ERS 154

INCREASING THE EFFICIENCY OF POWER USED FOR MATERIALS HANDLING IN SOUTHWESTERN COTTON GINS

U.S. DEPARTMENT OF AGRICULTURE Economic Research Service Agricultural Research Service

PREFACE

This is one of a group of reports to be issued on engineering and economic aspects of cotton ginning research now being conducted jointly by the Economic Research Service and the Agricultural Research Service of the U.S. Department of Agriculture. Wide variations and general excesses in power usage revealed in this study, particularly in the materials handling functions of ginning, suggest the need for some simple guides by which individual ginners can more easily and accurately select proper fan sizes, piping, and related equipment. Such information would be of particular value to those contemplating the erection of new gins or the modification of older ones. It is hoped that developments along this line may soon be forthcoming as a result of this concerted effort in ginning research.

The authors wish to thank their colleagues for assistance in planning this particular study and in reviewing the manuscript. Appreciation is extended to the personnel of the respective gin and power companies who gave so generously of their time and energies during the actual collection of data. Special thanks are due the Lummus Cotton Gin Company for authorizing the use of data concerning their centrifugal fans.

CONTENTS

Washington, D. C. March 1964

SUMMARY AND CONCLUSIONS

Over the past two decades, connected horsepower (the sum of rated horsepower of all electric equipment used in a plant) in gins has shown a three- to fourfold increase while per bale power costs have about doubled. Substantial savings in operating costs could be realized in most cotton ginning operations by peaking the efficiency of individual air systems used for materials handling and by rearranging gin machinery so as to eliminate unnecessary fans, motors, and piping. For example, a few relatively simple changes in the plant layout of one specific gin, fairly typical in size and arrangement of many gin plants throughout the Cotton Belt, would have netted savings equivalent to about one-fourth of the total gin operating costs of power in West Texas, more than one-third in California, and approximately one-half in New Mexico. These estimates were based on average cost figures derived from a study of 30 ginning installations in these 3 areas.

The specific objectives of this study were to (1) determine power requirements and costs incurred for individual materials handling functions, (2) analyze various trash disposal systems for causes of wide differences in power requirements and costs for materials handling among gins of comparable size and capacity, and (3) analyze possibilities for more efficient utlization of gin power by modifying current materials handling systems and gin layouts, and by adopting new engineering developments and principles.

Gins to be studied were chosen by make, size, and geographic area. In the San Joaquin Valley of California, 11 gin plants were selected; in the Mesilla Valley of New Mexico, 7; and in the Texas High Plains, 12. The information collected at each gin included total connected horsepower, complete air fan descriptions, power readings on all fans, a complete description of each trash conveying system, including piping and collectors, and a detailed sketch of the plant layout. These data and related information on costs and ginnings were collected during the 1961-62 season.

Total connected horsepower averaged 392 for New Mexico gins, 646 for West Texas gins, and 677 for California gins. Energy consumption per bale for ginning averaged 42.38 kilowatt-hours at a cost of $0.81 for New Mexico, 54.31 kilowatt-hours at $1.41 for West Texas, and 47.68 kilowatt-hours at $0.89 for California. Not only did West Texas gins, on an average, consume more energy per bale, but electrical rate schedules were generally less favorable to cotton gins compared with the other two areas studied.

Operating loads in horsepower hours for all air fans used in materials handling ranged from an average of 147 in New Mexico to 305 in California. Total energy consumption per bale for these fans averaged 25.47 kilowatt-hours at a cost of $0.47 in California, 28.91 kilowatt-hours at a cost of $0.75 in West Texas, and 19.89 kilowatt-hours at a cost of $0.38 in New Mexico.

In each of the areas studied, the three functions of (1) unloading, (2) moving seed cotton from the first separator to the gin stands, and (3) trash disposal accounted for approximately four-fifths of the total fan operating load.

The number of air fans per gin averaged 10.3 for New Mexico, 15.7 for West Texas, and 16.1 for California. Fan power requirements, as a proportion of the total gin operating load, ranged from an average of 47 percent in New Mexico to 53 percent in California and West Texas.

There was no indication of any interrelationship between gin make and number of fans used. However, gin size and number of fans were directly related, the largest plants having the most fans, on an average.

The number of trash fans per gin averaged 5.7 in California, 5.0 in West Texas, and 2.8 in New Mexico but varied widely among gins within each area. Energy consumed in trash handling showed the widest range in New Mexico, varying from 1.24 kilowatt-hours at a cost of $0.02 per bale to 17.00 kilowatt-hours at a cost of $0.31 per bale.

In addition to the benefits generally available from modifying existing equipment so as to incorporate operating economies, further savings in power costs are potentially available through the adoption of a newly developed pneumatic trash conveying system that uses a positive displacement rotary air pump, small diameter piping, vacuum wheel droppers, and medium air pressures.

INCREASING THE EFFICIENCY OF POWER USED FOR MATERIALS HANDLING IN SOUTHWESTERN COTTON GINS 1/

by

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PROBLEM AND OBJECTIVES

Cotton ginning has evolved from a very simple hand operation to one involving the use of a maze of complicated machinery and a per plant investment averaging hundreds of thousands of dollars. This transition has been accompanied by an increase in rate of output from about 5 pounds of lint per day for one or two men using the first known mechanical device, the "churcka," to more than 100 bales during an 8-hour shift in a modern, high-capacity gin plant with a crew of six or seven men.

Although the industry has made tremendous advancements, progress in the development and adoption of new technologies in ginning has been hampered by economic problems. During recent years, gin operating costs have spiraled continually upward while charges to the producer for ginning services have been held to a more conservative rate of increase by forces of competition.

This cost-price squeeze has caused ginners to devote increasing attention to ways and means of improving operating efficiencies and reducing ginning costs.

Gin operators are confronted with two types of costs--fixed and variable. Fixed costs, as the term implies, are relatively "sticky" and difficult to alter in the short run. They consist of depreciation, interest on investment, taxes, and insurance. Variable costs differ from fixed costs in that they are dependent on total output and general operating techniques. Power, labor, repairs, and maintenance are the major variable expense items. Of these, power and labor are two over which gin operators can exert the most direct control and, hence, derive the greatest immediate benefits from the introduction of operating efficiencies.

Power requirements in ginning can be divided into two major end uses--for processing, such as cleaning, ginning, and pressing operations; and for materials

1/ General use of the term "efficiency" throughout this report is in an economic sense which implies total inputs and outputs of a process or operation as compared to technical efficiency which may concern only one operational aspect. For example, an engine or machine might be very efficient from an engineering standpoint (favorable ratio of energy output to energy input) but practically useless economically because of its initial cost, size, maintenance, and labor requirements, or other reasons. All references to technical efficiency will be so specified.

2/ Agricultural Economist, Economic Research Service; and Agricultural Engineer, Agricultural Research Service, respectively.

handling, such as unloading and conveying seed cotton, and moving lint, cottonseed, and trash through and away from the gin plant. Pneumatic air systems, used almost exclusively for materials handling in gin plants, are encumbered with inefficiencies both inherent and manmade. Centrifugal air fans have a technical efficiency of only about 50 percent, and there are wide variations in numbers and sizes of fans, the diameters and lengths of piping, and numbers and shapes of elbows performing similar operations among gins otherwise quite comparable in size, layout, and capacity.

Because of the prevalence of these inefficiencies, this study was initiated in the fall of 1961 to determine actual power requirements and costs for materials handling in cotton gins and how they might be reduced. 3/ The specific objectives of this study were to (1) determine power requirements and costs incurred for individual materials handling functions, (2) analyze various trash disposal systems for causes of wide differences in power requirements and costs for materials handling among gins of comparable size and capacity, and (3) analyze possibilities for more efficient utilization of gin power by modifying current materials handling systems and gin layouts, and by adopting new engineering developments and principles.

METHODOLOGY

Detailed data on power requirements and costs for materials handling functions, and on layouts, specifications, and designs of various trash disposal systems, were obtained from a total of 30 gins. Eleven of these gins were located in the San Joaquin Valley of California; 7, in the Mesilla Valley of New Mexico; and 12, in the High Plains area of West Texas. Gins in these three areas were selected because of unique production and harvesting characteristics peculiar to each which directly affect power requirements and costs of ginning.

Production in the San Joaquin Valley skyrocketed from less than 1,500 bales in 1922 to an average of about 1-1/2 million bales for the past 5 years (6). 4/ The rate of adoption of mechanical harvesting in California has followed the production trend at a similar pace. From 1949 to 1961, mechanically harvested cotton increased from 13 to 93 percent of the total harvest (7). These developments have been accompanied by an equally aggressive gin construction and operating program. Consequently, modern gin plants and the use of the latest ginning techniques prevail throughout the San Joaquin Valley.

The cotton industry in the Texas High Plains has also developed at a rapid rate. Production climbed from about 100,000 bales in 1922 to just over 2 million bales in 1962 (6). Harvesting in this area--also almost completely mechanized--is accomplished primarily by stripping, rather than by picking. By this method of harvesting an extremely high percentage of foreign matter is collected, which has to be removed in the ginning process (2).

3/ Companion studies of power requirements and costs for gin processing and the costs and efficiency of gin labor utilization are also being conducted, and findings from these will be reported as soon as they are available. Detailed information on power requirements and costs of one specific operation under gin processing has already been released in a comprehensive report on lint cleaning: Looney, Z. M., LaPlue, L. D., Wilmot, C. A., Chapman, W. E., Jr., and Newton, F. E. Multiple Lint Cleaning at Cotton Gins, Mktg. Res. Rpt. No. 601, Econ. Res. Serv., Agr. Res. Serv., Agr. Mktg. Serv., May 1963.

4/ Numbers in parentheses and underlined refer to items in Literature Cited, p. 18.

In contrast to the growth rates in California and West Texas, the industry in the Mesilla Valley of New Mexico has changed at a much slower pace during the last few years. For example, as late as the 1957-58 season, about 81 percent of the New Mexico crop was still hand harvested (7). Thus, there has been little pressure on ginners in this area to modernize their plants. There is still a predominance of older 4- and 5-stand gins with 80 or 90 standard 12-inch saws per stand. Many of these plants have only one stage of drying, a minimum of overhead cleaning, and one or possibly two stages of lint cleaning.

Gin size and make, in addition to area, were also key factors in selecting the gins to be studied. Gin size groups were arbitrarily determined as follows: small--gins having up to 400 gin saws; medium--400 to 480 gin saws; and large--480 or more gin saws. Gin selection was confined to the standard 12-inch diameter saw size. 5/

The study was designed to include at least one plant of each make in each size group for each area. However, not all sizes or makes were available in some areas. A majority of New Mexico gins were of small or medium size, while those in California and West Texas were either medium or large. A summary of the gins studied, by area and size, follows:

Location	Small	Medium	Large	Total
California	1	5	5	11
New Mexico	3	3	1	7
West Texas	2	4	6	12
	6	12	12	30

At each gin the following information was collected for the purposes indicated:

Information collected	To determine--
1. Rated hp.--each motor.	Total connected load, and adequacy of size for purpose used.
2. Complete air fan description--type, size, model, speed.	Adequacy for function being performed, and efficiency and safety of fan operation.
3. Complete power readings on all fans--voltmeter, ammeter, wattmeter, and Pitot tube with manometer.	Actual energy consumption by each fan.
4. Complete description of each trash conveying system--length and diameter of piping, number and shape of elbows, points of trash pickup, and type of collectors at discharge end of pipe.	Economic feasibility of modifying or replacing any or all air systems.

5/ One major gin manufacturer has achieved approximately comparable capacity, using fewer standard 12-inch gin saws by incorporating a new engineering principle in the feed roll mechanism. Gin size determination for gins of this make were based on comparative performance with other makes, under actual field conditions, rather than on number of saws.

5. Sketches of plant layout--machinery sequence, cotton flow with alternatives provided by bypasses, etc.	Potential for increasing engineering and economic efficiencies in individual operations.

Physical power data for the California and West Texas gins were collected during the fall of 1961, at the beginning of the ginning season; those for New Mexico were gathered in the spring of 1962, at the close of the season. In addition to actual readings made on machinery and equipment at individual gin plants, information was collected from ginners or electric companies in each area at the close of the season on total ginnings, cost of electricity, and related items.

POWER REQUIREMENTS AND COSTS OF GINNING

The power requirements and costs for the total ginning operation were determined for the 30 gins in this study to provide a basis for analyzing and evaluating the power requirements and costs for the various materials handling functions.

Total Ginning Operation

In recent years, total connected horsepower per gin increased sharply in the three areas included in this study. In 1945-46, the average total connected load ranged from approximately 140 hp. for New Mexico gins to 185 hp. for California gins (table 1). During the 1961-62 season, the average total connected load for the studied gins ranged from 392 hp. to 677 hp. in the same two respective States.

This marked increase in connected horsepower can be attributed mainly to extra demands imposed on the industry by mechanical harvesting. The general trend toward machine harvesting has created a complex ginning problem. Gins must have adequate capacity to accommodate the greatly shortened harvest season, and they must be equipped to properly gin seed cotton harvested under an extreme range of conditions. This has meant incorporation of more and larger overhead and conditioning equipment, addition of one to three stages of lint cleaning, and use of more and larger centrifugal air fans.

During the period when average connected hp. for the three areas studied increased three- to fourfold, as shown above, power costs per unit of production, with the exception of West Texas, almost doubled. In California, these costs per bale advanced from \$0.46 to \$0.89; in New Mexico, from \$0.43 to \$0.81; and in West Texas, from \$0.59 to \$1.41. Energy consumption in kilowatt hours per bale, while not available for the 1945-46 period, averaged 47.68, 42.38, and 54.31 for California, New Mexico, and West Texas, respectively, during the 1961-62 season. Two factors primarily responsible for this relatively smaller rise in power costs per unit of production are: (1) an increase in average ginning volumes and (2) graduated electrical rate schedules usually favoring heavier power consumers. 6/

6/ Electrical rate schedules in West Texas appeared to be generally less favorable to cotton gins, which accounted mainly for their higher power costs, than for gins in the other two areas.

Table 1.--Connected load, volume ginned, energy consumed, and estimated power cost for ginning, averages for 30 cotton gins in California, West Texas, and New Mexico, 1945-46 and 1961-62 seasons

Year and geographic area	Cotton gins 1/	Connected load 2/	Volume ginned 1/	Energy consumed, per bale	Estimated power cost per bale 3/
	Number	Hp.	Bales	Kw.-hrs.	Dollars
1945-46					
California	94	185	3,753	n.a.	0.46
West Texas	191	159	638	n.a.	.59
New Mexico	13	140	4,526	n.a.	.43
1961-62 4/					
California	11	677	5,124	47.68	.89
West Texas	12	646	6,138	54.31	1.41
New Mexico	7	392	4,478	42.38	.81

1/ Data for 1945-46 season includes all active gins, U.S. Bureau of Census.

2/ Data for 1945-46 season taken from U.S. Bureau of Census. Cotton Ginning, Machinery and Equipment in the United States, 1945. Washington, D.C., 1946.

3/ Power cost data were not available for the 1945-46 season, hence estimates for the San Joaquin Valley and the Texas High Plains were based on studies made in these two areas during the following ginning season and for the Mesilla Valley on a study of the Rio Grande and Pecos Valleys in 1949 and 1950. The respective studies were (1) Looney, Z. M., and Franklin, W. E., Jr. Costs and Quality of Ginning Services in California, Season 1946-47. U.S. Dept. of Agr., Prod. Mktg. Admin., Washington, D.C., Oct. 1948; (2) Looney, Z. M., Montgomery, R. A., and Franklin, W. E., Jr. Evaluation of Cotton Ginning Costs and Quality, High Plains Area of Texas, 1946 through 1948. U.S. Dept. of Agr., Prod. Mktg. Admin., Washington, D.C., July 1959; (3) Fortenberry, W. H., and Looney, Z. M. Cotton Ginning Efficiency and Costs in the Rio Grande and Pecos Valleys, Seasons of 1949-50 and 1950-51. U.S. Dept. of Agr., Prod. Mktg. Admin., Washington, D.C., Oct. 1952.

4/ All Data for 1961-62 ginning season were based on a study of 30 gins located in the San Joaquin Valley, the Texas High Plains, and the Mesilla Valley of New Mexico.

Power for Materials Handling

Power utilized in cotton gins for materials handling can be subdivided into five major functions: (1) unloading seed cotton, (2) moving seed cotton to and through conditioning and cleaning machinery from the first separator up to the actual ginning point, (3) moving lint from stands to press box, (4) moving cottonseed to seed house or pile, and (5) disposing of trash. Many different types of mechanical devices are available for conveying both raw materials and finished products from one point to another within an industrial plant. Endless belts, carriers, chutes, augers, elevators, and pneumatic systems are examples of continuous conveyors employed in handling such items as grain, flour, cement, and fine coal (3).

The unloading of seed cotton and movement of lint from gin stands to press box is done exclusively by air. The movement of seed cotton to and through the various stages of conditioning and cleaning, once it has been lifted to the top of the gin, is usually accomplished by a combination of air, mechanical propulsion, and gravity.

Trash disposal, likewise, may be accomplished by any one or all of these means in a single gin plant. Cottonseed is normally conveyed, either by forced air or by mechanical augers, to the seed house outside the gin building.

Although air is the major means for materials handling in ginning, pneumatic conveying systems, in most gins, are very inefficient to operate, both technically and economically. These systems are favored, however, because of their lower initial cost, mechanical simplicity, ease of maintenance, and general flexibility.

The connected horsepower load in a cotton gin normally exceeds the actual operating load by a margin sufficient to safely provide for temporary overloading of the motors involved. In the case of fans, total operating loads averaged 84, 76, and 80 percent of connected loads in the respective ginning areas of California, West Texas, and New Mexico (table 2). In horsepower-hours these fan-operating loads ranged from an average of 147 in New Mexico to 305 in California. 7/ Total energy consumption per bale for all gin fan operations averaged 25.47 kw.-hrs. at a cost of $0.47 in California, 28.91 kw.-hrs. at a cost of $0.75 in West Texas, and 19.89 kw.-hrs. at a cost of $0.38 in New Mexico.

In each of the three areas, (1) unloading and (2) moving seed cotton from the first separator to and through the various stages of cleaning and conditioning up to the actual ginning point accounted for approximately 55 percent of the total fan operating load. Combined, these two materials handling functions required 165 hp.-hrs. and 13.78 kw.-hrs. per bale in California, 144 hp.-hrs. and 15.93 kw.-hrs. per bale in West Texas, and 81 hp.-hrs. and 11.02 kw.-hrs. per bale in New Mexico.

Trash disposal was the next most important materials handling function from a power consumption and cost standpoint, accounting for approximately 26 percent of the fan operating loads in all three areas. In California, trash removal required 80 hp.-hrs. and 6.68 kw.-hrs. per bale; in West Texas, 66 hp.-hrs. and 7.20 kw.-hrs. per bale; and in New Mexico, 38 hp.-hrs. and 5.09 kw.-hrs. per bale.

Trash disposal is a major problem to most ginners throughout the Cotton Belt. Not only is it the second most costly materials handling function, but thus far no completely satisfactory method has been devised to control the tremendous volumes of dirt and dust that trash disposal systems are called upon to handle. The general adoption of the small-diameter, high efficiency cyclone in connection with gin trash disposal did much to alleviate the dust collection problem, but the extremely high volumes of air under which some systems operate tend to limit the effectiveness of trash collectors. Consequently, air pollution from ginning continues to plague the industry (5).

7/ The term "horsepower-hour" is defined as the energy consumed by working at the rate of one horsepower for one hour. This unit of measurement is referred to hereafter by the abbreviation hp.-hr. Likewise, the term "kilowatt-hour," the unit of energy equal to that done by one kilowatt acting for one hour, is also referred to herein by its abbreviation kw.-hr.

Table 2.--Operating loads and energy costs for fans, averages for 30 cotton gins, by specific materials handling operations, California, West Texas, and New Mexico, 1961-62 season 1/

Geographic area and operation	Fan operating load: Per operation		Fan operating load: As percentage of connected fan load	Energy consumed by fans, per bale: Per operation	Energy consumed by fans, per bale: Cost
	Hp.-hrs.	Pct.	Pct.	Kw.-hrs.	Dol.
California					
Unloading seed cotton	45	15	85	3.76	0.07
Moving seed cotton--first separator to stands	120	39	84	10.02	.19
Moving lint--stands to press	53	18	84	4.43	.08
Moving cottonseed--stands to seed house	7	2	88	.58	.01
Trash disposal	80	26	84	6.68	.12
Total	305	100	84	25.47	.47
West Texas					
Unloading seed cotton	43	16	74	4.63	.12
Moving seed cotton--first separator to stands	101	39	78	11.30	.29
Moving lint--stands to press	47	18	76	5.20	.13
Moving cottonseed--stands to seed house	6	2	75	.58	.02
Trash disposal	66	25	77	7.20	.19
Total	263	100	76	28.91	.75
New Mexico					
Unloading seed cotton	28	19	80	3.92	.07
Moving seed cotton--first separator to stands	53	36	80	7.10	.13
Moving lint--stands to press	22	15	81	2.98	.06
Moving cottonseed--stands to seed house	6	4	75	.80	.02
Trash disposal	38	26	79	5.09	.10
Total	147	100	80	19.89	.38

1/ Operating loads expressed in horsepower-hours (hp.-hr.) and electrical energy consumption in kilowatt-hours (kw.-hr.)

EXTENT AND CAUSES OF VARIATIONS IN POWER AND NUMBER OF FANS REQUIRED

In this study of 30 gins, the average number of fans per gin was 16.1 in California, 15.7 in West Texas, and 10.3 in New Mexico (table 3). The smallest number in a single gin plant was 6 in New Mexico, and the largest was 20 in California. Power required in operating fans, as a proportion of the total operating load for the gin, ranged from an average of 47 percent in New Mexico to 53 percent in California and West Texas. However, ranges, both within and among areas, were much greater, varying from a low of 30 percent at one gin in New Mexico to a high of 78 percent at one gin in West Texas. These wide variations in fan power requirements and number of fans employed were due principally to differences in: (1) size of plants, (2) elaborateness of gin setups, (3) type of materials handled, and (4) personal preferences of gin manufacturers, engineers, and operators.

Table 3.--Fans per gin, fan operating loads and energy requirements, 30 cotton gins, California, West Texas, and New Mexico, 1961-62 season

Range and average by geographic area	Fans per gin	Fan operating load		Energy consumed by fans, per bale	
		Total, per gin	Fan load as percentage of gin total load		
	Number	Hp.-hrs.	Percent	Kw.-hrs.	Dollars
California					
Range	13-20	235-385	39-69	14.45-79.09	0.35-1.43
Average	16.1	305	53	25.47	0.47
West Texas					
Range	13-19	207-380	40-78	20.59-45.11	0.49-1.18
Average	15.7	263	53	28.91	0.75
New Mexico					
Range	6-16	79-226	30-58	7.68-36.14	0.15-0.68
Average	10.3	147	47	19-89	0.38

There was no indication of any interrelationship between gin machinery manufacturer and number of fans employed per gin. Among the three areas, there was no significant difference in the number of fans in gin plants that operated equipment supplied by one manufacturer than in gin plants operating equipment supplied by any other manufacturer. For example, Company D supplied the lowest average number of fans in California and the highest average number of fans in West Texas (table 4). 8/ For all three areas combined, Company A supplied 23 percent more fans than Company C. Similar inconsistencies were evident from the comparisons of proportion of fan operating load to total gin operating load.

The relationship between gin size and number of air fans was direct; the largest gins having the most fans, on an average. For the 30 gins studied, there was an average of 16.1 fans in the large group, 13.5 fans in the medium-sized plants, and 11.3

8/ To conceal the identity of individual manufacturers, the four major gin machinery manufacturers included in the study are referred to herein as Companies A-D.

Table 4.--Fans per gin, and fan operating load as percentage of total gin operating load, by make of gin machinery, 30 cotton gins in California, West Texas, and New Mexico, 1961-62 season

Range and average by geographic area	Gin machinery manufacturer							
	A		B		C		D	
	Fans per gin	Fan load as percentage of gin total load	Fans per gin	Fan load as percentage of gin total load	Fans per gin	Fan load as percentage of gin total load	Fans per gin	Fan load as percentage of gin total load
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
California								
Range	18-20	58-61	16-17	47-69	14-17	46-54	13-16	39-61
Average.....	19.0	59.2	16.0	55.4	15.5	49.3	14.7	49.8
West Texas								
Range.......	14-15	48-72	13-16	40-53	13-19	50-56	13-18	43-78
Average.....	14.3	58.0	14.3	46.2	15.0	54.0	15.3	56.0
New Mexico								
Range.......	12-16	42-58	12-1/	57-1/	6-7	30-51	8-11	36-54
Average.....	14.0	48.8	12.0	57.0	6.5	39.7	9.5	46.3
Three-area average.....	15.6	55.9	14.9	51.5	12.7	50.2	13.6	51.9

1/ Only one gin in this category, hence no range indicated.

fans in the small gins (table 5). Here again, ranges in numbers of fans per gin within a given size group were generally much greater than the average differences between size groups. The fan operating load as a proportion of the total for the gin averaged approximately 52 percent for large plants, 53 percent for medium-sized plants, and 56 percent for small plants.

As long as pneumatic conveying systems continue to be employed in cotton gins, there will be a need for certain basic fans, such as the unloader, airblast (in airblast gins), and one or more push or pull fans for the drying systems, regardless of gin size. In fact, there already appears to be some degree of standardization in the number and sizes of fans employed in these specific functions within gins of like size, and, with presently available equipment and knowledge, the opportunities for lowering the cost of these functions are limited. This does not hold true, however, for gin trash disposal.

Centrifugal air fans used in gin trash removal vary widely in number and size among gins otherwise comparable in size, machinery arrangement, ginning capacity, and operating conditions. Very often trash fans are installed to replace or to supplement existing equipment, with little regard to proper size or to the net effect on operating costs.

The number of fans used for trash disposal in the 30 gins studied averaged 5.7 in California, 5.0 in West Texas, and 2.8 for the gins in New Mexico (table 6). Variations in trash fan numbers within areas were considerable. The widest spread occurred in California, where one gin had three trash fans and another eight, both 5/90-saw plants. Energy consumed per bale in trash handling also showed wide variations. Within a given area, this spread was widest in New Mexico, ranging from 1.24 kw.-hrs. at a cost of $0.02 per bale to 17.00 kw.-hrs. at a cost of $0.31 per bale.

A pneumatic air system is an independent unit composed of fan(s) and piping with the efficiency of the whole dependent upon each integral part. The efficiency of the fan, alone, in addition to its inherent design, is limited by three main factors: speed of operation, its size in relation to the purpose for which it is intended, and its general mechanical condition or state of repair. In this study, wide variations were noted in the first two of these factors. Speeds ranged among trash fans of like size and use by several hundred r.p.m.'s. It was frequently noted that all major fans within a given gin tended to be operated at approximately the same speed, regardless of size and use. Fans ranged in size from No. 25 to No. 50, with Nos. 25, 35, and 40 being the most common. Although practically every fan combination imaginable was employed in trash removal from gins, the following setup was somewhat typical of those found in the gins studied: One main trash fan (No. 35 to 40) served the feeders, gin stands, and possibly one or more pieces of overhead equipment; one or more drier pull fans (No. 35 or 40) also acted as trash fans for overhead cleaners; and a No. 25 fan collected the motes at each stage of lint cleaning.

The degree to which piping systems incorporated sound engineering principles also varied markedly. Pipe diameters, particularly in the unloading systems, were often too small. Loose draw bands and open Y's and T's were common. Generally, valves were either completely lacking or improperly set. Excessive piping, resulting in excessive bends and curves, was notable, particularly in trash disposal systems. All added up to a total picture of unnecessary power consumption and waste in practically every installation.

Table 5.--Fans per gin and fan operating load as percentage of total gin operating load, by size of gin,1/ California, West Texas, and New Mexico, 1961-62 season

Range and average by geographic area	Size of gin					
	Large		Medium		Small	
	Fans per gin	Fan load as percentage of gin total load	Fans per gin	Fan load as percentage of gin total load	Fans per gin	Fan load as percentage of gin total load
	Number	Percent	Number	Percent	Number	Percent
California						
Range	14-20	46-58	13-18	39-69	16- 2/	61- 2/
Average	16.5	54.3	15.5	54.5	16.0	61.0
West Texas						
Range	13-19	40-72	13-15	43-57	13- 3/	56-78
Average	15.7	51.1	14.2	50.4	13.0	66.9
New Mexico						
Range	16- 2/	42- 2/	7-12	51-58	6-12	30-57
Average	16.0	42.0	10.0	55.1	8.7	40.1
Three-area average	16.1	51.9	13.5	52.9	11.3	56.4

1/ Gin size groups arbitrarily set as follows: Small gins having up to 400-12" gin saws; medium, 400-480 12" gin saws; and large, 480 or more 12" gin saws.
2/ Only one gin in this category, hence no range indicated.
3/ Only two gins in this category, and both had the same number of fans, hence no range indicated.

Table 6.--Trash fans per gin, operating loads, and energy requirements for 30 cotton gins, California, West Texas, and New Mexico, 1961-62 season

Range and average by geographic area	Total trash fans connected, per gin	Trash fan operating load: Total, per gin	Trash fan operating load: As percentage of gin total load	Energy consumed, per bale	
	Number	Hp.-hrs.	Percent	Kw.-hrs.	Dollars
California					
Range	3-8	46-122	9-25	3.25-17.13	0.06-0.25
Average	5.7	80	14	6.68	0.12
West Texas					
Range	4-7	44-86	9-18	4.83-9.19	0.12-0.24
Average	5.0	66	13	7.20	0.19
New Mexico					
Range	2-4	13-69	5-31	1.24-17.00	0.02-0.31
Average	2.8	38	12	5.09	0.10

POSSIBILITIES OF INCREASING EFFICIENCY IN MATERIALS HANDLING

By comparing materials handling systems, machinery arrangements, and plant layouts of the 30 gins studied, several possibilities for reducing power requirements were evident. For some gins, this could be accomplished with existing equipment by (1) peaking the efficiency of each individual air system, or by (2) rearranging gin machinery in order to reduce the number of fans and the amount of piping necessary to accomplish the job. For others, greater efficiencies in power usage seemed probable by incorporating new engineering developments and principles.

Peaking Efficiency of Individual Air Systems

Fans in gins are frequently operated at unnecessarily high pressures and rates of speed. Considering the fan laws:

> . . . (1) volume varies directly as the speed (if pressure is constant), (2) pressure varies as the square of the speed (if volume is constant), and (3) horsepower varies as the cube of the speed (3) . . .

The importance of keeping fan pressures and speeds at a minimum is obvious. For example, doffing with an F-176 fan in a 5/90-saw airblast gin should require approximately 7,000 c.f.m. of air at 11 inches static pressure under ideal operating conditions. To provide this volume and pressure would normally require a speed of around 1,575 r.p.m.'s and about 28 hp. (fig. 1). In one specific gin of this size and type, when unsatisfactory doffing developed, rather than look for such common causes as worn saws or improperly adjusted airblast nozzles, the ginner merely increased the fan speed by changing pulleys. Stepping up the speed of the fan to about 1,775 r.p.m.'s increased the static pressure from about 11 inches to approximately 14 inches and overcome the doffing problem. In so doing, however, power requirements were also boosted to approximately 35 hp. Hence, an increase of only 12 to 13 percent in fan speed resulted in an increase of 25 percent in power consumed. If this ginner had been more familiar

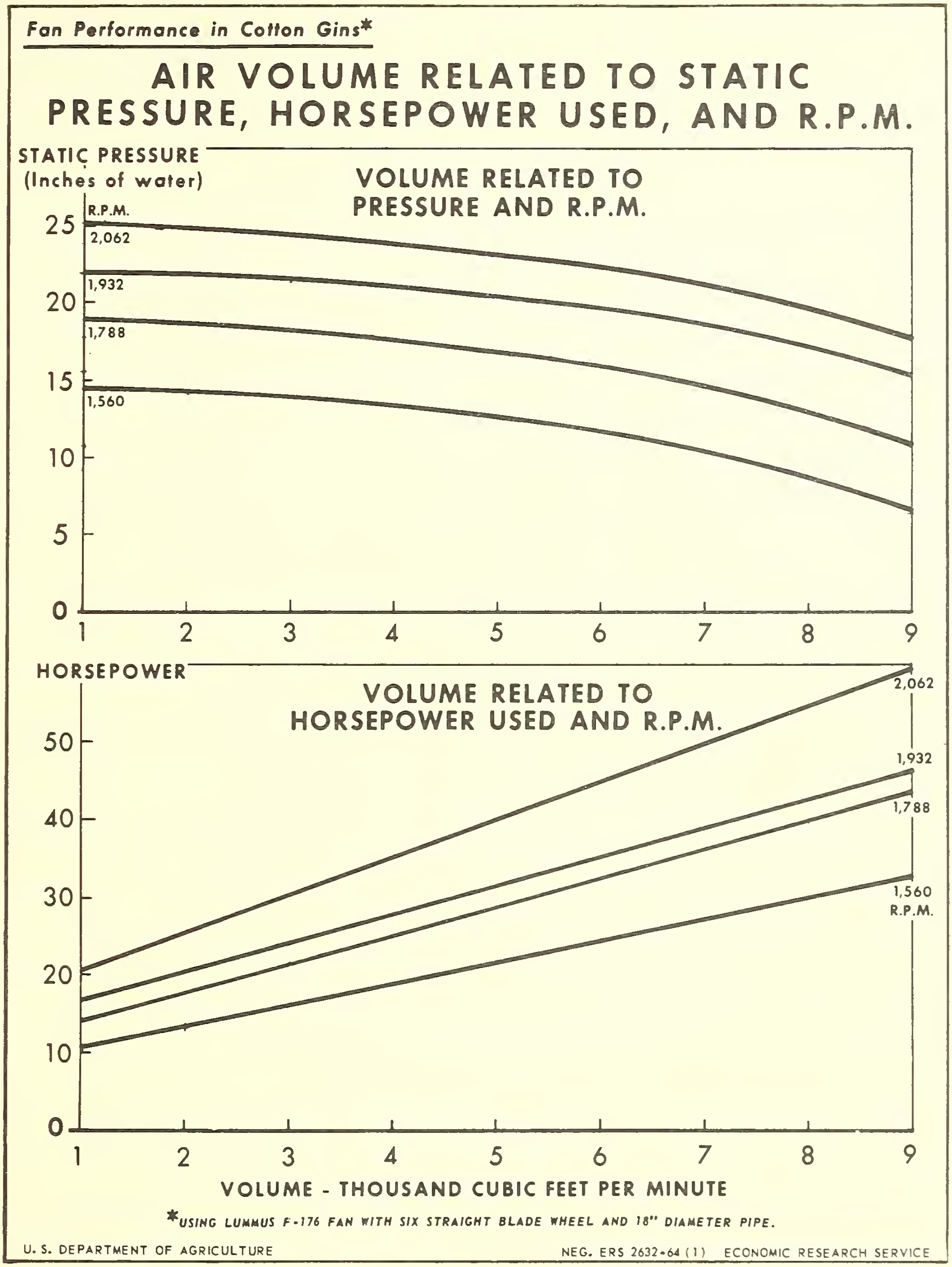
Fan Performance in Cotton Gins*
AIR VOLUME RELATED TO STATIC PRESSURE, HORSEPOWER USED, AND R.P.M.
STATIC PRESSURE (Inches of water)
VOLUME RELATED TO PRESSURE AND R.P.M.
R.P.M.
2,062
1,932
1,788
1,560
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9
HORSEPOWER
VOLUME RELATED TO HORSEPOWER USED AND R.P.M.
2,062
1,932
1,788
1,560 R.P.M.
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9
VOLUME - THOUSAND CUBIC FEET PER MINUTE
*USING LUMMUS F-176 FAN WITH SIX STRAIGHT BLADE WHEEL AND 18" DIAMETER PIPE.
U. S. DEPARTMENT OF AGRICULTURE
NEG. ERS 2632-64 (1) ECONOMIC RESEARCH SERVICE

Figure 1

with the general relationships of pressure and horsepower to speed, he would have hesitated to follow this age-old practice of simply increasing the fan speed to maintain capacity without first seeking to determine the cause of any change in performance which may have occurred.

Rearranging Gin Machinery

Gin machinery was often arranged with little regard for operating costs. Frequently, equipment was installed in such a manner as to necessitate the uneconomical duplication of fans, piping, and motors. Consider, for example a gin somewhat typical of the San Joaquin Valley, the Texas High Plains, and other major producing areas of the Cotton Belt. This particular plant was equipped with 28 cylinders of overhead cleaning, two stages of drying, three stages of lint cleaning, and a total connected load of approximately 650 hp. (fig. 2). Twelve centrifugal air fans and 5 vane-axial exhaust fans accounted for 380 hp. of the total connected load. Suction for unloading was provided by a No. 50 fan (#1). 9/ Seed cotton was first drawn to a separator from which it dropped by gravity into an automatic feeding device and on through a vacuum wheel into a hot air line where it was pushed by a No. 40 fan (#2) into a tower drier. From the drier, seed cotton was pulled through a 7-cylinder incline cleaner by a No. 40 moist air fan (#6). It was then picked up by a No. 40 fan (#4) and pulled through a second 7-cylinder incline cleaner, falling by gravity into split bur machines. Again the seed cotton was picked up in a stream of hot air supplied by a No. 40 hot air fan (#5) and pushed into another tower drier. From there it was pulled to a separator over two piggyback, 7-cylinder incline cleaners by a No. 40 moist air fan

9/ Numbers in parentheses indicate identifying fan numbers in figure 2.

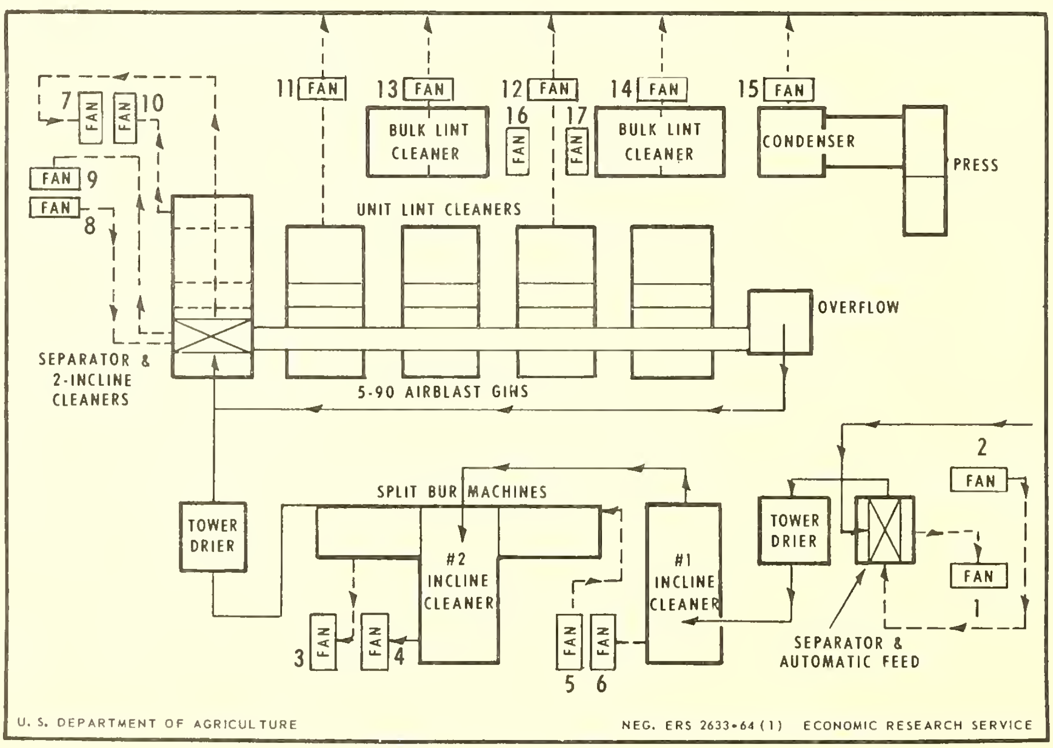

Figure 2.--Gin plant, before machinery rearrangement (total connected load--650 hp.)

(#7), which also acted as an overflow suction. It was then moved mechanically through an additional 14 cylinders of cleaning, dropping into the conveyor-distributor and on down into the feeders and gin stands. From the gin saws, lint was moved to a big condenser over the lint slide by a push-pull combination provided by the airblast fan (#8) and the vane-axial exhaust fans (#11, #12, #13, #14, and #15). From there it was allowed to gravitate down the lint slide and was then pushed mechanically into the press box.

This setup had five principal trash fans and two other fans playing secondary roles as trash fans. Burs from the bur machine were handled by a No. 40 fan (#3). Gin stand and feeder trash was picked up by a No. 40 fan (#9). Another No. 40 fan (#10) handled all trash from the third and fourth incline cleaners, and the unit lint cleaners. Two No. 25's (#16 and #17) handled the trash from the bulk lint cleaners and the two No. 40 pull fans (#4 and #6) served in secondary roles as trash fans by removing trash from the respective cleaners through which they pulled seed cotton, primarily.

This same gin setup could be modified to reduce power consumption in the following manner without adversely affecting the operation. The automatic feed could be relocated at the end of the conveyor-distributor, thus eliminating the need for (1) the overflow suction fan, (2) the separator over the third incline cleaner, and (3) the overflow bin (fig. 3). The fan handling trash from the third and fourth cleaners could also be made to serve a double role by pulling from the second tower drier through the third cleaner. The two incline cleaners could be mounted in a stacked array, thus eliminating the need for the second pull fan (#4). The bur machine trash fan (#3) could also be eliminated and the trash from it, along with that from the second incline cleaner, could be picked up by the main trash fan which handled the

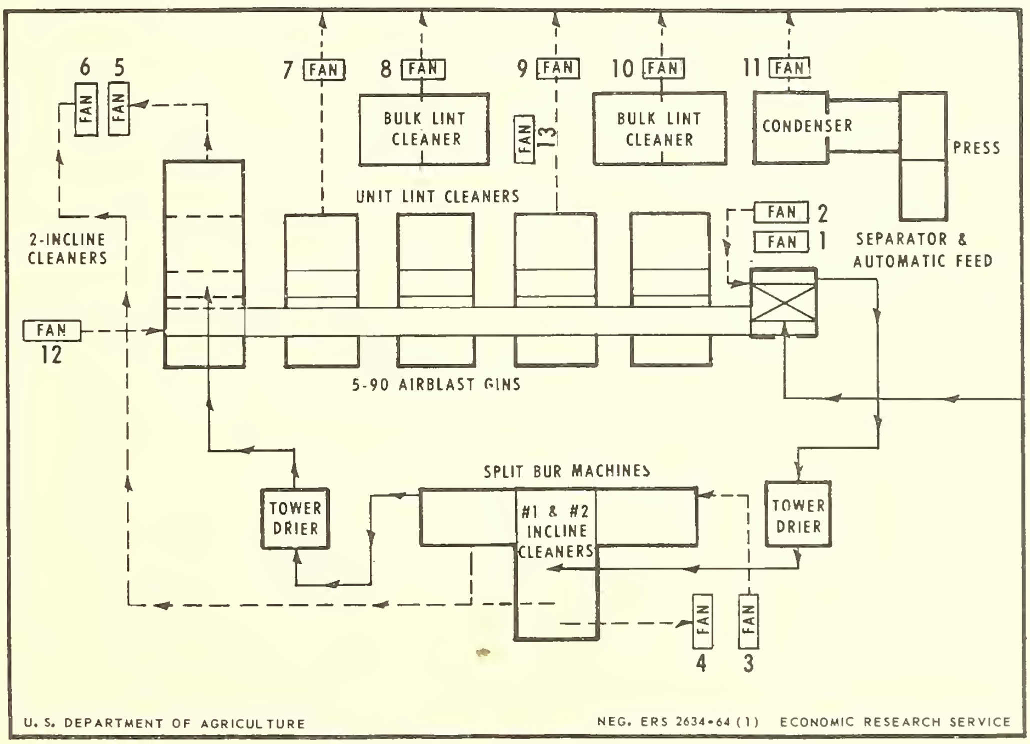

Figure 3.--Gin plant, after machinery rearrangement (total connected load--555 hp.)

gin stand and feeder trash. Finally, the two No. 25 trash fans (#16 and #17) serving the two bulk lint cleaners could be replaced by a No. 35 single fan operated with one 15 hp. motor instead of two separate 10 hp. motors.

The net result of this relatively simple modification would be reductions in power requirements, number of fans, piping, repairs, maintenance, and depreciation. Elimination of 95 hp. from the total connected load would reduce annual power costs, alone, by an average of about $1,270 per gin in West Texas, $640 in California, and $875 in New Mexico. Other savings accruing from the elimination of maintenance, repairs, and depreciation on four fans, motors, and related piping could easily amount to an additional $1,000 or more per gin per year. These savings combined would amount to an equivalent of about one-fourth, one-third, and one-half the total power costs for gins studied in West Texas, California, and New Mexico, respectively.

The above example has not been cited as the recommended or ideal gin rearrangement. It is merely one method of substantially reducing power costs with a minimum of effort and alteration expense in an arbitrarily selected situation.

Incorporating New Engineering Principles

The gin arrangement shown in figure 3 is also well adapted to the installation and use of a new principle in trash disposal which was developed at the Southwestern Cotton Ginning Research Laboratory in Mesilla Park, New Mexico (fig. 4). This experimental unit consists of (1) a positive displacement rotary air pump driven by a 5 hp. motor, (2) a 4-inch airline from the pump discharge to a vacuum wheel dropper,

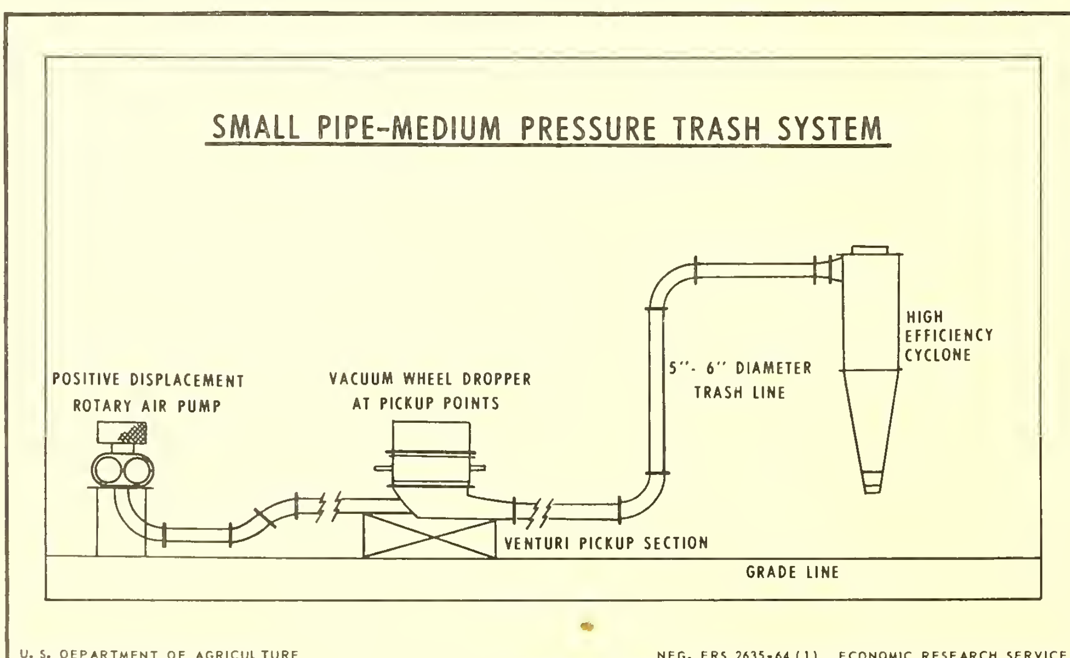

Figure 4

and (3) a 5- to 6-inch conveying pipe from the dropper discharge to a high efficiency cyclone collector (1). Laboratory and field tests have shown this device capable of handling up to 12,000 pounds of trash per hour with an air volume of only 600-800 cubic feet of air per minute. In comparison, conventional air fans, in conveying similar volumes of burs, trash, and dirt, often handle as high as 20,000 cubic feet of air per minute, with an accompanying increase in power consumption.

In adopting this new principle, the rotary air pump would replace the #6 fan in figure 3 and could be installed underground with the discharge line running laterally across the end of the building to a cyclone collector outside (fig. 5). Screw augers would be employed to convey trash from the bur machine, stands, feeders, incline cleaners, and unit cleaners to the discharge line. The use of this system could add another $0.02 to $0.04 per bale in average power savings over those already realized from the changes suggested in figure 3.

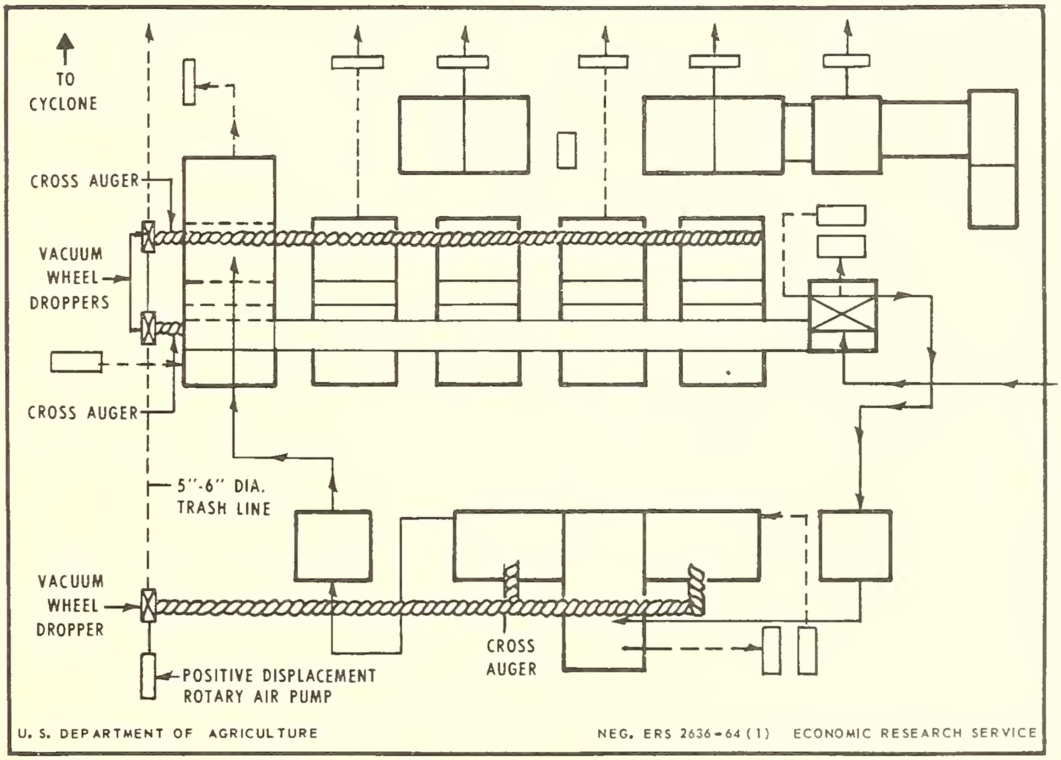

Figure 5.--Gin plant, after machinery rearrangement and incorporating small pipe-medium pressure trash system (total connected load--535 hp.)

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