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BACKGROUND INFORMATION FOR ESTABLISHMENT OF NATIONAL STANDARDS OF PERFORMANCE FOR NEW SOURCES

COTTON GINNING INDUSTRY

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NATIONAL STANDARDS OF PERFORMANCE
COTTON GINNING INDUSTRY

1.0 INTRODUCTION

1.1 The Cotton Industry

The cotton industry is an international industry and is therefore subject to many decisions made outside of the United States. In 1970-71 (the last quarter of 1970 and the first quarter of 1971) the projected free-world cotton consumption was 28.3 million bales. The 1970 U.S. production was 10.1 million bales.

As well as being an international industry the cotton market is part of the total fiber industry. The 1970-71 free-world consumption of fibers was 59.7 million bales (equivalent cotton bales). Synthetic fibers accounted for 31.4 million bales of this. The major difference in the consumption of these two fibers is that the cotton consumption has increased only 3.7 million bales in the past decade (16 percent) while the synthetic fiber consumption has increased 19.5 million bales (164 percent).

The trend in the U.S. market, where 85-90 percent of the U.S. produced cotton is consumed, has improved recently as far as the cotton industry is concerned. After a steady decline for cotton in the total U.S. fiber market during the 1960's, including a drastic drop in 1968, the cotton percentage leveled out during 1969 and 1970. An analysis of the U.S. economy and the textile market by the National Cotton Council of America (NCCA) indicates that cotton consumption is now holding its own and will perhaps increase slowly in the future[1].

There are several factors which may change this picture, however, as are pointed out in the NCCA report. These include world cotton shortages brought about by decreased cotton acreages and/or unfavorable weather, cotton price gyrations brought about by speculation in the cotton market, and, in the U.S., federally imposed cotton acreage quotes and federally sponsored price support programs. The latter programs are authorized by Food and Agriculture Acts. There will be no federal support programs during the 1971 and 1972 seasons.

Because of the number and complexity of all the factors influencing the cotton market the National Cotton Council finds it impossible to project the future of cotton even one year. All of the ramifications involved are detailed in the NCCA report(1).

For purposes of projecting the potential of the air pollution problem of the cotton ginning industry, an estimate of growth can be made based upon historic records of cotton production and the trend that indicates cotton is now holding its own in the world fiber market.

Historically, the production of cotton in the United States is very unique in that the annual production rate has remained generally constant since 1899. In that year 9.4 million bales of cotton were produced in the U.S. In 1970, 10.1 million bales were produced. During this 72 year period the U.S. production has ranged from a low of 7.4 million bales in 1967 to a high of 18.3 million bales in 1937. The average production during this period has been 12.4 million bales annually.

For purposes of estimating the air pollution potential of the cotton ginning industry over the next decade, it appears reasonable to assume that the production of cotton will remain in the 9-14 million blaes per year range.

This appears to be quite a range, but it is within the current production fluctuation and can be accomodated at existing gins simply by varying the duration of the ginning day or season.

1.2 Cotton Ginning

Cotton ginning involves receiving seed cotton at the gin, removing the green bolls and rocks; drying and removing sticks, field trash and leaves; ginning the cotton to remove the cotton seed; and cleaning and baling the lint. The cotton seeds are collected for oil production or for future planting. The trash and lint from the cotton is either incinerated, composted, or spread on fields.

1.2.1 The Cotton Ginning Industry

Although the production of cotton has remained quite constant during the past 70 years, several changes have occurred in the ginning industry. Probably the most important changes have been the developments and improvements in ginning equipment and the effects that these have had on the capacities of gins. In 1899, there were 29,620 active cotton gins in the U.S. and each gin averaged 317 bales of cotton per year (a bale of lint cotton has a nominal weight of 500 lbs). In 1969, there were only 3,943 active gins in the country, and each ginned an average of 2,522 bales of cotton annually.

Current projections are for cotton gins to continue to increase in size. It has been reported that presently a gin must have a capacity of 4,000-10,000 bales of cotton annually, depending upon the ginning rate, to break even financially[2,3,4].

The ginning rates for gins range from 5 bales per hour for old gins to 20-30 bales per hour for newly constructed gins. An average gin is rated at 10-15 bales/hr.

The increase in gin size has been made feasible by improvements in equipment and by automotive transportation, and it has been made necessary by increased capital and labor costs and a reduction in the length of the ginning season as a result of the mechanical harvesting of cotton.

1.2.2 Geographic Distribution

The cotton belt of the U.S. stretches across the southern part of the country from coast to coast as shown in Figure 1. The distribution of cotton gins pretty much parallels the distribution of cotton production. Table 1 shows the distribution of cotton gins in the U.S.

The number of cotton gins reported at any time is approximate since some gins do not operate each season.

1.2.3 Period of Operation

Cotton ginning is a seasonal industry. It begins with the maturing of cotton, which varies somewhat with geographic distribution, and ends shortly after the cotton harvest ends. This period begins around mid to late October, and extends through early January. The reason the ginning season follows the harvest of cotton so closely is that cotton fiber is degradated during storage.

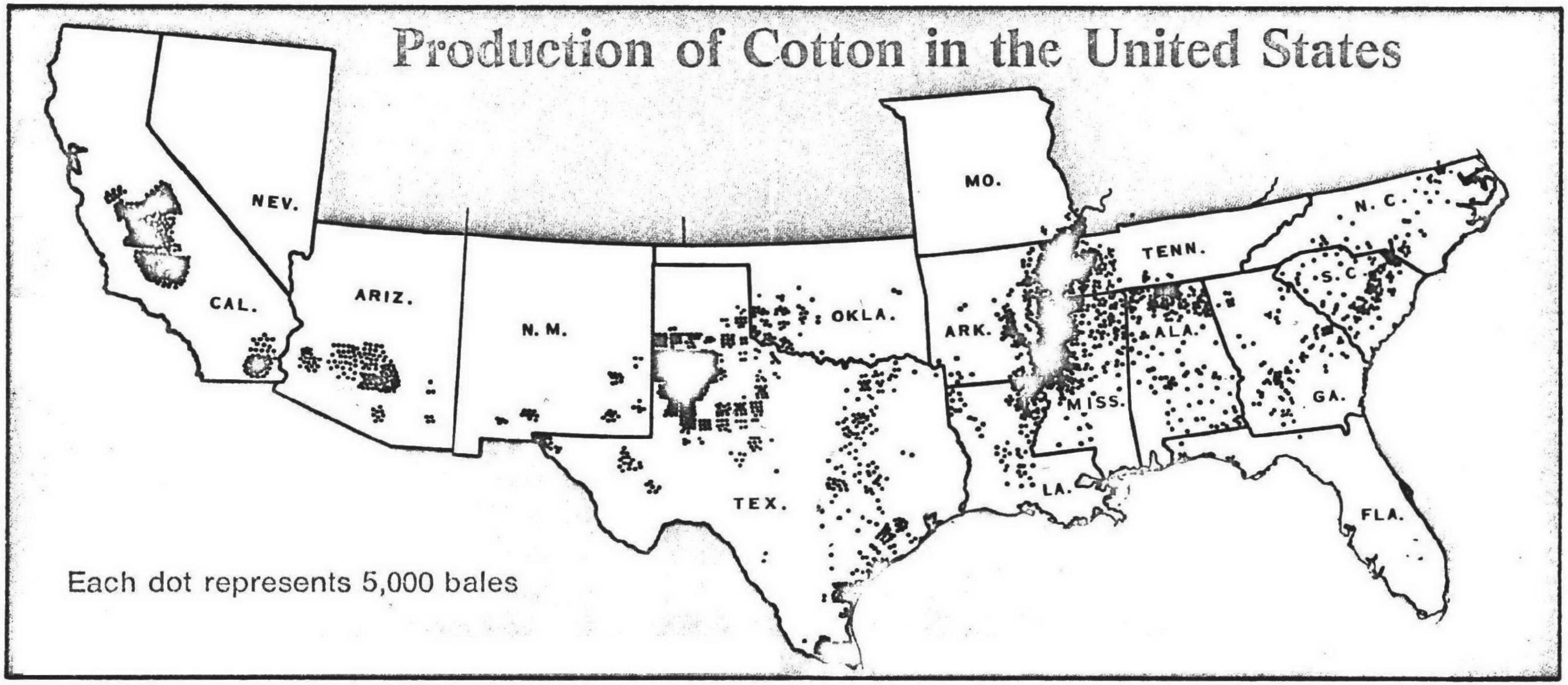


FIGURE 1

National Cotton Council
of America

TABLE 1

NUMBER OF ACTIVE COTTON GINS IN EACH STATE; 1968*

State	No. of Gins	State	No. of Gins
Georgia	255	Tennessee	23
Alabama	339	Missouri	115**
S. Carolina	224	Kentucky	1**
N. Carolina	143	Texas	1300
Virginia	7	Oklahoma	145
Florida	5	Arizona	116
Louisiana	181**	California	291
Arkansas	451	New Mexico	58
Mississippi	511**	Nevada	1
Total U.S. 1968	4218		
Total U.S. 1970	3754		

*Data from Cotton Division, Consumer and Marketing Service, U.S. Department of Agriculture

**1970 Data

The season for an individual gin is usually only 4-6 weeks. This may tail out somewhat depending upon lagging cotton harvesting, but the peak production period is 4-6 weeks. The remainder of the year the gin is idle.

1.2.4 Cost of Ginning Cotton

The cost per bale of lint cotton varies considerably throughout cotton belt and it varies considerably within a region from year to year. In 1966, the average cost to produce a bale of Upland cotton in the U.S. was $132.84. The costs ranged from $90.57 in the high plains of Texas to $184.39 in eastern Arkansas[5].

The 1966 cost of ginning averaged $18.36 (13.8 percent of the total cost) in the U.S., with a range of $14.45 to $21.24 (8.7-18.5 percent)[5]. In general, the lowest ginning costs were incurred in the southeast where hand picking was still practiced to a significant extent. This method of harvest has declined considerably since 1966.

The highest ginning costs were incurred in the southcentral section of the cotton belt from the Mississippi River to western Texas. Machine stripping is the predominant method of cotton harvest in this section of the cotton belt.

The U.S. Department of Agriculture Economic Research Service has conducted a study subsequent to the 1966 study, but results have not yet been published.

2.0 PROCESS DESCRIPTION

2.1 General

Cotton ginning involves separating cotton fibers from cotton seed and other field trash. Materials are transported through the gins pneumatically and sources of air pollution result each time material is separated from the air stream.

Factors which affect the ginning process are the type of cotton being ginned, the method of harvest, and the moisture content of the seed cotton.

2.1.1 Types of Cotton

The two types of cotton produced in the U.S. are Upland cotton and American Prima or American Egyptian cotton. Upland cotton accounts for about 99.2 percent of the cotton produced.

The main difference in the two species is the staple length (fiber length). The staple length of the Upland cotton ranges from 15/16 inch to 1 5/32 inch, depending upon the particular variety. The staple length of the American Prima cotton is longer; ranging from 1 3/8 inch to 1 9/16 inch.

American Prima cotton is produced in the El Paso, Texas area, the Carlsbad, New Mexico area, and the Phoenix, Arizona area.

The difference in the ginning processes for these two cotton species is in the gin stand. For the American Prima cotton, a roller type or McCarthy gin is used. This gin resembles a clothes wringer.

The two rollers have bearings which permit the rollers to wedge together close enough to grip the cotton fibers and to separate them from the seed. These gins are usually of a low capacity, but they do prevent breakage of the long American Prima cotton fibers.

The Upland cotton is ginned with a saw type gin which will be discussed in Section 2.2.5.

The air pollution problems of the two types of gins are similar. The main difference is that the Upland cotton gins are usually of a higher capacity and, hence, have an air pollution problem of a greater magnitude.

2.1.2 Methods of Harvest

The method of harvesting cotton determines the amount of trash in the cotton and, hence, determines the amount of cleaning equipment required at a gin.

(In this and succeding sections of this report reference is made to bales of cotton and bales of seed cotton. Seed cotton is cotton as it is received from the field. It contains the cotton fiber, cotton seed, and field trash. Cotton or lint cotton refers to cotton fiber as it leaves the gin. The nominal weight of a bale of lint cotton is 500 pounds. The weight of a bale of seed cotton is the weight of seed cotton which is required to produce a bale of lint cotton. This weight will usually vary from 1300-2500 pounds, depending upon the method of harvest.)

There are five methods of harvest presently used for cotton; three mechanical and two manual. The methods are machine picking, machine stripping, machine scrapping, hand picking, and hand snapping. The latter two methods are fast becoming obsolete because of the cost of labor and improvements in harvesting equipment.

Hand picking was the method originally used for harvesting cotton, and it produces the cleanest seed cotton; approximately 50-100 pounds of trash per bale of cotton. Table 2 presents the approximate weight of materials in a bale of seed cotton for various harvest methods.

The amount of trash varies considerably and depends upon field conditions at harvest time, machine conditions, and the skill of the operator. Toward the end of the season the trash content can be as high as 2000 pounds/bale.

The methods of harvest which are most prevalent are machine stripping and machine picking. In 1966, machine picking accounted for 62 percent of all harvested cotton in the U.S. and machine stripping accounted for 27 percent(5). These percentages have increased since then. Machine stripping is most common in Texas and New Mexico, where 96 percent of the cotton is harvested by this method. Machine picking is common throughout the remainder of the cotton belt.

In addition to controlling the amount of cleaning equipment the method of harvest also determines the amount of trash generated. When ginning 20 bales/hr of machine picked cotton, 3280 lbs/hr of

TABLE 2

COMPOSITION OF SEED COTTON PER 500 lb BALE OF COTTON

Method of Harvest	Weight of Seed Cotton	Weight of Cottonseed	Weight of Trash Moisture	Weight of Lint
Hand picked	1,383	808	75	500
Hand scrapped	2,049	808	741*	500
Machine picked	1,472	808	164*	500
Machine stripped	2,159	808	851*	500
Machine scrapped	2,473	808	1,165*	500

* Average Values from 1964 U.S. Cotton Crop[6]

trash are produced. With machine stripped cotton, on the other hand, the trash produced is 17,020 lbs/hr. If this material is disposed of by incineration, the potential for air pollution is changed considerably.

2.1.3 Moisture Content of Seed Cotton

The moisture content of seed cotton is critical in the storage and ginning of cotton. Ideally, cotton should be harvested when the moisture content of the lint is less than 10 percent. Seed cotton with this moisture content can be stored without degradation and moisture adjustments prior to ginning are minimized.

For ginning, the moisture content of the lint should be 6.5 to 8 percent. A moisture content higher than this improves the yarn strength and appearance, but decreases the lint grade; a lower moisture content increases the grade, but decreases strength and appearance.

The result of this is that the moisture content of the lint is adjusted prior to ginning. The usual adjustment is to decrease the moisture content by drying. Only in the arid southwest is it sometimes necessary to increase the moisture content of the lint.

2.2 The Ginning Process

The major objective during the ginning process is to obtain the maximum dollar return for the cotton producer and to maintain fiber quality for the manufacturer and consumer. The selection and proper use of ginning equipment as determined by the type of cotton, the condition of cotton, method of harvest, moisture content of the lint, and the status of the market has a great influence on attaining this objective.

A typical arrangement of ginning equipment is:

1. suction unloading telescope,
2. green-boil trap,
3. air line cleaner (recommended only in sandy areas to protect the machinery from abrasion).
4. bulk feed control unit,
5. dryer (24-shelf tower or equivalent) with 3-million BTU burner with modulating or automatic moisture-sensitive control,*
6. a 6- or 7-cylinder inclined cleaner with grid selection,
7. bur machine,
8. green leaf and stick machine,
9. dryer (24-shelf tower or equivaleent) with 3-million BTU burner with modulating or automatic moisture-sensitive control,*
10. a 6- or 7-cylinder inclined cleaner with grid selection,
11. extractor feeders,
12. gin stands,
13. tandem saw-type cleaning with complete bypass system,
14. press.

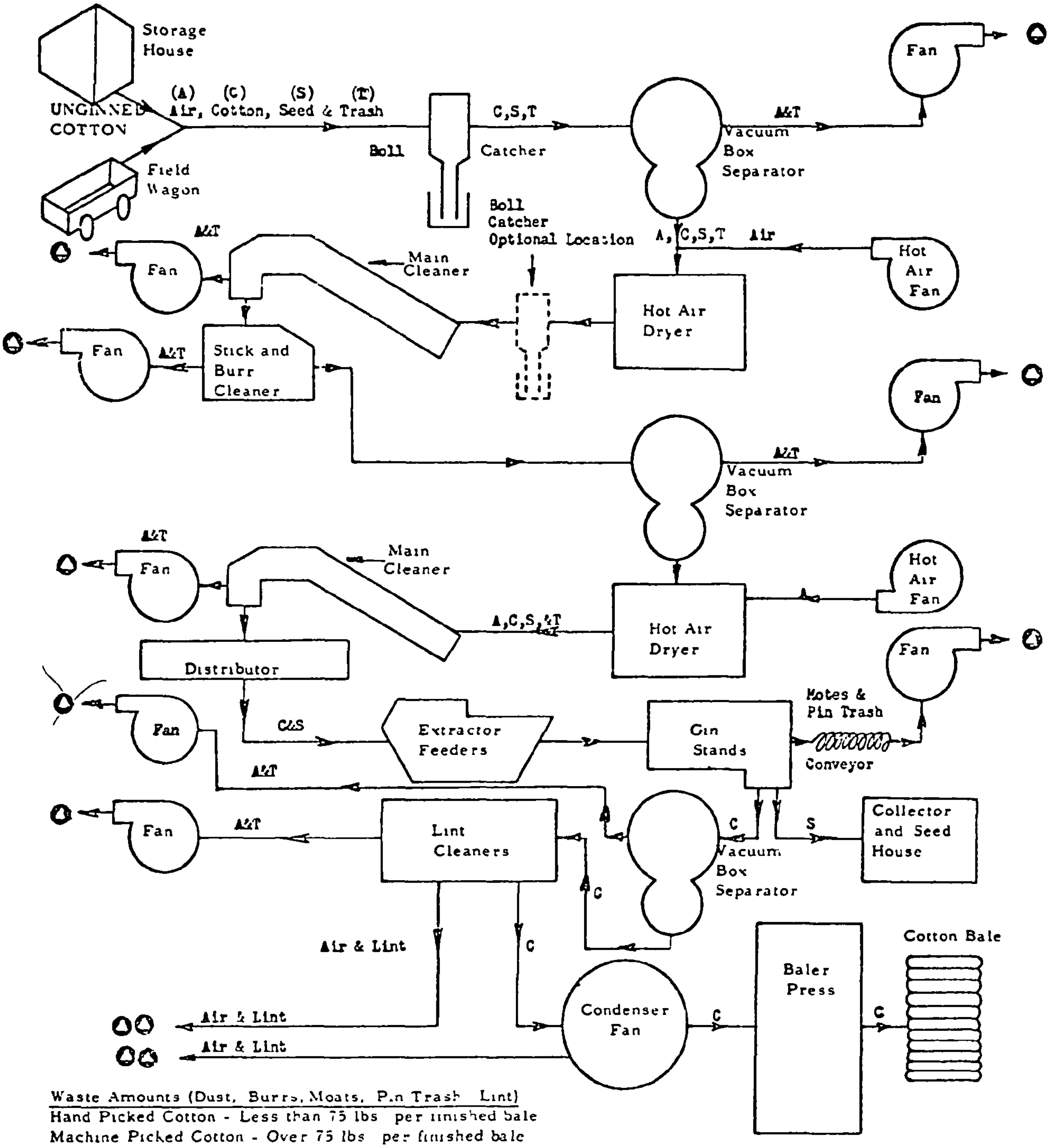
*Dryers should have a bypass in case lint does not require drying. In the High plains area of Texas, moisture restoration equipment would be included along with the dryers.

Figure 2 shows a flow diagram of a typical cotton gin. Figures 3, 4, and 5 show some basic modifications to the gin layout for specific conditions. These diagrams stop with the gin stand since they are similar to Figure 2 beyond this point.

Figure 3 shows a machinery layout for hand picked cotton. There are still some gins of this type in the Carolinas, Georgia, and Alabama. Little cleaning is necessary on the relatively clean early season, hand-picked cottons. A master feed-control unit to meter the seed cotton into the system, a full tower drier or the equivalent, 7 to 14 cylinders of seed cotton cleaning, a bur or stick-and-green-leaf machine, and large extractor feeders, are all the machinery necessary to produce satisfactory grades from clean, hand-picked cottons.

For machine-picked cotton, a much more elaborate gin is necessary to obtain grades acceptable to the mills and to yield good returns for the producer. The Midsouth has more moisture generally than does the Southeast; therefore, more drying of the cotton is needed. Because of moisture that is added on the picker spindles, more drying is generally needed on the machine-picked than on the hand-picked cottons. A gin to handle machine picked cotton is shown in Figure 4. It consists of a feed control, 2 full-sized tower driers or the equivalent, a boll trap, 12 to 14 cylinders of seed cotton cleaning, a bur machine or stick-and-green-leaf machine, large extractor feeders, and 2 lint cleaners.

Considerable extracting equipment is necessary to obtain satisfactory grades for machine-stripped cottons. Also, an air-line



Waste Amounts (Dust, Burrs, Moats, Pin Trash Lint)
Hand Picked Cotton - Less than 75 lbs per finished bale
Machine Picked Cotton - Over 75 lbs per finished bale
Defoliate, Snapped and Machine Picked Cotton - 300 to 2,000 lbs per finished bale 95% is estimated to be discharged through main cleaner fan exhausts, balance through suction, pin trash-moats-lint cleaner fan exhausts.

Air and trash discharged directly to atmosphere or dust collectors

Air and fly lint discharged directly to atmosphere or through "dog houses" (settling chambers) or fly lint catchers

Note The number of dryers and cleaners will vary with each gin and area harvesting methods

FIGURE 2-TYPICAL COTTON GINNING FLOW DIAGRAM

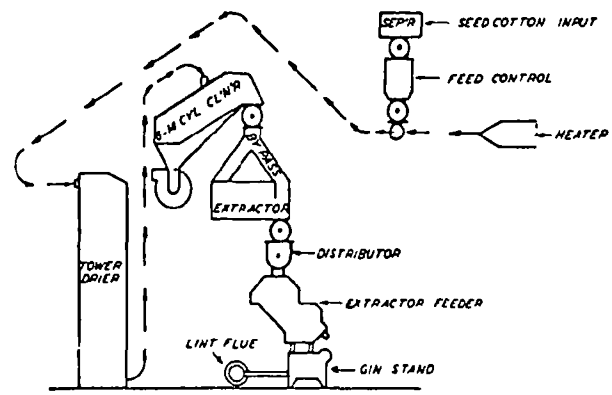


FIGURE 3 —Ginning machinery setup recommended for use with clean, hand-picked cotton.

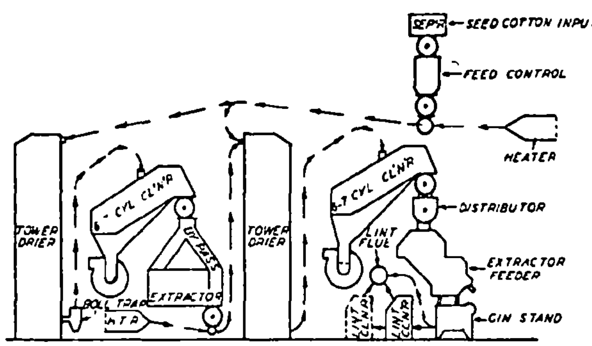


FIGURE 4—Ginning machinery setup recommended for use on machine-picked cotton.

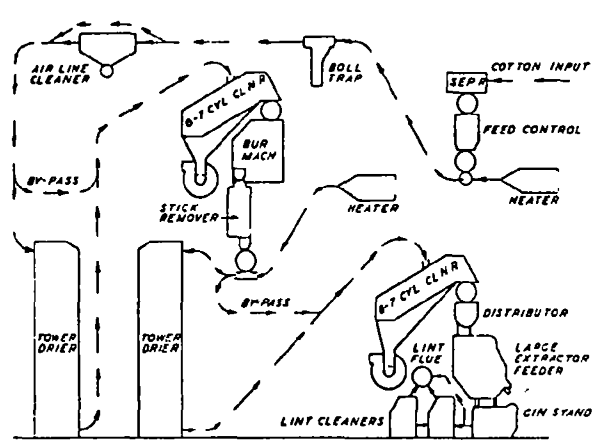


FIGURE 5 —Ginning machinery setup recommended for use on machine-stripped and hand-snapped cotton.

cleaner in the wagon unloading line is advisable. Machinery recommendations for handling hand-snapped and machine-stripped cotton in Oklahoma and the High Plains include a feed control, green boll trap, 6- or 7-cylinder air-line cleaner, tower drier or equivalent, 6- or 7-cylinder cleaner, large extractor feeders, and 2 lint cleaners (Figure 5).

2.2.1 Green-Boll Trap

All gins should be equipped with a green-boll trap. These units are sometimes referred to as rock traps. Rocks and tramp iron can damage gin machinery severely, and the wet fibers of green boll are likely to stick to gin saws and cause a considerable reduction in the gin plant efficiency. At times the sap from green bolls may cause dust and trash to build up inside fan scrolls, and this can also cause shutdown periods for cleaning.

Figures 6 and 7 show two types of green-boll traps. The type shown in Figure 7 will remove 87-92 percent of the green-bolls with a lint loss of less than 1/4 pound per bale.

2.2.2 Feed Control

Gin plants should be equipped with a bulk uniform-feed control unit. The unit should be located in the machinery sequence in such a way as to ensure that each machine is fed cotton at the proper uniform rate for peak efficiency. The bulk feed control unit should not be used as an overflow bin, since this results in a recirculation of the overflow cotton through the overhead clean and drying equipment.

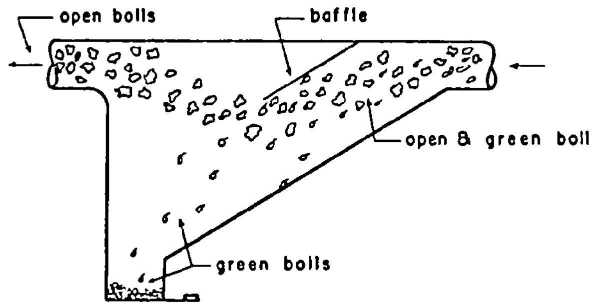


FIGURE 6—Conventional green-boll trap.

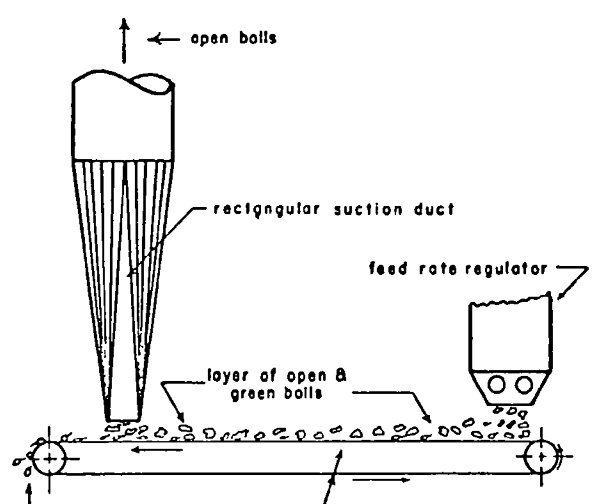


FIGURE 7 —Experimental green-boll trap.

2.2.3 Dryers and Moisture Regulation

The amount of moisture in seed cotton during cleaning and ginning is the most important factor affecting cotton quality. Temperatures of the dryer or the dryer by-pass mechanism should be adjusted on the basis of the moisture in the wagon sample and in the lint at the lint slide (entering the press). Temperatures of the dryer should be regulated so that cotton is presented to the gin saw within the 6.5 to 8 percent lint moisture range. Wet cotton passes through the cleaning equipment in wads that may cause chokages and inefficient cleaning. When cotton is ginned, damp samples are not as clean or as smooth, and lower grades result. If cotton is ginned while excessively dry, the fibers are brittle. Cotton cleans easily at the 3 to 5 percent moisture level, but the fibers are weakened or broken. This results in increased "short fiber" content. These facts emphasize the importance of fiber moisture during ginning, and the part controlled drying and moisture restoration play in efficient ginning. Figure 8 shows the cross-section of a typical shelf dryer.

2.2.4 Cleaners and Extractors

Seed cotton contains burs, bracts, sticks, stems, dead leaves, and sometimes green leaves. Each type of trash involves a special type of cleaning job. ~~Cylinder-type cleaners fluff the cotton and remove sand, fine leaf, and bract particles; bur machines extract sticks and type of cleaning job~~. Cylinder-type cleaners fluff the cotton and remove sand, fine leaf, and bract particles; bur machines extract sticks and

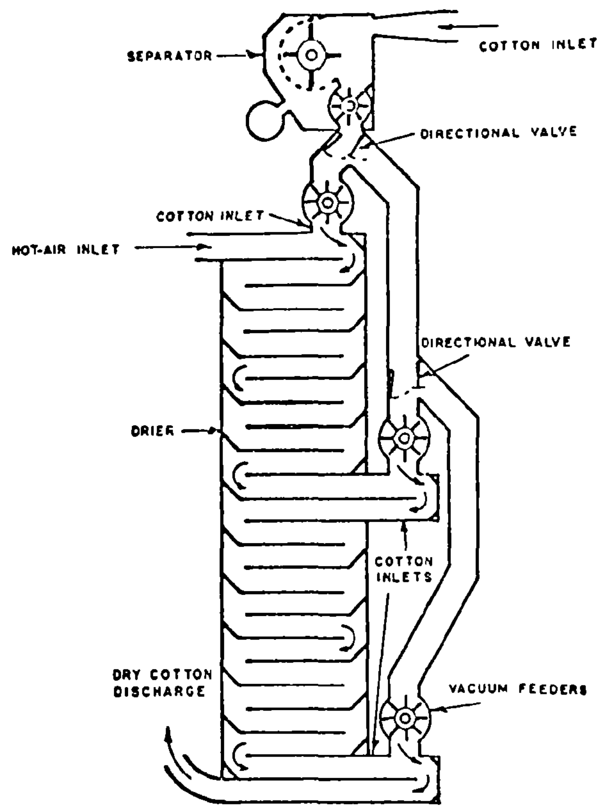


FIGURE 8—USDA-developed multipath seed cotton drier for controlled exposure drying.

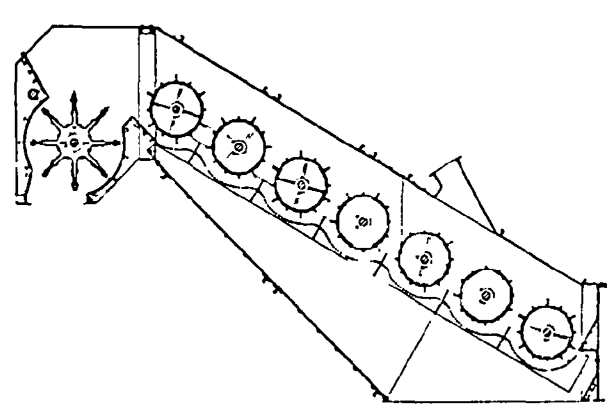


FIGURE 9—Cross section of 7-cylinder inclined cleaner.

burs; green leaf and stick machines extract, burs, sticks, stems, and green leaves. Since the bur machine is an efficient, high-capacity dry-bur extractor, good results are obtained by using a bur machine in combination with a green-leaf and stick machine. This allows the bur machine to remove the bulk of bur trash and prepare the cotton for the specialized action of the green-leaf and stick machine. The slingoff principle of the stick machine makes it especially efficient in green-leaf and stem removal. If the bulk of the bur trash has been removed when the cotton enters the green-leaf and stick machine, the benefits of the slingoff principle are fully used in the specialized removal of green leaves and stems. Research has shown that the best cleaning results are accomplished when two-stage drying, cylinder cleaning, and extraction are used alternately in the overhead cleaning sequence. In other words, the machinery sequence should be such that the two stages of drying are split with cleaning and extracting machinery. Figures 9 and 10 show various pieces of cleaning equipment.

2.2.5 Gin Stands

The gin stand is the heart of the gin plant and should be maintained in top condition to perform efficiently. Saws and ribs should be inspected frequently and necessary replacements made. Saws should be kept sharp and replaced when the diameter has been reduced by as much as 1/16 inch. Rib and saw clearance should be checked and maintained according to factory recommendations to avoid fiber damage and maintain ginning capacity. Figure 11 shows a cross-section of a gin stand.

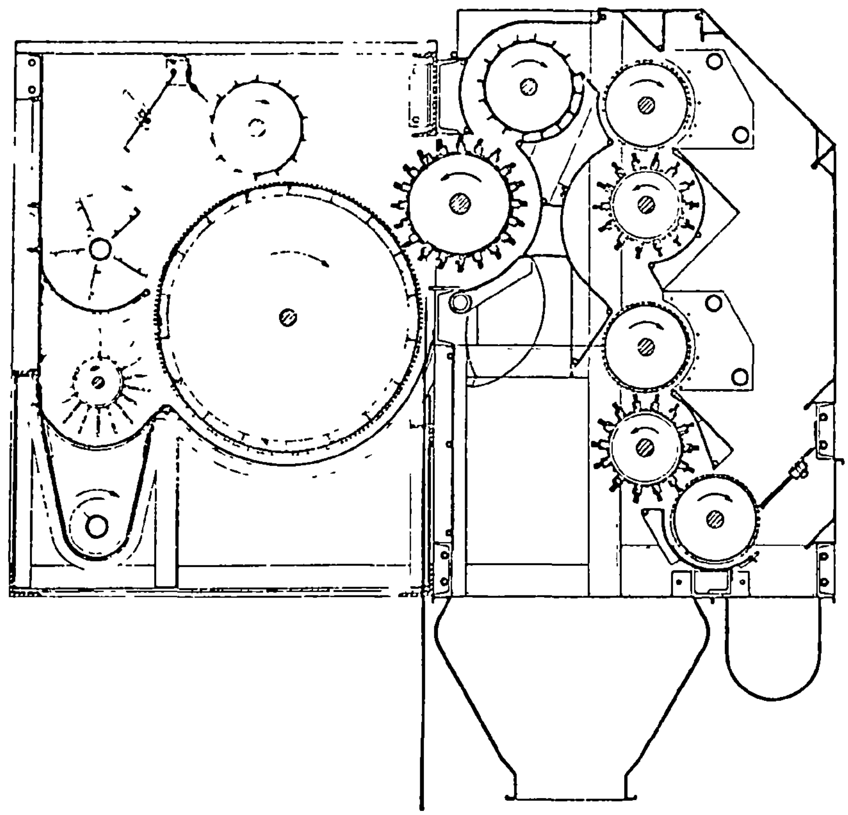


FIGURE 10 Cross section of bur machine (left) with stick remover attachment added (right).

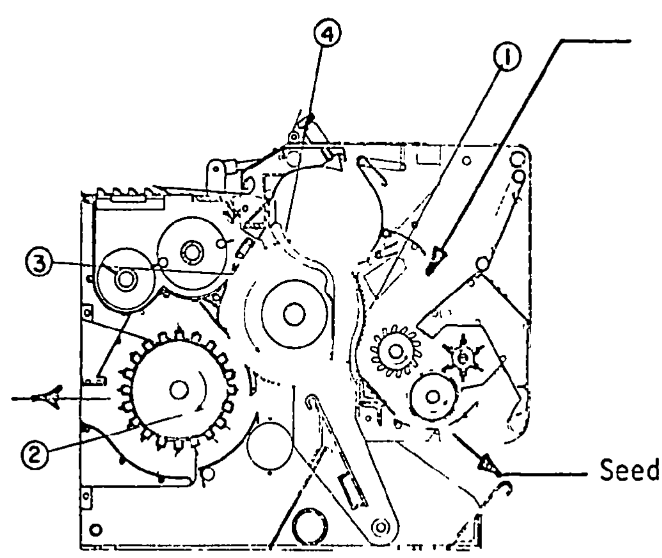


FIGURE 11-Cross section of a Saw type gin

2.2.6 Lint Cleaners

The use of lint cleaners in cotton gins is now as accepted practice, with more than 90 percent of the gins employing one or more lint cleaners. This development enables the ginner for the first time to remove foreign matter from lint cotton as a continuous process of ginning. It has contributed greatly to the success of cotton mechanization and mechanical harvesting. Lint cleaners can remove effectively and efficiently small leaf particles, motes, green leaves, and grass left in the cotton by seed cotton cleaners and extractors.

Lint cleaners are generally grouped into two categories, unit and bulk (battery). The unit machine implies that there will be one unit for each gin stand. A lint cleaner that receives lint from two or more gins is referred to as a bulk lint cleaner. Lint cleaners, either unit or bulk, placed in series so that the same lint passes through both of them result in what is commonly called tandem lint cleaning.

The use of one or two saw-type lint cleaners is an accepted practice, but the use of more than two in series should be discouraged since the appearance and strength of the yarn will be decreased.

Effectiveness of trash removal and grade improvements benefits resulting from use of lint cleaners are well established. But when grades are improved, bale weights and values are affected. Bale weights are reduced from 7 to 50 pounds or more per bale depending on harvesting practices, number of lint cleaners, and grades of cotton being ginned. Thus, improvements in grade may be offset by losses in bale weight.

With tandem saw-type lint cleaners, the first cleaner removes the most weight; the second, about half as much as the first; and the third, about half as much as the second. The foreign matter removed is composed of motes, fine leaf particles, grass, and green leaf in varying amounts. Figure 12 shows the cross-section of a lint cleaner.

2.2.7 Condensers

Condensers employ either one or two slow-turning screened drums on which the ginned lint forms a batt. The batt is discharged between doffing rollers to the lint side. The air is separated from the lint by venting the air through the screened drum to its ends where it is discharged in the direction provided in the manufacturers' design. The condenser is similar to the condenser in the top part of the lint cleaner shown in Figure 12.

2.2.8 Bale Presses

The lint batt is fed into a hydraulically operated press which compresses the lint into 500 pound bales. The presses are classified as low-, medium-, or high-density presses. These presses produce bales with densities of 12, 24, and 36 pounds of cotton per cubic foot, respectively.

2.2.9 Cotton Seed Handling

Cotton seed is removed from the gin stand either by mechanical or pneumatic conveyors and transported to seed storage bins. From the bins, the seed is either bagged or removed in bulk to cotton seed oil mills or it is returned to the cotton producer for future planting.

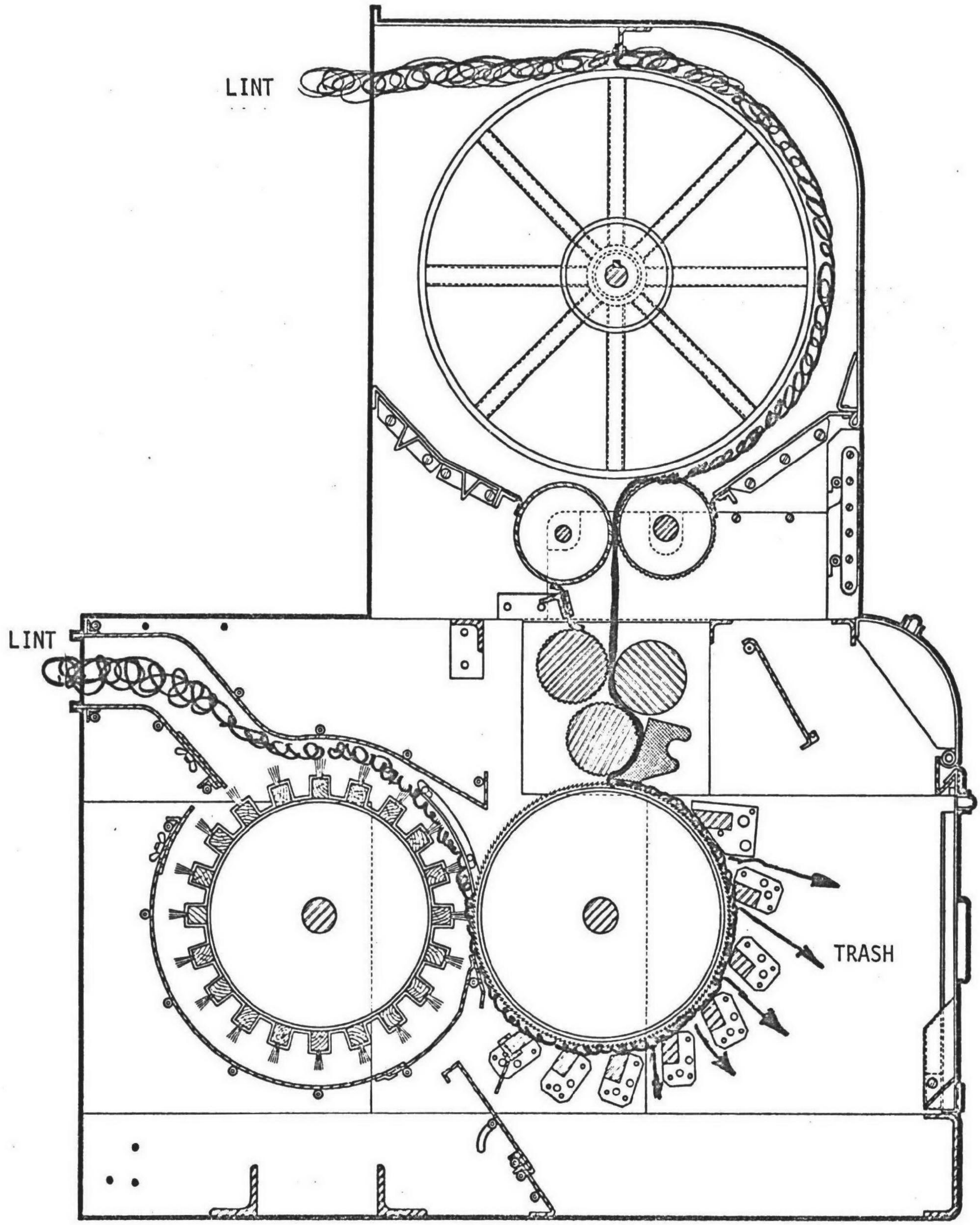


FIGURE 12-Unit controlled-batt saw-type lint cleaner.

2.2.10 Air Systems

The air handling system in a cotton gin can be separated into a high pressure system and a low pressure system.

The high pressure system includes the system from the suction unloader up through the trash fan on the lint cleaners. This system operates against a pressure of 10-20 inches of water. The most common type of emission control on this system is the small diameter cyclone (Figure 2).

The lint condenser and the waste lint condenser exhausts comprise the low pressure system. This system operates against a pressure of 1-5 inches of water. Control equipment for this system is primarily a filter type (Figure 2).

The volume of air handled at a gin is 50-75,000 cfm for an 8 bale/hr gin and 65-80,000 cfm for a 12 bale/hr gin. A gin located at the USDA Cotton Ginning Research Laboratory in Stoneville, Miss. was tested for particulate emissions in 1970[7]. The air flows at an 8.7 bale/hr ginning rate were:

High Pressure

Unloader fan	-	4,248 cfm
6 cylinder cleaner and stick machine	-	7,346
6 cylinder cleaner	-	8,436
Trash fan	-	8,208
		28,238 cfm

Low Pressure

No. 1 Lint cleaner	- 15,800 cfm	
No. 2 Lint cleaner	- 6,438	
Battery lint cleaner	- 15,874	
Lint cleaner waste	- 14,776	
		52,888 cfm
		81,126 cfm

2.2.11 Capital Cost

Cotton gins are generally designed and constructed by gin manufacturers on a turnkey basis. Therefore, the total cost for the construction of a new gin is easily obtained.

Presently, the new gins that are being constructed are in the 18-30 bale/hour category. The construction cost for these gins range from $350,000 to $500,000. This cost includes $15,000 - $30,000 for emission control equipment.

The largest gin in the U.S. was recently built for the J.G. Boswell Company of Corcoran, California, by the Continental, Moss Gorden Gin Company. This gin is completely automated and is rated at 40 bales/hr. The annual capacity is expected to be 33-35,000 bales. The cost of this gin was $1.5 million.

3.0 EMISSIONS FROM COTTON GINS

Emissions from cotton gins consist of hulls, sticks, stems, leaves, and dirt from the high pressure system (see section 2.2.10), and lint fly from the low pressure system.

An activity associated with cotton ginning is the disposal of the large volumes of trash removed from the seed cotton. The methods of disposal most commonly used are incineration, composting, spreading on the land, and use as cattle feed. With incineration there is a great potential for air pollution and with composting there is the possibility of odors if the process is not maintained properly.

Ambient air sampling in the vicinity of cotton gins has shown high concentrations of particulate matter, arsenic and bacteria.

3.1 Emissions from the Gin Building

3.1.1 High Pressure System

The emissions from the high pressure system consist of burs, sticks, leaves, and dirt which are brought to the gin with the seed cotton. The amount of this material per bale depends upon the method of harvest, the condition of the cotton and field, and the skill of the operator. Table 3 shows the quantity and composition of trash per bale for three methods of harvest.

Points of emission are shown in Figure 2. Emission tests have been conducted at the USDA Cotton Ginning Research Laboratories in Stoneville, Mississippi[7] and Mesilla Park, New Mexico[8]. The

TABLE 3

QUANTITY AND COMPOSITION OF TRASH PER BALE OF COTTON LINT

Trash	Harvest Method		
	Machine Picked	Machine Stripped	Machine Scrapped
Hulls	29 lb/bale	397 lb/bale	329 lb/bale
Sticks and Stems	9	50	143
Leaves and Dust	43	78	398
Total	81	525	870
Typical Range	75-164 lb/bale	447-1030 lb/bale	870-1300 lb/bale

results of these tests are shown in Tables 4 and 5. Both of these plants are equipped with small diameter cyclones and lint filters.

Several things are apparent from the two tables:

1) When ginning machine picked cotton with a trash content of 90 lb/bale, the emissions from the high pressure system average only 9.7 percent of the total gin emissions, whereas when ginning machine stripped cotton with trash contents varying from 447 -1,308 lb/bale, the high pressure system emissions account for 36.4 - 65.4 percent of the gin emissions.

2) The total emissions from the high pressure system are dependent upon the trash content of the seed cotton.

3) The unloader fan is the greatest single source of emissions in the high pressure system. This is especially true with ginning machine picked cotton.

Other tests conducted by Baker[(8)] indicated that emissions are not proportional to the ginning rate. Results showed that there was a significant decrease in emissions per bale of cotton from seed cotton cleaning equipment when the ginning rate was increased from 4 to 10 bales/hr. This was attributed to the fact that it was not necessary to increase the air flow rate for conveying the cotton in proportion to the increase in ginning rate.

TABLE 4 [7]

TOTAL EMISSIONS ADJUSTED TO A GINNING RATE
10 BALES PER HOUR (MACHINE PICKED COTTON)

Source	EMISSIONS					
	High*			Average		
	lb/hr	grains/scf	%	lb/hr	grains/scf	%
High Pressure						
Unloading	5.41	0.211	18.1	1.14	0.038	8.4
6 cylinder cleaner and stick machine	0.14	0.002	0.5	0.06	0.001	0.4
6 cylinder cleaner	0.08	0.001	0.3	0.04	<0.001	0.3
Trash fan	0.16	0.002	0.5	0.08	0.001	0.6
Total	5.79		19.4	1.32		9.7
Low Pressure						
3 No. 1 Lint Cleaners	13.92	0.036	46.4	6.98	0.017	51.8
3 No. 2 Lint Cleaners	5.62	0.032	18.7	2.08	0.012	15.4
Battery Lint Cleaner	2.10	0.010	7.0	1.33	0.007	9.8
Lint Cleaner Waste	2.55	0.011	8.5	1.80	0.008	13.3
Total	24.28		80.6	12.19		90.3
Gin Total	30.07		100.0	13.51		100.0

*Highest of 50 tests

NOTE: The trash content of the machine picked cotton was 90-100 lbs/bale.

TABLE 5 (8)

EMISSION RATE FROM A GIN PROCESSING MACHINE
STRIPPED COTTON (ADJUSTED TO 10 BALES PER HOUR)

	EMISSIONS							
	Early Season Harvest		Mid Season Harvest		Late Season Harvest		Extremely Dirty Cotton	
Source	lb/hr	%	lb/hr	%	lb/hr	%	lb/hr	%
Unloading	2.78	18.80	3.44	14.64	2.50	10.87	19.47	38.18
Total Cleaning System	2.75	18.57	4.94	21.00	7.43	32.29	10.81	21.20
Overflow	1.18	8.00	0.23	1.02	0.20	0.86	3.24	6.36
Total Lint Cleaning	8.09	54.63	14.88	63.34	12.88	55.98	17.47	34.26
Total	14.80	100.00	23.5	100.00	23.0	100.00	51.0	100.00
Range	6.6-23.0		14.0-33.1		13.4-32.5		30.3-71.6	
Trash/Bale	447 lbs		550 lbs		501 lbs		1308 lbs	

The studies at the USDA laboratories in Stoneville, Mississippi[7] and Mesilla Park, New Mexico[8] also included particle size analysis. These results are presented in Table 6 and show that the trash from stripper harvested cotton is coarser than that from picker harvested cotton. Both materials are quite coarse, however, and are effectively removed with high efficiency cyclones.

3.1.2 Low Pressure Systems

Emissions from the low pressure system are lint fly and small amounts of trash. This system accounts for about twice as much air as the high pressure system (Section 2.2.10). The emissions from the system comprise between 34 to 90 percent of the total gin emissions (Tables 4 and 5). With machine stripped cotton the range is from 34 to 63 percent with 55 to 63 percent being the common range. This is equivalent to a mass emission rate of 15 to 23 lb/hr at a ginning rate of 10 bales/hr[8].

With machine picked cotton, the low pressure system emissions comprise about 90 percent of the total gin emissions or about 12.2 lb/hr at a ginning rate of 10 bales/hr[7].

3.1.3 Total Gin Emissions

Several references are made to estimating emissions from cotton gins by making a material balance of materials entering the gin (seed cotton) and materials leaving the gin (lint cotton, cotton seed, green bolls, and trash). The difference in these two quantities, after correcting for moisture losses, has been attributed to "emissions plus other losses."

TABLE 6

PARTICLE SIZE DISTRIBUTION OF GIN TRASH

Particle Size (microns)	Percent by Weight		
	Stripper Trash(9)	Picker Trash(9)	Picker Trash(7)
> 3,300	67.5	49.8	
420-3,300	27.2	42.3	
74 - 420	4.5	5.7	
< 74	0.8	2.2	
> 150			96.7
50 - 150			0.5
25 - 50			1.1
10 - 25			1.0
5 - 10			0.3
0 - 5			0.4
Total	100.0	100.0	100.0

Gins have arrived at "emissions plus other losses" of 1.9 to 8.5 percent(10). Probably one of the most reliable studies of this nature was conducted at the USDA laboratory at Stoneville, Mississippi(11). The unaccountable fraction in this study was 3.8 percent or 52 lbs/bale. This is very much out of line with direct measurements of emissions and indicates that this method is not sensitive enough to estimate emissions.

3.1.4 Other Emissions

The gin trash collected by control equipment is conveyed either to a trash house or an incinerator. If the trash house is not sealed well, it can become a source of particulate emissions. Also, when transferring materials from the trash house to a truck for off-site disposal, considerable dust and lint can be released.

The incineration of the trash presents an obvious potential for air pollution. No data have been published on emissions from this source.

On-site composting of gin trash can result in odors or wind-blown trash, if the composting is not properly managed.

Trash disposal is probably the most baffling problem facing gin operators at the present. Methods used for disposal include open burning, incineration, composting, spreading on the land, and cattle feed filler.

Power requirements at cotton gins are provided by electricity, diesel, or diesel driven electric generators. Power requirements at most gins only run between 300 - 600 horsepower, therefore, power generation is an insignificant source of emissions.

3.1.5 Ambient Air Quality

Several ambient air quality studies have been conducted in the vicinity of cotton gins to assess the impact of this industry on adjacent communities[12,13,14,15]. Three of the studies were conducted by the Texas State Health Department[12,13,14].

One of the Texas studies[12] found suspended particulate concentrations 300 ft. downwind from a gin to be 227,000 $\mu g/m^3$. The calculated emission rate from the gin was 575 lb/hr. Other results from the Texas studies showed downwind concentrations of suspended particulates to range from 76,000 $\mu g/m^3$ at a distance of 150 ft. from a gin to 42 $\mu g/m^3$ 8,000 ft. from a gin. The average concentration at a distance of 100-200 ft. from the gin was 25,000 $\mu g/m^3$. At a distance of 1,200 ft. concentrations ranged from 350 - 2,100 $\mu g/m^3$ It was estimated that 93 - 99 percent of the emitted particulates fall out on the gin property[12]

The benzene soluble fraction of the suspended particulates ranged from 0.5 - 3.6 percent[12]

Dustfall rates ranged from 18.7 - 77.4 tons/mi^2/30 days, depending upon the distance from the gin[12]

Studies conducted in Mississippi[15] showed concentrations of suspended particulates to range from 3,352 to 287 $\mu g/m^3$, depending upon the distance from the gin and the wind speed. Concentrations

80 - 100 ft. from the gin ranged from 3,352 - 1638 $\mu g/m^3$, with wind speeds up to 9 mph. With wind speeds of 9 - 14 mph, concentrations of 1,062 $\mu g/m^3$ were recorded 600 ft. from the gin.

In the Texas studies, arsenic concentrations ranged from 0.01 to 141 $\mu g/m^3$ downwind from gins. These concentrations were found 150 - 300 ft. from gins. The source of arsenic is the incineration of gin trash. Arsenic is used in the fields to defoliate the cotton plants before harvest. Damage to garden crops and peach and pecan trees was attributed to arsenic[13]

Upwind bacteria and fungi counts in samples taken during the Texas studies were 88 to 100 and 33 to 70 per cubic meter of air, respectively, when collected on nutrient agar. The counts in samples taken downwind ranged from 172 to 1,752 and 19 to 129 per cubic meter of air, respectively.

Blood agar bacteria and fungi counts in samples taken upwind were 82 to 87, and 24 to 26 per cubic meter of air, respectively; bacteria and fungi counts in samples taken downwind were 248 to 285, and 22 to 57 cubic meter of air, respectively. Two samples of Aerobacter aerogenes taken upwind, were negative while two taken downwind were positive.

4.0 CONTROL TECHNOLOGY

Emission control methods used in the cotton ginning industry almost entirely involve add-on cyclones or filters. Therefore, control of emissions from existing gins would not be impractical. It would involve, at most, additional duct work, the control equipment, and perhaps increased fan sizes.

Control methods presently used include:

1) Settling chambers,
2) Cyclones (large and small diameter),
3) Scrubbers,
4) Baghouses,
5) Filters, and
6) Screen wire lint cages.

4.1 Description of Equipment

4.1.1 Settling Chambers

Settling chambers have been used with varying degrees of success, but are not recommended for new gins because of several inherent disadvantages. First, the chambers must be built large enough to provide a quiescent zone at the discharge with a discharge velocity of less than 75 fpm. With the new high capacity gins the space requirements for such a structure become prohibitive. Also, the screened walls must be brushed daily to remove lint so the back-pressure does not become too great, settling chambers are a fire hazard, they are not effective for dust removal, and they must be kept dry.

4.1.2 Cyclones

4.1.2.1 Large Diameter Cyclones

Large diameter cyclones were used for controlling emissions from the high pressure system of cotton gins for quite some time. They have been largely replaced by the more efficient small diameter cyclone. Large diameter cyclones are not recommended for new gins.

4.1.2.2 Small Diameter Cyclones

The small diameter cyclone or the AEC cyclone as it is commonly refered to is used almost exclusively for controlling emissions from the high pressure system of cotton gins. The cyclone was developed by the Atomic Energy Commission and adapted to cotton gins. Dimensions and design criteria for this cyclone are included in several references[16][17]

Tests conducted by the USDA[9][18] have shown this cyclone to be 99+ percent effective for removing particulate matter from the high pressure system air stream.

Multiple cyclone units are used with larger gas flow volumes (>6,000 cfm) so the diameter of the cyclones can be kept below four feet. The pressure drop across these cyclones is 4 - 5 inches of water.

4.1.3 Scrubbers

The few scrubbers that have been used in the ginning industry consist either of a spray chamber or water injuection prior to a cyclone. They appear to serve no effective purpose.

4.1.4 Baghouses

A baghouse was installed at the Valley Gin Company in Peoria, Arizona. The unit was effective for trash removal and for removal of lint fly from the low pressure system. The capital cost of the installation and maintenance costs are high. Captial costs are $1.75 per cubic foot per minute of air[19].

The baghouse is one possible method of controlling lint fly emissions from the low pressure system on new gins.

4.1.5 Filters

Various types of filters have been used to control the emissions of lint fly from the low pressure system of a gin.

4.1.5.1 In-line Filter

The in-line filter was developed at the USDA laboratory in Mesilla Park, New Mexico, and has been fairly effective for removing trash and lint fly.

The filter is simply a wire screen set in an enlarged section of an air line. The screen is usually stainless steel and has a mesh of between 40 x 40 and 105 x 105. The 40 x 40 mesh screen is effective for machine stripped cotton and the 105 x 105 mesh screen is effective for machine picked cotton[20]. The design face velocity at the screen is 1000 fpm.

The filters are equipped with wipers which are set to operate when the pressure differential builds to about 0.75 - 1.25 inches of water across the filter. Immediately after a wipe, the efficiency of the filters is reduced since most of the filter action is a result of the mat of lint and trash formed on the screen.

Tests have shown a filter with 105 x 105 mesh screen will remove 99 percent of all particles larger than 165 microns and 70 percent of particles smaller than 165 microns. The overall efficiency of the filter was 87 percent. A filter with a 70 x 70 mesh provided about the same efficiency, but emissions immediately after the screen was wiped were greater.

These filters have reportedly clogged when used in high humidity locations(3).

Design details for these units are given in USDA publication ARS 42-103. The cost of a commercial in-line filter is in the range $1,000 - $1,200.

4.1.5.2 Condenser Drum Screens

As an alternative to the in-line filter, the USDA laboratory at Stoneville, Mississippi has covered the condenser drum with stainless steel wire mesh(22) The standard condenser drum has a covering of perforated metal with 0.109 inch holes. The Stoneville laboratory has tried coverings with perforations ranging from 0.020 in. to 0.075 in. and has also covered the standard drum with 100 x 100 mesh screen. The following emission rates were measured:

Standard Drum Cover	(0.109 in. holes)	-	0.051 grains/SCF
Perforated Metal	(0.075 in. holes)	-	0.046 grains/SCF
Perforated Metal	(0.033 in. holes)	-	0.032 grains/SCF
Perforated Metal	(0.020 in. holes)	-	0.027 grains/SCF
100 x 100 mesh screen over std. drum		-	0.022 grains/SCF

This approach to emission control does increase the amount of short fibers in the lint cotton slightly. It is inexpensive and is not affected by high humidity, however.

4.1.5.3 Other Filters

The USDA Stoneville laboratory has worked on a lint filter for a battery lint cleaner which consists of a box about 8'x 8'x 8' lined with a foam filter. The air discharges through all sides of the box into the gin building. The unit is effective, but the pressure drop builds up relatively rapidly and no means of cleaning the unit during operation have been devised as of yet.

4.1.6 Lint Cages

The lint cage is a cage of 14, 16, or 18 mesh wire screen which is placed over the exhaust of the low pressure system. These units have been replaced with the in-line filter or the condenser drum filter.

4.1.7 New Systems

4.1.7.1 Small Diameter Trash Systems

A small-diameter-pipe trash system is described in USDA publication 42-59. This system employs a pressure blower to transport trash through a small diameter pipe rather than using a centrifugal and a large diameter pipe. This can reduce the volume of air which must be cleaned before discharge from 5,000 CFM to 600 CFM.

4.1.7.2 Monosystem

Perhaps the most promising system is the Monoflow ginning system developed at the USDA Mesilla Park laboratory. This system

Monoflow System

has only one fan exhausting into the atmosphere where conventional gins now have as many as five or six. In the Monoflow system, the seed cotton-conveying air is drawn into the system at the unloading telescope and follows the cotton through the entire drying, conditioning, and cleaning process. The air is cleaned by means of small-diameter cyclones and in-line filters, reused, and finally cleaned before discharging into the outside atmosphere.

The lint-conveying air from gin stands, lint cleaners, and condensers is also cleaned, washed, and returned to the inside of the gin house. With this sytem, dust and fly inside the building are practically eliminated, and only clean air is discharged to the outside.

4.2 Emission Control System

The wastes collected by all of the cyclones and lint filters are transported pneumatically to an incinerator or trash hopper. Figure 13 shows a typical installation.

4.3 Cost of Control Systems

Costs developed in 1967 for a control system for a complete gin are presented in Table 7[23]. Costs estimated by the Delta Council of Mississippi[4] for a gin collection system are $15,000 for a 6 bale/hr gin, and $25,500 for a 20 bale/hr gin.

TABLE 7

ESTIMATED COST OF TRASH-COLLECTING SYSTEM
FOR 12-BALE/HR GIN(23)

Three in-line filter traps-to specifications (condenser filters may be substituted for price of $1,200.00)	$ 4,125.00
Six sets twin cyclones-to specifications	1,966.00
One set quad cyclones-to specifications	639.00
One suction manifold for three lint traps	395.00
Cyclone stand for bank of cyclones on ground. Conveyor, drives, motor, blowbox, tail pipes, etc.	2,674.00
Delivery and erection-trash collection system	2,600.00
Total cost trash-collecting and trash-incinerating system	$12,399.00*

*Cost does not include trash hopper or trash incinerator.

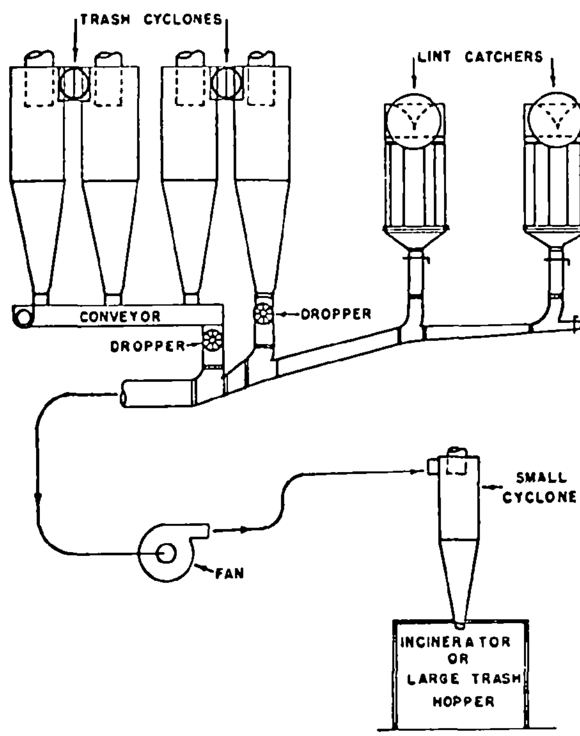


FIGURE 13 —Gin trash collection and disposal system.

5.0 COTTON GINS UTILIZING THE BEST TECHNOLOGY

The gins utilizing the best control technology are probably the USDA cotton gins at the Ginning Research Laboratories in Stoneville, Mississippi, and Mesilla Park, New Mexico. These gins are not typical in that they were developed for research, but they are functional. It has been at these laboratories where most of the emission control equipment has been developed, also. These gins employ small diameter cyclones on the entire high pressure system and in-line or condenser filters on the low pressure system.

The largest gin in the U.S. was recently built for the J. G. Boswell Company of Corcoran, California. This gin is completely automated and has a capacity of 40 bales/hr or 30 - 35,000 bales/season. The gin is equipped with cyclones and in-line filters.

The Valley Gin Company of Peoria, Arizona has cyclones and bag filters on one of their gins. The Community Gin Company of Phoenix, Arizona utilizes cyclones with water injection.

It appears that the most effective control methods now used are the small diameter cyclone and the in-line or condenser drum filter. The Monoflow system developed at the USDA Mesilla Park laboratory promises to be the best overall control system.

6.0 SPECIFIC REGULATIONS CURRENTLY PERTAINING TO THE COTTON INDUSTRY

At present the only regulation specifically pertaining to the cotton gin industry is a section in the Texas regulations[24] prohibiting the burning of wastes from cotton gin operations. General regulations are applicable to the various emissions from this industry. Incineration is one method of disposing of gin wastes, but since operation and regulation of incinerators have been covered elsewhere they are omitted here.

6.1 Particulate Matter

Particulate matter emissions are regulated in Arizona by a process weight table (Table 8), which limits the emission rate in pounds per hour according to the weight of the material being processed in pounds per hour. Although this table is not as restrictive as that of the State of Maryland, there are currently no cotton gins in Maryland.

Particulate matter emissions may result from the handling of materials. These emissions are subject to general regulations which require "reasonable" control efforts. The degree to which these general regulations are enforced would thus determine their strigency. An example of the control measures which may be required is shown in Arizona Regulations:

> 1. No person shall cause or permit the handling or transporting or storage of any material in a manner which allows or may allow controlable particulate matter to become airborne.
>
> 2. No person shall cause or permit a building or its appurtenances, or a road, or a driveway or an open area to

TABLE 8

ARIZONA STATE DEPARTMENT OF HEALTH

PROCESS WEIGHT RATE lbs.hr	tons/hr	Rate of Emission lb/hr	lbs/hr	tons/hr	Rate of Emission lb/hr
100.....	0.05.....	0.551	16,000.....	8.00.....	16.500
200.....	0.10.....	0.877	18,000.....	9.00.....	17.900
400.....	0.20.....	1.400	20,000.....	10.00.....	19.200
600.....	0.30.....	1.830	30,000.....	15.00.....	25.200
800.....	0.40.....	2.220	40,000.....	20.00.....	30.500
1,000.....	0.50.....	2.580	50,000.....	25.00.....	35.400
1,500.....	0.75.....	3.380	60,000.....	30.00.....	40.000
2,000.....	1.00.....	4.100	70,000.....	35.00.....	41,300
2,500.....	1.25.....	4.760	80,000.....	40.00.....	42.500
3,000.....	1.50.....	5.380	90,000.....	45.00.....	43.600
3,500.....	1.75.....	5.960	100,000.....	50.00.....	44.600
4,000.....	2.00.....	6.520	120,000.....	60.00.....	46.300
5,000.....	2.50.....	7.580	140,000.....	70.00.....	47.800
6,000.....	3.00.....	8.560	160,000.....	80.00.....	49.000
7,000.....	3.50.....	9.490	200,000.....	100.00.....	51.200
8,000.....	4.00.....	10.400	1,000,000.....	500.00.....	69.000
9,000.....	4.50.....	11.200	2,000,000.....	1,000.00.....	77.600
10,000.....	5.00.....	12.000	6,000,000.....	3,000.00.....	92.700

be constructed, used, repaired or demolished without applying all such reasonable measures as may be required to prevent particulate matter from becoming airborne, including but not limited to, paving or frequent cleaning of roads, driveways and parking lots; application of dust free surfaces; application of water; and the planting and maintenance of vegetative ground cover.

3. If reasonable measures are not taken to prevent particulate matter from becoming airborne, the Air Pollution Control Authority shall notify the owner, lessee, occupant, operator, or user, of said land that said situation is to be corrected within a specified period of time, dependent upon the scope and extent of the problem.

Potential particulate emissions from burning of wastes is eliminated in Texas bv a prohibition against such burning.

6.2 Odors

Of lesser concern in this industry is the problem of odors from composting gin wastes. Odors are regulated by a general nuisance clause in Texas. Several agencies outside the cotton gin belt have quantitative odor regulations involving dillution with odor free air. There are also guidelines in some regulations which may be used to determine if a nuisance exists such as the percent of time an odor exists.

8.0 PRODUCTION AND GROWTH OF THE COTTON GINNING INDUSTRY

The production and growth of the cotton ginning industry is covered in Section 1.0 of this report.

In summary, the cotton production in the U.S. has remained quite steady for the past 70 years. During the last 20 years the textile market in this country has increased considerably, but the increased market has been captured by the synthetic fiber industry. The cotton percentage of the total fiber market has decreased steadily during this period.

In the past two years the cotton percentage of the fiber market has leveled out and even increased slightly. Because of this and the expected continual growth in the fiber market, it is estimated that U.S. cotton production will remain at 9 - 14 million bales annually through the next 10 years. This is within current annual production fluctuations and can be handled with present gins.

The capacity of individual cotton gins has increased considerably. It is presently estimated that a gin must process 4,000 - 10,000 bales annually to be profitable, depending upon the size of the gin.

Currently, the ginning rate of gins varies from 5 - 20 bales/hr with an average of around 10 - 12 bales/hr. New gins are being constructed to gin 20 - 35 bales/hr. The largest gin in the U.S. has a capacity of 40 bales/hr.

Although the total industry probably will not show much growth in the near future, there is a steady move to replace smaller gins with much larger and more effective gins. This means the total number of gins in the U.S. will continue to decrease.

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23. Pendleton, A.M., in Control and Disposal of Cotton Ginning Wastes, Public Health Service Publication No. 999-AP-31, page 42.

24. Texas Air Control Board, Regulation I

9.2 Associations

9.2.1 Cotton

* National Cotton Council of America, Memphis, Tennessee

* Cotton, Incorporated (formerly Cotton Producers Institute).

9.2.2 Cotton Ginning

* National Cotton Ginners Association
  Box 128
  Maypearl, Texas
  Perry Willmon, Secretary/Treasurer

* Texas Ginners Association
  3724 Race Street
  Dallas, Texas

* Southeastern Cotton Ginners Association
  Box 866
  Daklonega, Georgia

* Carolina Ginners Association
  Box 512
  Bennetsville, S. C.

9.3 Manufacturers

* Continental, Moss, Gordon Gin Company
  Pratville, Alabama

* Lumus Gin Company
  Columbus, Georgia

* Hardwick-Etter Company
  Sherman, Texas

9.4 Government Agencies

* USDA Cotton Ginning Research Laboratories
  Stoneville, Mississippi - Vernon Moore
  Mesilla Park, New Mexico - V. L. Stedronsky
  Lubback, Texas - Roy Baker
  Clemson, South Carolina

* USDA, Cotton Division, Consumer and Marketing Service,
  Memphis, Tennessee

* U.S. Department of Commerce, Bureau of Census