Reports Bill Action

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF RESEARCH ADMINISTRATION

RESEARCH PROJECT INITIATION

Date: September 26, 1974

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Project Title: Improved Cotton Handling System

Project No: E-27-625

Principal Investigator W. D. Freeston

Sponsor: Georgia Institute of Genetics (thru the Board of Regents)

Agreement Period: From 8/1/74 Until 9/30/75

Type Agreement: Grant

Amount: $20,000

Reports Required: Semi-Annual Progress
Annual Progress

Sponsor Contact Person (s):

Technical Matters
A. P. Sheppard
Room 310
Administration Building
Campus

Administrative Matters
Office of Research Administration
Room 306B
Administration Building
Campus

Assigned to: Textile Engineering

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RA-3 (6-71)

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GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 6/29/82

Project Title: Improved Cotton Handling System

Project No: E-27-625

Project Director: W. D. Freeston

Sponsor: Georgia Institute of Genetics (thru the Board of Regents)

Effective Termination Date: 9/30/78

Clearance of Accounting Charges: 9/30/78

Grant/Contract Closeout Actions Remaining:

None

- ☐ Final Invoice and Closing Documents
- ☐ Final Fiscal Report
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other ______________________

Assigned to: Textile Engineering (School/~~Laboratory~~)

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FORM OCA 10:781

E-27-625

IMPROVED COTTON HANDLING PROJECT

Final Report
May 15, 1980

Dr. David Brookstein
Principal Investigator
School of Textile Engineering
Georgia Institute of Technology

Project E-27-625

Sponsor - Georgia Institute
of Genetics

Introduction

This report details the design and development of an improved cotton handling system. Specifically the task of packaging the cotton at the gin and transporting it to the textile mill has been investigated.

Criteria for an improved packaging scheme includes:

1. Reduction of exposure of workers to byssinnotic agents
2. Reduced mechanical working and subsequent damage of the cotton lint
3. Simpler opening procedures which can be integrated with present pneumatic chute feed system.

To meet these criteria, a system which implements vacuum densification to compress masses of cotton fiber was developed. The densification is accomplished by placing loose tufts of cotton in a large expanded highly elastic bag and then by drawing an internal vacuum on the bag. The technique for densification was conceived after filling prophylactics with cotton fiber. See Fig. 1, 2, and 3. With this system packaging densities of approximately 10 - 18 pounds per cubic foot can be attained. It will be demonstrated in this report how these densities can compete economically with the density of a standard bale (28 lbs/ft^3).

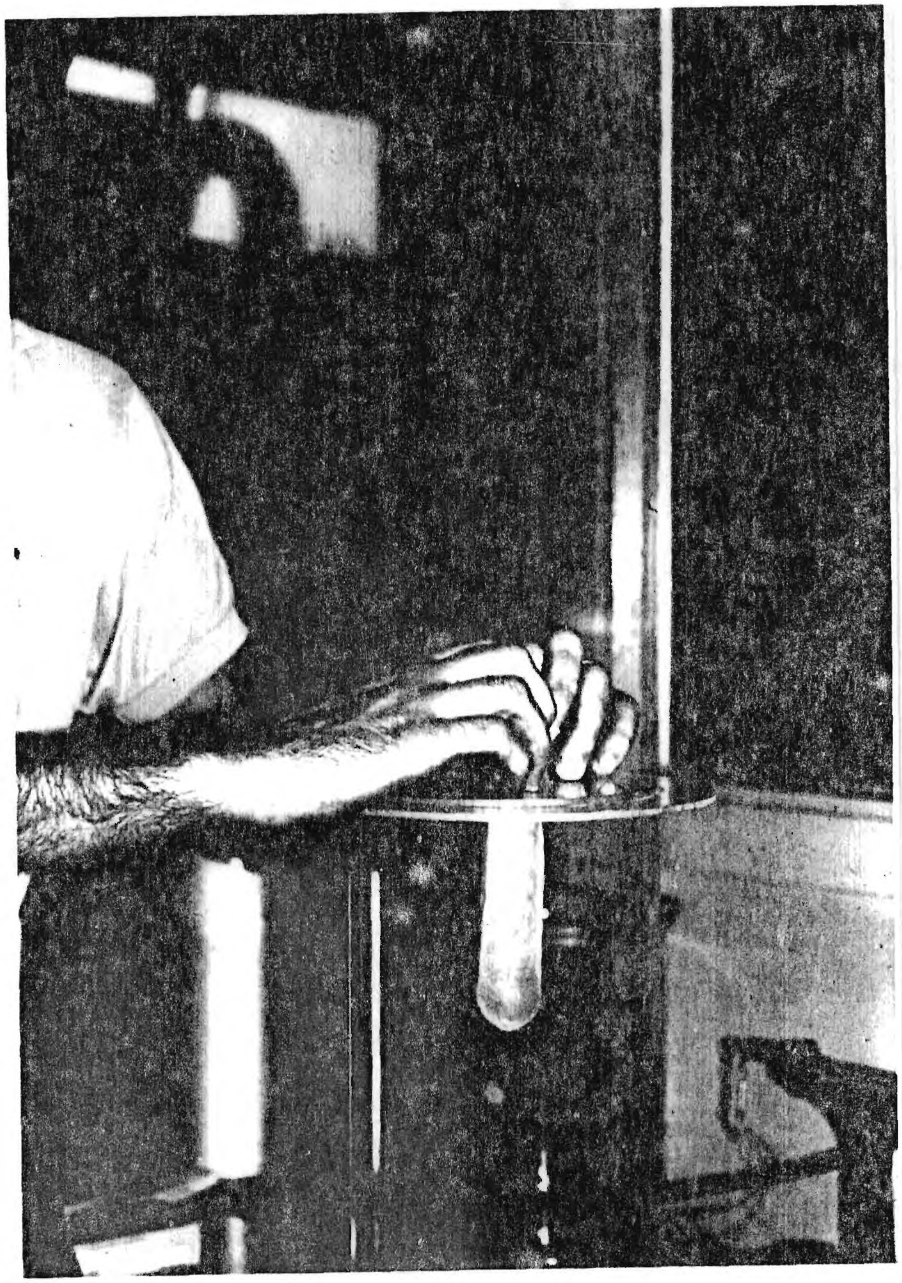


Figure 1. Placement of Propyhlactic in Vacuum Chamber

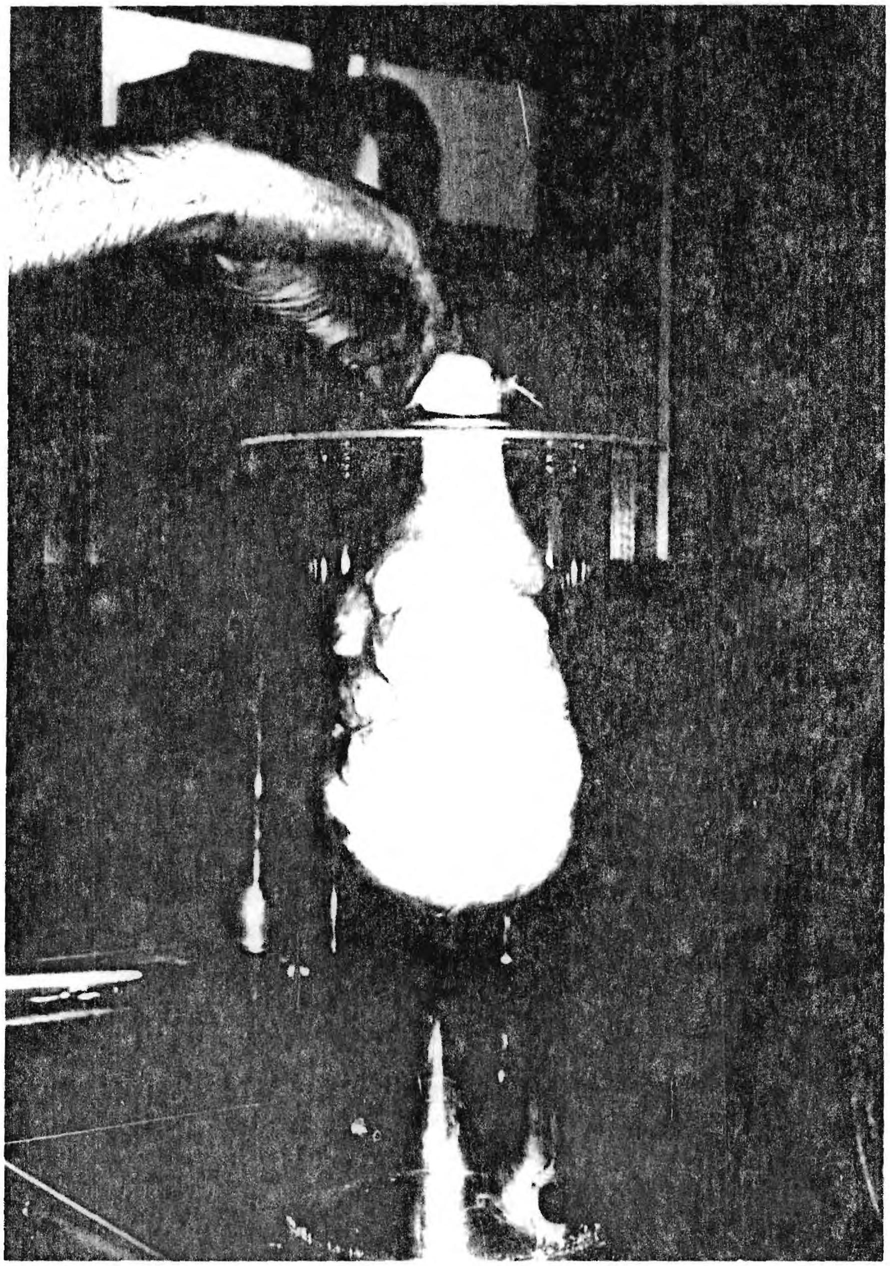


Figure 2. Filling of Prophylactic with Cotton

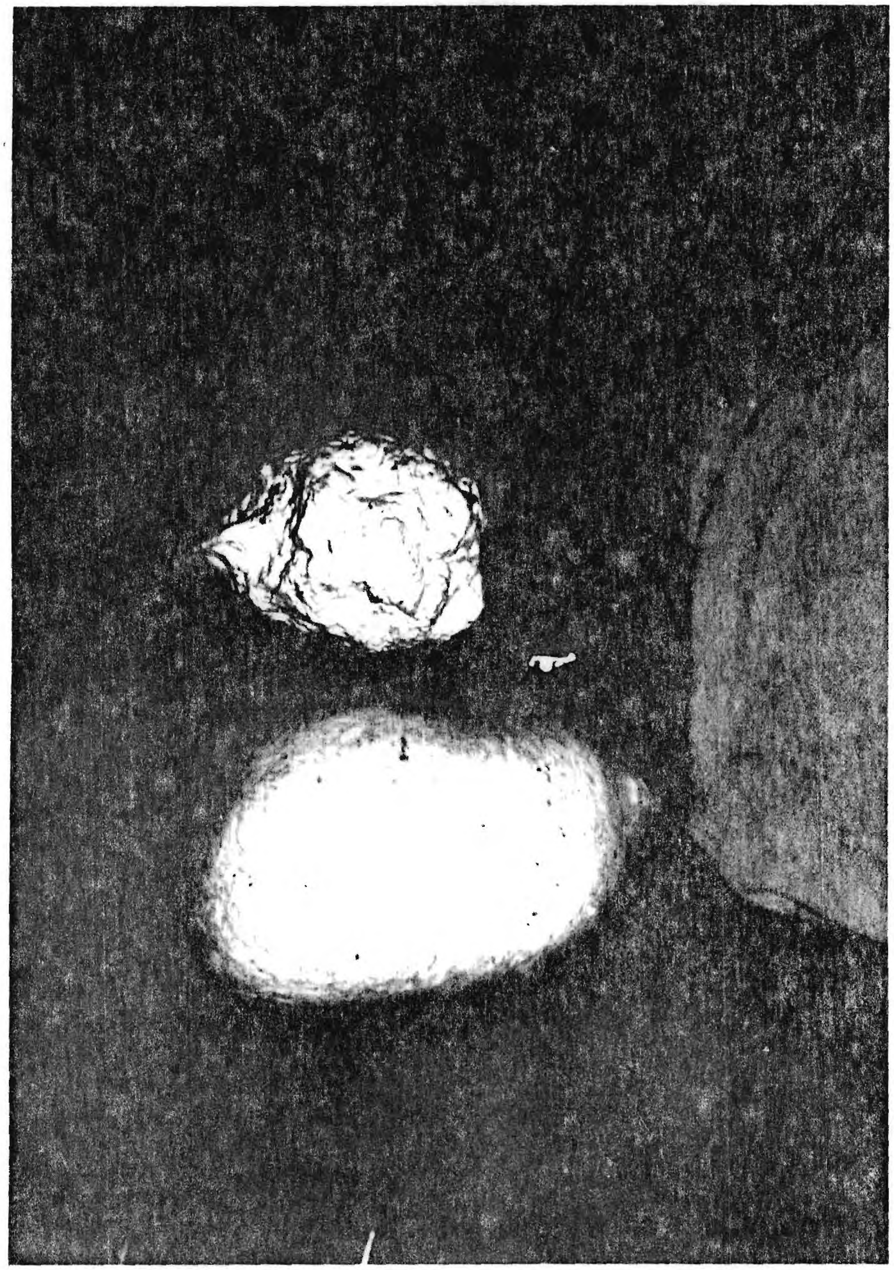


Figure 3. Cotton Filled Prophylactics Before and After Densification

Experimental Procedure and Results

A small scale prototype apparatus was set up to determine the feasibility of our system. A clear plastic cylinder was used as the tank and prophylactic rubber sheaths were used to hold the cotton. The technique used to fill the sheaths was identical to the general technique described above.

The results indicate volumetric densities as high as 18 lb/ft^3 can be obtained using vacuum densification.

It remained to test the concept on a large scale. This was accomplished with the apparatus described earlier. The general technique described previously was implemented for filling the large bags.

After the bags were filled it was necessary to determine their density. This was not a simple task and a rather novel approach was considered and later implemented. This approach called for submerging the filled bag in a box of polystyrene beads. These beads were about .10 inches in diameter and appeared to flow like a liquid around the bag exterior. Accordingly, the volume of the beads and bag could be measured and then the bag could be removed so that the only bead volume would be measured. Hence the bag volume could be determined by subtracting the bead volumes before and after bag removal. Coupled with the weight of the package cotton one could easily determine package density.

Technique for Bagging and Vacuum Densification of Ginned Cotton

Fig. 4,5,6 illustrates the bagging and vacuum densification system. A description of the technique follows.

1. A vacuum is drawn in the tank resulting in an expansion of the bag.
2. While the bag is expanded it is packed loosely with cotton fiber.
3. After the bag is filled the interior of the tank is vented to the atmosphere and the bag begins to recover.
4. A lid is placed on top of the bag and a vacuum is pulled inside the bag resulting in vacuum densification.
5. The interior vacuum is sealed and the bag is removed.

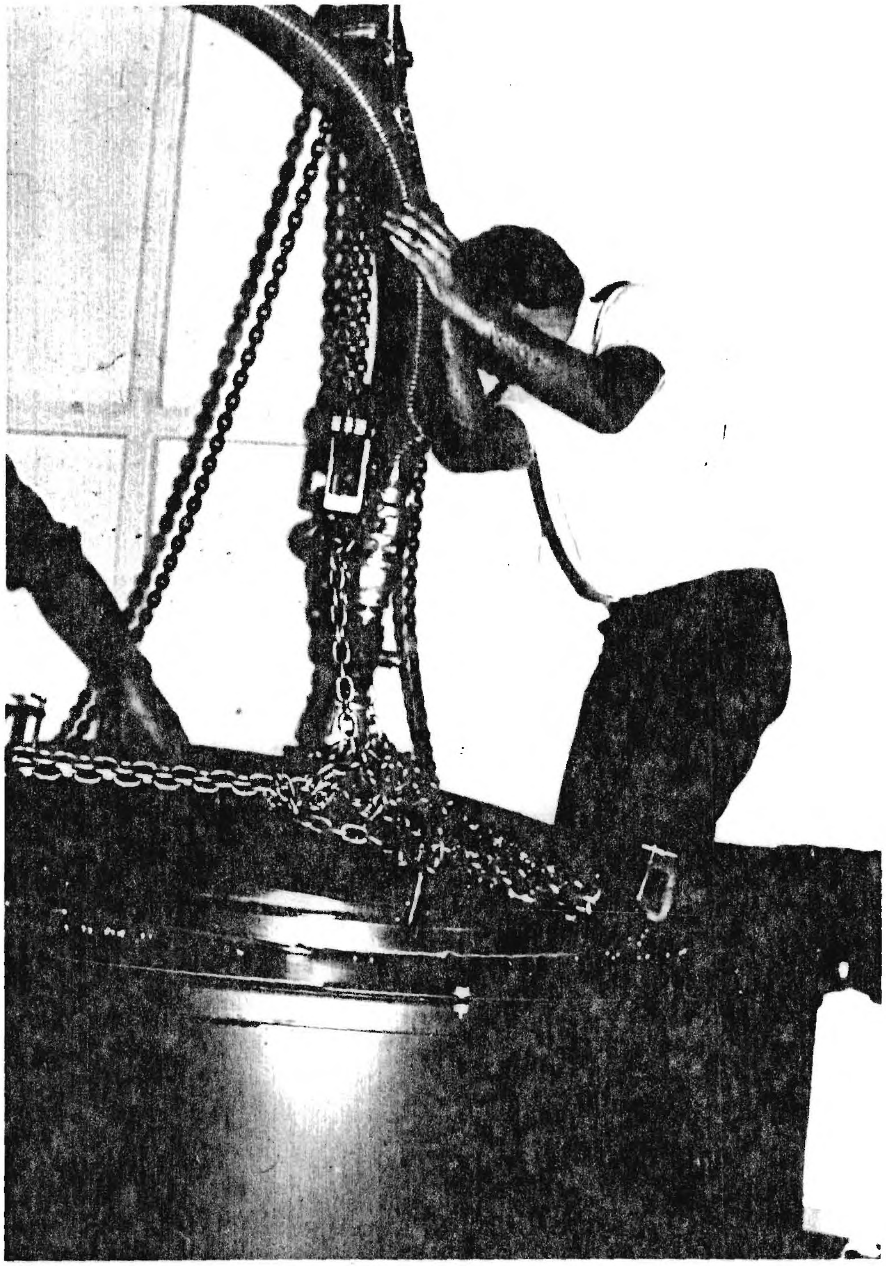


Figure 4. Bag Sealing

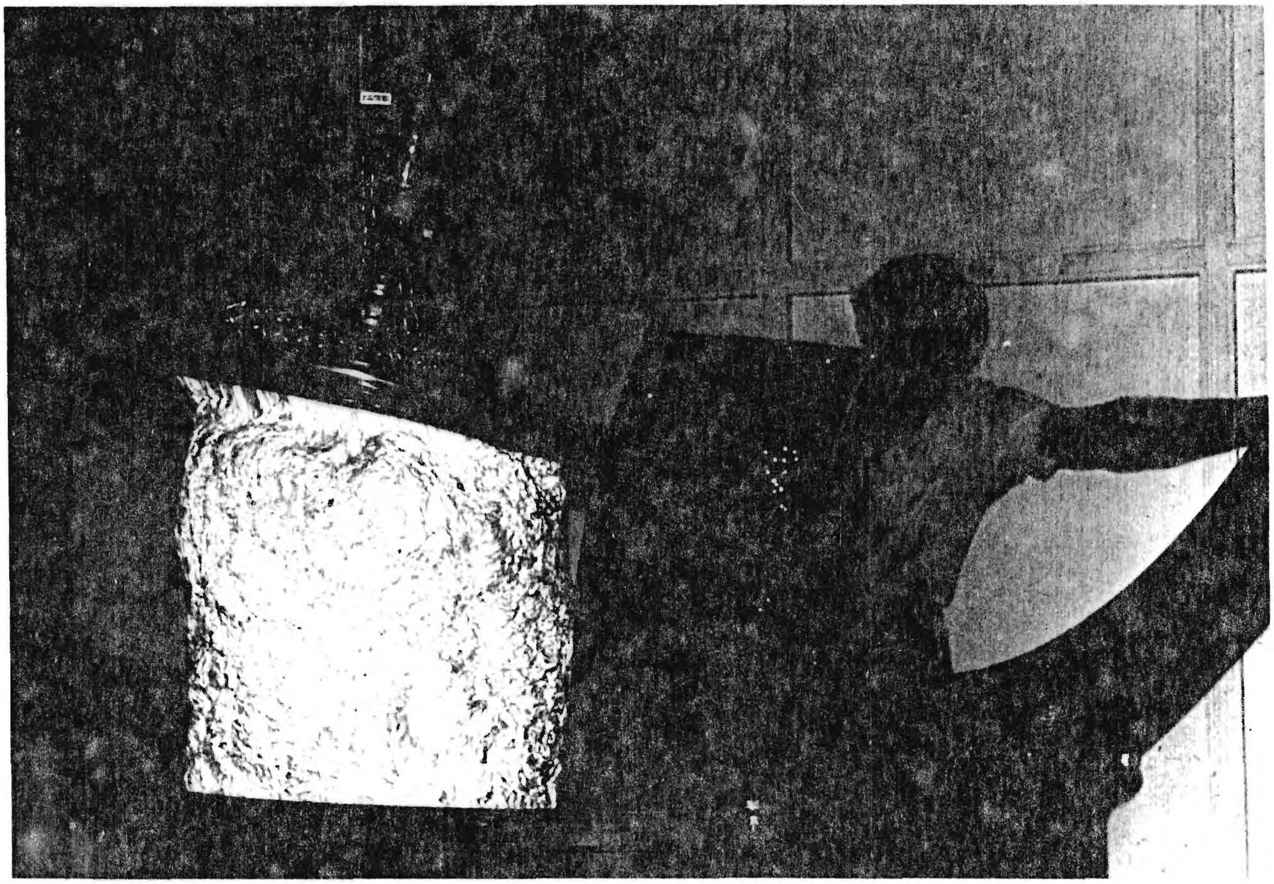


Figure 5. Bag Removed

Figure 6. Bag After Densification

Apparatus

A steel tank, used to support the bag and acts as a vacuum chamber during loading. The vessel is equipped with a hinged top for unloading filled bags of cotton. Secured to the hinged top is a flange to which the opening of the bag is fastened.

A sealing top was designed and developed for placing over the bag opening. This top has a valve for a vacuum hose to be mounted. The valve opening is protected with hardware cloth so that the valve is not damaged by loose cotton fibers during vacuum densification.

The tank and top were supplied by the American Sheet Metal Company in Doraville, Georgia.

The vacuum source necessary for both bag expansion and vacuum densification is a Rotron Cyclonaire Regenerative pump. It is capable of pulling 0 to 92 inches of water at 220 CFM to CFM. Accordingly, the pump capacity is sufficient for use during both bag expansion and densification.

The requirements for the bagging material are that it be tough, flexible and highly recoverable. The B.F. Goodrich Company provided Tuftane, a material which meets these requirements. Tuftane is a polyester-based thermoplastic polyurethane film containing a UV stabilization and antioxidant system which provides light stability.

Effect of Vacuum Densification in Cotton Yarn Properties

To determine if vacuum densification damaged the cotton fibers to an extent to which yarn properties might be effected, it proved necessary to manufacture cotton yarns from vacuum densified cotton and test them. This effort was accomplished at the United States Department of Agriculture facility at Knoxville. This facility has a system for spinning small (~ 50 grams) samples of cotton fibers.

Experimental Procedure and Results

Five samples were packaged experimentally in rubber sheaths and were held in this form for two weeks to determine the effects of packaging on processing characteristics of the fiber. A small lot spinning test was made on each drafting procedure. Five control samples taken from fiber that had not been compressed were also spun into yarn to determine the relative effects of compression on yarn properties and spinning performance. In this test, 1 50-gram mass of fiber is spun into a yarn having optimum twist for maximum strength. Twist level is based on fiber length and was the same for the five test samples and five control samples.

Fiber properties measured included length, fineness, and color. Length was measured with a digital Fibrograph, with fineness being measured on a Speedar II, an instrument using the resistance to airflow principle. Fiber color was measured with a Hunter D26 colorimeter, with R_d (greyness) and +b (yellowness) being determined.

Results of tests on fibers are shown in Table 1. An examination of the data shows that results are approximately the same for all samples whether compressed or not. Length uniformity index, which is a ratio of the 50% span length to the 2.5% span length, was the same for all of the samples.

Table 1. Results of Tests Made on Fibers

Sample No.	Compression Density, psi	Span Length, in. 50%	2.5%	Length Uniformity Index	Fineness	Color R_d	+b
1	14.4	0.44	1.02	43	<2.8	69.9	10.7
2	14.7	0.45	1.03	43	<2.8	69.3	10.7
3	14.6	0.45	1.03	43	<2.8	68.8	10.8
4	16.8	0.44	1.04	42	<2.8	68.1	10.5
5	15.9	0.45	1.04	43	<2.8	67.8	10.8
6	*	0.45	1.03	43	<2.8	68.4	10.8
7	*	0.43	1.02	42	<2.8	69.5	10.7
8	*	0.43	1.01	42	<2.8	69.6	10.6
9	*	0.45	1.03	43	<2.8	69.6	10.7
10	*	0.45	1.03	43	<2.8	69.2	10.7

* Samples were not compressed

Fineness was found to be very low, in fact, so low that it was not measurable on the instrument. Such results are typical of immature cotton and a definite deficiency in the mass per unit length of the fiber. Color measured by R_d is measured on a scale from 0 to 100 where 0 represents black and 100 white. The +b measurement is a measure of yellowness on a scale such that yellowness increases as the +b value increases.

Visual evaluations of trash content of the cotton fiber resulted in a rating of 2 for all of the samples, where 1 represents a low amount of trash and 5 a high amount.

Table 2. Results of Yarn Tests

Sample No.	Yarn Number, tex	Tenacity grams-force/tex	Color R_d	Color +b	Loss, %
1	26.8	10.3	72.0	10.8	12.4
2	29.9	10.2	71.8	10.6	12.2
3	27.3	10.2	72.0	10.8	11.2
4	26.8	10.3	71.7	10.7	11.6
5	27.1	10.2	71.1	10.5	14.5
6	27.0	10.4	72.1	10.8	12.4
7	27.6	10.4	71.8	10.8	11.8
8	27.7	10.2	71.3	10.7	12.7
9	26.9	10.4	71.7	10.7	12.7
10	27.3	10.2	71.9	10.8	12.9

Results of tests made on yarn are in Table 2. Yarn number in Tex was calculated from the weight of twenty small skeins. These same skeins were broken to determine the yarn strength. Color of the spun yarn was also measured to determine the relative improvement in whiteness resulting from trash removal.

As the data indicate, breaking tenacity of yarns spun from all of the samples was the same, being approximately 10.3 grams - force per tex. Fiber loss, calculated as the percentage difference between weight of fiber and yarn, was approximately the same for all samples. The expected increase in R_d from trash removal was the same for the compressed and uncompressed samples.

From these results it may be concluded that vacuum densification of cotton fibers does not significantly affect resulting yarn properties.

Economics of the Bag System

As discussed earlier, the introduction of the proposed bag cotton handling system may affect many aspects of the cotton industry. These include seed cotton storage, gin utilization and exposure of workers to byssinotic agents. The more immediate effects of using such a system, however, relate to changes in the costs associated with the materials and energy used to handle the cotton and transport it from one location to another.

Bag Material Costs

A supplier of the material that is proposed for the bags (B.F. Goodrich) has estimated that large quantities of the material, at a thickness of 4 mils, can be supplied at a cost of approximately \$0.08 per square foot. Since the bags are cylindrical the surface area will be $(2\pi rh\pi + 2\pi r^2)$ and the weight of cotton in the bag will be $\pi r^2 h\rho$ where r is the radius of the expanded bag, h is the height of the expanded bag and ρ is the density of cotton in the bag before compacting. By dividing the product of the cost per square foot and the surface area by the weight, a cost per pound of cotton bagged can be ascertained. However the bag system is designed to stretch the material before the filling operation. Thus the cost per square foot of the expanded bag is reduced by a factor which is proportional to the amount of stretching. Elongation of 50% in each direction have been used successfully in the laboratory resulting in a cost factor of $0.035 per square foot of stretched material. Using the above information, after some simplification the bag material cost, in $ per pound of cotton, can be estimated from

$$\frac{0.07}{\rho}\left[\frac{1}{r}+\frac{1}{h}\right]$$

Table 3 presents estimates of these costs for various values of r, h and ρ. It should be noted that the radius and heights are for the expanded bags; the values for the compacted bags would be considerably smaller.

Table 3. Bag Costs

Radius (feet)	Height (feet)	Fill Density (lb./ft.^{3})	Cost ($/lb.)
2	6	1	0.047
3	10	1	0.030
3	20	1	0.026
2	6	2	0.023
3	10	2	0.015
2	6	5	0.009
3	10	5	0.006

Cost of Compaction

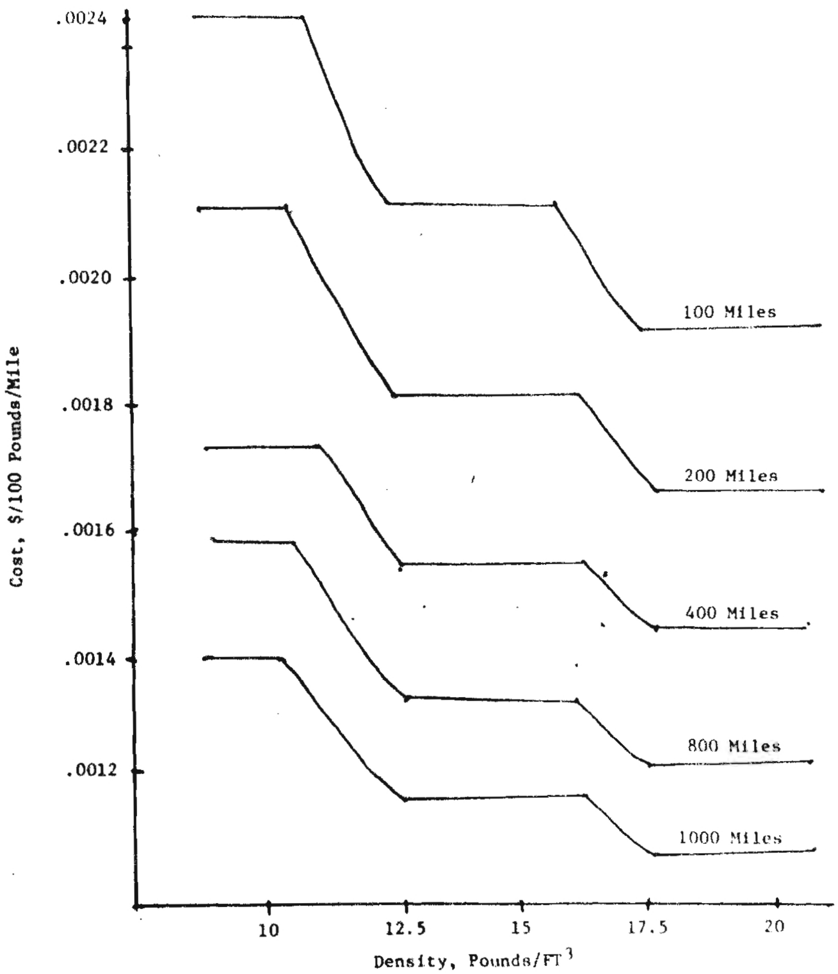
The primary factors involved are the cost of the equipment and cost of the energy required. The basic equipment being suggested for use is not complicated, consisting of a large tank and an air blower. The size of the bag used, the density to which the cotton is to be compacted, and the speed with which the bag filling operation is to be completed will most strongly influence these costs. The task of opening and stretching the bags can be accomplished with relatively low pressure differentials. Blowers, such as those used in this pilot project, which can achieve these pressure differentials with high flow rates are relatively inexpensive. Even for the largest bags that could be considered practical, a blower with the capacity to achieve the pressure differential desired in a matter of seconds would cost less than a thousand dollars.

The energy costs for a low pressure differential system are practically negligible, as illustrated by considering the following data for the compaction of a bag of cotton using the laboratory equipment. The operating time for the blower was less than one minute for a bag which holds approximately 300 pounds of seed cotton. The electric blower motor draws 3000 watts; resulting is electrical usage of 50 watt hours. Thus the energy used to compact a pound of cotton is roughly 0.00017 kilowatt hours. If electrical energy can be purchased at three cents per kilowatt hour, the cost of compaction is $\$5 \times 10^{-6}$ per pound.

If larger pressure differentials are desired in order to achieve higher densities, a more complex type of air pump is required. A pump of this type which would require the same amount of power and be in the same price range as the low pressure blower would have a much lower air flow rate (by approximately a factor of 10). In addition, as the pressure differential increases the flow rate drops off exponentially. Also, the experimental studies done have shown that densities increase quite slowly beyond pressures of a few pounds per square inch. While further data is needed to establish the relationship between density and cost over a wider range, it appears that it will not be a major cost of the bag system and considerations other than cost may determine the desired density.

Transportation Costs

These costs are highly dependent on the distance the cotton is transported and the density of the cotton. Different modes of transportation may also be used. Both rail and truck transportation of cotton from the gin to the mill are used, with rail accounting for a major portion. Costs of moving cotton for various distances at different densities are shown in the following figures. The data used to develop the costs relative to rail transportation are based on actual rates taken from SFTB Tariff 750-G, Item 9700. The data for costs of truck transportation are based on figures from Cost of Transporting Freight by Class I and Class II Motor Common Carriers of General Commodities - Southern Region, Statement No. 2C5-70, issued by the Interstate Commerce Commission, Bureau of Accounts. The figures were developed by assuming a typical container size and using this to estimate the weight of a load for different densities. The cost sources mentioned above report costs per unit weight for various total load weights and distances transported. The above information was converted to a cost per mile at various distances to facilitate comparisons of costs.



Costs of Transporting Cotton by Rail for Distances from 100 to 1000 Miles, Assuming 4000 FT^3 per 41 Foot Car

Figure 7.