The Flow-Through Lint-Cotton Cleaner

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EFFECTIVE CLEANING of mechanically and roughly harvested cotton at gins is necessary to obtain a bale with maximum market value. Extensive laboratory and field tests have demonstrated that from the standpoints of cotton quality and economic and mechanical feasibility, there is a limit to the degree that cotton can be cleaned without damage to the fiber in the seed-cotton stages. This limit varies with the type of seed cotton being cleaned. In general, the maximum processing that can be tolerated by seed cotton consists of a drying system and the equivalent of 24 cylinders of cleaning, together with a master bur extractor, extractor feeders, and the huller fronts of the gins.

Such limitation on seed cotton cleaning indicates that if more complete cleaning is to be obtained at gins it must be done on the lint cotton

The research and developmental work upon which this report is based was made possible by an allotment from the special research funds authorized by title I of the Bankhead-Jones Act of June 29, 1935. The lint-cleaning project was conducted under the general supervision of Charles A. Bennett, agricultural engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, and Francis L. Gerdes, cotton technologist, Cotton Branch; and under the general direction of George R. Boyd, head, Division of Mechanical Processing of Farm Products, and John W. Wright, chief, Research and Testing Division, Cotton Branch. Acknowledgment is made to the staff members of the United States Cotton Ginning Laboratory for valuable contributions and assistance rendered in performance of the ginning and lint-cleaning tests reported, and to the staffs of the Cotton Branch testing laboratories at College Station, Tex., and Clemson, S. C., for performing spinning and other tests in evaluation of the quality of the ginned lint.

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after it passes from the gin saws and before it reaches the condenser. This should be done without retarding normal ginning processes. Although for many years seed cotton has been cleaned before the actual ginning, attempts to remove foreign matter still remaining with the lint until recently have been confined almost entirely to "moting" within the gin stands.

To cope with the problem, the United States Cotton Ginning Laboratory has developed lint-cleaning machines for use in cotton gins as an integral part in the ginning operation, the saw type being the subject of this circular.

![Diagram](image)

**Figure 1.**—Sectional view of laboratory model double process gin used in early studies of lint-cotton cleaning.
DEVELOPMENT OF LINT-CLEANING PROCESSES

The A. Q. Withers patent No. 21,714, of October 5, 1858, disclosed the possibility of cleaning cotton fiber as it left the ginning saws, but the method caused an excessive loss of spinnable fiber. Later, screened devices, grids, and scrubbers, both stationary and moving, were tried by various agencies. Some of these devices are still in existence. A noteworthy example of cleaning by stationary means was the device covered by J. E. Cheeseman's patent No. 1,056,260, of March 18, 1913. James C. Garner's regin, patent No. 1,574,384, of February 23, 1926, is the basis for machines used rather extensively in cotton "pickeries" for processing bales of water- or fire-damaged lint and loose-cotton samples. Cottons of mixed grades or staples frequently are blended and reginned for certain markets.

However, studies indicated that there remained need for development of an auxiliary device for use in gins to clean the lint by removing fine leaf and pepper trash at some point between the gin saws and the press. Long advocacy for research in this field by the staff of the United States Ginning Laboratory at Stoneville, Miss., culminated in the start of some work in 1939. The series of tests and explorations from that date included work with a number of devices.

1. The double process gin. This device, as others, was a specially designed pilot model originating from the old Withers' patent (fig. 1). This gin employed 10 saws of 10-inch diameter and 2 sets of transfer saws. The second set of saws removed the fiber from the ginning saws and carried it around to be transferred in turn to a third set of saws from which the lint cotton was finally doffed by an air blast. Some cleaning was accomplished by this machine, but entirely too much fiber was lost by the successive transfers to make the machine practicable. Revisions made the device too costly.

2. Flotation lint cleaner (fig. 2). The theory of lint cleaning by the flotation principle was investigated. Lint was floated through a large chamber by means of a gentle current of air; thus, the leaf trash and heavier particles of foreign matter sifted into pockets by gravity and the cleaned lint floated to the gin condenser and press. In 1942, this type of cleaner was constructed at the laboratory. Many difficulties were encountered, and this cleaner did not operate successfully. It was found that the weights of lint and trash were too nearly equal and that leaf particles continued to adhere to the cotton fiber, making the separation of the trash by gravity alone inadequate.

3. A commercial cleaner employing the spiral-whirl principle, of the type generally used in textile mills, was installed in the laboratory's three-stand experimental gin (fig. 3). This was done in an effort to adapt mill-type opening-room cleaners to cotton-ginning conditions and to clean the loose lint directly as it came from the gin stands. This was the laboratory's first attempt to clean lint cotton concurrently with the ginning process through use of a machine installed in the ginning system between the gin stands and the press. In these tests the very small quantity of trash removed was not sufficient to bring about significant improvements in the grade of the cotton.

4. A Garner regin was installed in the laboratory, and in the many tests performed on this device (fig. 4) appreciable cleaning was achieved, but the loss of good fiber offset any benefits from grade improvement. The monetary value of the bale of cotton was therefore
Figure 2.—Flotation lint cleaner that was included in experimental lint-cleaning tests at the Cotton Ginning Laboratory, Stoneville, Miss.

Figure 3.—Mill-type “spirawhirl” lint-cotton cleaner tested at United States Cotton Ginning Laboratory for possible use in cotton gins.
Figure 4.—Garner regin used in early attempts to develop a lint-cleaning process for use at cotton gins.

Figure 5.—Lint-cleaning pilot plant installation that includes, from left to right: Unit condenser, a vertical-transfer saw-type lint cleaner, a 24-inch Buckley beater lint cleaner, and a 10-saw Eagle gin.
not increased. Another prohibitive factor was the lack of capacity to handle the normal lint delivery in cotton gins.

Results from the foregoing and numerous other experiments showed that the development of a practical lint cleaner would be difficult. Additional effort on the project was not feasible during the war years, owing to lack of personnel and shortage of material. After the war, however, a staff was assigned to the project, and the experience and data from previous findings were used in a renewed effort that resulted in development of the flow-through lint cleaner.

MACHINES AND PRINCIPLES EXPLORED

In the light of previous lint-cleaning research, it was evident that certain principles of cleaning required new methods of application to be efficient when operated as a part of the ginning process. Neither

![Figure 6.—Inside mechanism of vertical-transfer saw-cylinder lint cleaner.](image-url)
the flotation principle nor the scrubbing of lint over grid bars, when used separately, had achieved the desired results. It appeared that a combination of air-wash and mechanical scrubbing or combing action might offer promise. Cotton-mill methods in opening rooms had proved that mechanical combing or scrubbing action of beaters over grid bars served to straighten and agitate the tufts of fibers sufficiently to allow the release of some trash particles. Laboratory experience had also shown that a current of air was necessary to deliver the fibers to the cleaner and assist in removing the foreign matter as it was combed out of the lint. Accordingly, pilot-plant studies were set up and small test apparatus was constructed to combine these cleaning principles (fig. 5).

Two lines of approach were used. One consisted of a vertical-transfer saw-cylinder cleaner (fig. 6). This device employed two
gin-saw cylinders, one placed directly over the other. The teeth of the saw cylinders overlapped by about one-eighth inch. Lint from the gin entered onto the bottom saw and was carried over a cleaning surface and to the point of transfer to the top saw. The top saw, turning faster than the bottom saw, picked up the lint and again carried it over a cleaning surface. At the rear of the top saw cylinder was a revolving doffing brush that served to doff the fibers, after which they were conveyed in the air stream to the condenser.

The other method was the use of mill-type Buckley beaters. In this device lint and air entered the beater drum and the fibers were carried over a set of cleaning grid bars and then to the condenser (fig. 7).

The results of the pilot-model tests performed during the 1946 season were sufficiently encouraging to justify the construction of full-size units for exploratory testing.

The full-size units were modified somewhat, as the first tests indicated that the double saws of the vertical-transfer cleaner were too harsh in their treatment of the fiber and lint loss was extremely high. The double saw cylinders made the cleaner costly to construct and difficult to maintain. The design was changed to include only one saw cylinder in the full-size model built for testing in 1947. Also, the single-beater cleaner did not clean sufficiently. Therefore it was redesigned to include two beaters in tandem to increase cleaning effectiveness in the full-size model. Smooth-edge grid bars, which were originally used, did not give sufficient combing action, so the leading edges of the bars were notched to increase the effectiveness of the combing action.

**Figure 8.**—Full-size single-saw cylinder (A), and Buckley double-beater lint-cleaning units (B and C), installed behind an 80-saw air-blast gin stand for experimental testing. In permanent installations the drive and shaft should be guarded.
Figure 8—Lint-cleaning machinery installation as used in exploratory tests:
A, Single saw-cylinder lint cleaner; and B, Buckley double-beater lint cleaner.
In the design of the single saw-cylinder cleaner, an attempt was made to maintain simplicity while employing as many principles of cleaning as feasible to make the cleaning action effective (fig. 8). In this machine, following the initial cleaning action obtained by blowing the lint past a revolving screen cylinder before delivery to the saw cylinder, a combination of centrifugal force, scrubbing action, and gravity assisted by an air current was used.

The Buckley double-beater lint cleaner is quite simple in construction and does not have the usual feed rolls (figs. 9 and 10). Air and lint enter the beaters in the direction of their rotation on the downstroke of the beater cylinders. The beater arms sweep the fiber over a set of triangular-notched grid bars, dislodging the foreign matter by centrifugal force and scrubbing, assisted by gravity and the current of air blowing down through the grid bars. The line and its stream of conveying air leave the first beater on the upstroke side and loop onto the second beater, where the cleaning action is repeated before final delivery of the cotton to the condenser. With this cleaner the only additional power required is the small amount for revolving the two beater drums.
Performance of Machines

During the 1947 ginning season the redesigned cleaners were installed behind a full-size 80-saw gin stand for extensive exploratory tests. The devices were tested individually and in combination, using machine-picked, machine-stripped, and hand-picked cottons. The cotton was subjected to varying degrees of seed-cotton cleaning. This cleaning ranged from a simple seed-cotton-cleaning set-up employing 15 cylinders in addition to extractor feeders to a very elaborate seed-cotton-cleaning combination including 2 tower driers, 2 overhead bur machines, and 22 cylinders of cleaning in addition to extractor feeders.

An analysis of the data resulting from the lint-cleaning tests showed that for machine-picked cottons the saw-cylinder cleaner was superior to the beater-type cleaner in improving lint quality. However, the effectiveness of the double-beater device from the standpoint of trash removal was about equal to that of the single saw-cylinder cleaner, but the “smoothness” of the sample was not comparable. On machine-stripped cottons of shorter staple length, the beater-type cleaner produced grade improvements that compared favorably with those obtained with the saw-type cleaner.

In the tests involving a moderate degree of seed-cotton cleaning before ginning, machine-picked cottons improved in quality, on an average, almost two-thirds grade with the saw cylinder, and about one-half grade with the beater-type cleaner. The preparation of lint appeared to be smoother with the cotton representing the saw-cylinder cleaning method than with either the cotton cleaned by the beater unit or the control lots of cotton that were not subjected to lint cleaning. Taking into consideration both the extra costs that would be involved and bale-weight losses due to waste removed, there was not enough advantage from a grade-improvement standpoint shown by the use of both types of lint cleaners together over the use of the saw-cylinder alone to justify their use in tandem.

On a bale basis, waste removed during lint cleaning averaged 10.2 pounds with the saw-cylinder cleaner (8.1 pounds of trash and 2.1 pounds of short fiber) and 11.2 pounds with the double-beater cleaner (8.6 pounds of trash and 2.6 pounds of short fiber). When both cleaners were used in combination, the total waste removed averaged 17.4 pounds (13.1 pounds of trash and 4.3 pounds of short fiber). Despite the bale-weight losses resulting from the trash removal when the cleaners were used individually, bale-value improvements amounted to more than $6 with the saw-cylinder and almost $4 with the double-beater lint cleaners. These benefits were accomplished without injury to fiber and spinning quality. No significant differences were found in the strength and appearance grade of the yarn manufactured from the lint representing the two processes of lint cleaning after ginning as compared with lint not subjected to lint cleaning.

When saw-cylinder lint cleaning supplemented very elaborate seed-cotton cleaning on machine-picked cotton, the average grade of the lint ginned was Middling minus—the highest grade achieved in the tests. This compared with Strict Low Middling plus for the combination of moderate seed-cotton cleaning and saw-cylinder lint clean-
ing. With this grade improvement, there appeared to be a tendency for the extra drying and cleaning units of the very elaborate seed-cotton cleaning process to reduce the staple length of the cotton. Apparently, the baled lots so treated were worth no more than those representing the combination of moderate seed-cotton cleaning and saw-cylinder lint cleaning.

Tests made on machine-stripped cotton containing an excess of burs, branches, stems, and sand, along with the leaf trash of the type primarily found in mechanically picked cotton, showed that more elaborate seed-cotton cleaning is needed in cleaning machine-stripped cotton to put it in suitable condition for ginning and lint cleaning than is the case with machine-picked cotton. Elaborate seed-cotton cleaning followed by lint cleaning with either the saw-cylinder or the double-beater-type cleaner improved the grade from Good Ordinary plus to Strict Good Ordinary plus, or by about one full grade over the results obtained with moderate seed-cotton cleaning on stripped cotton.

In addition to improving the grade of mechanically harvested cotton, the saw-cylinder lint cleaner also improved grades of cotton hand-picked with all degrees of cleanliness throughout the 1947 season. Foreign-matter losses per bale ranged from less than 3.5 pounds on relatively clean early-season cotton to 7 pounds on late-season trashy cotton. Grade improvements for all hand-picked lots averaged one-third grade.

Throughout the entire period of research and development on lint cleaning, appropriate samples were taken of the seed cotton, the lint, and foreign material. The lint samples were classed and were subjected to fiber tests. Laboratory determinations were made of foreign matter and moisture content, and spinning tests were performed on representative samples. The results of these tests played an important part in the development and selection of the two most promising lint-cleaning machines.

FLOW-THROUGH LINT CLEANERS

The results of the numerous experiments on lint cleaning, coupled with the research and development on the pilot-model devices and with the exploratory testing of the saw-cylinder and double-beater-type cleaners, provided a sound basis for the construction of full-size lint cleaners for tests under simulated commercial operating conditions. The cleaners that use the saw-cylinder principle were installed on a three-stand commercial-type gin at the United States Cotton Ginning Laboratory and subjected to proof test during the 1948–49 ginning season (figs. 11, 12, and 13).

In the development, design, and construction of the flow-through lint cleaners, the aims and objectives were to provide: (1) A process and equipment for cleaning the lint cotton after it leaves the gin saws at a convenient point in the ginning system between the gin stands and the baling press; (2) an apparatus of relatively simple construction without the intricate details and expensive shopwork required in

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2 Designed and constructed by members of the U. S. Cotton Ginning Laboratory. Public service patents applied for.
FIGURE 11.—End view of one of the flow-through lint-cleaning units installed in a gin plant at the laboratory. In permanent installations the belt should be guarded 6 feet 6 inches from the floor.
Figure 12.—View of the assembly and installation of the flow-through lint cleaners.
Figure 13.—Completed installation of the flow-through lint cleaners in a three-stand gin at the United States Cotton Ginning Laboratory for proving-ground tests. In permanent installations the belt should be guarded 6 feet 6 inches from the floor.

Figure 14.—Side elevation, showing installation of flow-through lint cleaner in a three-stand commercial-type gin at the Cotton Ginning Laboratory.
a more complex machine; (3) a satisfactory method of introducing and delivering the fibers, in substantially the same individual form as received from the gin stands, to the lint cleaners with a continuous flow of the air stream; (4) a cleaning unit having sufficient capacity to handle adequately the variable quantities of lint fiber that are normally delivered from a full-sized, or 80-saw, cotton gin stand without retarding ginning processes and without requiring the condensation of the fibers into an intermediate bat form in the cleaning process;

Figure 15.—Side elevation of a flow-through lint-cleaner unit, showing (1) a revolving-screen assembly housed in a box casing with an air vent, (2) a metal connector with hinged damper, (3) a revolving saw cylinder and notched grid bars, (4) trash chamber, (5) doffing nozzle, and (6) an extension with lint valve to the lint flue.
(5) a trash chamber to receive and dispose of the trash and waste removed from the fiber by the cleaner; and (6) a satisfactory means of doffing the cleaned fibers from the cleaning apparatus so that there would be a continuous unrestricted flow of the cotton from the gins to the baling press.

Figure 14 shows a side elevation of the general lay-out and dimensions of the cleaners that were installed in the laboratory experimental three-stand gin. In figure 15 it will be seen that the salient parts of the cleaner consist of (1) a revolving-screen assembly housed in a box casing with an air vent, (2) a metal connector with hinged damper, (3) a revolving saw cylinder and notched grid bars, (4) a trash chamber, (5) a doffing nozzle, and (6) an extension with lint valve to the lint flue.

Details of the lint-separator revolving screen are shown in figure 16. Within the box casing is a horizontal, rotating screen cage that main-

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![Diagram of the lint-cotton cleaner](image_url)
tains a narrow passage for the lint fiber between the cage and the vertical side wall. This screen serves to help deflect the fibers to the cleaning cylinder, but its principal function is to divert enough air from the gin-stand discharge volume to assure best operation of the cleaner. Separation of fine dirt, dust, and pepper trash is also accomplished at this point, as the fibers are momentarily impinged against the revolving screen. The tip speed of this screened cage is slightly faster than the velocity of lint from the gin in order to permit the fibers to be delivered to the cleaning saw cylinder in the form of individual fibers or tufts as received from the gin stand without intermediate condensing. An air-vent opening and deflector plate are also provided. The screened cage is on an open-ended frame, and the screen wire is 8 mesh.

Details of the metal connector and hinged damper are shown in figure 17. This connector provides a passage for the fiber from the revolving screen or cage to the cleaning saws. The hinged damper
provides means for adjusting and controlling the proportion of air flow from the lint separator into the trash chamber. One of the operating principles of this cleaner is to use a part of the lint-conveying air from the separator screen to assist in the cleaning operation. If too much air enters the trash chamber through the saw cylinder and grid bars, objectionable turbulence may result in the trash chamber and impair the cleaning efficiency of the machine. It is important, therefore, that the proportions of air be so balanced that the volume of air entering the trash chamber is the same as that normally drawn out by the doffing nozzle.

Figure 17 also shows the air-vent connection that attaches to the separator framework. Air passing through from the revolving screen or cage enters the opening at the lower part of the rectangular duct, then flows on through the round pipe to a fan for discharge from the gin building. An exhaust fan is necessary in the vent system to keep the air moving and to overcome the resistance of the piping. The zero point between the push of air from the gin stand and the pull of air from the exhaust fan should be at the entrance to the rectangular duct.

Details of the saw cylinder and the notched grid bars are shown in figure 18. The saw cylinder may consist of any standard gin-saw mandrel and untrained standard gin saws. The space blocks are three-sixteenth-inch wide and 5 3/8 inches in diameter. The number of saws and the distance between the two end saws will vary, depending
on the kind of mandrel used and the make of gin stands with which
the cleaners are to be used. Wobble saws at three-eighths-inch cen-
ters may be used in place of straight saws. The laboratory cleaners
have 256 saws in a 561/2-inch space, and the saw cylinder is operated at
a speed of 1,000 r. p. m.

Sixteen grid bars, triangular in cross section and having keen edges,
are usually employed. The tip of the first bar is placed on the center
line of the saw cylinder and five-thirty-seconds inch from the tip
of the saw, and the bars continue around the lower circumference of
the saw cylinder at 1-inch spacings. The one-half-inch face of each
bar is set at a 10° rake tangent to the saw. The cleaning edge of each bar is notched with V-shaped grooves one-eighth inch apart, with an apex angle of 60°. The number of grid bars may vary, depending on the design and location of the air-blast doffing nozzle.

Figure 19 shows the air-venting system for the exhaust air from the lint separators. Approximately two-thirds of the air volume from the gin stands must be vented out. The piping should be of ample cross-sectional area to permit easy flow of air with a minimum of static resistance. An exhaust fan of the large-volume, low-pressure type is best suited for this purpose, as it has only to overcome the piping resistance in blowing the air out of the gin building. The venting system shown is for a three-stand gin installation. For four- and five-stand gin plants, proportionately larger piping and more risers are needed in order to maintain an even pull of air from each lint cleaner. The gin stands blow to one side of the lint separator screen and the exhaust fan pulls from the opposite side. It is, therefore, important that the neutral, or zero, point of pressure be maintained at the rear of the lint separator screen.

With further reference to figure 15, it may be seen that the freshly ginned cotton-lint fibers from the gin saws of the gin stand are delivered in their conveying air stream to the cage assembly, where the flow proceeds past the director plate. The surplus air passes freely through the screen cage to the vent, and the downward-traveling fibers are deflected through the narrow passage without forming a bat and continue to the cleaning cylinder where the lint fibers are delivered into the teeth of the saws. The regulation damper also helps direct the fibers into the cleaning teeth. Here, the lint is subjected to the combined action of centrifugal force, scrubbing, combing, and beating, as it is carried over the surface of the notched grid-bar assembly, where a final gravity separation of trash from the lint is achieved. The foreign matter or trash passes between the keen-angle grid bars and settles into the trash chamber for collection or removal. The cleaned lint is doffed by means of the air nozzle and conveyed through the gin-flue extension to the main lint-flue system, condenser, and press.

RESULTS OF FULL-SCALE TESTS

In subjecting the flow-through lint cleaners to proof tests during the 1948 ginning season, both machine- and hand-picked cottons were used. The cottons represented early, midseason, and late-season, and late-season exposed harvestings and included tests on machine-stripped and hand-snapped cottons. Most of the cottons were of Mississippi Delta growth.

METHODS OF TESTING

In performing the lint-cleaner tests in the three-stand commercial-type gin, uniform lots of cotton harvested from the same cotton-field were obtained and divided into the required number of bales for a series of tests. The cotton was subjected to various degrees of seed-

* Designed and constructed by members of the U. S. Cotton Ginning Laboratory. Public Service patent applied for.
cotton cleaning, involving two or more of the following four combinations of machines.

1. Simple seed-cotton cleaning: Tower drier 160° F.; 7-cylinder cleaner; and extractor feeders without heat.
2. Moderate seed-cotton cleaning: Tower drier 160° F.; 6-cylinder cleaner; big-bur machine; and extractor feeders without heat.
3. Elaborate seed-cotton cleaning: Tower drier 160° F.; 6-cylinder cleaner; big-bur machine; combined tower drier and 15-cylinder cleaner 160°; and extractor feeders without heat.
4. Very elaborate seed-cotton cleaning: Tower drier 160° F.; 6-cylinder cleaner; big-bur machine; 7-cylinder cleaner; tower drier 160°; 6-cylinder cleaner; big-bur machine; combined tower drier and 15-cylinder cleaner without heat; and extractor feeders without heat.

In each series of tests, paired bales representing each type of seed-cotton cleaning were so handled as to permit the ginning and delivery of one bale to the condenser and press in the conventional manner without lint cleaning while the other corresponding bale was processed through the flow-through lint cleaners.

In connection with all tests of the flow-through lint cleaners, appropriate samples were taken of the seed cotton, the lint, and the foreign material. The qualities of the lint samples were evaluated through classification, fiber tests, and laboratory determinations of foreign matter and moisture content. On representative samples spinning tests were also made.

**Results of Tests**

In three-stand commercial-type operations throughout the 1948 ginning season, excellent results were obtained with the flow-through cleaners from the standpoints both of engineering and technological performance. No serious operating difficulties were experienced, and the test runs proved that the cleaners have the capacity and endurance for constant use in handling the full lint delivery from cotton gins.

The staple length of the cottons used in the tests ranged from \( \frac{1}{2} \) inch to \( \frac{5}{8} \) inches, and average grades ranged from Strict Middling on early hand-picked cottons down to Strict Good Ordinary on late-exposed machine-picked cottons. The early-season machine-picked cottons contained a considerable quantity of green grass. Rains and mild temperatures in the Mississippi Delta area caused an excessive grass and weed growth in the early fall of 1948. As a result the grades of early-season machine-picked cottons averaged slightly lower than the midseason harvestings. The lint-cleaning machines provided consistent and significant grade improvements on all types of cotton without injuring fiber and spinning qualities of the lint.

The average grades of the early-season machine-picked cottons ranged from Low Middling for the moderate seed-cotton-cleaning process up to Strict Low Middling for the elaborate seed-cotton-cleaning process in combination with the flow-through lint cleaners. On the late-exposed machine-picked cottons, grades averaged Strict Good Ordinary minus for the moderate cleaning set-up without lint cleaning, while an average grade of Low Middling minus was obtained by the very elaborate cleaning process including the lint cleaners. The late-exposed machine-picked cotton had a high foreign-matter
content consisting of sticks, stems, burs, leaves, and dirt, and the color was very poor.

The average grades obtained in processing machine-picked cotton by the various seed-cotton-cleaning combinations including the lint cleaners averaged about two-thirds grade higher in each instance than the same machinery combinations without lint cleaning. Best all around grade improvements were obtained on machine-picked cotton by the elaborate seed-cotton cleaning in conjunction with lint cleaners (table 1).

Evaluations on the bale values obtained in connection with the processing of machine-picked cotton through the lint cleaners as compared with corresponding bales not lint-cleaned show a seasonal average premium of $7.33 per bale for the lint-cleaned bales. This average includes all seasonal harvesting periods and all of the various seed-cotton-cleaning combinations used in the three-stand gin tests. The benefits of lint cleaners usually ranged from $5 to $10 per bale, based on 1948 cotton prices.

On the machine-stripped cotton, which had a very heavy trash content of 33.5 percent, a grade of Good Ordinary plus was obtained with the moderate seed-cotton-cleaning combination without lint cleaning. Low Middling grades were obtained when the elaborate and very elaborate machinery arrangements were used in conjunction with the lint cleaners. With this machine-stripped cotton the lint cleaners provided grade improvements of one full grade with the moderate seed-cotton-cleaning combination and improvements of one-third grade and two-thirds grade with the elaborate and very elaborate set-ups, respectively.

The grades of the hand-harvested cotton ranged from Strict Middling on the early-season hand-picked down to Strict Good Ordinary plus on the late exposed hand-snapped cottons, and the trend of improvement resulting from lint cleaning ranged from one-third to two-thirds grade. Although these small grade improvements in the lower range of grades result in cotton price increases of sufficient magnitude to provide significant bale value benefits after considering bale weight losses associated with lint cleaning, such improvements in the higher range of grades of Middling and better do not always result in bale value advantages for lint cleaning. This emphasizes the fact that lint cleaning is designed primarily for increasing the value of machine and trashy hand-harvested cottons.

In all the tests with the various types of cottons and machinery combinations, the staple length of the cotton was not affected by the lint-cleaning process. A study was conducted at the laboratory involving fiber-length array tests on corresponding samples of hand-pulled and conventionally ginned lint samples. Despite the strong mechanical force and heavy friction involved in processing cotton through the gin stand, these fiber-length tests showed an average loss of only one-thirty-second inch in the staple length of the mechanically ginned lint as compared with the hand-pulled fibers.

The action of the lint-cleaning saws is a very gentle process as compared with the forceful pulling action of the gin saws in contact with gin seed rolls and in passing through narrow rib spaces. Fibers are received and released from the saws of the flow-through lint cleaners
Table 1.—Grade and staple length results obtained in processing cottons representing the designated harvesting methods and harvesting stages by the indicated seed-cotton and lint-cleaning combinations, crop of 1948

<table>
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<tr>
<th>Harvesting method</th>
<th>Stage of harvesting</th>
<th>Samples tested</th>
<th>Simple seed-cotton cleaning 1</th>
<th>Moderate seed-cotton cleaning 1</th>
<th>Elaborate seed-cotton cleaning 1</th>
<th>Very elaborate seed-cotton cleaning 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>No lint cleaning</td>
<td>Flow-through lint cleaner</td>
<td>No lint cleaning</td>
<td>Flow-through lint cleaner</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grade 2</td>
<td>Staple length</td>
<td>Grade 2</td>
<td>Staple length</td>
</tr>
<tr>
<td>Machine-picked</td>
<td>Early-season</td>
<td>11</td>
<td>1½ inch</td>
<td>1½ inch</td>
<td>34.3</td>
<td>34.4</td>
</tr>
<tr>
<td>Do</td>
<td>Midseason</td>
<td>13</td>
<td>1½ inch</td>
<td>1½ inch</td>
<td>34.1</td>
<td>34.2</td>
</tr>
<tr>
<td>Do</td>
<td>Late-season</td>
<td>5</td>
<td>1½ inch</td>
<td>1½ inch</td>
<td>34.2</td>
<td>34.2</td>
</tr>
<tr>
<td>Do</td>
<td>Late-exposed</td>
<td>2</td>
<td>1½ inch</td>
<td>1½ inch</td>
<td>34.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Machine-stripped</td>
<td>Late-season</td>
<td>1</td>
<td>SM-</td>
<td>35.0</td>
<td>35.2</td>
<td>35.2</td>
</tr>
<tr>
<td>Hand-picked</td>
<td>Early-season</td>
<td>6</td>
<td>SM-</td>
<td>35.0</td>
<td>35.2</td>
<td>35.2</td>
</tr>
<tr>
<td>Do</td>
<td>Midseason</td>
<td>4</td>
<td>M</td>
<td>34.2</td>
<td>34.2</td>
<td>34.2</td>
</tr>
<tr>
<td>Do</td>
<td>Late-season</td>
<td>7</td>
<td>LM+</td>
<td>34.3</td>
<td>34.4</td>
<td>34.4</td>
</tr>
<tr>
<td>Hand-snapped</td>
<td>Late-exposed</td>
<td>2</td>
<td>SGO+</td>
<td>34.5</td>
<td>34.5</td>
<td>34.5</td>
</tr>
</tbody>
</table>

1 Simple cleaning: Tower drier 160°F, 7-cylinder cleaner, and extractor feeders without heat.
Moderate cleaning: Tower drier 160°F, 6-cylinder cleaner, big-bur machine, combined tower drier and 15-cylinder cleaner 160°F, and extractor feeders without heat.
Elaborate cleaning: Tower drier 160°F, 6-cylinder cleaner, big-bur machine, and extractor feeders without heat.
Very elaborate cleaning: Tower drier 160°F, 6-cylinder cleaner, big-bur machine, 7-cylinder cleaner, tower drier 160°F, 6-cylinder cleaner, big-bur machine, combined tower drier and 15-cylinder cleaner without heat, and extractor feeders without heat.

1 SGO = Strict Good Ordinary; LM = Low Middling; SLM = Strict Low Middling; M = Middling; and SM = Strict Middling.
<table>
<thead>
<tr>
<th>Harvesting method</th>
<th>Stage of harvesting</th>
<th>Samples tested</th>
<th>Foreign-matter content of seed cotton as received at gin</th>
<th>Simple seed-cotton cleaning</th>
<th>Moderate seed-cotton cleaning</th>
<th>Elaborate seed-cotton cleaning</th>
<th>Very elaborate seed-cotton cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine-picked</td>
<td>Early-season</td>
<td>11</td>
<td>4.6%</td>
<td>37.9 ft lbs per 100 lb seed</td>
<td>41.0 ft lbs per 100 lb seed</td>
<td>49.2 ft lbs per 100 lb seed</td>
<td>57.6 ft lbs per 100 lb seed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machine-stripped</td>
<td>Late-season</td>
<td>2</td>
<td>5.5%</td>
<td>68.4 ft lbs per 100 lb seed</td>
<td>76.2 ft lbs per 100 lb seed</td>
<td>85.5 ft lbs per 100 lb seed</td>
<td>94.0 ft lbs per 100 lb seed</td>
</tr>
<tr>
<td>Hand-picked</td>
<td>Late-season</td>
<td>1</td>
<td>43.5%</td>
<td>482.5 ft lbs per 100 lb seed</td>
<td>492.2 ft lbs per 100 lb seed</td>
<td>482.5 ft lbs per 100 lb seed</td>
<td>482.5 ft lbs per 100 lb seed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-snapped</td>
<td>Late-exposed</td>
<td>2</td>
<td>24.4%</td>
<td>55.7 ft lbs per 100 lb seed</td>
<td>61.6 ft lbs per 100 lb seed</td>
<td>68.4 ft lbs per 100 lb seed</td>
<td>75.2 ft lbs per 100 lb seed</td>
</tr>
</tbody>
</table>

1 Based on laboratory fractionation tests performed on representative wagon samples of seed cotton.

2 Simple cleaning: Tower drier 160° F., 7-cylinder cleaner, and extractor feeders without heat.

Moderate cleaning: Tower drier 160° F., 6-cylinder cleaner, big-bur machine, and extractor feeders without heat.

Elaborate cleaning: Tower drier 160° F., 6-cylinder cleaner, big-bur machine, combined tower drier and 15-cylinder cleaner 160°, and extractor feeders without heat.

Very elaborate cleaning: Tower drier 160° F., 6-cylinder cleaner, big-bur machine, 7-cylinder cleaner, tower drier 160°, 6-cylinder cleaner, big-bur machine, combined tower drier and 15-cylinder cleaner without heat, and extractor feeders without heat.
The average grade improvement obtained with the lint cleaners on the machine-picked and roughly harvested cottons as compared with clean hand-picked cottons indicates the greater cleaning potential of the flow-through cleaners on the trashier cottons. This is further borne out by an increase in weight of waste removed by the lint cleaners per bale, which accompanies increases in foreign matter content of the seed cotton. Likewise there is a consistent decrease in the weight of lint-cleaner waste accompanying increases in the intensity of seed-cotton cleaning.

The weight of lint-cleaner trash on a bale basis is small compared with the weight of trash removed by the seed-cotton-cleaning equipment (table 2). The lint-cleaner trash is very important, however, because it is comprised principally of small leaf particles, pepper trash, dirt, motes, and short irregular fibers that would be reflected in lower grades if left in the cotton.

The average weight of waste removed by the lint cleaners obtained in the 1948 season tests ranged from 3.5 pounds on the clean hand-picked cottons up to as much as 11.0 pounds on late-season, trashy, machine-picked cottons, and to 16.1 pounds on late-season, machine-stripped. As based on Shirley analyzer tests, the samples of lint-cleaner waste, representing all types of harvesting, contained an average of 82 percent actual trash and 18 percent short irregular fiber, such as would normally be removed in cleaning processes at textile mills.

A further analysis of average amounts of lint-cleaner waste and its components of trash and fiber as associated with lint cotton of different grades shows a progression in total lint-cleaner waste ranging from 5.6 pounds per bale on Strict Middling cotton up to 17.6 pounds per bale for Good Ordinary grades (table 3). The fiber loss was generally about the same, regardless of the grade of cotton, being from 1.6 to 2.2 pounds per bale for this range of grades.

As shown by spinning tests performed on representative samples taken in connection with the 1948 lint-cleaning studies, the foreign matter removed by the flow-through lint cleaners at the gin was reflected in lower manufacturing waste in the picker and carding processes. Yarn skein strength, yarn appearance, and the number of nep
<table>
<thead>
<tr>
<th>Grade:</th>
<th>Early-season cotton</th>
<th>Midseason cotton</th>
<th>Late-season cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade:</td>
<td>Moderate seed-</td>
<td>Moderate seed-</td>
<td>Moderate seed-</td>
</tr>
<tr>
<td></td>
<td>lint cleaning $^2$</td>
<td>lint cleaning $^2$</td>
<td>lint cleaning $^2$</td>
</tr>
<tr>
<td>Lint cleaning waste per bale,</td>
<td>No lint cleaning</td>
<td>Flow-through lint cleaner</td>
<td>No lint cleaning</td>
</tr>
<tr>
<td>pounds.</td>
<td>no lint cleaning</td>
<td>flow-through lint cleaner</td>
<td>no lint cleaning</td>
</tr>
<tr>
<td>86.6</td>
<td>90.9</td>
<td>88.8</td>
<td>88.7</td>
</tr>
<tr>
<td>34.3</td>
<td>34.4</td>
<td>34.4</td>
<td>34.1</td>
</tr>
<tr>
<td>8.5</td>
<td>7.5</td>
<td>7.8</td>
<td>6.4</td>
</tr>
<tr>
<td>11.8</td>
<td>10.6</td>
<td>11.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Yarn skein strength, pounds:</td>
<td>268</td>
<td>268</td>
<td>268</td>
</tr>
<tr>
<td>106</td>
<td>112</td>
<td>113</td>
<td>108</td>
</tr>
<tr>
<td>Yarn appearance, code points:</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

1 The classification and lint-cleaner waste represent averages for 11 cottons early in season, 15 during midseason, and 5 during the late season; and the spinning data, 1 cotton for each stage of picking.

2 Moderate cleaning: Tower drier 160°F, 6-cylinder, big-bur machine, and extractor feeders without heat.
Elaborate cleaning: Tower drier 160°F, 6-cylinder cleaner, big-bur machine, combined tower drier and 15-cylinder cleaner 100°F, and extractor feeders without heat.
Very elaborate cleaning: Tower drier 160°F, 6-cylinder cleaner, big-bur machine, 7-cylinder cleaner, tower drier 160°F, 6-cylinder cleaner, big-bur machine, combined tower drier and 15-cylinder cleaner without heat, and extractor feeders without heat.

3 SGO = Strict Good Ordinary = 78; LM = Low Middling = 83; SLM = Strict Low Middling = 84.

4 V = B; 5 = C+; 6 = C; 7 = D+; and 8 = D.
in the card web were not significantly affected by lint cleaning (table 4). The lower mill waste in favor of lint-cotton cleaning at gins should be reflected to some extent in savings in transportation and manufacturing costs. Trash in lint cotton adds to the weight of mill shipments and increases transportation expense.

USING LINT CLEANERS IN OLD AND NEW PLANTS

In the design and development of the flow-through cleaners, consideration has been given to mechanical and installation features that would permit their adaptation to both old and new gin plants. In either instance, however, the necessary space for installations must be available and sufficient power must be provided. Approximately 10 additional horsepower is required for each flow-through lint-cleaner unit. This should provide for the operation of the saws and revolving screens as well as for the additional air-blast doffing fan, the venting air-system fan, and the trash conveyor.

The matter of deciding on the soundness of investment in installing lint cleaners must be based upon such factors as the annual ginning volume and the quantity of mechanically and roughly harvested cotton to be processed at the gin. Consideration must also be given to any other factors that would normally enter into the matter of deciding on any equipment to meet custom-service demands and yet be feasible from both engineering and economic standpoints. It should be kept in mind that the lint cleaners are intended to supplement an adequate amount of seed-cotton cleaning.

At 1950 prices, as quoted by gin manufacturers, it is estimated that the cost of providing lint-cleaning service in a 4-stand gin plant having an annual volume of 3,000 bales would be about $1 per bale. This estimate takes into account the initial investment, 4 percent interest, depreciation at 8 percent per year, and liberal allowances for operating and maintenance costs.

SUMMARY AND CONCLUSIONS

In order to cope with the problems confronting the ginning industry in cleaning the American cotton crop and improving grades, the United States Cotton Ginning Laboratory has developed a type of lint-cleaning machine for use in cotton gins. This flow-through lint cleaner is the outcome of extensive research and developmental work in lint-cotton cleaning that began in 1939. The machine has been designed to satisfy requirements from the standpoint of simplicity, engineering features, and technological performance. The equipment provides a continuous process for cleaning the lint cotton after it leaves the gin saws at a convenient point in the ginning system between the gin stands and the baling press. The salient parts of the cleaner consist of (1) a revolving-screen assembly housed in a box casing with an air vent, (2) a metal connector with hinged damper,

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4 The spinning and Shirley analyzer tests were performed at the Fiber and Spinning Laboratory, College Station, Tex., under the supervision of Leonard J. Watson.
(3) a revolving saw cylinder and notched grid bars, (4) a trash chamber, (5) a doffing nozzle, and (6) an extension with lint valve to the lint flue. A satisfactory method is provided for introducing and delivering the fibers to, and carrying the fibers from, the lint cleaning units in substantially the same form as received from the gin stands. This is done by means of a continuous flow of the air stream and without retarding the ginning processes.

The flow-through cleaner uses combinations of centrifugal force, combing, gravity, and air-wash separation, plus the cleaning action obtained by blowing small tufts of ginned lint past a revolving screen drum. In passing the revolving screen drum, the fibers are directed into a revolving saw cylinder that does the major cleaning in conjunction with grid bars.

In both the exploratory testing of the flow-through cleaner during the 1947 ginning season and in the 3-stand gin tests conducted throughout the 1948 ginning season, excellent results were obtained. Both machine- and hand-harvested cottons were used in the tests. The cottons represented early, midseason, late-season, and very late-exposed pickings and included tests on machine-stripped and hand-snapped cottons. In performing the tests in a 3-stand commercial-type gin, uniform lots of cotton harvested from the same cottonfield were obtained and composited for each series of tests. Portions of each cotton were subjected to varying degrees of cleaning in the seed-cotton-handling stage.

In each series of tests, paired bales representing each type of seed-cotton cleaning were so handled as to permit the ginning and delivery of one bale to the condenser and press in the conventional manner without lint cleaning while the corresponding bale was processed in the flow-through lint cleaner. No serious operating difficulties were experienced, and the tests have proved that the cleaner has the capacity and endurance for constant use in handling the full delivery from cotton gins.

In connection with the lint-cleaning experiments, appropriate samples for quality-evaluation tests were taken of the seed cotton, the lint, and the foreign matter. The lint samples were classed, fiber tests were run, laboratory determinations of foreign matter and moisture content were made, and spinning tests were performed on representative samples of the lint cotton.

The lint-cleaning machine provided consistent and significant grade improvements on all types of cotton without injuring fiber and spinning qualities of the lint. The grades obtained in processing machine-picked cotton by the various seed-cotton-cleaning combinations where the lint cleaner was used averaged about two-thirds grade higher in each instance than the grade produced with the same machinery combinations used without the lint cleaner. These grade improvements were reflected in lower manufacturing waste when the cotton was subjected to spinning tests.

In the design and development of the flow-through lint cleaner, consideration has been given to mechanical and installation features that would permit its adaptation to both old and new gin plants. In either instance, however, the necessary space for installation must be available and sufficient power must be provided.
The matter of deciding economic feasibility of installing lint cleaners must be based upon such factors as the annual ginning volume and the quantity of mechanically and roughly harvested cotton to be processed at the gin. At 1950 prices, as quoted by gin manufacturers, it is estimated that the cost of providing lint-cleaning services in a 4-stand gin plant having an annual volume of 3,000 bales would be about $1 per bale.