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THE ECONOMIC FEASIBILITY

of

ACTIVATED CARBON PRODUCTION

in the

El Dorado, Kansas Area

VOLUME I

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INTRODUCTION

In the summer of 1966, the Kansas State Geological Survey, the city of El Dorado, and two of the state's universities, the University of Kansas and Wichita State University, joined together to initiate a new concept in industrial development. The Mineral Resources Section of the Kansas Geological Survey supplied funds, through research grants, to the University of Kansas and Wichita State University to conduct feasibility studies of the industrial development of a mineral resource of the El Dorado, Kansas area. The project was broken down into two sections: first, the Economics Department of Wichita State University was to develop an economic feasibility study in order to determine a market cost-and-production analysis for the selected mineral resource. Secondly, the Chemical and Petroleum Engineering Department of the University of Kansas was to develop a production feasibility study to determine whether production of the product chosen was possible from the existing basic materials by available production techniques.

The initial step in the project was the selection of eighteen possible mineral resources of the El Dorado, Kansas area by the representatives of the city. These choices were evaluated by the Knasas Geological Survey and the city, with the four most promising resources selected for a detailed evaluation. The evaluation consisted of a weighted analysis of four key factors: marketability, durability, production possibilities, and growth potential. Within each key factor there were a number of subdivisions and for each subdivision a rating was given. The result of this approach was to produce a relative rating of intangible factors with the highest cumulative rating suggesting the most favorable product.

The four resources which were rated the highest were activated carbon from petroleum coke, epoxy resin, ammonia fertilizer, and salt extraction of oil field brine, in that order. The first three resources exhibited less than a five percentage point spread while the last fell almost six percentage points behind the rest. Due to the limitations of time, funds, and manpower, a detailed study of all of the resources was not possible, so the highest ranked, activated carbon, was selected for closer examination.

The project of evaluating a mineral resource of the El Dorado area required a survey of the users of activated carbon to determine the extent of the available market. The two user groups, which were covered in the mail questionnaire, were municipal water companies in Kansas, Oklahoma, and Missouri, and beet sugar companies in Colorado. The answers obtained from the municipal water companies were adjusted for the percentage responding and the ratio of towns with and without treatment facilities, in order to arrive at a population equivalent. The beet sugar producers in Colorado represented forty-five percent of the nation's beet sugar carbon usage. As a by-product of the producers section of the questionnaire, a small number of firms, who utilize activated carbon in filtering equipment and sell small quantities as a service to customers, were noted and a weighted adjustment was added for these firms.

A telephone survey of the dry cleaning establishments and the carbonated beverage producers in Wichita, Kansas, was conducted and population equivalents for these user groups were obtained.

The transportation study was developed in order to define the market area. Rates (rail and truck) were obtained from the production sites of the major activated carbon companies to selected cities in the western United States. The interface of equal transportation costs between El Dorado and the plant sites of various activated carbon producers represented the boundaries for the El Dorado market area. In order to establish the population of the market area, adjustments were made to include and/or exclude various overlapping portions of states so that only whole states were included. The only exception to this practice was the state of Texas where an evaluation of included market population was made and so noted.

The other half of the questionnaire survey dealt with the producers of activated carbon. In this area, an attempt was made to determine the production facilities, methods and sales of the activated carbon producers; however, the highly competitive nature of the industry resulted in the exclusion of a large amount of such data from the company replies. The firms did include a large volume of sales information of a general nature and this was helpful in the survey of products and applications. In order to establish the size and scope of the operations of existing producers of activated carbon, an indirect method of evaluation was used. This indirect method involved a survey of the literature regarding the corporate structure of each firm and the acquisition of activated carbon firms through mergers to estimate the size of the activated carbon production facilities which each company possessed.

To establish the cost relationship of the factors of production necessary for the production of activated carbon in El Dorado a base study of the city was conducted. In order to conduct this study, several field trips were made to El Dorado and the inputs which were required were surveyed. The officials of the city of El Dorado rendered valuable assistance during the survey and the necessary cost relationships were derived. These cost relationships deal in general terms; that is, in rates and schedules rather than in specific costs of an operational plant due to the lack of a plant input analysis.

The final phase of the project was to construct a table of feasibility for returns from an activated carbon facility at El Dorado. The basis of this table is the returns expected as a function of capital requirements and sales volume. The purpose of this diagrammatic solution is to provide a reference for profitability under various situations.

The result has been to construct a picture of the activated carbon industry and to develop a framework within which an activated carbon producer, located at El Dorado, could operate. The information gathered and derived represents a collection of data necessary for the creation of a new mineral industry at El Dorado.

This is Volume One of the economic study. Volume Two contains the detail of the material which was collected in the process of making the study, and only one copy has been produced. Volume Two has been placed in the hands of the City of El Dorado.

It is hoped that this study will lead to the development of a new industry in the El Dorado, Kansas area. Even more important, however, it is believed that there has been developed a method by which the state universities and appropriate state agencies can cooperate with local communities to develop to the fullest extent the industrial potential of the state. We hope that this arrangement will be used by many other communities as they seek to improve their economic well-being.

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PART I

ECONOMIC RESOURCES OF EL DORADO

Introduction

El Dorado is an industrial city of 12,607 persons located in Butler County which has a population of 38,430 people. It is situated in the south central section of Kansas, approximately 180 miles to the southwest of Kansas City, 180 miles to the north of Oklahoma City, and 130 miles to the northwest of Tulsa. Located 25 miles to the west is the city of Wichita, which has a population of 280,000. Location near Kansas' largest city provides El Dorado with transportation and human resources without the problems associated with large urban centers.

The city of El Dorado was founded in 1868 when B. Frank Gardy filed on the original townsite. By the year 1910 the population had grown to 3,129 persons. In the period between 1910 and 1920 the discovery of a large oil field created an economic boom which spiraled the population of El Dorado to 10,995 by 1920.[1] The El Dorado oil field has had a substantial effect on the continued growth of the city. Although the original rise in population was a result of the opening of the field and with all of the new construction which was required at the start of the exploitation of the field, the subsequent growth of the city has been due to the substantial investment in processing facilities and to various service organizations.

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[1]Report to the City Planning Commission, Comprehensive Plan, Hare & Hare planners and Black & Veatch, engineers, 1963, p. 1.

Butler County is one of 35 of Kansas' 105 counties which experienced an increase in population between 1950 and 1960. It is one of 19 counties which has shown an increase in its rural population during this period.[2] This growth can be accounted for by the substantial growth of Wichita and Sedgwick County during this same time period.

In order to determine what resources were available in El Dorado which would aid in the operation of an industrial facility for the production of activated carbon, a study of the basic resources of the community was conducted. The necessary requirements for such a facility would fall into four main groups: raw materials, power, labor, and city services. The raw materials for an activated carbon facility would be petroleum coke as the main requirement with water for steam activation as a substantial second material. In order to conduct the activation process, power would be needed to elevate the steam temperature as well as to operate other supporting activities. The labor supply and costs of city services were the final two areas studied. The information presented here has been gathered through personal interviews. The literature on rates and service costs were provided by those responsible for each service.

Resources Needed

The inputs required for the production of activated carbon are raw materials (coke and water), power (gas and electricity), labor and taxes.

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[2] *Ibid.*, p. 2.

a. Petroleum coke

The supply of petroleum coke for the production of activated carbon is the Skelly Oil Company's refinery at the south edge of El Dorado. The annual production of petroleum coke is approximately 100,000 tons and costs are estimated to be $8 per ton at the refinery. The coking unit at the Skelly Refinery is on an industrial spur and the coke is loaded directly on to railroad cars. Normally the coke is taken to a holding area and dumped until it is to be shipped from the refinery. The Skelly Refinery is on the Santa Fe railroad but switching operations between the Santa Fe and Missouri Pacific railroads are possible, which allows for a speedy transfer.

b. Water

The supply of water for industrial use is adequate for the present and is in the process of enlargement with the construction of a large surface storage reservoir.[3] The cost of treated water in the city

[3]Municipal water supply--In 1957 El Dorado as well as many other communities in Kansas experienced a water shortage. In order to avoid this problem in the future the city of El Dorado sought added capacity and reserves.

Sources:

El Dorado lake--the estimated firm yield is 1.5 million gallons per day with a potential of 3.0 million gallons per day if an eleven foot addition is made to the present dam.

Bluestem lake--the estimated firm yield of this lake is 3.6 million gallons per day.

Mulvane well supply--the city of El Dorado has available a firm daily supply of 5.4 million gallons. The water quality is much improved as of late because of improved Arkansas River conditions and better treatment of Wichita sewage.

Sewage plant effluent--an important source of industrial water is the two million gallons per day sewer plant effluent.

The total water supply available now and in the future is adequate within the present storage and reserve situations. An addition to this water supply is the Walnut River project which would be constructed on the north side of the community at approximately the site of the present Country Club golf course and would provide an estimated 20 million gallons per day by 1972.

limits of El Dorado is a minimum of $2.25 (first 300 cubic feet) with a decreasing schedule up to 50,000 cubic feet. The rate then declines to 18 cents per 100 cubic feet. The rate for users outside of the corporate limits of El Dorado but within a water benefit district is 150 per cent of the above charges. Further, the rate for users outside the corporate limits of El Dorado and not in a water benefit district is 175 per cent of the above charges. These rates are for residential users and are presented to facilitate comparison with rates elsewhere. The charge for industrial users is determined by the Waterworks Commission and varies with volume of water used.

The costs of connecting with the water system must be met by the customer. Work is done by the city and then billed immediately. A typical hook up cost is $450 for a 2" line with a meter. Installation of the connecting line costs from $1.50 to $6.50 per running foot.

c. Power

Another set of required inputs are those of electricity and natural gas. The rates for industrial users as well as the availability of these resources is presented in order to show the availability of these resources for activated carbon production.

Within El Dorado there are at present two sources of natural gas. The first is the city natural gas supply system, which is not considered adequate for industrial purposes. The priority on usage of this system is with the residential customer. When gas is purchased by the industrial user it is subject to either reduction or complete by-pass. As long as this system is operated in this manner it cannot be considered a reliable supply for the industrial user.

The Anadarko Production Company of Liberal, Kansas has installed an industrial gas line to the city to provide a non-interruptible supply of gas for Skelly Oil Company. This gas line runs along the southern edge of the city and terminates at the Skelly Refinery. The company has established a rate schedule for domestic and small commercial buyers as follows:

first 1000 cubic feet -- $1.25

second 1000 cubic feet -- $0.95

third 1000 cubic feet -- $0.80

Gas purchased in excess of 3000 cubic feet per month costs $0.60 (sixty cents) per 1000 cubic feet. The minimum charge for gas service is two dollars per meter per month.

In regard to installation of service lines, the Anadarko Production Company will pay for the installation of a service line from a point on their main line to a company-selected point near the buyers plant. The cost of installing a lateral line from the service line to the regulators, up to a sum of $150 will be paid by the supplier. The costs which exceed $150 must be met by the purchaser. The facilities which are constructed will be the property of the Anadarko Production Company and will be maintained by the company. All lines from the regulators to the plant will be constructed and maintained by the purchaser under maintenance agreements set up by the gas company.

Electric service for the El Dorado area is provided by the Kansas Gas & Electric Company. Kansas Gas & Electric Company has a total generating capacity of 778,000 kilowatts and has a demand of approximately 600,000 kilowatts. Service to El Dorado is located in an advantageous position since the transmission to other utilities is from the Wichita generating station to the El Dorado substation and then on to other utilities. Due to this collection operation El Dorado is assured of a non-interruptible supply of electric power.

d. Labor

The fourth input for the production of activated carbon is labor. The employed labor force in the El Dorado area is approximately 5,000 persons. The number of unemployed varies from 1000 persons in the winter months to less than 500 during the summer.[4]

The amount of labor available increases annually due to the consolidation of agricultural productive lands with a resultant displacement of farmers who migrate to the urban areas seeking employment. The quality of the labor force is high, and the average age of the labor force is lower than the United States average. The median number of years of school completed for the population of El Dorado is 11.2 years for males and 11.8 years for females; both figures are higher than the United States median of 10.3 and 10.9, respectively.[5]

In 1960 the age characteristics of the population of El Dorado versus the United States characteristics were as follows:

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[4] El Dorado, Kansas Summary, Chamber of Commerce Bulletin, December 1966, p. 7.

[5] Hare & Hare, et al., p. 9.

TABLE--AGE CHARACTERISTICS--1960

Male	Years	El Dorado	United States	El Dorado Difference
	14-17	4.17%	3.21%	+0.98
	18-24	13.56	12.89	+0.67
	25-34	24.45	22.34	+2.11
	35-44	21.74	23.65	-1.91
	45-64	30.82	33.21	-2.39
	65-over	6.42	4.70	+1.72
		100.00%	100.00%	
Female	14-17	5.28%	3.45%	+1.83
	18-24	14.70	16.04	-1.34
	25-34	12.40	18.37	-5.97
	35-44	18.70	23.50	-4.80
	45-64	41.94	34.55	+7.39
	65-over	6.98	4.10	+2.88
		100.00%	100.00%	

Source: Hare and Hare, Comprehensive Plan, 1963, p. 9.

Work stoppages, resulting from union disputes, are almost non-existant in the El Dorado area. The only major firms which are unionized are the two refineries and a construction firm.

e. Community Services

The last set of inputs are those required by the community: taxes, sewage and trash charges.

The office of the city clerk and county clerk has provided the following tax information based on each $1,000.00 of real and personal property (assessed value):

State levy		1.50 mills
County levy		
Mandatory levies	14.22	
County commission Controlled levies	12.04	
. .		26.26

Junior college levy	4.28
City levy or	38.59
Township levy	4.75
School District levy	variable depending on plant location
Miscellaneous levies	16.80 min -- 51.48 max
Water shed district	0.53
Fire district	1.07 min -- 2.21 max (township and city)
Sewer District	2.27 min -- 3.68 max (township only)

Total tax levy, in mills:

City	89.00 min -- 124.82 max
Township	57.43 min -- 94.66 max

In addition, a tax holiday (omission from tax roles) for a period of ten years is authorized by the state.

The charge for sewage disposal is based on the volume of waste effluent flow. The rates in the corporate limits of El Dorado are:

1st 1000 cubic feet -- \$1.90 minimum
2nd 1000 cubic feet -- \$ .15 per 100 cubic feet
Over 2000 cubic feet -- \$10 per 100 cubic feet

The rates outside the corporate limits of El Dorado are:

1st 1000 cubic feet -- \$10.00 minimum
2nd 1000 cubic feet -- \$ 8.50 minimum
Over 2000 cubic feet -- \$ .40 per 100 cubic feet

These rates are based on an effluent of not more than 1000 parts per million Biological Oxygen Demand. B.O.D's higher than 1000 ppm will be assessed a higher rate.

There are no charges for connecting to the sewer system, but the cost of a sewer line is paid by the customers. The cost for an eight inch line would be between \$6 and \$10 per foot but the type of terrain affects the cost. That is, heavy rock might double the cost of connection.

The only restriction to the waste effluent besides that of a high B.O.D. is the exclusion of oil from the sewer system.

The last of the community charges is the collection of trash. Industrial customers pay a flat rate of $9 per hour for collection of refuse.

f. Financing

The financial resources necessary to start activated carbon production are available in El Dorado. Three methods of financing could be considered--bank loan, Industrial Revenue Bonds and local stock purchase.

The banks of El Dorado can supply directly a limited amount of capital. The banking facilities of El Dorado also have the capacity to make a large loan (shared by a number of banks) and can thereby increase the amount available for the initial needs. The bank rate of interest would be in the six to seven per cent range and would only be for a percentage of the total amount needed.

Industrial Revenue Bonds have been issued by the city of El Dorado in the past to finance local industrial development. The rate of interest for Revenue Bonds is approximately five or six per cent and would cover the cost of the necessary capital equipment. The Bonds are issued for a period of twenty years. Machinery so financed would not be considered subject to the personal property tax and this adds to the attractiveness of this method of financing.

If the amount of the capital outlay is small, the necessary capital might be raised from local investors. This type of financing has been used before and the loss of money to those connected with a previous unsuccessful venture has reduced the ease with which this type of financing could be accomplished.

The information which has been presented in the preceding pages does not represent the total picture of El Dorado, but only the resources necessary for activated carbon production. In addition to these considerations, information on the climate, educational facilities, and other attributes of the community, while not discussed here, are easily available to those interested.

The second section of this base study deals with an important part of the resources of the area--the availability of fast and economical transportation. Within the structure of the transportation study is the means by which the market area for activated carbon was derived and the estimates of markets which will be considered for the purposes of this study.

PART II

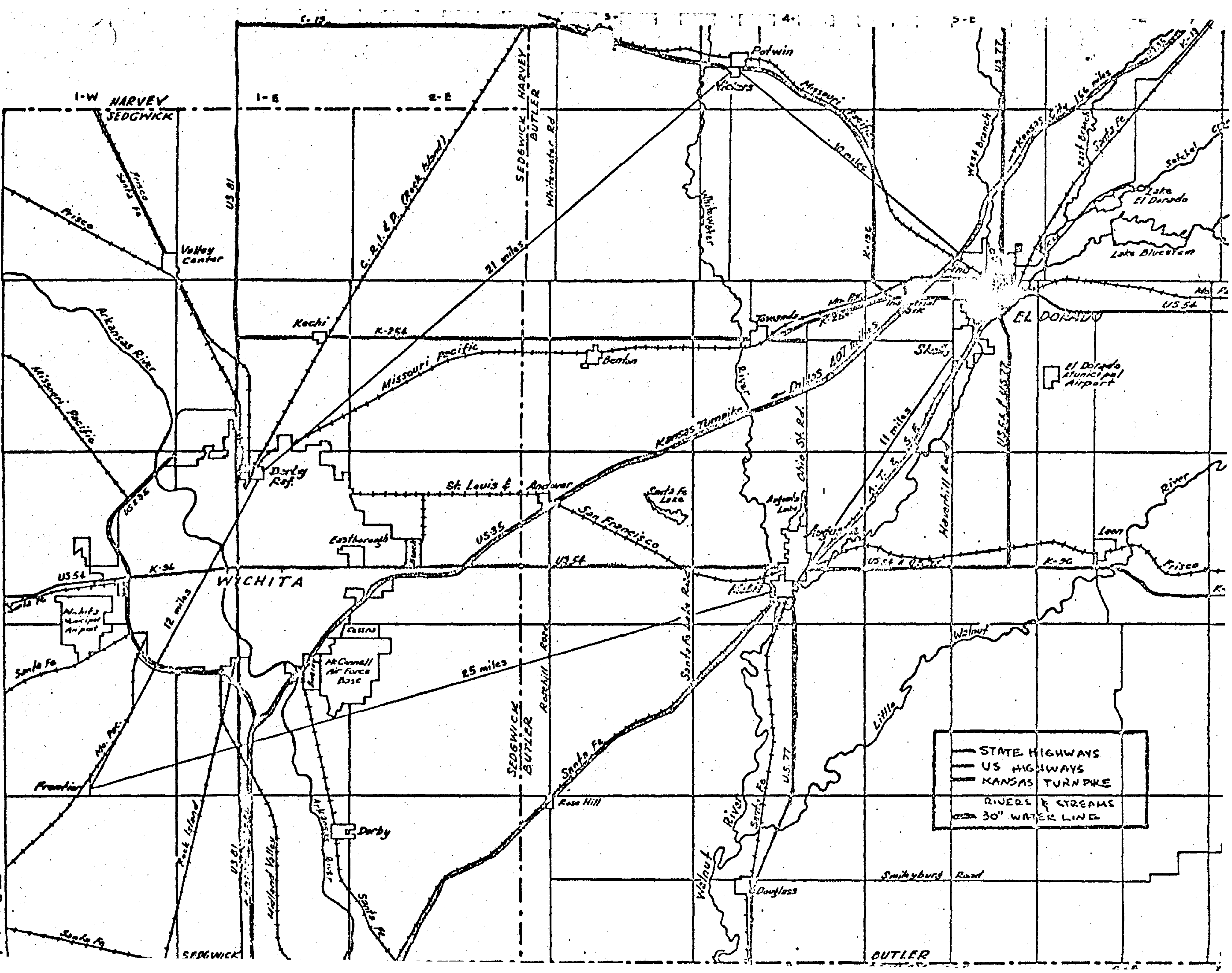
TRANSPORTATION

Transportation Facilities

El Dorado is located at the intersection of U.S. Highways 54 and 77, and in addition several Kansas highways traverse the city (K254, K196 and K13). El Dorado is adjacent to the Kansas Turnpike (I35) which links Kansas City, Topeka and Wichita via a four lane, 80 mile per hour expressway. The Kansas Turnpike and connecting Interstate highways allow a two and one-half hour travel time to Oklahoma City and Kansas City.

El Dorado is served by five regularly scheduled trucking firms and several non-scheduled carriers. These truck lines have the advantage of direct, highspeed routes to several major cities.

Railroad service to El Dorado is provided by the Atchison, Topeka and Santa Fe and the Missouri Pacific Railroads. The Santa Fe System through El Dorado is the mainline from Chicago to the South and Southwest. The Missouri Pacific System through El Dorado serves the South and Southwest plus the mountain route to the Far West. Wichita, 21 miles to the southwest is served by the Santa Fe, the Missouri Pacific, the Rock Island and the Frisco Railway Systems. The Rock Island System through Wichita serves the south and southwest plus the states to the north and northeast of Kansas. The Frisco Railway System through Wichita serves the south and the states to the east and southeast of Kansas.


HARVEY
SEDGWICK
BUTLER
1-W
1-E
2-E
Potwin
Vickers
Valley Center
Kechi
Benton
Towanda
EL DORADO
Lake El Dorado
Lake Bluestem
El Dorado Municipal Airport
Andover
Santa Fe Lake
Augusta
Leon
WICHITA
Wichita Municipal Airport
McConnell Air Force Base
Eastborough
Derby Ref.
Derby
Rose Hill
Douglass
Frontier
C.R.I.&P. (Rock Island)
Missouri Pacific
Frisco
Santa Fe
St. Louis & San Francisco
Kansas Turnpike
A.T.&S.F.
Arkansas River
Whitewater River
Walnut River
Little Walnut River
Whitewater Rd
Rosehill Road
Santa Fe Lake Road
Ohio St. Rd.
Haverhill Rd
Smileyburg Road
Midland Valley
US 81
US 54
US 77
US 35
K-96
K-254
K-196
21 miles
12 miles
25 miles
11 miles
10 miles
Kansas City 166 miles
Tulsa 107 miles
STATE HIGHWAYS
US HIGHWAYS
KANSAS TURNPIKE
RIVERS & STREAMS
30" WATER LINE

TRAN-1

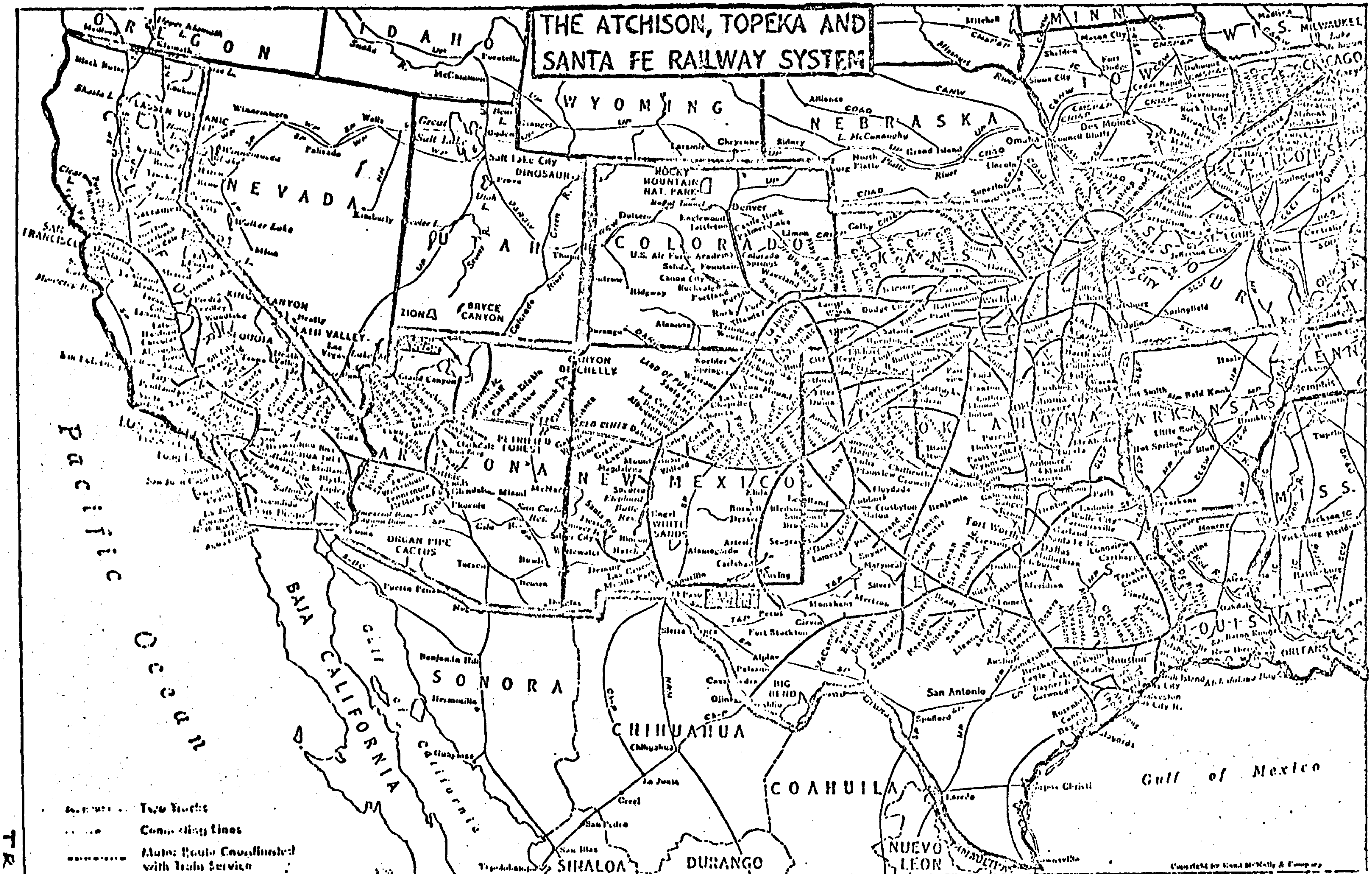
Airline connections, while not available in El Dorado, are available in Wichita, a short 45 minute drive. Air charter and facilities for private aircraft are available at the El Dorado Municipal Airport. The charter service operates five-passenger Cessna aircraft to all parts of the United States and to Mexico and Canada. The municipal airport is ten minutes from downtown, is open 24 hours a day, and has a 3000 foot lighted and paved runway. Several auxiliary runways of heavy sod are also provided.

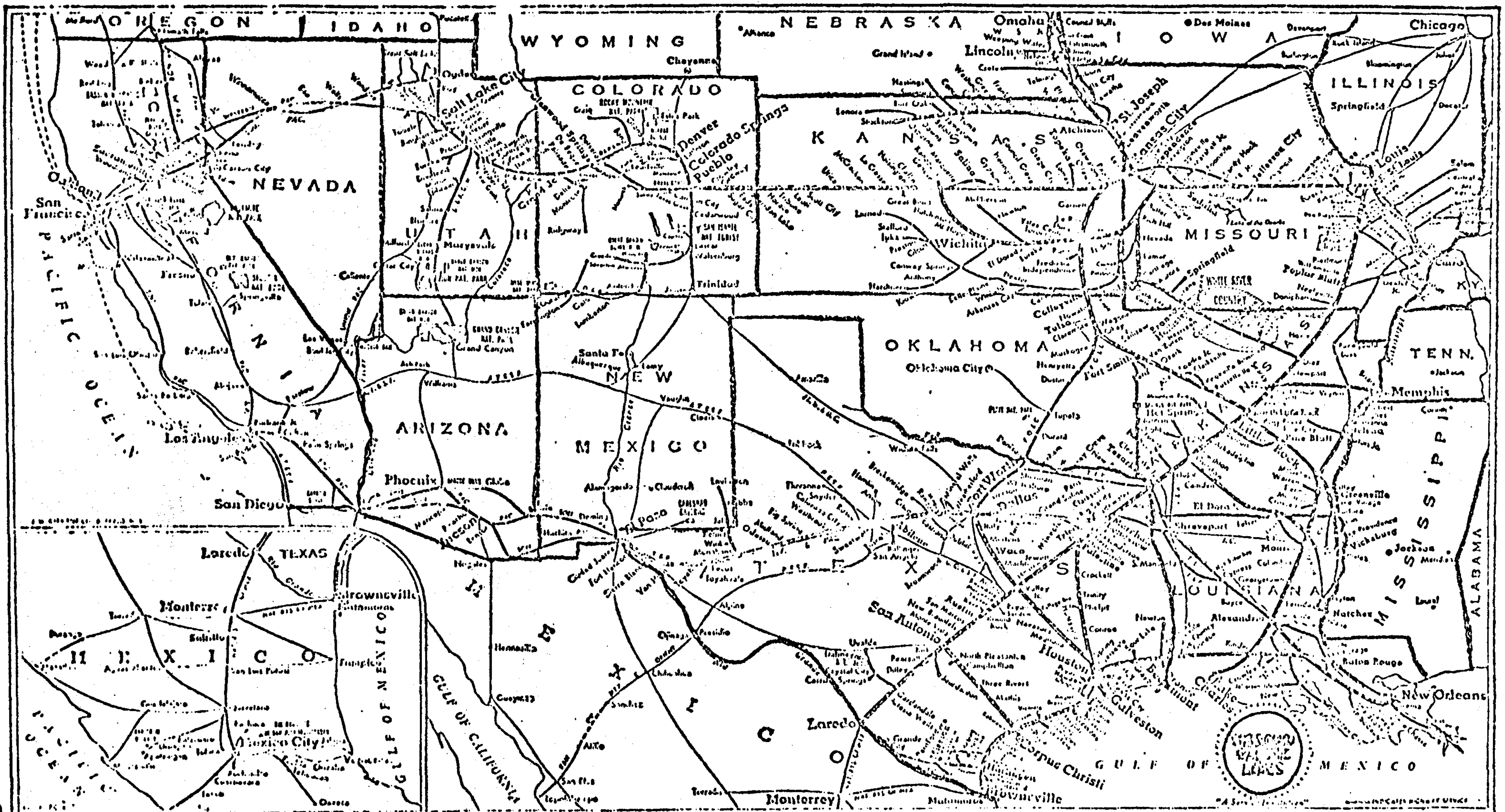
Installation Costs

Since the production of activated carbon will require the bulk shipments of certain inputs and the final product, as survey of costs related to the installation of an industrial railroad spur is included at this point.

In April, 1966, a survey of two possible railroad industrial spur lines was conducted by the Missouri Pacific Railroad for the city of El Dorado. These estimates were made for two specific locations within the area but the costs are representative of similar installations in the area. The railroad offered to construct a 715 foot track from the switching point to a terminal point in the industrial area. The cost was to be shared by the Railroad and the purchaser, with the remaining footage from the end of the railroad right of way to the terminal point being financer by the purchaser alone. Based on this survey, the cost of constructing a rail spur line from the company's operating line would be slightly more than $3 per running foot on the company right of way and almost $12 per running foot on the purchaser's property.

It should be noted that this survey was performed in mid 1966 and costs of labor and materials have increased during the subsequent time period, so these estimates may be lower than those which would be actually encountered. Also, the costs shown here do not include the special charges for telephone, telegraph or other service lines, since each location would encounter different conditions.


THE ATCHISON, TOPEKA AND SANTA FE RAILWAY SYSTEM
OREGON
IDAHO
WYOMING
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MISS.
SONORA
CHIHUAHUA
COAHUILA
NUEVO LEON
DURANGO
SINALOA
BAJA CALIFORNIA
Pacific Ocean
Gulf of Mexico
CHICAGO
Denver
Salt Lake City
Grand Canyon
PETRIFIED FOREST
ORGAN PIPE CACTUS
WHITE SANDS
BIG BEND
ZION
BRYCE CANYON
San Antonio
Fort Worth
Dallas
Houston
Two Tracks
Connecting Lines
Motor Route Coordinated with Train Service


OREGON
IDAHO
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NEVADA
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ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
MISSISSIPPI
ALABAMA
MEXICO
PACIFIC OCEAN
GULF OF MEXICO
GULF OF CALIFORNIA
Chicago
Omaha
Lincoln
Des Moines
Cheyenne
Salt Lake City
Ogden
Denver
Colorado Springs
Pueblo
Trinidad
St. Joseph
Kansas City
Jefferson City
St. Louis
Springfield
Wichita
Oklahoma City
Tulsa
Fort Smith
Memphis
Little Rock
Hot Springs
Pine Bluff
Shreveport
Fort Worth
Dallas
Waco
Austin
San Antonio
Houston
Galveston
Beaumont
Corpus Christi
Brownsville
Laredo
Monterrey
Mexico City
Vicksburg
Jackson
Natchez
Baton Rouge
New Orleans
Alexandria
El Paso
Santa Fe
Albuquerque
Phoenix
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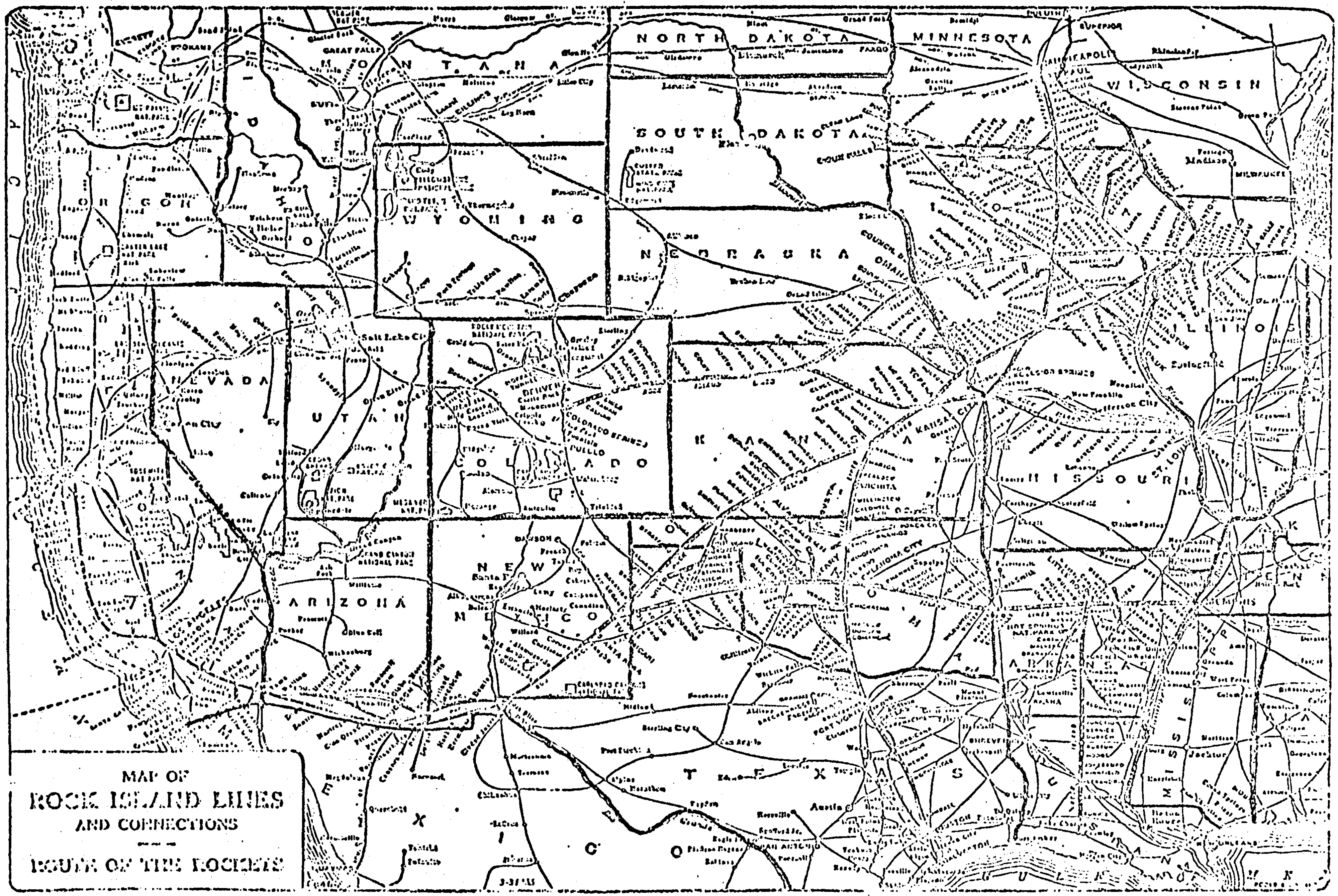
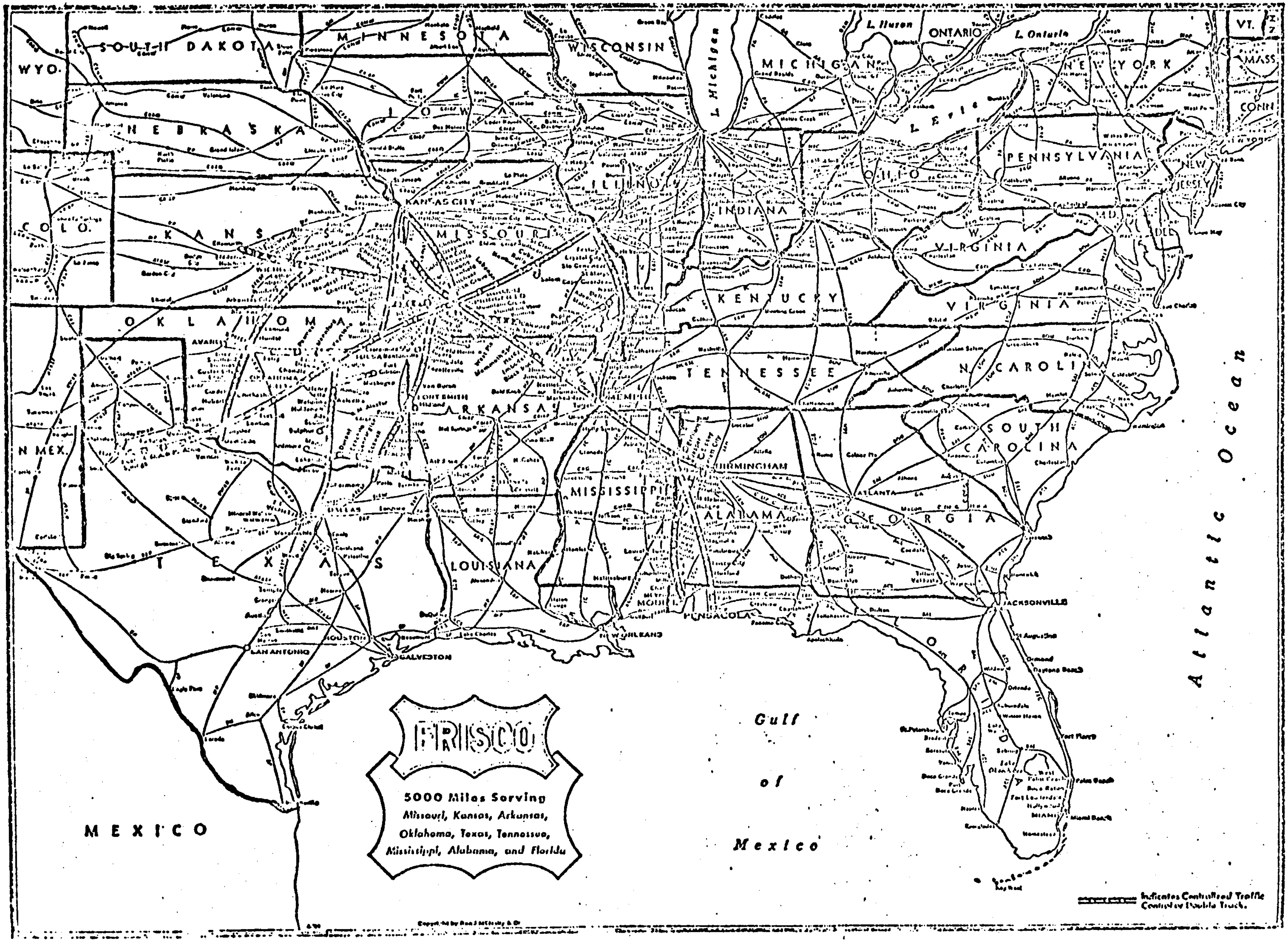
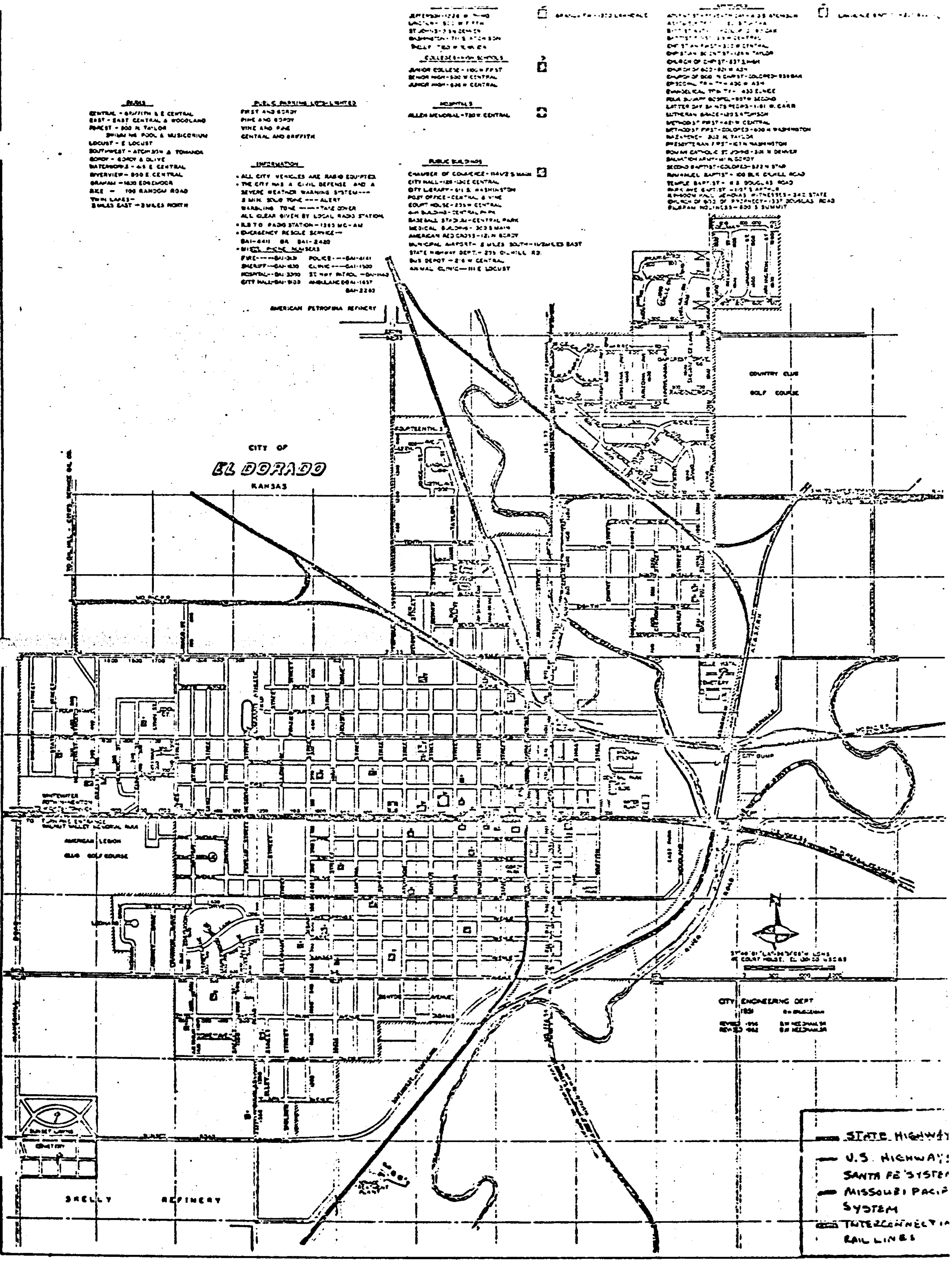
Los Angeles
San Francisco
Oakland
Fresno
Grand Canyon
Abilene
San Angelo
Del Rio
Uvalde

TRAN-3


MAP OF
ROCK ISLAND LINES
AND CONNECTIONS
ROUTE OF THE ROCKETS
MONTANA
NORTH DAKOTA
MINNESOTA
WISCONSIN
SOUTH DAKOTA
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ILLINOIS
ARIZONA
NEW MEXICO
ARKANSAS
TEXAS
MEXICO
DENVER
PUEBLO
COLORADO SPRINGS
KANSAS CITY
WICHITA
FORT WORTH
OMAHA
COUNCIL BLUFFS
SUPERIOR
Salt Lake City
Cheyenne
Milwaukee
Madison
Sioux Falls
Austin

TRAN-4


FRISCO
5000 Miles Serving
Missouri, Kansas, Arkansas,
Oklahoma, Texas, Tennessee,
Mississippi, Alabama, and Florida
SOUTH DAKOTA
MINNESOTA
WISCONSIN
MICHIGAN
ONTARIO
L. Huron
L. Ontario
L. Michigan
NEW YORK
MASS.
CONN.
VT.
WYO.
IOWA
NEBRASKA
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW JERSEY
COLO.
KANSAS
KANSAS CITY
MISSOURI
W. VIRGINIA
KENTUCKY
VIRGINIA
OKLAHOMA
TENNESSEE
N. CAROLINA
ARKANSAS
MEMPHIS
SOUTH CAROLINA
N. MEX.
BIRMINGHAM
ATLANTA
MISSISSIPPI
ALABAMA
GEORGIA
TEXAS
DALLAS
LOUISIANA
JACKSONVILLE
HOUSTON
GALVESTON
SAN ANTONIO
PENSACOLA
MOBILE
NEW ORLEANS
FLORIDA
MIAMI
MEXICO
Gulf of Mexico
Atlantic Ocean
Indicates Controlled Traffic Control or Double Track.

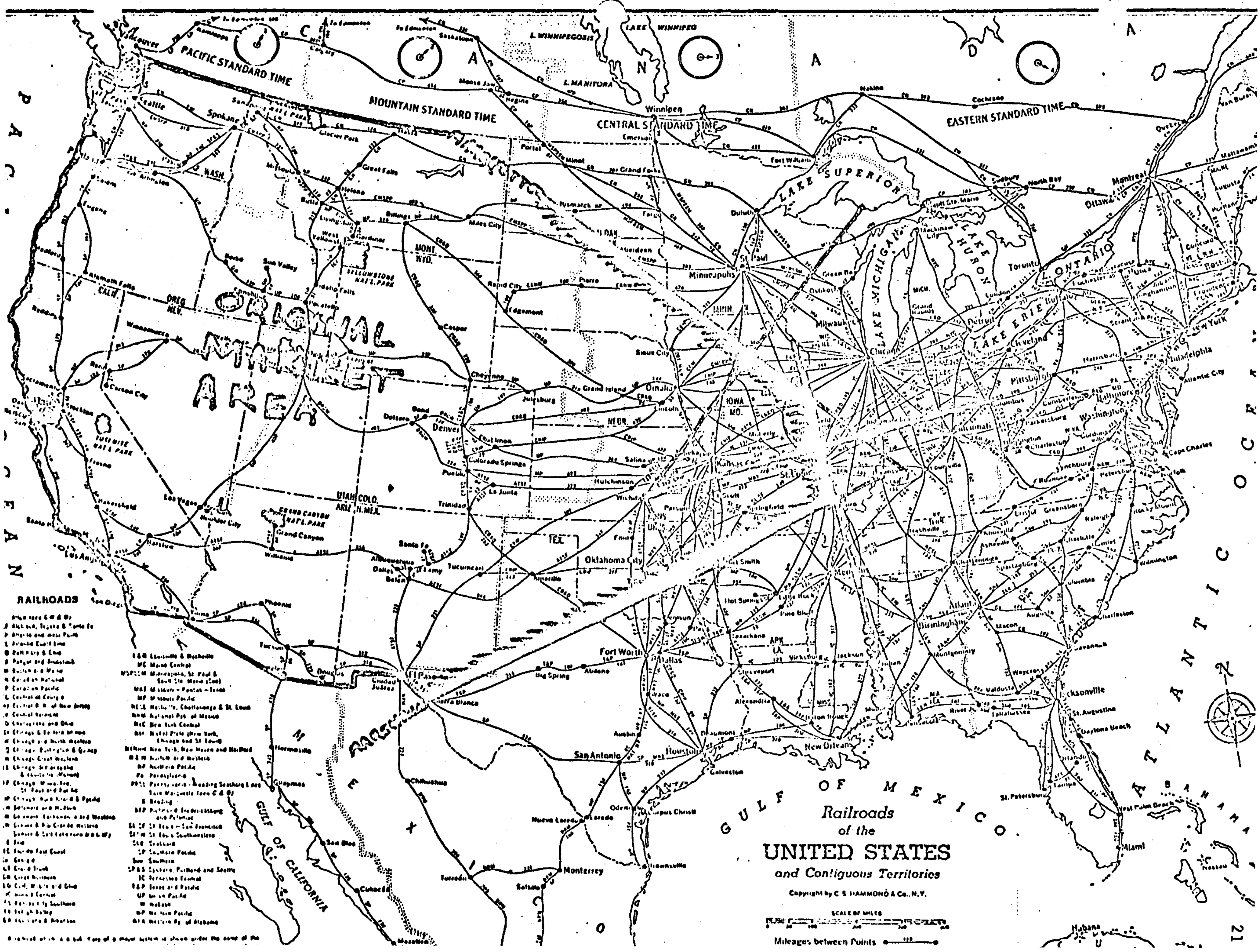

CITY OF
EL DORADO
KANSAS
CENTRAL - GRIFFITH & E CENTRAL
EAST - EAST CENTRAL & WOODLAND
FOREST - 800 N TAYLOR
SWIMMING POOL & MUSICORIUM
LOCUST - E LOCUST
SOUTHWEST - ATCHISON & TOWANDA
GORDY - GORDY & OLIVE
WATERWORKS - 415 E CENTRAL
RIVERVIEW - 800 E CENTRAL
GRAHAM - 1830 EDGEMOOR
LAKE - 100 RANDOM ROAD
TWIN LAKES -
3 MILES EAST - 3 MILES NORTH
FIRST AND GORDY
PINE AND GORDY
VINE AND PINE
CENTRAL AND GRIFFITH
INFORMATION
• ALL CITY VEHICLES ARE RADIO EQUIPPED
• THE CITY HAS A CIVIL DEFENSE AND A
SEVERE WEATHER WARNING SYSTEM---
3 MIN. SOLID TONE --- ALERT
WARBLING TONE ---- TAKE COVER
ALL CLEAR GIVEN BY LOCAL RADIO STATION
• KBTO RADIO STATION - 1360 KC - AM
• EMERGENCY RESCUE SERVICE -
BA1-4411 OR BA1-2420
AMERICAN PETROFINA REFINERY
JUNIOR COLLEGE - 100 W FIRST
SENIOR HIGH - 500 W CENTRAL
JUNIOR HIGH - 636 W CENTRAL
HOSPITALS
ALLEN MEMORIAL - 720 W CENTRAL
PUBLIC BUILDINGS
CHAMBER OF COMMERCE - 114 1/2 S MAIN
CITY LIBRARY - 611 S. WASHINGTON
POST OFFICE - CENTRAL & VINE
BASEBALL STADIUM - CENTRAL PARK
MEDICAL BUILDING - 300 S MAIN
STATE HIGHWAY DEPT. - 275 OIL HILL RD.
BUS DEPOT - 216 W CENTRAL
ANIMAL CLINIC - 111 E LOCUST
COUNTRY CLUB
GOLF COURSE
AMERICAN LEGION
CLUB GOLF COURSE
CITY DUMP
SUNSET LAWNS
CEMETERY
SKELLY REFINERY
CITY ENGINEERING DEPT
STATE HIGHWAYS
U.S. HIGHWAYS
SANTA FE SYSTEM
MISSOURI PACIFIC
SYSTEM
INTERCONNECTING
RAIL LINES

PART III

MARKETING AREA

In order to derive a market area for the sale of activated carbon, freight rates from Wichita to various cities in all sections of the country were established. Since activated carbon is produced at five locations in the United States (Marshall, Texas; Columbus, Ohio; Jacksonville, Florida; Marquette, Michigan and Covington, Virginia) rates from these points were also needed. In order to determine a market area in which an El Dorado plant would have a transportation advantage the following method was used:

1. Lines were drawn from Wichita to each of the five cities.
2. At the halfway point of each of the lines, a second line perpendicular to the first was drawn. This line represented equal cost of shipment point from Wichita to each of the cities.
3. Since the equal cost of shipment points from Jacksonville, Florida and Covington, Virginia lie to the south and east of the Marshall, Texas; Marquette, Michigan and Columbus, Ohio interfaces they were discarded.
4. The market area for activated carbon is now described by the inter-section of the Marquette--Columbus--Marshall interfaces on the east, the United States--Canadian border on the north, the Pacific Ocean on the west and the United States--Mexican border on the south.
5. The next step of the analysis was to add the small areas of each state lying outside the interface line to those states where the largest portion of the state was within the transportation advantage area. This allows for the use of complete states for market analysis. An exception was made for Texas where the net value of the market in the state was used. This step allows for easier analysis of data comparison then the county by county analysis required by the interface determination.



Railroads of the UNITED STATES and Contiguous Territories
Copyright by C. S. HAMMOND & Co., N.Y.
SCALE OF MILES
Mileages between Points
PACIFIC STANDARD TIME
MOUNTAIN STANDARD TIME
CENTRAL STANDARD TIME
EASTERN STANDARD TIME
ORIGINAL MARKET AREA
RAILROADS
CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
GULF OF CALIFORNIA
MEXICO
BAHAMAS
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
LAKE WINNIPEG
L. WINNIPEGOSIS
L. MANITOBA
Seattle
Spokane
Winnipeg
Minneapolis
St. Paul
Duluth
Chicago
Detroit
Cleveland
Pittsburgh
Toronto
Montreal
Ottawa
Quebec
New York
Philadelphia
Baltimore
Washington
Denver
Cheyenne
Omaha
Lincoln
Kansas City
St. Louis
Oklahoma City
Amarillo
Albuquerque
Santa Fe
Tucumcari
Phoenix
Tucson
El Paso
Las Vegas
Los Angeles
San Diego
Sacramento
Fresno
Bakersfield
Reno
Winnemucca
Carson City
Salt Lake City
Boise
Sun Valley
Butte
Helena
Great Falls
Billings
Miles City
Bismarck
Fargo
Pierre
Rapid City
Casper
Grand Island
Salina
Hutchinson
Wichita
Pueblo
Colorado Springs
La Junta
Trinidad
Fort Worth
Dallas
Abilene
Big Spring
San Antonio
Austin
Houston
Galveston
Beaumont
New Orleans
Shreveport
Little Rock
Hot Springs
Memphis
Nashville
Louisville
Cincinnati
Chattanooga
Atlanta
Birmingham
Montgomery
Jackson
Vicksburg
Mobile
Savannah
Charleston
Jacksonville
St. Augustine
Daytona Beach
Tampa
St. Petersburg
West Palm Beach
Miami
Habana
Nassau
Monterrey
Saltillo
Chihuahua
Laredo
Nuevo Laredo
Corpus Christi
Brownsville
Hermosillo
Guaymas
Torreon
Mazatlan
Ciudad Juarez
Grand Canyon
Williams
Yosemite Nat'l Park
Yellowstone Nat'l Park
Glacier Park

ACTIVATED CARBON TRANSPORTATION RATES SCHEDULE
FROM WICHITA TO SELECTED CITIES

	Rail Freight Rates			Truck Rates	
City, State	50K	60K	80K	2000	-10,000
Albuquerque, New Mexico	116	106	87	297	297
Amarillo, Texas	81	74	60.5	212	212
Atlanta, Georgia	143	131	131	348	348
Baltimore, Maryland	172	159	159	413	406
Billings, Montana	190	190	190	418	418
Birmingham, Alabama	129	118	118	312	312
Bismarck, North Dakota	207	207	190	---	---
Boise, Idaho	207	207	190	---	---
Boston, Massachusetts	193	178	178	460	452
Buffalo, New York	154	142	142	413	394
Butte, Montana	227	227	227	499	499
Casper, Wyoming	120	110	110	---	---
Cheyenne, Wyoming	110	101	82	344	327
Chicago, Illinois	112	102	84	297	282
Cincinnati, Ohio	127	117	117	349	232
Cleveland, Ohio	139	128	128	376	358
Columbia, South Carolina	162	149	149	395	395
Dallas, Texas	87	80	65.5	228	228
Denver, Colorado	99	91	75	318	302
Des Moines, Iowa	87	80	67	256	242
Detroit, Michigan	135	125	125	366	349
Duluth, Minnesota	129	118	97	359	342

ACTIVATED CARBON TRANSPORTATION RATES SCHEDULE
FROM WICHITA TO SELECTED CITIES (CONTINUED)

City, State	Rail Freight Rates 50K	60K	80K	Truck Rates 2000	-10,000
El Paso, Texes	124	114	93	318	318
Fargo, North Dakota	126	116	95	375	357
Houston, Texas	112	102	84	286	286
Indianapolis, Indiana	118	108	108	334	317
Jacksonville, Florida	183	168	168	400	400
Julesburg, Colorado	93	85	85	---	---
Kansas City, Missouri	62.5	57.5	47.5	180	166
Knoxville, Tennessee	143	131	131	348	348
Las Vegas, Nevada	207	207	190	---	---
Los Angeles, California	207	207	190	471	471
Louisville, Kentucky	120	110	110	349	332
Memphis, Tennessee	102	93	93	261	261
Miami, Florida	191	175	175	465	465
Mobile, Alabama	187	172	172	333	333
Nashville, Tennessee	126	116	116	307	307
New Orleans, Louisiana	133	122	122	337	337
New York, New York	185	171	171	443	435
Oklahoma City, Oklahoma	60.5	55.5	45.5	163	163
Omaha, Nebraska	78	72	58.5	229	216
Phildelphia, Pennsylvania	179	165	165	425	418
Pittsburg, Pennsylvania	150	138	138	423	383
Portland, Oregon	232	232	232	471	471
Richmond, Virginia	176	162	162	415	408

ACTIVATED CARBON TRANSPORTATION RATES SCHEDULE
FROM WICHITA TO SELECTED CITIES (CONTINUED)

	Rail Freight Rates			Truck Rates	
City, State	50K	60K	80K	2000	-10,000
Reno, Nevada	207	207	190	---	---
St. Louis, Missouri	93	85	70	256	242
St. Paul, Minnesota	114	105	86	327	311
Salt Lake City, Utah	196	196	196	418	418
San Antonio, Texas	112	102	84	286	286
San Francisco, California	207	190	471	471	
Seattle, Washington	207	207	190	471	471
Sioux City, Iowa	87	80	80	---	---
Spokane, Washington	207	207	190	471	471
Springfield, Illinois	98	90	90	---	---
Springfield, Missouri	72	65.5	53.5	---	---
Trinidad, Colorado	93	85	85	---	---
Tucson, Arizona	207	207	190	426	426
Washington, D.C.	170	157	157	413	406
Williams, Arizona	207	207	190	---	---

ACTIVATED CARBON RATE SCHEDULE FROM MARSHALL, TEXAS AND MARQUETTE, MICHIGAN TO SELECTED CITIES

Marshall, Texas				Marquette, Michigan		
City, State	50K	60K	80K	City, State	50K	60K
Albuquerque, New Mexico	135	124	101	Billings, Montana		
Amarillo, Texas	99	91	75	Butte, Montana	240	240
Billings, Montana	207	207	190	Boise, Idaho	293	293
Boise, Idaho	207	190	190	Cheyenne, Wyoming	158	145
Butte, Montana	207	190	190	Denver, Colorado	180	140
Casper, Wyoming	164	151	123	Des Moines, Iowa	108	99
Cheyenne, Wyoming	152	139	114	Duluth, Minnesota	69	62.5
Chicago, Illinois	130	120	98	Fargo, North Dakota	98	90
Dallas, Texas	59.5	54.5	44.5	Julesburg, Colorado	147	135
Denver,Colorado	141	129	106	Portland, Oregon	274	241
Des Moines, Iowa	126	116	95	Rapid City, So. Dakota	139	128
Duluth, Minnesota	160	146	120	St. Louis, Missouri	112	102
El Paso, Texas	129	118	97	St. Paul, Minnesota	83	76
Fargo, North Dakota	164	151	123	Salt Lake City, Utah	259	259
Houston, Texas	72	65.5	53.5	Seattle, Washington	274	241
Julesburg, Colorado	141	129	106	Sioux City, Iowa	108	99
Kansas City, Missouri	104	95	78	Spokane, Washington	274	241
Las Vegas, Nevada	207	207	207	Springfield, Illinois	102	93
Los Angeles, California	207	207	207			
Nashville, Tennessee	106	97				
New Orleans, Louisiana	83	76	61.5			
Oklahoma City, Oklahoma	81	74	60.5			

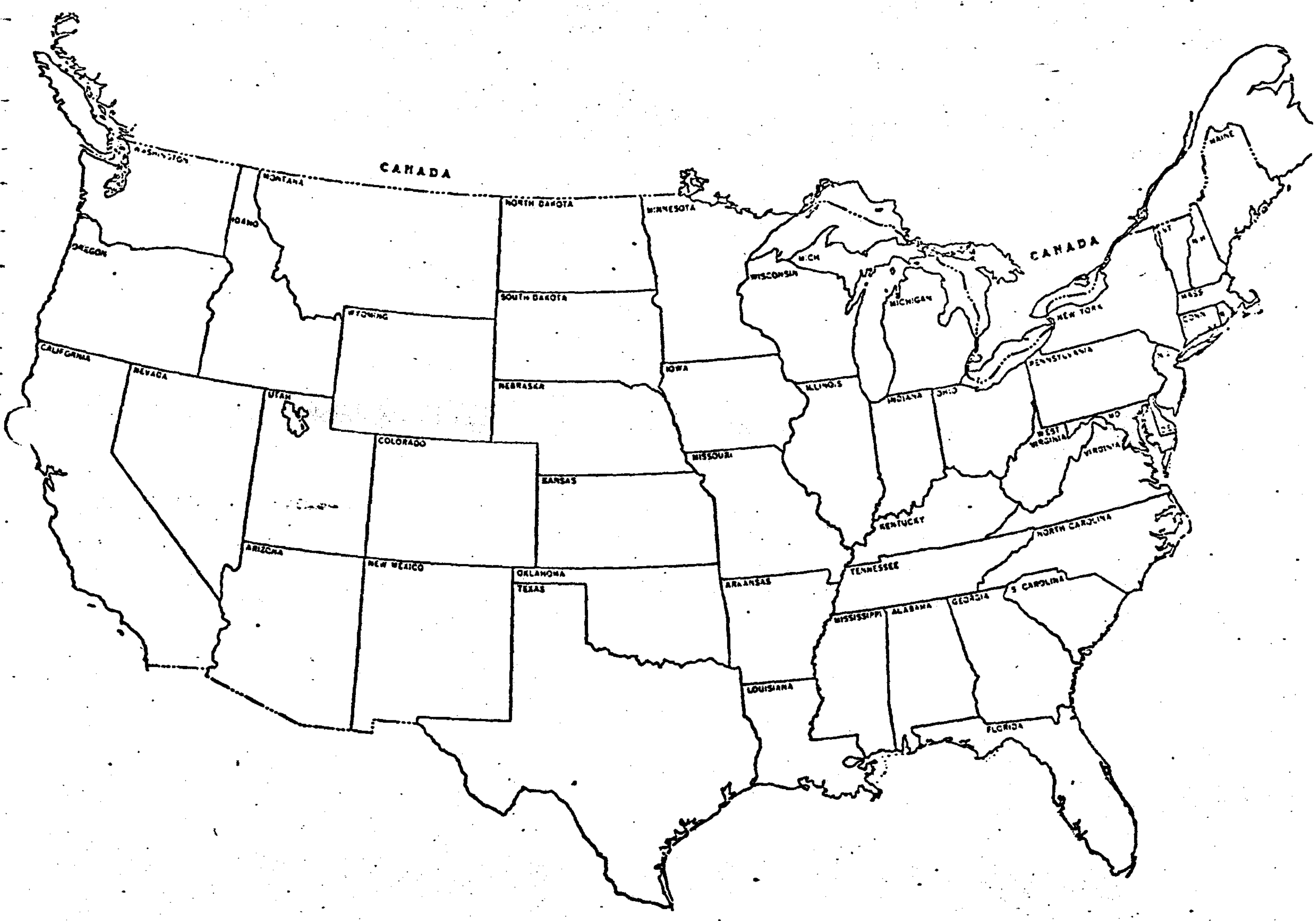
ACTIVATED CARBON RATE SCHEDULE FROM MARSHALL, TEXAS
AND MARQUETTE, MICHIGAN TO SELECTED CITIES (CONTINUED)

Marshall, Texas			
City, State			
Omaha, Nebraska	122	112	92
Portland, Oregon	207	190	190
Rapid City, So. Dakota	164	151	123
Reno, Nevada	207	207	207
St. Louis, Missouri	104	95	78
St. Paul, Minnesota	147	135	117
Salt Lake City, Utah	207	207	207
San Antonio, Texas	85	78	63.5
San Francisco, California	207	190	190
Seattle, Washington	207	190	190
Sioux City, Iowa	133	122	100
Spokane, Washington	207	190	190
Springfield, Illinois	114	105	84
Springfield, Missouri	91	84	69
Trinidad, Colorado	126	116	95
Tucson, Arizona	207	190	190
Wichita, Kansas	98	90	73
Williams, Arizona	207	190	190

SEVENTEEN STATE ACTIVATED CARBON MARKET AREA WITH SELECTED CHARACTERISTICS

State	Area(sq.miles)	# of Households (1965 Est.)	Population (1965 Est.)	Population (1960 Census)	1960-1965 Pop. Inc. %	1965 Pop. % of U.S.
California	156,573	5,790,400	18,338,000	15,717,204	16.7	9.49
Colorado	103,884	601,200	2,003,000	1,753,947	14.2	1.04
Idaho	82,708	204,200	702,000	667,191	5.2	0.36
Iowa	56,032	847,800	2,783,000	2,759,537	0.9	1.44
Kansas	87,048	692,500	2,251,000	2,178,611	3.3	1.16
Missouri	69,138	1,392,400	4,446,000	4,319,813	2.9	2.30
Montana	145,736	214,400	717,000	647,767	6.3	0.37
Nebraska	76,612	461,900	1,507,000	1,411,330	6.8	0.78
Nevada	109,788	136,700	426,000	285,278	49.3	0.22
New Mexico	121,510	276,300	1,048,000	951,023	10.2	0.54
Oklahoma	68,887	791,000	2,512,000	2,328,284	7.9	1.30
Oregon	96,248	597,400	1,896,000	1,768,687	7.2	0.98
South Dakota	76,378	203,400	711,000	680,514	4.5	0.37
Texas (Net)	41,990	242,500	872,500	791,358	10.2	0.45
Utah	82,339	273,700	1,008,000	890,627	13.2	0.52
Washington	66,709	956,000	3,051,000	2,853,214	6.9	1.58
Wyoming	97,411	106,800	355,000	330,069	7.6	0.17
Market Area	1,533,991	13,788,600	44,626,500	40,334,454	10.6	23.07
United States	3,548,974	57,064,000	193,200,000	179,323,175	7.7	100.00

Source: U.S. Department of Commerce, Bureau of the Census, Population, 1960.


CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
IDAHO
OREGON
SOUTH DAKOTA
WYOMING
WISCONSIN
MICH
MICHIGAN
CANADA
MAINE
NEW YORK
MASS
CONN
CALIFORNIA
NEVADA
UTAH
IOWA
NEBRASKA
ILLINOIS
INDIANA
PENNSYLVANIA
COLORADO
MISSOURI
KANSAS
WEST VIRGINIA
VIRGINIA
KENTUCKY
NORTH CAROLINA
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
ARKANSAS
TENNESSEE
S CAROLINA
MISSISSIPPI
ALABAMA
GEORGIA
LOUISIANA
FLORIDA

FREIGHT RATES AND TRANSPORTATION DIFFERENTIALS FOR
WICHITA, KANSAS; MARQUETTE, MICHIGAN
AND MARSHALL, TEXAS

To	50K Rate			60K Rate			50K Diff		60K Diff	
City, State	From Wich Kan	Mars Tex	Marq Mich	From Wich Kan	Mars Tex	Marq Mich	Mars Tex	Marq Mich	Mars Tex	Marq Mich
Albuquerque, NM	116	135	---	106	124	---	19	---	19	---
Amarillo, Tex	81	99	---	74	91	---	18	---	17	---
Billings, Mont	190		---	190						
Boise, Idaho	207	207	---	207						
Butte, Mont	227	207	---	227						
Casper, Wyom	120	164		110	151		44		41	
Cheyenne, Wyom	110	152	158	101	139	145	42	48	38	44
Chicago, Ill	112	130	---	102	120	---	18	---	18	---
Dallas, Tex	87	59½	---	80	54½	---	-27½	---	-25½	---
Denver, Colo	99	141	170	91	129	149	42	71	38	58
Des Moines, Iow	87	126	108	80	116	99	39	21	36	19
Duluth, Minn	129	160	69	118	146	62½	31	-60	28	-55½
El Paso, Tex	124	129	---	114	118	---	5	---	4	---
Fargo, N Dak	126	164	98	116	151	90	38	-28	35	-26
Houston, Tex	112	72	---	102	65½	---	-40	---	-36½	---
Julesburg, Colo	93	141	147	85	129	135	47	54	44	50
Kansas City, Mo	62½	104	---	57½	95	---	41½	---	37½	---
Las Vegas, Nev	207	207	---							
Los Angeles, Cal	207	207	---							
Nashville, Tenn	126	106	---	116	97	---	-20	---	-19	---
New Orleans, La	133	83	---	122	76	---	-50	---	-46	---
Oklahoma City, Ok	60½	81	---	55½	74	---	20½	---	19½	---
Omaha, Neb	78	122	---	72	112	---	44	---	40	---
Portland, Ore	232	207	241	232						
Rapid City, S Dak	---	164	139		151	128				
Reno, Nev 207	207	---								
St. Louis, Mo	93	104	112	85	95	102	11	19	10	17
St. Paul, Minn	114	147	83	105	135	76	33	-31	30	-29
Salt Lake City, U	196	---	---	196						
San Antonio, Tex	112	85	---	102	78	---	27	---	24	---
San Francisco, Cal	207	207	---	207		---		---		---
Seattle, Wash	207	207	241	207						
Sioux City, Iowa	87	133	108	80	22	99	46	21	42	19
Spokane, Wash	207	207	241	207						
Springfield, Ill	98	114	102	90	105	93	16	4	15	3
Springfield, Mo	72	91	---	65½	84	---	19	---	18½	---
Trinidad, Colo	93	126	---	85	116		33		31	

The transportation study showed that within the seventeen state area, activated carbon from a production facility at El Dorado would have equal or lower transportation costs than the other two production facilities in the United States.

As long distance freight rates tend to become more equalized the location of a plant further west than El Dorado would not result in a major saving in transportation costs and would at the same time have a serious effect on the shorter distances to the market area in the east. If a plant were located further east it would experience serious competition from the eastern producers. The location of an activated carbon production facility in El Dorado would seem to have a transportation advantage over the other producers in the western part of the United States without experiencing major competition from the concentrated eastern producers.

PART IV

USES OF ACTIVATED CARBON

The present applications of activated carbon are so diverse they defy any neat or simple classification. In all, over one hundred applications were found for activated carbon during the course of the study. A selection of these are listed below for reference purposes. The majority of these applications are not considered relevant to the project from a marketing standpoint as they involve small volume, highly specialized uses for which the market would be hard to penetrate and in which there would not be an adequate volume of sales to justify the construction of a plant. However, brief non-technical descriptions of some of the uses have been included as background material. This information may also serve as an information source if markets, other than those studied in greater depth in Part VI, are to be considered. No attempt is made in the following descriptions to identify the market potential for these applications as this information is contained in Part VI.

The uses for activated carbon have been divided into the following general categories:

1. Agricultural Uses
2. Air Purification
3. Decolorizing
4. Metal Mining
5. Removal Applications

6. Separation of Permanent Gasses
7. Solvent Recovery
8. Storage of Gasses
9. Water Purification
10. Prevention of Migration in Plastic Solids
11. Miscellaneous Uses

Although these overlap somewhat it is felt that they reflect the major areas in which activated carbon is used and this breakdown will aid in the market analysis contained in Part VI.

Agricultural Uses

The benefits of activated carbon in agricultural applications are disputed; however, the following uses have been cited:

Aids the biological fixation of nitrogen

There is some data to indicate that activated carbon, by holding nitrogen, may make plants better able to utilize the nitrogen contained in the carbon.[1]

Adsorbtion of toxins

Activated carbon may be used to protect young plants or seeds from weed killers. One source stated that after a plot had been treated with 2,4-D, only 2.5 per cent of the sweet potato plants planted survived; however, when dusted with activated carbon

[1]O. Verona and P. Ciriotti, Boll. ist. super. agrar. Pisa. (1935) Vol. XI, 401, cited by John W. Hassler, Activated Carbon (New York: Chemical Publishing Company, Inc., 1963), p. 149.

95 per cent of the plants survived and produced plants normal in every respect.[2]

Higher soil temperature

Increased water capacity. Activated carbon will adsorb water and hold it; however, some doubt exists as to whether it is possible for appreciable desorbtion to exist in the temperature ranges encountered in farm land.

Improved aeration[3]

Regulation of fertilizer consumption. Normally, much of the fertilizer applied to a plot of ground is wasted via evaporation of perculation deep into the soil. By holding the fertilizer near the plant appreciable savings could be realized; however, again the problem of desorbtion is encountered.

Prolong the protection of crops from weeds. The use of activated carbon in applying weed killers could not only reduce risks of crop damage but also could make the toxins effective for a much longer period of time by gradually releasing the adsorbed toxins.[4]

As previously stated, the agricultural uses and benefits are the subject of considerable dispute. Information from Kansas State University indicates there is no conclusive evidence that activated carbon is useful

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[2] H. F. Arle, O. A. Leonard, and U. C. Harris, Science, Vol. CVII (1948), 247.

[3] John W. Hassler, Activated Carbon (New York: Chemical Publishing Company, Inc., 1963), p. 150.

[4] Ibid., p. 12.

in this area.[5] On the other hand, at least one manufacturer claims that when

> combined with systemic insecticides for coating seeds (activated carbon will) prolong the effectiveness of the insecticides, i.e., the insecticide is adsorbed by the carbon, then released slowly over a longer period of time than if it had been added without having been adsorbed on the carbon.[6]

As the Kansas State University letter indicates, more study is required before agricultural benefits of activated carbon can be firmly established.

Air Purification

A second major area where activated carbon is used is in air purification. The possible increases in the demand for activated carbon in this field due to the federal interest in air and water purification are considered in more detail in the marketing portion of this study. The current primary uses of activated carbon in this field are:

Air conditioning

Activated carbon finds uses in air conditioning whenever objectionable or toxic fumes are present. It is normally used in conjunction with other filtering devices which rid the air of larger suspended particles. Some of the specific benefits derived from using activated carbon in filtering air are:

1. Increased well-being and efficiency of personnel by removing stuffiness and irritating vapors from the air.
2. Recirculation of all or part of the ventilating air, saving heat in the winter and refrigeration in the summer.

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[5] Letter from Floyd W. Smith, Director, Agricultural Experiment Station, Manhattan, Kansas, April 3, 1967.

[6] Nuchar for Purification and Reclamation, Chemical Division, West Virginia Pulp and Paper Company (New York), p. 8.

3. Purification of outside air used for ventilation or pressuring.

4. Ventilation of spaces not conveniently connected to the central ventilating, heating or cooling system, i.e., toilets.

5. Use of one circulating system for all rooms no matter what odors are released in the individual areas.

6. Elimination of odors from air exhausted to the atmosphere.

7. Recovery of values from vapors present in the space.

8. Increased safety by removing combustible or toxic vapors.[7]

Activated carbon increases air purity in two ways; first, by removing impurities by adsorbtion, and second, by permitting the recirculation of air so that atmospheric impurities are left outside.[8]

Gas masks

During the second world war the demand for charcoal to be used in gas masks increased tremendously and as a result at least one new manufacturer began producing activated carbon and continues to do so today. Although traditionally carbon for gas masks was produced from cocoanut shells, the second world war and the accompanying undependable supply of this material caused research to be done which resulted in the successful activation and utilization of coal for this purpose.[9]

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[7] H. L. Barnebey, "Activated Charcoal for Air Purification," Heating Piping and Air Conditioning (March, 1958), p. 153.

[8] Ibid.

[9] William Haynes, American Chemical Industries (New York: D. Van Nostrand Company, Inc., 1949), Vol. V, p. 340.

Cigarette filters

The amount of charcoal contained in a single cigarette filter is small but when the billions of cigarettes sold annually are considered it can be seen this is a large use of activated carbon. The interest in activated carbon for this purpose began with the tobacco health scares of the 1950's and has been stimulated by the popularity of low tar and nicotine content cigarettes.

Automobile exhaust

No evidence has been found to support the idea that activated carbon would be useful as an automobile exhaust gas purifier. Although activated carbon could quite probably handle the vapors formed during combustion, two problems arise. First, a gallon of water vapor is created for every gallon of gasoline burned and because the activated carbon would adsorb this vapor a very large filter would be required. The filter would also have to be frequently changed. Secondly, when automobile exhausts become thoroughly heated, the temperatures encountered would not be conducive to adsorbtion; rather, it would be more likely that desorbtion would occur.

Factory waste gasses

At the present time, electrostatic precipitators seems to be the most feasible solution economically for recovering material from factory waste gasses; however, the extraction of coke plant waste gasses has been mentioned as a possible application for activated carbon.[10]

The uses for activated carbon in air purification are somewhat limited and the markets are well established. Federal pressure to decrease air pollution is bound to have widespread effects on the industries involved in producing filteration systems and it is therefore highly likely that new applications or methods of utilization will be developed for activated carbon in this field.

Decolorizing Applications

Decolorizing applications constitute the market for a very large portion of the activated carbon produced in the United States. This is not only because of large size of the individual industrial users but is also due to the great variety of applications which take advantage of this property of activated carbon. As will be noted below, the principal applications deal with making food products more suitable for public consumption. Examples of decolorizing applications are:

Cane Sugar Refining

Activated carbon is applied to raw washed sugar solutions which clarifies them prior to their final purification and crystallization. In the past, bone char was used extensively because of filtration problems caused by using powdered vegetable carbons; however, the vegetable carbons are much more efficient and with the advent of improved filtering they have largely replaced bone char for

[10] V. R. Deitz, Bibliography of Solid Adsorbents (Washington, D.C.: United States Cane Sugar Refiners and Bone Char Manufacturers and National Bureau of Standards, 1944, Supplementary volume published in 1956).

this application. To give some idea of the difference in efficienty, bone char requires from 1/3 to 1/2 pound of bone char for every pound of sugar produced; however, the same job can be accomplished with about 1/2 to 2 pounds of powdered activated carbon for each 100 pounds of sugar produced.[11, 12] Considering the multibillion pound market for sugar it can be seen that this is a very important application.

Beet sugar

Beet sugar is more easily purified than cane sugar and many times activated carbon is not required for color control; in fact, in some cases its use may hinder the sugar refining process.[13] One sugar producer stated that activated carbon was used by his firm only when rotten beets were used. Thus the application of activated carbon in beet sugar refining is a rather unstable and fluctuating market.

Corn sugar

Corn and other sugars produced through the conversion of starch are treated with activated carbon to remove hydroxymethyl furfural (HMF), iron, lime, and phosphate. The resulting corn syrup is stable and will not darken with age. Both granular and powdered carbons are used for this purpose.

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[11] Hassler, op. cit., p. 111, 113.

[12] Pieter Honig, Principals of Sugar Technology (New York: Elsevier Publishing Company, 1953), Vol. I, p. 416.

[13] Hassler, op. cit., p. 113.

Water Purification

Municipal Water Supplies

This is the largest single use of activated carbon.[21] The effect of using activated carbon in municipal water systems is to remove objectionable tastes and odors. Also, when applied to water reservoirs, it can prevent the growth of algae by obscuring the sunlight required for the growth of these micro-organisms. Amounts of carbon required vary considerably from summer to winter with the heaviest requirements coming in the winter when low river flows are experienced. Some of the tastes and odors which activated carbon can eliminate are listed below.[22]

Mine waste	Woody
Sewage	Grassy
Musty	Hydrogen sulfide
Fishy	Rotten
Oil Refinery	Oily
Brackish	Lime
	Chlorinous

Relatively small dosages are required to achieve the desired results, with some applications needing only 3 parts carbon per million parts water to eliminate completely the objectionable odors and tastes.

The use of activated carbon may increase sharply in the near future due to some recently announced technological breakthroughs. Using

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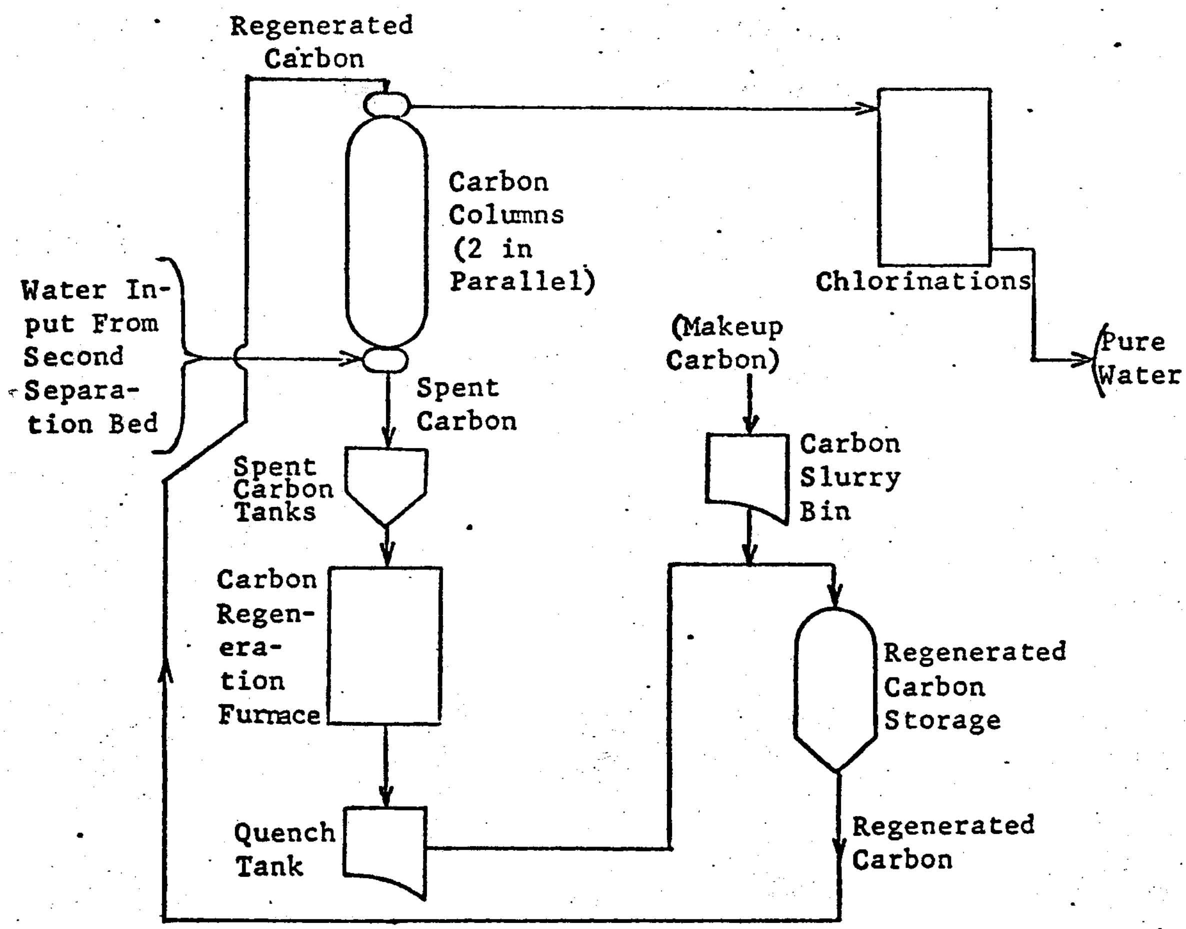
[21] Richard H. Parry, Thesis (Unpublished Master's dissertation, Department of Mineral Economics, Pennsylvania State University, December 1961), p. 123.

[22] Taste and Odor Control in Water Purification, Chemical Division, West Virginia Pulp and Paper Company (New York, 1966), p. 25.

a new process, sewage can be so thoroughly purified that the effluent waters are of drinking quality. The process is reported to require only one-tenth the land and operates at two-thirds the operating cost of current sewage treatment facilities. The process involves treating the sewage with a settling floc first and then passing the resulting waters through activated carbon beds. Figure 4-1 shows the details of the activated carbon treatment portion of this process.

Figure 4-1

Flow Chart of a New Water Purification Process
Using Activated Carbon



Fats and oils

Activated carbon has a variety of uses in the production of edible fats and oils; among these are decolorization, the prevention of the reoccurrence of color, and the prevention of bloom formation due to the removal of mineral oil.[14]

Dry cleaning solvents

Dry cleaning solvents are treated with activated carbon in order to remove the color build-up from dye fade and solvent soluble soils. They are normally treated on a daily basis or after approximately three pounds of clothes have been cleaned for every gallon of solvent in the system.

These are the primary decolorization applications for activated carbon. Several of the above products are also treated with activated carbon to rid them of other undesirable properties; however, these uses are treated under the deodorization or removal application sections.[15]

Metal Mining

Recovery of Metallic Compounds

Activated carbon can be used to recover antimony, mercury, chromium, molybdenum, silver, and feric salts. The recovery process usually involves the direct adsorbtion of a compound containing the metal and subsequent smelting of the carbon to recover the metal; however, sometimes a co-adsorbate is used. When a co-adsorbate is used the

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[14] *Ibid.*, p. 115.

[15] *Ibid.*, p. 115, 118.

carbon is first saturated with the co-adsorbate and then exposed to the solution containing the metal compound. The compound, which was not appreciably adsorbable using carbon alone, is absorbed by the co-adsorbate. Then the co-adsorbate is removed from the carbon using water or some other solvent in which the co-adsorbant is readily soluable.[16]

Removal applications

There are a variety of uses for activated carbon which are not specific enough to be put into any of the other categories, yet are not so general as to be called "miscellaneous applications." Removal applications have in common the fact that they are used to reduce or eliminate the concentration of certain substances in various products, not for the recovery of the substance removed, but rather to improve the quality of the product from which it is removed.

Examples of this application for activated carbon are the removal of:

Oil from boiler water

Aldehydes from fermented liquids

Mercury compounds from hyposylptes

DDT from water supplies

Carcinogens

Fluorescence from certain oils

Soaps from alkali-refined oils

Peroxides from rancid oils

[16] Ibid., p. 138-139.

Conradson residue from used crank-case oil

Sulfonates from mineral oils

Tetraethyl lead from gasoline

Impurities from electroplating solutions

Unsaturates from mineral oils

Prevention of chill cloud formation in whiskey production

Radioactive substances

Production of canned draft beer

Prevention of gum in certain liquids

Iodine from oil well brines

Impurities from pharmaceuticals

Pharmaceuticals from broth

Separation of Permanent Gasses

Activated carbon can be employed to separate certain gasses because different gasses have different boiling points. First, the incoming gas mixture is cooled and passed through activated carbon. The carbon adsorbs portions of all the gasses in the mixture so in order to recover the desired gas, the carbon is heated until the unwanted gasses have evaporated and only the desired gas remains in the carbon. Further heating is then used to recover the desired gas.

In another application activated carbon is used to increase the purity of helium gas by removing the nitrogen with which it is mixed. This process is required only when very high purity gasses are desired.

Storage of Gasses

With the aid of activated carbon, some rather interesting variations to normal gas storage methods can be accomplished, as activated carbon makes possible the storage of greater quantities of gas in the same area as well as at reduced pressures or even atmospheric pressure.

1. For example, at 35 atmospheres of pressure, the capacity for the storage of nitrogen is increased 66 per cent by filling the cylinder with cocoanut charcoal.[17]

2. Also, dimethyl ether and ethyl chloride may be stored at atmospheric pressure in a container containing activated carbon. They are then released by gentle heating.[18]

Other Vapor Phase Applications

Activated carbon has been found useful in achieving extremely low temperatures. This is because heat is evolved when adsorbtion occurs and the removal of the gas has a cooling effect. Using this principle, temperatures as low as 1.6 K. have been achieved by using super cooled carbon to adsorb remaining vapors in a previously exhausted vessel.[19]

Solvent Recovery

This field has considerable commercial application; in fact, one producer concentrates its efforts almost entirely in this area. The

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[17] H. Briggs and W. Cooper, Proc. Roy. Soc. Edinburgh, Vol. 41 (1920-1921), p. 119, cited in Ibid., p. 63.

[18] O. L. Barnebey, U. S. Patent 1,608,155.

[19] J. Servar, Chemical News (January 10, 1908), p. 16, cited in Hassler, op. cit., p. 64.

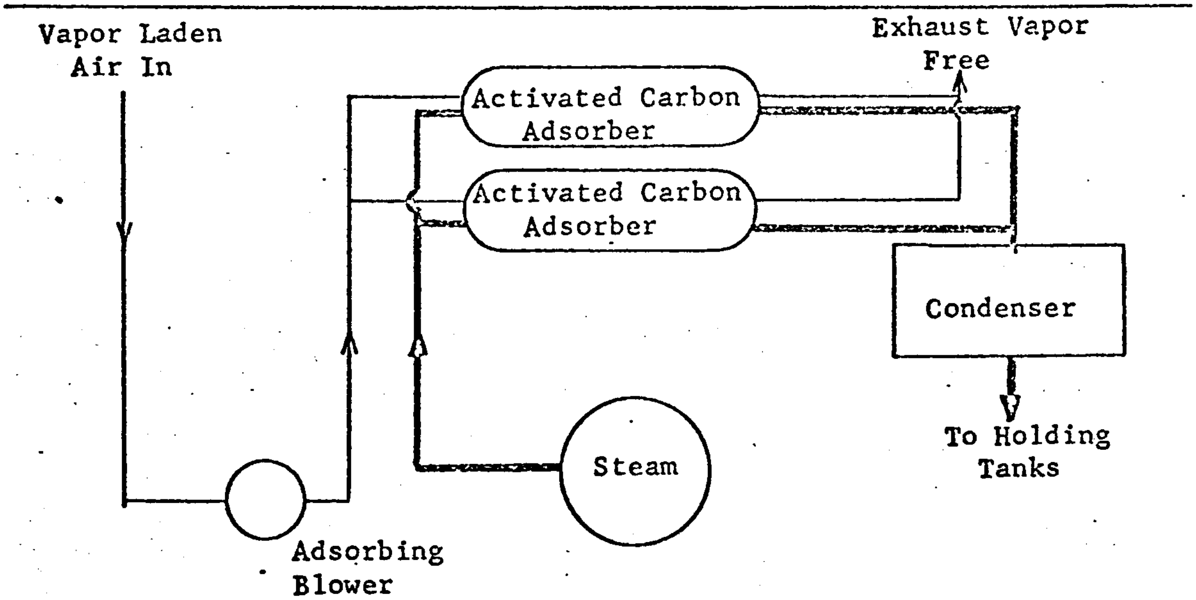
following is a list of solvents which have been found to be economically recoverable using activated carbon.

Acetone	Methyl Acetate
Benzene	Methyl ethyl keotone
Ethanol	Petroleum naphtha
Ethyl acetate	Solvent naphtha
Ethyl ether	Tetrachloroethylene
Isopropanol	Trichloroethylene
Methanol	Tolnene
	Xylene

In order to recover solvents, generally three adsorbing tanks are required. While one is being regenerated by passing steam through it (which then goes to a condenser for recovery of the solvent) the vapor ladden air is passed over the other two tanks in the following order: first through the most saturated carbon adsorber and then through the most recently activated adsorber. When the first tank becomes completely saturated it is regenerated. The second adscrber becomes the first to contact the vapor ladden air and the tank which was previously being regenerated becomes the second adsorber. Figure 4-2 illustrates this process. Using one manufacturer's recovery systems, over 2 billion pounds of solvents are recovered annually.

Figure 4-2

Flow Chart of a Solvent-Recovery Plant



Adapted from diagram by Carbide and Chemicals Corporation, New York.

Prevention of Migration in Plastic Solids

Activated carbon is used in rubber reclamination to prevent the migration of carbon black, which has previously been added to increase the strength and durability of tires, into the white sidewall. When this migration does occur, the white sidewall becomes discolored, but the use of activated carbon in the manufacturing process effectively blocks this action.[20]

[20] *Ibid.*, p. 13.

Industrial Water Supplies

The principal industrial user of activated carbon for water purification is the beverage industry. The water which goes into the production of carbonated soft drinks is first super-chlorinated in order to kill all bacteria. Since this high level of chlorination would affect the taste of the drink produced, the water is then run through an activated carbon bed to remove the chlorine. The same treatment is given to water used in many other food processing plants. A few examples are: ice plants, breweries, and canneries.

Miscellaneous Applications

The following uses for activated carbon are limited and provide small markets. They are included primarily because they are interesting and demonstrate the great variety of uses which exist for activated carbon.

Miscellaneous uses are for:

Kitchen woods (adsorbs odors)

Storage of fruits and flowers (retards spoilage)

Fermentation odor control

As was stated, the previous pages do not contain all uses for activated carbon; only those which are significant have been mentioned. Those desiring more detailed information concerning these uses and the additional applications for activated carbon are referred to Sutz's Bibliography of Solid Adsorbants and Hassler's Activated Carbon, both of which contain extensive technical data on the uses of activated carbon.

PART V

THE ACTIVATED CARBON INDUSTRY

The purpose of this portion of the study is to identify and describe the producers of activated carbon, the methods used to market their products, and the markets for these products. In order to accomplish these tasks, a number of surveys were conducted to gather data from the various producers, sellers, and users of activated carbon. This material, in addition to that gleaned from the literature, has provided a good picture of the activated carbon industry.

The Producers

In general, the industry is rather small with a limited number of producers, each of which seems to be dominant in one or two of the activated carbon markets. It is an industry which has seen a number of firms come and go during its 70 year history, as attested to by the fact that while there have been more than 140 different brands produced, there are currently less than twelve firms producing activated carbon. Since World War II, the number of firms producing activated carbon has tended to stabilize, with but a few firms added in recent years. Many of the current producers do not treat activated carbon as a primary part of their product line; instead, the activated carbon is produced as a by-product and is not actively marketed.

Due to the small size of the industry, there was some resistance on the part of the producing firms to furnishing the information requested from them. Also, there is very little data available in the literature concerning the firms. However, by piecing together all the data gathered, a fairly clear picture has emerged. What follows is a summary of the information which was deemed relevant to an understanding of the structure of the industry.

The total number of producers of activated carbon is unclear because of the lack of advertising and because anyone making charcoal briquettes could conceivably call himself a producer of activated carbon. Also, several marketers of activated carbon refer to themselves as producers, when in fact they only use activated carbon in some filtration device and purchase this carbon from an outside source. Table 5-1 exemplifies how even authorities in this field are not in agreement as to what firms are producers of activated carbon. The firms which have been definitely identified as significant producers of activated carbon are the following:

American Norit Company

Atlas Chemical Industries

Barneby-Cheney Company

Cliffs Dow Chemical Company

Pittsburgh Activated Carbon Company

North American Carbon Company

Union Carbide Corporation

West Virginia Pulp and Paper Company

Witco Chemical Company

TABLE 5-1

FIRMS LISTED AS ACTIVATED CARBON PRODUCERS
BY VARIOUS SOURCES

Firm	Listed As A Producer By:					All
	Hassler[a]	Parry[b]	Pitt. Activ.Carb.[c]	U.S. Govt.[d]	Thomas Register[e]	
American Norit Company		X	X	X	X	
Atlas Chemical Industries	X	X	X	X	X	X
Barneby-Cheney Company	X	X	X	X	X	X
Cliff-Dow Chemical Company	X	X	X	X	X	X
Cleveland Cliffs Iron Company			X			
FMC Corporation			X			
Girdler Catalysts					X	
Hanson-Van Winkle-Manning Division of M & T Chemicals					X	
North American Carbon Company			X		X	
Pittsburgh Activated Carbon Company	X	X	X	X	X	X
T. Melsheimer and Son			X			
Union Carbide Corporation			X		X	
West Virginia Pulp and Paper	X	X	X	X	X	X
Witco Chemical Company			X			

*Under the classification of Carbon, Activated, Thomas Register lists 26 firms of which many are obviously suppliers and therefore are not listed here.

Source: [a]Letter from John W. Hassler, Author of Activated Carbon, January 18, 1967.
[b]Richard H. Parry, Thesis (Unpublished Master's dissertation, Department of Mineral Economics, Pennsylvania State University, December, 1961).
[c]Letter from Jonathan C. Cooper, President, Pittsburgh Activated Carbon Company, Pittsburgh, Pennsylvania, January 10, 1967.
[d]U. S. Department of Commerce, Census of Manufacturers: Current Industrial Reports.
[e]Thomas Register (57 ed.; New York: Thomas Publishing Company, 1967) Vol. I, p. 1015.

Of these nine firms, production records are kept for six of them by the Department of Commerce. One producer estimates that these records represent over 90 per cent of the United States production.[1]

These firms and the primary types of activated carbon they produce are shown in Table 5-2. It is important to note that while 83 per cent of these producers are involved in the production of decolorizing and water purification carbons, only 17 per cent of the firms shown produce deodorizing and solvent recovery carbons. These facts are useful in showing the importance and size of the market for each type of carbon. Also, although there are other producers, those shown in Table 5-2 are by far the most important. Of the three firms which are not shown in this table, Union Carbide is the only one for which there is any relevant data available. Witco Chemical Company is such a recent addition to the field that little is known of its operations or marketing intentions, and North American Carbon Company is a very small firm on which no information was found other than it is listed as a producer by Thomas Register, Pittsburgh Activated Carbon Company, and the Cleveland Telephone Directory. Details about each of these producers are presented later in this part of the study..

In order to get some idea of the size and growth trend of the industry, Table 5-3 and Figure 5-1 have been compiled. From Table 5-3 it can be seen that the production of activated carbon grew at the moderate rate of 6.4 per cent, compounded annually, during the 27 year period

[1]Letter from Jonathan C. Cooper, President, Pittsburgh Activated Carbon Company, Pittsburgh, Pennsylvania, January 10, 1967.

TABLE 5-2

MAJOR PRODUCERS OF VARIOUS GRADES OF ACTIVATED CARBON

1960

Producer	Decolor-izing	Deodor-izing	Water Purification	Solvent Recovery, Gas Adsorption
Pittsburgh Activated Carbon Company Pittsburgh, Pa.	1		1	
West Virginia Pulp & Paper Co. Covington, Virginia	1		1	
American Norit Co. Jacksonville, Fla.	1		1	
Atlas Chemical Industries Marshall, Texas	1		1	
Barneby-Cheney Cassaday at 8th Columbus, Ohio		1		1
Barneby-Cheney	1		1	
The Dow Chemical Co. Marquette, Michigan			1	
Total	5	1	5	2

Source: U. S. Department of Commerce, Census of Manufacturers: Current Industrial Reports.

TABLE 5-3

U.S. PRODUCTION, VALUE, AND AVERAGE UNIT VALUE OF WATER PURIFICATION AND DECOLORIZING GRADES OF ACTIVATED CARBON FOR SELECTED YEARS 1935 - 1966

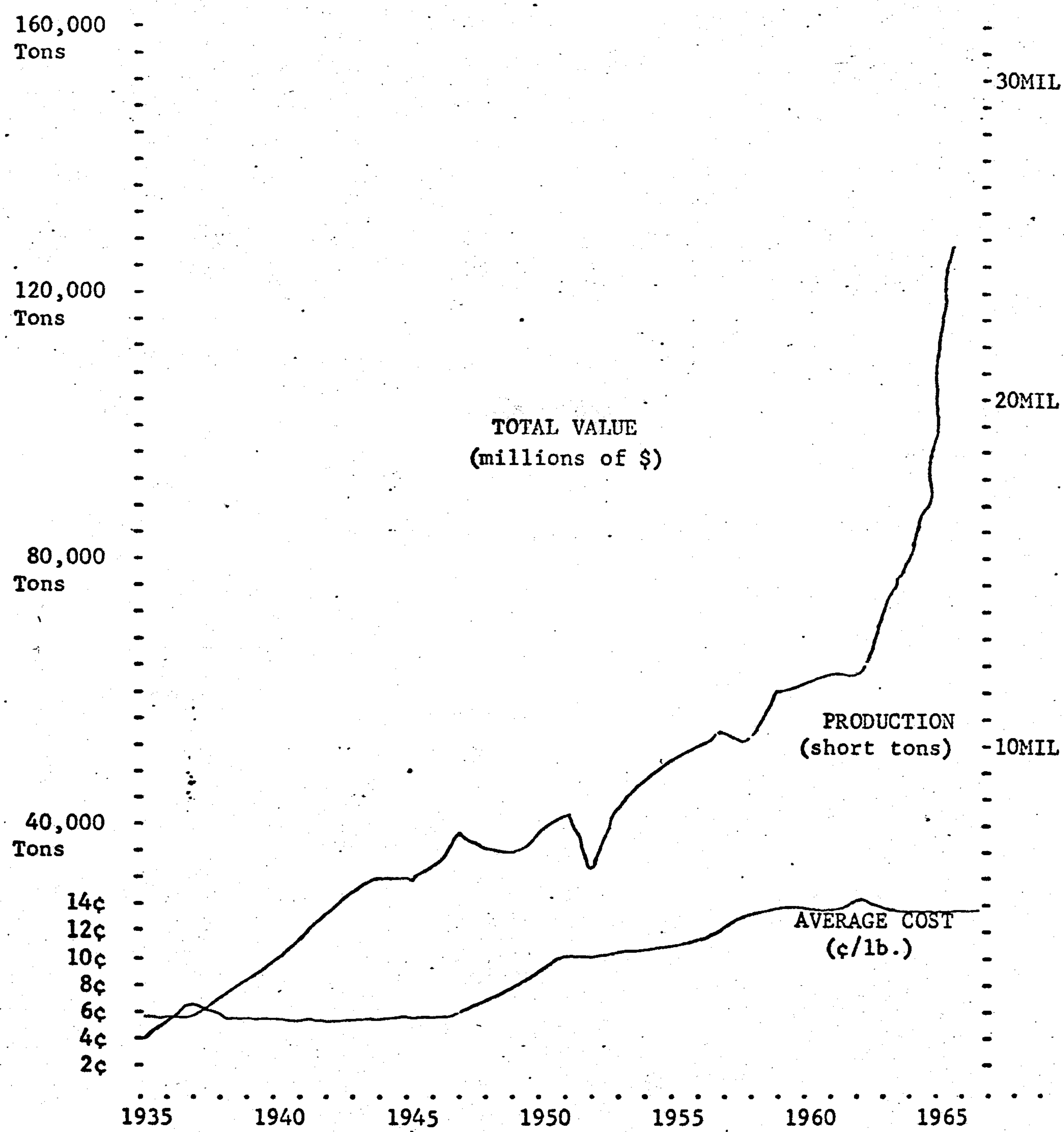
Year	Production (short tons)	Value (dollars)	Average Unit Value (cents per pound)
1966	124,000[e,a]	33,728,000[e]	13.6[e]
1965	86,809	23,612,048[e]	13.6[e]
1964	78,820	21,486,000	13.6
1963	72,096	19,823,000	13.7
1962	61,618	17,864,000	14.0
1961	59,660	15,346,000	13.0
1960	59,963	15,509,000	13.3
1959	58,436	15,451,000	13.2
1958	53,297	13,834,000	13.0
1957	52,757	12,953,000	12.3
1956	53,469	11,608,000	10.9
1955	48,518	10,318,000	10.6
1954	46,200	9,326,000	10.1
1953	42,388	8,555,000	10.1
1952	32,446	6,744,000	10.4
1951	41,656	7,656,000	10.1
1950	37,921	6,737,000	8.8
1949	33,558	NA	NA
1948	33,016	NA	NA
1947	36,169	4,249,000	5.9
1946	32,551	NA	NA
1945	31,289	NA	NA
1944	30,785	NA	NA
1943	39,625	NA	NA
1939	16,168	1,881,000	5.8
1937	10,655	1,444,000	6.7
1935	11,477	925,600	4.3

[e] estimated [a] based on first 11 months production
NA Indicates data not available

Sources: U. S. Department of Commerce, Census of Manufacturers: Current Industrial Reports
(Formerly Facts for Industry)

FIGURE 5-1

U.S. PRODUCTION, TOTAL AND AVERAGE VALUE OR WATER PURIFICATION AND DECOLORIZING GRADES OF ACTIVATED CARBON FOR SELECTED YEARS 1935 - 1966



from 1935 to 1962; however, during the three year period from 1963 to 1966, it has grown at a 20 per cent compounded rate. For the entire 31 year period from 1935-1966, the rate of growth has averaged 8 per cent compounded annually.

The value of this production has increased somewhat faster than the production itself. During the 31 year period, the value of the production increased from just under one million dollars to over 33 million dollars, for an average rate of increase of 12.3 per cent compounded annually. The average cost per pound of the water purification and decolorizing grades of carbon has increased at the rate of 3.8 per cent per year, and this compares very favorably with the general price level increase of 3.7 per cent for the same period.

At this point perhaps some comment should be made concerning the 50 per cent increase in production which was experienced between 1965 and 1966. Although the 1966 production figure is an estimate, it is based on the first eleven months actual production and an estimate for December, and therefore is considered to be very near to the actual production level. The large increase is probably being experienced because of the following:

1. Increased government purchases for military requirements brought about by the Viet-Nam war.
2. Increasing governmental pressure for clean air and water.
3. Technological developments in the field of water purification which use activated carbon in greatly increased amounts.
4. Witco Chemical Company's entrance into the industry with a multi-million pound per year plant.

With the foregoing background information in mind, the characteristics of the individual producers will be considered. This study attempted to determine as much information concerning the firms' facilities for production and marketing as possible. What follows is a summary of this information for each firm.

American Norit Company

This firm is located in Jacksonville, Florida, and has produced activated carbon at that location since 1935. Their carbon is produced from southern pine, using steam as an activating agent. The U. S. Government's statistics indicate they produce decolorizing and water purification grades of carbon, and a review of their sales literature indicates that they are also active in the purification of fats and oils, fine chemicals and pharmaceuticals. This firm is rather small, with total assets estimated to be between $100,000 and $300,000. They report a sales staff of two and are known to market their product both directly and through L. A. Solomon and Brothers, Inc., and R. W. Greeff and Company, Inc., both of New York. American Norit will analyze and test samples of the product a firm desires to have purified in order to find the best grade of carbon to be used.

This firm was originally Dutch and may possibly be tied to Calgon Corporation through their subsidiary, Pittsburgh Activated Carbon, which owns 60 per cent of British Carbo-Norit Union Ltd. of Great Britain.

Atlas Chemical Industries

This firm is located in Wilmington, Delaware, but its production facilities are located at Marshall, Texas. Their carbon, called Darco, is produced from lignite and wood charcoal, using steam and phosphoric acid as the activating agents. U. S. Government statistics indicate that Atlas is primarily a producer of decolorizing and water purification grades of carbon, but sales literature lists grades for beer purification and electroplating solution purification as well. Atlas has a substantial portion of the water purification market. In the survey conducted of municipal water companies in this area, Hydro-Darco represented 63 per cent of the total quantity used, but it was sold to only 29.2 per cent of the users, so it can be seen that they are selling primarily to the larger users. Atlas Chemical Industries has both total assets and gross sales of over $100 million. Its Marshall plant employs between 100 and 499 of the 4,346 total employment of Atlas. Sales of Darco are estimated to be between $1 and $10 million annually. Darco activated carbons are marketed both directly and through authorized distributors. Their services include analyzing which carbon is best for a job, information on the type of equipment required in an application, and providing various charts to aid in determining dosage requirements. Warehouses are located at nine points including Kansas City and St. Louis, while sales offices are in five locations. Thirty-five salesmen are involved in the distribution of Darco activated carbons.

Barneby-Cheney Company

This producer has a plant at its headquarters in Columbus, Ohio and another in Texas. Carbons are produced by this company from coal and from cocoanut shells using steam or acid as activating agents. U. S. Government statistics list deodorizing and solvent recovery as the primary grades of carbon they produce. Although no sales literature was received from this firm, a search of the literature reveals gas recovery and cigarette filters as other grades produced. The total assets of Barneby-Cheney are estimated to be between $1 and $10 million dollars. This firm also produced solvent recovery and air purification equipment which utilizes some of the carbon produced. Barneby-Cheney has two warehouses and forty salesmen involved in the distribution of its products. It maintains five sales offices in the United States and Canada. They are the largest producer of specialty grades of activated carbons. The company expressed interest in the production of activated carbon in this area if a suitable raw material were available. The company conducts a considerable amount of research on the production processes and raw materials used to manufacture activated carbon.

Cliffs-Dow Chemical Company, Inc.

This firm was formed in 1935 through a merger of Cleveland Cliffs Iron Company with Dow Chemical Company. It produced Cliffchar activated carbon at Marquette, Michigan from hardwood scrap, using an electric furnace and steam to activate the carbon. U. S. Government statistics list this firm as a producer of water purification grades of carbon. It is also believed to supply its parent with carbon for use in extracting minerals from brines. The Dow Chemical Company has total assets of 1.5 billion dollars and 1965 gross sales of 1.7 billion dollars. The sales of Cliffchar activated carbon are estimates to be $250,600. This represents half of the total sales of the Marquette plant, which also produces methanol and acetic acid. This carbon is marketed both directly and through intermediate marketing agencies. The company has one sales office and one salesman. They have a research department and will tailor the size of their carbons. The annual production is 895 tons in a plant with a 900 ton capacity.

Pittsburgh Activated Carbon Company

This firm has been a subsidiary of the Calgon Company since it was sold to them by Pittsburgh Coke and Chemical Company in 1965. The plant is located on Neville Island near Pittsburgh, Pennsylvania, and was formed in 1942 to produce activated carbon for gas masks. The raw material activated is bituminous coal, using steam as the activating agent. U. S. Government statistics indicate that this firm is a primary producer of decolorization and water purification grades of activated carbon. Sales information and other data indicate it is also an active supplier of carbons for cigarette filters and catalysts, and is the largest supplier of carbon for the production of streptomycin. This firm has also recently announced two sewage treatment systems which make extensive use of activated carbon and produce effluent waters of drinking quality. Should these methods prove to be as economical as Calgon reports, they should greatly increase the use of activated carbon in this field. Calgon's total assets are $39 million and 1965 sales were $60 million. Pittsburgh Activated Carbon's assets are estimated at $7.2 million with 1965 sales estimated to be from $7 to $15 million dollars. It also produces and markets other coal by-products.

Union Carbide Corporation

The carbon products division of this firm produces Columbia activated carbons from a petroleum by-product using steam and flugas as the activating agents. The firm has produced activated carbon since 1917 at a plant believed to be in Columbia, Tennessee. There are no government statistics kept for this firm; however, their sales literature lists air conditioning, gas purification and solvent recovery as uses for their product. Union Carbide employs 74,000 people, has total assets of $2.3 billion, and 1965 gross sales of $2.1 billion. The Carbon Products Division had 1965 sales of $13 million and is composed of eight plants producing 25 different carbon products. Columbia activated carbon is marketed directly by four salesmen located in four different sales offices throughout the United States. The firm provides aid in designing solvent recovery systems and reactivation services. Solvent recovery is believed to be their major activated carbon market.

West Virginia Pulp and Paper

The chemical division of this firm has produced activated carbon since 1912 at locations including Covington, Virginia; Tyrone, Pennsylvanis; and Luke, Maryland. They produce Nuchar activated carbons from wood pulp waste, which is a combination of leacher waste and black ash, using steam as the activating agent. U. S. Government statistics indicate the primary grades of carbon produced are for decolorizing and water purification. In addition, sales literature indicates applications in plastic solids, pharmaceuticals, agriculture and alcohol decolorization. West Virginia Pulp and Paper employs 14,500 persons, has total assets of $275 million and 1965 gross sales of $302 million. Nuchar is primarily marketed directly, but some sales are through agencies. They have nine salesmen working from four sales offices throughout the United States. Their warehouse is at Covington, Virginia and they have specially designed railroad cars and handling equipment for large users of activated carbon. The firm is the largest supplier of water purification carbon and is a supplier for over 1,200 municipal water companies. West Virginia Pulp and Paper is probably the largest producer of activated carbon in the United States.

Witco Chemical Company

The Sonneborn Division of this firm produces activated carbon at its plant in Pelrolia, Pennsylvania. The material activated is petroleum coke using steam as the activating agent. In late 1966, Witco became the first firm to produce activated carbon from petroleum crude, while controlling the input hydro-carbon from the beginning of the process to the finished product. Witco produces grades of activated carbon for purification, solvent recovery, gas purification, air conditioning, and chemical calatysts. Witco employs over 12,100 persons, has total assets of $51 million and gross sales of $95 million. The firm has technical service laboratories in New York. Their plant is rated as a multi-million pound-year capacity.

PART VI

MARKET ANALYSIS

This portion of the study deals with the structure and size of the current and future market for activated carbon. Using the data contained herein, some conclusions will be drawn with respect to the markets which hold the most potential and the type of firm which would be able best to exploit these markets.

In Part IV most of the uses for activated carbon were listed, but, as was stated in that section, many of these uses represent small, distant markets which would be difficult to penetrate. In this section the markets which are significant in the area in which El Dorado has a transportation advantage will be examined. This area, hereafter called the market area, is comprised of states primarily to the north and west of El Dorado containing some 45 million people, and was discussed in detail in Part III of this study.

The major markets for activated carbon from a standpoint of dollar sales and quantity sold are given in Table 6-1. Close examination of this list reveals that many of these markets do not exist to a significant extent in the market area; however, the following are the markets which are important in this area:

USE	Sales Volume Ranking	Dollar Sales Ranking
Municipal Water Purification	1	2
Dry Cleaning	5	4
Beet Sugar Refining	9	11
Industrial Water Purification	11	9

The following paragraphs evaluate the size of each of the markets for each of these uses based upon the surveys made during the study.

Municipal Water Purification

As stated in part 2, activated carbon is used for the taste and odor control of water. The market for activated carbon for this purpose is scattered fairly evenly over the entire United States. Normally, activated carbon is required in treatment whenever surface water from lakes or streams is used as a source of supply.

The data from which the size of this market was estimated came from a questionnaire sent to the municipal water producers in Kansas, Oklahoma, and Missouri who were reported to be users of activated carbon. Fifty-four questionnaires were mailed and twenty-six were returned for a net return of 48 percent. A summary of the responses is presented in Volume II, and a summary of the type and quantities of activated carbons used in the survey area is contained in Table 6-2.

TABLE 6-1

RANKING OF ACTIVATED CARBON MARKETS

	Sales Volume (Pounds)	Dollar Sales Volume
1.	Municipal Water Purification	(2)
2.	Corn Sugar	(1)
3.	Cane Sugar	(7)
4.	Gas Adsorption	(3)
5.	Dry Cleaning	(4)
6.	Reclaimed Rubber	(8)
7.	Pharmaceuticals	(5)
8.	Fats and Oils	(6)
9.	Beet Sugar	(11)
10.	Plasticizers	(10)
11.	Industrial Water Purification	(9)
12.	Electroplating	(12)
13.	Alcoholic Beverages	(13)

Source: Richard H. Parry, Thesis (Unpublished Master's dissertation, Department of Mineral Economics, Pennsylvania State University, December 1961), p. 123.

TABLE 6-2

SUMMARY OF BRANDS OF ACTIVATED CARBON USED BY MUNICIPAL WATER PRODUCERS

Name of Carbon	Total Quantity Supplied (lbs.)	Average Price per 100 lbs.	Total Value
Aqua Nuchar	290,825	13.70	$30,151.46
Hydro Darco	500,672	7.20	36,564.11
Norit Carbonated	100	14.70	14.70
Unclassified	5,000	14.46	723.00
Total	796,597	8.47 (Average)	$67,453.27

It should be noted that two producers dominate this market as Atlas's Hydro-Darco has 63 percent of the market and West Virginia Pulp and Paper's Aqua Nuchar has 36 percent of the market leaving less than 1 percent to all other producers. More importantly, in Parry's analysis of the markets he stated that, "essentially only one brand is used".[1] This survey showed two brands are used and since his study was made on the east coast it is evident that transportation charges have a significant effect on the type of carbon used because the producer he was referring to was located in Virginia, whereas 63 percent of the market in this area is supplied by a Texas producer.

[1] John W. Hassler, Activated Carbon, (New York:Chemical Publishing Company, Inc., 1963), p. 2-3.

In order to estimate the amount of activated carbon used in the market area, a population equivalent of the number of pounds of activated carbon used per person in the area of the survey was determined. This was done by taking the total population of the area included in the survey and dividing this into the estimated number of pounds of activated carbon used. This yielded the pounds used per person. Applying this factor to the number of people in the market area gives the total estimated use in the market area.

Approximately 4,908,000 persons live in the area where the survey was taken and the total quantity used by those responding to the survey (48 percent) was 795,129 pounds per year. Therefore, the population equivalent is:

$\frac{795129}{.48} \div 4{,}908{,}000 = .3375$ pounds per person per year. Using this equivalent and the average price paid per pound from Table 6-3 the following estimates of the market for municipal water purification grades of activated carbon are made.

AREA	POPULATION	ANNUAL QUANTITY USED	VALUE
Sample	4,908,000	1,656,520 lbs.	$ 140,307
Market Area	44,626,500	15,061,444	1,275,704
United States	195,857,000	66,101,738	5,598,817

Thus it is estimated that there is a market for 15 million pounds of activated carbon with a value of over $12 million in the market area for water purification.

For reference purposes, a list of all cities with more than 25,000 population which use activated carbon has been included in Volume II of this study.

TABLE 6-3

TYPICAL DELIVERED PRICES FOR ACTIVATED CARBON
CLASSIFIED ACCORDING TO APPLICATION

Application	Typical Price or Price Range (cents per pound)	
	Powdered	Granular
Municipal Water Purification	8-17	--
Industrial Water Purification	--	25-50
Beet Sugar	13	--
Cane Sugar	11-17	30
Corn Sugar	11	28
Dry Cleaning	40	--
Electroplating	18	33
Fats and Oils	11-30	--
Pharmaceuticals	15-40	30
Reclaimed Rubber	10-15	--
Air Conditioning and Purification	--	60-80
Catalyst and Catalyst Carriers	--	40-250
Gas Masks	--	45
Gas Purification	--	75
Gas Separation	--	43-60
Solvent Recovery	--	60

Source: Survey of Producers of Activated Carbon.

Cane Sugar

As most cane sugar production is located outside the Continental United States or in coastal cities, there are many producers of activated carbon which have a distinct advantage in freight, proximity, and tradition which would make penetration into this market difficult. As will be noted from Volume II, all United States cane sugar producers are in coastal states except one which is located near the mouth of the Mississippi River. Further, out of a total of seventeen producers, nine are located very near Texas manufacturers of activated carbons, three are very near the Florida producer, and all others are in a position to easily import the material. Only Crockett, California offers a transportation advantage and this would seem to be a considerable distance to initially sell and serve a single account. The foregoing is not meant to rule out the future desirability of entering this market. As shown by Table 6-1 it is a large and stable market and sugar consumption has grown at approximately the same rate as the U.S. population. It should also be noted that there is a protective tariff on activated carbon of 20 to 45 per cent which should be adequate to discourage most importation of the decolorizing carbon and bone char which are used for sugar refining. In fact, total U.S. imports of activated carbons and chars for 1965 were only 2 per cent of U.S. production. Table 6-4 gives a summary of the U.S. imports of activated carbon for 1965.

Kansas Geological Survey

Open File Report 1967-03

Missing Page 70 (Table 6-4)

The market for activated carbon for the production of cane sugar is based upon data indicating 1.5 to 2.0 pounds of carbon are required to produce 100 pounds of sugar and that the losses due to recharging of the spent carbon amount to 60 per cent per year (i.e., 5 per cent loss per recharge X 12 cycles per year).[2]

Using this data the following estimates are made:

CANE SUGAR PRODUCTION AND ACTIVATED
CARBON USAGE

Area Considered	Sugar Produced (tons)	Carbon Used (pounds)	Value $
United States	2,175,000	39,150,000 to 52,200,000	4,306,500 to 15,660,000

As previously stated this is a large market but not one suited for initial penetration.

Beet Sugar

In Part IV it was pointed out that the use of activated carbon in the production of beet sugar is limited to those periods when a poor quality of sugar beets are being used. Also, the estimates of carbon usage are based upon the questionnaire response of two producers which have 31 of the 66 plants which produce beet sugar. A list of the producers is contained in Volume II. All these plants are located in the market area, and based upon these replies the following estimates are made:

[2]Letter from Jonathan C. Cooper, President, Pittsburgh Activated Carbon Company, Pittsburgh, Pennsylvania, January 10, 1967.

ACTIVATED CARBON UTILIZATION
IN BEET SUGAR REFINING

Number of Plants		Quantity Used (Pounds)	Value $
In survey	31	335,000	43,550
Total	66	713,000	92,690

Industrial Water Purification

Soft Drink Production

In the production of soft drinks activated carbon is used to declorinate water. A sample was taken of the quantity of activated carbon used by Wichita bottling plants (a summary of which is contained in Volume II). Based on this survey it is estimated that each bottling company uses 486.7 pounds of carbon per year which is the equivalent of .0119 pounds per person per year. Using these data, the following estimates are made for this market:

ACTIVATED CARBON USED BY
SOFT DRINK PRODUCERS

Area Considered	Number of Bottlers	Population	Quantity Used (pounds)
Sample	6	270,000	2,920
Kansas	55	2,251,000	26,768
Market Area		44,626,300	531,053
United States		193,200,000	2,299,080

Dry Cleaning

The last use for which market estimates have been made is that of dry cleaning solvent purification. A survey of the Wichita dry cleaning plants was conducted and a summary of the results is contained in Volume II. Based on this survey an average use of .136 pounds per person per year was calculated at a median retail price of $.50 per pound.

Using this information the following market estimates were made:

ACTIVATED CARBON USED BY
DRY CLEANING PLANTS

Area Considered	Population	Quantity Used (pounds)
Sample	270,000	37.440
Market Area	44,626,300	6,199,400
United States	193,200,000	26,854,800

Some comments about a few of the other large markets for activated carbon seems in order. As was stated these are large markets but they are not within the market area and therefore are included for information only.

Corn Sugar

Volume II lists the corn sugar producers and their location. Inspection of this list reveals that only one plant is within the market area. Information concerning the use of activated carbon in corn sugar production is very scarce but it is believed that roughly the same quantities are required as in the production of cane sugar;

that is, 1½ to 2 pounds of carbon per 100 pounds of sugar produced. Since corn sugar production is about 10 per cent of all production, this market should amount to 4 or 5 million pounds annually.

Gas Adsorption

With increasing emphasis on the removal of pollution from the air, the gas adsorption market seems to be one which should grow considerably in the near future. However, this market is not currently based around the utilization of activated carbon as much as it is around the production of the filters and filtering equipment which utilize both carbon and other materials for filteration. Further, one producer of activated carbon clorinates this market and as the air purification portion of the gas adsorption market is small it would not seem to be a good potential market for a new producer. It should also be noted that although a great deal of discussion has taken place about air and water pollution, the federal funds allocated to date have been aimed primarily at water pollution. The federal interest in air pollution has been primarily directed at automobile exhaust and industrial waste gasses, neither of which have been treatable economically with activated carbon.

In view of the above discussion, the proper attitude toward this market should be that of "wait and see." If home and office filters become more important this market could become significant.

Pharmaceuticals

The use of activated carbon in this field has grown considerably in recent years. At one time it was used primarily for the purification of various medicines; however, it is now being used as the extracting agent for the medicine itself. The manufacture of penicilian and strytromycim provide good examples of this type of process. While the use of activated carbon in this field has grown, the market is of limited potential because of the eastern location of most pharmaceutical manufacturers and because of the already heavy competition. All of the current producers manufacture activated carbon for use in this field and two of the manufacturers have divisions of subsidiaries which make pharmaceuticals. Thus, breaking into this market would seem to be difficult at best. It should be pointed out that Kansas City and St. Louis both have pharaceutical plants so this field should not be overlooked entirely. However, it would not seem to be an appropriate starting point.

Electroplating

This is one of the smallest of all the classified markets both in quantity and dollar value. Most electroplating is done near the automobile manufacturing centers (not assembly plants) and thus the market lies outside of the market area as defined in Part III. Due to the lack of volume in this field and the distance to the primary market it is felt that it would not be profitable to pursue this market. To reduce further the attractiveness of this market, chrome trim has been replaced on automobiles to a considerable degree in recent years with aluminum and other metals as well as painted surfaces, and this has cut considerably the demand for electroplating.

The Marketing of Activated Carbon

In order to determine the methods and facilities used in the marketing of activated carbon a survey was made of all known sellers. Table 6-5 is a summary of the response to this questionnaire.

From this table it can be seen that 89 per cent of the producers sell directly to the ultimate users while 78 per cent sell through intermediate marketing agencies. The average number of salesmen employed in the marketing of activated carbon by these firms (excluding Culligan) is 18. The sales of activated carbon represents approximately 26 or 27 per cent of total dollar sales of these producers. All sell their products regionally, nationally and internationally. However 23 per cent do not have regional sales offices. The average number of sales offices, again excluding Culligan, is 10; however, the two largest producers have only four offices each.

Culligan has been excluded in two of the above statistics because of its extremely large distribution system which is primarily engaged in water softening products. Adding their 1,000 outlets to the above averages would give an unrealistic impression of the average type of marketing agency used in the distribution of activated carbon.

TABLE 6-5

SUMMARY OF MARKETING QUESTIONNAIRE DATA

	Type of Selling					Size of Market			Sales Office	
	Direct to users	To intermediate marketing agencies	Number of salesmen	Do salesmen sell other products	% of salesmen's total sales carbon represents	Regional	National	International	Regional	Number
American Norit	Yes	Yes	2	Yes	50%	Yes		Yes	No	0
Atlas Chemical Industries	Yes	Yes	35	Yes some	25-30%	Yes	Yes	Yes	Yes	4
Barnebey Cheney	Yes	Yes	40[e]	Yes	1-5%[e]	Yes	Yes	Yes	Yes	40
Cliffs Dow Chemical Company	Yes	Yes	1	Yes	50%	Yes	Yes	Yes	No	0
Culligan Pittsburgh Activated Carbon	No	Yes	1,000	Yes	1-2%	Yes	Yes		Yes	1,000
Hungerford and Terry	Yes	No	30	Yes	5%	Yes	Yes	Yes	Yes	16
Infilco	Yes	No	23	Yes	1%	Yes	Yes	Yes	Yes	15
Union Carbide	Yes	Yes	4	Yes some	50%[e]	Yes	Yes	Yes	Yes	4
West Virginia Pulp and Paper Company	Yes	Yes	8-9	Yes	50%	Yes	Yes	Yes	Yes	3

PART VII

SUMMARY AND CONCLUSIONS

The results of the survey indicate that El Dorado is a suitable site for the production of activated carbon. Raw materials, power and fuel, labor, and industrial sites are all readily available in the quantities which would be required for the production of a product of this type. Further, El Dorado enjoys a transportation advantage over all other producers of activated carbon in a large market area. This type of advantage becomes most important when the unit cost per pound of a material is low, for this causes the freight costs, as a percentage of unit costs, to be very high. Since many of the users have high volume operations and the unit cost of activated carbon is low, the yearly freight bill is often significant. One producer has built bulk train cars to serve the large volume users in an attempt to lower these freight costs.

Table 7-1 gives a summary of the size of the market for the significant activated carbon uses in this market area.

TABLE 7-1

ESTIMATED QUANTITY AND VALUE OF MARKET FOR ACTIVATED CARBON IN THE MARKET AREA

Use	Quantity (lbs.)	Value ($)
Municipal Water Purification	14,061,444	1,275,704
Dry Cleaning	6,199,400	3,099,700
Beet Sugar Production	713,000	92,690
Industrial Water Purification	531,053	53,105
Total	22,504,897	4,521,199

From these estimates it is clear that the potential market is more than adequate to justify the production of activated carbon in this area.

The survey of the producers revealed that the distribution of this product does not require a large selling staff, as the major producers have an average of between eight and nine salesmen assigned to selling carbon, with three producers employing fewer than four salesmen. Most of these salesmen also sell products other than activated carbon. Activated carbon sales ranged from 1 per cent to 50 per cent of the total dollar volume of these producers. Perhaps some consideration should be given to marketing the carbon either through chemical supply houses, as is done with the dry cleaning solvent purification grades of activated carbon, or as part of a line of similar chemical products.

Although no conclusions can be made as to the plant and equipment costs of constructing a plant at El Dorado, the assets of the current producers did not indicate that an initial plant would have to be extremely large or expensive, probably requiring an initial investment of less than $100,000. In order to determine whether a venture of this type would be profitable estimates of the segment of the market which can be captured along with a value judgment as to what rate of return will be required for this type of venture must be made. In order to make some comparisons Table 7-2 has been included to show what rates of return on investment would result from various market shares and production and selling costs when the investment in plant and equipment is assumed to be $100,000.

TABLE 7-2

RETURN ON $100,000 INVESTMENT AT VARIOUS MARKET SHARES WHEN COSTS ARE 30, 50, AND 70 PER CENT OF SELLING PRICE

MARKET SHARE		PER CENT RETURN AND DOLLAR VALUE WHEN COSTS ARE					
		30 PER CENT		50 PER CENT		70 PER CENT	
%	Dollars	%	Dollars	%	Dollars	%	Dollars
1	45,212	33	31,648	23	22,606	14	13,564
3	135,636	95	94,945	68	67,818	41	40,691
5	226,060	158	158,242	113	113,030	68	67,818
10	452,120	316	316,480	226	226,060	136	135,636
15	678,179	475	474,725	339	339,089	203	203,454
20	904,240	633	632,968	452	452,120	271	271,272
25	1,130,300	791	791,210	565	565,150	339	339,090

From Table 7-2 it can be seen that the venture would be quite attractive if the share of the market were as much as 3 per cent of the total; and production, distribution, and selling costs are no more than

70 per cent of the selling price. Due to the favorable locational advantage 3 per cent of the market in the area served would not seem to be an unreasonable goal.

In conclusion, provided a high grade activated carbon can be produced from available resources, there appears to be an attractive opportunity at El Dorado for interested persons to establish a plant for the production of activated carbon. Further, such a project would benefit not only the investors but the area, through the providing of additional jobs by further developing the resources. Hopefully, this study will aid in achieving these ends.