

SAMUEL JACKSON DRYING SYSTEMS

Background and Design Principles

The people at Samuel Jackson have committed many decades of research in the development of knowledge and products to further cotton fiber moisture measurement and control. Much of this work has been directed toward the need to dry and prepare moist or green cotton. Following is a summary of the principles and techniques used in Samuel Jackson seed cotton drying systems. This is offered, in particular, to those evaluating changes to their cotton drying systems for optimum return on investment.

1. **ECONOMIC OBJECTIVES OF SEED COTTON DRYING SYSTEMS**

1.1 *Priorities in Drying System Design* -- We rank the objectives of a seed cotton drying system in the following order of economic importance:

- (1) To maximize the *value* of the ginned cotton
- (2) To maximize *throughput*, or bales per week
- (3) To minimize *horsepower* consumption per bale
- (4) To minimize dryer *fuel* consumption per bale



Priorities 1 and 2 -- On the subject of cotton value, there are three viewpoints to consider: The textile mill wants good spinning quality. The producer wants high lint turn-out and market price. The ginner wants to put the cotton through the gin as fast as possible to lessen his per-bale costs for labor, electricity and fuel.

With a properly designed drying system, spinning quality need not be sacrificed for high market value. We can have both clean cotton and high lint turnout without overdrying the cotton or using high temperatures. Proper drying keeps the pre-cleaners from entangling trash particles in the fiber, and this greatly reduces lint cleaner waste. Contrary to traditional beliefs, inadequate drying results in lower lint turnout as well as a trashier sample.

Effective drying not only solves the apparent conflict between spinning value, market value and lint turnout, it also raises the average throughput of the gin plant. While it usually does nothing for maximum bales per hour, it can dramatically increase the bales per week by efficiently drying wet seed cotton so the gin does not have to slow down.



Priority 3 -- Reducing the connected horsepower in the gin plant does not always reduce the power cost per bale. There are proper places to use smaller motors, but if a small motor reduces the average throughput, it will increase the total cost of power, labor and fuel per bale. One must be careful not to focus all his attention on one factor -- "balance" is the key word to keep in mind.

Priority 4 -- Using larger drying heaters does not necessarily increase the fuel cost per bale. In high air/cotton drying systems, large heaters are necessary to maintain maximum throughput with wet seed cotton on cold days. On warm dry days, high air volume uses the natural drying capacity of the ambient air to reduce fuel consumption. The overall result is usually the same or lower fuel cost per bale, but with greatly reduced labor and power costs per bale. Again, it is wise to consider all economic factors.

1.2 *Drying Before Cleaning* -- We must dry seed cotton thoroughly before cleaning it, use reasonable temperatures, and avoid machining the seed cotton until it is dry. Of course, we need to break up wads to dry the cotton uniformly.



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There are two advantages to drying before cleaning. We naturally obtain higher grades as the pre-cleaners can clean dry cotton more efficiently. Curiously, we get higher lint turn-out as well. Pre-drying avoids entangling trash in wet cotton fibers. The lint cleaners then throw away less lint with the motes. The result is a cleaner sample and higher lint turn-out, as well. Samuel Jackson system designers watch this occur with each system, as Sam Jackson observed when building his first high air volume system in 1965.

1.3 "Overdrying" Damage and Moisture Restoration -- As we make drying systems more effective, we must avoid "overdrying damage" to the cotton. This term is loosely used to describe two different types of damage.

The first type, "overheating damage," is caused by drying with high temperature air, which permanently injures the fibers. We find this in systems of many types today. It occurs wherever air volume is restricted and production pressures are high. Even when before-mix point temperatures are monitored or limited, it is not uncommon to find these limits ignored or bypassed by operators in the name of production during a wet season. Often, especially when pulling through shelf dryers or other devices with a significant resistance to free flow of air, air volume is high when the system is lightly loaded. The resistance of the system becomes apparent when trying to handle large volumes of wet or trashy cotton. The operator often resorts to raising temperatures above recommended maximums. Samuel Jackson designers avoid this type of damage by using three elements.



1. The system is designed for high volumes of drying air.
2. The system is designed with an eye toward eliminating resistance to air flow throughout the system.
3. A cascaded temperature control system is used to gently limit temperatures before the mixpoint while avoiding nuisance shutdowns.

Drying cotton fiber to a low moisture content does not, in itself, injure the fiber. Nature often dries cotton in the field without bad effects. While the fiber is dry, however, it is susceptible to damage if it is treated improperly. This second type of damage is usually inflicted by gin saws and lint cleaner saws on cotton fibers that are temporarily brittle because of low moisture content. The symptoms of this type of damage include staple shortening, poor length uniformity and excessive short fiber content. Interestingly, this type of damage is not caused by the gin's drying system. Samuel Jackson research has led our designers to suspect that this is due to inherent protection of the fiber by moist seed. The fiber damage cannot be avoided by adjustment of drying temperatures or even with all heaters in the system turned off. It can only be helped by increasing the moisture of the fiber before ginning. In arid cotton ginning regions, moist air is often applied to seed cotton to eliminate static electricity, which can slow down operations. At the same time, fiber quality benefits are often realized, particularly if the cotton fiber has been storm damaged or subjected to flooding, which washes the protective waxes from the fiber, leaving it vulnerable to dry ginning conditions.



Samuel Jackson designers recommend preventing this second type of damage by applying humid air to the seed cotton in conditioning hoppers above the extractor feeders (see Figure 3). A Humidaire Unit provides humid air to the special hoppers. Longtime users of these hoppers report longer staple length (1/16" span-length), better length uniformity ratio, and improved short fiber index. In the mill-direct marketplace, spinners have declared a preference for fiber that was conditioned prior to the gin stands.



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2. ASSUMPTIONS FOR DRYING SYSTEM DESIGN

2.1 Drying Power Required -- Drying power required in a gin will vary depending on several variables. These include the geographic region the gin serves and existing machinery type and arrangement.

2.2 A Basic Drying Assumption -- We formerly assumed that any seed cotton drying system dried only the fiber, with negligible effect on the seed and trash. Extensive experience with Samuel Jackson systems has shown that we can dry the leaf trash sufficiently to eliminate problems of trash accumulation in the extractor-feeders. We still assume that the seed loses very little moisture during the seed cotton drying process.

2.3 High Air Volume, Low Temperature – We want to use as much air as possible in each drying stage, and particularly in the first stage. Air volume in each stage is typically limited by the amount of air we may pull through the cleaners without interfering with cotton flow in the system. A good indicator of a drying system's potential drying capacity is expressed through the ratio of hot air volume (expressed in cubic feet per minute) per pound of seed cotton being processed. Moderately powerful systems typically have air to cotton ratios of 20-25 CFM/pound. Air to cotton ratios exceeding 50 CFM/pound are the most powerful.

High air volume with low temperature drying air is the only way to avoid three undesirable alternatives:

1. Damaging fiber properties with high temperature drying air, or
2. Accepting poor cleaning performance, or
3. Slowing the ginning rate.

When we dry with a high volume of low temperature air, we can expect a longer staple length. High temperature air embrittles the ends of the fibers and subsequent ginning and lint cleaning breaks them off. We limit the air temperature before the mix point with cascaded temperature controls.

2.4 Multiple Stage Drying -- As pointed out in Section 1.2, drying should be done before the cotton enters the first precleaner. We do use multiple drying effects, and all of these, but one, take place before precleaning. Depending on air volumes available in the system and the cotton varieties being processed, additional dryers may be desired in subsequent stages with turbulent collisions or injections of fresh hot air. These devices should be applied toward the goal of improving grade (especially on hairy leaf varieties) through opening and fluffing of the already dry cotton. The majority of Samuel Jackson drying systems employ a single stage of drying and simply keep the dried cotton warm as it is conveyed through second stage cleaning equipment.

2.5 Drying Seed Cotton for Storage -- In some countries, gins use hot air to dry seed cotton before storing it for later ginning. These systems are usually not effective because they only dry the fiber. The moisture soon migrates from the seed to the fiber. We also have the problem of storing hot wet seed cotton, which means quality degradation.

As a general rule, we should store seed cotton only when its moisture content is less than 12%, at most 14%. We should not use hot air to dry it before storage. Cotton wetter than this should be ginned immediately so only the seed, not the fiber, will deteriorate in storage. If it is necessary to store wet seed cotton or cottonseed, the storage building should be equipped to circulate outside air through the cotton. Such long- term drying will dry both fiber and seed.



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Where the gin purchases seed cotton, the ginner can use a moisture meter and discount the purchase price for moisture content. The discount should reflect more than the weight of water purchased. It should cover also the cost of drying, the economic cost of having to gin the cotton immediately, and the economic loss due to probable deterioration of the seed.

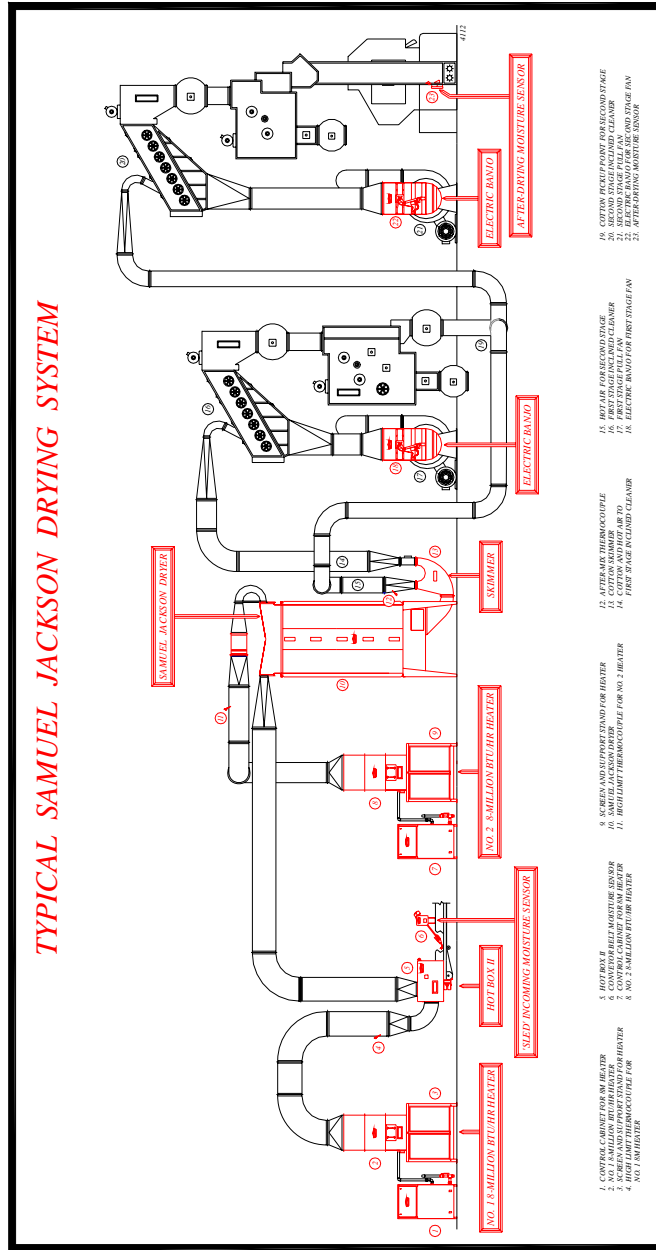


Figure 1



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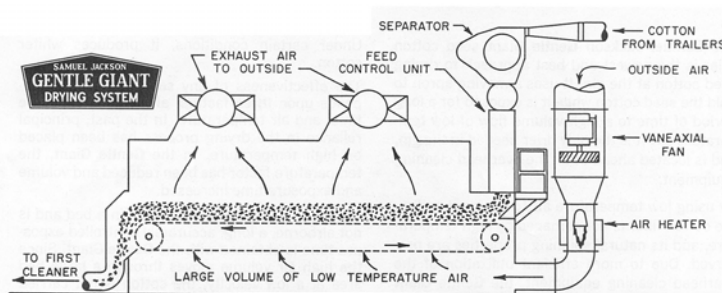
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3. DRYING METHODS AND TECHNIQUES

3.1 Historical Notes -- For centuries, seed cotton was not dried before ginning. It was hand-picked, usually during dry weather. The ginner bought the seed cotton prior to ginning it, and they were reluctant to buy wet seed cotton. Research on cotton drying began at the USDA's Stoneville Cotton Ginning Laboratory in the 1920's. This work resulted in the tower or shelf dryer, which has been widely used since then. Other dryers have been commercially available at various times, including the screw conveyor dryer, the Big Reel dryer and the Counterflow dryer. Most of these were abandoned in favor of the shelf dryer. The advent of mechanical picking and stripping greatly increased the need for seed cotton drying. The change, in America, to ginning farmer-owned cotton made drying essential.

In the early 1990's there was some interest in drying seed cotton lying on a slowly moving conveyor. The method has several advantages. It can have a very high ratio of drying air to seed cotton if designed to take advantage of this capability. Properly designed, the moving bed dryer can be mechanically reliable. Samuel Jackson designed and installed a moving bed dryer in a commercial gin in 1966, and it remains in commercial use at this writing at

the same gin. The method has some disadvantages, such as its high first cost and large floor space requirement. Its principal weakness is the "front" which advances through the bed during the drying process. Behind this front, the cotton is very dry. Ahead of the front, the cotton can be wetted by the "drying" process. Unless belt speed and bed depth are carefully monitored, unacceptable non-uniformity can result.



In 1983, a large grower-ginner conducted tests to find the ideal number of shelves for a tower dryer. These tests showed that the cotton fiber did not lose any significant amount of moisture to the air in the tower dryer nor in the conveying pipes. Their conclusion was that the ideal number of tower shelves is zero and they subsequently removed their shelf dryers. Since that research, many industry leaders acknowledge that the primary characteristic given to seed cotton by shelf dryers is not drying of the fiber, but heat imparted to the seed. Some feel that hot seed helps keep downstream cleaners and gin stands warm. Samuel Jackson designers feel that hot seed is best avoided due to the reasons given in section 2.2. The relatively cool temperature of the seed has never prevented a high air volume pull-through system from delivering excellent performance in respect of both capacity and fiber quality over hundreds of millions of bales. As a bonus to avoiding shelf dryers, seed quality is enhanced, power consumption is reduced, and push fans are not necessary.

As the shelf dryer conferred no fiber drying benefit, the question remained, "Where did the drying take place?" They found that in a typical tower dryer stage, most of the drying occurred at the mix-point where the wet seed cotton entered the hot air stream. The slippage of air past the seed cotton while accelerating it up to the air velocity apparently did the job. Their studies also found that significant drying occurred in the inclined cleaner that separated the air from the seed cotton. Here, like the mix-point, there is slippage of air past the seed cotton. Today, cotton drying systems referred to as "slip" systems can take advantage of this effect, if properly designed. It needs to be noted that a

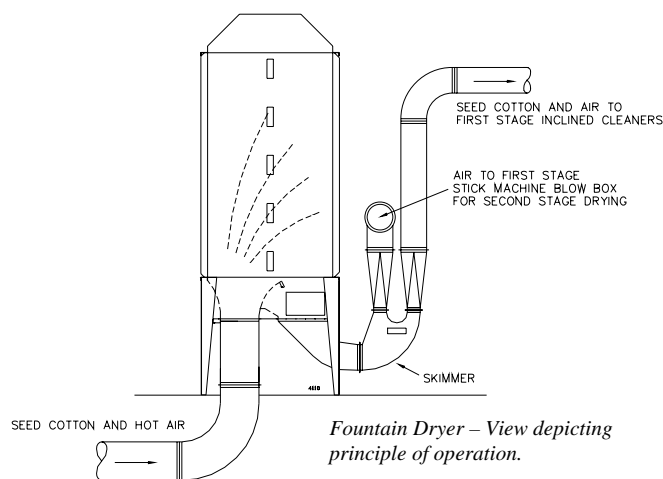


high air to cotton ratio must still be maintained to fully capitalize on this effect without having to raise temperatures. Samuel Jackson system designers use turbulence and calculated collisions between cotton and hot air to increase slippage. These techniques permit high air-to-cotton ratios and keep drying temperatures low.

3.2 Drying “in the pipe” – In the 1980’s and early 90’s, many gins in West Texas and other areas where drying was traditionally not a critical problem, simply removed their tower dryers and push fans. Those simple pull-through drying systems performed better than the tower systems they replaced. Those pull-through systems put more hot air through the cotton with less horsepower and many remain in operation today with profitable results. Gins with these simple systems often remark that they are “drying in the pipe,” but this is not an accurate statement. The length of pipe that replaces the tower is not important. In fact, when dealing with high capacity systems, pipe length ultimately becomes a limiting factor to drying system capacity. No drying takes place in the pipe, just as no drying takes place within the shelves of a tower. This is because there is no turbulence or slippage of air through the cotton in the pipe, except immediately following the mix point. The gins enjoyed their improvement because they eliminated a major restriction to the air flow.

In recent years, harvesting practices have changed significantly and green, wet cotton is common in West Texas. Powerful dryers traditionally used in wet growing areas are now needed to

handle these conditions. The dryers must have the ability to handle greatly increased volumes of seed cotton due to the stripper varieties still common on the high plains. These dryers must have the ability to break up this material and provide it with as much turbulence as possible in hot air without choking or restricting air flow.



3.3 Early devices – In 1987 Samuel Jackson introduced a dryer called the “Fountain Dryer” to the gin industry. The design of the Fountain was chosen because of the extra slippage and turbulence it introduced to the cotton and hot air mix, without restricting the air volume critical to high capacity drying and ginning.

The Fountain’s principle of operation is to spew a mixture of hot air and seed cotton upward like a fountain at one side of an empty chamber. The velocity of the jet is adjustable to make the seed cotton float lazily in the hot air. It then falls to the bottom of the chamber where the same hot air picks it up and accelerates it to the normal conveying velocity. The slippage which occurs during acceleration actually does the drying. The Fountain Dryer makes a significant improvement in drying performance over towers or “pipe drying”, while the pressure drop across it is only 0.3 inches of water.





A Fountain Dryer with hot air injection before the inclined cleaner.

The Fountain Dryer is a mature product and has been widely used and copied worldwide. Its success has spurred cotton industry leaders to enthusiastically embrace high air volume, low temperature drying techniques in their efforts for developing better and faster cotton gins in many forms. This universal progress in improved drying has been rewarding to Samuel Jackson system designers.

Later introductions were made to enhance the effectiveness of Fountain drying systems. One or more auxiliary heaters were added for high-velocity streams of air to turbulate the cotton in conjunction with the Fountain. This is simple to do in a pull-through system, as no push fan is required. In some cases, the collision method used had special modifications to precisely separate rocks, green bolls, and

rotten seed cotton, dramatically helping ginning rate in extreme conditions.

In other applications, the added hot air was simply injected at the Fountain discharge just before the skimmer. This method was used where the total air volume was greater than that recommended for the Fountain. It was an effective and popular drying technique, as the added hot air followed the seed cotton into the first-stage inclines, greatly improving the drying done there.



A Fountain Dryer with a collider-rock trap to separate debris with hot air.

3.4 Skimmer Method for High Air Volume – In the late 1980’s, Samuel Jackson developed an unusual method of increasing the air volume in the first stage of drying. A large volume of hot air takes the seed cotton to the dryer. Coming out of the dryer, the seed cotton and air pass through a skimmer (see Figure 2), which slings the cotton to the outside of a curved path by centrifugal force. Half the air and all the seed cotton enter the first cleaner.



Left: A seed cotton skimmer to double drying air volume.

Right: High speed photo of seed cotton inside skimmer.



The other half of the hot air goes to the blow box under the stick machine below the first inclined cleaner. It takes the cotton directly to the second inclined cleaner over the conveyor distributor. Thus all of the hot air has been applied to the cotton in the first stage using this technique. Although the second half of the air does double duty, it still keeps the cotton dry. The technique is not new and has been used on millions of bales. To take maximum advantage of this effect, careful engineering and system commissioning is required. Trained personnel at the gin are also a necessity to maximize return on investment in this type of drying system. It is this technique which can yield hot air to cotton ratios in excess of 50 CFM/pound for very powerful systems, as mentioned in Section 2.3.

If a very powerful drying system using a skimmer is in place, it is not uncommon for it to replace multiple tower dryers in a conventional cotton gin. The skimmer divides the cotton to two



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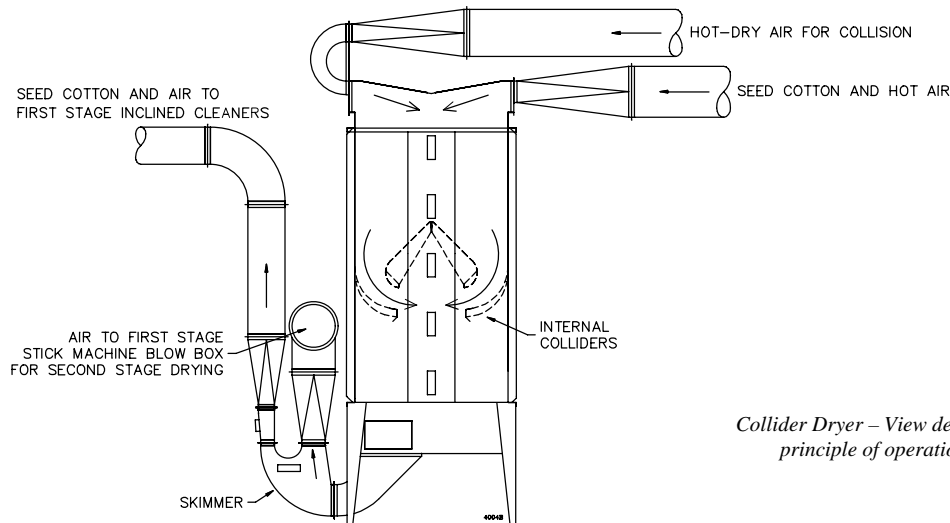
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first-stage cleaners and the second-stage air to the other cleaners. This provides greatly improved drying by eliminating the multiple air bottlenecks imposed by the towers.

3.5 Collider Dryer – Although there are many good possible dryers when pull-through techniques are used, our system designers prefer to make use a collision effect that collides two opposing streams of cotton and hot air with each other for maximum turbulence and opening of the cotton. Samuel Jackson offers two types of “Collider Dryer”. The full Collider Dryer brings cotton and hot air from the module feeder into a chamber where a direct collision with additional drying air takes place. Following this point of extreme turbulence, the cotton and hot air mixture is divided and taken through a second collision just above the outlet to the skimmer. Although the pressure drop is slightly higher than the traditional Fountain, the drying effect is greatly magnified because of multiple collisions and turbulence. Air to cotton ratios are typically greater than 50:1 with this approach.



A Collider-Dryer



Collider Dryer – View depicting principle of operation

3.6 Mini-Collider Dryer -- For situations where only moderate drying and opening are needed, without extensive attention to fans, pipe sizes, air leakage, and dust handling, the Mini-Collider offers a cost-effective and easy method to employ collision drying effects. As mentioned in Section 2.1, not all cotton gins are located in wet regions where very powerful drying is needed or the gin’s machinery configuration may not be adaptable to work with a skimmer. A battery of Mini-Collider dryers used in any or all drying stages at the gin can provide an excellent drying and opening effect in non-challenging conditions. The simplicity of deployment, with no special engineering or commissioning services, is a key factor in keeping implementation costs of the Mini-Collider low.



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4. SYSTEM DESIGN CONSIDERATIONS

4.1 High Air Volume and Fuel Economy -- A common fear is that a high air volume drying system will use more fuel. Our experience with such systems has been that the fuel cost per bale is usually about the same as with a conventional system. Under the worst conditions (wet seed cotton and cold, damp air) the hourly fuel consumption might be twice that of a conventional system. However, the ginning rate continues at a high capacity. When the atmospheric air conditions are warm and dry, the high- volume system uses less fuel because of natural drying. Through the peaks and valleys, the result is that average fuel cost per bale is usually about the same as for a conventional system. It should be noted here that if a high air volume drying system is run at a high temperature regardless of cotton moisture content, fuel cost for the season will be higher than with a conventional system as air volume to heat is greater. In addition, if a moisture restoration system is used at the press, its effectiveness will drop by at least 5 pounds per bale due to the difficulty of restoring moisture to overheated, dry fiber. Samuel Jackson designers take time to educate gin personnel in these matters and they recommend use of an automatic moisture control device to set drying temperatures appropriately.

4.2 Limitation on Air Volume – As mentioned in Section 2.3, the practical limitation on the air volume used in a drying system is the air handling capacity of the inclined cleaners that separate the seed cotton from the air. We use the rule that we can pull from each cleaner about 1500 cfm per foot of width. This would be 12,000 cfm from an 8-foot wide cleaner. We may substantially increase the operating air volume through the use of devices like the “Electric Banjo” that unload a pull fan while the gin is at idle. This device loads a centrifugal pull fan fully when air is warm and the system is fully loaded with cotton, thus providing an additional 30% air volume over the normal maximum limit. This increase in hot air volume is a welcome addition when system designers are allocating hot air volumes to various injections and collisions throughout a system.

4.3 Pull-Through Operation -- Almost all of the drying systems we have designed have been pull-through systems, instead of push-pull. By designing with an eye to elimination of air flow restrictions, push fans are not necessary. In fact, they become limitations to high air volume. We do specify high-efficiency pull fans capable of operating with stability at high static pressures.



System commissioning involves checking air leakages against the charts to find surprises before operation.

There are several advantages to the pull-through arrangement. The gin plant is cleaner because air is leaking into instead of out of the system. Vacuum feeders last much longer, because a small amount of cold air leaks through into the system, instead of hot air leaking out. Another plus is the ease of applying air from one heater to more than one drying point, as described in Sections 3.3 and 3.5.

4.4 Air Leakage Into the System -- In designing a pull-through system, we must allow for air leakage into system, or there may not be enough air to convey the seed cotton properly at the mix point. This leakage occurs at the inclined cleaners, vacuum feeders, and Hot Box.

Our estimates of leakage into inclined cleaners are based on our experience. Typical leakages range from 2000 to 4000 cfm per incline. We allow 1000 cfm for leakage through each vacuum feeder at the second stage mix points.

When Samuel Jackson commissions a full-size Collider Dryer system, careful air measurements are taken multiple times and compared to those projected on the system design charts.



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All conveying velocities, air volumes, and system backpressure readings are checked and verified again. Any surprises are found well before cotton enters the system. This type of work is not considered “insurance” or a luxury. It is absolutely critical on any high air volume pull through system, as these systems can be unforgiving if the designer is neglectful. For those using Mini-Collider Dryers, this document will provide the background you need to get the most from your drying system, as the principles are the same, although on a different scale and implemented by you, rather than a Samuel Jackson system designer.

4.5 Hot Box at Module Feeder -- Wet seed cotton can clog the screens of the unloading separators. In 1986, we devised a simple way to apply hot air to the seed cotton at the module feeder belt. It is a mature product, widely copied (with many variations) called the Hot Box. Today Samuel Jackson designers use the "Hot Box II", with greatly improved performance. Its place and function in the drying system is shown in Fig 1. We enclose the module belt at the pickup point with the Hot Box II. The seed cotton on the conveyor belt is pulled by the belt into the box under a pivoted door that restricts the entry of air. The air that pulls the seed cotton into the gin plant comes out of this box, producing a vacuum in it. This pulls hot air from a heater. We not only remove a bottleneck in the cotton flow stream, but do additional drying economically. The Hot Box II needs neither push fan nor vacuum feeder. It has no motors and needs no regular maintenance. When installed per our recommendations, green bolls and rocks are removed in large quantity through its trash gate and an efficient trash conveyor is strongly recommended.



A Hot Box II installed with a fixed head module feeder. Seed cotton travels into the gin with hot air – rocks and green bolls are dropped.

It is commonplace, particularly in locations with a high water table, to specify a conveyor belt feed for cotton from the module feeder into the gin, rather than using a pit with a rotary airlock (vacuum) under the module feeder head. The Hot Box II may be equipped with a sensor to automatically adjust drying temperature based on moisture of incoming seed cotton on the belt. This greatly enhances fuel savings.



A chain flail located above the Hot Box can disperse wet UNR and stripper cotton for better drying and cleaning.

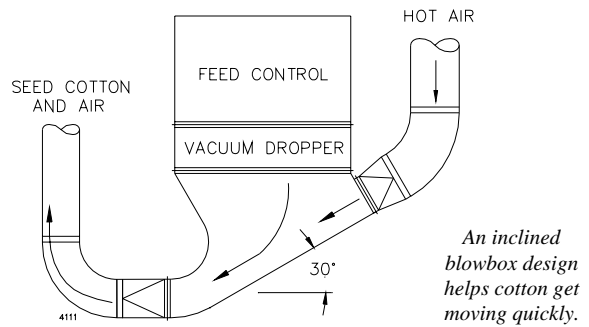
4.55 Flail over Hot Box -- When processing wet stripper cotton, it is possible for wet, undispersed clumps of trashy cotton to pass through the dispersing cylinders of some module feeders and the Hot Box. These clumps impede drying and pre-cleaning efficiency and can cause chokes in situations where feed rate is high and conditions are challenging. Samuel Jackson engineers have addressed this problem by the use of a chain flail option that can be placed directly above the outlet of a Hot Box II. The rotating heavy chains help further disperse challenging cotton and maintain drying and pre-cleaning efficiencies.



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4.6 Blow Boxes -- The blow box at the mix point where wet seed cotton enters the first-stage hot air stream has long been a source of trouble. We incline the bottom of the blow box at 30° from the horizontal to help slide the seed cotton down into the pipe where the hot air can capture and convey it. We specify the usual horizontal blow box at the second stage mix points under the stick machines, since the seed cotton is dry and fluffy at this point. If properly designed, both longitudinal and cross blow boxes can provide trouble-free operation.



4.7 Feed Control Units -- When using a module feeder at a gin that receives mostly moduled cotton, it is desirable to avoid passing the moduled cotton through unloading separators and feed control units. We handle this by using hot air to pull cotton from the Hot box directly into the drying system, as shown in Fig. 1. The advance speed of the module feeder regulates the cotton feed rate. For trailer cotton, the feed control unit drops it on the conveyor belt so it passes under the moisture sensing “Sled” and through the Hot Box into the drying system. The unloading fan, separator and feed control can be turned off when ginning modules.

We find the most popular reason for wanting to preserve the feed control is for its function in protecting the precleaning system from surges of cotton coming from unexpected density changes in a module entering the feeder. Often we find that gin personnel are unaware that they have multiple solutions (often already on hand) for protecting their gin from surges. These are in the form of inclined cleaner load alarm contacts and static pressure sensors with alarm contacts. Samuel Jackson technical personnel are happy to assist with ideas for using these to best advantage.

In wet regions, there is an important reason for avoiding use of a feed control if possible. The feed control, by its nature, compacts wet seed cotton into wads that are difficult to dry and clean. Where one must use a feed control, it should have a good disperser.

We have prepared a memorandum, "Layout of New Gin Plants", which treats in detail the possibilities of various arrangements of module feeders, feed control units, cross conveyors and moisture measuring methods. Its ideas have been incorporated into many new and existing gin plants. We will send this memo upon request.

4.8 Unloading Fans – Although ginning cotton from trailers has all but disappeared in the United States, we have friends in developing nations where suction systems are still widely used. Where a gin handles both moduled and trailer cotton, the ideas of Section 4.7 should be used because if a separator handles both types, we have another problem. The suction pipes for trailers need high suction to break the tightly packed cotton away from the load. We will have to run the unloading fan fast enough to make high suction. Then when we pick up dispersed moduled cotton, the low resistance usually results in such high air volume that it overloads the fan motor, and the high air velocity can crack the seed. This can ruin the germination and put seed coat fragments into the ginned lint. The “Electric Banjo” mentioned in section 4.2 is also applicable when considering unloading fans.



The Electric Banjo can be used on unloading fans or on drying system pull fans to increase operating air volume 30%



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Unloading suction power is increased 30% without an increase in motor size.

On moduled cotton, the pull fans for the drying system move the cotton from the module feeder. For this use and for unloading separators, we recommend using high static pressure No. 60 or No. 80 fans. With such fans, it is not necessary to use two fans in tandem to get the necessary suction.

4.9 Selection of Heaters -- A cotton gin cannot perform any better than its drying system. A drying system cannot perform any better than the air heaters used. The following check list can help avoid problems.

- (1) Will the heater actually put out the heat needed?
- (2) Is the heater designed to handle high air volume?
- (3) Does the heater have wide modulating range (20:1)?
- (4) Will the heater turn off to save fuel and restart automatically, quickly, and safely as cotton moisture conditions demand?
- (5) Does the heater provide clear diagnostics and operation statistics?
- (6) Can the heater controls connect to automatic moisture controls?
- (7) Does the heater have adequate combustion safeguards?
- (8) How efficient is its combustion?



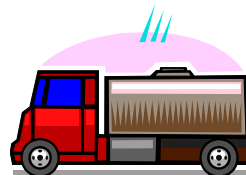
Samuel Jackson heaters are designed and built specifically for pull-through drying.

4.10 Calculation of Heat Required -- Determine the amount of heat required to raise a known volume flowrate of air (CFM) from one Fahrenheit temperature T_1 to another T_2 by using the following formula:

$$\text{Btu/hr} = 1.08 \times \text{CFM} \times (T_2 - T_1)$$

4.11 Calculation of Fuel Consumption -- Determine the maximum rate of fuel consumption in order to specify the proper size of gas meter, supply pipe, vaporizers and regulators. Do this by adding up the Btu/hr ratings of all your burners, then divide the total by the lower heating value of the fuel. Lower heating values of some common fuels are as follows:

Natural Gas	913.	Btu/ft ³
Propane, gas	2,385.	Btu/ft ³
Propane, liquid	84,240.	Btu/US gallon
Propane, liquid	43,870.	Btu/kilogram
Diesel fuel	132,100.	Btu/US gallon
Diesel fuel	34,900.	Btu/liter



Remember that the maximum consumption rate will be much greater than the average rate. It is important to have the maximum flow available to keep from slowing ginning when adverse conditions occur.



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4.12 Air Velocities -- We use a design velocity of 4500 to 5000 feet per minute when conveying wet seed cotton in drying air. If an abnormal circumstance reduces this even down to 3500 fpm, the system will still operate. For conducting hot air from the heater to the mix point, we use a design velocity of about 4000 fpm based on standard air. This allows for thermal expansion of the hot air.

5. AUTOMATIC CONTROLS FOR THE DRYING SYSTEM

5.1 Temperature Control of the Drying System -- The best way to make the heater responsive to cotton moisture conditions is to place its temperature sensor after the cotton-air mix point. This turns the burner down when the gin is idling, and turns it high when the cotton is wet.



There is something lacking here. We also need to limit the temperature of the hot air ahead of the mix point to prevent heat damage to the fiber. In some cases the maximum permissible temperature will be specified by the mills buying the cotton to preserve fiber quality.

In the late 1980's our company pioneered the use of cascaded temperature controls for cotton drying systems. We used Honeywell digital temperature controls to accomplish this as depicted in Figure 2. Its principle was as follows. The primary controller has its temperature sensor after the cotton mix point while the high limit controller has its temperature sensor before the mix point. The output of the primary controller determines the temperature set point of the high limit controller, while the output of the high limit controller modulates the fuel valve of the heater. We programmed the high limit controller to accept only a specified range of set points. The result was a smooth modulation of the hot air temperature up to the desired maximum.

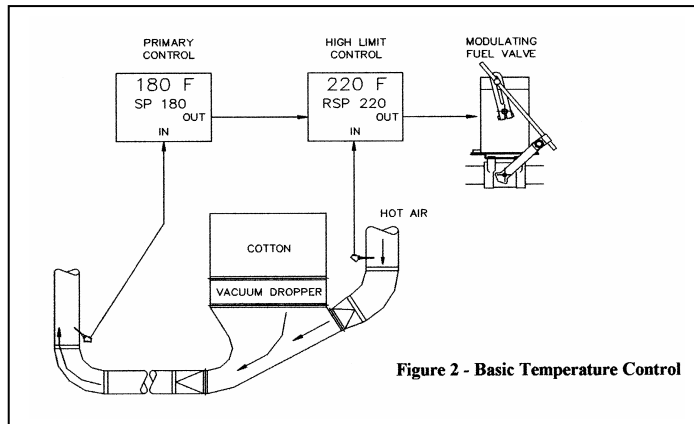
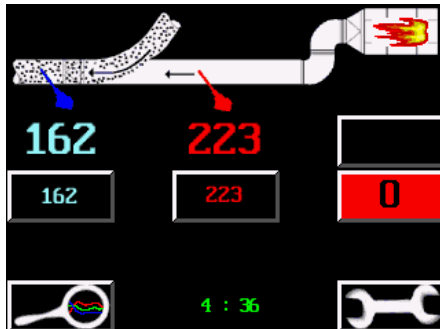


Figure 2 - Basic Temperature Control



Beginning in 2004 our product line migrated toward accomplishing the cascaded temperature control wholly within each burner's PLC control system, with overall coordination by a Moisture Mirror II. This arrangement has the advantage of making the control simpler to understand for the gin operator and the wiring simpler for the installing electrician. Conventional Ethernet cable is used to connect the components. We assign color codes to the temperature sensors to make the system easier to understand and troubleshoot.



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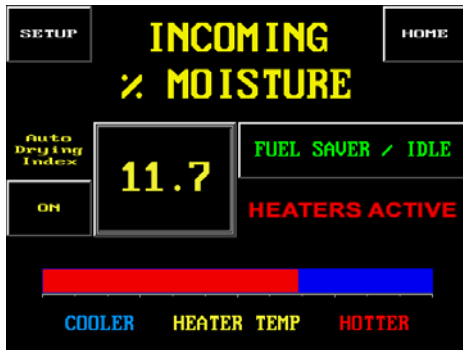
5.2 Moisture Control of the Drying System -- For years, there have been cotton dryer controls that use the moisture content of the cotton to modulate the burner fuel valves. Since this control arrangement cannot take into account the ambient air temperature, heater efficiency or the feed rate of the cotton, it is easy to over-dry the cotton, especially in hot weather.

This problem has been solved with controls that measure the incoming cotton moisture and then raise and lower the temperature set points of all the drying heaters in the gin. Using these controls, the operator can bias the general drying temperature level upward or downward. Each heater's primary controller can be programmed to progress through a different temperature range as the moisture content changes from low to high.

The cascade arrangement, in which the moisture content produces changes in temperature instead of simply modulating a gas valve, has several advantages. The control system will adapt the heater output to climatic conditions, using more heat in cold weather than in hot. The primary temperature controllers, having their sensors after the mix point, also react to the wetness and feed rate of the cotton, using more heat on wet cotton. We also have the benefit of the high limit control, which avoids exposing the cotton to excessively hot drying air.



A sensor like the sled pictured here can provide an advance signal to turn drying temperature up or down in response to moisture..

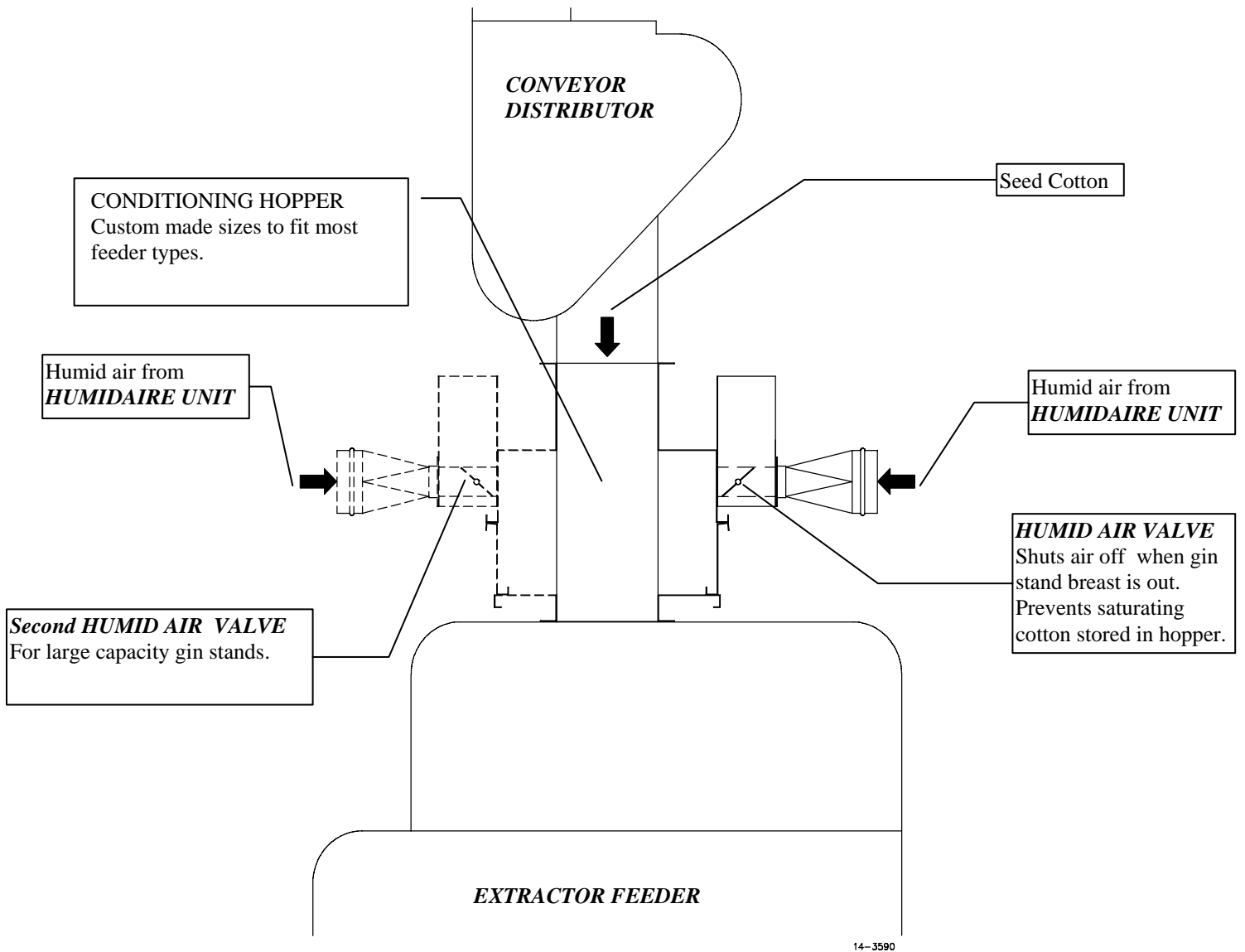


Fully automatic control for the drying system can be biased by the operator by adjusting the red and blue bar on the lower screen.

In 2001 the Moisture Mirror product was introduced. This “Moisture Coordinator” uses a color touch screen to let the operator know about changing moisture values and lets the operator easily program control action to compensate for the changes. In 2003 the Moisture Mirror II was introduced to augment this product line. Among its other enhanced capabilities, the Mirror II permits control of cotton moisture at the gin stand, without sacrificing fast response to incoming cotton conditions.

In 2007, a new feature was added to the Mirror II which allows it to turn off drying system heaters automatically when incoming cotton moisture is below an operator specified level. This saves significant drying fuel and further helps to preserve fiber staple and strength. Previous to this, gin operators were reluctant to turn off heaters completely because of the delay in turning them back on when conditions demand heat. A safe and effective “Quick Light” feature has been added to the heaters which takes care of this problem and allows the operator to run without heat until it is actually needed, at which point the burners reignite automatically and modulate to the appropriate temperature to achieve the specified fiber moisture setpoint.





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Figure 3 - Seed Cotton Conditioning Hopper



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