ginning moisture content is 7 percent, but moistures between 6 and 7 1/2 percent are acceptable. Ginning at moistures outside this range can cause machinery operation and fiber quality problems.

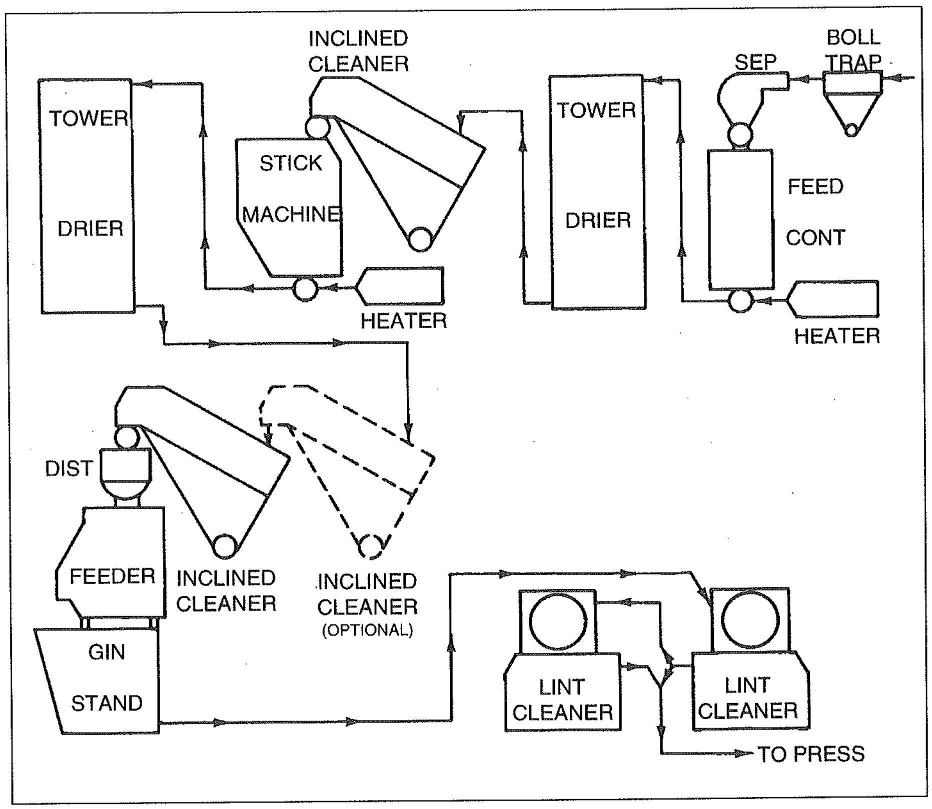

Figure 10: Recommended ginning system for machine-picked cotton.

Machinery Systems Recommendations

Spindle-Picked System

For spindle-picked cotton, the generally recommended machinery sequence is as follows (Fig. 10):

1. Rock and green-boll traps
2. Feed control
3. Tower drier
4. Cylinder cleaner
5. Stick machine
6. Tower Drier
7. Cylinder cleaner
8. Impact cleaner (optional)
9. Extractor feeder
10. Gin Stand
11. Lint cleaner
12. Lint cleaner
13. Press

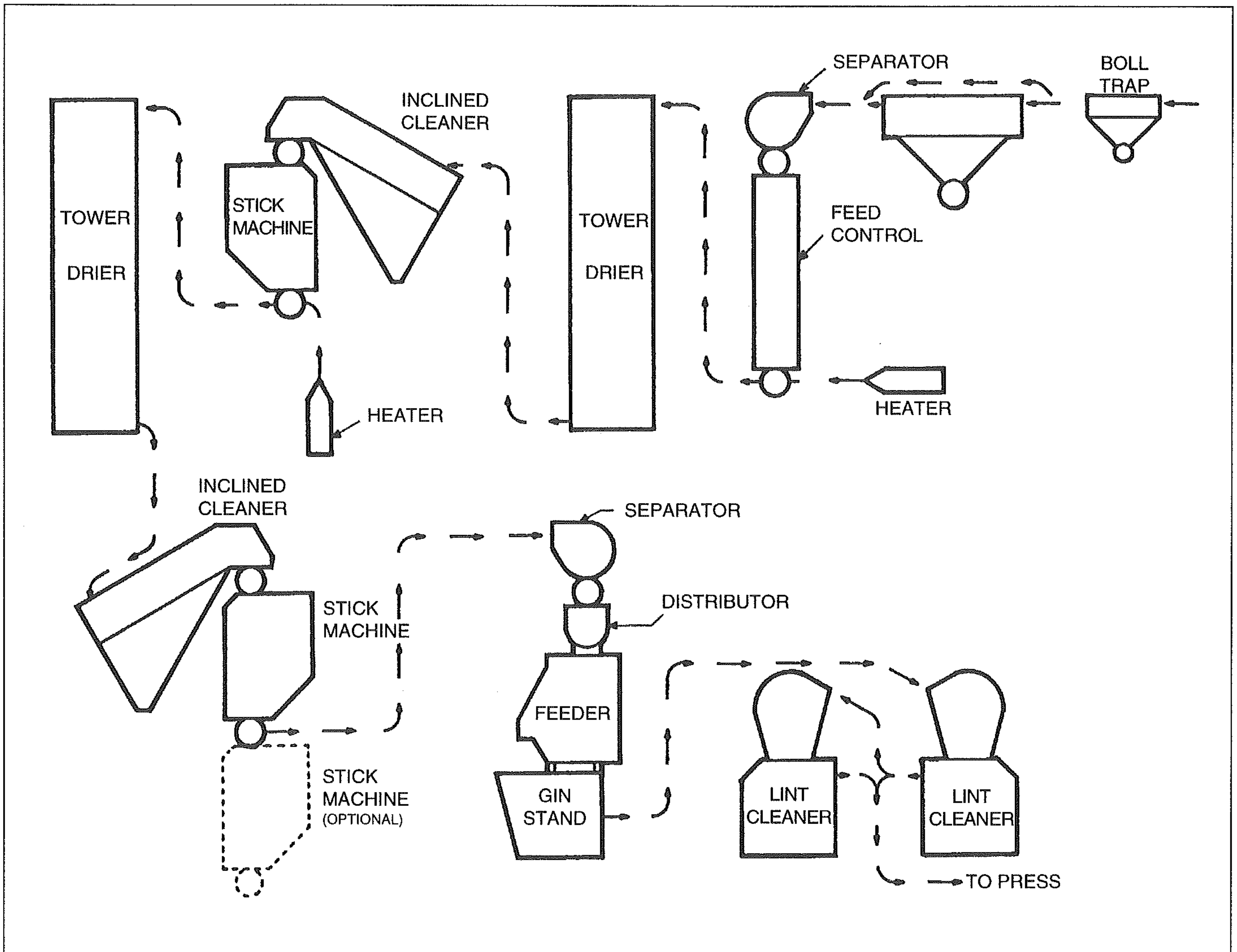

Figure 11: Recommended ginning system for machine-stripped cotton.

Machine-Stripped System

Since machine-stripped cotton that was not cleaned on the harvester contains 6 to 10 times as much foreign matter as machine-picked cotton, ginning systems in stripper areas need more cleaning equipment to maintain fiber quality. The following system of gin machinery (Fig. 11) is generally recommended for stripped cotton:

1. Green-boll trap
2. Air-line cleaner
3. Feed control
4. Tower drier
5. Cylinder cleaner
6. Stick machine
7. Tower drier
8. Cylinder cleaner
9. Stick machine
10. Stick machine (The optional stick machine is recommended only for stripped cotton containing in excess of 32 percent foreign matter (lint turnout less than 22 percent).)
11. Extractor feeder
12. Gin stand
13. Lint cleaner
14. Lint cleaner
15. Press

These recommendations are the maximum amount of machinery that should be needed. Any machinery which is not necessary for the particular lot of cotton should be by passed. Driers, seed cotton cleaners, and lint cleaners should have bypass valves so they are not used unless they are needed.

Roller Gins

The first mechanical gin (Churka) was a roller gin consisting of two rollers (one metal, one hardwood) less than one inch in diameter, turned together by means of a hand crank. In 1840, Fones McCarthy invented a more efficient roller gin which consisted of a single leather ginning roller, a stationary knife, and a reciprocating knife which pulled the seed from the lint as the lint was held by the roller and stationary knife. Although the McCarthy gin was a major improvement over the Churka-type gin, machine vibration due to the reciprocating knife along with maintenance problems prohibited high ginning rates.

In the late 1950s and early 1960s, a rotary-knife roller gin was developed by the USDA Southwestern Cotton Ginning Research Laboratory, gin manufacturers, and private ginneries. The ginning roller and stationary knife were retained from the McCarthy gin while a rotary knife replaced the reciprocating knife, eliminating the lost time of the backstroke of the reciprocating knife and reducing the vibration. The rotary knife allowed increased ginning rates and is currently the only roller-type gin used in the United States. A typical rotary knife roller gin stand is shown in Figure 12.

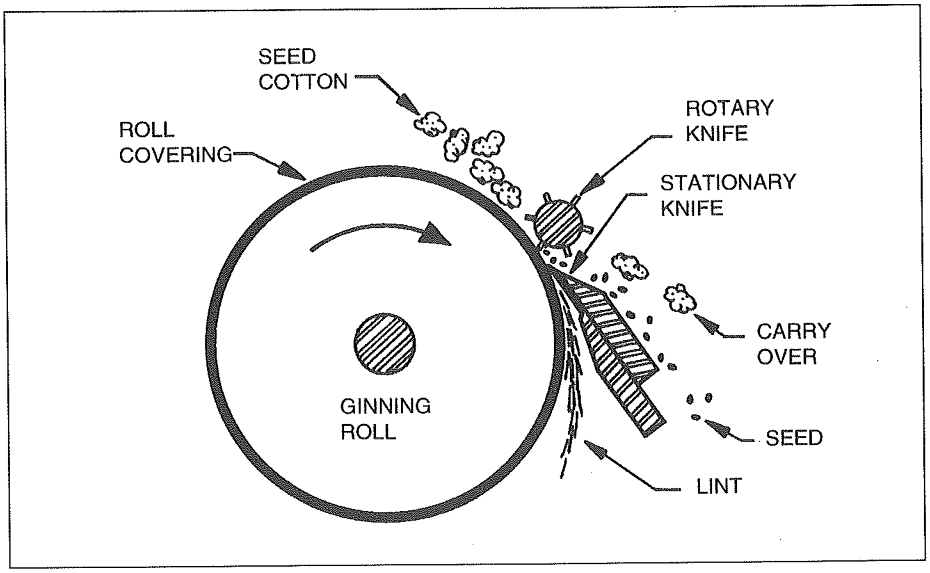

Figure 12: A modern roller gin stand commonly used for extra long staple cotton.

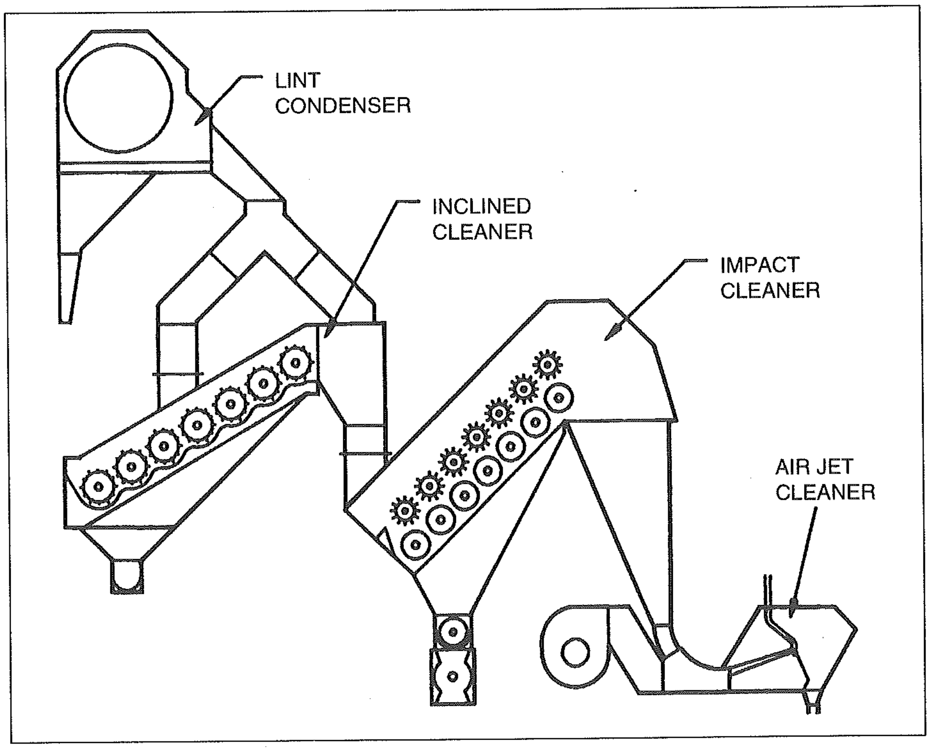

Figure 13: The most common lint cleaning sequence for roller ginned cotton.

Roller gins are used to preserve the quality of extra long staple (Pima) cottons grown in the western United States. Although only about 5 percent of the U.S. cotton crop is Pima, it is a highly valued specialty crop which demands a premium price. Roller gins are slow, averaging about 1 to 1.5 bales/hr/gin stand on good running cotton, compared to as much as 15 bales/hr/sawstand. Consequently, the cost of roller ginning is about 50 percent higher than saw ginning.

Since it is a very valuable product, the harvesting, seed cotton storage, and seed cotton conditioning of Pima cotton are critical. Seed cotton conditioning equipment in roller gins is similar to the type used in saw gins. Roller ginning systems normally include four or five seed cotton cleaners while a ginning system for machine picked upland cotton would normally include three or four seed cotton cleaners. Improper adjustment of seed cotton cleaning equipment causing roping or recirculation of cotton can damage the quality of Pima cotton by stringing out and twisting the locks.

Tower dryers and hot-air cylinder cleaners are commonly used for seed cotton drying. Optimum fiber-moisture content for roller ginning is 5 to 6 percent. Drying fiber lower than 4 percent may result in static-electricity problems and fiber breakage. All United States roller-ginning plants have at least one stage of drying, 98 percent of the plants have at least two drying stages, and 59 percent have three drying stages. Drying temperatures should be monitored or automatically limited to no more than 300 °F because high drying temperatures damage fiber and waste energy.

The ginning roller is the most important and expensive component in the gin stand. Roller-covering material is made from 13 layers of plain-woven cotton fabric cemented together with a white rubber compound. The fabric lays on the bias so that neither the warp or fill yarn are parallel to the direction of cutting; this prevents the material from unraveling from the roller surface. The roller material mounts on to the roller core with the cut edges of the fabric layers serving as the ginning surface.

Rotary-knife roller gin stands separate fiber from seed by using the frictional forces between a moving roller and fixed stationary-knife surface. During normal ginning, the roller-to-fiber force is greater than the stationary-knife-to-fiber force; therefore, the fiber sticks to the roller surface and slips on the stationary knife surface. Cotton is ginned as fibers adhered to the roller surface slip under the stationary knife which holds the seed.

Each stroke of the rotary knife clears the stationary knife edge of accumulated seed cotton and ginned and partially-ginned seed. Partially ginned seed are either pulled back to the stationary knife and completely ginned or swept along with the seed and carryover and later reclaimed. At the ginning point, seed cotton trash is separated with about 45 to 50 percent going with the lint and the remainder with the seed.

The carryover reclaimer removes unginned and partially-ginned seed cotton and spindle twist from the seed flow and returns them to the distributor for ginning. The reclaimer usually cannot distinguish between seed cotton and spindle twist. Most of the spindle twists are returned and accumulate at the gin stand, resulting in reduced ginning efficiency and premature wear of the roller and rotary knife. Carryover percentage increases with feed rate but is typically less than 6 percent of the seed cotton fed.

Lint cleaning in roller gins is different from saw gins and varies among gins. Traditionally, the mill-type opener/air-jet lint cleaner combination was used to remove motes, broken seed, entanglements caused by the machine pickers, and pin trash not removed in seed cotton cleaning. But because if low capacity, many of the mill-type openers have been replaced by cylinder and revolving screen (impact) cleaners used in combination with air-jet cleaners. Currently, the most common lint-cleaning sequence is an incline, impact, and air-jet cleaners (Fig. 13); 35 percent of the plants have such an arrangement.

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