

**CARDING COTTON FOR THE  
NONWOVENS MARKET**  
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**Abstract**

The paper will cover the following key points in the processing of cotton for today's nonwovens market:

- Cleaning cotton prior to bleaching
- Opening cotton prior to carding
- Selecting the correct card for processing cotton nonwovens
- Selecting the correct metallic clothing

**Introduction**

The popularity of both bleached and greige cotton fibers has increased in recent years. However, presenting a suitable cotton fiber to the nonwovens industry requires certain adaptations to existing processes. Cotton for bleaching must be free of imbedded contaminants. Greige cotton must also be free of trash, and the fiber must be virtually individualized in order to form a uniform web. Today, we will discuss how superb cleaning prior to bleaching and high-quality opening prior to carding positively impact web quality at carding. We will then investigate a selection of nonwovens cards and focus on a likely candidate for processing cotton. Finally, we will discuss metallic clothing selections for both opening and carding in nonwovens.

**Discussion**

**Cleaning Cotton Prior to Bleaching**

Since 1960, fiber cleaning has become of much greater consequence in the processing of cotton, for two reasons. First, automated cotton picking dramatically increased the amount of agricultural residue found in baled cotton, and equipment manufacturers had to develop machines to remove the additional trash. Second, new potential uses for cotton have forced a new definition of *clean*. Consumer demand for *natural* fibers, particularly in personal, food-packaging, and medical products, calls for equipment that can maintain cotton cleaning efficiencies in excess of 70% while generating no more than 10% additional neps. Machinery manufacturers have only recently been able to provide the nonwovens industry with the potential to meet this demand. To introduce these innovations in cotton cleaning technology, it will be helpful to review the progression of cleaning

equipment design, with special attention to machines intended to clean cotton prior to bleaching.

*When is cotton clean?* Baled raw cotton normally contains trash, including stalks, stems, and bark; motes (hard lumps of unopened fiber where trash hides); short fibers; and pepper trash (ground leaves and seed fragments) at levels of 2% to 3%. Cotton is considered clean for nonwovens purposes when it contains nominal trash levels of 0.5% to 1.0%, which reflects a 70% cleaning efficiency. The only effective way to achieve this level of cotton cleaning is to individualize the fibers and remove the unwanted material.

*Types of Cotton Cleaners.* Machines used to clean cotton fiber fall primarily into two basic categories: 1) cleaning by rolls with mechanical fingers or pin beaters and 2) cleaning by metallic clothing.

The first automated cotton cleaners, developed in the early 1960's, were largely adaptations of existing opening equipment. These machines were designed to remove large trash from the cotton, leaving short fibers, pepper trash, and neps for the card flats to remove. Bale breakers, horizontal and step cleaners, and Kirschner beaters flail the cotton against grid cages underneath each roll, encouraging larger trash to exit through these grids (Figure 1). These machines give adequate cleaning for nonwovens end uses like mattress padding, feminine hygiene products, facial pads, and cotton swabs. But the cotton presented to the card is still heavily impregnated with motes and trash.

In the late 1960's, Cotton Incorporated and Hollingsworth jointly introduced a cotton cleaner that improved horizontal cleaning technology. The COTTONMASTER® used metallic card clothing, stationary plates, and mote knives for cleaning (Figure 2). The machine was chute fed to control weight and density and was equipped with advanced lickerin combing and air doffing. Throughput was only 200 to 250 lb/hr, but the improved cleaning efficiency gave birth to a new generation of cotton cleaners.

In the mid-1980's, Hergeth took the next step toward achieving better cotton cleaning (Figure 3). Their cleaner employed a feed roll/feed plate, an accelerator roll much like a lickerin, and a cylinder. Mote knives and carding segments were mounted on the working surfaces of the accelerator and the cylinder for trash removal. The unit's coarse metallic clothing allowed for production rates of 1000 lb/hr. The throughputs resulting from this design encouraged other manufacturers to introduce similar machines.

*The Card as a Cleaner.* Early in this decade, Cotton Incorporated and Hollingsworth once again were instrumental in advancing cotton cleaning. They introduced the first

textile card modified for use as a cleaner (Figure 4). Its features include:

- a feed roll/feed plate and lickerin, offering excellent large trash removal with minimal fiber loss.
- a 50" card cylinder with cleaning slots over the top, providing excellent removal of fine trash with minimal fiber loss.
- an air doffing system that eliminates the doffer, allowing for increased capacity.
- a modified lickerin and cylinder, also allowing for increased capacity.

This modified-card cleaner better controls fiber across all cleaning surfaces. The high cylinder speed and air doffing allow for increased throughput. The larger cylinder also provides more surface for aggressive carding, better trash removal, and lower nep generation. The clean and individualized fibers will remain open even through rigorous bleaching, kier breaking, drying, and baling.

Although cotton may be cleaned after bleaching, cleaning before bleaching is better. Bleaching sets trash in the fiber, making it more difficult to remove. Resulting fiber breakage will generate short fibers that will be lost to the filter house. For optimum cleaning prior to bleaching, the most advanced cleaner available should be placed between the bale breaking/blending module and the bleaching equipment. Then, clean, individualized fibers are baled for processing into a quality nonwoven web.

### **Opening Cotton Prior to Carding**

It is impossible to discuss cleaning cotton without discussing opening it as well. In textile cotton carding, preparatory equipment is generally referred to as *cleaning* equipment. The nonwovens industry, on the other hand, uses *opening* equipment to prepare fibers for carding. In reality, the machinery is virtually identical, and many units will, to some degree, perform both functions. To properly prepare cotton fibers for the nonwovens card, comprehensive waste removal devices are paramount, for several reasons:

- Unlike textile cotton cards, nonwovens cards are not equipped with adequate cleaning devices. Cotton waste will prematurely wear the metallic clothing on the carding rolls, segments, and plates, requiring more frequent replacement.
- Cotton fiber residue will build up on finishing equipment, such as aprons, crosslappers, thermal ovens, needle looms, and stitch-bonding machines. This means that downtime is required for cleanup. Also, needles are dulled by cotton trash.
- Fiber impurities interfere with web uniformity. Trash can be visible in the carded web. Also,

notes will be noticeable in the web unless they are sufficiently opened and the fibers are evenly distributed.

- Individualized fibers are essential in products that blend low-melt binders with cotton. Thermal bonding binds fibers together by depositing liquid polymer on the cross-section. The more the fibers are individualized, the stronger the resulting bonded structure will be.
- Cotton trash will eventually contaminate the end product.

There are several options for effectively opening and cleaning cotton fibers.

*Hoppers/Opening Roll/Cleaner/Card.* Raw cotton can be fed to blending machinery, through a cleaning module, and then to the card (Figure 5). A cleaning module may be inserted in place of an opening machine on the existing nonwovens line. The fiber exits the opening roll and travels through the cleaner en route to the card.

*Hoppers/Opening Roll/Cleaner/Opener/Card.* Raw cotton can be fed to blending machinery, through a cleaning module, then through a fine opening module, and on to the card (Figure 6). This would allow all equipment required for processing synthetics to remain on the line. To avoid increasing neps, a diversion valve can feed the reserve closest to the card with cleaned cotton while bypassing the fine opener.

*Bale Breaker-Blender/Cleaner/Baler/Nonwovens Line.* Raw cotton can be fed through an off-line cleaning system (Figure 7). The benefits of this method include optimum fiber mixing, the ability to clean one product while carding another, and the ability to run product with few, if any, adjustments to the existing nonwovens line.

In selecting the best opening and cleaning method for the operation, versatility is always preferred. With any option you choose, the quality of blending will significantly affect the quality of the end product. Raw cotton varies in trash content, micronaire, length, and color. The number of bales blended prior to cleaning should be at least as many as the number of different grades of cotton used. When running cotton alone, the careful blending of the bales through existing blending hoppers is acceptable. To ensure that cotton opening and cleaning equipment is functioning at peak efficiency, neps, fiber length distribution, and trash content should be quantified through a fiber-testing laboratory.

### **Selecting the Correct Card for Processing Cotton Nonwovens**

Selecting the best card for processing greige or bleached cotton for nonwovens applications requires an understanding

of the types of cards available and the fibers they process. It also requires a thorough understanding of the required process. Will the web weight be heavy or light? Will the end use require waste expulsion in the card itself? Will the process require aggressive carding, or will it make significant use of recirculation? By reviewing the types of cards currently available, one can determine which is best for nonwovens cotton carding.

*The Textile Cotton Card.* This card is equipped with a feed roll/feed plate configuration, one or more lickerins, flats above the cylinder, and a doffer (Figure 8). The feed roll compresses the fiber, which is then raked by the lickerin to provide maximum opening. A first lickerin may feed as many as two other lickerins, each with a mote knife or air wash to remove large cotton waste. Revolving flats positioned above the cylinder parallelize fibers and open them to extract short fibers, neps, and small trash, as well as prepare the fibers for web formation on the doffer. The fibers then exit the card as a clean web condensed to sliver that is ready for drafting and spinning operations. The textile cotton card excels in waste expulsion, intense above-cylinder carding, fiber individualization, and handling short fibers, but because of the narrow working width of the card (40"), as many as 8 cards in a line in tandem are required to produce the desired product weight.

*The Lightweight Nonwovens Roller-Top Card.* Designed to process synthetics and synthetic blends, the lightweight nonwovens roller-top card uses a larger, slower lickerin that transfers fiber to the working surfaces (Figure 9). Workers and strippers incrementally comb and recirculate fibers above the cylinder. This type of card can be set up in tandem, providing gradual carding as the fiber is transferred from breaker through finisher cylinders. Cotton can be run on this card, but high maintenance costs and poor web uniformity make it less desirable for high-quality cotton processing.

*The Heavyweight Nonwovens Roller-Top Card.* This card performs best on medium to coarse synthetic fibers or fiber blends at high throughputs. A larger lickerin and multiple feed rolls or an inverted feed plate make it ideal for processing longer fibers (Figure 10). Opening at the lickerin region is limited and, as with lightweight nonwovens roller-top cards, blending and carding are performed by workers and strippers. Presenting cotton fibers to a heavyweight nonwovens card is possible, but not feasible. Inadequate control of short cotton fibers at the feed section and through the cylinder tops will create neps.

*The Garnett.* Garnetting allows for extremely high throughputs with very little individualization of fibers. The notable differences between the garnett and the heavyweight nonwovens roller-top card are the fancy roll and the fancy strippers (Figure 11). The high-speed fancy roll transfers

fiber from the cylinder to the fancy stripper. The fancy stripper then gently lays the fiber back on the cylinder so that the doffer can remove it with ease. This machine can produce mattress padding and shoddy, but it delivers what appears to be a thick mat as opposed to a web.

*The Lightweight CARDMASTER®-Top Tandem Nonwovens Card.* This type of card is designed with a feed roll/feed plate and a single lickerin (Figure 12). The lickerin combs the fiber against the feed plate prior to the breaker cylinder. Stationary plates cover two-thirds of the cylinder to provide it with a surface against which to comb. Fiber leaving the cylinder is distributed onto the surface of a breaker doffer. To achieve better opening and uniformity, a finisher lickerin, cylinder, and doffer are positioned in tandem to the breaker section. This configuration can provide a uniform, light- to medium-weight cotton web suitable for nonwovens end products.

The chart below compares and contrasts the features of the cards we have reviewed (Figure 13). The simplicity of the CARDMASTER®-top tandem card makes it highly versatile. Trash remaining in the cotton will wear the wire on this card as well, but fewer rolls to reclothe and greater ease of teardown and setup translate into lower maintenance costs. Aggressive carding is achieved between the cylinder and the stationary plates, and two such carding units in tandem provide increased individualization of fibers. The premier feature of this card, however, is its consistent control of fibers at all points within the machine.

Of course, any of the carding machines discussed here could be modified to run cotton better. This would primarily involve changing the types of metallic clothing on the carding rolls.

### **Selecting the Correct Metallic Clothing**

Selecting the best metallic clothing (saw-tooth wire) for nonwovens applications requires a working knowledge of how wire functions. To understand these functions, it is important to first become familiar with the basic terminology used to discuss wire. For this discussion, the following four terms will suffice:

- **Threads/Inch** - Refers to the number of cross-directional wire wraps present on a clothed roll. Thread counts range from very coarse to very fine (Figures 14 and 15).
- **Points/Inch<sup>2</sup>** - Derived by multiplying the number of teeth in one linear inch of wire (PPI) by the number of threads per inch. This is often called the *tooth population* of the wire.
- **Front Angle** - The angle, in degrees, that the point of the wire is tilted forward from 90° to the surface of a roll.

- **Tooth Height** - The height of the wire tooth, which is one of the factors that determine the capacity of the wire.

The two basic functions of metallic clothing are pulling fiber and releasing fiber. Both actions take place on each wire tooth. The front of the tooth pulls the fiber, and the back of the tooth releases it. If there is no release of fiber, the tooth will load up, exceeding its capacity, and then will be unable to pull more fiber. As the roll speed is increased, more teeth are presented to pull fiber, and capacity increases.

There are three major criteria for selecting the correct metallic clothing for the desired end product:

- **The Product.** How is it possible to open, clean, and comb cotton fibers that are fine, short, not of uniform staple length, difficult to disentangle, and hard to keep in the machines?
- **The Quality.** How open, uniform, and clean must the web be for the desired end product?
- **Production Rate.** What rate of throughput can be achieved while maintaining the desired quality?

Wire selection may begin when these three criteria have been quantified. For those accustomed to processing traditional cotton sliver, synthetic sliver, or synthetic nonwovens, some comparisons and contrasts among the major working points may be helpful. Traditional cotton cleaning takes place in the card (Figure 16). Today, production rates for greige cotton have reached an average of 150 lb/hr. The lickerin is generally clothed with a coarse thread, 10° wire with 40 points/in.<sup>2</sup> that is aggressive enough to comb and remove larger trash at a feed rate of 1.8 yd/min, with a batt weight of 22 oz/yd<sup>2</sup>. The cylinder wire usually has 800 to 900 points/in.<sup>2</sup> with a front angle of approximately 35° to control and pull the fibers through the revolving flats.

Using a card specifically for cleaning cotton requires wires that can open the fiber for removal of all but the smallest trash at capacities as high as 700 lb/hr (Figure 17). This greater throughput requires a lickerin wire with a front angle of 15° to 25° to hold the fiber on the roll. More points per square inch, in a range of 60 to 120, are required to effectively separate and clean the fiber at a feed rate of 6.25 yd/min, with a batt weight of 30 oz/yd<sup>2</sup>. Wire with a front angle of 10° to 20° and 200 to 250 points/in.<sup>2</sup> is required on the cylinder to allow for the increased throughput.

The lightweight CARDMASTER®-top tandem nonwovens card utilizes wires that are virtually identical to those used on the card-type cleaner in order to achieve the desired web quality (Figure 18). The lickerin wire has a 15° to 25° front angle with 60 to 120 points/in.<sup>2</sup> for excellent combing. The card cylinders are wound with a slightly finer thread wire than the cleaner cylinder; namely, a 10° to 20° front angle with

250 to 300 points/in.<sup>2</sup>. The 700 lb/hr throughput is spread over the width of a 2.5 meter machine, resulting in less load on the metallic clothing. Finer thread counts allow for a higher level of opening and individualization of fibers. By the time the fiber reaches the finisher cylinder, the displacement of the load on the cylinder is so uniform that a virtually perfect web can be collected on the doffer.

### Summary

The nonwovens market has been calling for clean, uniform products made from cotton. Carding and cleaning technology now exists for successfully processing bleached and greige cottons for these products. Better opening and cleaning prior to bleaching and carding translate into higher quality end products at lower processing costs. Metallic clothing is the common denominator in cleaning, opening, and carding that makes this possible. The wire selection criteria presented here set the guidelines for a discussion between the nonwovens producer and a wire expert.

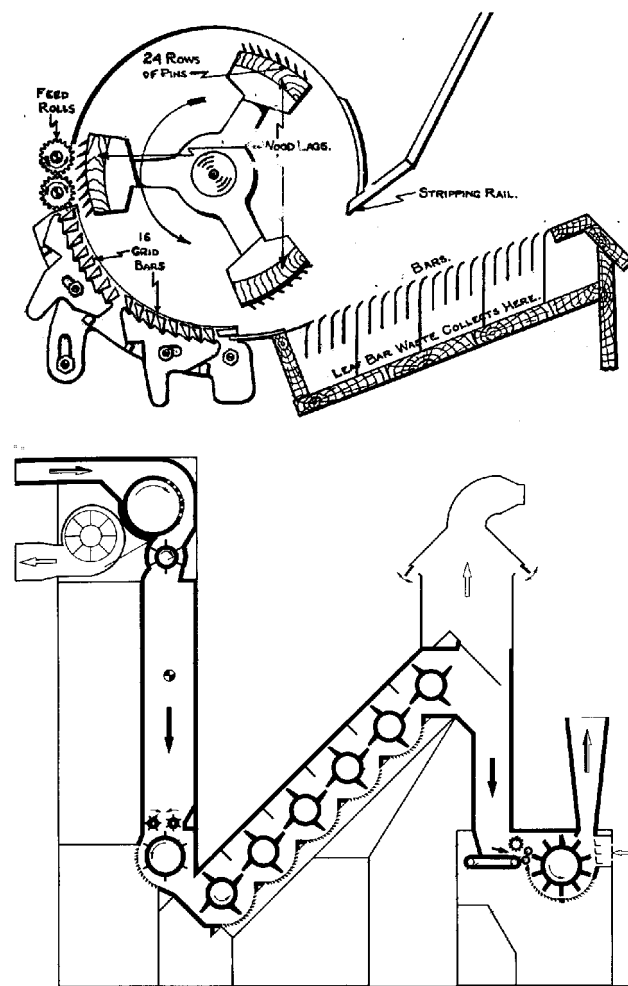


Figure 1. Kirschner Beater and Step Cleaner

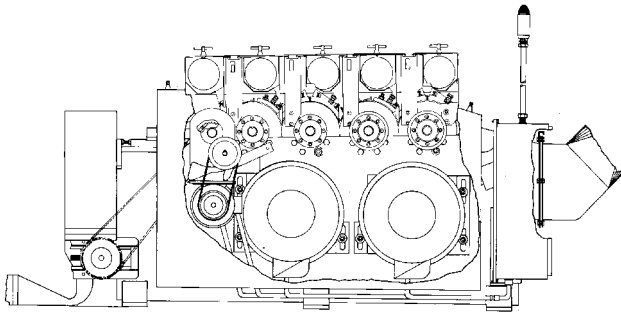


Figure 2. Horizontal Cotton Cleaner

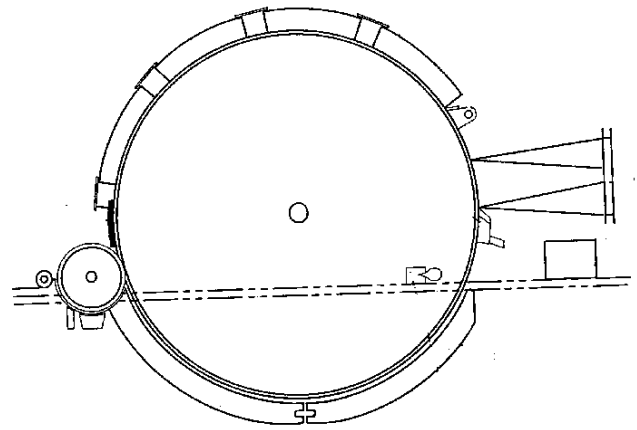


Figure 4. Card-Like Cleaner

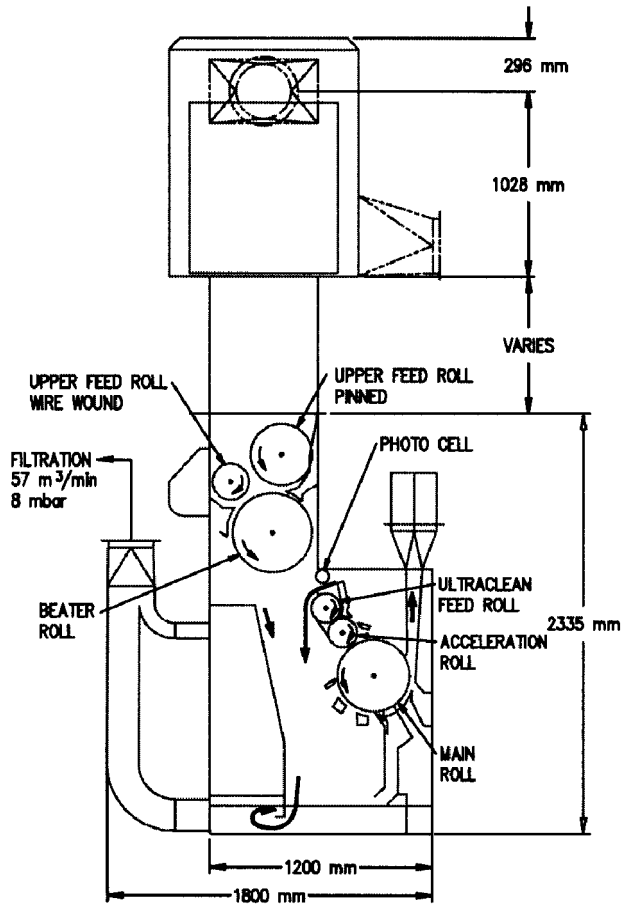


Figure 3. Hergeth Cleaner

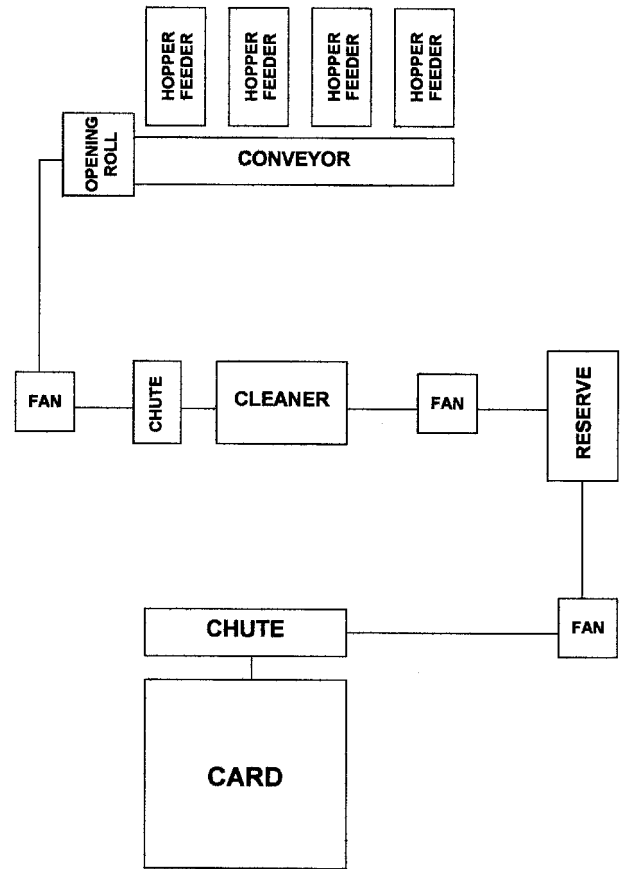


Figure 5. Hoppers/Opening Roll/Cleaner/Card

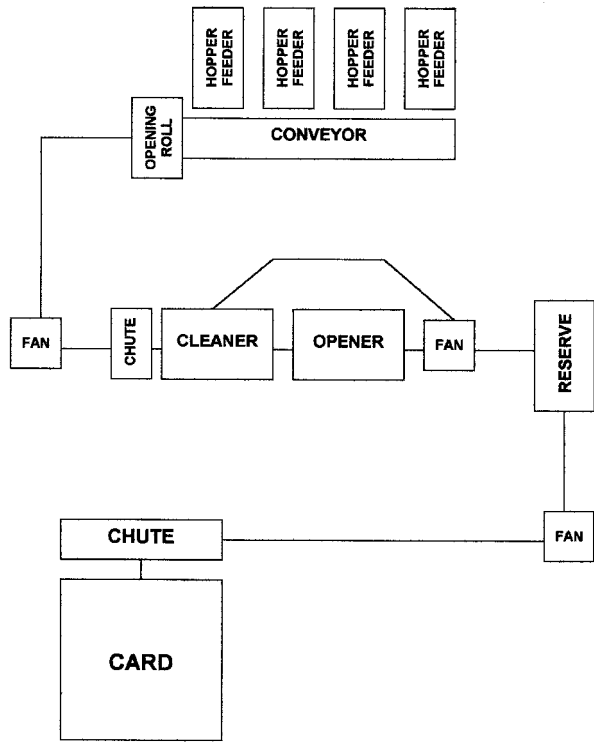


Figure 6. Hoppers/Opening Roll/Cleaner/Opener/Card

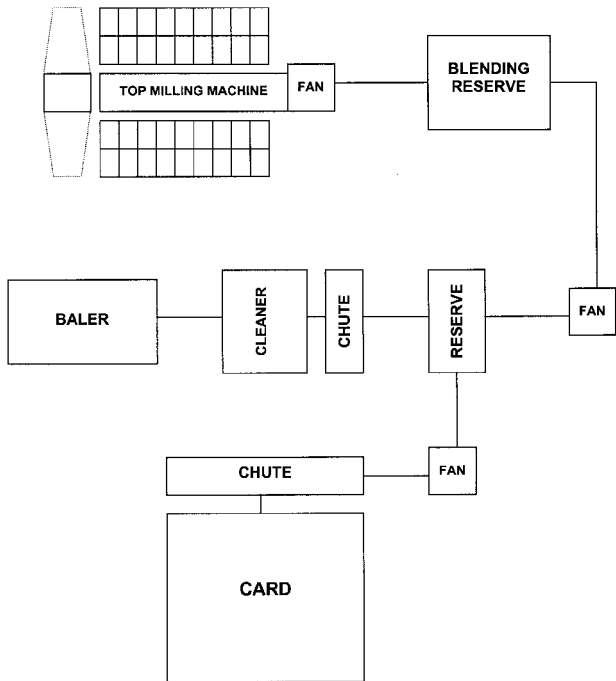


Figure 7. Bale Breaker-Blender/Cleaner/Baler/Nonwovens Line

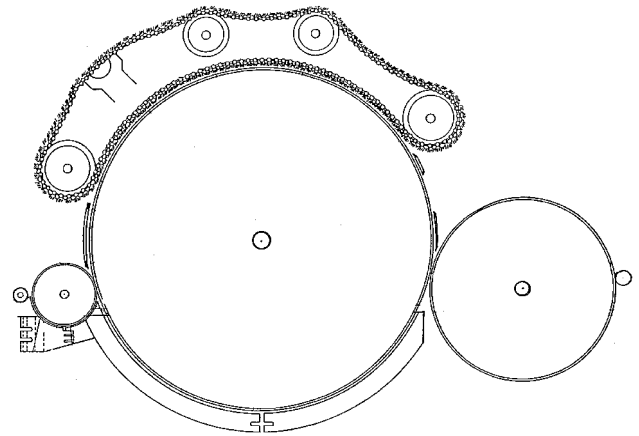


Figure 8. Textile Cotton Card

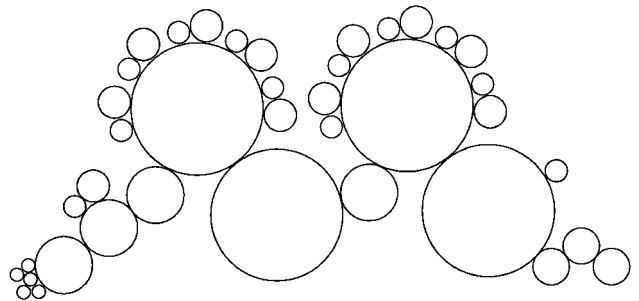


Figure 9. Lightweight Nonwovens Roller-Top Card

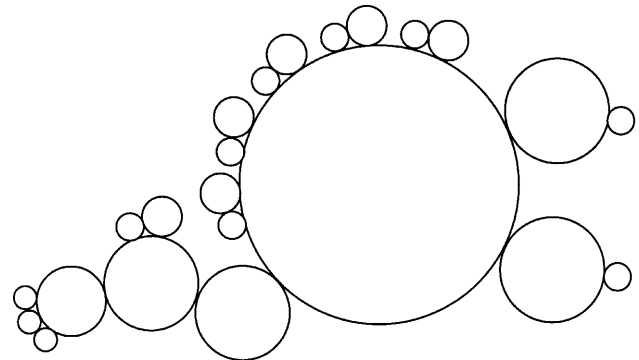


Figure 10. Heavyweight Nonwovens Roller-Top Card

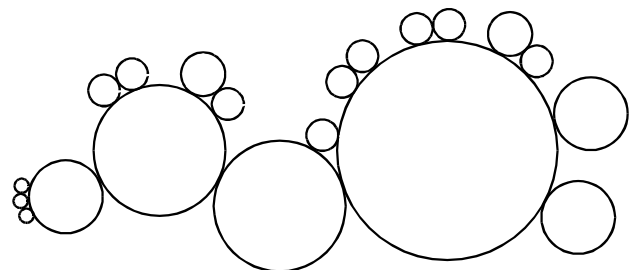


Figure 11. Garnett

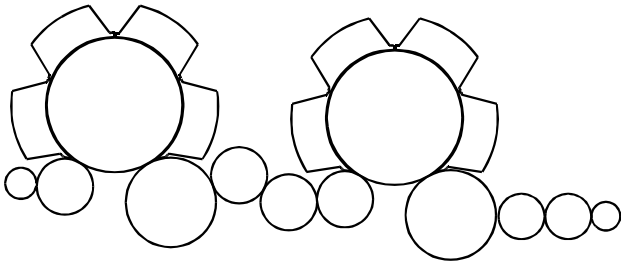


Figure 12. Lightweight CARDMASTER®-Top Tandem Nonwovens Card

CARD TYPES AND FEATURES	Textile Cotton Card	Lightweight Nonwovens Roller-Top Card	Heavyweight Nonwovens Roller-Top Card	Garnet	CARDMASTER® Top Tandem Nonwovens Card
Waste Expulsion	Yes				
Aggressive Carding	Yes	Yes			Yes
Recirculation		Yes	Yes		
Heavyweight Web			Yes	Yes	
Lightweight Web		Yes			Yes
Fiber Individualization	Yes	Yes			Yes
Short Fiber Capability	Yes			Yes	Yes
Low Maintenance Costs					Yes

Figure 13. Card Types and Features

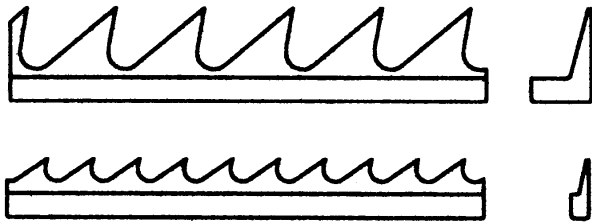


Figure 14. Coarse and Fine Wire

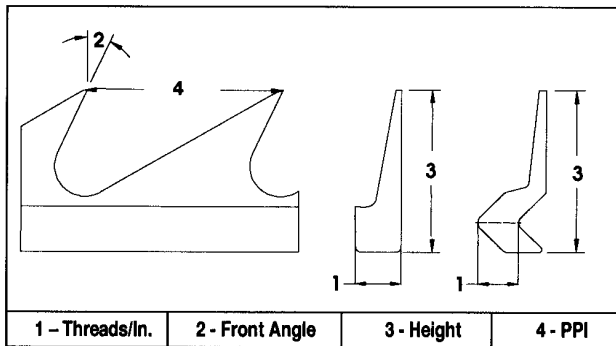


Figure 15. Wire Terminology

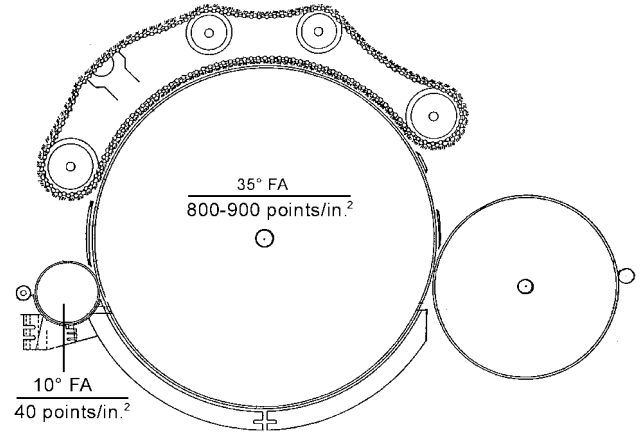


Figure 16. Traditional Cotton Card - Wire Selections

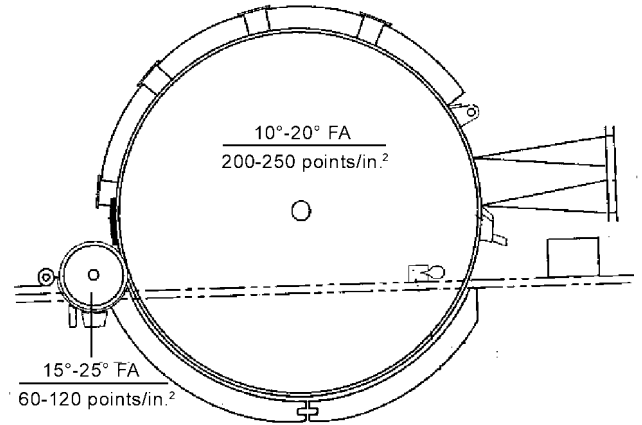


Figure 17. Card-Like Cleaner - Wire Selections

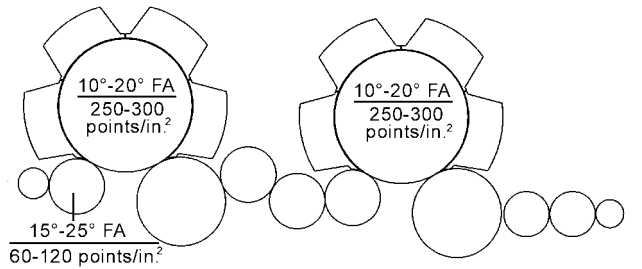


Figure 18. Lightweight CARDMASTER®-Top Tandem Nonwovens Card - Wire Selections