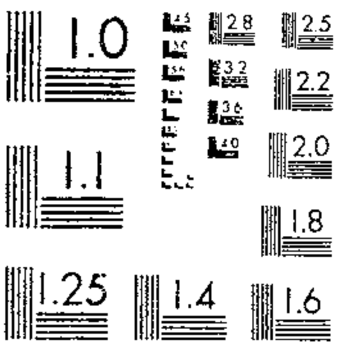
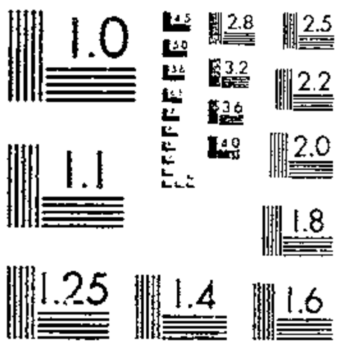
TB 1553 (1977) USDA TECHNICAL BULLETINS UPDATA
RESTORING MOISTURE TO COTTON AT MIDSOUTH GINS
MANGIALARDI, G J, GRIFFIN, JR, A C 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RESTORING MOISTURE TO COTTON AT MIDSOUTH GINS

Technical Bulletin No. 1553

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Mississippi Agricultural and Forestry Experiment Station

CONTENTS

ILLUSTRATIONS

TABLES

Washington, D.C. Issued January 1977

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price
Stock No.

RESTORING MOISTURE TO COTTON AT MIDSOUTH GINS

By GINO J. MANGIALARDI, JR., *agricultural engineer*, and ANSELM C. GRIFFIN, JR., *research physicist, Agricultural Research Service, U.S. Department of Agriculture, Stoneville, Miss. 38776*

ABSTRACT

Two moisture-restoration procedures were tested. In the first, a vapor generator delivered humid air to a seed-cotton conditioning hopper where the air mixed with cotton. The air averaged 75 to 85 percent relative humidity. In the second method, two atomizing nozzles emitted water as an airblown mist into seed cotton falling from a separator into the conveyor-distributor. In both experiments the moisture added to seed cotton was statistically significant. At the feeder apron, moisture content averaged 7.6 percent for the control (no moisture added), and 9.0, 8.6, and 9.5 percent for the nozzle, the vapor, and a combination of the nozzle and the vapor treatments. Corresponding moisture content of lint after ginning averaged 5.5, 7.1, 6.2, and 7.4 percent. Fiber length and uniformity increased as the moisture content was raised. Span length (2.5-percent) averaged 1.116 inches for the control, and 1.130, 1.126, and 1.136 inches for the nozzle, the vapor, and the combination treatments. Both methods were also tested as part of an automatic moisture-control system for the ginning of low-moisture cotton. All ginning equipment functioned normally, and no electrical, mechanical, or cotton-flow problems were encountered. **KEYWORDS: cotton, cotton ginning, cotton moisture, cotton-moisture restoration, textile equipment.**

INTRODUCTION

Restoration Needs

The restoration of moisture to low-moisture seed cotton prior to the separation of fiber and seeds in the gin stand can improve fiber quality and enhance production during spinning. Fibers retain their inherent properties best when the fiber and seeds are separated at a fiber-moisture content of 6 to 8 percent. Moisture added to cotton at the lint slide eliminates some of the problems associated with static electricity and aids in the pressing of the bale, but it does not restore fiber length that might have been damaged by ginning at low moisture levels.

The need to restore moisture to cotton fibers at the gin is dependent to a large degree on the atmospheric conditions normally expected in that location, because cotton harvested on dry days often arrives at gins with a fiber moisture below the recommended 6- to 8-percent range. Ambient temperatures and relative humidities occurring in the Midsouth on a typical day during the normal harvest period are depicted in figures 1 and 2. The temperatures and relative humidities that might be expected over a harvesting and ginning season extending from mid-August through December are shown for four different hours in table 1.

During a normal day, an increase in the ambient temperature is accompanied by a corresponding decrease in the relative humidity, creating curves that approach sine waves in shape. The periods of lowest temperature and highest humidity are usually shortly before sunrise. The curves shown are considered the norm, except when interrupted by precipitation.

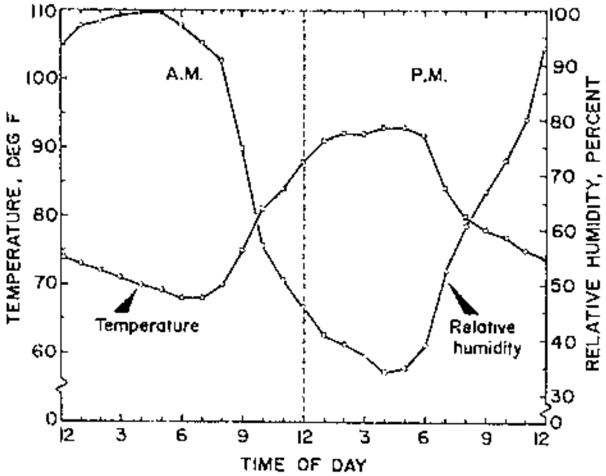


FIGURE 1.—Typical hourly temperatures and relative humidities expected in the Midsouth in September and October.

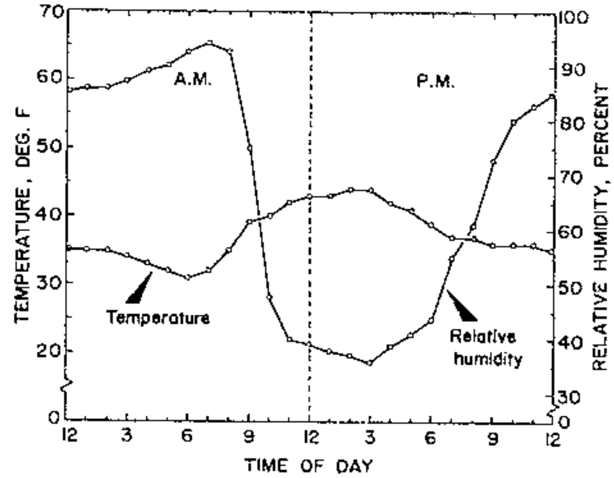


FIGURE 2.—Typical hourly temperatures and relative humidities expected in the Midsouth in November and December.

Montgomery and Wooten have shown that the moisture content of seed-cotton samples selected from the stalk prior to picking correlates fairly highly with the prevailing relative humidity *(18)*.[1] Approximately 64 percent of the variation in stalk seed-cotton moisture for early-season picking was related to prevailing relative humidity (fig. 3).

When raw cotton fibers are subjected to an ambient relative humidity of 55 percent at 70° F, they approach an equilibrium moisture content of (1) 7.5 percent when preconditioned wet and (2) 6.0 percent when preconditioned dry (fig. 4). Moisture restoration at the gin plant would be desired when the relative humidity of the air transporting cotton through the various gin processes is below 55 percent.

The relative humidity on a typical Midsouth fall day decreases sharply at approximately 8:00 a.m., drops below 55 percent near 10:00 a.m., reaches a low point of 35 percent at 3:00 to 4:00 p.m., and increases above the 55-percent level at approximately 7:00 p.m. If 55 percent relative humidity is used as a guide, moisture restoration would be required on a normal day between 10:00 a.m. and 7:00 p.m. Moisture restoration would be particularly needed when ginning seed cotton from storage

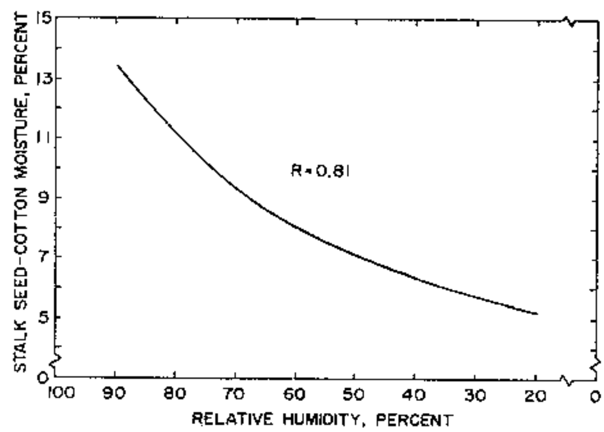


FIGURE 3.—Relation of seed-cotton moisture on stalk to relative humidity.

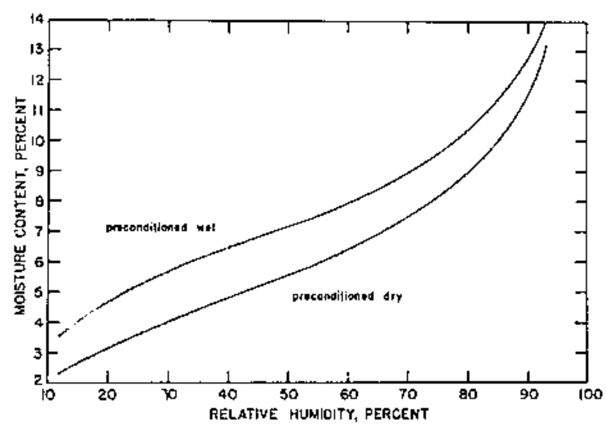


FIGURE 4.—Equilibrium moisture content of cotton fibers as a function of relative humidity at 70° F.

[1] Italic numbers in parentheses refer to items in "Literature Cited," p. 19.

TABLE 1.—*Ambient temperature and relative humidity at four daily times for 20 days during the ginning season, Stoneville, Miss.*

Date[1]		Time of day							
		12 p.m.		6 a.m.		12 a.m.		6 p.m.	
		Temp. (°F)	Relative humidity (pct)	Temp. (°F)	Relative humidity (pct)	Temp. (°F)	Relative humidity (pct)	Temp. (°F)	Relative humidity (pct)
Aug.	16	78	84	72	100	98	50	83	69
	23	74	100	72	100	93	53	87	54
	30	72	78	67	100	87	40	87	41
Sept.	6	67	100	64	100	83	55	85	53
	13	75	92	71	100	89	55	91	45
	20	77	100	72	100	89	50	91	50
	27	74	100	72	100	81	74	85	69
Oct.	4	69	100	66	100	81	55	83	42
	11	68	69	64	91	81	53	83	44
	18	75	86	70	100	81	66	84	47
	25	50	81	49	80	52	63	50	66
Nov.	1	70	100	69	100	81	53	70	100
	8	49	100	45	100	59	42	54	63
	15	44	68	42	73	44	71	43	81
	22	41	100	40	92	42	68	40	68
	29	36	94	34	99	46	56	43	60
Dec.	6	64	98	38	78	38	48	32	56
	13	39	94	38	86	41	71	39	78
	20	55	98	50	100	54	99	57	98
	27	34	78	30	93	52	29	46	44
Average		61	91	56	95	69	58	67	61

[1] Starting in mid-August, days were selected at 1-week intervals.

during the late season when it is not unusual for the cool ambient air to dip to 20 percent relative humidity.

Background

Research record

Excess moisture in seed cotton has long been recognized as one of the most important problems involved in cotton ginning. An estimate made during 1932 indicated that about one-fifth to one-third of U.S. cotton was damaged in the ginning process as a result of too much moisture in the seed cotton. A vertical drier was developed by USDA engineers for drying damp seed cotton to reduce the damage caused by the ginning of wet cotton. Higher lint grades, smoother preparation, brighter color, and reduced leaf content resulted. Facilities for drying at the gin permitted cotton picking to be continued during damp periods and in fields of heavy foliage sooner than would otherwise be desirable (*5*).

Experiments in the 1930's showed that the percentage of bales called "press cut" varied with the moisture content of the cotton. Press cutting was more frequent with dry cotton than with damp cotton. Bales having a low moisture content were usually cut, because greater pressure must be applied to obtain a given density if the cotton is dry. Increases in hydraulic and press-platen pressures consistently accompanied decreases in the moisture content of the bales, raising the horsepower required for the bale-pressing system (*24*).

Drying tests at Stoneville in 1949 and 1950 showed that the greater the moisture removal during drying, the higher the grade of the ginned lint. Fiber length and strength and yarn appearance were usually lower with increased drying. Cottons dried to 4 percent fiber moisture for cleaning and ginning produced lint of somewhat inferior fiber and spinning quality, compared to similar cottons dried and ginned in the 6.5- to 8-percent range. Fiber- and spinning-quality changes resulting from gin drying correlated much better with fiber-moisture content at the time of ginning than with drying-air temperatures. The conclusion was that advice to ginners regarding cotton-drying practices should be based on achieving a particular fiber-moisture content at the gin stand instead of recommending specific drying-air temperatures (*7*).

About 1950, other experiments showed that some of the damage resulting from overdry cotton in the gin plant could be prevented by increasing the moisture content of the cotton to near normal prior to separation of fiber and seeds. The addition of moisture by spray nozzles in the unloading suction telescope was found to be partially successful on low-moisture cottons, even though only a relatively small percentage of the moisture was retained. The lower the moisture content of the cotton being handled, the higher was the percentage of moisture retained. The addition of moisture to dry cotton at the wagon telescope preserved an additional one-sixteenth inch of staple length, and the fiber-quality benefits were substantiated by spinning tests (*9*).

After the 1950 tests correlating fiber-moisture content to fiber-quality preservation, further work explored vapor-phase moisture restoration. The work involved both steam and regain from controlled and uncontrolled atmospheres. Steam-pressure tests showed an average moisture increase of two percentage points after excess moisture evaporated. This was accomplished as a batch process and deemed unsuited to gin plant use. In some of the continuous-flow tests, steam proved to be a drying medium rather than a moistening agent. The best restoration from controlled atmospheres was from high-temperature and high-humidity atmospheres. A pilot moisture-restoration unit operating at 90° F and 94 percent relative humidity increased fiber-moisture content from 3 to 7.2 percent in 1 minute. This work was discontinued because delays in ginning are undesirable, and controlled drying to a predetermined fiber-moisture level seemed to offer a better end product than one heavily dried and returned to a specified moisture level (*7*).

Work with liquid-phase regain showed that overdried cottons could be returned to high levels of fiber-property retention concurrently with ginning but that some delay and agitation after spraying were required for adequate moisture distribution ahead of the gin stand. These experiments were discontinued because the efficiency of cleaning units following moisture restoration was seriously impaired. This work was done on gins with single lint cleaners (*7*).

From 1953 to 1955, misting nozzles were used to control moisture added to lint on the lint slide after ginning. This treatment provided no quality improvement in cotton, compared to cotton similarly dried and ginned with no moisture added at the lint slide. The reasons for replacing some of the moisture removed during ginning included improvement of the feel of the sample, easier and safer bale pressing, and minimization of postginning bale-weight changes resulting from atmospheric moisture absorption. Bales of the cotton lint packaged in humid cotton-growing areas at less than 7 percent moisture would be expected to gain weight, and those packaged at more than 7 percent moisture would be expected to lose weight (*6*).

After extensive testing, Speakes and Griffin obtained in 1956 a patent covering a method of moisture restoration or drying for ginning systems. The concept involved adjusting the moisture content of seed cotton or lint between gin processing stages (*21*).

Also in 1956, Harrell received a patent for the invention of an apparatus for the restoration of moisture to the fibers of seed cotton. The apparatus used nozzle sprays to deposit chemical wetting-agent solutions or fog mists of water on loose seed cotton dropping through a vertical chute (*10*).

Tests made in New Mexico in 1957 showed that static electricity could be controlled during saw ginning by treating the cotton with a 25-percent concentration of the antistatic agent Avcosol-20 in tapwater. The agent was sprayed in a seed-cotton-handling pipe before cleaning and extracting. No ill effects appeared in ginning. Fiber and spinning quality and chemical finishing were not affected (*12*).

Many researchers have studied the general relationship of tensile strength to fiber-moisture content. In 1961, work at Stoneville on the preservation of the inherent length distribution of cotton during ginning showed that the tensile strength of raw cotton fibers increases as moisture content increases and that the force required to separate fibers from their seed does not increase but may even decrease under certain conditions. Some experiments indicated that cotton could be overdried for cleaning and some moisture then restored before ginning to preserve fiber quality and spinning performance. Yet, later experiments showed that grade, the farmer's norm of quality, had not been improved. It was concluded that the intentional overdrying of cotton and the restoration of moisture to it before ginning was not beneficial to the producer, and that cotton having a fiber-moisture content of less than 6 to 7 percent should not be gin-dried. Instead, moisture should be added before fiber and seed separation in order to improve the ginning quality of the cotton. Difficulties in operation and rough preparation often resulted when cotton was ginned with a fiber-moisture content above 8 percent (*19*).

In 1961 and 1962, Mangialardi, Griffin, and Shanklin demonstrated that fibers in bulk do not readily absorb moisture and that a long exposure to a moisture-restoring medium is required, if a substantial quantity of moisture is to be restored to dry cotton. Tests using two commercially available methods showed that the moisture restored to cotton falling through a mist of water, then held in bale-size lots for about 20 minutes before the cotton was further processed and ginned, was greater than the amount restored by the delivery of humid air to the extractor-feeders where the air mixed with cotton. As a rule, the restoration of moisture to cotton after drying and cleaning but before fiber and seed separation slightly decreased grade index and yarn appearance, but it improved fiber and spinning properties. The restoration of moisture increased fiber length and lowered the coefficient of length variation, increased the fiber strength and the yarn break factor, reduced the number of ends down, and decreased yarn imperfections (*16*).

In 1964, a "monoflow" cotton-ginning system was tested at the Southwestern Cotton Ginning Research Laboratory, Mesilla Park, N. Mex. The system depended on water vapor added to the airstream that conveys the cotton to bring the cotton into moisture equilibrium. Two independent airflows were tried. Seed-cotton-handling airflows were put in series to form the first stream, and the second stream was used to convey lint from the gin stands to the lint cleaner, then to the press condenser. The objective of the development was twofold: to find a means of controlling the moisture content of cotton during ginning in an arid region and to alleviate the dust nuisance both inside and outside the ginnery (*13*).

A study during the 1964 harvest season evaluated the interaction of fiber moisture and lint cleanings. An increase in the fiber-moisture content at lint cleaners decreased the cleaning efficiency of the machines, but it increased the classer's staple length and 2.5-percent span length. Changes in fiber-moisture content showed essentially no differences in the number of neps per 100 square inches of web (*14*).

In 1966, the authors experimented with doffing lint from the gin saws with humid air. The procedure proved to be operationally sound when the relative humidity of the doffing air did not exceed about 85 percent. Cotton ginned at a 4.5-percent lint-moisture content was increased to 6.3 percent, and that at 6.0 percent was raised to 7.6 percent during the 3.6-second exposure (*15*).

In 1967, a completely integrated moisture-control system for gins was demonstrated at the U.S. Cotton Ginning Research Laboratory, Stoneville, Miss. Depending on the measured moisture content of incoming cotton, the system routed damp cotton to a variable-exposure drying system: cotton of desired moisture content bypassed the driers, except for a minimum exposure, and dry cotton was exposed to a moisture-restoration unit located between the conveyor-distributor and the extractor-feeder (*8*). This system has been installed in the laboratory's commercial-size ginning plant and used several years in moisture-control research.

In South Carolina in 1968, Cocke and Garner showed that a fiber-moisture level of 3 to 4 percent during processing resulted in highly efficient foreign-matter removal in the seed-cotton and lint-cleaning system, improved color of the lint, increased grades, raised unit lint price, and reduced picker and card waste in spinning lots, compared to cotton processed at a fiber-moisture level of 6 to 8 percent. The 6- to 8-percent level resulted in higher 2.5-percent span length, uniformity ratio, fiber strength, staple length, lint turnout, 50s and 22s yarn strength, break factor, and appearance index. Bale value did not differ by fiber-moisture level during processing (*8*). These experiments confirmed the earlier tests at Stoneville on the importance of fiber moisture during gin processing.

In 1971 and 1972, a pilot model of a closed-loop cotton-moisturization system for cotton ginning was developed and tested at the South Plains Ginning Research Laboratory, Lubbock, Tex. The system included a plenum chamber and used humid air to convey lint between the gin stand and lint-cleaning operations. The closed-loop concept proved feasible for increasing lint-moisture content during lint cleaning, and it also reduced the dust and short fibers exhausted to the atmosphere (*4*).

Commercial equipment

Steam or mist had been customarily introduced into the cleaning feeders and air-blast gins when static electricity interefered with cotton ginning. Earl M. Heard devised a gin-building humidification system in the late 1930's in cooperation with ginners of the Lubbock, Tex., area and USDA ginning engineers. Wetting-agent solutions and other methods for the introduction of moisture into the cotton and into the air used for conveying the cotton were tried (*2*).

In 1959, R. L. Bryant of Leachville, Ark., a farmer and ginner, incorporated a liquid-phase moisture-restoration system in his gin plant. Bryant redeposited moisture-sprayed cotton on a trailer for a 20-minute delay before final processing. This system was later manufactured by the John E. Mitchell Co., Dallas, Tex., and installed in 1962 in gins at Paragould and Victoria, Ark. The manufactured system stored the dampened cotton in bins within the gin plant (*17*).

About 1960, the Samuel Jackson Manufacturing Co. of Lubbock, Tex., began marketing a vapor moisture-restoration device. The Jackson humidifier consisted of a fan system, a gas heater, and a water-spray and wringer chamber. Heated air was pulled through the spray chamber, where it absorbed moisture that was then delivered into the extractor-feeder over each gin stand, where some of the moisture was absorbed by the cotton as it passed through the feeder. Later the system included conditioning hoppers located between the conveyor-distributor and each feeder, and a special hopper where a slowly moving bed of seed cotton was retained for about 15 to 20 seconds while humid air was blown upward through it (*11*).

During this period, L. D. France & Co., Lubbock, Tex., introduced the "HUMI-DRIER." In addition to providing humid air for moisture restoration, this unit, by means of a damper above the burner, could bypass the moisturizing chamber, allowing the device to serve as a source of heated air for drying cotton.

The Continental Gin Co. introduced its two- or four-trough conveyor-distributor cotton drier. Although designed to be used primarily as a drier, it was later described as suitable also for humidifying seed cotton (*20*).

Tabulation of gin equipment in 1972 indicated that 592 cotton gin batteries, or 16 percent of the total number of batteries in the United States, included a moisture-restoration system. The percentages were 20 for the States of Texas, New Mexico, Arizona, and California, compared to only 9 for the more humid States of Mississippi, Tennessee, Missouri, Arkansas, and Louisiana. Although there was a sharp decrease in the total number of batteries during the previous 5-year period, the number of cotton gin batteries with moisture-restoration systems had increased (*23*).

Experimental Methods

This bulletin presents the results of moisture-restoration experiments conducted from 1967 to 1973 at the U.S. Cotton Ginning Research Laboratory, Stoneville, Miss. The objectives of the investigations were (1) to investigate the conditions under which moisture restoration should be used in humid cotton-growing areas such as the Midsouth, (2) to establish the merits of two methods for restoring moisture to seed cotton at the gin after it has passed through the overhead cleaning equipment but before it is ginned, and (3) to incorporate these methods into an automatic moisture-control system that includes drying and moisture addition. The two restoration procedures tested were (1) a vapor-generator method and (2) an atomizing-nozzle method.

The cottons used in the experiments were 'Stoneville 7A' and 'Stoneville 213', grown and harvested by spindle pickers in Washington County, Miss. Data used to develop the weather charts and table were recorded at Stoneville in 1972 by the National Weather Service. The U.S. Department of Agriculture Consumer and Marketing Service (now Agricultural Marketing Service) classed the cotton samples at Greenwood, Miss., and made fiber tests at Clemson, S.C.

VAPOR-GENERATOR RESTORATION

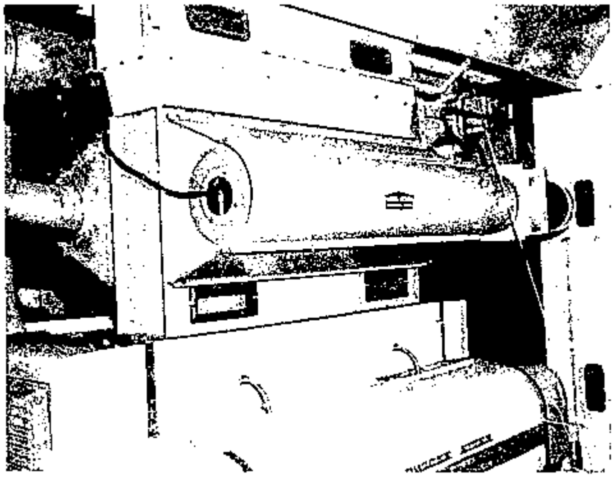
Methodology

During the summer of 1967, a heated-air moisture-restoration system was assembled and installed in the laboratory's commercial-size ginning plant. The system consisted of a vapor generator delivering humid air to a seed-cotton conditioning hopper (feeder chute) where the air mixed with cotton (fig. 5). The conditioning hopper was located between the conveyor-distributor and the extractor-feeder. The length of the moisture-exposure period was a function of the ginning rate, which regulated cotton flow through the hopper. This unit operated concurrently with ginning and required no special routing of cotton.

The vapor was passed through the conditioning hopper by two centrifugal fans in a push-pull arrangement. Humid air was piped through a 12-inch-diameter pipe into the front of the hopper, where it was blown through the cotton, and it was exhausted from the backside through a 9-inch pipe. The hopper was 63 inches long and conditioned the 12-inch-thick seed-cotton batt over a 24-inch vertical movement. Adjustable openings in the back of the hopper introduced ambient air, aiding in the control of the airflow and pressure.

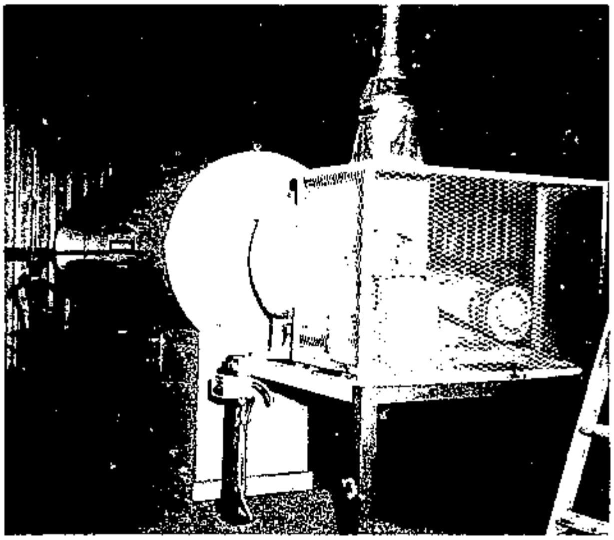
The moisture in the humid airstream was controlled by adjusting the temperature of the air passing through four sets of misting nozzles located within the vapor generator (fig. 6). An increase in the air temperature increased the vaporization.

The sequence of the ginning machinery was feed controller, tower drier, six-cylinder cleaner, stick machine, tower drier, six-cylinder cleaner, conveyor-distributor, conditioning hopper, extractor-feeder, gin stand, and two stages of saw-cylinder lint cleaning (fig. 7).



PN-5162

FIGURE 5.—Seed-cotton conditioning hopper located between the conveyor-distributor and the extractor-feeder.



PN-5163

FIGURE 6.—Vapor generator used to produce warm air containing a large amount of water vapor.

Results

The quantity of air flowing through the seed-cotton conditioning hopper was found to be critical. Too great an airflow into the inlet section suspended cotton in the distributor above the hopper, and too great a suction in the exhaust section held cotton to the hopper walls. Proper airflow could be obtained through

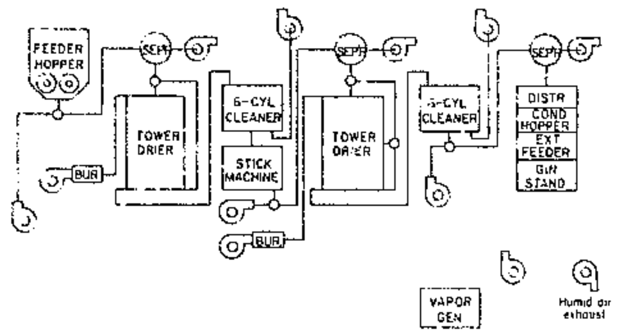


FIGURE 7.—Ginning sequence depicting vapor-generator system used in experiments.

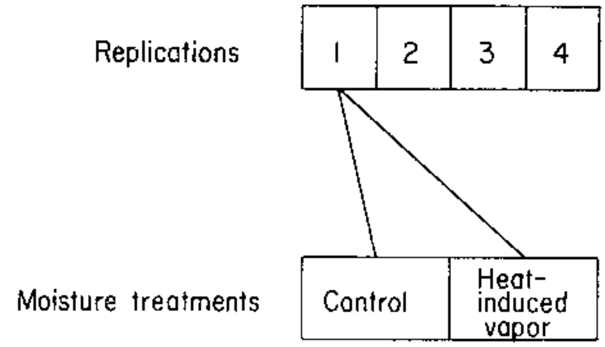


FIGURE 8.—Experimental test layout for vapor-generator treatments.

the hopper at rates of 800 to 1,220 cubic feet per minute, while maintaining a static pressure of +0.3 to +0.5 inch and −0.2 to −0.8 inch of water in the hopper intake and exhaust manifolds, respectively.

Two vapor-restoration treatments were tested in four replications from the 1968 crop cotton (fig. 8). The treatments were (1) no humid air passing through the conditioning hopper (control) and (2) vapor restoration in the hopper.

A temperature of 200° F was maintained in both tower driers; the ginning rate was 2.5 bales per hour, providing a 15-second exposure; and humid air available for the restoration treatment was 62 cubic feet per pound of lint.

The ambient temperature and relative humidity during the study averaged 67° F and 45 percent. The vapor generator provided humid air at 90° F and 72 percent relative humidity at the conditioning hopper. Higher humidities were not attempted because of likely moisture condensation on the gin machinery, causing chokeups.

Cotton-moisture content.—Moisture content of seed cotton at the wagon averaged 9.1 percent for the experiments, and this level dropped to 7.0 percent during seed-cotton drying and cleaning (table 2). The moisture-restoration treatments increased the moisture content of the cotton passing through the conditioning hopper. Seed-cotton moistures at the feeder apron for the control and moisture-restoration treatments were 7.0 percent and 7.7 percent, respectively (*1*).

Corresponding lint-moisture contents for the control and restoration-treatment samples taken between the gin stand and the first lint cleaner averaged 4.7 and 5.6 percent, and samples taken at the press averaged 5.1 and 6.0 percent. Differences in the moisture contents at the press, resulting from the moisture treatments, were found to be statistically significant (*22*). Cottonseed-moisture content at ginning averaged 8.9 percent for the study.

Proper intermingling of air and cotton within the conditioning hopper should have been accompanied by greater moisture-content changes than were observed. Static air-pressure measurements indicated that the seed-cotton mass within the hopper served as a barrier to airflow, causing some of the moist air to short circuit around it.

Foreign-matter content.—Fractionation tests of the initial foreign-matter content of seed cotton averaged 3.7 percent, which was re-

TABLE 2.—*Moisture content obtained in vapor-generator experiments*[1]

[Percent]

Item	Treatment	
	Control	Moisture restoration
Seed cotton:		
At wagon	8.9	9.3
After drying and cleaning	6.9	7.0
At feeder apron	7.0	7.7
Seed	8.8	8.9
Lint:		
Before lint cleaning	4.7	5.6
At press	5.1	6.0

[1] Moisture treatments were replicated 4 times. Data represent average findings for sampling subjected to oven moisture-determination tests, ASTM Designation: D 2495 (*1*).

TABLE 3.—*Foreign-matter content for vapor-generator experiments*[1]

[Percent]

Item	Treatment	
	Control	Moisture restoration
Seed cotton:[2]		
At wagon	3.7	3.7
After cleaning	1.2	1.2
At feeder apron	1.0	.9
Lint[3]	1.69	1.71

[1] Moisture treatments were replicated 4 times.

[2] Data represent average findings for samples subjected to fractionation tests.

[3] Data represent average findings for samples obtained after 2 lint cleaners and subjected to analyses with a Shirley analyzer.

duced to 1.2 percent during passage through the drying and cleaning machinery and to 1.0 percent at the feeder apron (table 3). The lint foreign-matter content was analyzed for two lint-cleaning stages. Total foreign matter, as determined by a Shirley analyzer, averaged 1.69 percent for the control lots and 1.71 percent for the treated lots. Foreign-matter differences attributed to moisture treatment were not statistically significant.

Classer's grade.—Lint grades assigned by the classer for cotton after two stages of lint cleaning averaged Strict Low Middling plus for the control treatment, and Strict Low Middling for the treated lots (table 4). Grade-index differences attributed to moisture treatment were significant at the 10-percent level. Staple-length differences between moisture treatments after two lint cleaners were small and not significant.

Fiber tests.—Samples for fibrograph length analyses were obtained between the gin stand and the first lint cleaner. These data showed that the moisture treatment gave a slight but statistically significant increase in the uniformity ratio (table 4). Uniformity ratios for the control and moisture-treated lots averaged 45.0 and 45.8 percent, and corresponding 2.5-percent span lengths averaged 1.113 and 1.118 inches.

TABLE 4.—*Classer's grade and staple length, and digital fibrograph data for vapor-generator experiments*[1]

[Percent]

Item	Treatment	
	Control	Moisture restoration
Grade:[2]		
Index	97.7	94.9
Designation	SLM+	SLM
Staple length (1/32 in)	34.8	34.9
Fibrograph:[3]		
2.5-percent span length (in)	1.113	1.118
Uniformity ratio (pct)	45.0	45.8

[1] Moisture treatments were replicated 4 times.

[2] Samples were obtained after 2 stages of lint cleaning. Grade designation and corresponding grade index: M=100; SLM+=97; SLM=94; LM+=90; LM=85.

[3] Sampling was performed before lint cleaning.

Automated System

In 1970, the vapor generator was merged with driers into an automatic moisture-control system and installed in the laboratory's ginning plant (fig. 9). Cotton-moisture content was sensed by a commercial moisture detector that transformed the moisture reading to a 0–10 millivolt output, which was transmitted to a chart recorder. Based on previously conducted experiments, the detector was calibrated to condition automatically seed cotton arriving at the gin plant at moisture levels ranging from less than 7.5 percent to greater than 14.0 percent (fig. 10).

Cam-operated electric switches, installed on the pen motor hub of the recorder of the moisture-measuring instruments, were used to select alternate drying routes through the driers, based on the need of the cotton for drying, and to activate the moisture-restoration apparatus when the detector showed a cotton-moisture content too low for proper ginning.

The drying system was two 24-shelf tower driers, where the drying period could be varied by selecting any of four drying-path combinations. Damp cotton at the input feed controller requiring more than one stage of drying was automatically routed to the first drier and then passed to the finishing drier. Cotton requiring only one stage of drying, or less than a full drier, automatically bypassed the first drier and was routed through all, or part, of the second drier.

When the detector measured seed-cotton

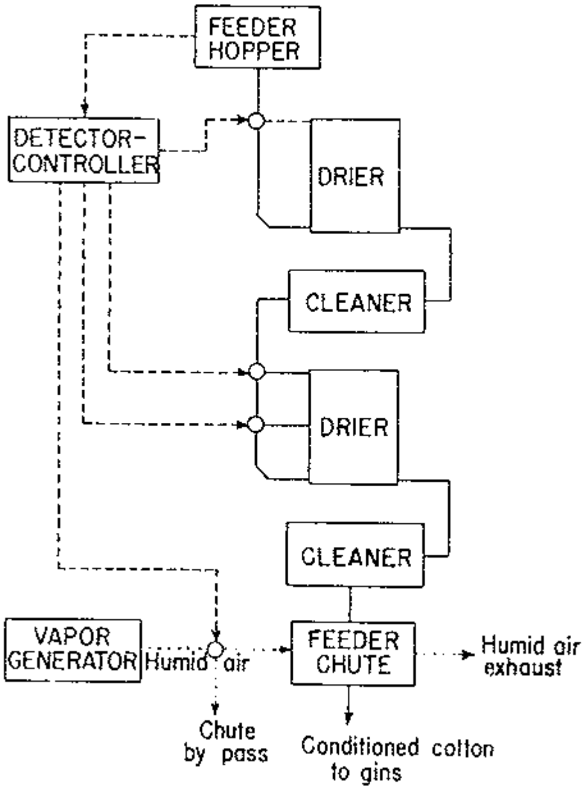


FIGURE 9.—Block diagram of the automatic moisture-control system used with the vapor generator.

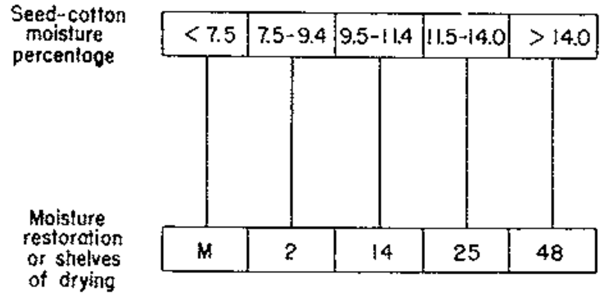


FIGURE 10.—Moisture restoration and drying shelves selected by the moisture detector to condition automatically seed cotton of various moisture levels.

moisture less than 7.5 percent, humid air was directed through the conditioning hopper where it mixed with seed cotton. For cottons containing 7.5 percent or greater seed-cotton moisture, the humid air bypassed the hopper and was exhausted outside the gin plant. When the gin stand was not in operation, the humid air was also bypassed to the outside to prevent an overwetting of the seed cotton standing in the hopper.

The performance of this equipment with the selected-control settings was tested on 14 experimental bales designed to cover the range of moisture contents normally expected at the gin. Desired initial moisture levels were obtained by monitoring the ambient relative humidity, selecting the time of day to harvest, and controlling the amount of water applied to the picker spindles. During the tests all subsystems of the installation were monitored, and the cotton sampled for moisture determination before and after conditioning. Moisture contents were determined by the ASTM ovendrying method for cotton (*1*).

Drying temperatures in the top shelf (cotton-air mix point) of driers No. 1 and No. 2 averaged 195° and 180° F, respectively. For the ginning rate used, the exposure period for seed cotton was 24 seconds. Humid air available at the conditioning hopper was 33.1 cubic feet (0.052 pound) of water vapor per pound of lint. The heated water vapor averaged 87° F and 77 percent relative humidity.

Each component of the installed automatic conditioning system performed its intended function, and no electrical or mechanical problems were encountered.

Moisture content of seed cotton at the feed controller during the 14-bale test varied from 6.7 to 16.3 percent, and ambient relative humidity ranged from 32 to 70 percent (table 5). For these cottons, the moisture detector automatically selected conditioning paths of 48 shelves, 25 shelves, 14 shelves, the 2-shelf bypass, and moisture addition. The system produced seed-cotton-moisture contents of 6.5 to 13.1 percent at the feeder apron and lint-moisture contents of 4.3 to 7.5 percent at fiber and seed separation.

Three bales with seed-cotton-moisture contents of 6.7 to 7.6 percent at the feed controller gave seed-cotton-moisture contents of 6.2 to 6.5 percent at the feeder apron and lint-moisture contents of 4.1 to 4.3 percent at ginning, after being subjected to humid air in the conditioning hopper. This indicates that a greater amount of moisture was evaporated while passing through the drier system bypass and to the ambient air than that absorbed at the conditioning hopper. It is probable that a somewhat higher amount of moisture than the quantity measured was added to cotton in the

TABLE 5.—*Performance of automatic moisture-conditioning system on 14 experimental bales*[1]

Initial seed-cotton-moisture content[2] (pct)	Ambient relative humidity (pct)	Conditioning path[3]			Moisture content after conditioning	
		Drier No. 1 (shelves)	Drier No. 2 (shelves)	Moisture-vapor delivery	Seed cotton[4] (pct)	Lint[5] (pct)
16.3	52	24	24	Bypass	13.1	7.5
15.8	70	24	24	Bypass	11.3	8.0
14.3	53	24	24	Bypass	11.9	6.3
14.0	57	24	24	Bypass	12.3	8.1
11.2	55	1	13	Bypass	11.4	6.8
10.7	57	1 1	1 13	Bypass Bypass	8.0	5.6
10.2	32	1 1	1 1	Bypass Chute	7.4	4.4
9.5	36	1 1	13 24	Bypass Bypass	7.3	5.5
9.4	56	1 1	1 13	Bypass Bypass	7.0	4.8
8.4	36	1	1	Bypass	6.9	5.5
8.3	60	1 1	1 1	Bypass Chute	7.5	5.7
7.6	62	1	1	Chute	6.2	4.1
6.7	64	1	1	Chute	6.2	4.2
6.7	60	1	1	Chute	6.5	4.3

[1] Data for each experimental bale represent an average from 5 samplings.
[2] Sampled from the feed-controller hopper.
[3] Where 2 paths are shown, the controller changed the path during the bale.
[4] Sampled at the feeder apron.
[5] Sampled after ginning but before lint cleaning.

hopper, but it was given up to ambient air while being processed through the extractor-feeder and during fiber and seed separation.

Some cotton-flow difficulty was attributed to static electricity when processing the low-moisture cottons. When moisture was applied to cotton at the hopper, the flow was normal.

The vapor-generator subsystem may be utilized in an automatic moisture-conditioning system. But, if greater amounts of moisture are to be added, means should be provided to give (1) longer exposure periods, (2) better intermingling of seed cotton and humid air, and (3) humidity control of the air conveying cotton between gin machinery.

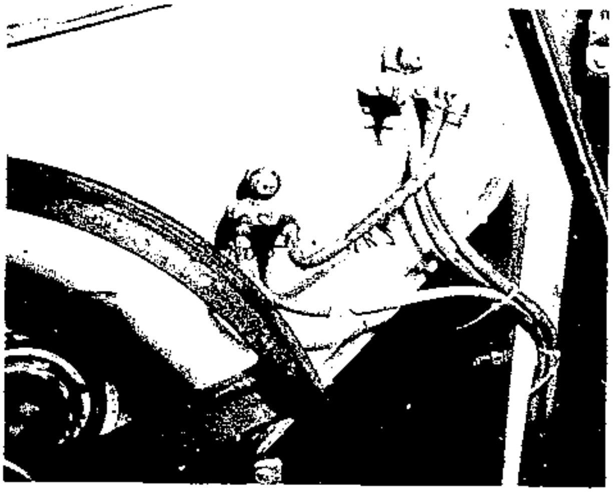
ATOMIZING-NOZZLE RESTORATION

Methodology

Because of the need for adding moisture to cotton at high ginning rates, technology for adding moisture in the liquid phase was considered. The work was initiated to determine the feasibility of calibrating moisture-addition equipment in terms of the ginning rate and to evaluate the operating characteristics of an airblown-mist applicator mounted in the conveyor-distributor endplate, where the mist could be blown into cotton falling from a separator into the distributor (fig. 11).

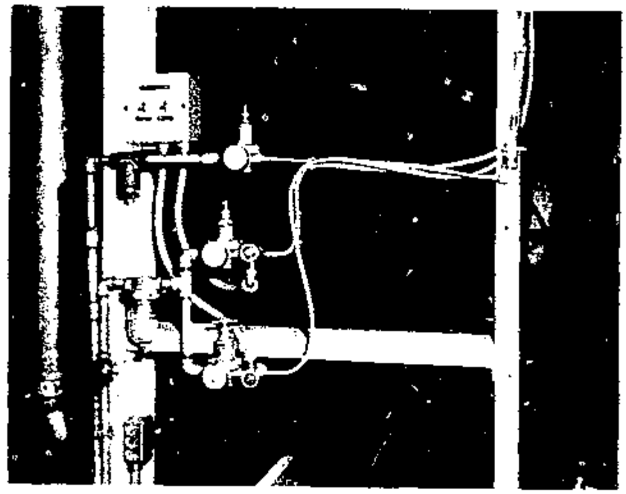
A special type of moisture-restoration nozzle and orifice setup was tested. Two nozzles were used. Air and water were supplied to these nozzles, which in turn emitted water as an airblown mist. Water was supplied to both nozzles by means of a common pressure regulator, and the air for each nozzle was controlled by separate pressure regulators (fig. 12). Each nozzle was operated by the electrical solenoid located in its air-supply line, allowing for the operation of the nozzles singly or in combination.

The water was obtained directly from the



PN-5164

FIGURE 11.—Atomizing nozzles mounted in the conveyor-distributor end plate underneath the separator.



PN-5165

FIGURE 12.—Control switches and air- and water-pressure regulators used with two atomizing nozzles in restoration experiments.

water supply of the gin plant at a line pressure of 48 pounds per square inch gage. Air for the nozzles was furnished by a compressor rated at an operating pressure of 150 lb in²g. The amount of water emitted for various water-pressure and air-pressure combinations was determined by laboratory trials (fig. 13).

The amount of moisture restoration required to increase the lint-moisture content by 1, 2, and 3 percent was determined for processing rates of 4 to 30 bales per hour based on a lint weight of 479 pounds per bale (table 6). A plant operating at a ginning rate of 30 bales per hour requires water at a rate of approximately 52 gallons per hour, if the moisture content of the lint is to be increased by 3 percentage points, assuming that all of the water emitted is absorbed by the cotton fibers.

In 1973, the atomizing nozzles were incorporated into the laboratory's automatic moisture-conditioning system. The nozzles could be used alone or in combination with a vapor generator. A photoelectric relay was installed near the atomizing nozzles so that water was emitted only when seed cotton was falling from the separator into the conveyor-distributor (fig. 14), preventing the wetting of the distributor when no cotton was flowing.

Results

The first cotton experiment was run with the nozzles operating at water pressures of 20, 30, and 40 lb/in². Air pressures were selected to give a water-emission rate of 39 lb/h per nozzle, the equivalent of adding 2 percent moisture to lint when seed cotton was flowing at four bales per hour. The operation was also tested using two gin stands with two nozzles working simultaneously. The moisture-restoration rate for each nozzle and for both nozzles was reasonably constant and indicated that the system calibration was reliable (table 7).

The ability of the ginning equipment to

TABLE 6.—*Moisture absorption rate required to increase fiber-moisture content by 1, 2, and 3 percent*

Processing rate[1] (bales/h)	Water emitted (gal/h) to raise lint-moisture content by[2]—		
	1 pct	2 pct	3 pct
4	2.3	4.6	6.9
5	2.9	5.8	8.7
6	3.4	6.8	10.2
7	4.0	8.0	12.0
8	4.6	9.2	13.8
9	5.2	10.4	15.6
10	5.7	11.4	17.1
12	6.9	13.8	20.7
14	8.0	16.0	24.0
16	9.2	18.4	27.6
18	10.3	20.6	30.9
20	11.5	23.0	34.5
25	14.4	28.8	43.2
30	17.2	34.4	51.6

[1] 1 bale is equal to 479 pounds of fiber.
[2] 1 gal/h = 0.139 lb/min.

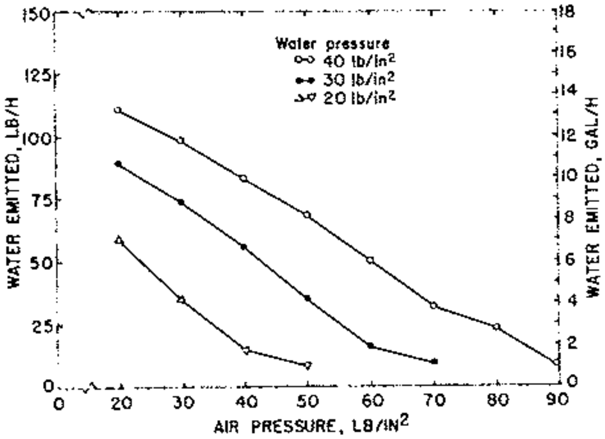


FIGURE 13.—Water emitted by one atomizing nozzle for various water and air pressures.

function at a double moisture-restoration rate was also tested. Water equal to 4 percent of the weight of the flowing lint was emitted with two nozzles at a ginning rate of four bales per hour. The conveyor-distributor, the extractor-feeder, the gin stand, and the lint cleaners functioned normally. A hand feeling of the cotton at the feeder apron did not reveal "wet spot" cotton.

A second experiment was designed to determine the moisture retained for different amounts added. Comparisons were made on "before spray" and "after spray" samples of seed cotton and lint (table 8). Atmospheric

PN-5166
FIGURE 14.—Photoelectric relay installed at the conveyor-distributor near the atomizing nozzles.

relative humidity during the experiment was low, from 36 to 64 percent. Moisture-emission rates were 40, 72, 90, 105, and 120 pounds of water per hour on cotton ginned at four bales per hour. Both seed cotton and lint gave up some of their moisture to the atmosphere on the no-emission treatments (control). Lint sampled after ginning but before the first lint cleaner generally showed a progressive in-

TABLE 7.—*Moisture content of cotton before and after moisture restoration, atomizing-nozzle experiment 1*[1]

[Percent]

Item	Water pressure					
	20 lb/in²		30 lb/in²		40 lb/in²	
	1 nozzle	2 nozzles	1 nozzle	2 nozzles	1 nozzle	2 nozzles
Seed cotton:[2]						
Before spray	8.9	8.9	8.9	9.7	8.8	9.2
After spray	9.2	9.7	9.0	10.1	9.0	9.1
Lint[3]	6.0	7.0	6.1	7.0	6.2	6.6

[1] Moisture treatments were replicated 3 times, and data represent the average findings for the samples subjected to oven moisture-determination tests. The atomizing nozzles were located in the conveyor-distributor: a processing rate of 4 bales/h was used for single nozzles and 8 bales/h for 2 nozzles. The air pressure was determined by laboratory calibration to give a water-emission rate of 39 lb/h per nozzle.

[2] "Before spray" samples were obtained after seed-cotton cleaning but before delivery to the distributor, and "after spray" samples were taken at the feeder apron.

[3] Sampling was performed after ginning but before lint cleaning.

crease in the quantity of retained moisture as the emission rate increased, but the amount retained was considered small in comparison to the quantity emitted by the nozzles. At higher ambient relative humidities the amount retained would have been greater.

COMBINATION RESTORATION

Previous moisture-restoration experiments had been conducted with the atomizing nozzles and the vapor generator as separate tests. Further experiments were performed to determine the moisture that could be added to seed cotton with the atomizing nozzles, compared to the amount that might be added by the vapor generator.

TABLE 8.—*Effect of an airblown mist on the moisture content of seed cotton and lint, atomizing-nozzle experiment 2*[1]

Moisture emission rate[2] (lb/h)	Moisture content— Before spray[3] (pct)	After spray[4] (pct)
	Seed cotton[5]	
0	9.7	9.3
40	8.6	9.7
72	8.8	9.7
90	9.0	10.2
105	9.8	9.8
120	10.3	10.7
	Lint[6]	
0	5.5	5.1
40	5.3	5.3
72	5.6	5.9
90	5.5	6.0
105	5.5	6.0
120	5.3	6.3

[1]Each datum represents the average finding for 5 samples subjected to oven moisture-determination tests.

[2]1 gal/h = 8.3 lb/h. An emission rate of 19.2 lb/h is equal to 1 percent of the weight of the lint processed.

[3]Samples were obtained as seed cotton after seed-cotton cleaning but before delivery to the distributor. Part of the sampled seed cotton was ginned on a 6-inch-diameter saw-gin stand to obtain lint for moisture analyses.

[4]Seed cotton was sampled at the feeder apron, and lint was sampled after ginning but before lint cleaning.

[5]Ambient relative humidity during this test series ranged from 49 to 64 percent.

[6]Ambient relative humidity averaged 36 percent.

Methodology

The combination tests were conducted in eight replications. Each replication consisted of four half-bale test lots comprised of a control treatment plus three moisture-restoration treatments: (1) atomizing nozzles, (2) vapor generator, and (3) a combination of the two (fig. 15).

The experiment was conducted in the laboratory's commercial-size ginning plant with a ginning sequence consisting of feed controller, 24-shelf tower drier, 6-cylinder cleaner, stick machine, 24-shelf tower drier, 6-cylinder cleaner, conveyor-distributor, extractor-feeder, gin stand, and two stages of lint cleaning.

The two atomizing nozzles operated at an air pressure of 60 lb/in² and a water pressure of 40 lb/in², providing a total emission rate of 96 lb/h. The vapor was passed through the conditioning hopper located between the conveyor-distributor and the extractor-feeder, where there was an intermingling of seed cotton and vapor. Pitot-tube measurements with cotton in the conditioning hopper showed that air flowed through the hopper at a rate of approximately 800 ft³/min.

Both moisture-restoration procedures operated concurrently with ginning and required no special routing of cotton. During the processing of test lots, all components of the installation were monitored, and the cotton was sampled for moisture content and fiber testing before and after conditioning.

Results

Restoration-test conditions.—The ambient air temperature during the experiments ranged from 53° to 86° F, and the relative humidity

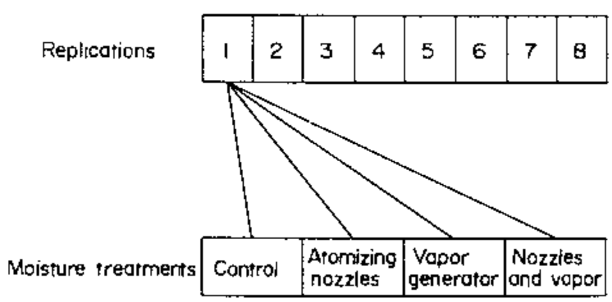


FIGURE 15.—Experimental test layout used in comparing the atomizing-nozzle and vapor-generator treatments, combination tests.

TABLE 9.—*Test conditions for the eight replications of the combination experiments*

Replication	Ambient air		Drier No. 1 temp.[1] (°F)	Humid air at hopper[2]		
	Temp. (°F)	Relative humidity (pct)		Temp. (°F)	Relative humidity (pct)	Moisture available (lb/lb)[3]
1	85	53	180	104	82	0.078
2	84	58	180	94	76	.054
3	77	78	180	94	79	.056
4	79	65	79	100	81	.069
5	85	52	85	104	82	.078
6	53	69	180	93	86	.060
7	86	55	86	94	75	.052
8	53	65	180	78	76	.031
Average	75	62	...	95	80	0.060

[1] Drier No. 2 operated at the ambient temperature for all replications.
[2] For the vapor-generator treatment, humid air was supplied to the conditioning hopper located between the conveyor-distributor and the extractor-feeder.
[3] Pound of water in the airstream per pound of lint.

varied from 52 to 78 percent (table 9). Drier No. 1 operated with a heated-air and seed-cotton mix-point temperature of 180° F on the damper cottons to insure that all replications were at a low moisture level prior to the restoration treatments. The ambient temperature was used on drier No. 2 for all replications. The ginning rate was controlled on all tests at approximately 3.9 bales per hour.

The atomizing nozzles provided enough water to raise the moisture content of the fibers by about 5.1 percent. Elapsed time between moisture application and seed-cotton passage to the extractor-feeder was 44 seconds.

The vapor generator provided humid air ranging from 78° to 104° F and from 75 to 86 percent relative humidity at the conditioning hopper. Higher humidities were attempted, but they resulted in condensation on the gin machinery and an interruption of cotton flow. The seed-cotton exposure period in the vapor hopper was 18 seconds. The quantity of humid air available was 25.7 ft^3/lb of lint, which was 0.060 pound of water vapor per pound of lint. Lint cotton in a moisture equilibrium with the average humid-air test conditions of 95° F and 80 percent relative humidity would contain approximately 10.1 percent moisture (wet basis).

Preconditioned seed cotton.—Moisture content of seed cotton before testing averaged 8.6 percent for the control and 9.2, 9.5, and 9.4 percent for the atomizing-nozzle, vapor-generator, and combination treatments, respectively (table 10). Differences in the moisture content of the seed cotton after drying and before moisture application were not statistically significant among the control (no moisture added) and the three restoration treatments (table 11). The mean value for all treatments was 8.0 percent.

TABLE 10.—*Moisture content of wagon samples of seed cotton processed before moisture-restoration treatments, combination tests*[1]

Replication	Moisture percentage for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	10.4	12.0	11.5	10.6
2	8.5	8.7	12.3	13.1
3	8.4	9.1	10.4	9.3
4	8.7	9.7	9.4	8.3
5	8.4	8.4	8.7	8.9
6	7.8	8.9	8.0	8.6
7	8.8	8.7	7.2	8.0
8	7.6	8.0	8.5	8.7
Average	8.6	9.2	9.5	9.4

[1]Data for each replicate represent the average for 5 samples subjected to oven moisture-determination tests.

Foreign-matter contents, determined by the fractionation procedure, averaged 4.5, 4.2, 4.1, and 4.5 percent for the corresponding treatments (table 12).

TABLE 11.—*Moisture content of samples of seed cotton after drying and cleaning but before moisture-restoration treatments, combinations tests*[1]

Replication	Moisture percentage for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	8.6	9.2	9.5	8.5
2	7.3	8.5	9.1	9.8
3	8.6	7.2	7.7	8.8
4	7.8	9.5	9.4	7.6
5	6.8	7.6	8.5	7.6
6	7.3	7.7	6.8	7.9
7	8.0	7.6	7.1	7.8
8	7.2	6.6	6.9	7.6
Average	7.7	8.0	8.1	8.2

[1] Data for each replicate represent the average for 5 samples subjected to oven moisture-determination tests. Samples were taken after seed-cotton drying and cleaning but before delivery to the conveyor-distributor.

[2] Differences in the moisture percentages are not statistically significant among any of the treatments tested.

Cotton moisture added.—Samples at the feeder apron showed that the amount of moisture added to seed cotton by either the atomizing-nozzles or the vapor-generator was statistically significant at the 5-percent level, and that the amount added by the combination treatment was significant at the 1-percent level. Seed-cotton-moisture content resulting from these treatments averaged 7.6 percent for the control, and 9.0, 8.6, and 9.5 percent for the nozzle, vapor, and combination treatments (table 13).

The moisture content of the ginned lint sampled between the gin stand and first lint cleaner averaged 5.5 percent for the control and 7.1, 6.2, and 7.4 percent for the nozzle, vapor, and combination treatments (table 14). The moisture added to the lint by the vapor generator was statistically significant at the 5-percent level, and the amount added by atomizing nozzles was significant at the 1-percent level. Moisture content of the cottons subjected to the nozzle and the combination treatments did not differ significantly.

Cottonseed-moisture contents at ginning averaged 9.2, 10.2, 10.3, and 10.5 percent for the control, nozzle, vapor, and combination

TABLE 12.—*Foreign-matter content of wagon samples of seed cotton processed before moisture-restoration treatments, combination tests*[1]

Replication	Foreign-matter percentage for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	6.1	4.4	3.7	5.6
2	5.7	4.7	3.8	4.7
3	4.5	4.1	4.7	4.5
4	4.6	4.5	4.2	5.0
5	4.6	4.5	5.2	5.6
6	2.9	2.9	2.7	3.2
7	4.5	5.0	5.0	4.7
8	2.9	3.2	3.2	3.1
Average	4.5	4.2	4.1	4.5

[1] Data for each replicate represent the average for 5 samples subjected to fractionation tests.

TABLE 13.—*Moisture content of feeder-apron samples of seed cotton after moisture-restoration treatments, combination tests*[1]

Replication	Moisture percentage for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	8.3	9.5	8.9	9.8
2	7.6	9.7	10.6	12.1
3	7.7	8.7	8.9	9.2
4	7.8	10.3	9.7	8.5
5	7.4	8.6	8.0	9.1
6	7.1	8.9	8.3	8.9
7	7.5	8.5	7.7	9.7
8	7.2	7.5	7.1	8.7
Average[2]	7.6a	9.0b	8.6b	9.5b

[1] Data for each replicate represent the average for 5 samples subjected to oven moisture-determination tests.

[2] Numbers in the row followed by the same letter are not significantly different.

treatments (table 15). Differences in seed-moisture content attributable to moisture-restoration treatment were not statistically significant.

Fiber-length tests.—Digital fibrograph measurements showed a consistent and progressive increase in fiber length and length uniformity with an increase in the cotton-moisture content (tables 16–18).

The 2.5-percent span length averaged 1.116

TABLE 14.—*Moisture content of lint samples after moisture-restoration treatments, combination tests*[1]

Replication	Moisture percentage for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	4.8	6.7	5.8	6.6
2	5.6	6.9	5.8	7.2
3	6.4	7.8	6.5	8.3
4	6.0	7.4	7.6	7.9
5	5.3	6.7	6.4	7.2
6	4.8	7.5	5.8	7.9
7	6.3	7.0	6.3	7.3
8	5.1	6.5	5.2	7.0
Average[2]	5.5a	7.1b	6.2a	7.4b

[1] Data for each replicate represent the average for 5 samples taken between the gin stand and the lint cleaner and subjected to oven moisture-determination tests.

[2] Numbers in the row followed by the same letter are not significantly different.

inches for the control (no conditioning), and 1.130, 1.126, and 1.136 inches for the nozzle, vapor, and combination methods. The increase in 2.5-percent span length obtained with the vapor treatment was significant at the 5-percent level, and the total increase for the nozzle treatment was significant at the 1-percent level.

The increases in 50-percent span lengths for both the atomizing nozzle and the vapor-generator treatments were statistically significant at the 1-percent level. Average 50-percent span lengths were 0.522, 0.536, 0.532, and 0.541 inch for the control, nozzle, vapor, and combination methods.

Uniformity ratios of length for the control, nozzle, vapor, and combination treatments averaged 46.8, 47.4, 47.2, and 47.7 percent. The uniformity increase was not significant for the vapor-generator treatment, but it was significant at the 5-percent level for the atomizing-nozzle procedure and at the 1-percent level when both methods were used.

Observations.—Proper intermingling of vapor and cotton within the conditioning chute should have been accompanied by greater moisture-content changes. It is highly probable that a greater amount of moisture than was measured was absorbed during the restoration treatments but was given up to ambient air during passage through the extractor-feeder and during fiber and seed separation.

TABLE 15.—*Moisture content during ginning of cottonseed samples tested after moisture-restoration treatments, combination tests*[1]

Replication	Moisture percentage for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	11.6	13.7	12.9	12.0
2	10.3	11.2	12.5	14.3
3	8.9	10.1	11.5	9.7
4	9.3	11.0	10.2	8.0
5	8.3	9.2	9.1	9.7
6	9.1	8.4	8.2	10.5
7	8.3	8.9	10.4	10.9
8	7.4	8.9	7.4	8.7
Average[2]	9.2	10.2	10.3	10.5

[1] Data for each replicate represent the average for 5 samples collected from the seed belt and subjected to oven moisture-determination tests.

[2] Differences in the moisture percentages are not statistically significant among any of the treatments tested.

TABLE 16.—*Span length (2.5-percent) of ginned-lint samples after moisture-restoration treatments, combination tests*[1]

[Inches]

Replication	Span length for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	1.118	1.132	1.116	1.130
2	1.122	1.136	1.130	1.144
3	1.128	1.140	1.132	1.156
4	1.116	1.116	1.136	1.130
5	1.116	1.134	1.144	1.144
6	1.098	1.120	1.114	1.130
7	1.130	1.150	1.134	1.138
8	1.096	1.116	1.102	1.114
Average[2]	1.116a	1.130bc	1.126b	1.136c

[1] Data for each replicate represent the average for 5 samples subjected to digital fibrograph measurements.

[2] Numbers in the row followed by the same letter are not significantly different.

The vapor-generator method, as used in these experiments, cannot increase the moisture level of low-moisture seed cottons to a sufficient degree that the cotton can be delivered to the gin stand at 6 to 7.5 percent fiber-moisture content. But this moisture level can

TABLE 17.—*Span length (50-percent) of ginned-lint samples after moisture-restoration treatments, combination tests*[1]

[Inches]

Replication	Span length for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	0.514	0.525	0.520	0.529
2	.521	.538	.533	.536
3	.530	.540	.530	.557
4	.545	.547	.552	.549
5	.534	.549	.557	.549
6	.498	.515	.517	.531
7	.533	.552	.537	.553
8	.504	.520	.509	.524
Average[2]	0.522a	0.536bc	0.532b	0.541c

[1] Data for each replicate represent the average for 5 samples subjected to digital fibrograph measurements.

[2] Numbers in the row followed by the same letter are not significantly different.

TABLE 18.—*Uniformity ratio of length for lint samples after moisture-restoration treatments, combination tests*[1]

[Percent]

Replication	Uniformity ratio for—			
	Control	Nozzles	Vapor	Nozzle and vapor
1	46.0	46.4	46.4	46.8
2	46.4	47.4	47.2	46.8
3	47.0	47.4	46.8	48.2
4	48.2	49.0	48.6	48.6
5	47.8	48.4	48.6	48.0
6	45.4	46.0	46.4	47.6
7	47.2	48.0	47.4	48.6
8	46.0	46.4	46.2	47.0
Average[2]	46.8a	47.4b	47.2ab	47.7b

[1] Data for each replicate represent the average for 5 samples subjected to digital fibrograph measurements.

[2] Numbers in the row followed by the same letter are not significantly different.

be attained by utilizing the atomizing-nozzle and the combination procedures when the seed-cotton-moisture content is not lower than 6.5 percent, and ambient relative humidity is not below 50 percent.

The amounts of moisture added by both procedures were excessive on days when the ambient relative humidity exceeded 65 percent. On these days seed-cotton flow along the conveyor-distributor was sluggish, and flow through the extractor-feeder was uneven or intermittent. Excessive moisture added to cotton during ginning can result in unacceptable reduction in grades.

CONCLUSIONS AND RECOMMENDATIONS

Low moisture in seed cotton has long been recognized as one of the most important problems involved in the ginning of cotton for preserving its inherent length characteristics. The need for restoring moisture to cotton fibers at the gin is dependent to a large degree on weather conditions. It is recommended that 55 percent relative humidity be used as a guide and that moisture-restoration equipment on a normal day in the Midsouth be activated between 10:00 a.m. and 7:00 p.m.

Moisture addition to seed cotton.—The restoration of moisture to low-moisture cottons can aid in achieving a particular fiber-moisture content at the gin stand. Both atomizing-nozzle and the vapor generator methods are adaptable to automatic moisture-control systems. Automatic safety cutoffs should be used to prevent wetting the cotton or machinery when cotton flow is stopped. When the gin stand is not in operation, the humid air can be directed to bypass the conditioning chute. A photoelectric relay, installed near the atomizing nozzles, can insure that water is emitted only when seed cotton is falling from the separator into the conveyor-distributor.

From a practical point of view, considering investment costs and the quantity of moisture added, the atomizing-nozzle method is less expensive and more efficient than the vapor-generator treatment. Any restoration system requires (1) long exposure periods, (2) good intermingling of seed cotton and moist air, and (3) humidity control of the air conveying cotton between gin machinery.

Moisture addition to lint at lint slide.—Moisture added to cotton at the lint slide provides no quality improvement, but it eliminates some of the problems associated with static electricity and minimizes postginning bale-weight changes resulting from the absorption of atmospheric moisture. It also allows the use of lower hydraulic and press-platen pressure, reducing the horsepower requirements for the bale-pressing system.

LITERATURE CITED

(1) American Society for Testing and Materials. 1971. Standard method of test for moisture in cotton by oven-drying. ASTM Designation: D 2495. The Society, Philadelphia.

(2) Bennett, Charles A. 1962. Cotton ginning systems in the United States and auxiliary development. 101 pp. The Cotton Ginners' Journal and The Cotton Gin and Oil Mill Press, Dallas, Tex.

(3) Cocke, Joseph B., and Garner, Warren E. 1972. Effect on ginning and spinning efficiency and cotton quality of: fiber moisture, seed-cotton cleaning, lint cleaning. U.S. Dep. Agric. Prod. Res. Rep. 143, 14 pp.

(4) Columbus, Eugene P., and Baker, Roy V. 1975. A closed-loop cotton-moisturization system for cotton ginning. U.S. Dep. Agric. Tech. Bull. 1513, 12 pp.

(5) Gerdes, Francis L., and Bennett, Charles A. 1936. Effect of artificially drying seed cotton before ginning on certain quality elements of the lint and seed and on the operation of the gin stand. U.S. Dep. Agric. Tech. Bull 508, 62 pp.

(6) Griffin, A. C., and Harrell, E. A. 1957. Effects of moisture added at lint slide on lint quality and bale weight in humid cotton-growing areas. U.S. Dep. Agric. Prod. Res. Rep. 14, 16 pp.

(7) ———, and Mangialardi, Gino J., Jr. 1961. Automatic control of seed cotton drying at cotton gins, a review of research. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 42–57, 14 pp.

(8) ———, and Mangialardi, Gino J., Jr. 1967. Another first—a completely integrated moisture control system for gins. Cotton Gin Oil Mill Press 68(11): 7.

(9) ———, and Merkel, Charles M. 1953. Moisture content of seed cotton in relation to cleaning and ginning efficiency and lint quality. Production Marketing Administration and Agricultural Research Service, U.S. Department of Agriculture (mimeographed report), 16 pp.

(10) Harrell, Edsel A. 1956. Apparatus for the restoration of moisture to the fibers of seed cotton. U.S. Pat. No. 2,764,013.

(11) Jackson, Samuel G. 1967. Conditioning hopper. U.S. Pat. No. 3,357,061.

(12) Leonard, Clarence G. 1960. Controlling static electricity on cotton during ginning with an antistatic agent. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 42–39, 16 pp.

(13) ———, and Gillum, Marvis N. 1968. The monoflow air system for cotton ginning. Cotton Gin Oil Mill Press 69(11): 10–11, 23–24.

(14) Mangialardi, Gino J., Jr., and Griffin, Anselm C., Jr. 1966. Lint cleaning at cotton gins: Effect of fiber moisture and amount of cleaning on lint quality. U.S. Dep. Agric. Tech. Bull. 1359, 24 pp.

(15) ———, and Griffin, Anselm C., Jr. 1967. Increasing the moisture content of lint during lint cleaning for retention of maximum inherent quality of cotton. Annual Report, U.S. Cotton Ginning Research Laboratory, Stoneville, Miss., 15 pp.

(16) ———, Griffin, Anselm C., Jr., and Shanklin, Edward H. 1965. Moisture restoration to cotton at the gin: Effects on fiber and spinning properties. U.S. Dep. Agric. Mark. Res. Rep. 708, 10 pp.

(17) Mitchell, Orville. 1963. Restoration and maintenance of cotton fiber moisture. 9 pp. (Report to the National Cotton Council Meeting.) John E. Mitchell Co., Dallas, Tex.

(18) Montgomery, R. A., and Wooten, O. B. 1958. Lint quality and moisture relationships in cotton through harvesting and ginning. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 42–14, 19 pp.

(19) Moore, Vernon P., and Griffin, Clyde, Jr. 1964. The relationship of moisture to cotton quality preservation at gins. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 42–105, 12 pp.

(20) Moss, Hoyle G., and Schwartz, Robert C. 1966. Jet spiral drier. U.S. Pat. No. 3,269,029.

(21) Speakes, Charles C., and Griffin, Anselm C., Jr. 1956. Method of moisture restoration to cotton. U.S. Pat. No. 2,747,234.

(22) Steel, R. G. D., and Torrie, J. H. 1960. Principles and procedures of statistics. 481 pp. McGraw-Hill, New York.

(23) U.S. Department of Agriculture. 1972. Cotton gin equipment—United States. Agric. Mark. Serv. Rep., 16 pp.

(24) Wright, John W., and Bennett, Charles A. 1940. The compression of cotton, and related problems. U.S. Dep. Agric., Agric. Mark. Serv., and Bur. Agric. Chem. Eng. Rep., 68 pp.

ADDITIONAL REFERENCES

Bennett, Charles A., and Gerdes, Francis L. 1936. The vertical drier for seed cotton. U.S. Dep. Agric. Misc. Publ. 239, 22 pp.

Faucher, Andrew J. 1959. Apparatus for drying and humidifying materials. U.S. Pat. No. 2,867,913.

Gerdes, Francis L. 1950. Cotton drying practices in relation to quality and efficiency of ginning. Cotton Ginners' J. Yearb. 18(1): 26–27.

Gillum, Marvis N., LaFerney, Preston E., and Mullikin, Robert A. 1972. Effects of the monoflow cotton gin air system on ginning operations, lint quality, and spinning performance. U.S. Dep. Agric. Mark. Res. Rep. 967, 27 pp.

Leonard, Clarence G., Ross, John E., and Mullikin,

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
HYATTSVILLE, MARYLAND 20782

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. DEPARTMENT OF
AGRICULTURE
AGR 101

U.S.MAIL

Robert A. 1970. Moisture conditioning of seed cotton in ginning as related to fiber quality and spinning performance. U.S. Dep. Agric. Mark. Res. Rep. 859, 16 pp.

Mangialardi, Gino J., Jr., Griffin, Anselm C., Jr., and Moore, Vernon P. 1968. Cotton ginning system having automatic seed cotton conditioner. U.S. Pat. No. 3,392,424.

END