DISTRIBUTION OF PETROLEUM PRODUCTS BY PIPE LINE

By

SAMMY SEMINOFF

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Thesis Approved:

Robert C. Fite
Thesis Adviser

Edward R. Keso

D. C. McIntosh
Dean of the Graduate School

PREFACE

This study examines the factors influencing the development and expansion of the petroleum products pipe line industry. An attempt is made to analyze these factors in an effort to establish clearly the current significance of petroleum products lines and to evaluate their possible future expansion as modes of transportation.

Many of the background materials for this study were obtained by the writer while working for the Great Lakes Pipe Line Company during the summer of 1951. The desire for further study of the industry was stimulated by the growing realization that information available to the general public regarding the significance of pipe line transportation in our economy is generally lacking.

Certain related aspects which influence but are not a component part of the products pipe line industry have been omitted. Only a brief survey is made of the technological phases of the industry to acquaint the reader with their overall significance to the problem. Governmental activities in the industry have been summarized from government documents and reports pertaining to the industry.

Methods employed in the preparation of this study include personal interviews with several industry officials, personal correspondence, and library research. The American Petroleum Institute and the editor of The Oil and Gas Journal provided numerous maps, charts and figures for the development of the study. Library materials included numerous government documents, industrial periodicals, books, newspapers, and other printed matter.

The writer is especially indebted to the following officials in the industry for their aid in this study: Ted Aude, chief engineer, Service Pipe Line Company, Tulsa, Oklahoma; R. J. Evans, chief, Engineering Branch, Texas

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Sammy Seminoff

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INTRODUCTION

The fastest-growing transport medium in the world today is one which is least visible and of which the public is generally least aware. It is the long, pressure-operated, metal pipe line; a phenomenon uniquely American.

The public comes in contact almost daily with the physical facilities of other transportation agencies--the train, the truck, and the airplane--and those who live near navigable waters see and are fascinated by movements of the vessels of water transport. Meanwhile, the pipe line moves its river of crude petroleum or petroleum products quietly underground, and, even in the localities of pump stations, ohe is only vaguely aware of the significance of the constantly running machinery. Yet these common carrier pipe lines transport more than ten per cent of the domestic freight traffic moved by all common carriers in the United States--a larger share than that handled by all motor common carriers combined.

Day and night, frequently without a minute's halt in a year or ten years, pipe line columns of cargo push on by force of gravity or by the pulsing urge of pumping stations. As a rule the cargo columns move slowly, rarely less than three or more than six miles per hour, but tirelessly through every hour of the day. "Beneath grain fields and meadows, up and down hillsides, under the crust of mountains, beneath railroads, rivers, lakes, bays, and seas, beneath great cities and crossroad villages, the steel veins and arteries of pipe lines do their work."[1]

Working incessantly, for the most part beneath our feet and out of our sight, these underground Paul Bunyans are a fifth dimension of transportation.

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[1]Charles Morrow Wilson, <u>Oil Across the World</u> (1946), p. 1.

Pipe lines effect maximum haulage with the lowest consumption of power, more cheaply than railroads or highway trucks, and far more cheaply than airplanes. Taxes and the cost of transportation are the two great cost factors of most power sources. Reducing transportation costs and raising the efficiency of distribution constitute the consumer's best chance, if not his only chance, to effect a saving. Well-built pipe lines are proving to be the best instrument for lowering transportation costs and otherwise improving distribution of petroleum and petroleum products, and in time perhaps many other basic fluid commodities will also be distributed by pipe line.

Pipe lines are not hampered with the extravagances and eccentricities of the wheel, the propeller, the rail, or the hull. Underground, they are better protected from natural and man-made violence than any other means of transportation. They are free from that basic transport extravagance of the empty haul; the non-productive return of empty containers and empty vehicles.

Contemporary pipe lines are part of the petroleum game. To date at least, petroleum and natural gas are their chief passengers. Every day in the United States about 5,000,000 barrels (210 million gallons) of petroleum are gathered and transported in steel pipe lines. The United States is veined with some 129,000 miles of trunk pipe lines for oil, 245,000 miles of pipe lines for natural gas, and 20,109 miles of pipe lines for gasoline or other petroleum products. Within the United States boundaries these three types of subway carriers total about 394,109 miles, almost enough to circle the earth twelve times.[2]

Pipe lines today carry or help carry about 45 per cent of all the power and heat requirements of the United States. They carry about half the power requirements for our railroads, three-fourths of the fuel required by merchant

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[2] Marvin L. Fair and Ernest W. Williams, Jr., Economics of Transportation (1950), p. 103.

shipping, two-thirds of fuels required by highway motor vehicles, and almost all the power needs of aviation. The above statistics demonstrate the immense usefulness of our busily silent pipe lines, the remarkable economy and efficiency with which they operate.

Statement of Problem

Technically, pipe lines operate very smoothly. It is the legality of pipe line operations that has caused the friction between the petroleum industry and the courts of the land.

In recent years, demands for vertical disintegration of the oil industry have "swelled, roared, and sullenly subsided, only to rise again like the crest of an angry sea."[3] The apex of the attack has been directed at divorcement of pipe lines from major integrated oil companies. The fact of integration has been viewed by some as an original sin, with pipe lines the serpent and "monopolistic profits" the apple.[4] But common experience tells us that the world is not all black and white, nor can an industry clearly be placed either in the category of competition or of monopoly.

The bitter fights with railroads, teamsters and other means of transportation have not added to the friendliness of pipe lines. Products pipe lines were the last large medium of modern transportation to be developed.[5] What great internal powers caused them to develop and become established as one of our great

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[3]House of Representatives Bill 7800, United States 75th Congress, First Session (1937), p. 16.

[4]George S. Wolbert, Jr., American Pipe Lines (1952), p. 5.

[5]"Petroleum products" as defined for this paper include refined crude oil, motor fuels such as the different grades of gasoline, kerosene, diesel fuels, tractor fuels and heating fuels or fuel oil. Furthermore, this study, even though it is written primarily on products pipe lines, inevitably refers to crude oil lines in places where the latter influences the former in some manner, be it the past, present or future.

transportation systems? Why did they continue to grow in spite of such great opposition as government regulations and severe economic depressions? What factors affected the development of pipe line transportation for petroleum products? What is the current status of these carriers in the total transportation economy? This study will attempt to analyze these problems in an effort to establish clearly the current significance of this transportation medium for petroleum products and to evaluate the possible future expansion and development of pipe lines as the common carriers of the fluids of commerce.

With this in mind, an examination of the development of pipe lines is necessary to understand the peculiarities of their structure and to evaluate intelligently their social performance. They will be studied against the backdrop of the present industrial anatomy and the behavior and performance of the oil industry.

"Oil in the field tanks is like a fat steer on the range; it needs to be taken thence and made into something useful."[6]

Methods and Procedures

This study begins with the historical development of pipe lines of which numerous petroleum periodicals and books have been invaluable sources of information. Private interviews and correspondence have aided in the basic knowledge of pipe line parlance and management. Much of the material on the development and current status of the pipe line industry was obtained from government documents of the Department of Commerce, Department of Interior, and Bureau of Mines.

The nature of the study involves some technical and industrial information on the various phases of pipe line operations and methods which have been helpful

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[6]Max Ball, <u>This Fascinating Oil Business</u> (1940), p. 173.

in understanding the foundation and recent developments of the industry.

Despite the richness of the literature available on the oil industry in general, the specific subject of pipe lines has remained largely unexplored. This situation is rendered even more unfortunate by the aura of controversy which has surrounded pipe lines during the past two decades. Many of the conclusions set forth are personal judgments of the writer. It is obvious that, even though they are based upon the evidence of careful research, they may be open to challenge.

Origin of Petroleum Products Pipe Line Transportation

In considering the history and development of products pipe lines, it seems the year 1930 may be taken as the initial year of commercial-products pipe line operations in the United States. Developments in the pipe line transportation of natural gasoline and kerosene, however, go back considerably further than 1930; and, as they are factors contributing to the start of a new industry, it would be well to review them now.

Early Refined-Products Lines.--Probably the earliest movement of refined products of any significance started in 1901, when the United States Pipe Line Company started using one of a pair of parallel 4-inch and 5-inch lines for the batching of three grades of kerosene. The lines had been laid in 1892 between Titusville and Wilkes Barre, Pennsylvania, and the success of the kerosene movement prompted an extension of the system in 1902 to Marcus Hook, Pennsylvania. The system remained in intermittent kerosene service until 1926. In 1902, the Standard Oil Company (Ohio) placed in operation a 4-inch line from its refinery to the East Ohio gas plant, a distance of seven miles through a congested section of Cleveland.[7] The only other refined-product movement of record, prior to

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[7]The line was abandoned in 1914, and, upon being opened recently, was found to be in excellent condition with a few pounds of pressure on it.

1930, started in 1929 when the Standard Oil Company of California converted a 20-mile, 10-year-old, crude-oil line to motor-gasoline service; and that line, with a subsequent rebuilding, remains in service today.

Gasoline transportation by pipe line is believed to have started in 1912 in southern California with the building of two miles of 2-inch line, followed in 1913 and 1914 with other 2-inch lines sixteen and thirty miles long, respectively. The year 1915 saw the first natural-gasoline line in Pennsylvania when the Peoples Natural Gas Company of Pittsburgh completed a 2-inch line from an absorption plant to a railroad twenty-three miles away. The Midwest Refining Company, in 1918, placed in service what is believed to be the first all-welded liquid-petroleum pipe line from its Salt Creek gasoline plant to Casper, Wyoming. The forty miles of 3-inch line introduced gasoline pipe line transportation to the Rocky Mountain area.[8]

By 1930, natural-gasoline pipe lines had invaded the "larger and longer" class with three lines in southern California of 4-inch and 6-inch diameter and totaling 260 miles in length. Of these three lines, Shell Oil Company's 97½-mile 4-inch line from the Ventura Field to Wilmington, California, had an intermediate pumping station which employed a motor-driven centrifugal pump. This was the beginning of booster stations on long distance pipe lines. By the end of 1930 there were 1,289 miles of products lines starting a new era of transportation.[9]

<u>Growth During the Depression</u>.--The Tuscarora Oil Company, Limited, started pumping its first tender of motor gasoline out of Bayway, New Jersey, toward its destination in Midland, Pennsylvania, 370 pipeline miles away, on February

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[8]C. P. Bowie, "Transportation of Gasoline by Pipe Line," <u>United States Department of Commerce</u>, <u>Technical Paper 517</u> (1932), pp. 1-12.

[9]Generally, the use of the word "pipe lines" in this paper will be construed as petroleum products lines unless otherwise stated.

1, 1930. The event climaxed a preparation period of almost a year, during which time the 20-year-old line had been converted from a west-to-east crude-oil pipe line to an east-to-west gasoline line.

At about the same time the Phillips Pipe Line Company began work on a 735-mile gasoline line from its refinery at Borger (Texas Panhandle) to Kansas City and St. Louis, completing the line and placing it in service the same year.

Early in 1930 plans were announced for the joint venture of six leading Mid Continent refiners in the formation of the Great Lakes Pipe Line Company to build a 1,240-mile gasoline pipe line from eight northern Oklahoma and Kansas refineries to heavy consuming areas around Kansas City, Omaha, Des Moines, Minneapolis-St. Paul, and Chicago. Construction began the same year.

This great burst of activity in the year 1930 marked the real beginning of refined-products pipe line construction. It is not surprising that late in 1930 the midwestern railroads considered a proposal to lower rates on petroleum products in their area to meet the impending competition by pipe line transportation.[10]

In connection with rates, the first Tuscarora gasoline tariff showed rates twenty-five to sixty per cent below rail rates for equivalent distances. For example, the range included a sixty-per cent decrease on longer hauls and a twenty-five-per cent decrease on shorter hauls, computed on the ratio of decreasing costs for increasing distances. After a few months of operation at these rates, the resulting greater percentage increase in saving was sufficient to establish an overall ten-per cent pipe line tariff reduction.

The year 1931 was another year of great activity in the new race to build gasoline pipe lines from refining to consumption areas. The industry in Pennsylvania really began to become products-pipeline-conscious. The Susquehanna Pipe

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[10]"Prices in Transportation," The Oil and Gas Journal, XXIV (May, 1930), p. 29.

Line Company, in 1931, completed its system from Marcus Hook across Pennsylvania to Akron and Cleveland, Ohio, and north through the coal regions to Syracuse, New York. The formation of the Keystone Pipe Line Company for the purpose of building gasoline lines in Pennsylvania was announced that same year, and work was started promptly on 225 miles of line to serve Reading, Harrisburg, and Scranton-Wilkes Barre with refined products from Philadelphia. National Transit Company in 1931 built and placed in operation six miles of 2-inch gasoline line from a cracking plant at McClintock to Reno, Pennsylvania.

Also in 1931 the Standard Oil Company of New York built a gasoline line out of its Providence, Rhode Island, refinery to serve Worcester and Springfield, Massachusetts, the first products pipe line for New England. The Great Lakes System, started in 1930, was completed and placed in service in 1931.[11]

The beginnings of the products pipe line industry were well established during the first two years of the 1930's and have led us on through the intervening years in an ever-increasing pattern of growth (Tables 1, 2, and 3).

Recent Growth of the Industry.--The areas of future products-line concentration were defined by the two major lines which extended from Texas to St. Louis and from northern Oklahoma to terminals in Minnesota.[12] By 1940, these two areas were largely covered with products lines. During the war years, links reached out which almost joined these two areas, and a third section of the country, the southeastern states, came into products-line prominence. By 1948, northern expansion of the Mid Continent outlet lines sprang up, together with a link between the Gulf Coast and the central states. The late 1940's

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[11] John Power, "Gasoline by Pipeline," National Petroleum News, XXII (November 26, 1931), pp. 31-35.

[12] These areas included the pipe line right-of-way, terminals, refinery storage facilities, and pumping stations of the Phillips and Great Lakes Pipe Line Companies, respectively.

brought further products-line concentration to the heavily lined areas which established a through link from the Gulf Coast to eastern refining centers and pushed a products line out toward a new pipe line frontier--the Pacific Northwest.

In Table 1 are tabulated what might be called the "fundamental statistics" of the products pipe line industry. Although the pre-war growth of the industry is spectacular in itself, the post-war expansion is even more amazing. In the four-year period of 1945-1949, an increase of more than fifty-five per cent was realized in both mileage of products lines and barrels delivered to terminals. The war years themselves were a period of tremendous pipe line growth, with sixty per cent more mileage in operation in 1945 than in 1940, and with the barrels delivered to terminals more than doubling in this five-year period.

TABLE 1

TOTAL MILEAGE OF REFINED PRODUCTS PIPE LINES, RIGHT-OF-WAYS, BARRELS (of 42 gallons) TERMINATED, AND BARREL-MILES PUMPED, 1930-1949*

Mileage and Barrels	Year				
	1930	1935	1940	1945	1949
Total mileage of pipe in refined-products pipe line service . . .	1,289	4,471	8,040	12,857	20,109
Total right-of-way mileage in refined-products pipeline service	1,125	4,015	6,890	11,439	18,053
Total refined products, barrels terminated by pipe line (1000) .	5,491	45,746	105,835	230,019	365,603
Total refined products, barrel-miles pumped (1,000,000)	2,245	16,749	29,221	76,061	109,973

*John W. de Groot, "History and Development of Products Pipe Lines," American Petroleum Institute (November 8, 1949), p. 3.

The ratio between miles of pipe and miles of right-of-way is indicative of how many parallel lines are in operation; and, surprisingly, this has changed little during the entire existence of products lines.

A similar situation prevails with the "average haul", the ratio of barrel-miles to barrels. It has varied considerably from interval to interval, but shows consistent reduction in post-war years.

A tabulation of pipe by sizes is shown in Table 2. No stability in trends is shown for the early years. From 1945 on, however, decreases in 4-inch and 6-inch pipe are offset by corresponding increases in the prevalence of 8-inch, 10-inch, and 12-inch pipe.

TABLE 2

REFINED-PRODUCTS PIPE LINE MILEAGE--BY PIPE SIZE, 1930-1949*

Pipe Line Sizes	1930	1935	1940	1945	1949
2-Inch	---	11	15	35	40
3-Inch	---	73	78	85	136
4-Inch	1	233	514	675	717
5-Inch	---	---	83	83	83
6-Inch	197	2,136	3,457	5,204	6,266
8-Inch	998	1,926	3,761	5,530	10,217
10-Inch	---	1	4	690	1,602
12-Inch	93	91	128	549	1,048
	1,289	4,471	8,040	12,857	20,109

*John W. de Groot, "History and Development of Products Pipe Lines," American Petroleum Institute (November 8, 1949), p. 8.

Table 3 shows some of the less important but more interesting statistics for the products pipe line industry. The number of pumping stations increased, but not in proportion to the right-of-way mileage. Thus a definite, although small, increase in the average station spacing is seen from 1935 to the present time. This increase is consistent with the recent trend toward the larger pipe sizes and higher working pressures.

The average spacing of delivery terminals decreased in the pre-war decade, but since that time has been increasing. A possible reason for this behavior is that during 1930-40 construction was principally concentrated in competitive pipe line areas, with a resulting closeness of delivery points. The post-1940 tendency of products lines to enter new more-sparsely populated frontiers, together with improvements in tank-wagon hauling range, has doubtless contributed to the present trend.

TABLE 3

REFINED-PRODUCTS PIPE LINES--MISCELLANEOUS STATISTICS, 1930-1949*

Quantities of Stations, Terminals and Pipes	1930	1935	1940	1945	1949
Number of pump stations	18	99	150	236	325
Average station spacing (miles) .	62.5	40.6	46.0	48.5	55.5
Number of delivery terminals . .	11	65	133	204	280
Average terminal spacing (miles).	102	61.8	51.8	56.0	64.5
Miles of pipe coated against corrosion	23	310	1,617	4,817	10,993
Average coated, per cent	1.8	6.9	20.1	37.5	54.7

*John W. de Groot, "History and Development of Products Pipe Lines," American Petroleum Institute (November 8, 1949), p. 8.

The great increase in the use of protective coating is due not only to the newer lines' coating a greater percentage of their pipe mileage, but to the coating of older lines during reconditioning as well.[13]

Thus the products pipe line industry has passed the 22-year mark in its continuing program to serve the petroleum consumer. Larger pipe, higher

[13]"Protective coating" consists of cleaning the pipe, applying tar or asphalt and wrapping with heavy paper to protect it from soil corrosion.

pressures, greater station spacing, and a willingness to accept and adopt technical advancements--all have contributed to the industry's pattern of growth and efficiency.

CHAPTER II

FACTORS AFFECTING THE DEVELOPMENT OF PIPE LINE TRANSPORTATION

As the age of the automobile emerged loud and shiny, and as filling stations began replacing livery stables, hack barns and blacksmithies at roadsides throughout the nation, petroleum grew mighty--with thousands of new oil wells and scores of new fields and pools "coming in." Iron pipes and, after a time, steel pipes, were the latter's lifelines. Pipes were claiming their place as a proportionate as well as an indispensable factor in petroleum investments. By 1910 about ten per cent of all capital staked in United States petroleum was in pipe lines. That percentage remains approximately stable even to this day.[1]

The inconspicuous webs of crude oil pipe lines had increased, by 1910, to at least 40,090 miles; by 1920 to about 52,993 miles; and by 1930, according to United States Bureau of Mines estimates, to 88,728 miles.

During those three decades steel pipe had begun to replace cast iron; seamless steel pipe that was lighter, thinner-walled, far stronger and longer lived than the early cast-iron pipe. Electrical and other types of welding had begun replacing the highly breakable and toilsome screw joints. Pipe lengths were being doubled or tripled. Improved rotary pumps, most of them driven by gasoline or oil-burning engines, were replacing the earlier and generally inferior steam-driven pumps. Line pressures were raised, friction waste was diminished, and general efficiency increased. With weather-coated steel, the working life of oil lines increased with each decade. Tractors and trucks began replacing mules, horses and freighting wagons. Tractor-drawn ditching machines roared and wabbled across open country, digging and filling in a few hours better ditches than those that had previously taken months of pick-and-shovel digging. Electrical control boards, operated from central stations, were serving to locate line leaks and to replace in some part the plodding watchfulness of the pipe line walkers,

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[1]Charles Morrow Wilson, Oil Across the World (1946), p. 70.

or more recent air observers, who regularly inspected the pipes for leaks through all kinds of weather, vegetation and topography.[2]

Founded as common carriers to fulfill a specific transportation need, oil pipe lines, at least by legal definition, have remained common carriers.[3] Regulatory authority covering pipe lines is the outgrowth of serious abuses which characterized oil transportation at the turn of the century. The railroads were first used for the transportation of petroleum and its products. Before effective railroad regulation and during the period of growth of the great Standard Oil Trust, outrageous abuses flourished, extending not only to rebates but even to the payment to the trust of portions of the rates collected from smaller competitors. These were brought under control as the authority of the Interstate Commerce Commission over railroad rates and services was broadened and confirmed.

However, recourse to pipe line transportation of petroleum had begun. The large refining companies invested heavily in the construction of trunk pipe lines from producing areas to refineries, made themselves largely independent of the railroads for the transportation of crude oil, and placed the smaller independents at an increasing transportation disadvantage. The latter were seldom able to finance pipe lines of any length, and the high rates and burdensome conditions of carriage imposed by the pipe line subsidiaries of large refiners effectively excluded independent oil from those lines. This condition gave rise to Congressional action designed to find some correction and to strengthen the competition offered by the smaller companies. "Discrimination in transportation had undoubtedly been an important factor in the concentration of the refining and distribution of oil in the hands of a few concerns, and the lack of common carrier

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[2] Ibid., p. 71.

[3] Congressional enactment of the Hepburn Act of 1906, the Federal Government's regulatory act for interstate pipe lines, classified all oil pipe lines as common carriers.

pipe lines threatened to preserve if not enhance their advantage."[4]

After the dissolution of the Standard Oil Trust in 1911 in response to the Supreme Court's order in Standard Oil Company of New Jersey vs. United States, the dissolved companies, dealing largely with only one phase of the industry, found they could not compete effectively with the new integrated companies. They, too, undertook to combine the various operations from well-head to service station pump. The result has been that integration of all phases of the industry has become a competitive necessity for large scale operators. Today the structure of the industry is composed of many fully integrated companies, more partially integrated companies, and a "competitive fringe" of independents in each phase.[5]

Not all governmental activities in the industry have been of a regulatory measure. The two biggest crude oil and products pipe lines in the world, the Big Inch and the Little Big Inch, extending from the Houston, Texas, petroleum field and refineries to the industrial areas of New York and Philadelphia, were built and operated by the United States government as a primary war utility. As such, they proved to be our government's most successful adventure in operating war facilities.[6]

When the first oil field was undergoing a frenzied development initiated by the pioneer discovery well "brought in" by Colonel Drake on August 27, 1859, the problem of transportation had few alternative solutions. Since the railroads were twenty to twenty-five miles away, the drilling program at that time caused wells to be adjacent to streams tributary to the Allegheny River. The natural course of events led to water transportation down these tributary

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[4]Marvin L. Fair, et. al., Economics of Transportation (1950), p. 503.

[5]George S. Wolbert, Jr., American Pipe Lines (1952), p. 12.

[6]Wilson, op. cit., p. 151.

streams to the Allegheny, then to Pittsburgh. But as the limits of the producing fields were extended, it became necessary to use the horse-and-wagon means of hauling the oil to shipping points. The charges for this service varied with the distance, road conditions and season of the year, ranging from one to five dollars per barrel.[7]

The increase in development of the field caused teamsters to haul the oil to the river barges. This method soon proved too expensive and hazardous to operate. The only permanent answer was the construction of crude oil pipe lines. This solution, however, did not easily fulfill the dreams of the construction men who ran into opposition ranging from barge carriers to the railroads.

The shifting and westward movement of the petroleum frontiers tended to necessitate increased transportation facilities to bring petroleum and its products to the industrial northeastern part of the United States.

In practice and through the years the petroleum pipe line remains an operational tool in the now highly integrated petroleum industry, much like a conveyor belt in a factory.

Inadequacy of Other Transportation Facilities

Basically, the development of pipe line transportation was due to the increasing production of petroleum and inadequacy of the teamsters, barges, railroads and tankers as a means of transportation.

The first oil fields were discovered in sparsely populated areas yet unlinked by adequate transportation facilities to the cities which were to furnish the great markets for the products of the rising new petroleum industry. A transportation bottleneck soon was formed when the horse-and-wagon teamsters, who hauled crude oil from the producing fields to nearby railheads and refineries,

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[7]Wolbert, op. cit., p. 5.

began to charge excessive prices for their carriage.[8]

The producers first sought relief from this excessive expense by building flat boats which were floated down Oil Creek, Pennsylvania, on natural high water levels or by means of "pond freshets," a device adapted from the lumbermen whereby synchronized flood gate operation would loose a stage of water sufficient to carry the boats downstream to deeper water. However, the expense and hazard of this method of operation ended its use as a permanent solution.

The challenge thus presented became the stimulus of pipe line invention. As early as November, 1860, Colonel S. D. Karnes had envisioned a pipe line project. In 1862 a small diameter pipe line was laid from a producing well over a hill to a refinery. Oil was siphoned approximately 1,000 feet from this point. It remained for Samuel Van Syckel to complete the first successful crude oil pipe line on October 7, 1865, a 2-inch wrought-iron line carrying eighty-one barrels an hour over the five-mile journey from Pithole City to Miller's Farm, Pennsylvania. The teamsters reacted violently, cutting the line and tearing up portions of it, necessitating armed guards for protection. Resistance was futile. The pipe line was a mechanical success and the first transportation bottleneck was broken.

At this time, the railroads favored pipe line development as it fed increased quantities to the loading racks along the right-of-way, from which the oil was loaded into tank cars and shipped to refineries on the eastern seaboard. However, the railroads merely created another transportation problem by establishing a monopoly of their own, dictating prices to producers and driving shippers from the field. The oil pioneers promptly met this new threat by building trunk pipe lines directly from the fields to the refineries. This turn of events quickly changed the tolerant attitude of the railroads into one of determined

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[8]Fair, _op. cit._, p. 160.

resistance. Pipe lines were refused access across railroad right-of-ways, and numerous physical and legal clashes occurred as a result of the violent competition which followed. But again economics tipped the scales in favor of the pipe lines, which established themselves as the favored means of oil transportation.

In 1878 a line was started which eventually crossed the Allegheny Mountains and moved oil to the Atlantic Seaboard cheaply, swiftly, and in enormous quantities. By 1880, over 1,200 miles of pipe lines served the Appalachian producing fields. The year 1900 found about 18,000 miles of pipe lines operating in the United States. Four years later, pipe lines were built from the Mid Continent area to join the eastern carriers, and the rough framework of the existing system was sketched out. Since that time, extensions to new fields, "looping" of lines along existing routes to increase capacity, and the advent of products lines have greatly increased pipe line mileage.

The inadequacy of other transportation can thus readily be seen. The pipe line industry developed not only because of the inadequacies of other transportation facilities, but also as a result of the expanded growth and development of the petroleum industry in relation to the growth of industrial areas in the United States.

Westward Movement of Petroleum Frontiers

The growth of the United States has followed its avenue of communication, first along waterways and wagon trails and then along railroads and highways. The history of that growth is one in which the transportation agency pioneered the route, then encouraged and aided settlement and industrial development, thus seeking a constant increase in traffic. The crude oil pipe line, on the contrary, was built or extended to serve new oil discoveries which reach their maximum production during the initial period of production, then constantly diminished. Often a line has been built to a new discovery which never developed the contemplated traffic. This is one of the greatest business risks facing a pipe line company.[9]

Although most all crude oil lines, and some products lines, are common carriers transporting for the general public, the fact is inherent that the public interested in pipe line transportation service is limited largely to those people in the petroleum industry. Crude oil lines, for instance, transport only a raw material having no more intrinsic value than any other product of the mine or forest until processed and pipelined to the terminals. So the maximum "public" which such pipe lines can serve consists of producers and processors of crude oil and petroleum products and their representatives, such as oil brokers.

Many pipe lines were built from the Houston, St. Louis or Chicago refining centers to the producing fields of Texas, Oklahoma and Kansas, in the same manner that the Santa Fe Railroad, for example, was built from Chicago and Kansas City to the west and southwest. Each pipe line generally is connected to and serves refineries at its terminus, just as the railroad serves many industries.

The Movement of Crude Oil Lines.--The areas which produce the major part of crude oil used in the United States are not located close to heavy consumption areas of petroleum products; thus some means of efficient transportation for crude petroleum is required (Table 4). Eighty-five per cent of the production comes from the states of Texas, California, Louisiana, Oklahoma and Kansas. Major production comes from that section of the United States lying west of the Mississippi River; whereas, major consumption is in the area east of the Mississippi River. Also, local areas, such as the section embracing the states of Texas, Arkansas, Louisiana and Mississippi, have production located away from export points along the Gulf Coast. Crude oil is transported, for example, by

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[9]Paul Graber, Common Carriers Pipeline Operations (1949), p. 55.

pipe lines from East Texas to the Gulf Coast, some of it being refined and used in the Gulf Coast area, and some being loaded aboard tankers for transportation by water to points as far away as the New England states. Crude oil is also transported inland by pipe line from the mid-continent areas to far distant West Virginia and the Great Lakes area. Refineries, for the most part, are located in heavy consumer demand areas; but, for efficiency, refineries usually manufacture more petroleum products than can be consumed in the immediate area. This presents a problem in transporting refined petroleum products from refineries into consumer areas somewhat remote from refining districts. To handle this transportation, products pipe lines are constructed from the refineries to retail market outlets.

TABLE 4

PETROLEUM PRODUCING DISTRICTS OF THE UNITED STATES*
(Percentage of National Production)

District	Per Cent
1. The Eastern District	1.5 per cent
2. The Mid Continent District	20.0 per cent
3. The Gulf Coast District	57.5 per cent
4. Rocky Mountain District	3.0 per cent
5. Pacific Coast District	<u>18.0</u> per cent
Total	100.0 per cent

*"Petroleum," <u>American Petroleum Institute</u> (1949), pp. 42-43.

<u>The Products Pipe Line</u>.--Although the early refineries were centralized at points where the demand for finished products was great, when crude oil production shifted from the older areas of the Appalachian region to the southwest, many refineries were built near the source of the crude oil rather than the point of demand for products. These refineries generally began as skimming

plants, started by individuals or small companies, which have grown in size in slightly more than a generation until they are now among the leaders of the oil industry. With the expansion of the refineries for more economical and efficient utilization of crude came a greater volume of finished products and the natural American desire of the companies to expand their marketing into wider areas.

Companies operating refineries in the oil fields found themselves at a competitive disadvantage with the refineries located in heavy consuming areas, which secured their crude oil supply through pipe lines, because of the necessity of using less economical means of transportation for finished products. So the first products pipe line built solely for transportation of petroleum products reached from the refineries located near the raw material supply to the point of greatest demand for products. Then the refiner in the oil fields could compete with the refiner in the larger midwestern cities.

As all American industry has adapted the motor truck, the ocean vessel, and the barge to its needs, so has the oil industry adapted the products pipe line. The manufacturing concern whose volume of transportation warrants it, buys its trucks or its own vessels and operates them for itself alone as a private transportation agency. A company whose volume of business does not warrant investment in its own truck transportation facilities depends upon a public carrier, either contract or common, in some cases joining with other companies in organizing and financing such a transportation company.

The oil industry has done the same thing with truck, water, and pipe line transportation facilities. The first products pipe line was financed by a group of refiners whose individual businesses did not warrant such a heavy investment. It was built to serve as a common carrier. Many of the products pipe lines, however, were built by companies whose volume of traffic justified the construction of a private transportation system. They applied the same economic tests as those used for truck or water transportation, and they operate as private lines today.

As the oil rush began spreading farther west and south, more and more pipe lines began to connect new and more distant oil wells and fields with frontier refineries or with city or seaboard markets. The usually invisible spider-webbings of iron pipes were coming to stay. They were following the slippery trails of oil beyond Pennsylvania to the still newer oil frontiers of Ohio, Illinois, Indiana, Kentucky, and still farther west to the ever greater bonanzas of crude in Oklahoma, Texas and the Gulf Coast areas (Figure 1).

Over a billion dollars of private capital is invested in pipe line facilities. The pipe line industry has grown to its present stature in less than eighty-five years, without subsidy or public aid of any kind in its construction or operation. In this respect it is unique in the transportation industry.

Governmental Activities in the Industry

Due to the tremendous initial outlay of capital required for long-distance pipe lines and the extremely hazardous nature of the venture, the lead in constructing and acquiring long distance lines was assumed by the large refining companies. They had to assure themselves of constant, large-quantity supplies of crude oil in order to realize the economies of large-scale refinery operation. At the same time, they desired to locate their plants convenient to consuming territory. Since successful pipe line operation depends on a constant high-level demand for carriage, and the refineries need a steady supply of crude oil, the union of pipe lines and refineries quickly was effected.[10]

Not only were pipe lines and refineries united by their functional

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[10] *Ibid.*, p. 61.

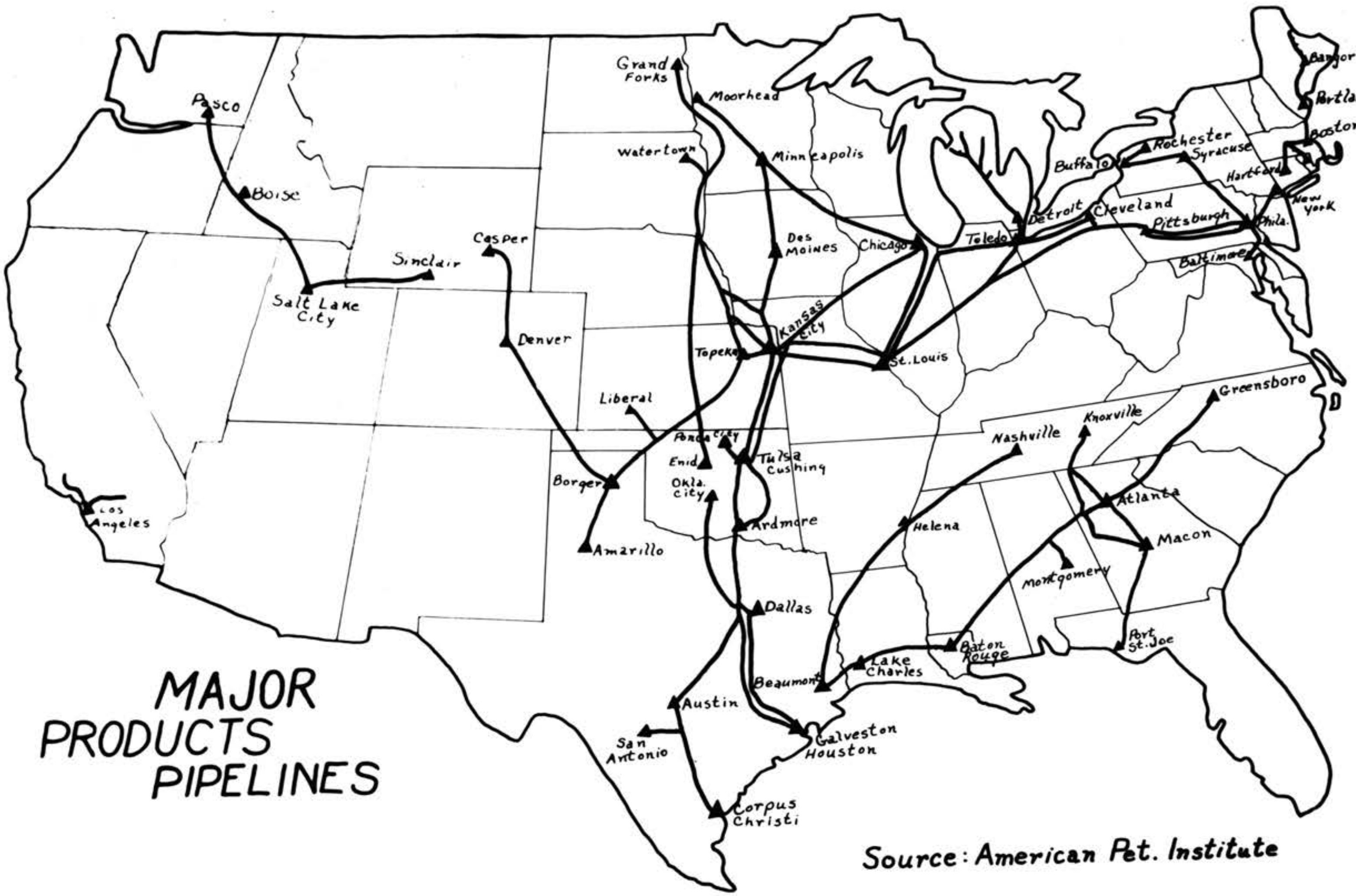
MAJOR
PRODUCTS
PIPELINES
Source: American Pet. Institute
Pasco
Boise
Salt Lake City
Sinclair
Casper
Denver
Los Angeles
Grand Forks
Moorhead
Watertown
Minneapolis
Des Moines
Chicago
Kansas City
Topeka
St. Louis
Liberal
Ponca City
Enid
Okla. city
Tulsa
Cushing
Ardmore
Borger
Amarillo
Dallas
Austin
San Antonio
Corpus Christi
Galveston
Houston
Beaumont
Lake Charles
Baton Rouge
Helena
Nashville
Knoxville
Greensboro
Atlanta
Macon
Montgomery
Port St. Joe
Toledo
Detroit
Cleveland
Pittsburgh
Buffalo
Rochester
Syracuse
Hartford
New York
Phila.
Baltimore
Boston
Portland
Bangor

Figure 1

interdependence, but the wild nature of the competition in the early days of the petroleum industry forced the larger companies to integrate fully in order to avoid vulnerability in one or more stages of the process from the well-head to the service station pump. Integration became a competitive necessity for large-scale operators, and those companies who failed to realize this fact or who were unable to accomplish it, were either consumed by their more aggressive rivals or were reduced to a minor role in the industry. In turn, this led to concentration of control in the hands of the "major" oil companies.

For example, in 1941 twenty integrated "majors" owned or controlled 57.4 per cent of the crude oil gathering line mileage, 89 per cent of the crude oil trunk mileage and 96.1 per cent of the products line mileage. Numerous complaints have been voiced against this concentration. Insofar as these complaints related specifically to pipe lines, an effort was made to examine and evaluate their content. The complaints were classified as: (1) alleged denial of independent company access to pipe lines; (2) inequalities of competition caused by major company pipe line ownership; and (3) alleged creation of monopoly in the oil industry through the instrumentality of pipe line control.[11]

The alleged denial of independent company access to pipe lines involved rates, services requirements, and shippers' use of pipe lines. Initially, pipe line rates were set to match the comparable rail rates. Apparently this was done in order to keep outside shippers from using the lines or to repay quickly the investment therein. Later, a more competitive situation arose and rates were somewhat reduced. Still later, the Interstate Commerce Commission initiated a program of active supervision and ordered rates reduced to a level where they would return eight per cent on crude line valuations and ten per cent on products lines property.

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[11]Marvin L. Fair, et. al., Economics of Transportation (1950), p. 162.

The complaints against pipe lines for failure to furnish storage facilities were found to be misdirected inasmuch as the business of pipe lines is carriage, not the furnishing of storage.

The financial union of the shipper and pipe line is allegedly productive of discrimination among shippers and tends toward monopoly. This was true in the coal-railroad set-up, but a comparison between railroads and pipe lines is hardly safe.[12] The following fundamental differences between the two methods of transportation make the analogy impossible: (1) pipe lines were built by the shippers who use them--the oil companies themselves; (2) pipe lines were built to serve one industry whereas railroads were built to serve all industries, as well as passengers; (3) the typical products line was constructed from the refinery to a specific marketing area desired to be reached by the shipper-owner. Consequently, the public served by these lines is limited to the producers and shippers in originating areas and to the refineries at their termini, or along their established routes. Railroads, on the other hand, were built for the purpose of engaging in the business of transportation for a profit. Within the limits of their trackage, they have available a vast number of potential customers from the public at large; (4) pipe lines carry only petroleum products in one direction.[13] Railroads haul all kinds of commodities in as many directions as their lines run; (5) a pipe line either transports crude oil from the field to the refinery, or refined products from the refinery to the marketing area. It would not likely carry crude to the refinery and then transport the refined product back to the producing area. By contrast, a railroad,

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[12]"United States vs. Reading Company," <u>United States Supreme Court Report No. 424</u>, Vol. 253 (1920), sec. 26, 40.

[13]Occasionally the direction of flow through a pipe line has been reversed. This requires a resetting of pumping stations to conform to the new hydraulic design. Expense and time involved cause these changes to be very infrequent.

hauling some products predominantly in one direction, has the advantage of return hauls of other products; (6) crude pipe lines have a limited expectancy. Every barrel of oil transported reduces the amount remaining to be carried. But the typical railroad can expect increasing traffic as the community being served continues to grow with the passing of time; (7) pipe line capacity is limited. Unlike a railroad, it cannot run additional trains or add cars. To obtain greater capacity, additional lines or pumping stations must be added at great cost; (8) pipe lines are extended to the property where the crude is produced and will make the necessary connections to the shipper's tanks without additional charge. A railroad will construct sidetracks only at the shipper's expense. These do not exhaust the many differences between railroads and pipe lines, but they serve to show that the problems involved in regulating pipe lines and railroads are not the same.

In view of the foregoing, governmental activity in the industry was quickly forthcoming, which not only regulated the early pipe lines, but laws were passed which affect the industry today and probably will in the future.

Fundamentally, government regulation of pipe lines has its source deep in English common law. The English courts, in their efforts to define the legal duties and responsibilities of carriers, early developed the concept of a "common carrier". Any person who held himself out to the public as engaged in the business of transporting persons or property from place to place, for compensation, was declared to be a common carrier. The distinctive characteristic of a common carrier is that he undertakes to carry for all people indifferently and therefore he is regarded as a public servant, in some respects. He is distinguished from a private carrier by reason of his obligation to carry for the public generally, and by the higher degree of responsibility imposed on him for loss or injury to persons or property transported.

The common carrier doctrine was first applied to stagecoaches and hacks, but with the coming of modern transportation facilities such as railroads and pipe lines, it was extended to them.[14]

The Interstate Commerce Act.--For a long time, Congress made no attempt to regulate railroads and other common carriers, but in 1887 the statute to regulate commerce, known as the Interstate Commerce Act, was passed. The statute resulted from the inability of the states to cope by legislative means with the railroad corporations whose lines extended across many states. The principal objects of the Act were to secure just and reasonable charges for transportation; to prohibit unjust discrimination in the rendering of services; to prevent undue or unreasonable preference to persons, corporations or localities; and to abolish combinations for the pooling of freight. Subject to the two principal provisions that charges should not be unjust and unreasonable and that there should be no unjust discrimination, the Act left the common carriers as they were at common law, free to manage and operate their businesses in the interest of their owners.[15]

The Act required the filing, posting and observance of tariffs and the filing of annual statistical reports. It created the Interstate Commerce Commission, which now consists of eleven members appointed by the President.

The Act of 1887 applied only to common carriers engaged in the transportation of passengers or property by railroad, or partly by railroad and partly by water. It did not cover petroleum pipe lines.

The Interstate Commerce Act requires that pipe line rates and classifications of freight and practices be just and reasonable; that there be no unjust

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[14] Paul Graber, Common Carrier Pipeline Operations (1949), p. 41.

[15] "United States Statutes at Large," 49th United States Congress, Vol. 24 (1887), p. 379.

discrimination or unreasonable preferences; that pipe lines provide reasonable facilities for interchange of traffic without discrimination, and that traffic or revenues not be pooled without the Commission's approval. Common carrier pipe lines are required to publish joint through rates and to file rate schedules with the Commission, and are subject to the valuation provisions of the Act. On the other hand, a common carrier pipe line need not secure a Federal Certificate of Convenience and Necessity before proceeding with construction or abandonment, as is required of a railroad. The Commission does not pass on pipe line securities as it does on railroad securities. The merger restrictions of the Act are not applicable to pipe lines. The pipe lines are not covered by the "commodities clause" which prohibits carriers from transporting their own goods. The lines may extend credit to shippers to such extent as they please. In other minor respects the pipe lines are held to a lesser degree of accountability than the railroads and other more closely regulated carriers.

The differing authority of the Interstate Commerce Commission as between railroads and pipe lines is a recognition of the inherent differences in the operations of the two types of carriers. For example, to require pipe lines to secure certificates of convenience and necessity before extending their lines would restrict the flexibility so essential in speedily connecting to newly discovered fields. The commodities clause in the Interstate Commerce Act was not applied to pipe lines because of the adverse effect this would have on both producers and refiners.[16]

State Regulation of Operations.--Only those pipe line common carriers engaged in interstate commerce fall within the scope of federal regulation. While certain carriers are engaged solely in interstate commerce and are regulated only by the Interstate Commerce Commission, other carriers' operations are

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[16] Ibid., p. 380.

restricted to intrastate business. For this reason, these carriers escape federal regulation but are subject to such control as exists in the states wherein they operate. A third group of carriers are those who are engaged in both interstate and intrastate operations. This group includes most of the big crude oil common carrier pipe line companies. They are subject not only to the authority of the Interstate Commerce Commission but to the regulatory authority of various states which have enacted pipe line common-carrier legislation.

The Hepburn Act.--In the early days of the oil industry in Pennsylvania, some of the operators, in an effort to reduce transportation costs, built short pipe lines to nearby railroads, refineries, or water courses. The owners of some of these lines carried not only their own oil but the oil of others, giving receipts for this service and transmitting the oil for a fixed fee. Courts of law early saw signs of close similarity between pipe lines transporting for others and the traditional common law of common carriers. Once the Courts had declared the pipe lines to be common carriers, it was a natural step for Congress and the legislatures to enact regulatory statutes pertaining to them.

Some of the pipe lines submitted to the common carrier designation, but most of them, including the lines of the Standard Oil group, did not. For example, Standard sought to avoid the imposition of common carrier status by buying at the leases all of the oil transported in its lines in addition to its own oil and by setting up separate pipe line companies in each state. Standard would refuse to transport oil for another producer. The only way in which he could have his oil shipped through Standard lines was to sell it to Standard. Under this arrangement, many producers and other refiners were largely at the mercy of the Standard group. Producers sold their oil at prices more or less dictated by the group. Refiners located at some distance from the oil fields were dependent upon Standard for their crude supply. Inasmuch as Standard was in the refining business itself, there were instances of discrimination between the Standard refineries and other refineries in securing adequate crude supplies.

These persons, of course, had the alternative of building their own pipe lines, but substantial amounts of capital were required for this purpose. Once it was determined to build such a pipe line, right-of-way difficulties and trouble with the railroads often developed. After lines were built, Standard frequently bought interests in them to gain control of them.[17]

Little is to be gained by attempting to evaluate the morals of the parties involved in this struggle, for the Standard group was dissolved by court action in 1911 and the industry today is characterized by vigorous competition between many units, both large and small.[18]

Largely as a result of the manner in which the Standard group operated its pipe lines, pressure was put on Congress to declare the lines to be common carriers and to bring them under governmental regulation. This pressure contributed to the amendment of the Interstate Commerce Act by the passage of the Hepburn Act, approved June 29, 1906.[19] The Act declared oil pipe line companies to be common carriers subject to the regulatory provisions of the Interstate Commerce Act and the Interstate Commerce Commission.

Despite the passage of the Hepburn Act, the Standard group continued to operate their pipe lines much as they had in the past, relying on the fact that they purchased all of the oil transported through the lines prior to its entering the lines. In 1912, the Interstate Commerce Commission construed theHepburn

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[17]"Oil Supply and Distribution Problems," Senate Miscellaneous Reports No. 25, 81st Congress (January 31, 1949), pp. 21-23.

[18]Standard Oil Company of New Jersey vs. United States, United States Supreme Court Report No. 619, Vol. 221 (1911), sec. 1, 31.

[19]United States Statutes at Large, 59th United States Congress, Vol. 34 (1906), p. 584.

Act to bring under its regulatory authority most of the country's crude pipe lines, including those operated by the former Standard group. It ordered the pipe lines to file with the Commission tariffs showing rates charged for transportation. The carriers resisted the order and litigation ensued.[20]

The United States Supreme Court ruled on the appeals of a number of pipe lines from the action of the Commission in seeking to exercise authority over them. Since most of the carriers had been part of the Standard group, they sought to escape classification as common carriers by urging that they refused to haul oil unless it was first sold to them at the wells and, by reason thereof, they were engaged only as private carriers. In his opinion holding against the pipe lines, Justice Holmes concluded that the statute was intended to reach the Standard lines. He said that inasmuch as these lines carried everybody's oil to a market, they were, in fact and in law, common carriers. The Court freed only one defendant from common carrier designation, the Uncle Sam Oil Company, which operated a small line extending from its own wells in Oklahoma to its refinery in Kansas.[21] This decision made it plain that a pipe line moving substantial quantities of oil in interstate commerce, which oil is produced from wells owned by a variety of persons, is covered by the Interstate Commerce Act even though the carrier requires the producer to sell the oil at the wells.

Big Inch and Little Big Inch.--Not all governmental activities have been of a regulatory nature. The two biggest oil pipe lines in the world were built and operated by the United States Government as primary war utilities, and as such they proved to be our Government's most successful adventure in operating war facilities.

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[20] "The Pipe Line Cases," United States Supreme Court Report No. 548, Vol. 234 (October, 1913), p. 1459.

[21] Ibid., p. 1476.

The huge gullets, one 24 inches in diameter, the other 20 inches, led across the continent from Longview and Houston-Baytown, Texas, and lower Louisiana to the industrial areas of New York and Philadelphia. Both of the big lines were built for war use. Before their loads were discontinued early in September, 1945, the two big inches carried crude oils, gasolines, kerosene, and fuel oils with unprecedented efficiency and economy--about 500,000 barrels or 21,000,000 gallons every twenty-four hours, or about $7\frac{1}{2}$ billion gallons a year. If that total were divided evenly it would provide about 275 gallons yearly for every household in the United States.

Built to last and work for at least a third of a century, probably a half century or longer, the Big Inch and Little Big Inch more than paid for their entire cost during their first two years of war-enforced operation.

Fifty men can operate and maintain about 250 miles of such a big-inch oil line. Stating the problem another way, a 24-inch pipe line built cross-country from the big oil fields of the West to the Atlantic seaboard, a line requiring about 200,000 tons of steel, about 67,500 horsepower of pump energy and an operating force of 190 men, could carry as much petroleum as coastwise tanker fleets built of an estimated 800,000 tons of steel and using 850,000 horsepower and at least 1200 seamen. Also, an underground pipe line would suffer only slight danger of enemy action, whereas Nazi submarines were blasting tankers to threatened extinction. Further, the tankers required convoys which called for additional thousands of horsepower and manhours for every sea mile of the hard-pressed tanker run.[22]

In its report to Congress dated January 4, 1946, the Surplus Property Administration declared that the Big Inches have three distinct possibilities for post-war use: the continuation of the service for which they were originally

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[22]"War Emergency Pipelines," <u>New Republic</u>, CXIII (July 23, 1945), pp. 96-98.

designed; reversal, or division for use in petroleum transport; or use as major carriers of natural gas. The latter use was made because of the great need for natural gas in the Northeast.[23]

From a structural standpoint the most ingenious of all war pipe lines linked England with Europe to support history's greatest invasion. Their story was withheld until several weeks after V-E Day, when Geoffrey Lloyd, Britain's Minister of Petroleum Warfare, disclosed that twenty pipe lines laid under the English Channel had supplied gasoline to the Allied armies that overran and crushed Germany. All twenty were 3-inch lines; four of them led from the Isle of Wight to Cherbourg, a distance of 66 miles; sixteen from the Dungeness to Boulogne, about 29 miles. Linked with pipe line systems in England and later on the continent, the lines carried hundreds of millions of gallons, all the way from Liverpool to Frankfort-on-the-Main, east of the Rhine. They continue to carry gasoline.[24]

Since the interstate products pipe lines are principally owned and controlled by the integrated oil companies or groups of them combining together in the building, ownership and operation thereof, the rates for transportation of products over these pipe lines is less than half that of rail freight. Product pipe line rates have remained steady during a period when rail freight rates have advanced substantially.

The products pipe lines professing to operate as common carriers in the Middle West have connections to numerous refineries, majors and independents, which have no ownership in the pipe lines. But inspection of the list of shippers over the products pipe lines indicates that they are all refiners. None but the refiner is able to take advantage of shipping products over the products pipe lines

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[23]"What To Do With Big Inch," New Republic, CXV (August 12, 1946), p. 175.

[24]Wilson, op. cit., p. 183.

and to participate in the freight advantage, one which runs into cents per gallon. Some refiners shipping over the products pipe lines sell their products f.o.b. at their refinery and add rail freight, even though all or part of the transportation is made at the lower pipe line rate.

There are many ways to correct these practices. One method would be to recommend that the appropriate committees of Congress study the question and propose legislation that will make pipe line companies accessible to all shippers on an equal basis and prevent any part of the transportation saving being held by or returned to the shipper of the product. Such committees might also look into the matter of companies collecting full rail freight from the public for their products while only paying or charging themselves with the much lower pipe line rate. Separation of pipe lines from their shipper-owners is recommended.

Improvements in Pipe Fabrication

Although different kinds of pipe materials for transporting water for short distances have been used for several thousand years, the use of wrought-iron or steel for making pipe is of comparatively recent origin. The discovery of petroleum in 1859 was a great stimulus for progress in the manufacture of iron and steel tubular products.

For pipe line transportation, the pipe used is made of either (1) open hearth steel, (2) Bessemer steel, (3) electric process steel, or (4) wrought-iron. By far the largest amount of line pipe manufactured today is made of steel. Wrought-iron is used to a lesser extent for special conditions. Gathering lines vary in size from two to eight inches in diameter, and trunk lines usually vary from four to twelve inches. In sizes over four inches most of the pipe lines are now laid by welding the joints together. In the smaller sizes, used in the gathering lines, the joints are generally screwed together with threads and couplings.

Development of Modern Pipe Materials.--The development of the puddling process to produce wrought-iron in 1784 made available the first ferrous metal suitable for welding.[25] Tubes were made by bending a strip of rolled iron into a circular form heating to a welding temperature, and then welding or forging the joint together by hand over a mandrel.[26] The use of wrought-iron increased rapidly by reason of the demand for boiler tubes, water mains, and artificial gas lines. In 1830 the first wrought-iron furnaces were built in the United States.

The Bessemer process for making steel was developed in 1855 and the open-hearth process in 1861; but in the early days of both of these processes the output was entirely consumed for rails, plates, and structural steel, so that steel pipe in commercial quantities was not made until 1887. In 1890 less than five per cent of the tubular products were made of steel. Today more than 95 per cent is made of Bessemer and open-hearth steel, the latter being used almost entirely in the larger sizes of pipe.

Most of the trunk lines being laid at present are made of steel having a tensile strength of 60,000 pounds per square inch, although a considerable number of large users specify a minimum tensile strength of 65,000 pounds.[27] The use of thin wall pipe was advocated more than ten years ago. It has only recently been generally accepted that pipe wall thickness should be limited by the requirements of strength to withstand internal fluid pressure, and not allow for additional wall thickness to withstand soil corrosion and pitting. As

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[25]"Puddling" is the process of converting pig iron into wrought-iron by subjecting it to heat and frequent stirring in a puddling furnace in the presence of oxidizing substances.

[26]"Mandrel" is a metal bar used as the core around which metal is molded and shaped.

[27]"Tensile strength" of steel is its strength under tension or pulling stress measured in pounds per square inch.

a rule, soil corrosion is better and more cheaply controlled by the use of a protective coating rather than by additional pipe wall thickness.

Pipe Making Processes.--One method of classifying line pipe is based on methods of manufacturing processes. Each process was developed to provide a reduction in the cost of manufacture or to make an improvement in quality, either in relation to the physical properties of the metal or to the workmanship and finish of the product. Pipe is now made in varying proportions by each of these methods, and each has its place in satisfying the combined requirements of price and physical properties for specific purposes. Improvements in the details of each process are continually being made for the purpose of eliminating or reducing some characteristic defect in order to further reduce the cost. As a result of the development of new processes, improvements, and enlarged capacity in the older pipe mills, this country now has a mill capacity for making in excess of 200 miles of line pipe per day.

One of the first pipe manufacturing processes to be developed was the butt-weld process which is now limited to pipes three inches in diameter and smaller.[28] This process promoted the development of the lap-weld process when the need for pipe diameters up to 30 inches was required.[29] By far the greater proportion of lap-weld pipe is made of open-hearth steel.[30]

The third process to be developed was the electric weld process which permits the manufacture of pipe having a high degree of roundness and uniform wall thickness and makes possible the use of joints about 52 feet in length and 30 inches in diameter. Unlike the above processes which join the flat pieces of

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[28] L. E. Davis and Charles Cyrus, Oil Pipe Line Transportation Practices (1947), pp. 14-17.

[29] J. M. Camp and C. B. Francis, The Lap-Weld Process (1925), pp. 1043-1059.

[30] Lester Charles Uren, Petroleum Production Engineering (1939), pp. 653-656.

metal together by fusion and pressure, this process automatically welds the pipe as it is shaped and thereby gives added strength.

The latest development in pipe fabrication is seamless pipe. It is rapidly becoming the most popular pipe in the oil industry, particularly where abnormal conditions must be met. It is entirely without welds and has superior strength and smoother finish than some of the other methods of manufacturing pipe. Seamless pipe is made from open-hearth steel only, as this material has been found to have the properties best adapted to the severity of the operations used in its manufacture. The usual sizes of line pipe made by the seamless process vary from $3\frac{1}{2}$ inches to 24 inches in diameter. Because of its extensive use and popularity, a brief discussion of its fabrication is desirable.

In the piercing process, used for sizes up to 14 inches, the steel is delivered to the heating furnace in the form of solid cylindrical billets, center punched at one end and of proper diameter and length to make the size and length of tube required. The billets are heated uniformly to the proper temperature in a continuous furnace. The heated billet is then pushed into the piercing mill until it is caught by revolving rolls.

The action of the rolls upon the billet is difficult to explain, but it will be sufficient to state that the action is such that the metal is drawn away from the center of the billet to form a hole or cavity which is then enlarged by a mandrel or piercing point as the billet passes through the mill. When the billet issues from the mill having passed entirely over the mandrel, it is in the form of a thick-walled seamless tube, somewhat rough on its surface but fairly uniform as to thickness of wall.

The pierced billet is transferred from the piercing mill to the rolling mill where it passes between two rolls set one above the other, each having a semicircle groove, so that the two together form a circular pass. Between these rolls, a mandrel or plug is held in position by a water-cooled bar. The wall of the tube, supported by the mandrel on the inside and subjected to the action of the rolls on the outside is reduced in thickness to the gauge desired. Thus the tube is lengthened and reduced to required diameter.[31]

Improvements in Pipe Line Construction

The primary object in the design and construction of facilities for any business enterprise, be it factory, mill, railroad or merchandising establishment, is to design and construct so that the desired service may be performed in the most efficient and economical manner. In the case of a pipe line facility, the service to be performed is the economical transportation of crude oil or products from the point of production to the point of use.

Many factors must be considered in the construction of a pipe line system. The origin and destination points are usually more or less fixed by the locations of the supply and of the market. The volume of business for a products pipe line is subject to fluctuation due to shifting centers of population and changing economic conditions. Examples of the latter are the increased use of oil for home heating and the mechanization of farms.

From the first ground reconnaissance to the final "back fill operation", pipe line building always has been a merging of elaborate machines and physical labor. Tractive equipment replaced mules and horses. Ditching machines took over much of the work of the hard-swinging crews of pick-and-shovel men. Steel tubes replaced iron pipe, strong welding replaced the screwed joints, and in time, seamless steel pipe replaced the earlier welded pipe.[32]

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[31] N. E. Sanders, "Progress in Steel Manufacturing With Particular Reference to Seamless Pipe," <u>American Iron and Steel Institute</u> (May, 1947), pp. 45-47.

[32] Graber, *op. cit.*, p. 87.

The Analysis for Pipe Line Construction.--The transportation analysis is the first and a very large step in pipe line construction. Here the oil or gas company reaches its decision as to the needs for the new pipe line project. Determination is made as to where the pipe line will originate and where it will terminate. The minimum, average, and maximum load demands are calculated. The services to be rendered to industry and consumers are ascertained.

In products pipe line planning, studies are made of the "contributing" sources (refineries) at the point of origination and of the demand for products by consumers at intermediate taps and the terminus.

The "supply and demand" data next must be translated into terms of "engineering sizes and facilities." This phase definitely places the project into a pipe line (1) of an approximate length, (2) of certain pipe diameters, and (3) with a given number of pumping stations.

In the early planning for a large project, aerial surveys and the science of photogrammetry are new and important tools. They save much time and ground-survey crew expense.

Reconnaissance flights in the early planning stages take the pipe line owners, engineers, and pipe line contractors over the general route to obtain preliminary views. Detail route photography is employed later.[33] Detailed ground surveying is also done, using transit and leveling instruments. Special profiling equipment may be used in some instances for reconnaissance and topographical work.

Later steps in engineering, administrative, and legal talent are combined in preparing adequate specifications which permit the pipe line contractor to calculate labor, material, and other related costs, together with the time

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[33] L. T. Eliel, "Faults Undiscovered on the Ground Revealed by Aerial Maps," Oil Field Engineering, V (January, 1929), pp. 24-27.

required to complete construction. Specifications for the pipe line project are reproduced in multiple units, usually bound together in booklet form. These are distributed to the pipe line contractors for their studies and bid-making preparations.

Some pipe line contractors maintain organizations which are set up to handle the installation of complete systems, including design, construction, and turning over the completed project to the owner ready for operation. Other pipe line contracting organizations, both large and small, are specialists in one or more of the phases.[34]

When the successful bidders have been awarded contracts, work begins, either immediately or in a few weeks, and here the pipe line contractors co-operate very closely with the contractee. The contractee uses members of its own organization as inspectors and in the making of the daily progress reports.

Obtaining Right-of-Way and Clearing.--Right-of-way easements are obtained by the pipe line company. The company's organization must have detailed maps from its engineering department which show the exact route to be followed by the line. Names and addresses of individual landowners are obtained from public records and abstracting firms.

Usual payments for easements may be one dollar per rod, more or less, and the easement may be for a width varying from 30 to 100 feet. In cases where the landowner does not "sign up," legal action may be instigated, using the particular state laws under the rights of "eminent domain." In conditions of extreme necessity, however, the line route may be diverted to avoid delay and cost of court action. The establishment of good relationship with property owners and tenants on and adjacent to the pipe line route is of prime interest

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[34] W. G. Heltzel, "Progress in Pipe Line Transportation," Pipe Line News, II (February, 1930), pp. 14-19.

to the pipe line company. Consequently the contractor and company combine their efforts generally to maintain that objective.[35]

Clearing equipment for right-of-way includes bulldozers, gasoline-powered saws, mobile units, fence gangs to cut fences and make gates, and the brush gangs with axes and cross-cut saws.

The purpose of this step is to put the ground in shape for the passage of vehicles necessary for construction work--stringing, ditching, cleaning-priming and coating-wrapping machinery, and backfills. The ground must be smooth enough for the passage of both heavy equipment and lighter construction units, including automobiles and jeeps.

Pipe Handling and Stringing.--The manufacture, shipping, handling, and stringing of pipe for a big construction project are spectacular operations to the casual observer. But these steps are vital to the success of the project. To the pipe contractor, efficient pipe stringing is one of the vital logistics of pipe line contracting because subsequent construction operations cannot start until the pipe is strung. Pipe stringing is the transportation and laying down of the pipe joints alongside the pipe-trench route.

Pipe line contractors customarily follow a regular procedure of operations in construction. The pipe stringing is always done on the right-hand side of the trench location, when looking in the direction of progress of the pipe line spread. This is because the ditching machines throw backfill to the left side of the trench. The pipe joints are strung with their ends overlapping, so that sufficient pipe is available to account for material out for bends, pipe rejections and damaged ends. After stringing the pipe, the joints are arranged in staggered positions for convenience of pipe gang tractors.

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[35] "Pipe Line Construction," Oil and Gas Journal, XLIX (September 21, 1950), p. 1949.

Ditching and Crossings.--The vast majority of all pipe line systems are trenched and installed underground for the following reasons: (1) agricultural usage of the surface; (2) prevention of tampering and to remove from potential vandalism and "curiosity seekers"; (3) to smooth out temperature variations troublesome in surface installations; and (4) in other ways to permit access and full movement across the land surface of a pipe line route.

Principal types of equipment involved in trenching are wheel-type ditchers, rock drills, backhoes, and draglines. Equipment used in trenching depends on the nature of both surface and subsurface conditions.

Construction work involving crossings is very common. On land, it involves boring and even tunneling underneath highways and railroads. As to water locations, pipe lines are constructed to go under rivers, lakes, bays, and other bodies of water. Special pipe line bridges or crossings are also built over creeks, bayous, and rivers. At crossings under highways and railroads, most state laws require installation of the pipe in casing of larger diameter, which is remotely vented, to allow for maintenance without obstructing traffic.

Bending and Welding Operations.--The shortest distance between two points, according to geometry books, is a straight line. But in pipe line construction the optimum distance, to an important degree, is not always the shortest distance. The most desirable and practical distance may involve curves, bends, and gradual arcs, all arising from problems in topography and the procurement of right-of-way.[36]

Pipe-bending operations are almost altogether done in the field by use of portable hydraulic or mechanical pipe-bending units.

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[36] Ibid., p. 196.

One of the greatest improvements in pipe lining has been the widespread developments in welding, and techniques and procedures for better and faster welds. It was only twenty to twenty-five years ago that screw-coupled lines began going out of use, and the first all-welded lines appeared on the scene. Today welded pipe lines are firmly established.

The early lines were welded by both oxy-acetylene and electric-arc methods; however, the latter within the past decade has become the most acceptable. Oxy-acetylene "cutting", however, still has an important place in special pipe line detail and reconditioning work.

Pipe Line Protection.--Buried pipe lines are coated with tar and asphalt and wrapped with kraft paper to prevent the ravages of corrosion.[37] Exhaustive experimental tests and years of actual experience have demonstrated that properly protected pipe lines last longer than uncoated lines, in circumstances where electrolysis and galvanic action occur. Cleaning, priming, coating, and wrapping of pipe lines, therefore, are in the nature of "insurance", just as painting of houses, buildings, or automobiles insures them against deterioration.[38]

Laying, Backfilling, and Cleaning Up Operations.--"Cradling into the ditch" is lowering the pipe into the ditch directly behind the coating and wrapping machine. Ridges or mounds of soft dirt are placed at 10- to 30-foot intervals along the trench bottom to support the pipe so that its hot enamel surface is not damaged when cradled into the ditch. In rocky ground, the pipe line company usually specifies that the pipe be protected above, below, and on the sides by soft dirt or sand, known as "padding", or by a hard fiber board.

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[37] S. P. Ewing, "Soil Corrosion and Pipe Line Protection," American Gas Association (1938), pp. 26-41.

[38] Erick Larson, "Pipe Corrosion and Coatings," American Gas Journal, CXLVII (1938), p. 263.

Backfilling operations are accomplished rapidly by bulldozing equipment. "Cleanup work" consists of removing everything off the right-of-way which was left during construction.

Pumping Stations.--Numerous factors are involved in the design of a modern pipe line station. These factors range from selection of the building site, through equipment sizes and arrangement, to the layout plans for the various buildings comprising the overall station installations (Table 3).

Modern pipe line and pumping stations are as well constructed and equipped as any other types of industrial plants. Air conditioning, good lighting, both artificial and natural, and color schemes on building walls and ceilings provide the operating personnel of a remotely located station with all the working comfort found in a large-city office building.

Power for pumping operations is normally provided by the following prime movers: (1) internal-combustion engines, and (2) electric motors. Steam turbines and gas turbines are comparatively recent innovations in United States pipelining, for driving centrifugal equipment.[39] As a general rule, internal-combustion engines, either diesel, gas, or dual-fuel equipment, are employed to operate reciprocating pumps and compressors.

Pipe Line Facilities and Service.--Part of the necessities for the construction and operation of a pipe line system includes in general four different divisions. Without respect to design or construction these divisions are: communication, storage and terminals, metering and control, and maintenance.

To obtain efficiency in operation of a pipe line system, all divisions connected with the movement of petroleum products are closely co-ordinated with one or more methods of communications. Generally, wired circuits for telegraph and

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[39] C. P. Bowies, "Transportation of Gasoline by Pipeline," Technical Paper 517, United States Department of Commerce, Bureau of Mines (1932), pp. 7-8.

telephone of the older stations have been augmented with teletype equipment in the systems where co-ordination of operations involves only a small number of stations and terminals.

The trend in recent years has been toward the reduction of tankage for storage at intermediate points on pipe line systems. Tankage is generally installed at stations to provide flexibility of operation and for emergency purposes. At certain junction and terminal points there is large tankage, sometimes amounting to several million barrels, to facilitate deliveries to shippers and for transfer to other lines.

Basically, pipe line terminals are made up of a pumping station and a group of tanks. This general combination of station and tanks comprises either inland or waterway (marine) installations. The principal difference between the two kinds of terminals is that the inland terminal makes delivery to initial consumers or receives products via pipe line, tank car, or tank truck, or a combination of these three types of transportation, whereas the marine terminal receives from or delivers to barges, tankers, or both.

To keep account on deliveries and receipts, all pipe line systems are provided with some type of equipment which permits suitably accurate measurements on the incoming and outgoing material being transported. In addition to these measurements of the particular commodity, still another is required to balance accounts in the overall system when storage tanks are involved. This particular measurement is the inventory of all involved storage at any given time. Another accounting involving measurement is the contents of the pipe line itself, which, in effect, serves as a storage vessel.[40]

As a result of the foregoing, products pipe lines will undoubtedly continue to be constructed primarily due to the following reasons: (1) the

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[40] Heltzel, op. cit., p. 18.

decreased cost of transportation, (2) the ease with which the capacity of such a system can be increased by speeding up the pumps, by looping certain portions of the line, and building additional pump stations, (3) minimum losses from evaporation, (4) dependability of service, and (5) the constantly increasing demand for gasoline and other petroleum products.

Domestic products pipe line projects completed in 1951 totaled 1050 miles, and those underway totaled 1570 miles.[41]

Other Factors Affecting the Development of the Industry

The petroleum and refining industries have grown rapidly in response to the greater use of the internal-combustion motor. The development of two other modes of transportation, namely, motor highway and air, account for much of this growth. Petroleum products have become the fuel of the Navy and much of the merchant marine, and millions of homes and office buildings are now heated by fuel oil.[42]

Fuel oil, being a seasonal product for most of the northern states, is regularly pumped to terminals in the North for winter consumption. The per capita consumption is not closely related to the coldness of the area but to the presence or absence of competing fuels, urban concentrations, cost of transportation, cost of fuels and convenience of use (Figure 2). For example, Ohio and Florida, regions of great winter temperature differences, both use less than forty gallons per capita per year. Florida with its mild temperature can easily consume small amounts of other competing fuels, such as natural gas and thus avoid the transportation costs and the inconvenience of heating oils. On the

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[41]Paul Reed, "Projects Completed and Underway," The Oil and Gas Journal XLIX (November, 1951), pp. 226-229.

[42]Marvin L. Fair and Ernest Williams, Jr., Economics of Transportation (1950), p. 104.

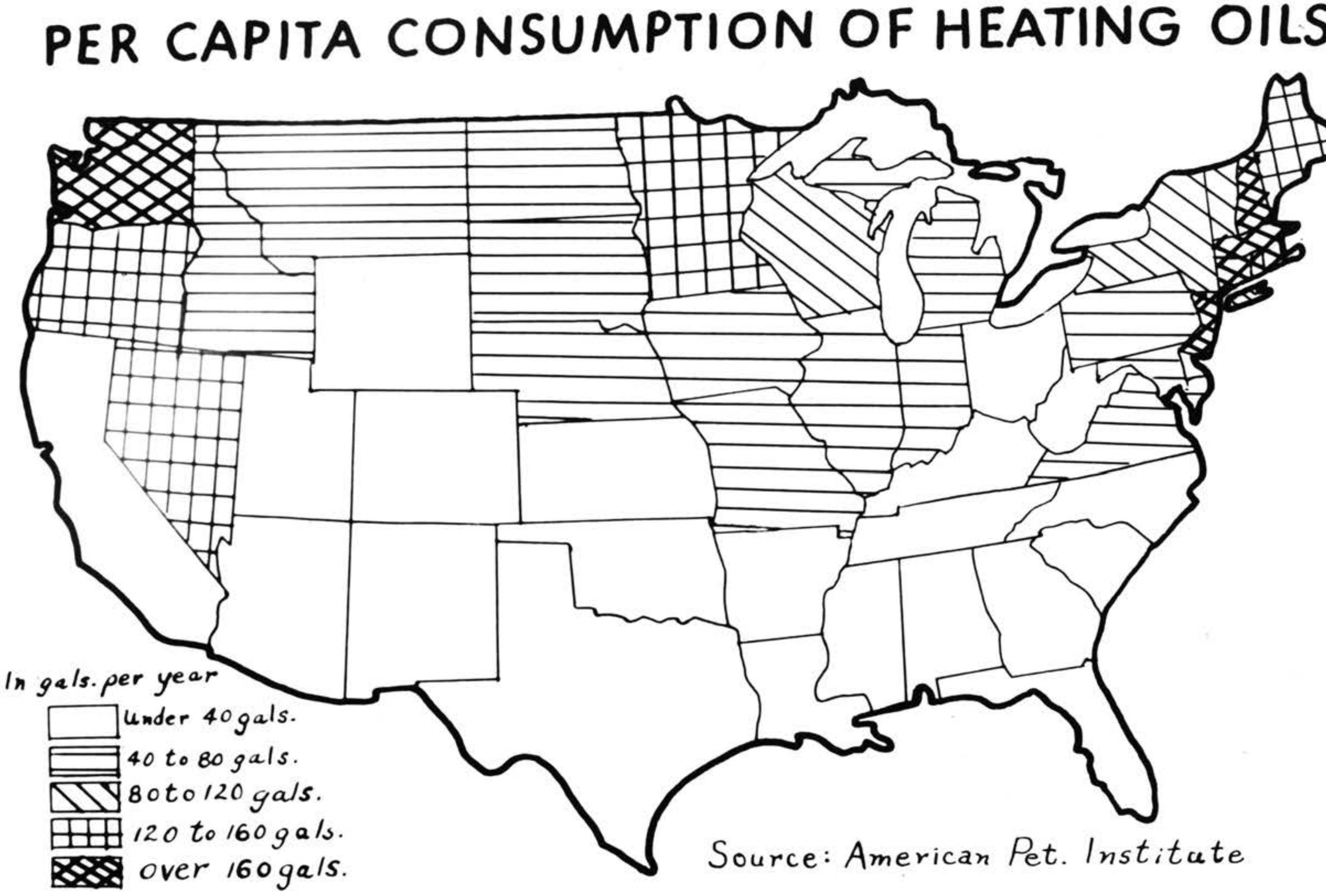
PER CAPITA CONSUMPTION OF HEATING OILS
In gals. per year
under 40 gals.
40 to 80 gals.
80 to 120 gals.
120 to 160 gals.
over 160 gals.
Source: American Pet. Institute

Figure 2

other hand, Ohio with its urban concentration can use the competing fuels of coal and natural gas more cheaply than fuel oils.

About 68 per cent of the crude petroleum production is in Texas, Oklahoma, and California, but the greater part of the consumption of petroleum and its refined products takes place in the northeastern part of the United States, i.e., north of the Ohio River and east of the Mississippi River.

Improvements in Pipe Line Communications.--During the early days of pipe line operation, operating orders, messages, and other communications were sent to personnel along the pipe line by horseback or by mail. Inasmuch as most of the oil flowed by gravity, faster methods of communication were not so essential to successful operations as they are today.

As pipe lines were made longer and pumps were installed, quick communication contact between pump stations and to delivery terminals became necessary. This need for fast communication was met by using Morse telegraphy.[43]

As improved telephones gained acceptance for general business and industry use, they were connected to the existing pipe line company telegraph wires. By means of equipment developed to keep the telegraph dots and dashes out of the voice circuits, and to isolate the voice from the telegraph sounders, both telephones and telegraph were operated over the same wires.

In recent years teletype service has been adopted by some pipe line operators for message handling between headquarters, division offices, and delivery terminals. The two immediately apparent advantages are: a written record is provided for every order or report; and the receiving operators at stations and terminals can do other work while the messages are being received.

Because of the inherent limitations on line-of-sight transmission of ultra

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[43] V. J. Sittel, "Developments in Pipe Line Communication," Pipe Line News, XXIV (January, 1952), pp. 35-38.

high frequencies, microwave systems must utilize repeater stations which ordinarily are completely unattended. These repeater locations are determined by the topography of the route traversed. The towers supporting the radio antenna must be so spaced that the radio signal, focused toward the next tower, will clear all intervening obstructions by at least fifty feet. With the use of 150-foot to 250-foot towers, over average terrain, repeater points are spaced approximately thirty to thirty-five miles apart.[44]

Pipe lines have pioneered in this recent development of microwave radio communication. It would be difficult to guess what the next big development might be, but when newer and better means of communication become usable you may be sure that the pipe line industry will find ways to make use of them to improve further the efficiency of pipe line operations.

Electrification vs. Combustion Engines for Power.--The trend to electric motor instead of motor fuel engine drive is due principally to three factors: (1) the increasing reliability of network electric power supplies; (2) the continually-increasing improvement in the ratio of the cost of electricity versus fuel oil or fuel gas as an energy source; and (3) the recognized advantages of electrified sequence control for operating large pump stations on large-diameter lines. The many advantages of electrified equipment operation provide the margin on which to decide in favor of electric power. These include more foolproof construction with better continuity of operation, cleanliness, reliability, flexibility, and ease of control.

Now that most common carrier products pipe line companies are limited by federal regulations to earnings of seven per cent on fair value, the tendency when selecting equipment for new lines is to compare all forecasted costs--capital and operating--over a ten-year period. (Some companies use a seven-year

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[44] Ibid., pp. 37-38.

period.) On the modern large stations, with electricity at 8 mills per kwh and fuel oil at $2.65 per barrel, the ten-year total capital and operating costs of diesel and electric motor-driven centrifugal pump stations are about equal, but the distribution of costs vary greatly (Table 5).

TABLE 5

DISTRIBUTION OF CAPITAL PLUS TEN-YEAR OPERATING COSTS*
(Diesel Drive vs. Electric Drive)

Expenses	Diesel Drive	Electric Drive
Capital Investment	26%	13%
Ten-Year Maintenance Expense	8	2
Ten-Year Operating Cost (Except Fuel Oil or Electric Power)	28	13
Fuel Oil or Electric Power	38	72
Total Ten-Year Costs	100%	100%

*H. H. Anderson, "The History of Oil Pipe Line Development," Pipe Line News, XXIV (April, 1952), pp. 24-30.

Sometimes the overall economy of electrification is obscured because the monthly electric bill is just about twice the monthly fuel oil bill. In the long run, the capital and operating costs in the engine-driven station are about 2¼ times those of the electrified station.

Experience has proven that oil- and gas-engines are quite reliable pipe line prime movers. Thus the choice of electric motors versus such engines will remain principally one of economics. On the recently-built large Mid-Valley Company lines, diesel engines were installed in those areas where electric power is still a luxury. The prudent pipe line operator still hopes to keep the engine manufacturers and the electric utility companies in cost-minded competition for his business.

Regardless of the type of prime mover used, the operators should always consider the advantages that can be obtained by use of electric sequence control. On the larger lines these advantages include the manpower saving, the reliability and consequent safety, and the minimizing of revenue losses through pipe line switching and service interruption.[45]

The trend is to use more and more automatic controls. For some time the stations of many trunk lines, particularly the products lines, have been equipped with automatic pressure controls to permit all stations on the line to operate "in step". This enables the fluids to move from origin to destination without having to enter station balance tanks where intermixture between successive pumpings can occur. This condition is essential when segregated batches of different oils are to be delivered without interbatch contamination that may adversely affect the closely controlled specifications of refined products. Also, as larger gate- and stop-valves must be opened and closed on larger diameter lines, it is becoming imperative to use motor-driven valve-operators that can be adapted to automatic control.

Some of the latest stations incorporate the use of sequence relay controllers that do everything except the employee's yardwork. For example, in the new Ozark System stations, which use two 1500- and one 750-horsepower motor-driven pumps to deliver about 275,000 barrels of petroleum daily, the mere pressing of three buttons on the console by a single employee will cause the automatic performance of twelve operations in six minutes that would otherwise take two or three husky men an hour to accomplish. This means a great time-saving during a service shut-down and start-up.

With a revenue of $75 per minute depending on getting the line under way,

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[45] H. H. Anderson, "The History of Oil Pipe Line Development," <u>Pipe Line News</u>, XXIV (April, 1952), pp. 24-30.

the direct saving to be gained by a $10,000 investment in sequence controllers is obvious. Perhaps even more important, however, is the insurance of a fool-proof job of starting. Any group of men having twelve critical operations to be performed in a required sequence can easily make an error that might cause an accident and further losses.

"The application of this sequence relay equipment to an electric station is, of course, but a mere extension of the orthodox control layout. But similar equipment to a major extent is equally applicable and effective on a large station driven by motor fuel engine prime movers."[46]

The role played by the "Big Inch" and "Little Big Inch" lines in solving the transportation problem during World War II is well known. A less publicized but equally important contribution was made by military pipe lines on the battlefront. In addition, the industry may point with pride to the tremendous improvement in construction methods and operational techniques which have increased the capacity of the lines and contributed to flexibility and efficiency of operation. These have made possible large reductions in pipe line rates. These reductions, together with the increasing rail tariffs, have created such a differential in shipping costs that the railroads have lost steadily to the pipe lines the carriage of petroleum products.

The great bulk of the nation's crude supply is produced in the southwestern states of Texas, Oklahoma, Arkansas, Louisiana, and New Mexico. The greatest gasoline consumption is concentrated along the Atlantic Coast and in the North Central states. Some of the needs of the North Central states can be supplied by the Rocky Mountain states, and California can furnish part of the Pacific Coast requirements, but it is obvious that the Southwestern states must furnish most of the crude oil and gasoline used in the Atlantic coastal states

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[46] _Ibid._, p. 29.

and a substantial part of that required by the North Central states. The great distances separating the producing fields from the consuming areas make transportation vitally important.

Shortly after pipe lines were introduced in 1865, they demonstrated their superior efficiency and economy as a means of transporting crude oil to the refinery. By 1937, crude lines had taken the bulk of the traffic away from the railroads. In 1940 their tariff rates were roughly one-third the rail rates. Since that time, crude line rates have decreased and rail rates have increased to the extent that crude pipe lines and rail transportation cannot even be considered competitive. The products lines, although starting as late as 1930, quickly duplicated the record of the crude lines. The situation had become so clear-cut by 1944 that the railroads admitted that they could not compete on equal terms with either crude or refined products lines.

Tankers are even cheaper than pipe line rates, but their utility is limited to slow coastal and inland water movement. Long-distance trucking is beginning to assert itself as a competitive force. Still, today, pipe lines are the dominant medium of overland petroleum transportation.

CHAPTER III

CURRENT STATUS OF PETROLEUM PRODUCTS TRANSPORTATION BY PIPE LINES

Pipe lines, now operated at an amazingly high level of productivity compared with all other forms of transportation, are ranging strongly toward more and more automatic operation and control, safety and regularity of delivery of products to the consumers.

This is a typical development, reflecting the aggressive forward thinking that has stimulated technological progress in the pipe line industry and made it one of the fastest growing large businesses in the country today. More than 1,600 miles of line pipe were laid last year by the industry and an equal amount, depending on the steel supply, is forecast for 1952.[1] By the end of 1952, there will be approximately 23,000 miles of products pipe line in operation.

Engineering and operating techniques are under constant study and review. Many of the principles already are established but some changes in procedure remain to be discovered. It can be stated that in the future no pipe line of any consequence is likely to be built without using beamed radio (microwave) in its operation. At the same time, there will be a strong trend toward increased instrumentation.

While the importance of the human element in actual routine operations cannot be discounted, the fact remains that advanced engineering has enabled pipe lines to proceed with their normal function of delivering petroleum products, with less and less manual attention. Basically, of course, the consideration foremost in the minds of competitive pipe lines is efficient operation at the lowest possible cost. It follows that uses of unattended stations and remote

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[1] W. C. Kinsolving, "The Trend in Pipe Line Design and Operation," The Petroleum Engineer, XXIV (May, 1952), p. D-3.

control installations depend on the ratio of automatic cost to that of manual operation.

Another important phase of the industry's advance is its trend toward use of minimum amounts of steel. Scientific progress in certain phases of pipelining, such as electrolysis prevention, has been bolstered by sound engineering studies leading to decreased need for extra steel in pipe walls. Pipe line engineers are keenly aware of the critical supply of steel, as well as the important factors of cost.

As a result of these studies, pipe line engineers have developed the design of lines to conform more closely to the actual hydraulic pressures required in various sections of the line. In other words, the principle of "telescoping" has been further extended. Thus, the old accepted working pressure safety factor of 4 to 1 has been reduced to 1.75 to 1.[2] For example, diminishing the pipe wall thickness as line pressure declines will save many thousands of tons of steel, an invaluable contribution today when steel is in such short supply.

The industry will continue to recheck specifications and to trim its construction costs through such means as tapered lines until the law of diminishing returns makes it economically impractical. If permitted sufficient steel by the Government, the industry will continue to grow in answer to the seemingly endless demand of consumers in this country. As it grows, operating and engineering will continue to advance with it, meeting new problems as they arise.

Location, Distribution and Operation of Pipe Line Facilities

The pipe line is a relative newcomer to the long-distance transport of bulk freight. It developed originally as essentially an industrial facility gathering

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[2] F. H. Love, "Crude Oil and Products Transportation Nearly Doubles in Ten-Year Period," The Petroleum Engineer, XXII (January, 1950), p. D-7.

oil from the producing wells and concentrating it at railhead or port for subsequent movement by rail or water. After World War I the pattern changed, and a truck system began to develop connecting the Illinois producing areas with the Chicago district refineries, the Mid-Continent field with refineries in the St. Louis and Alton areas, the East Texas fields with Gulf ports, and Pennsylvania producing areas with the Atlantic Coast refineries. Thus the pipe line became a method of long-distance bulk transportation. It could be built only where a large and continuous flow of liquid traffic was available, for its capacity is large and it must be kept continuously full while in operation.

Six-inch lines gave way to larger sizes of pipe which, because of reduced friction, made possible greater "throughput" with a given amount of power. Pumping pressures grew and pumping equipment itself improved. Steam-driven pumps gave way to electric and diesel power. The construction of pipe lines reached a climax with the 20- and 24-inch lines built during the war to connect southwestern producing areas with the Atlantic Coast refining and distributing systems. It is now rumored that a 26- or 30-inch line may be undertaken through the same areas. These larger sizes of pipe are already in use in lines in Venezuela and some other foreign producing countries.[3]

In many parts of the world the pipe line still remains a feeder to other forms of transport. For example, this is true of the large system conveying to Gulf ports from the Texas and Louisiana fields where the products move by tanker to the Atlantic range of ports. The ocean-going tanker has long been the cheapest form of petroleum transport, but it is possible that the larger sizes of pipe will enable trunk pipe lines to compete on the Gulf-to-Atlantic movement (Figure 1).

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[3]Marvin L. Fair and Ernest W. Williams, Jr., Economics of Transportation (1950), p. 294.

Modern Pipe Line Facilities.--A modern products pipe line system consists of (1) gathering lines, (2) storage tanks, (3) trunk lines, varying from eight to twenty-five inches in diameter, (4) pumping stations, (5) communication facilities, and (6) control offices.

Gathering Lines.--Gathering lines connect the refineries with the storage tanks of the originating pumping stations of petroleum products. These lines may or may not be owned by the pipe line companies but they are usually maintained and operated by them.

Storage Tanks.--The storage tanks have three uses in pipe line facilities: (1) They act as reservoirs for the gathering lines until a certain product is ready for movement by the pumping station; (2) they may be located at intermediate pumping stations and store the liquids for distribution or for further shipment to the terminals; (3) or they are located at the terminals for distribution to the consumer via other means of transportation, such as trucks, rail tank cars, barges or tankers.

Trunk Lines.--Trunk lines with pumping stations which are located at varying distances apart carry products from refineries to a port for transhipment by water to terminals or large storage tank terminals from which it may be further transported later by vessel, rail, or pipe line.[4]

Pumping Stations.--As explained in the previous chapter under construction, pumping stations are located at various intervals depending upon the size of the pipe line, the topography (more stations are required with increased elevation), the products pumped, changes in pressures on lines, number of refineries and the constant changing condition of employee and company wage agreements (Table 3). For instance, during recent years petroleum unions have been so strong and have made such high wage demands on the companies that they have

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[4]Ibid., p. 104.

in turn begun to shift to automatic stations to avoid the high wage payments. With the recent blanket wage increase of fifteen cents per hour, pipeliners' wages range from $1.70 per hour for station labor to $2.25 per hour for station engineers excluding increase in night shift differentials and double time on holidays.

Communication Facilities and Control Offices.--Communication facilities and control offices are very closely allied due to the regulations, orders, and shipping schedules that are sent out by the control offices, located in key industrial city markets, over the various communication facilities. Generally the communication facilities belong to the pipe line company with exception of a few rented telephone lines. The importance of the control offices cannot be overemphasized. They are the heart of the pipe line system with the lines acting as arteries and veins. The responsibility of millions of dollars worth of equipment lies in the hands of the dispatchers on duty. These workers give shipping orders, pumping pressures and the outlines for smooth and continuous flow of products in the system.

Petroleum Products Distribution.--Although petroleum is produced in commercially important quantities in twenty-one states, three of these, namely, Texas, California, and Oklahoma, account for 68.7 per cent of the total.[5] Of the petroleum products refined, 89 per cent can be transported by pipe line. Motor fuels constitute over half of these transportable products (Figure 3).

Transportation of petroleum products to the terminals is but the first step in a complicated distribution enterprise. From the terminals the finished products must be distributed widely into scattered consuming areas. Before the war there were a few important products pipe lines in use including

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[5]G. Lloyd Wilson, "Pipe Line Transportation," Transportation and National Policy (1942), p. 456.

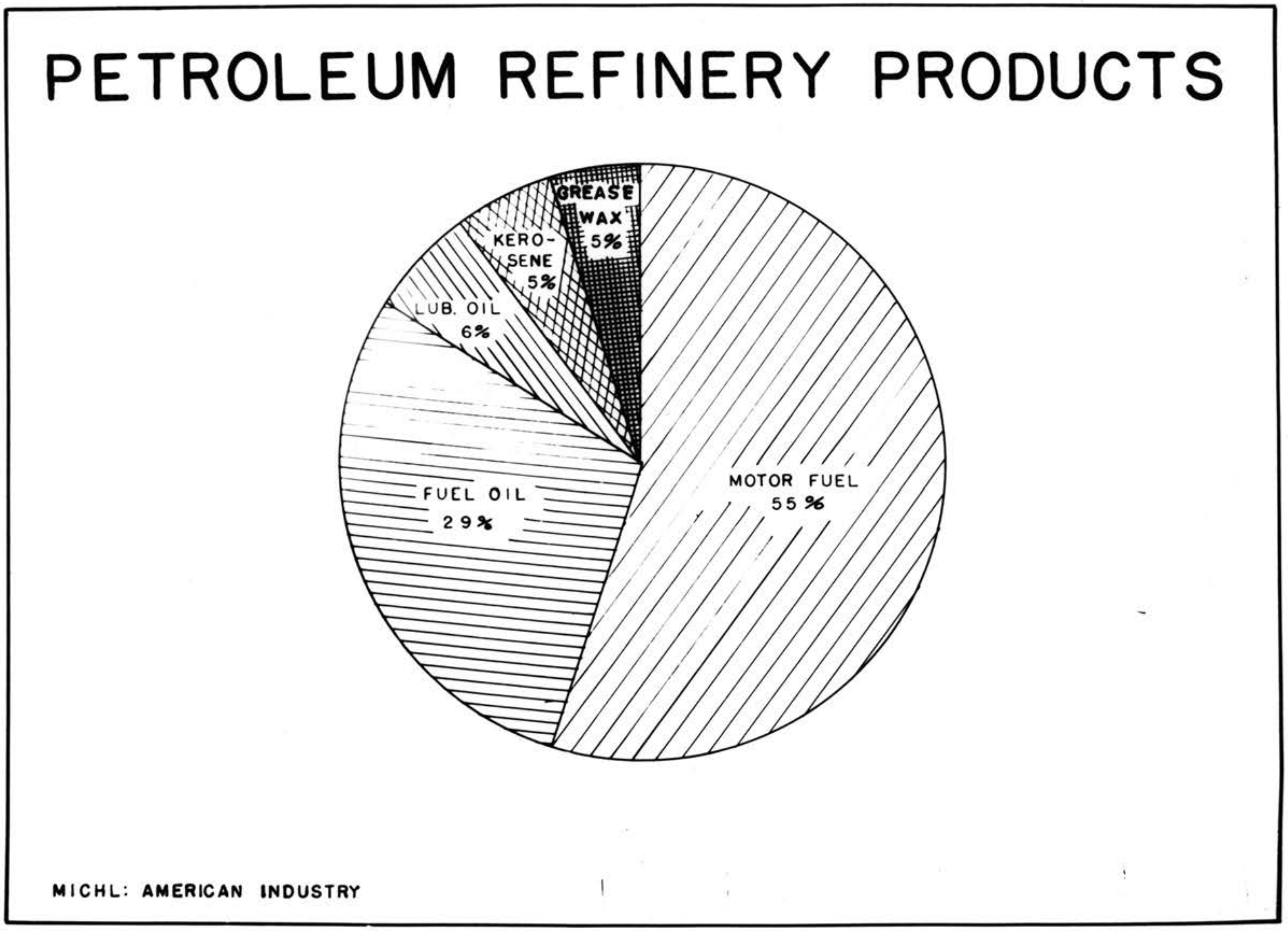
PETROLEUM REFINERY PRODUCTS
GREASE WAX 5%
KERO-SENE 5%
LUB. OIL 6%
FUEL OIL 29%
MOTOR FUEL 55%
MICHL: AMERICAN INDUSTRY

Figure 3

several leading from New York and Philadelphia to inland consuming points around the Great Lake cities of Rochester, Buffalo, Cleveland, Toledo and Detroit. In the Midwest the first pipe lines extended from Borger, Texas, north to Topeka, Kansas City, and St. Louis with later war extensions from St. Louis to Chicago, Toledo, and the lower Great Lakes area. Another pioneering line built during the early 1930's extended from refineries around the Tulsa area north to Kansas City with branches northwest to Minneapolis and Grand Forks, North Dakota, and northeast to the Chicago area.

War-time construction of pipe lines extended down into the southeast Texas area of Beaumont, Houston, and Corpus Christi. Southern post-war expansion was primarily from southeast Texas and Louisiana northeast to Nashville, Tennessee. Another line from these same refineries branched out to Alabama, Georgia, Florida, and North Carolina (Figure 1). The western half of the United States is very sparcely pipelined. Extensions from Borger, Texas, run northwest to Denver, Colorado, and Casper, Wyoming. From Sinclair, Wyoming, a line connects Salt Lake City, Utah; Boise, Idaho; and Pasco, Washington. California has two lines branching out short distances from Los Angeles.

The greatest concentration of these pipe lines falls into an arc extending from the petroleum refineries of the southwest to the heavily populated industrial and manufacturing northeastern part of the United States (Figure 1).

Additional products pipe lines were constructed during the war and more are projected. Much of the movement from the terminals is made by railroad tank cars and by small coastwise and river tankers or tank barges to conveniently located bulk stations, from where it is moved to filling stations and other consumers by motor truck. In some areas of the country, however, and particularly on the Pacific Coast and in the northwest, where limited quantities are consumed in comparatively broad areas, long-distance movement of petroleum products to bulk stations by truck has been substituted for rail or water movement. In the Columbia River Valley intense competition developed between motor, barge, and rail transport of this commodity.[6]

The Economy of Pipe Line Transportation

Pipe line transportation over long distances is a recent economic development. Rust and corrosion, leakage and limited pumped power, made large long-distance lines impractical. The development of better steel and alloy pipes, better abrasives in the machining process to reduce friction on the inside surface, electric welding of joints, and improved pumping engines, both gasoline and diesel, have occurred during the past two decades. These improvements overcame difficulties and gave birth to a new phase of pipe line transportation.

The two greatest assets of modern pipe line transportation are economy and dependability. Although the construction costs of the trunk lines amount to tens of thousands of dollars per miles, maintenance and operating costs are low compared to other forms of transportation. Once the pumps are started, the operation is semi-automatic.

Pipe line transportation is quite dependable, being less influenced by weather than is any other form of transportation. The ton-mile costs of any mode of transportation vary inversely with the length of haul and the percentage of capacity used. Costs therefore have a wide range in the movement of a commodity by any mode. The estimated average costs of transportation of petroleum products by the several modes vary greatly (Table 6).

It is apparent from Table 6 that only tank vessels can compare favorably with pipe lines in the economy of transportation. The growth of long products pipe lines caused the railroads to lose much of their tank-car traffic. They could not compete with pipe line rates.

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[6] Fair, op. cit., p. 162.

TABLE 6

TRANSPORTATION COSTS*

Kinds of Transportation	Cost Per Ton-Mile
Railroad tank car	8.3 mills
Vessel (ocean tanker)	0.7 to 1.25 mills
Pipe line	3.2 mills
Motor (tank trailers)	15.0 to 50 mills

*Marvin L. Fair and Ernest W. Williams, Jr., Economics of Transportation (1950), p. 105.

Despite the admitted operating cost differential between gasoline lines and railroads, the earlier rates charged by the gasoline pipe lines tended to match the existing rail rates. For example, the rate quoted by the Great Lakes Pipe Line Company from Tulsa to Omaha was 94 cents per barrel or 33.9 cents per 100 pounds, which is rather close to the rail rate of 33.0 cents.[7] Phillips Pipe Line Company posted a rate of 70.5 cents per barrel for shipment from Borger, Texas, to Wichita, Kansas, which exactly matches the 25.5 cents per 100 pounds rail rate. Moreover, when an additional one per cent emergency charge was made available to the railroads, the Great Lakes Pipe Line advanced its rate an equivalent amount.

In view of the large capital investment of pipe lines, one might wonder if the early rates were not justifiably high in order to recover the heavy investment by charging a rate comparable to existing competitive forms of transportation. This argument loses weight when one realizes that although the pipe lines were paid out fully in 1941 the rates still were well above cost plus six per

[7] House of Representatives Report No. 2192, 72nd Congress, Second Session (1933), p. 491.

cent on investment.[8] Moreover, the complaints concerning the virtual use of Tulsa as a basing point and the collection of "quasi-phantom freight" are numerous.[9]

It is evident that the rates charged by the pipe line companies are not made with any relation to the cost of service, but rather are measured by the benefits to be derived therefrom by the owners rather than by the benefits directly derived from common-carrier operations.[10]

The pipe lines have exerted a considerable influence on rail rates by controlling shipments of petroleum products. The effect of this significant development has been to influence not only the rates on rail movements of petroleum and its products but also the rates on bituminous and anthracite coal, which are competitors, in many respects, of petroleum products in both industrial and domestic markets.[11]

Nor is it possible to compare the relative costs of pipe line and railroad transportation. Inspection of the detailed reports of interstate pipe line companies indicates wide cost variations. Three items, however, always make up the bulk of the investment total. In order of importance they are pipe, construction, and station equipment, which together account for about 70 to 85 per cent of the total.[12]

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[8] George S. Wolbert, Jr., American Pipe Lines (1952), p. 18.

[9] Under a basing point system, any time a purchaser pays an allowance for freight which is greater than the actual cost of freight delivery, he is said to be paying "phantom freight". For example, the rail rate and pipe line rate is 36 cents per 100 pounds. The pipe line cost, including six per cent return on investment, is 12.83 cents per 100 pounds. Therefore, the quasi-phantom freight is 23.17 cents per 100 pounds.

[10] "Reduced Pipe Line Rates and Gathering Charges," Interstate Commerce Commission, Vol. 243 (1940), pp. 115-139.

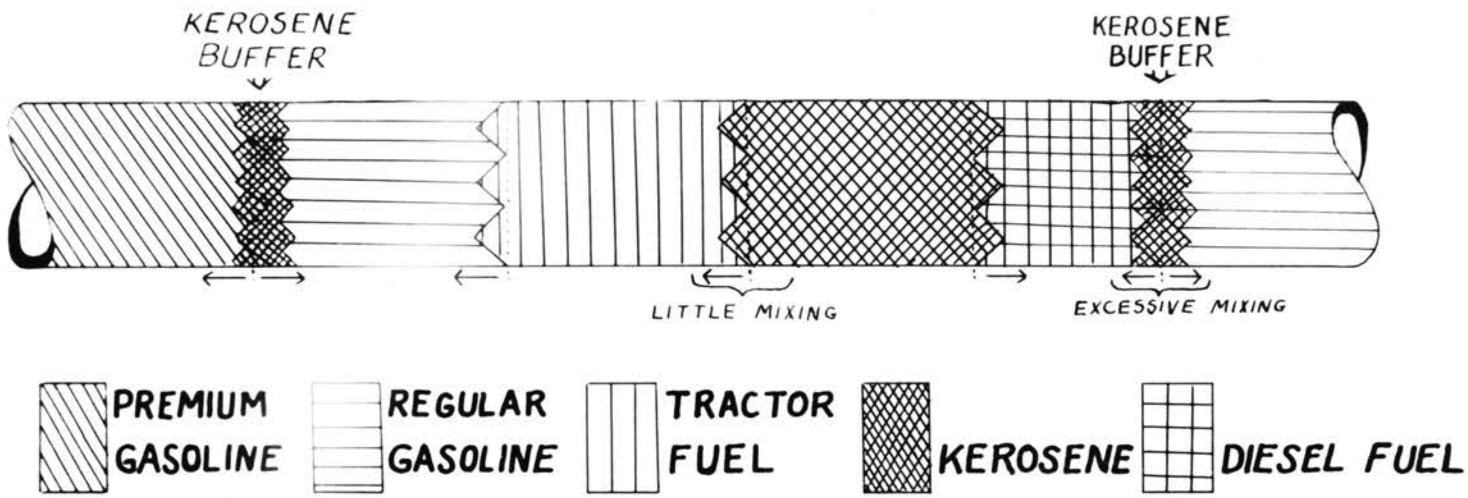
[11] Harold G. Moulton and associates, The American Transportation Problem (1933), p. 715.

[12] Ibid., p. 716.

As compared with railroads, the costs of pipe line operations are relatively low mainly because of the simplicity of the operations and the comparatively small number of laborers required. The ratio of employees' compensation to operating expenses in 1931, for example, was 65 per cent on the railroads as compared with 38 per cent on the pipe lines. The wages per employee, however, differ only slightly. In 1930, the average amount earned per employee on the railroads was $1,714 and on the pipe lines $1,844. The relatively high wages of pipe line employees are doubtless attributable to the relatively high proportion of skilled workers. The pipe line companies, like the railways, are subject to property taxation on both fixed structures and equipment, and to corporate income taxes. The pipe lines are the only form of transportation other than the railways which does not receive annual subsidies from the government, nor have they at any period received land grants.

To prove further the economy of pipe line transportation, it alone among transportation agencies requires neither packaging or packing of the commodity it transports, nor is it faced with the requirement of returning empty cars, vehicles or vessels. Performing its service by the application of power direct to the commodity being moved, it could be said to "impel" or "push" its cargo rather than "transport" or "carry" it.

Separate shipments of products are put into the pipe line one after another often without a barrier between them, depending upon the specific gravity. The head of the new stream or product butts against the end of the one ahead of it with very little intermixing and both form a continuous flow which fills the entire diameter of the pipe. When two products with nearly the same specific gravity, such as premium gasoline and regular gasoline or diesel fuel and regular gasoline, are shipped, a kerosene buffer is sometimes used to prevent excessive mixing and contamination at the terminals where the products are separated into individual tanks (Figure 4).



SEQUENCE OF PRODUCTS THROUGH A PIPELINE TO PREVENT MIXING

Source: Oil For The World; Harper Bros.

Figure 4

How, then, is it possible to know when a particular product shipment has reached its delivery point? Numerous methods have been devised to locate and divert the different shipments at the delivery points. Two of the oldest methods of detecting the product are still in use today. One method is to drop a small amount of dye at the head of each batch as it is pumped into the line, and this dye can be detected easily at the terminal. The other method is to know the speed at which the pumps are moving the product, so that a gravity test can be started at the receiving end and as soon as the shipment meets its weight the valves are switched and the shipment is diverted to its particular storage tank. One of the latest methods of detecting a new product shipment is by dropping a small amount of radio-active material into the line and using a Geiger counter at the receiving end.[13] Thus with no dead weight to move, pipe lines attain a relatively high efficiency in the use of power.

In general, then, the facts seem to demonstrate that the rates charged by pipe lines seriously limit the amount of competition that exists in the distribution of gasoline. It is also significant that the cost of transporting gasoline by rail is approximately three times the cost of transporting it by pipe line. If the railroad rates for transporting gasoline are sufficient to cover costs, one would expect the pipe lines to be very profitable since their rates are practically the same as the railroads. This leads to an analysis of the earnings of pipe line companies.

The pipe line companies have frequently been accused of monopolistic tendencies possibly because of the enormous profits they make. They have been unreasonably large over a long period of time. The average return for several

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[13] W. L. Shannon, "The Block Method of Transporting Several Grades of Petroleum Products Through the Same Line," The Oil and Gas Journal, XLIX (September 21, 1950), pp. 284-296.

products pipe line companies from 1934-1939 as reported by the Interstate Commerce Commission valuations ranged from 9.47 per cent to 53.47 per cent of their total evaluation. Thus products pipe line companies can easily pay for themselves in a short time. For example, the Great Lakes Pipe Line Company, which is the largest in the field owned by several oil companies, paid dividends totaling $28,864,673 for the years 1934-1939 on an investment as of December 31, 1939, of $24,430,424.[14]

Safety and Regularity of Delivery to Consumers

The safety of pipe lines over other forms of transportation can be noticed daily in our newspapers and magazines. Truck transports are frequently involved in highway accidents burning their contents and often the occupants. Railroad cars, although not as frequently as motor transports, have plunged into an open switch or some other obstacle and caused great damage to equipment, petroleum products and surrounding rights-of-way. Recently a Santa Fe train in Texas lost twenty-seven tank cars as the train was derailed and 500,000 gallons of blazing gasoline were loosed on the countryside. Fortunately, there were no injuries.[15] Barges as well as tankers have been known to catch fire through careless fire precautions.

Naturally the pipe line industry has its share of fires but not nearly as high a rate as other transportation agencies. Pipe line companies in order to safeguard personnel and property have become very fire-conscious because of the high combustibility of their products.

It is customary for the industry to build a dike of earth or concrete

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[14] Roy A. Prewitt, "Operation and Regulations of Pipelines," Quarterly Journal of Economics, XVI (February, 1942), pp. 177-221.

[15] Stillwater News-Press (June 14, 1952), p. 7.

around storage tanks. In case of fire or leaks the fire will be confined to the immediate vicinity where special fire fighting equipment is available. Precautions are taken to prevent fires by prohibiting employees to smoke or carry non-safety matches while on duty.

Trunk lines are buried for the convenience and safety of the public. As the stream of fluid is pumped thousands of miles underground, there is no danger of collision or fire. At the receiving terminals the same precautions are taken.

Pipe lines are not only safe but they also give terminals and consumers a regular flow of products, rain or shine, day or night, throughout the year. There is very little interruption in flow as might occur because of crowded switching yards or rail labor strikes. Had it not been for the pipe lines during the recent rail strike, this nation's production and economy would have been extremely hampered. As it happened, the steady flow and distribution of products to the various terminals was not interrupted.

Ownership and Control of Pipe Lines

In recent years a number of pipe line carriers have constructed and operated trunk pipe line systems on a joint ownership (undivided interest) basis. This type of operation is generally used by companies having access to oil and serving refineries in the same general area. They find it financially advantageous to join together in the construction and operation of a line or lines of large diameter to handle their joint transportation needs, rather than for each of them to construct duplicating transportation facilities of less capacity. Each co-owner is entitled to share in the capacity of the joint pipe line on the basis of its undivided ownership.

The construction of long-distance pipe lines involves a tremendous initial outlay of capital, and few small producers or independent firms are able to provide such a facility. Another factor tending to concentrate pipe line ownership is the large-scale refiner who must maintain a high percentage of throughput capacity in order to avail himself of large-scale operational economies.

In view of the above factors, the concentration of several refineries into one large pipe line company is quite reasonable. A hypothetical situation is shown in Table 7. The greatest saving effected by jointly owned and operated pipe lines over a separately owned and operated pipe line is the investment of facilities, amounting to a total of $21,733,000. As further shown in Table 7, the annual operating expense shows a saving of $1,708,748, and the operating expense per barrel nets a total saving of 2.177 cents.[16]

Thus in an organization of this kind, the co-owners are working together for operating purposes only, for to all intents and purposes each co-owner operates his part of the joint venture exactly as though he were operating a pipe line in which he had a 100 per cent interest. Each co-owner transacts his business and carries out his normal corporate purpose separately and independently of the other co-owners, each being directly responsible to his consumers.

From an accounting standpoint, such an organization is unique in that it is not incorporated as a separate entity and it does not represent a partnership. Accounting-wise, each co-owner must account for his undivided share of the properties and the cost of the operations.

Recent Developments in the Industry

Pipe line transportation is highly specialized and is devoted solely to the movement of freight traffic in liquid form. Of the recent developments in the industry, most have been in the use of improved technical equipment and materials.

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[16]Paul Graber, Common Carrier Pipe Line Operations (1949), p. 210.

TABLE 7

SEPARATELY OWNED AND OPERATED PIPE LINES VS. A JOINTLY OWNED AND OPERATED LINE: CONSTRUCTION AND OPERATING COSTS*
(Hypothetical Case)

I. Separately Owned and Operated Lines	Company A	Company B	Company C	Total
Capacity required--barrels daily	34,000	64,000	117,000	215,000
Diameter of Pipe	12"	16"	20"	----
No. of Stations (diesel)	3	3	3	9
Operating Pressure (lbs.)	1000	1000	1000	----
Length of Line (miles)	500	500	500	1,500
Investment in Facilities--total	$12,786,000	$19,007,000	$26,940,000	$59,733,000
Investment in Facilities--per daily barrel	$405.50	$296.98	$230.03	$277.83
Annual estimated operating expense (including depreciation)	$1,191,360	$1,506,720	$2,071,193	$4,769,273
Operating expense per bbl.	9.6¢	6.45¢	4.85¢	6.077¢
Tariff to earn 7% return	23.2¢	16.5¢	12.5¢	15.38¢

II. Jointly Owned and Operated Line

	Company A	Company B	Company C	Total
Capacity allocated--barrels daily	34,000	64,000	117,000	215,000
Percentage owned	15.81	29.77	54.42	100
Diameter of Pipe	-	-	-	24"
No. of Stations (diesel)	-	-	-	4
Operating Pressure (lbs.)	-	-	-	850
Length of Line (miles)	-	-	-	500
Investment in Facilities	$6,007,800	$11,312,600	$20,679,600	$38,000,000
Investment in Facilities--per daily barrel	$176.74	$176.74	$176.74	$176.74
Annual estimated operating expense (including depreciation)	$483,869	$911,118	$1,665,538	$3,060,525
Operating expense per bbl.	3.9¢	3.9¢	3.9¢	3.9¢
Tariff to earn 7% return	9.5¢	9.5¢	9.5¢	9.5¢

*Paul Graber, Common Carrier Pipe Line Operations (1949), p. 212.

New Pipe Line Metals and Materials.--Various suppliers of materials to the petroleum industry are constantly attempting to improve their quality and to introduce new and better products. Typical of this effort is the attempt to supply metals to meet its needs more satisfactorily. In improving the quality of this metal supply, new alloys are introduced, old ones are reapplied, and new metals tested. High among the many challenging requirements are better corrosion resistance, lighter weight, higher strength, reduced pipe frictions, and lower costs.

Aluminum.--Aluminum is beginning to take its place among the metals best suited to petroleum service. At present, large quantities of aluminum are used in the oil industry for tank decks, drillable castings, casing windows, pipe wrap and insulation, condenser tubes, cathodic protection anodes, non-sparking nails, building products, electrical conductors, light-weight pulleys, pumps, and widely varying forms of pipe and tubing.[17]

Aluminum tubular products are produced by extrusion and, in certain instances, further processed by drawing or tube reducing. Extruded pipe and tubing have many good points. First, they are seamless. In addition, their smooth inner surfaces make available a low fanning friction factor.

Aluminum pipe and tubing are available in a variety of alloys and tempers, ranging from a tensile strength of 13,000 pounds per square inch to 90,000 pounds per square inch.

Temporary fuel transportation and gathering systems of light-wall aluminum pipe are gaining in popularity. The ratio of standard iron pipe weight to aluminum pipe is approximately 15 to 1. The outstanding application of aluminum in the petroleum field is in pipe lines for gas and oil. The factors of corrosion

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[17] William B. Moore, Jr., "Use of Aluminum Pipe in Oil Country Applications," The Petroleum Engineer, XXIV (April, 1952), pp. D-28-D-32.

resistance, light weight, and reduced fluid friction inherent in an extruded aluminum pipe has long been of interest to officials concerned with the transportation of petroleum products. In recent years, therefore, several test installations of aluminum pipe have been made in order that the adaptability of aluminum to this service might be determined. Test lines have been operating in Arkansas and Louisiana for several years and additional lines recently have been installed in northern Alabama, Oklahoma, and Texas.

The cost of installing aluminum pipe was found to be approximately 30 per cent less than that for installing the presently utilized material. The light weight of the aluminum pipe made savings possible in the stringing operation, handling during welding, lowering in, and other operations. The already clean surface of aluminum pipe made it unnecessary to clean before wrapping, and effected a saving in wrapping and coating.

The aluminum pipe line tests show that aluminum has high corrosion resistance to many types of soil. In certain soils, aluminum pipe may be installed bare with no danger of corrosion damage. The low friction factor of aluminum pipe leads to low pumping costs.

Of the conditions favoring the use of aluminum pipe, the most obvious is in any type of suspended crossing where the light weight of the pipe makes possible a cable support design.[18] Experience with these crossings indicates that the low cost of this structure will offset the additional cost of aluminum pipe in the average length crossing. Further savings are, of course, made in the relative ease with which the aluminum pipe is handled and the fact that aluminum needs no protection from atmospheric corrosion.

In general, conditions favoring aluminum are those requiring high installation costs, high enough that the savings in installation will offset the increase

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[18]"Oil Pipe Line Suspension Bridge," <u>World Oil</u>, CXXXI (August, 1950), p. 203.

in cost of material.

The total cost of an 8-inch aluminum line is some 27 per cent greater than a standard steel line. It has been determined, however, in several installations that the ratio of installation costs remain essentially constant with aluminum being about 30 per cent less expensive to install. Thus the break-even point, or the type of terrain that will so equalize this installation cost advantage, must be considered.

Still using the 8-inch line as a means of illustrating the economics involved in the selection of aluminum pipe, it is seen that in the mountains, or in marshy underwater, or otherwise inaccessible terrain where installation costs approach or exceed $2.50 per foot, aluminum pipe can be used to advantage.[19]

Future installation of aluminum pipe will naturally depend on the availability of aluminum for line pipe construction. With the present demand for aluminum in defense uses, pipeliners will have to wait several years to begin significant construction with aluminum pipe lines.

Plastics.--A recent innovation in pipe line construction has been plastics. Engineers have laid 1,940 feet of 4-inch plastic pipe in a section of Interstate Oil Pipe Line's gathering system in southern Arkansas as an experiment. The pipe weighs one pound per foot, comparing with 10.79 pounds per foot for regular 4-inch steel pipe.

Crude oil in this area of Arkansas contains sulphur which creates heavy corrosion in metal pipe lines; the soil is also very corrosive and repair costs are high on the gathering lines. Plastic pipe also resists paraffin accumulation. The experimental section will be checked every few months to determine the feasibility and future use of plastics in pipe line construction.[20]

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[19] _Ibid._, p. D-30.

[20] _The Daily Oklahoman_ (June 15, 1952), p. 24.

Recent Developments in Corrosion Protection.--Two of the most recent discoveries of the industry are the dehydration of products prior to shipment in pipe lines to prevent rust and corrosion, and the external protective coatings of cathodic protection.

Internal Pipe Line Protection.--In the process of manufacture of gasolines and certain distillate fuels, the products are washed with water for the purpose of removing undesirable compounds and finely divided solids that may be carried over from the treating plant. This washing is effected just prior to running the products into their respective storage tanks. Consequently, products received at the point of origin of a pipe line contain adsorbed water and water in solution. Inner surface rusting of the pipe is the direct result of precipitation of this water from the product while the product is in the line.

Commonly, two entirely different methods of preventing internal corrosion are used by pipe line companies. One method consists of injecting rust inhibitors, either water soluble or oil soluble, directly into the products pumped. These inhibitors so coat the interior of the pipe that the water does not attack the metal. The other method is to dehydrate the products so that no free water can precipitate in the line and cause rusting. Both methods have their adherents and both perform the required function of preventing internal corrosion.[21]

External Pipe Line Protection.--Another interesting feature of recent pipe line operations is the problem of pipe line corrosion maintenance. When steel is buried in the ground, it is immediately subject to attack by corrosion. The corrosion rate varies according to the type of soil in which the line is buried.

Corrosion is caused by electrolysis. The minerals in the soil serve as

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[21]R. P. Dougherty, "Dehydration on Products Pipe Lines," The Petroleum Engineer, XXIV (June, 1952), p. D-10.

the electrolyte and electric currents flow from the pipe into the electrolyte and back on the pipe in a different location. The anode, or point at which the current leaves the pipe line, is the spot where the metal is carried away with the current. Pit holes eventually occur at these spots.[22]

One method of combating this type of deterioration is to coat the entire line with a protective coating of grease, asphalt or tar. All three basic materials are used. In addition to the basic coating applied, the line is frequently wrapped with a paper or asbestos felt wrapper throughout its entire length over the particular coating used. Such coating insulates the pipe to a great extent from current flow. It has been found, though, that the coating alone will not stop the corrosion. This is true because it is impossible to apply a coating without some "holidays".[23] Electric currents will flow from the line through the holes in the coating resulting in pitting of the steel; therefore, additional protective measures must be taken.

Lines corrode only at points where electric current leaves them. Therefore, if it could be made certain that no current would leave the pipe line, corrosion would be eliminated. A protective method termed "cathodic protection", is now in wide use.[24] This method, in effect, pumps current from the soil into the line at all times, thus preventing currents from leaving the line, and as a result practically no corrosion occurs. This form of protection is accomplished by placing a scrap iron ground bed adjacent to the line and forcing current into the ground bed by means of a generator or other power

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[22]"Cathodic Protection Technical Practices," <u>The Petroleum Engineer</u>, XXIII (July, 1951), pp. D-9-D-16.

[23]The term "holidays" refers to small holes in the coating caused by handling the pipe in the pipe laying operations.

[24]Marshall E. Parker, "The Rational Approach to Cathodic Protection," <u>The Petroleum Engineer</u>, XXIII (September, 1951), pp. D-14-D-18.

source. The current then flows from the ground bed through the soil to the pipe line. The current is returned to the power source from the line by a conductor. If a line has a good coating on it and is cathodically protected, it is possible for it to operate for years without having a single leak.

Automatic Pipe Line Stations.--There is a trend to more and more automatic controls and stations. One of the most modern methods of station operation is used by the Shell Oil Company which has four new, completely remote-controlled, pumping stations in the Midwest. They were put into operation by a spin of a dial in the RCA Building in New York City.[25] The line carries petroleum products from Shell Oil Company's Wood River, Illinois, refinery to industrial centers further east at Toledo and Columbus, Ohio. From a dispatcher's office in New York City, the new stations are operated by long distance wire. The new stations are not wholly without the human touch, however. One man is assigned to each station to perform routine upkeep and maintenance and to operate the controls by hand, if necessary. A siren is provided to summon the attendant in the event of such a necessity, and as everything else at the station, it is set in motion by a signal from New York City.

The reason for central control of a products pipe line is the great variety of products that it handles one after the other. Gasoline, kerosene, fuel oil, and other bulk products are pumped through the line at convenient intervals, and a portion of the products is taken off and put in tanks for distribution to local customers. Without scheduling of these take-offs from a central point, the operation of a products pipe line would be a hopeless muddle.

Problems of Financing Investment in Carrier Property.--For pipe line carriers operating under the terms of the Pipe Line Consent Decree, signed

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[25] "Push-Button Pipe Line Stations," The Petroleum Engineer, XXII (August, 1950), p. D-38.

December 23, 1941, a serious problem is posed of providing funds for replacement of existing facilities and construction of additional carrier properties.

This decree limits the amount of annual earnings derived from "transportation or other common carrier services" that can be distributed by the carrier to its shipper-owner. The shipper-owner's share is seven per cent of the carrier's adjusted Interstate Commerce Commission's valuation as of the close of the preceding year. The carrier's earnings, subject to the decree's limitation, may be distributed in the year earned or in later years unless such earnings have been retained and invested in properties included in the carrier's valuation base. This has the effect of restricting earnings as a source of capital for increasing investment in carrier property.[26]

The decree also requires that earnings in excess of seven per cent of the carrier's valuation be set aside in a "Surplus Account" within ninety days after the close of the year in which they are earned and specifies the purposes for which such funds may be used. One purpose specified is that these funds may be used for constructing or acquiring common carrier facilities for maintaining normal working capital requirements during the current calendar year, and for retiring any outstanding debts.

It was the hope of the Justice Department in writing the concent decree that it would result in reduced rates since the stockholders were allowed only seven per cent return of the company's evaluation. However, an official statement made in 1944 by the Justice Department indicated that the object of rate reduction was not accomplished by the decree.[27] According to one writer, the reason for this is that the amount of restricted funds is less than the loss

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[26]George S. Wolbert, Jr., American Pipe Lines (1952), p. 142.

[27]Ibid., p. 146.

of profits which would follow from an increase in independent refiner competition brought by reduction in pipe line rates.

Because of the restraints on the distribution of earnings imposed by the Pipe Line Consent Decree, forecasts of earnings and valuations for the current and several future years are of great importance to the economic welfare of the carrier and its shipper-owner.

Ideally a carrier subject to the restrictions of the Consent Decree would so conduct its operations as to realize annual earnings of slightly over seven per cent of valuation. So operated, the carrier will be able to pay maximum dividends to the shipper-owner and would avoid having to freeze substantial amounts of excess earnings in a "Surplus Account". The attainment of this ideal operating condition is dependent, however, on the balancing of several factors, the most important of which are: (1) quantities of products available for transportation, (2) tariff rates which are generally competitive, (3) operating costs, and (4) construction program. Forecasts of these factors must be sufficiently frequent and accurate to serve as the basis for policy decisions with respect to matters affecting the carrier's operating program.

In summary the above are some of the most important factors in the current status of petroleum products transportation by pipe line. There is an unending amount of research and development of new and better pipe line practices and technology. When technical advances cease to be made by the industry, the decline of pipe lines as a mode of modern transportation is almost sure to follow.

CHAPTER IV

OUTLOOK FOR PRODUCTS PIPE LINES IN AMERICA

The fastest-growing transport medium in the world today is the long, pressure-operated, metal pipe lines. The pipe line network transports more than ten per cent of the domestic freight moved by all common carriers in the United States. It effects maximum overland haulage at a lower cost per unit than any other medium of transport. Originally, pipe lines were used only to transport such commodities as crude petroleum, natural gas and water. A recent innovation, however, has been the distribution of refined petroleum products by this medium. Thus, an effort has been made to determine the extent of this development and the factors contributing to its rapid growth. These factors, as summarized below, have been instrumental in predicting the future significance of pipe lines as a medium of transport in the American economy.

Summary

Before World War II, the United States had about 8,000 miles of products pipe lines concentrated in an arc extending from the Southwest to the Northeast. By the end of 1952, domestic pipe lines for refined petroleum products will probably exceed 23,000 miles.

Historical Development of Products Pipe Lines.--The earliest pipe lines to transport petroleum products were laid in Pennsylvania in 1901. The only other development of any importance, prior to a great expansion period during the 1930's, was a short 7-mile line built by Standard Oil Company in Ohio. Other lines were being increased in diameter and length in California.

By the end of 1930, there were 1,289 miles of products lines, starting a new era of transportation. By 1940, lines extending from Texas and Oklahoma to St. Louis and Chicago increased the total mileage to 8,040. The mileage had increased to 20,109 by 1949, due primarily to war-time construction from the Texas Gulf area to the southeastern states. New developments after World War II began in the Northwest in response to the expansion of the Wyoming petroleum fields.

Economy and Dependability of Service.--The great need for a more economical and dependable mode of transportation caused the refineries to develop products pipe lines. In relation to the economy of other modes of transportation, pipe lines rank second only to ocean tankers; they are first in overland transportation.

As for dependability of service, there is little doubt that pipe lines rank first. They are not hampered by the weather, highway or rail accidents, or overburdened transportation systems, and being buried beneath the ground, they are much less susceptible to war-time enemy attacks.

Technical Improvements in the Industry.--Probably two of the most important factors affecting the development of pipe lines have been the improvements made in pipe fabrication and construction methods. Seamless steel pipe replaced cast-iron pipe, and electric welding replaced the toilsome screw joints. Recently, aluminum and plastic pipe have been used by the industry on an experimental basis.

Improved rotary pumps, driven by internal combustion engines or electric power, replaced the earlier inferior steam-driven pumps. Thus, line pressures were raised and friction wastes were reduced to further increase the transport efficiency.

Other technical improvements in the industry have been in communications, in the development of better automatic controls, and in corrosion protection.

Governmental Regulation of the Industry.--Because of the concentration of pipe line ownership among the major oil companies, numerous complaints developed against the industry. The pipe line companies were accused of monopolistic tendencies, unfair competition and discrimination of privileges among the potential customers. Jealousy and price cuts among the various transportation mediums kindled fires of discontent which ultimately reached the courts and the Halls of Congress.

Governmental intervention was inevitable. In 1887, the Interstate Commerce Act was passed regulating common carriers to post just rates, to avoid preferences with refineries, and to regulate pooling of revenue. Pipe lines, however, were not classified as common carriers until 1906 with the passage of the Hepburn Act. They then became common carriers and were subject to the regulations of the Interstate Commerce Commission.

The latest governmental intervention of major consequence was in 1941 when the major pipe line companies met with the Justice Department to answer excess profits charges. The resulting agreement, known as the Pipe Line Concent Decree, was reached on December 23, 1941. This decree limited the amount of earnings to seven per cent of total evaluation that could be paid by a company to its stockholders as annual dividends. Any excess was put into a Surplus Fund which could be invested in securities or spent on construction, labor, and other essentials the following year.

<u>Current Location and Distribution of Pipe Line Facilities</u>.--Transportation of petroleum products is but a first step in a complicated distribution enterprise. From the line terminals, other modes of transportation carry the products to the retailer and the public.

The major pipe lines extend from the Texas and Oklahoma refineries to the north and northeastern states. Lines running inland from the East Coast cities show the influence of tanker carriers. Only a few products lines are found west of the 100th meridian. One line extends from Texas to Wyoming and another from Wyoming to Washington. Southern California has two small lines leading from refineries to the Los Angeles area.

Conclusions

Pipe lines are second only to ocean tankers in the economy of petroleum products transportation. It is possible that in some areas, such as the Great Lakes region where the water is frozen for part of the year, pipe lines may be even more efficient than tankers. New technical developments will likely continue to reduce the economic advantage of water transportation in the future. It should be emphasized, however, that pipe lines for the distribution of petroleum products are economically feasible only where the volume of products to be transported is large enough to permit the economy of continuous operation.

In comparison with railroads, the cost of pipe line operations are relatively low, mainly because of the simplicity of operation and the small number of employees required. The greatest cost factors facing pipe lines are their initial costs for construction, pipe, and station equipment. However, these expenses might be substantially reduced with the use of improved technology in pipe fabrication and the use of substitutes for the expensive steel pipe.

These technological improvements are continually being explored and accepted in an industry that is constantly seeking to lower the cost of construction and operation.

The industry has recently explored the possibility of using substitutes for steel pipe, a commodity often in short supply, expensive, and difficult to handle. Plastic pipe has great potentialities in the pipe line industry, provided strength and durability can be developed in large diameter pipes at a nominal cost. In addition, with extremely cheap pipe, it may become feasible to service smaller and smaller consumer markets by direct pipe line connections, thus eliminating the final trans-shipment by tank truck or railroad tank car.

Aluminum pipes may also revolutionize the industry. Defense production needs are consuming aluminum to such an extent at present that it is in short supply for civilian needs. New technologies in aluminum processing, however, could promote aluminum, with its lightness, strength, non-corrosiveness and ease in handling, to compete favorably with steel pipe. Certain construction problems, where the above features are especially desirable, already create a demand for aluminum pipe by the industry.

More economical construction methods are constantly being developed to meet competition in the field. Construction units which operate with greater efficiency are able to charge less for construction.

Microwave radio, the newest technical development in communications, is being adopted generally where there is new construction. It will be some time before the present efficient teletype and telephone systems are replaced, although the microwave radio has the advantage of a low maintenance cost and conversational privacy.

One of the problems facing the industry is the choice to be made between electric or combustible motors. In areas where electricity and motor fuels are similar in price, the competition is passed on to the manufacturers who must ever improve their individual products in order to make future sales.

The geographical expansion of the products pipe line industry is limited. The major population growth is taking place in areas already served by existing lines. The resulting increased demand for petroleum products is satisfied by either looping present lines or replacing old lines with larger pipe. Since the present lines reach from the refineries to all densely populated areas of the United States, any increased demand for petroleum products will likely be handled by new construction of lines on existing rights-of-way. If an old line is in need of repair, the entire line may be salvaged and a larger diameter pipe put in its place. New lines may be constructed toward the Northwest if the demand for heating fuel becomes sufficient.

The petroleum producing areas of the United States are moving westward, but it is unlikely that refineries will follow this movement. Crude oil could be piped to existing refineries in the Midwest and the petroleum products would then flow through the existing products lines.

Pipe line transportation is chiefly confined to petroleum, petroleum products, and natural gas. Although experiments have been made with the movement by pipe line of other products, such as cement aggregates, powdered coal, and other pulverized solids, this traffic has not yet proved economically practical.

Recommendations

The larger refineries, through their control of the pipe line systems, are able to restrict operations of independents. Recommendation is made for legislation which would require the separation of pipe line operation from other phases of the oil industry. Such a separation should correct the abuses of favoritism and effectively convert pipe line transportation to a common carrier business.

Increased storage facilities should be provided at many of the pipe line terminals. These facilities should always be large enough to care for fluctuations in consumer demand for it is only with continuous pipe line flow that maximum transportational efficiency is realized. Occasionally, severe winters create serious heating problems because of an inadequate fuel supply which could have been accumulated during the slack summer months.

Further study is needed by the Federal Government on the question of unjust pricing procedures among the various companies before regulations can be properly enacted to eliminate them.

Almost any industry, during a period of rapid expansion, develops certain undesirable competitive techniques and operational practices that later must be corrected by law. The petroleum products pipe line industry has been no exception. Yet, this industry has developed against the resistance of strong competitive forces to provide one of the most efficient means of modern transportation.

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VITA

Sammy Seminoff
candidate for the degree of
Master of Science

Thesis: THE DISTRIBUTION OF PETROLEUM PRODUCTS BY PIPE LINE

Major: Geography

Biographical and Other Items:

Born: November 29, 1923, at Hobart, Oklahoma

Undergraduate Study: O.A.M.C., 1947-1951

Graduate Study: O.A.M.C., 1951-1952

Experiences: Farming, 1933-1943; Army, Third Army, 358th Engineering Regiment in England, France, Belgium and Germany, 1943-1946; War Department Civil Service in Munich, Germany, with visits to Switzerland, Austria, Denmark and Sweden, 1946-1947; Employed part-time by Western Union, 1949-1951; Employed by Great Lakes Pipe Line Company, summer, 1951; Graduate Fellowship, Geography Department, 1951-1952.

Member of Gamma Theta Upsilon

Date of Final Examination: July 12, 1952

THESIS TITLE: Distribution of Petroleum Products By Pipe Line

AUTHOR: Sammy Seminoff

THESIS ADVISER: Dr. Robert C. Fite

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TYPIST: Doris Seminoff