Project A-682
Technical Report No. 4

MAN-MADE FIBERS

A Manufacturing Opportunity
in the Central Savannah River Area

Prepared for

Central Savannah River Area
Planning and Development Commission

by

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Foreword

A previous analysis of "Chemical and Other Manufacturing Possibilities for the Central Savannah River Area" identified synthetic fibers as one of the best potentials for developing new industrial payrolls in the area. The present study provides the necessary follow-up analysis of specifics on that potential.

Within the scope of the present contract it was not possible to prepare still more detailed analyses for individual companies which logically should consider the Augusta area as a location for a new plant. Additional information can, however, be prepared on a confidential basis for any company interested in securing a further analysis tailored to its special needs.

This is the first special product analysis to follow a series of basic studies previously completed by the Industrial Development Division on various aspects of the economy of the Central Savannah River Area. In addition to the investigation of manufacturing possibilities in the chemical and related fields, previous studies include basic resource audits of the 13 counties, an industrial site survey, and an assessment of manpower resources in the area.

A number of other products have been identified preliminarily as being well suited to the study area. Other chemical products so identified include fatty acids and glycerine, methanol, formaldehyde and methylamines, pesticides, and phenol. More detailed analyses are required to fully appraise the potentials of each.

A major expansion has already taken place in one of the fields not directly related to chemicals which was identified as offering excellent potential -- the pulp and paper industry," . . . especially in the fields of newsprint and foodboard." Since the study was completed a $30,000,000 newsprint mill has been announced, together with a $22,000,000 expansion of the Continental Can Company's existing pulp and paperboard plant.

Requests for additional information and comments or questions on this or previous reports in this series will be welcomed.

Kenneth C. Wagner, Chief
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Summary

The Central Savannah River Area (CSRA), a group of 13 counties surrounding Augusta, Georgia, is a very favorable location for the man-made fiber industry. Because of the growth expected in the industry there will be a need for between 20 and 30 new plants, in addition to those already announced, between 1965 and 1970. The Augusta area offers a number of advantages for the manufacture of man-made fibers.

A major advantage is the area's location in the middle of the textile market, the major portion of which extends from Alabama to the Carolinas.

The CSRA also has excellent transportation facilities for providing efficient service to this market. A barge channel on the Savannah River connects Augusta with the port of Savannah and the Intracoastal Waterway, bringing lower freight rates than would exist without water transportation. Competitive rail service is provided by railroads. Three airlines provide good service to and from Augusta that will be of particular interest to management. In addition, Augusta has good highway access to the southeastern textile belt and is on the Interstate Highway System. Forty motor carriers provide interstate service from Augusta.

One of the outstanding features of the Augusta area is its water resources and its waste-disposal capacity. The Savannah River, with large storage reservoirs upriver, provides one dependable water source and high-yielding wells in the Coastal Plain province provide another. Waste effluents can be disposed to the Savannah River, which is free-running for 200 miles below Augusta through sparsely populated areas.

Natural gas rates are lower in the CSRA than in South Carolina and other more northern states along the pipeline. Augusta is the farthest point from the wellheads which has reasonable gas rates.

Among the CSRA's greatest assets are the availability and excellent work attitudes of the area's labor force. In addition, wage rates compare favorably with those in other sections of the country.

Augusta also is a good location for the manufacture of many of the chemical intermediates that are the raw materials for a man-made fiber plant. A good example of such an intermediate is caprolactam, used in the manufacture

of nylon 6. Because of caprolactam's special shipping requirements, there would be a big advantage to producing it near or at nylon fiber plants.

Within the last three years a chemical complex has been building up at Augusta. This complex produces a number of supplies and raw materials for both man-made fiber plants and chemical intermediate plants.

INTRODUCTION

The natural fibers -- cotton, linen, jute, wool, mohair, and silk -- were the only fibers available until the development of man-made fibers was begun in 1900. Man-made fiber production had grown to over two billion pounds in the United States alone by 1962, and its consumption was over 30% of total fiber consumption.

Seventeen generic names for the various types of man-made fibers have been assigned by the Federal Trade Commission. Each generic name (shown below) is defined by the Commission according to the chemical composition of the fiber-forming substance rather than its properties.

The generic types of man-made fibers do not break down easily into logical groupings, but it is possible to make some rather arbitrary classifications as follows:

Cellulosics	Fibers from Synthetic Long-chain Polymers (Non-cellulosics or synthetics)	Fibers Manufactured from Nonfibrous Natural Substances
Rayon	Nylon	Glass
Acetate	Modacrylic	Metallic
Triacetate	Acrylic	Rubber
	Polyester	Azlon
	Spandex	
	Olefin	
	Saran	
	Vinyon	
	Vinal	
	Nytril	

Rayon, acetate, and triacetate are called cellulosic fibers because they are derived from cellulose.

Another class of fibers is made from synthetic long-chain polymers -- man-made chemicals derived mainly from petroleum and petrochemical raw materials. These fibers, which are termed non-cellulosics in government reports, are also called synthetic fibers in the industry. The common use of the term "synthetic fibers" is rather ambiguous. Nylon fiber consists of polyamides. Acrylic fibers are composed primarily of acrylonitrile, while modacrylic fibers consist of acrylonitrile to which certain specified amounts of modifying chemicals have been added. Polyester fibers are composed principally of esters of dihydric alcohol and terephthalic acid. Spandex fibers are composed primarily of segmented polyurethane and exhibit characteristics of extremely high stretch and recovery from stretch. Olefin fibers consist of polymers of ethylene, propylene, or other olefins. Of these, polypropylene fibers are being developed by several companies. Nytril fibers, not currently produced in the United States, contain vinylidene dinitrile. Vinyon fibers are made from vinyl chloride. Saran fibers contain vinylidene chloride. Vinal fibers are made from vinyl alcohol.

Additional fibers are made through the conversion of nonfibrous natural materials. These include glass, metallic, rubber, and azlon fibers. Glass fibers are made by extruding special formulations of glass through heated orifices and quickly stretching them to the desired fineness. Metallic fibers, used for decorative elements in woven and knitted fabrics, are produced by inserting bright metal foils between films of plastic to protect the metal from abrasion and to prevent tarnishing. Rubber filaments, extruded from natural or synthetic rubbers, are used as the core of elastic threads. Azlon, not currently produced in the United States, is made from natural proteins, including those obtained from casein, corn kernels, and peanuts.

This study is concerned with the feasibility of establishing manufacturing operations in the Central Savannah River Area (CSRA) to serve the southeastern market.

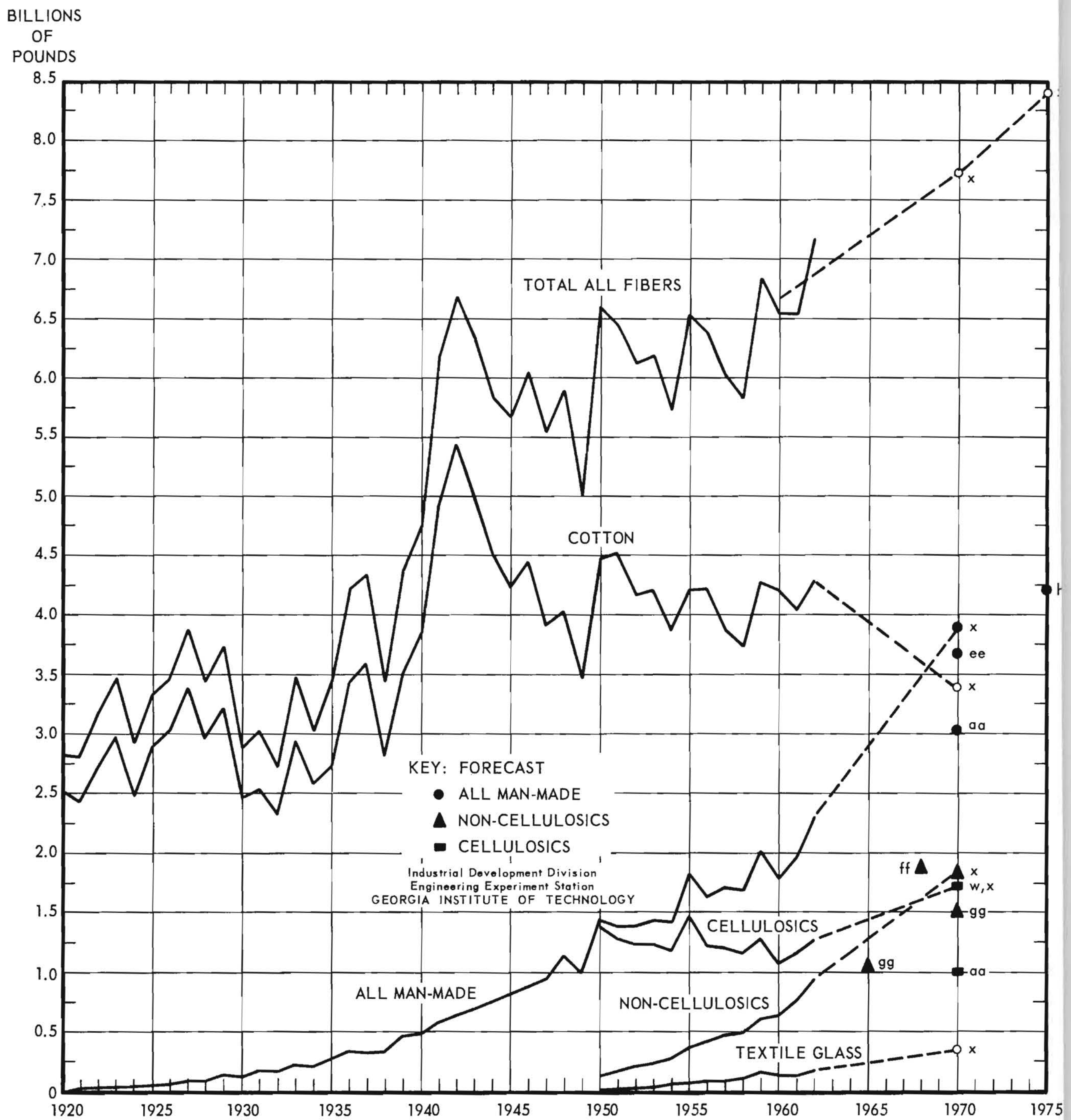
This report does not discuss all of the man-made fibers, but only those that account for a major share of U. S. production. The fibers dealt with are: the cellulosics (rayon and acetate), the synthetics or non-cellulosics (nylons, polyesters, olefins, acrylics, and modacrylics), and textile glass fibers.

Markets and forecasts for individual fibers are considered. If forecasts for individual fibers by people in the industry are totaled, the result is a prediction for all man-made fibers of almost 60% of the total textile fiber market in 1970. However, forecasters of the total share of man-made fibers have issued a cautious estimate of 50% by 1975. In this report, the Industrial Development Division has scaled down the expectations of the individual fibers forecasts in order to fit them into the framework of total textile fiber consumption in the United States. It is assumed in this study that man-made fibers will account for 50% of the textile fiber market in 1970.

In considering the advantages of a location in the CSRA for a man-made fibers plant, this report covers the regional market, transportation facilities, water supplies and waste disposal facilities, utility costs, and manpower.

The advantages of manufacturing the chemical intermediates for man-made fibers in the CSRA also are discussed.

FIGURE 1
TEXTILE FIBER CONSUMPTION IN THE U. S.



SOURCES: Alphabetic Symbols Refer to Forecast Sources in Appendix 1.

GROWTH OF THE MAN-MADE FIBER MARKET IN THE U. S.

The man-made fiber industry is now in a strong growth period which is expected to continue until at least 1970. Within the past year announcements have been made of substantial new capacity which is scheduled to be in operation by the end of 1965. Between 1965 and 1970 the equivalent of approximately 20 to 30 new plants will be needed to provide the approximately one billion pounds of additional capacity that is now forecast. Rayon and nylon are expected to show the strongest growth.

Man-made fibers' greatest growth has been at the expense of cotton, although wool also has lost markets to man-made fibers. Wool is a minor fiber compared with cotton, having a consumption volume approximately one-tenth of that of cotton. Cotton's share of total fiber consumption was 60% in 1962, a decline from approximately 80% in 1940. The feeling in the industry is that man-made fibers will continue to grow at the expense of cotton. The many forecasts for individual fibers by persons in the industry indicate that man-made fibers will have at least 50% of the fiber market in 1970. This amounts to an increase of 1.5 billion pounds, or 68%, over 1962. To fulfill this forecast the consumption of cotton and wool would actually have to decrease approximately one billion pounds in the eight-year period.

Total Textile Fiber Consumption

The growth of textile fiber consumption is expected to be in direct relationship to population growth. Figure 1 shows the consumption from 1920 to 1962 and projects it to 1975. The forecast for 1970 is 7.7 billion pounds, an 8% increase over 1962. Yearly figures are given in Table 1.[1/]

The per capita consumption of textile fibers in the U. S. since 1920 is shown in Figure 2. Per capita consumption over the 40-year period has increased approximately 10 pounds, from 27 to 37 pounds per capita.

The departure from the estimated trend of per capita consumption over the 40-year period has been caused by three major upsetting factors: the depression

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1/ Alphabetic symbols used in the figures and tables of this report refer to reference sources listed in Appendix 1, "Master Reference Key."

Table 1

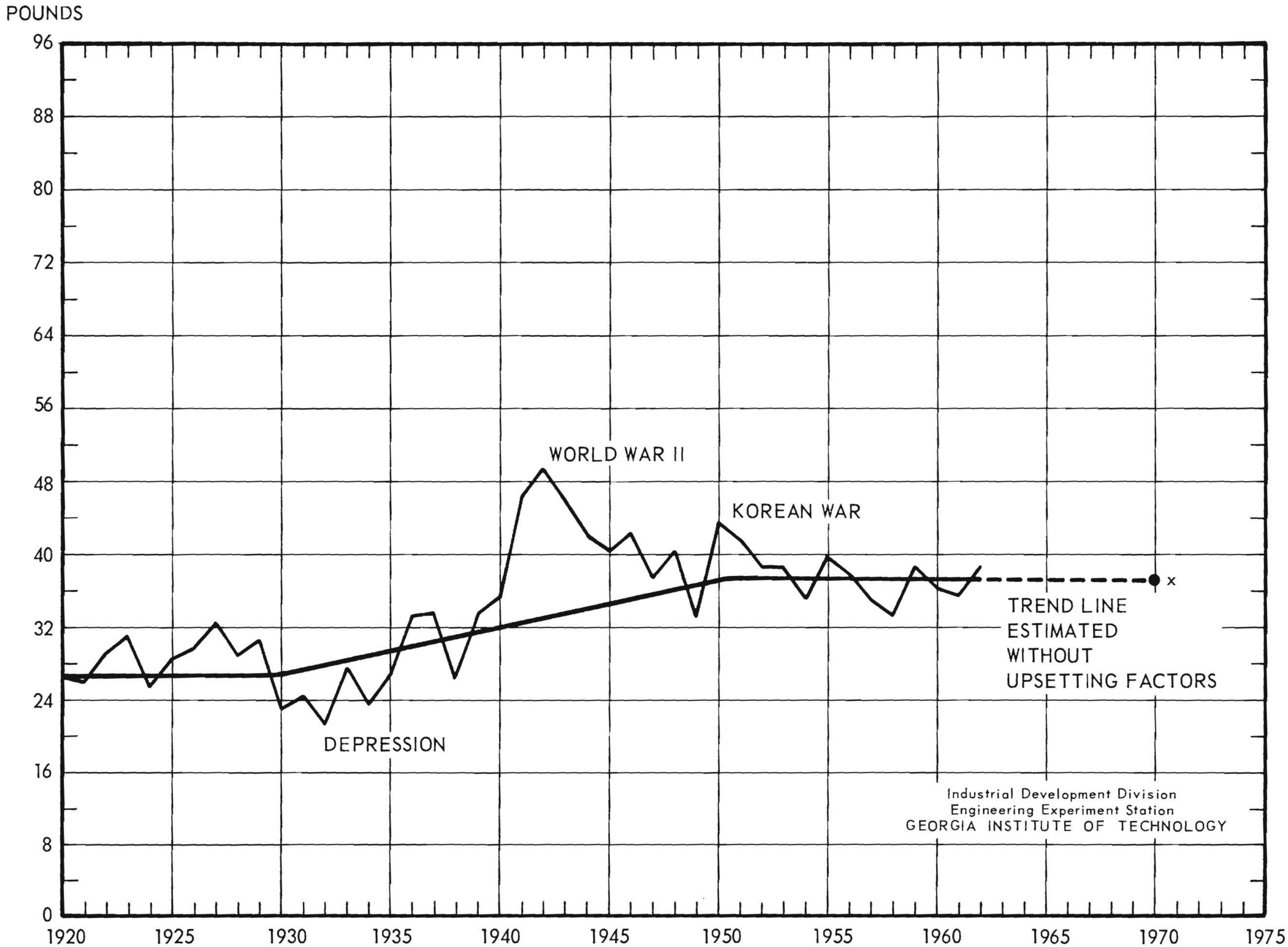
TEXTILE FIBER CONSUMPTION IN THE U. S.

(All figures in millions of pounds unless otherwise indicated)

Year	Population (millions)	All Textile Fibers: Total	All Textile Fibers: Per Capita (pounds)	Cotton	Wool	All Man-Made	Cellulosics	Non-Cellulosics
1920	106.5	2,833	26.6	2,505	320	8		
1921	108.5	2,826	26.0	2,426	381	19		
1922	110.1	3,190	29.0	2,721	444	24		
1923	112.0	3,483	31.1	2,985	466	32		
1924	114.1	2,925	25.6	2,499	385	40		
1925	115.8	3,333	28.8	2,889	388	57		
1926	117.4	3,458	29.5	3,021	377	60		
1927	119.0	3,861	32.4	3,366	396	99		
1928	120.5	3,441	28.6	2,968	373	99		
1929	121.8	3,743	30.7	3,206	406	131		
1930	123.2	2,861	23.2	2,458	287	117		
1931	124.1	3,002	24.2	2,520	325	158		
1932	124.9	2,724	21.8	2,328	241	154		
1933	125.7	3,489	27.8	2,942	331	216		
1934	126.5	3,025	23.9	2,580	239	206		
1935	127.4	3,406	26.8	2,701	434	272		
1936	128.2	4,208	32.8	3,433	434	341		
1937	129.0	4,330	33.6	3,599	405	327		
1938	130.0	3,441	26.5	2,809	496	336		
1939	131.0	4,393	33.6	3,509	419	465		
1940	132.6	4,727	35.8	3,823	417	487		
1941	133.9	6,196	46.4	4,937	663	596		
1942	135.4	6,675	49.5	5,424	607	644		
1943	137.3	6,312	46.2	5,009	605	698		
1944	138.9	5,821	42.1	4,508	562	752		
1945	140.5	5,668	40.5	4,249	605	815		
1946	141.9	6,046	42.8	4,450	699	896		
1947	144.7	5,531	38.4	3,916	668	947		
1948	147.2	5,887	40.2	4,026	715	1,147		
1949	149.8	5,003	33.5	3,473	534	997		
1950	152.3	6,597	43.5	4,464	691	1,441	1,375	123
1951	154.9	6,437	41.7	4,514	532	1,391	1,281	167
1952	157.6	6,112	38.9	4,165	548	1,398	1,237	212
1953	161.2	6,193	38.8	4,209	551	1,432	1,241	236
1954	163.0	5,742	35.4	3,886	440	1,417	1,175	279
1955	165.9	6,518	39.4	4,207	490	1,822	1,455	371
1956	168.9	6,385	37.8	4,216	526	1,644	1,225	409
1957	172.0	6,032	35.1	3,878	449	1,704	1,203	493
1958	174.9	5,833	33.3	3,729	417	1,687	1,162	498
1959	177.8	6,830	38.4	4,271	557	2,002	1,294	620
1960	180.7	6,535	36.2	4,210	538	1,786	1,082	648
1961	183.7	6,534	35.6	4,031	535	1,968	1,158	758
1962	186.6	7,160	38.4	4,278	569	2,313	1,297	951
1970	208.9	7,740	37	3,390	450	3,900	1,730	1,830
1975	226	8,400	37					

Sources: Consumption figures for 1920 through 1949 are from source b listed in Appendix 1, those for 1950 through 1962 are from source a, and the 1970 and 1975 forecasts are from source x. Data for per capita consumption of all textile fibers for 1950-1955, however, are from source b.

FIGURE 2
PER CAPITA CONSUMPTION OF TEXTILE FIBERS



of the 1930's, World War II, and the Korean War. It appears that through 197 the pounds of fiber consumed per capita will not change significantly over th 1960 figures. The tendency of per capita fiber consumption in pounds to rema constant is due primarily to two counteracting factors. The per capita owner ship of clothing is increasing but the use of man-made fibers, which are ligh in weight than cotton and wool, is also increasing.

Textile Organon expresses more specifically the factors affecting fiber consumption:[1/]

> There has been a trend toward lighter-weight clothing, especially in men's suiting and slacking fabrics, as well as a decline in the output of men's overcoats and an increase in the lighter-weight topcoats. Analogous changes have taken place in women's wear, offset to some degree by bulky-knit sweaters and heavier, woolen-spun suitings.
>
> Color and style often lead to an obsolescence of clothing, particularly in women's and misses' wear, long before the full wear-life of the product has been realized.
>
> There has been an increased use of sport and leisure apparel over the period, which apparently has taken place without causing a decline in the consumption of business-wear items.

Forecasts for Individual Fibers

The new capacity that will be needed as a result of the forecast growth in individual fibers is summarized in Table 2. The capacity shown for 1965 has been announced and is under construction. The 1970 capacity figure is the result of this market study.

The Cellulosics

Rayon. The surprise of the 1960's is the dynamic growth of rayon staple and tow, growth of which is expected to outstrip any other man-made fibers in the next six years.

The demand for cellulosics is once again growing after a general decline from 1950 to 1960. This increase is due mainly to growth in demand for rayon staple as a result of the development of high-modulus rayon fibers, which has put rayon staple into previously unhoped-for markets, such as sheets and towel The rayon staple producer's ultimate aim is cotton's entire market. Producers

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1/ Textile Organon, December 1963, p. 189.

Table 2

SUMMARY OF FORECASTS FOR MAN-MADE FIBERS PRODUCTION AND CAPACITY

(in millions of pounds)

	Production			Capacity					
	1963	Estimate for 1970	Increase 1963-70	1963	1965	Estimate for 1970	Increase 1965-70	Equivalent New Plants	1970 Production as % of Capacity
Cellulosics									
Rayon staple & tow	580	920	340	640	800	1080	280	3 to 4	85
Rayon yarn	400	400	0	430	420	420	0	------	95
Acetate yarn	310	350	40	350	350	410	60	2 to 3	85
Acetate tow	60	60	0	80	80	80	0	------	75
Total	1350	1730	380	1500	1650	1990	340	5 to 7	
Synthetics									
Nylon*	625	935	310	780	980	1170	190	4 to 6	80
Polyester	160	300	140	170	215	350	135	3 to 4	85
Olefins*	30	180	150	56	80	240	160	5 to 7	75
Acrylic & Modacrylic*	200	270	70	260	325	360	35	1 to 2	75
Other synthetics	135	145	10	122	220	220	0	------	65
Total	1150	1830	680	1388	1820	2340	520	13 to 19	
Textile glass	190	340	145	287	320	410	90	2 to 4	75
Total man-made fibers	2690	3900	1200	3175	3790	4740	950	20 to 30	80

*Production figures are not available, so domestic shipment figures are used.

capacity for rayon staple and tow, either installed or under construction, wi amount to approximately 800 million pounds in 1965 -- a 50% increase over the 1960 capacity. Production is expected to grow to over 900 million pounds a year by 1970, while capacity should be over 1 billion pounds. The additional capacity of 280 million pounds that must be constructed between 1965 and 1970 is equivalent to three to four new plants.

Rayon filament and yarn is not expected to need new capacity by 1970. Although production in 1970 will probably be greater than 1963, it is not expected to be as high as it was in the 1950's.

The history and forecast for rayon are shown in Figure 3 and Table 3.

Acetate. Acetate yarn production is expected to grow to 350 million pounds a year by 1970. This is an increase of 40 million pounds over 1963 pro duction. Consequently, acetate yarn plant capacity is expected to increase to 410 million pounds a year, an increase of 60 million pounds over the 1965 capacity of 350 million pounds. This increase in capacity is equivalent to two to three new plants. The history and forecast for acetate are shown in Figure 4 and Table 3.

The Synthetic Fibers (Non-Cellulosics)

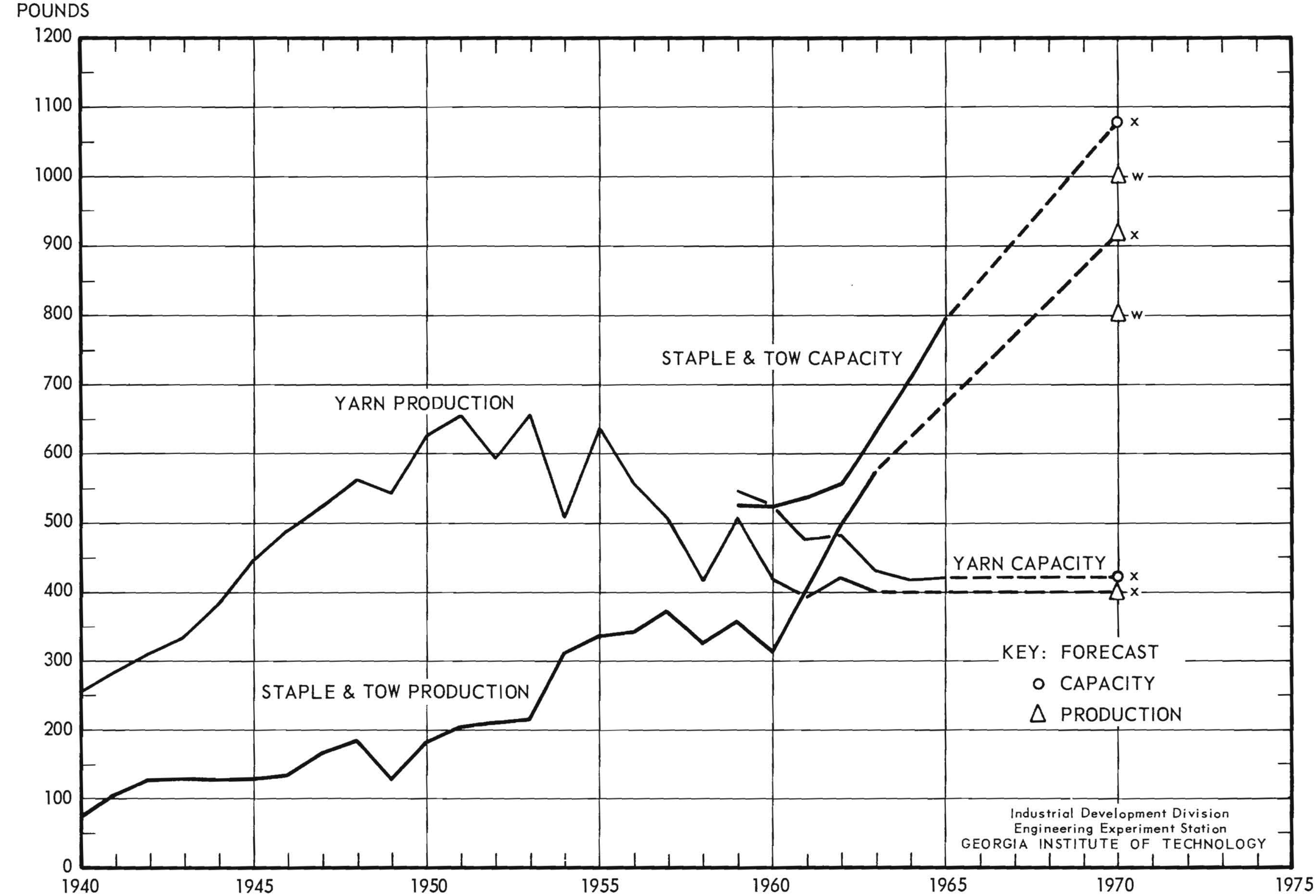
The major growth will occur in five of the ten classifications of synthet fibers. These are nylons, polyesters, olefins, acrylics, and modacrylics.

Nylon. Nylon production totaled 625 million pounds in 1963 and is expected to expand to over 900 million pounds by 1970. Capacity for 1970 is forecast to be 1,170 million pounds, which is a 190-million-pound increase over the announced capacity for 1965. This will require the equivalent of from four to six new plants. For the history and forecast for nylon fibers see Figure 5 and Table 4.

Polyester. Polyester production has been estimated by several trade magazines. The estimates average approximately 160 million pounds for 1963 and 300 million pounds for 1970. Many expect polyesters to become a major factor in the tire cord market.

The estimate for capacity by 1970 is 350 million pounds, a 135-million-pound increase over the 1965 estimate of 215 million pounds. Such a capacity

FIGURE 3
RAYON PRODUCTION AND CAPACITY, WITH FORECASTS TO 1970



SOURCES: Alphabetic Symbols Refer to Forecast Sources in Appendix 1.

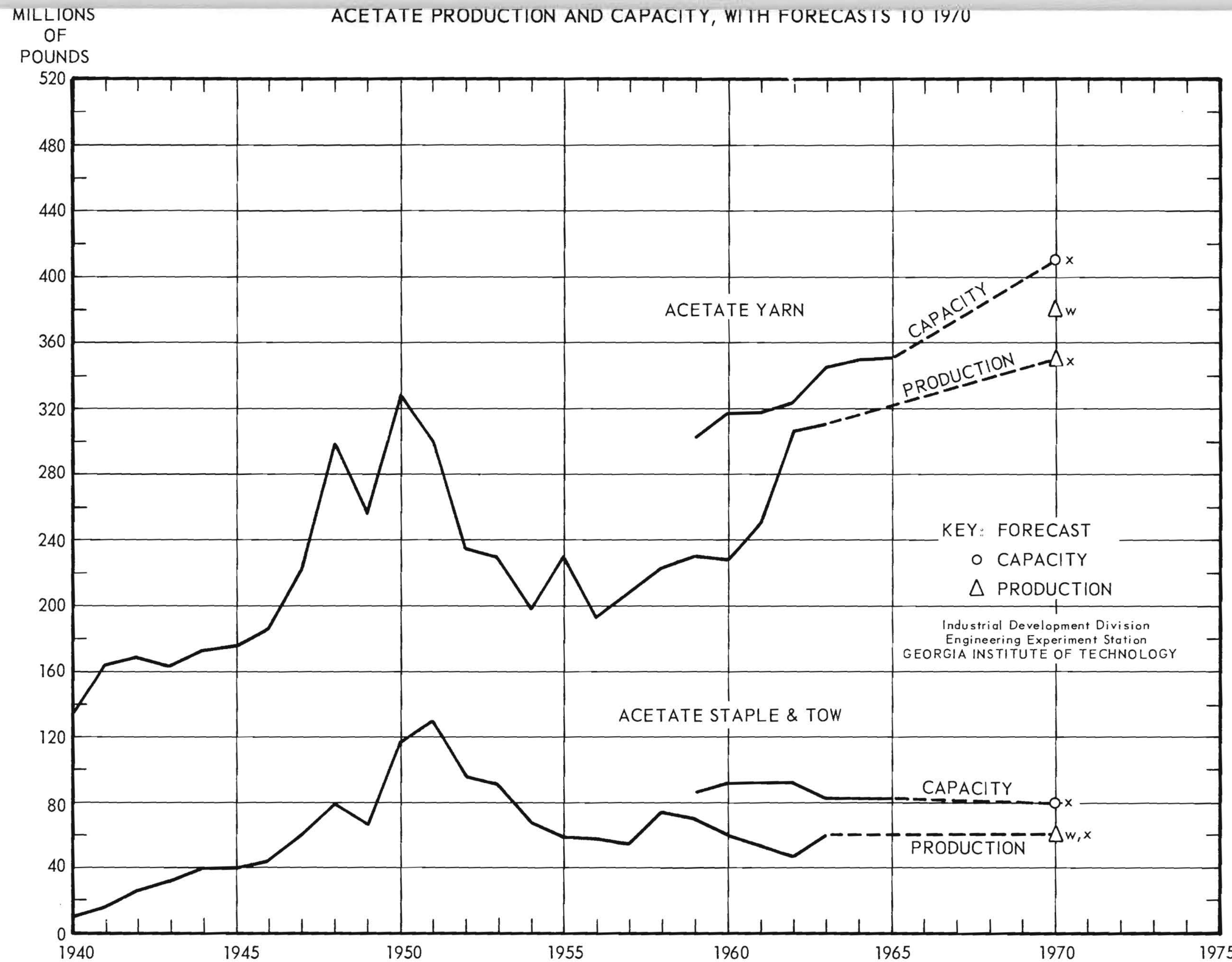
Table 3

RAYON AND ACETATE HISTORY AND FORECAST
(in millions of pounds)

	Rayon							Acetate							
	Staple & Tow			Filament & Yarn			Total	Yarn			Staple & Tow			Total	TOTAL
Year	Production	Capacity	Prod. as % of Cap.	Production	Capacity	Prod. as % of Cap.	Production	Production	Capacity	Prod. as % of Cap.	Production	Capacity	Prod. as % of Cap.	Production	CELLULOSICS PRODUCTION
1940	71			257			328	133						144	471
1941	105			288			393	164						180	573
1942	128			311			439	169						195	633
1943	130			339			469	163						195	663
1944	128			384			512	172						212	724
1945	129			449			578	175						214	792
1946	133			491			624	186						230	854
1947	168			525			693	222						282	975
1948	185			562			747	299						378	1,124
1949	130			544			674	256						322	996
1950	189			627			816	327						444	1,259
1951	207			658			865	300						429	1,294
1952	212			595			807	234						330	1,136
1953	219			658			877	229			91			320	1,197
1954	312			509			821	198			67			265	1,086
1955	338			635			973	230			58			288	1,261
1956	341			557			898	193			57			250	1,148
1957	371			506			877	208			54			262	1,139
1958	324			413			737	223			75			298	1,035
1959	359	529	68	508	545	93	867	230	302	76	70	87	80	300	1,167
1960	314	528	59	420	529	79	734	228	318	72	60	92	65	288	1,029
1961	401	538	74	393	474	83	794	249	317	79	53	92	58	302	1,095
1962	500	557	90	420	480	88	920	306	324	94	46	92	50	352	1,272
1963	579	635	91	400	429	93	979	310	347	89	60	82	73	370	1,349
1964		711			419				350			82			
1965		798			420				350			82			
1967														400(ii)	
1970	800(w)	1,000	80	440				380(w)	450	85	60(w)	80	75	410(x)	
	1,000(w)	1,110	90	400(x)	420	95	1,320	350(x)	410	85					1,730(x)
	920(x)	1,080	85												

Source: Unless otherwise indicated, the source is Textile Organon, February 1964. Other sources are listed in Appendix 1, by alphabetic symbol.

ACETATE PRODUCTION AND CAPACITY, WITH FORECASTS TO 1970



SOURCES: Alphabetic Symbols Refer to Forecast Sources in Appendix 1.

FIGURE 5
NYLON CONSUMPTION AND CAPACITY, WITH FORECASTS TO 1970

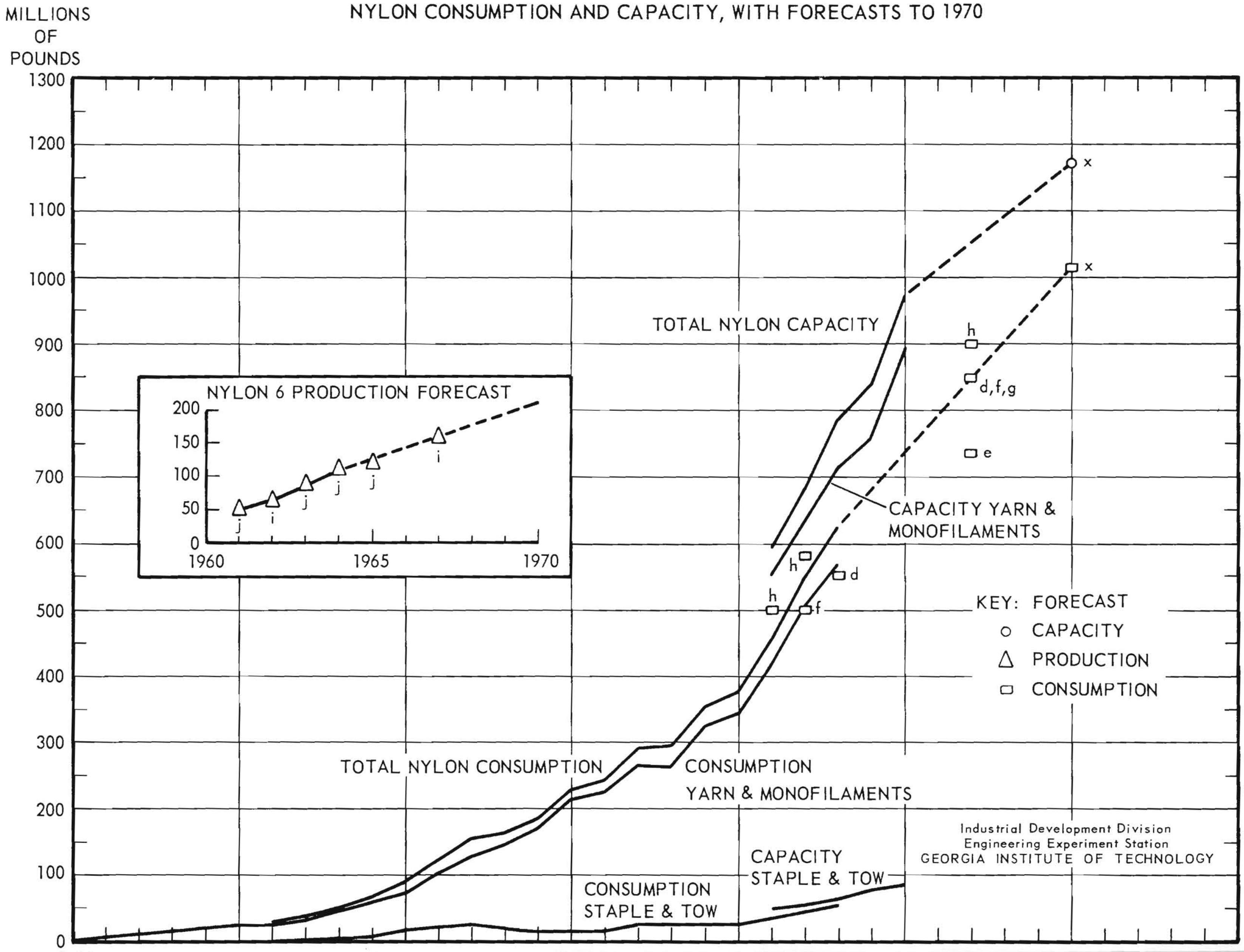


Table 4

NYLON HISTORY AND FORECAST
(in millions of pounds)

	Consumption			Production Capacity			Consumption as Per Cent of Capacity			
ar	Yarn and Monofil*	Staple and Tow*	Total	Yarn and Monofil	Staple and Tow	Total	Yarn and Monofil	Staple and Tow	Total	Production Nylon 6 Fiber
40	2.6		2.6							
41	7.2		7.2							
42	11.4		11.4							
43	15.6		15.6							
44	21.9		21.9							
45	25.1		25.1							
46	25.1	0.3	25.4							
47	31.6	1.1	32.7							
48	46.4	3.2	49.6							
49	60.2	8.0	68.2							
50	72.9	17.2	90.1							
51	101.0	21.5	122.5							
52	130.3	26.0	156.3							
53	147.8	20.2	168.0							
54	171.3	16.6	187.9							
55	213.3	17.6	230.9							
56	227.2	18.8	246.0							
57	268.4	24.7	293.1							
58	266.2	26.8	293.0							
59	327.1	28.8	355.9							
60	347.8	27.7	375.5							
61	419.0	36.0	455.0	552	42	594	76	86	77	50 (j)
			455 (g)							
			500 (h)							
62	503.1	47.5	550.6	635	53	688	79	90	80	60± (i)
			500 (f)							
			543 (g)							
			580 (h)							
63	570.0	55.0	625.0	716	67	783	80	82	80	85 (j)
			550 (d)							
64				760	80	840				110 (j)
65				892	86	978				120 (j)
67			850 (d)							160± (i)
			735 (e)							
			840± (f)							
			850 (g)							
			900 (h)							
70			1,015 (x)			1,170(x)			80(x)	

onsumption figures are actually producers' domestic shipments.

urce: Unless otherwise indicated, the source is <u>Textile Organon</u>, February 1964. Other sources are listed in Appendix 1.

increase will require the equivalent of from three to four new plants. Forecasts are shown in Figure 6 and Table 5.

Table 5

POLYESTER HISTORY AND FORECAST

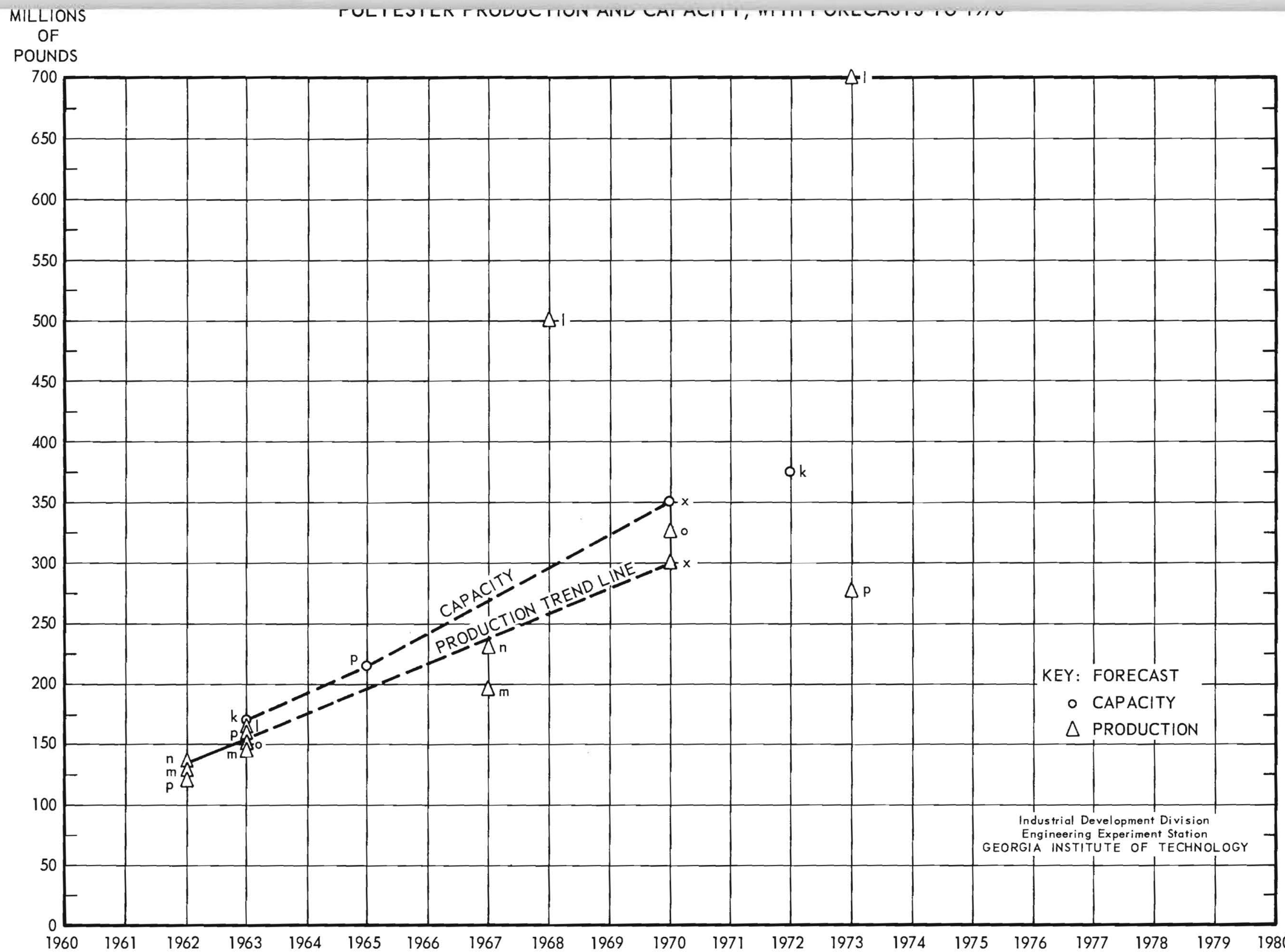
(in millions of pounds)

Year	Capacity	Production(1)	Consumption(p)	Production as Per Cent of Capacity
1960			64	
1961			50-74	
1962		127 (m) 135 (n) 120 (p)	90-92	
1963	170(k)	165 (1) 145 (m) 150 (o) 160 (p)	115	94
1965	215(p)			98
1966			190	
1967		195 (m) 230 (n)	283	
1968		500		
1970	350(x)	325 (o) 300 (x)		87
1972	375(k)			
1973		700 275± (p)		85(x)

Sources: Alphabetic symbols refer to sources listed in Appendix 1.

Olefins. Most of the new capacity in olefins will be polypropylene yarn and monofilaments. Capacity for 1970 is estimated to be approximately 240 million pounds, a 160-million-pound increase over the planned 1965 capacity of 80 million pounds. This will require the equivalent of from five to seven new plants. The history and forecast are shown in Figure 7 and Table 6.

POLYESTER PRODUCTION AND CAPACITY, WITH FORECASTS TO 1970



SOURCES: Alphabetic Symbols Refer to Data Sources in Appendix 1.

FIGURE 7
OLEFIN CONSUMPTION AND CAPACITY, WITH FORECASTS FOR POLYPROPYLENE TO 1970

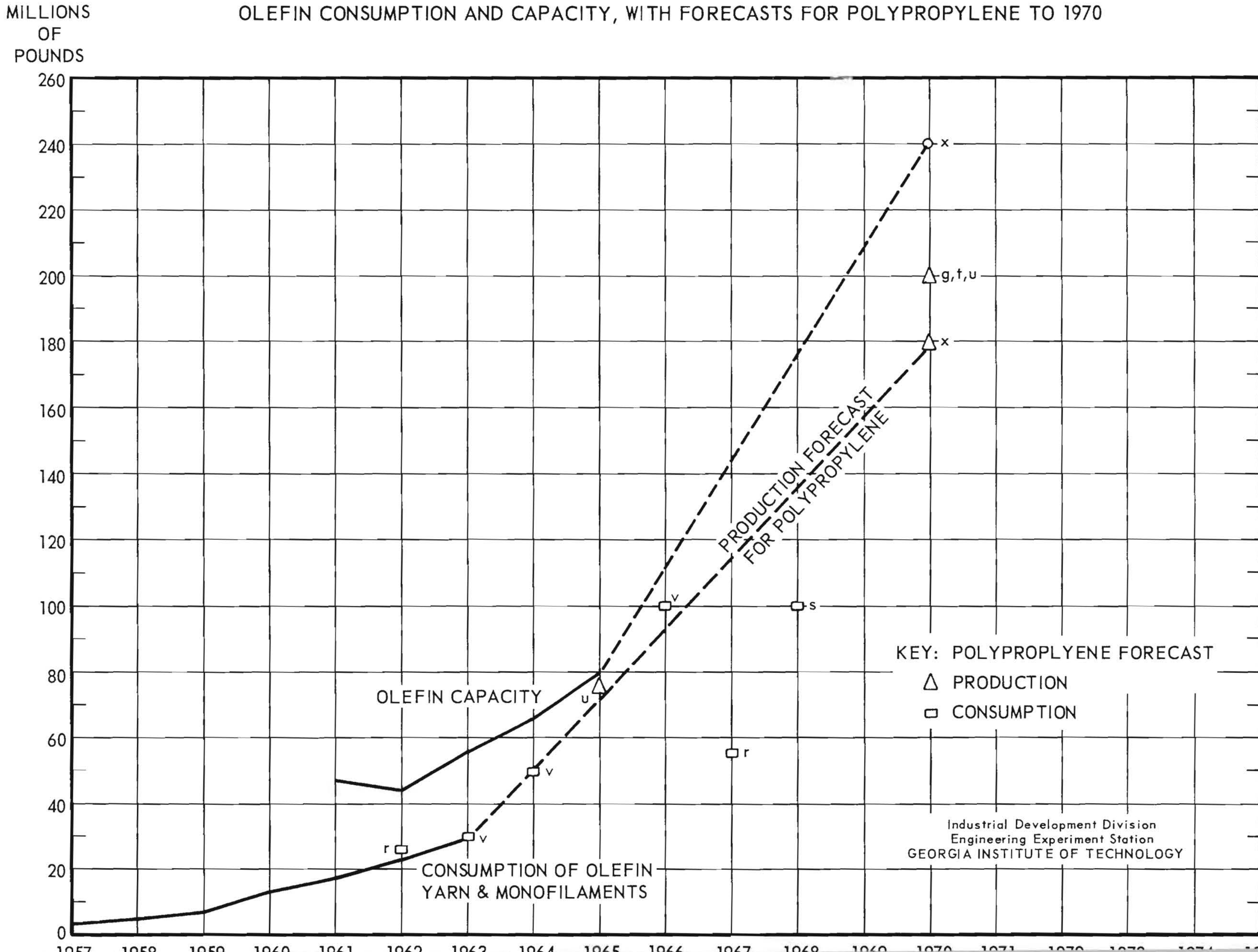


Table 6

OLEFIN FIBER HISTORY AND FORECAST
Essentially Yarn and Monofilaments

(in millions of pounds)

	All Olefins			Polypropylene	
Year	Consumption(c)	Capacity(c)	Consumption as Per Cent of Capacity	Consumption	Production(u)
1957	3.4				
1958	4.6				
1959	6.9				
1960	13.2				
1961	17.5	45	37.2	1(t)	
1962	22.5	44	51.2	26(r)	5.5
1963	29.1	56	52	5(t) 10(s) 30(v)	
1964		66		50(v)	
1965		75-79			75
1966				100(v)	
1967				55(r)	
1968				100(s)	
1970		240(x)		200(q) 200(t)	200 180 (x)

Sources: Alphabetic symbols refer to sources listed in Appendix 1.

Acrylic and Modacrylic. Capacity, essentially staple and tow, in 1970 is expected to be 360 million pounds a year, an increase of 35 million pounds over the 1965 planned capacity of 325 million pounds. This will require the equivalent of from one to two new plants. The history and forecast are shown in Figure 8 and Table 7.

Polyurethane Fibers. Since the introduction of spandex, approximately five years ago, it has captured the majority of the rubber thread market. Planned capacity is sufficient to supply this market. The tremendous new markets spandex may find through the introduction of stretch fabrics, now in their development stage, are not forecast in this study.

FIGURE 8

ACRYLIC AND MODACRYLIC CONSUMPTION AND CAPACITY, WITH FORECASTS TO 1970

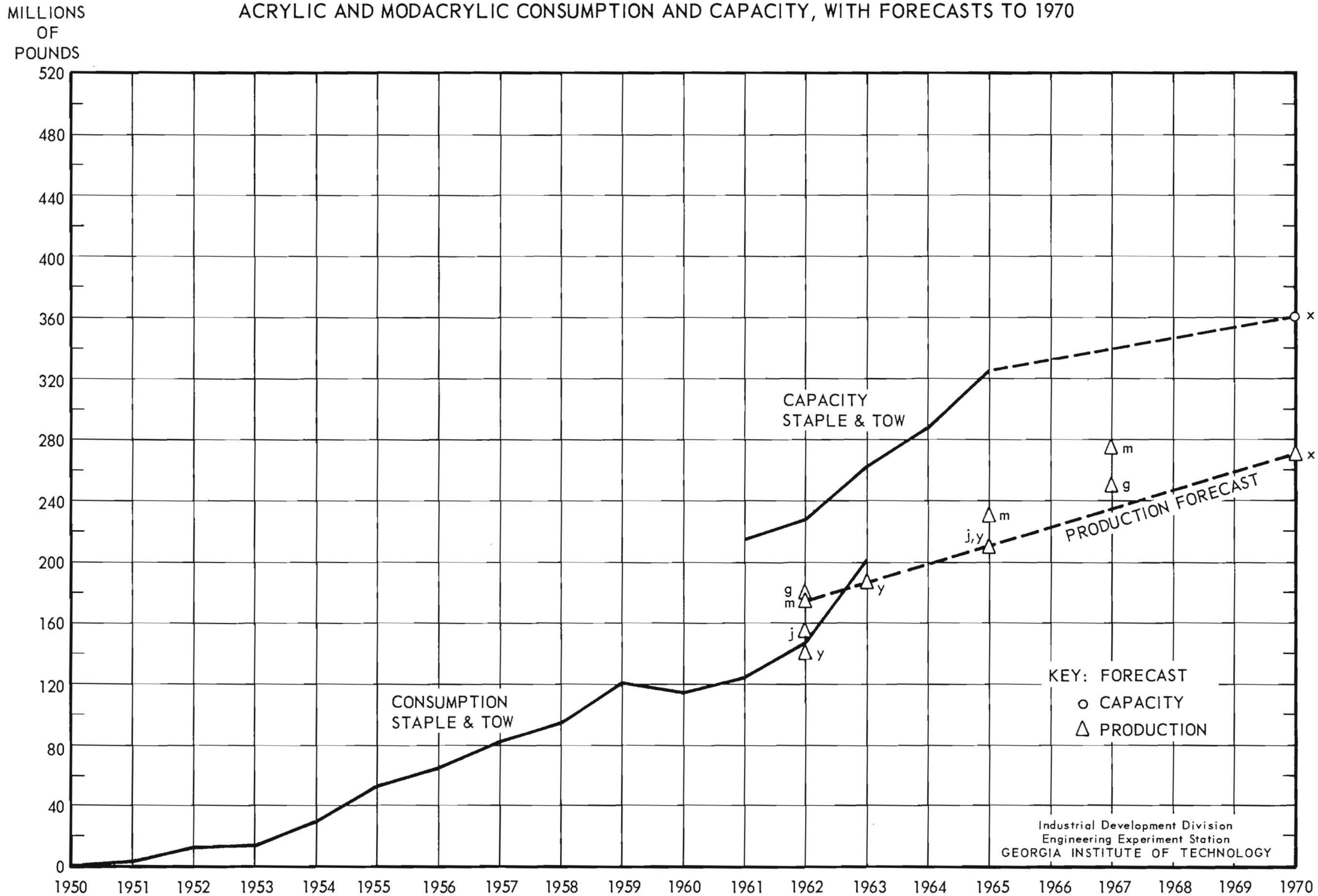


Table 7

ACRYLIC AND MODACRYLIC HISTORY AND FORECAST
Essentially Staple and Tow

(in millions of pounds)

Year	Consumption(c)	Capacity(c)	Production	Production as Approximate Per Cent of Capacity
1950	.9			
1951	2.8			
1952	12.3			
1953	12.8			
1954	29.4			
1955	54.6			
1956	65.2			
1957	82.0			
1958	96.7			
1959	120.8			
1960	116.0 140 (aa)			
1961	123.8 127 (z)	215		58
1962	147.1 143 (z)	228	140(y) 155(j) 180(g) 175(m)	66
1963	201.9	263	185(y)	76
1964		288		74
1965	215 (z)	325	210(y) 211(j) 230(m)	71
1967			250(g) 275(m)	
1970	280 (aa)	360(x)	270(x)	
1980	430 (aa)			

Sources: Alphabetic symbols refer to sources listed in Appendix 1.

Textile Glass Fibers

Capacity in 1970 is expected to be 410 million pounds a year, an increase of 90 million pounds over the 1965 planned capacity of approximately 320 million pounds. This will require the equivalent of from two to four new plants The history and forecast are shown in Figure 9 and Table 8.

Table 8

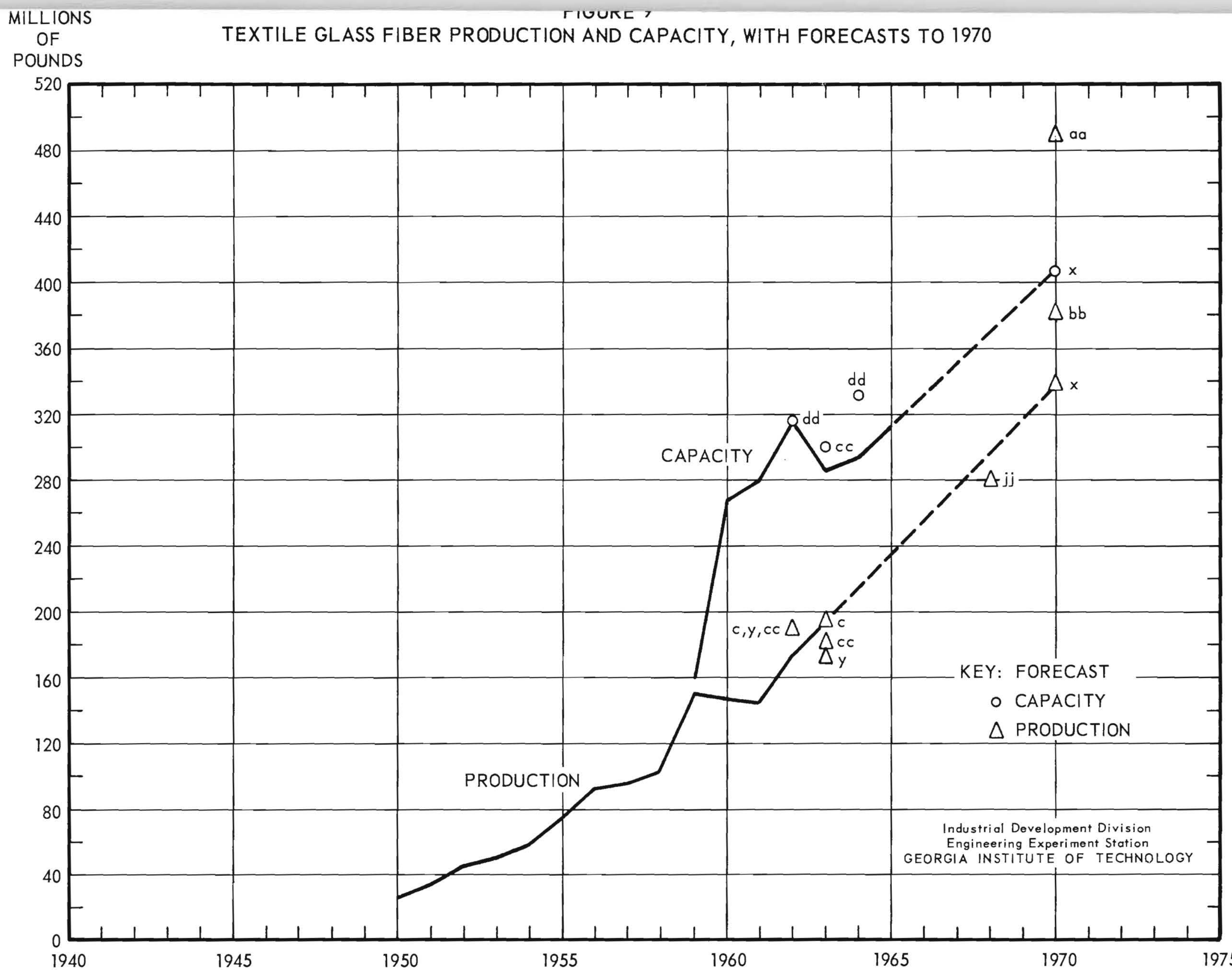
TEXTILE GLASS FIBER HISTORY AND FORECAST
(in millions of pounds)

Year	Consumption (Domestic Shipment) (c)	Production (c)	Capacity (c)	Production as Per Cent of Capacity
1950	21.3	24		
1951	30.6	35		
1952	40.9	45		
1953	46.7	50		
1954	54.7	59		
1955	76.9	76		
1956	93.9	97		
1957	96.6	111		
1958	104.1	104		
1959	151.4	147	160	92
1960	148.2	177	269	66
1961	147.2	149	281	53
1962	176.5	190 188.5(y) 189.4(cc)	319 319(dd)	60
1963	179 (cc)	194 175± (y) 180 (cc)	287 300(cc)	68
1964			292 331(dd)	
1965	217 (cc)		318	
1968		280 (jj)		
1970		340 (x) 490 (aa) 380 (bb)	410(x)	 75(x)
1980		940 (aa)		

Sources: Alphabetic symbols refer to sources listed in Appendix 1.

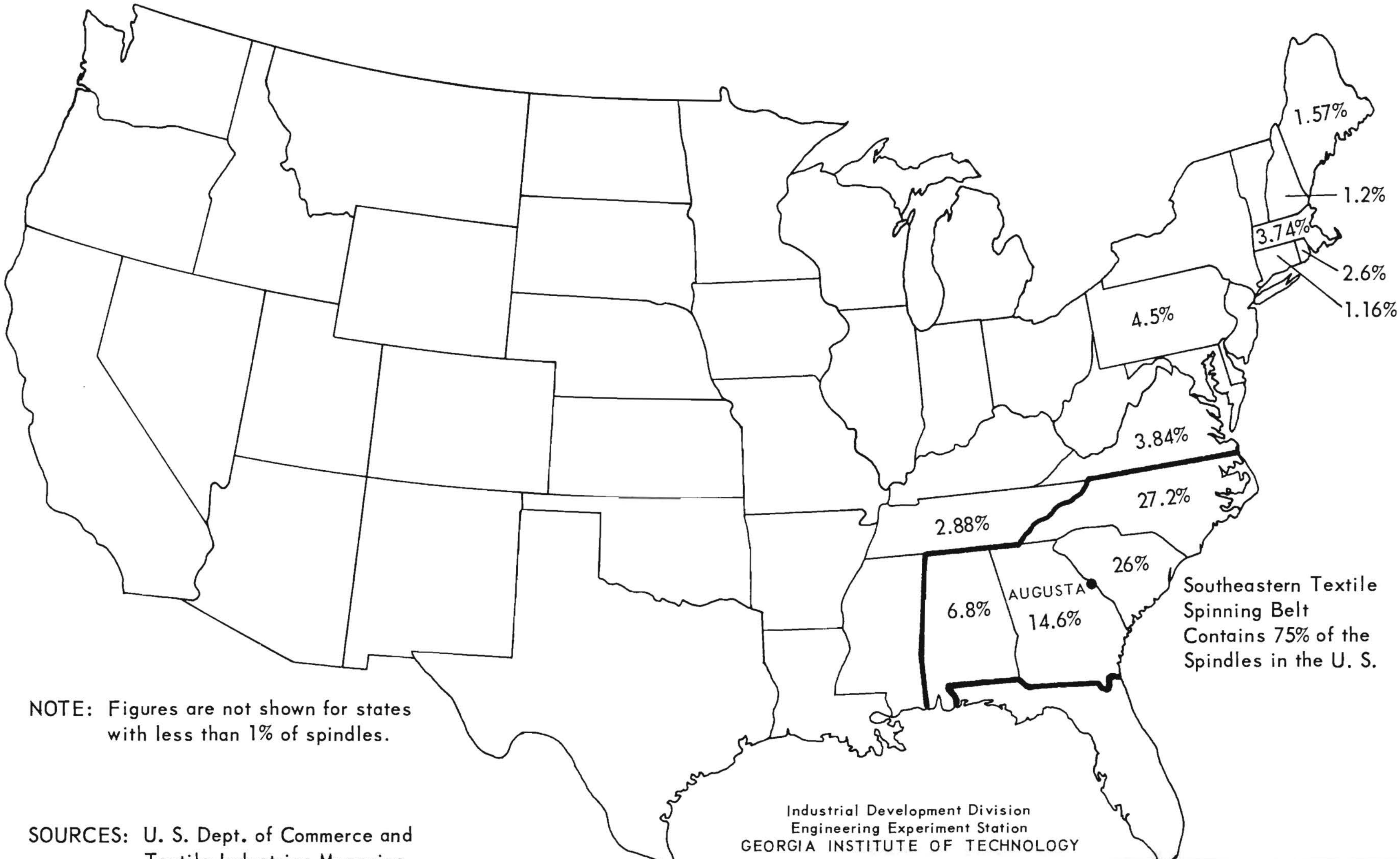
FIGURE 9

TEXTILE GLASS FIBER PRODUCTION AND CAPACITY, WITH FORECASTS TO 1970



SOURCES: Alphabetic Symbols Refer to Data Sources in Appendix 1.

MAP 1
MARKETS FOR TEXTILE STAPLE FIBERS BY STATE
(Percentage Represents the State's Proportion of Spindles for Spinning in the U. S.)



NOTE: Figures are not shown for states with less than 1% of spindles.

SOURCES: U. S. Dept. of Commerce and Textile Industries Magazine

Industrial Development Division
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY

ADVANTAGES OF THE AUGUSTA AREA AS A LOCATION FOR MAN-MADE FIBER PLANTS

Location in the Market Area

The market for man-made fibers is concentrated in the Southeast. Augusta is in the middle of the southeastern textile spinning belt which lies in Alabama, Georgia, North Carolina, and South Carolina, and contains 75% of the spindles in the U. S. (See Map 1.) The spinning mills are the market for staple and tow.

The markets for continuous filaments are the weaving and knitting mills, and 71% of the looms are located within the same belt mentioned above. The knitting mills are not as concentrated, however. The four-state belt contains 40% of the knitting machines in the U. S., but 92% of the knitting machines are within 700 miles of Augusta.

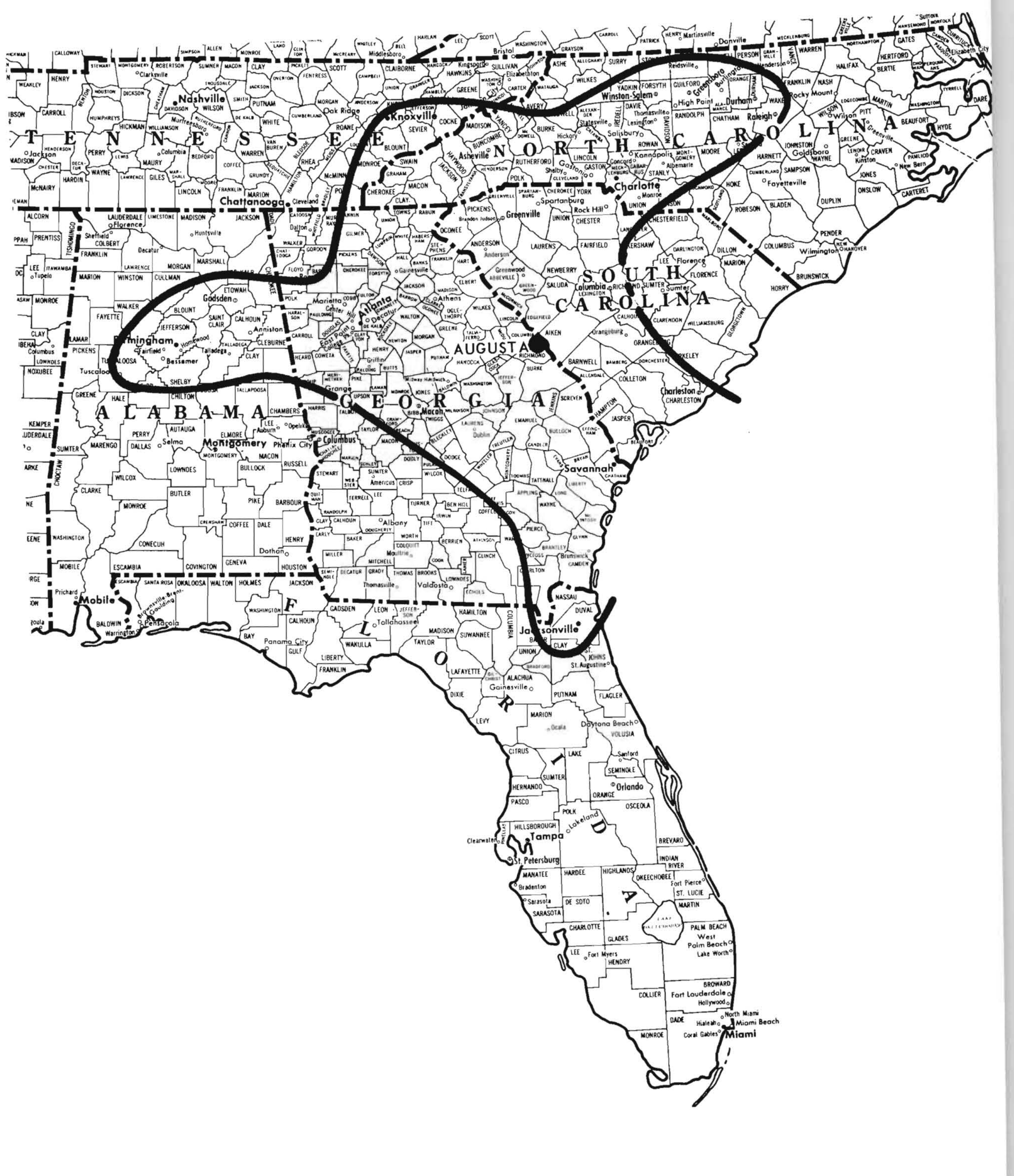
Transportation Facilities

The transportation facilities in the Augusta area will provide a man-made fiber plant the services needed for marketing and distribution, and for obtaining raw materials and supplies. The airline service will be of particular interest to management. Transportation services are provided by 75 trucking companies, four railroads, three airlines, and an inland port with barge lines serving points along the Atlantic Intracoastal Waterway system.

Truck Service. The majority of shipments from man-made fiber plants are by truck. Cities and areas to which truckload shipments may be sent in one day, or overnight, from Augusta are shown on Map 2. Direct, single-line service between major U. S. cities and the Augusta area is furnished by numerous interstate carriers. Augusta has 40 motor carriers with certificated interstate operating rights to transport "general commodities" with the "usual exceptions." The large number of carriers creates competition for freight which tends to reduce rates and improve service. Augusta has good highway access to the southeastern textile belt, and Interstate Highway 20, now under construction, will pass through the city.

Rail Service. Raw materials are brought into man-made fiber plants mainly by rail. Lower rail rates usually exist in areas where shipment by water is possible, as in the Augusta area. The four railroads that serve the Augusta

MAP 2
ONE-DAY TRUCKLOAD SERVICE FROM AUGUSTA



area are Central of Georgia Railway (part of Southern Railway System), Atlantic Coast Line Railroad, Georgia & Florida Railroad, and Georgia Railroad.

Railroads serving Georgia have led the railroad industry in designing modern cars with broad applications. Routings from several points in Texas and Louisiana to points in Georgia have been checked and are adequate for handling the new 30,000-gallon tank car.

The locations of railroads in the Augusta area are shown on Map 3.

Trailer-on-flatcar rail service, better known as "piggyback," is available at Augusta.

Of the five basic piggyback plans, plans 2 and 3 are the standard service in Augusta. Under plan 2, the railroad owns or leases trailers and bills the shipper direct for its services at rates competitive with those charged by trucking firms. The railroad provides door-to-door service and deals with the shipper on a direct basis.

Plan 3 provides that railroads carry trailers owned or leased by shippers, at a flat rate per mile. The shipper delivers trailers to the railroad, and the railroad puts them aboard flatcars, ties them down, transports them to their destination, and grounds them. The shipper picks them up at the rail terminal.

Plans 1 and 4 are little used in Augusta; plan 5 is nonexistent, according to published tariffs. Under plan 1, railroads carry trailers owned by motor common carriers. The shipper pays regular truck rates to the motor carrier and has no contact himself with the railroad. Under plan 4, the railroad provides only motive power and rails. The shipper provides owned or leased flatcars and trailers and takes care of pickup, delivery, loading, unloading, and tie down. Charges are assessed on a movement basis without commodity classifications. Plan 5 is similar to plan 1, operationally. Normally it involves a truck road haul on one or both ends of the rail movement; the shipper pays joint rail-truck rates.

Specific piggyback service plans available between Augusta and selected cities in other states are presented in Table 9. In addition 11 Georgia connections are available.

MAP 3
THE CENTRAL SAVANNAH RIVER AREA

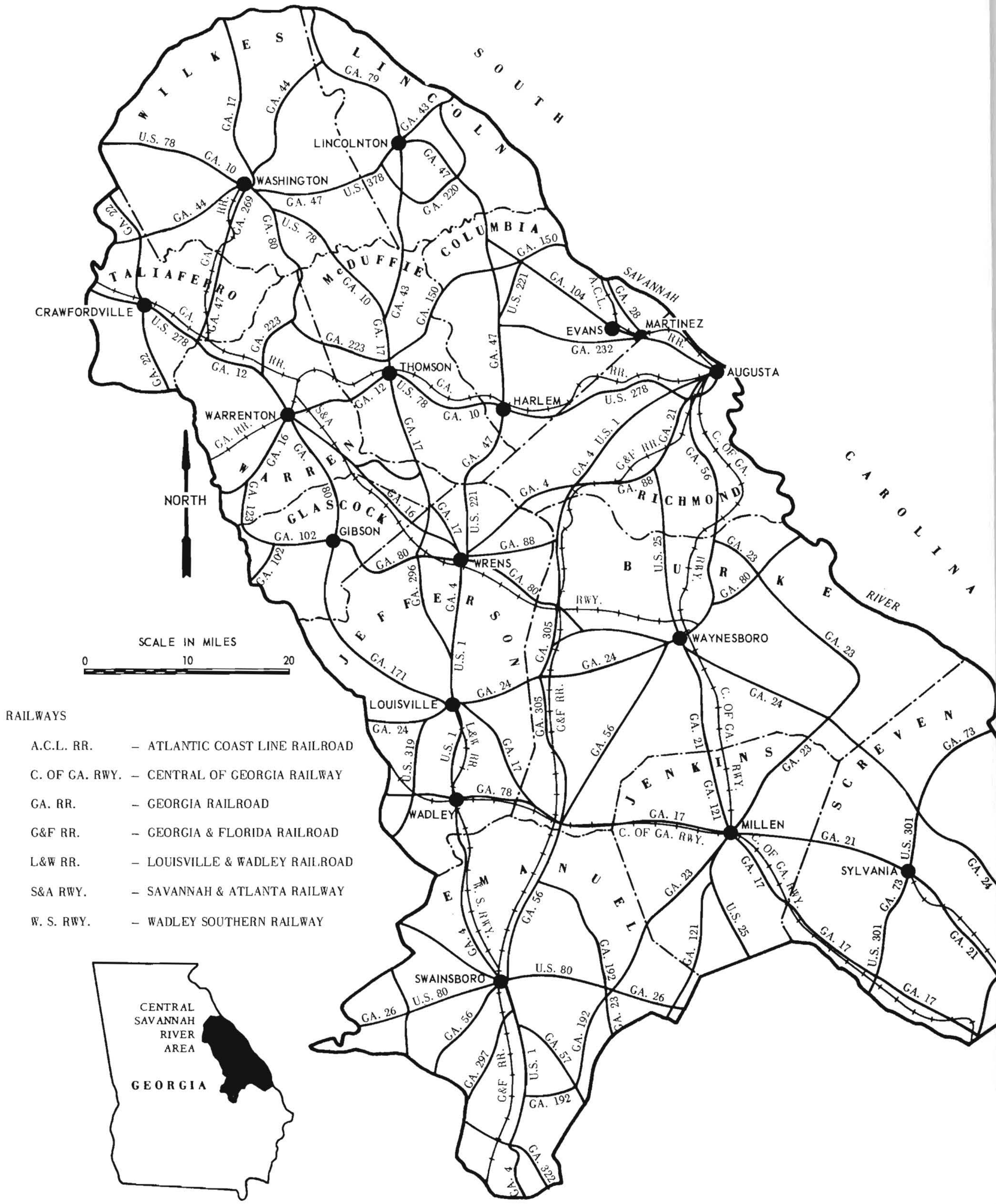


Table 9

SELECTED AUGUSTA PIGGYBACK SERVICE CONNECTIONS
(Plans in effect to and from selected cities)

Cities	Plans	Cities	Plans
Baltimore, Md.	2	Louisville, Ky.	2-3
Birmingham, Ala.	2-3	Memphis, Tenn.	2-3-4
Boston, Mass.	2-3	Miami, Fla.	2-3
Buffalo, N. Y.	2-3	Mobile, Ala.	2-3
Charleston, S. C.	2-3	Monroe, La.	2
Chattanooga, Tenn.	2-3	Montgomery, Ala.	2-3
Chicago, Ill.	2	Nashville, Tenn.	2-3
Cincinnati, Ohio	2-3	New Orleans, La.	2-3
Columbia, S. C.	2-3	New York, N. Y.	2
Columbus, Ohio	2	Norfolk, Va.	1-2-3
Dallas, Tex.	2	Oklahoma City, Okla.	2
Detroit, Mich.	2	Orlando, Fla.	2-3
Ft. Lauderdale, Fla.	2-3	Pensacola, Fla.	2-3
Ft. Worth, Tex.	2	Philadelphia, Pa.	2
Gary, Ind.	2	Portsmouth, Va.	2-3
Greenville, S. C.	2-3	Richmond, Va.	1-2-3
Hammond, Ind.	2	St. Louis, Mo.	2-3
Houston, Tex.	2	St. Petersburg, Fla.	2-3
Huntsville, Ala.	2-3	San Antonio, Tex.	2
Jacksonville, Fla.	2-3	Shreveport, La.	2
Knoxville, Tenn.	2-3	Tampa, Fla.	2-3
Lake Charles, La.	2	Washington, D. C.	2
Lexington, Ky.	2-3	West Palm Beach, Fla.	2-3
Little Rock, Ark.	2	Winston-Salem, N. C.	3

Air Transportation. Augusta is served by three airlines: Delta, Eastern, and Piedmont. The passenger accommodation facilities of the airport are good. They include taxi service, rent-a-car service from three national concerns (Hertz, Avis, and National), new hotel facilities with a cocktail lounge and swimming pool, and a restaurant. The airport has a jet runway and handles over 100,000 aircraft a year with no traffic problem. Over 60,000 of these are commercial aircraft.

Augusta has a second field (Daniel Field), located inside the city limits, which is used primarily by private and business planes.

Delta, Eastern, and Piedmont airlines operate a total of 24 daily schedules in and out of Augusta. Cities which may be reached from Augusta without changing planes are shown on Map 4. Many other cities and flights connect wit the Augusta service, mainly at Atlanta and Charlotte.

Water Transportation. Some man-made fiber plants receive raw materials b barge. Augusta is the head of navigation of the Savannah River and the most inland port in the Southeast on the Atlantic Intracoastal Waterway system.

The Augusta State Docks include one barge berth totaling 200 lineal feet, one transit shed of 42,500 square feet, marginal tracks, and equipment for handling liquid or solid bulk commodities and general cargo. The channel, with a controlling project depth of 9 feet and width of 90 feet, runs some 188 miles to the Port of Savannah, from which the Atlantic section of the Intracoastal Waterway may be reached. Over a year's time the controlling depth wil be 9 feet about 45% of the time, 8 feet 75% of the time, and 7½ feet 100% of the time. The highest flows occur in the period from January through June, with the flows declining some during the summer and the lowest flows occurring from October through December. Ability to maintain this minimum depth is assured by the substantial storage of water that exists above Augusta. (See section on "Water Supplies and Waste Disposal.")

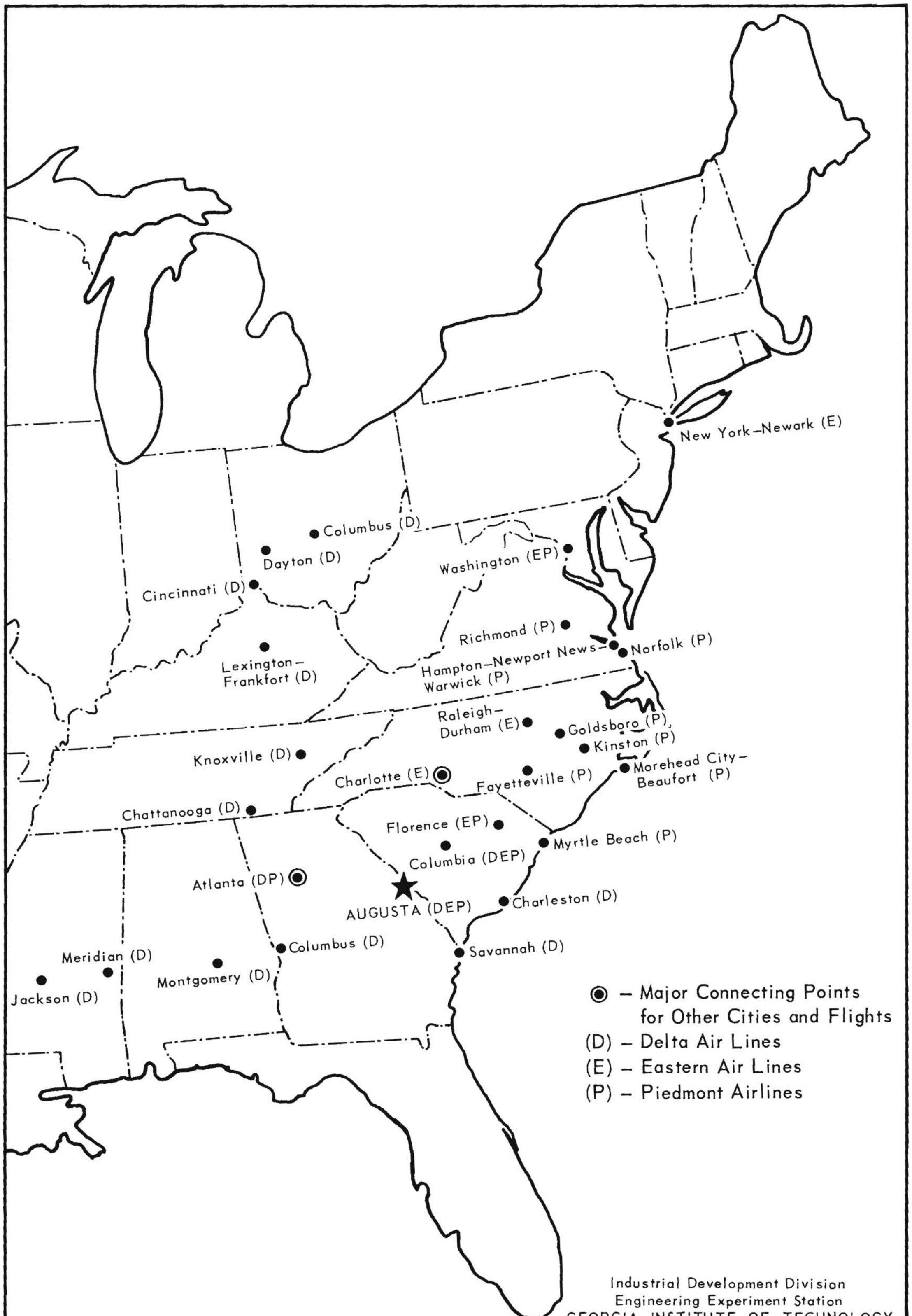
The single lock on the Savannah River (New Savannah Bluff Lock and Dam) has inside dimensions of 56 feet by 360 feet and a lift of 15 feet. It will accommodate one standard barge or four "Warrior" barges at one time. The Atlantic Intracoastal Waterway is scheduled to be connected to the Gulf Intracoastal Waterway in 1972 when the cross-Florida barge canal, which is now unde construction, is completed. (See Map 5.)

The Merry Shipping Company, Inc., of Augusta is currently operating barge to and from Augusta. It operates as an exempt carrier between Augusta and points along the Atlantic Intracoastal Waterway and has recently obtained common-carrier rights. Two other barge firms also have obtained such rights -- O. J. Willis, Inc., of Paulsboro, N. J. and S. C. Loveland Company of Philadelphia.

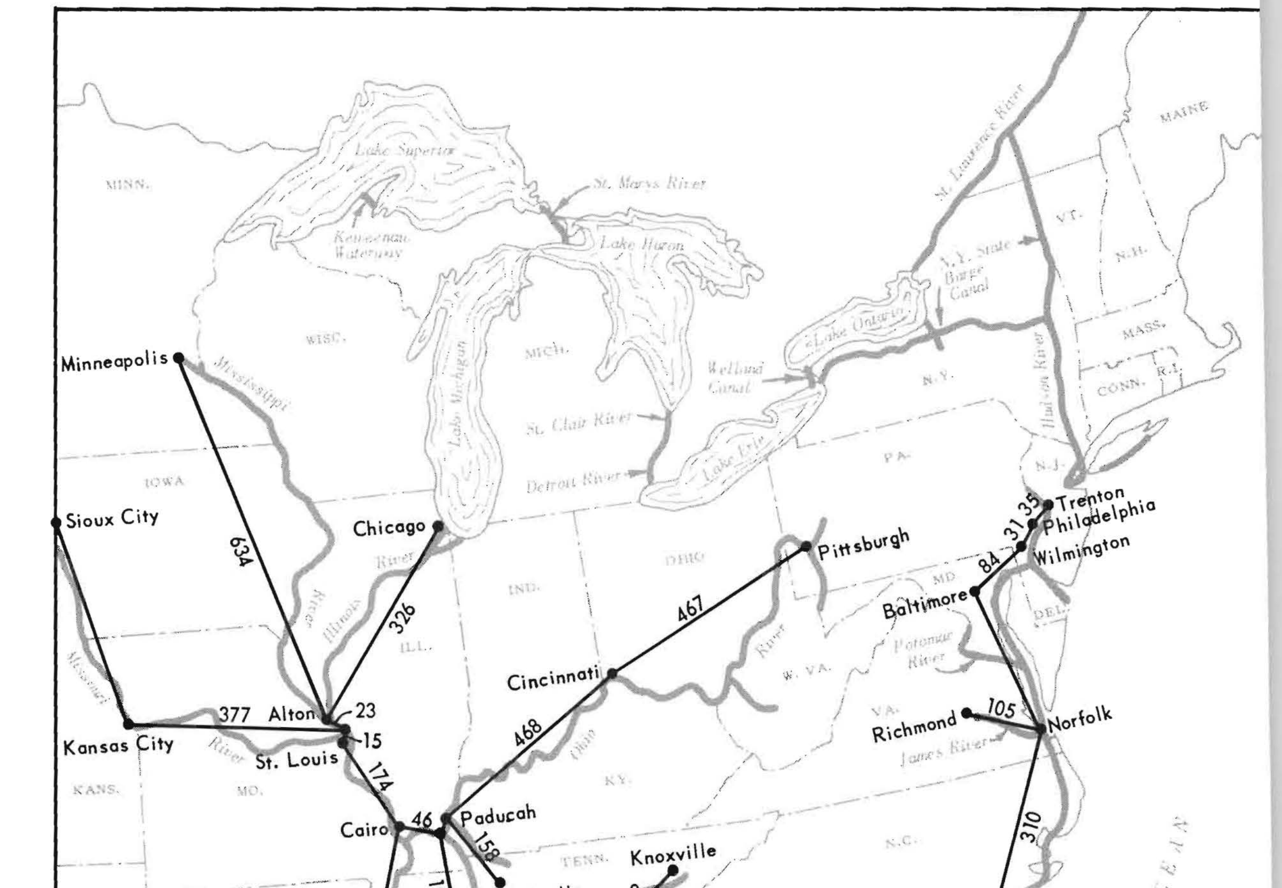
Water Supplies and Waste Disposal

One of the outstanding features of the Augusta area is its water resource and its waste-disposal capacity. This is in contrast to many other communities in the U. S. that are faced with water-supply limitations and pollution problem

MAP 4
CITIES WITH DIRECT AIRLINE SERVICE TO AND FROM AUGUSTA



MAP 5
WATERWAYS OF THE EASTERN UNITED STATES



The large quantities of good quality water that are required by man-made fiber manufacturers are available in the Augusta area from two sources -- ground water from wells and the Savannah River. The Savannah River discharges an average of about 10,000 cubic feet per second at Augusta, with extremes of 5,000 and 30,000 cubic feet per second. The river flow at Augusta is regulated by two large reservoirs, Clark Hill and Hartwell, which cover 126,000 acres and have storage for river flow regulation alone amounting to over 100 billion cubic feet. This storage is in addition to the power pool and is designed for a minimum flow of 5,800 cubic feet per second for navigation.

Augusta, located near the northern border of the Coastal Plain province, is underlain by a large Cretaceous sand aquifer. Yields from existing wells range from 50 to 1,200 gallons per minute; water is generally soft, with a temperature of about 65° F.

The river also provides waste-disposal facilities for a man-made fiber plant. The Savannah River below Augusta is free-running (without impoundment, except for one small navigation dam) for 200 miles through sparsely populated areas before it reaches Savannah, Georgia, and the Atlantic Ocean.

The city of Augusta began construction in 1963 of a $3 million sewage treatment plant with a capacity of 24 million gallons per day to handle the increasing population of the Augusta area.

Natural Gas and Other Fuel Costs

Natural gas fulfills most industrial fuel requirements in Augusta because of the attractive low rates. Firm gas can be purchased for 40¢ per thousand standard cubic feet (SCF), and interruptible rates run 26¢ per thousand SCF. Similar rates apply in much of Georgia and Alabama. While rates are lower in Mississippi, Louisiana, and Texas, they are higher in South Carolina and other more northern states along the pipelines. Augusta is the farthest point from the wellheads which has reasonable gas rates.

Table 10 presents data on natural gas rates in Augusta and in 21 other cities. Costs of the other fuels used in the Augusta area (coal, fuel oil, and liquefied petroleum gas) are presented in Table 11.

Table 10

COMPARATIVE NATURAL GAS RATES FOR 23 U. S. CITIES

	10,000 Therms/mo (1,000 MCF)1/	50,000 Therms/mo (5,000 MCF)2/	100,000 Therms/mo (10,000 MCF)2/
Oklahoma City, Okla.	$254	$1,044	$1,945
Houston, Tex.	268	1,000	(a)
Memphis, Tenn.	412	1,282	2,213
Augusta, Ga.	467	1,380	2,760
Columbus, Ga.	478	1,574	2,858
Kansas City, Mo.	488	1,314	2,558
San Francisco, Cal.	598	2,614	4,964
Louisville, Ky.	602	2,540	4,890
Gaffney, S. C.	611	1,919	3,319
St. Louis, Mo.	612	(a)	(a)
Cincinnati, O.	628	3,108	6,209
Columbia, S. C.	665	(b)	(b)
Athens, Tenn.	675	2,210	4,410
Cleveland, O.	678	3,133	6,083
Knoxville, Tenn.	724	3,173	4,188
Chicago, Ill.	741	1,575	3,150
Nashville, Tenn.	750	1,500	3,000
Richmond, Va.	780	3,580	7,080
Bristol, Va.	795	2,300	4,550
Detroit, Mich.	838	2,366	4,731
Chattanooga, Tenn.	845	2,290	4,340
Syracuse, N. Y.	968	3,471	6,921
Charlotte, N. C.	1,176	2,325	4,263

1/ Firm service

2/ Interruptible service.

(a) Rates negotiated by special contract

(b) Rates not quoted

Source: Based on American Gas Association Rate Book, September 23, 1963.

Table 11

COMPETITIVE FUEL DATA FOR AUGUSTA, GEORGIA

Fuel	Current Cost per Unit	Cost per Therm as Purchased
#2 Fuel Oil	13.35¢ per gallon	9.60¢
#2 Fuel Oil (special contract)	10.17¢ per gallon	7.32¢
#5 Fuel Oil	8.60¢ per gallon	5.85¢
#5 Fuel Oil (special contract)	7.90¢ per gallon	5.40¢
#6 Fuel Oil	7.00¢ per gallon	4.61¢
#6 Fuel Oil (special contract)	6.75¢ per gallon	4.44¢
Stoker Coal (nut and slack)	$9.00 per ton	3.38¢
Steam Coal (nut and slack) (special contract)	$8.87 per ton	3.33¢
LP Gas (large volume)	10.04¢ per gallon	10.93¢
Natural Gas (part firm)[a/]	2.80¢ per therm	2.80¢
Natural Gas (interruptible)	2.76¢ per therm	2.76¢

a/ Atlanta Gas Light Company average costs for 12 months ending September 30, 1962.

Source: Atlanta Gas Light Company (October 1, 1962).

Electric Power

The Georgia Power Company serves approximately 90% of the state's area, including Augusta. Typical monthly electric bills for three rates of power consumption are shown for Augusta and 63 other U. S. cities in Table 12. It is the general policy to extend service to the customer's premises and to supply transformers to provide standard voltages.

Manpower

The single greatest asset of the CSRA, according to a recent survey of manufacturers in the area, is the "excellent labor climate." Most of the labor-intensive firms interviewed gave the availability of labor as the single most decisive reason for locating a plant in the area. All of the plant managers with supervisory experience in other parts of the country praised local

Table 12

TYPICAL MONTHLY INDUSTRIAL ELECTRIC BILLS
FOR 64 U. S. CITIES

(Cities of 50,000 Population and More)

	150 Kilowatts 30,000 kwh	500 Kilowatts 100,000 kwh	1,000 Kilowatts 400,000 kwh
Gadsden, Ala.	$501	$1,573	$4,070
Mobile, Ala.	501	1,573	4,070
Phoenix, Ariz.	708	1,959	5,031
Little Rock, Ark.	575	1,696	4,657
Los Angeles, Cal.	423	1,262	3,422
San Francisco, Cal.	573	1,533	4,343
Denver, Colo.	559	1,589	4,374
Hartford, Conn.	727	2,103	5,798
New Haven, Conn.	566	1,626	5,166
Wilmington, Del.	615	1,711	4,744
Orlando, Fla.	650	1,750	4,875
St. Petersburg, Fla.	747	2,016	6,797
Albany, Ga.	509	1,408	3,806
Atlanta, Ga.	564	1,522	4,015
Augusta, Ga.	564	1,522	4,015
Columbus, Ga.	564	1,522	4,015
Macon, Ga.	564	1,522	4,015
Savannah, Ga.	522	1,548	4,050
Chicago, Ill.	756	2,009	5,024
Peoria, Ill.	634	1,919	5,803
East Chicago, Ind.	666	1,734	4,568
South Bend, Ind.	600	1,737	4,965
Sioux City, Ia.	649	1,965	5,870
Topeka, Kan.	540	1,681	4,599
Lexington, Ky.	609	1,801	5,176
Louisville, Ky.	565	1,673	4,460
Baton Rouge, La.	678	1,903	5,295
New Orleans, La.	582	1,565	4,525
Portland, Me.	636	2,149	5,138
Baltimore, Md.	753	2,328	6,265
Boston, Mass.	751	2,180	6,078
Detroit, Mich.	699	2,025	5,582
Duluth, Minn.	703	2,089	6,356

Table 12 (continued)

	150 Kilowatts 30,000 kwh	500 Kilowatts 100,000 kwh	1,000 Kilowatts 400,000 kwh
Jackson, Miss.	648	1,793	4,890
St. Louis, Mo.	561	1,741	5,016
Butte, Mont.	467	1,342	3,742
Lincoln, Neb.	554	1,696	4,629
Las Vegas, Nev.	522	1,583	4,421
Concord, N. H.	563	1,826	5,489
Newark, N. J.	695	1,849	4,946
Albany, N. Y.	511	1,390	3,848
Binghampton, N. Y.	637	1,781	5,150
Buffalo, N. Y.	469	1,252	3,385
New York (all boroughs)	849	2,415	6,872
Charlotte, N. C.	420	1,340	3,600
Raleigh, N. C.	433	1,385	4,065
Grand Forks, N. Dak.	838	2,346	6,821
Cincinnati, O.	643	1,728	4,760
Toledo, O.	705	2,042	6,047
Tulsa, Okla.	588	1,578	4,216
Portland, Ore.	405	1,164	2,789
Erie, Pa.	696	1,940	4,902
Pittsburgh, Pa.	606	1,663	4,560
Pawtucket, R. I.	703	2,068	5,954
Charleston, S. C.	616	1,567	4,062
Columbia, S. C.	616	1,567	4,062
Greenville, S. C.	420	1,340	3,600
Rapid City, S. Dak.	697	1,936	5,493
Knoxville, Tenn.	360	1,010	2,410
Nashville, Tenn.	360	1,010	2,410
Dallas, Tex.	602	1,610	3,917
Richmond, Va.	620	1,810	4,910
Charleston, W. Va.	536	1,398	4,693
Green Bay, Wisc.	782	2,225	5,615

Source: Federal Power Commission, Typical Electric Bills, Jan. 1, 1961 workers for their "excellent work attitudes," stating that workers in the CSRA exhibited more initiative and had greater pride in their work than members of the more sophisticated labor force in the highly industrialized parts of the country.[1/]

The personnel experience of the new General Electric Company plant in Augusta provides a comparison of Augusta workers with workers in another regio

General Electric put a replacement television tube plant in Augusta in 1959. Soon after the plant was in operation a contest was started between the new plant and a GE plant in Joliet, Illinois. Both plants were comparable in size, number of personnel, and production set-up, but the Joliet plant had bee in operation for four years. The contest, which lasted six months, covered production yields, end-production shrinkage, operating effect, tubes produced per direct operator hour, shipping and receiving, schedule realization, and the quality of the tubes on the final pre-shipping test made 30 days after pro duction. When the final score was in, the Augusta plant had received 27 out of 42 points, with the Joliet plant receiving 15 points. A. J. Kenerleber, the Augusta plant manager, who came to Augusta from the Joliet plant stated, "I've been telling other industries thinking of locating in this area that local labor can't be beat."

The cost of labor in the manufacture of man-made fibers can be a significant part of the cost. Table 13 lists some illustrations where labor account for from 3% to 53% of the manufacturing cost.

The Central Savannah River Area, located in Georgia and bordered by South Carolina, is located in a low-wage area. For comparison purposes, a special tabulation is presented in Table 14, showing what the average wage rate would be for a state if it had the same industrial composition as Georgia.

Using the New Jersey wage rate of $2.09 as 100%, Georgia and its borderin states (Alabama, Florida, North Carolina, South Carolina, and Tennessee) fall into the lowest category of 70% to 80% of the maximum rate. Vermont is the only man-made fiber manufacturing state outside of the South to fall into that category.

1/ M. Dale Henson and Robert H. McDonough, Manpower Resources in the Central Savannah River Area, Industrial Development Division, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, 1963, pp. 8, 9

Table 13

LABOR COST AS A PERCENTAGE OF TOTAL MANUFACTURING COST OF SOME MAN-MADE FIBERS

Fiber	Labor Cost (per cent of total)
Textile yarn 140/150 Denier:	
Viscose	38
Acetate	27
Nylon 6	17
Nylon 66	16
Staple:	
Viscose	10
Acetate	9
Acrylic fiber	5
Polyester	3
Monofilament nylon:	
Nylon 6	53
Nylon 66	52

Source: Man-Made Textile Encyclopedia, ed. J. J. Press, Textile Book Publishers, Inc., Division of Inter-Science Publishers, New York, 1959, p. 54.

About one-third of the states with man-made fiber plants are in the 90% and above group. States without man-made fiber plants that would show up in the low group of 70% to 80% are: Arkansas, Mississippi, New Hampshire, Maine, New Mexico, and Texas.

Table 14

WAGE RATE COMPARISONS FOR STATES WITH MAN-MADE FIBER PLANTS

	Rate--Actual Average for Each State	Rate--Based on Ga. Employment Structure	Per Cent of Highest Rate
Alabama	$1.87	$1.60	77
Connecticut	2.23	1.95	93
Florida	1.75	1.60	77
Georgia	1.55	1.55	74
Iowa	2.22	1.76	84
Kansas	2.32	2.00	96
Maryland	2.21	1.78	85
Massachusetts	1.99	1.89	90
New Jersey	2.28	2.09	100
New York	2.18	2.01	96
North Carolina	1.46	1.49	71
Ohio	2.52	2.02	97
Pennsylvania	2.22	1.86	89
Rhode Island	1.79	1.74	83
South Carolina	1.48	1.46	70
Tennessee	1.73	1.56	75
Vermont	1.82	1.66	79
Virginia	1.64	1.54	74
West Virginia	2.38	1.65	79

Source: Ronald J. Wonnacott, Manufacturing Costs and the Comparative Advantage of United States Regions, Upper Midwest Economic Study, April 1963, p. 16 (Table 2).

ADVANTAGES OF THE AUGUSTA AREA AS A LOCATION FOR PLANTS PRODUCING CHEMICAL INTERMEDIATES

Augusta, in addition to being a good location for the manufacture of man-made fibers, is also a good location for the manufacture of many of the chemical intermediates that are used as raw materials for man-made fiber plants. The factors that, together, make Augusta outstanding are:

1. proximity to the eastern concentration of fiber plants;
2. a combination of land, water, and air transportation facilities;
3. abundant water supplies and waste disposal facilities;
4. low natural gas rates; and
5. a growing chemical complex.

A good example of such an intermediate is caprolactam, used in the manufacture of nylon 6. Because of caprolactam's special shipping requirements, there would be a big advantage to producing it near or at nylon fiber plants. Cyclohexane, a principal raw material, can be barged in or brought to the site in 20,000-gallon tank cars. Other large-volume raw materials are ammonia and sulfuric acid. Anhydrous ammonia is produced by Columbia Nitrogen at Augusta, while a very low-cost source of sulfuric acid exists at The Tennessee Corporation plant at Copperhill, Tennessee.

Within the last three years, a chemical complex has been building up at Augusta. This complex produces a number of supplies and raw materials for both man-made fiber plants and chemical intermediate plants. Materials already available are:

Anhydrous ammonia	Columbia Nitrogen Corporation
Chlorine and caustic soda	Olin Mathieson Chemical Corporation (plant under construction)
Dyes and organic pigments	Augusta Chemical Company
Nitric acid	Columbia Nitrogen Corporation
Phosphoric acid	Monsanto Company
Sodium silicate solutions and glasses	E. I. du Pont de Nemours & Company Philadelphia Quartz Company (plant under construction)
Sodium tripolyphosphate	Monsanto Company
Urea	Columbia Nitrogen Corporation (plant under construction)

Other companies that are a part of the Augusta complex are Continental Can Company, Inc. (pulp and paper, crude tall oil), Southern Glassine Company (glassine paper), and The Babcock & Wilcox Company (refractory materials).

The Augusta area has an extensive wood supply for supporting a dissolving cellulose plant, the raw material for cellulosic fibers. Continental Can is the only company presently using the area's wood supply. Approximately 50% of the U. S. production capacity for dissolving cellulose is located in the Southeast at Jesup, Georgia; Fernandina Beach, Florida; Foley, Florida; and Natchez, Mississippi. The states of Washington and Alaska have most of the capacity outside of the Southeast. Some man-made fiber raw materials that could be produced in the CSRA are listed below:

- Acetaldehyde
- Acetic acid
- Acetic anhydride
- Acetone
- Acrylonitrile
- Adipic acid
- Ammonia
- Caprolactam
- Carbon disulfide
- Caustic soda
- Cellulose, dissolving
- Chlorine
- Cyclohexanone
- Cyclohexanol
- Dimethyl terephthalate
- Hexamethylene diamine
- Hydrogen cyanide
- Sulfuric acid
- Terephthalic acid

Among the area's other naturally occurring raw materials are clay and sand. Babcock & Wilcox and Merry Brothers Brick & Tile Company use large quantities of clay. The area's sand deposits, some of which appear to be suitable for glass manufacture, are not presently used to anywhere near the extent justified by the quantity available.

Movement of propylene to Augusta by pipeline from the Southwest is possible through Dixie Pipeline Company's facilities. This pipeline can provide transportation of raw materials to a polypropylene plant and subsequently to a polypropylene fibers plant. Another method for transporting propylene is the recently developed 30,000-gallon tank car.

The pipeline presently transports propane, which can be the raw material for an oxidation plant producing some of the raw materials listed above.

APPENDIX

Appendix 1

MASTER REFERENCE KEY

a. *Textile Organon*, March 1963

b. *The Demand for Textile Fibers in the United States*, U. S. Department of Agriculture, November 1963

c. *Textile Organon*, February 1964

d. *Chemical Week*, October 12, 1963

e. *Chemical and Engineering News*, October 22, 1962

f. *Petroleum Refining*, April 1963

g. *Chemical Week*, March 23, 1963

h. *Barron's*, August 27, 1962

i. *Chemical and Engineering News*, November 12, 1962

j. *Petroleum Refining*, May 1963

k. *Chemical Engineering*, November 25, 1963

l. *Oil, Paint and Drug Reporter*, November 4, 1963

m. *Chemical and Engineering News*, December 31, 1962

n. *Chemical and Engineering News*, September 10, 1962

o. *Chemical and Engineering News*, April 22, 1963

p. *Chemical Week*, February 9, 1963

q. *Oil, Paint and Drug Reporter*, July 8, 1963

r. *Plastic World*, April 1963

s. *Chemical and Engineering News*, May 13, 1963

t. *Chemical Week*, October 6, 1962

u. *Chemical and Engineering News*, November 19, 1962

v. *Chemical Engineering*, April 27, 1964

w. Sources of forecast are from IDD's special files of interviews with people in the industry.

x. Industrial Development Division forecast

y. *Chemical and Engineering News*, September 2, 1963

z. *Chemical Week*, October 20, 1962

aa. Hans H. Landsberg and others, *Resources in America's Future*, The Johns Hopkins Press, Baltimore, Maryland, 1963.

bb. *Barron's*, September 16, 1963

cc. *Chemical and Engineering News*, November 11, 1963

dd. *America's Textile Reporter*, January 17, 1963

ee. *America's Textile Reporter*, May 30, 1963

Appendix 1 (continued)

MASTER REFERENCE KEY

ff. America's Textile Reporter, November 28, 1963

gg. Printer's Ink, August 31, 1962

hh. Oil, Paint and Drug Reporter, March 4, 1963

ii. Chemical Week, March 30, 1963

jj. Chemical and Engineering News, November 4, 1963