REPORT OF DEPARTMENT OF HIGHWAY TRANSPORTATION ECONOMICS

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THE PROGRESS OF IOWA COORDINATION STUDIES OF TRANSPORTATION AGENCIES

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SYNOPSIS

The progress to date on certain research projects relating to transportation coordination in Iowa is reported with particular emphasis on railways and highways A general discussion of the railways includes traffic densities, grade crossing elimination, the probable future of Iowa railways, and their coordination with the highways With regard to the latter, scientific analysis of highway taxes and fees must supplant present legislative dictum, and fundamental data which may serve to promote wise planning, construction, and management of highways are described from the Iowa researches planned or now in progress These studies include traffic and financial surveys, highway property inventories, truck and bus taxes, actual service lives of highway surfaces, probable future services of existing highway surfaces, correct methods of determining highway property depreciation, and a discussion of a uniform system of classification of highway accounts

A DESCRIPTION OF THE VARIOUS IOWA TRANSPORTATION AGENCIES (RAILWAYS, HIGHWAYS, WATERWAYS, AIRWAYS, TRUNK PIPE-LINES)

Iowa Railways

Iowa Railways are shown in Figures 1, 2, 3, 4 Their approximate mileages August 1, 1934, are given in Table I

Additional minor branch lines are being abandoned from time to time.

Iowa Highways

Iowa highways are divided into "state primary roads," "country trunk roads," and "county local roads" Some transfers between these three systems are made from time to time, their mileages November 1, 1934, are given in Table II

Iowa Primary Roads are shown in Figure 5

Typical primary, "county trunk" and "county local" road systems are shown on the map of Cerro Gordo County in Figure 6 The first mile of rural highway pavement in Iowa was built in this county in 1913 The improvement of Cerro Gordo County state and county roads has progressed so far that 85 per cent of the farm homes now have surfaced roads in

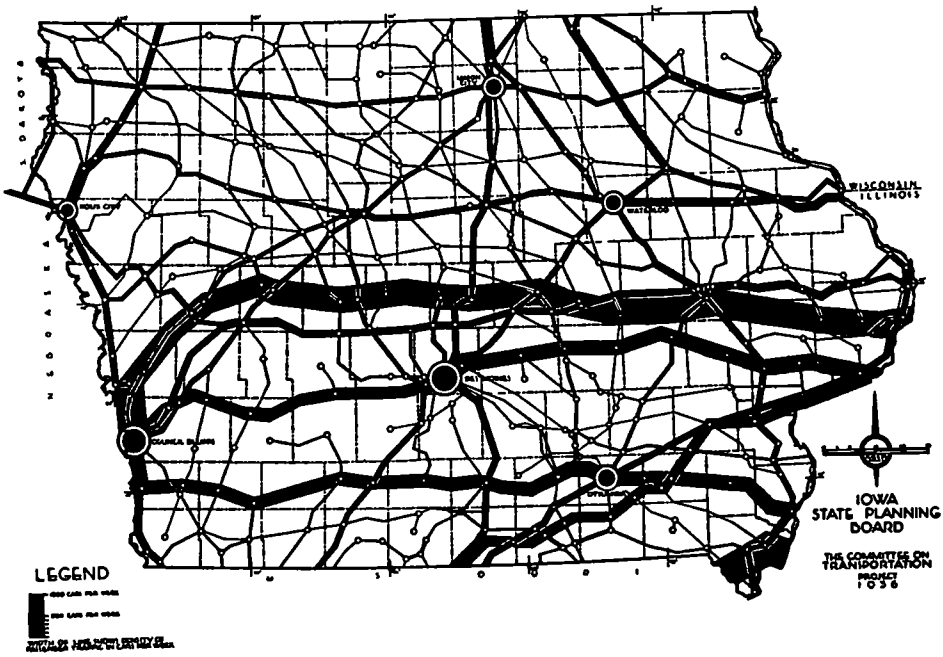

Figure 1. Density of Iowa Railway Passenger Traffic—1934

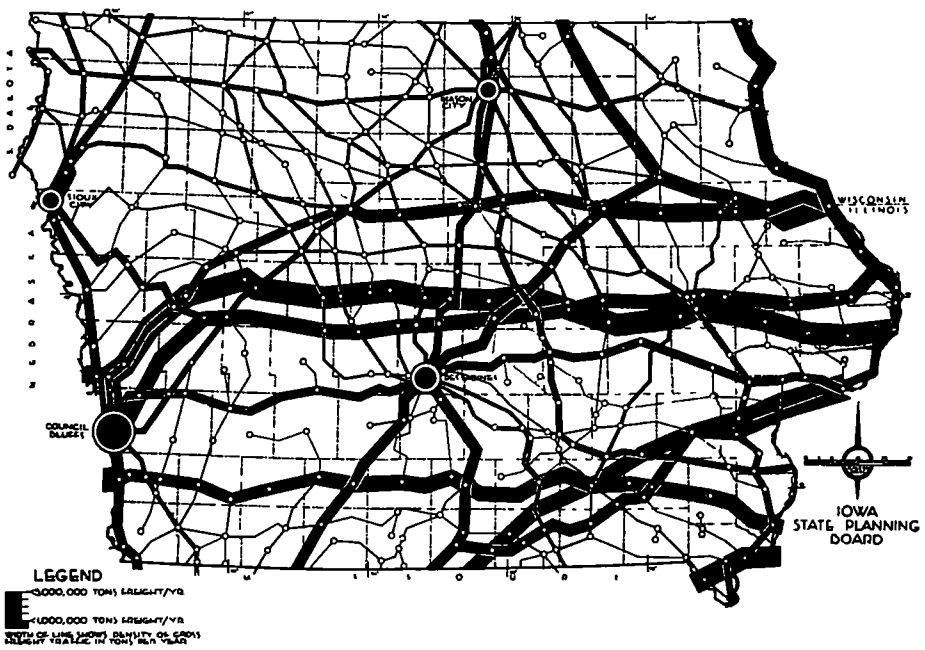

Figure 2 Density of Iowa Railway Freight Traffic—1934

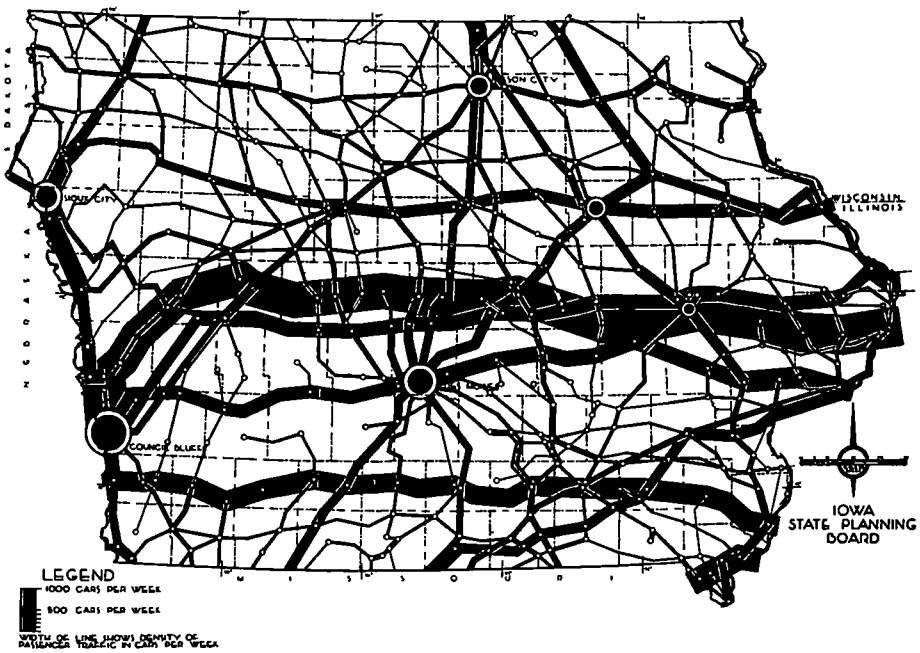

Figure 3. Density of Iowa Railway Passenger Traffic—1924

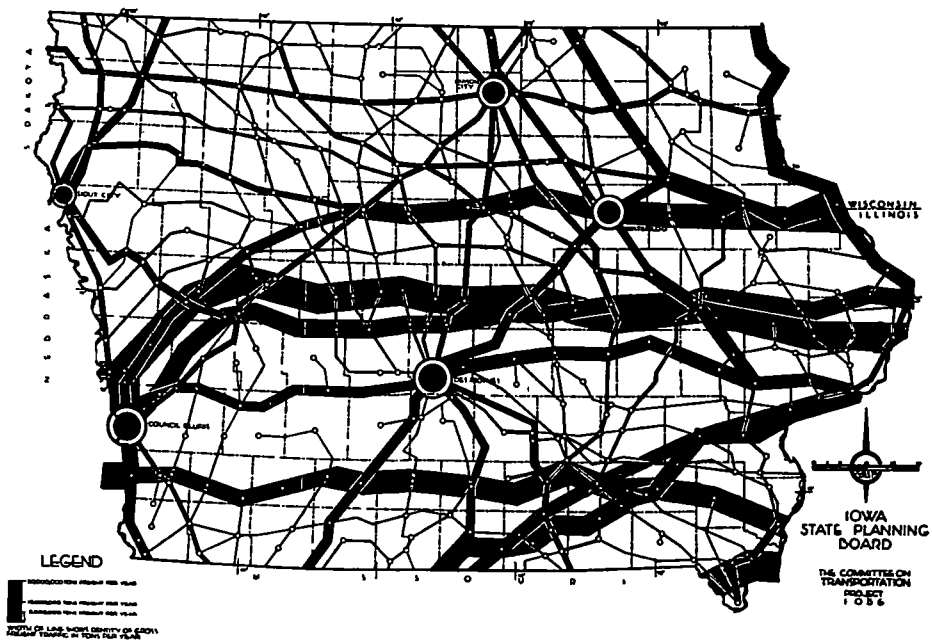

Figure 4 Density of Iowa Railway Freight Traffic—1924

front of their gates A considerable number of other Iowa counties are similarly advanced, many others are far behind.

Iowa Waterways

The Iowa waterways situation is shown in Figure 7 Improved waterways border the state on the east and the west, they are parts of an extensive system of modern improved internal waterways, steamboats, will be available from both Iowa's eastern and western boundaries, in all but the winter months, not only to the richest parts of the Mississippi Valley but to all ocean ports The research transportation studies have not yet been made which are required to determine what kinds and what volumes of Iowa freight can and will profitably utilize these great waterways

TABLE I

IOWA RAILWAY SYSTEM

August 1, 1934

	Miles
Main Lines	3,627
Principal Branch Lines	1,806
Minor Branch Lines	4,637
Total Present System	10,070
Abandoned Branches	408
Total Original System	10,478

Iowa Airways

Iowa airways are shown in Figures 8 and 9 Evidently, not many *through airways* are likely to cross Iowa Those which do cross are not very likely to have many stopping points within the state

The development of Iowa's airway facilities should include the construction and maintenance of such number of local airports, suitably distributed, as may be required to serve the needs of airplanes

TABLE II

IOWA HIGHWAY SYSTEMS

November 1, 1934

System	Mileages				
	Paved	Other Surfaces	Graded Only	Not Graded	Total
State Primary Roads	4,313	3,256	175	165	7,909
County Trunk Roads	21	8,920	916	3,533	13,390
County Local Roads	5	15,273	2,828	63,128	81,234
Totals	4,339	27,449	3,919	66,826	102,533

reaching Sioux City, St Paul, Chicago, Pittsburgh, and New Orleans, and connecting with the Great Lakes, the St Lawrence River, the Atlantic Ocean, and the Gulf of Mexico

Upon completion of the Missouri and the Upper Mississippi River waterways now under construction, through waterways transportation, in single tow cargoes equal to those of 20 to 30 old time river

owned within and without the state, operated for recreation, private business uses, or public taxi service.

Iowa Trunk Pipe-Lines

Iowa trunk pipe-lines are shown in Figure 10, they represent a large, comparatively recent investment, and already are an important part of the state's transportation facilities It would appear that

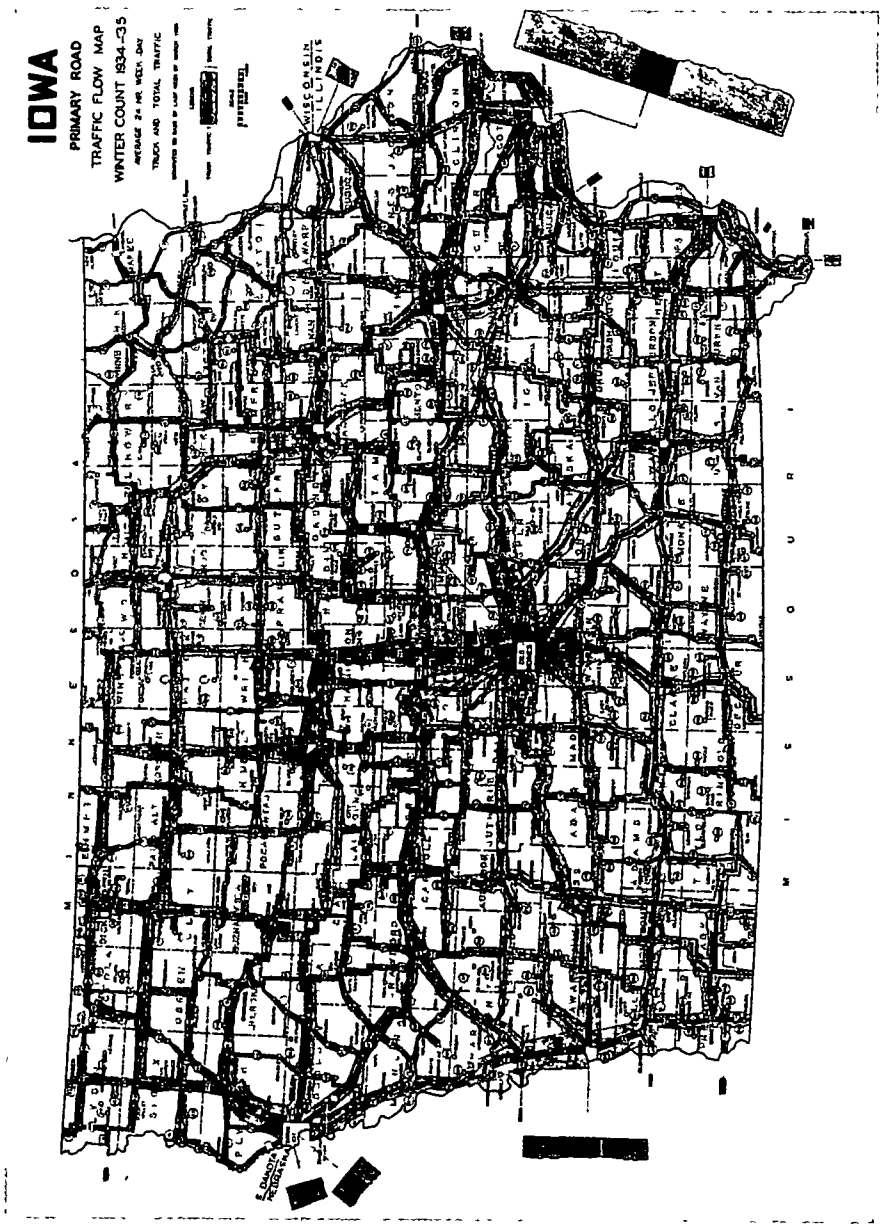

Figure 5 Iowa Primary Road Traffic-Flow Map. Winter Count 1934–35, Average 24-Hour Week Day Computed to Base of Last Week of March, 1935.

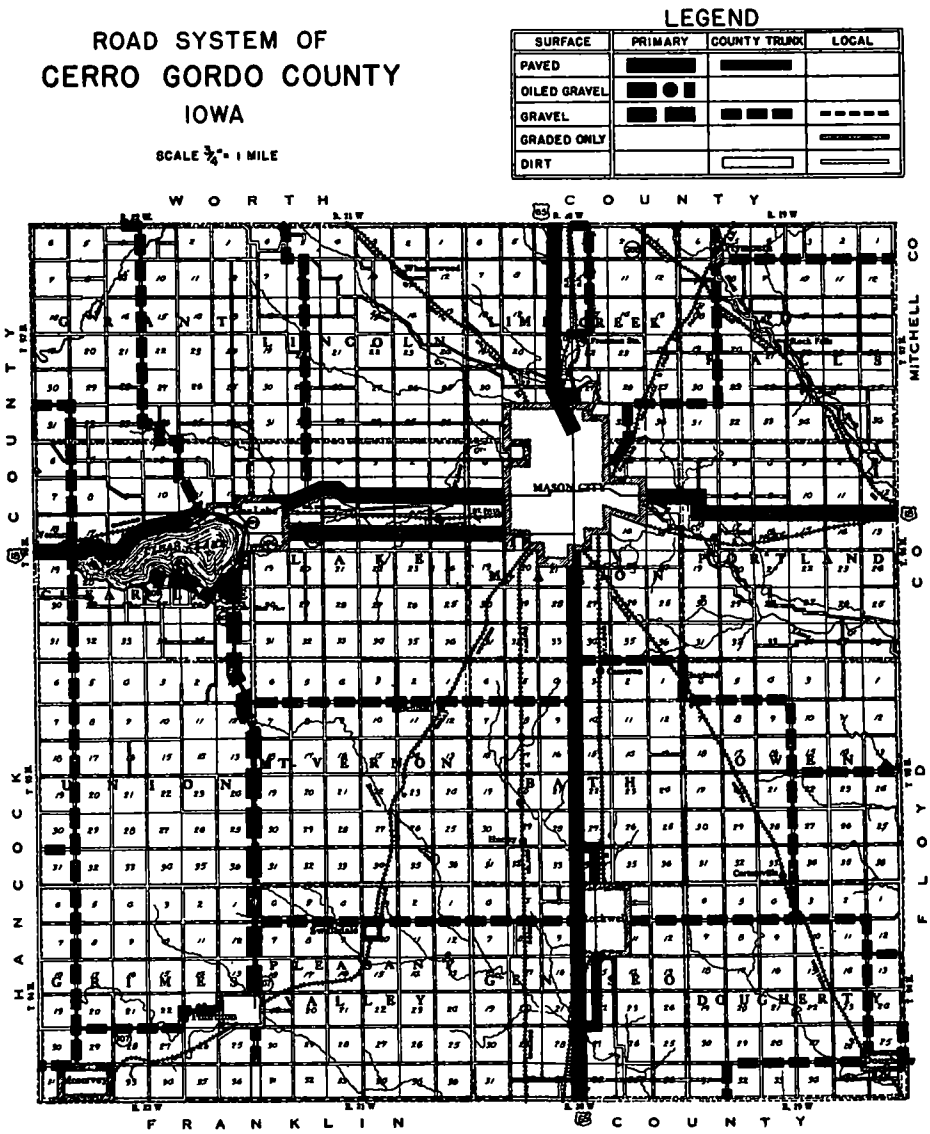

Figure 6

their future development can safely be left to private initiative Their proper regulation is one of the state's transportation problems.

There will be no further discussion in this paper of waterways, airways, or trunk pipe-lines Iowa transportation coordination research studies have been mainly confined to the state's railways and highways.

COORDINATION RESEARCH STUDIES OF IOWA RAILWAYS

The railway system in Iowa was never planned to serve Iowa's transportation needs most satisfactorily and efficiently

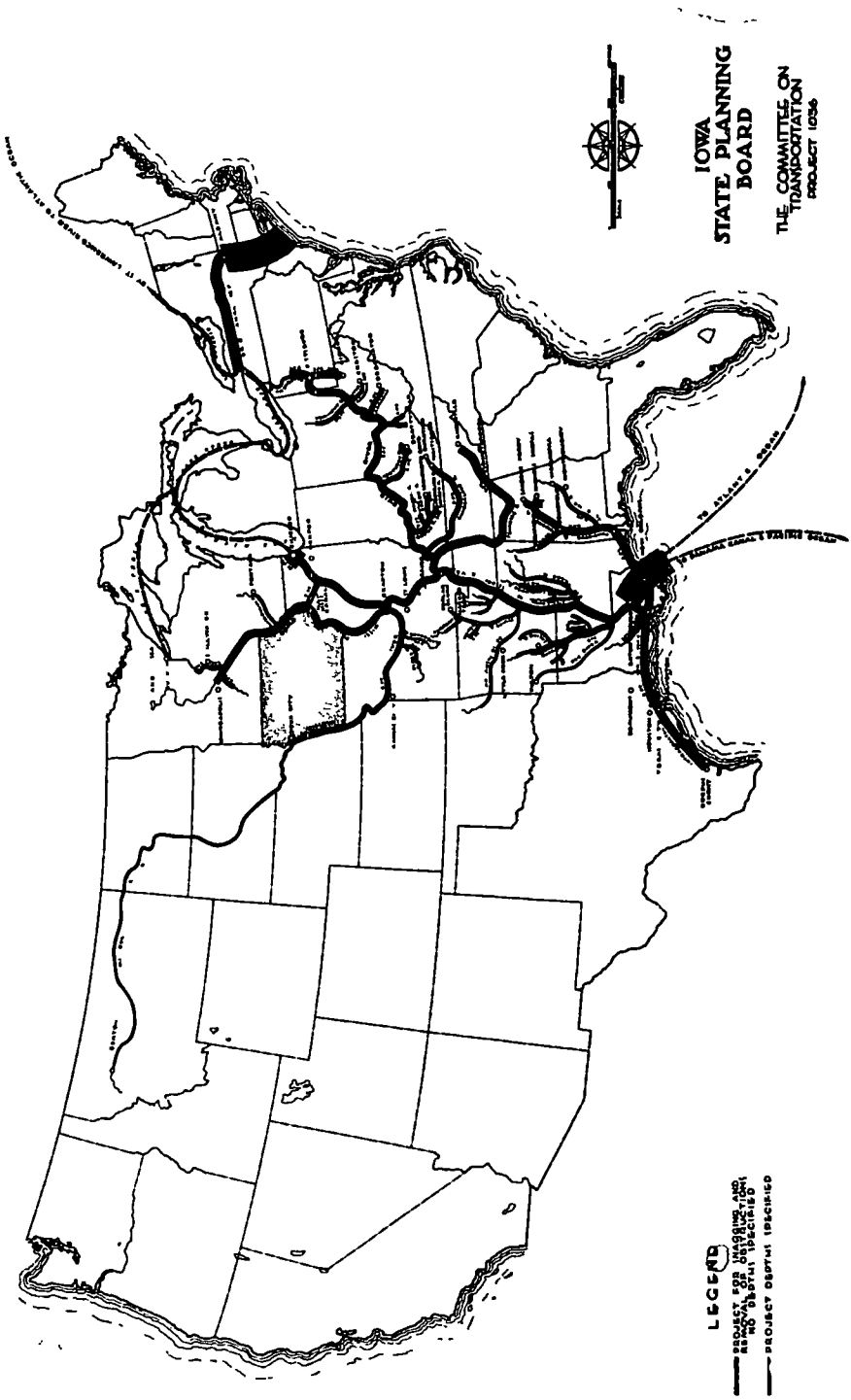

Figure 7. Inland Waterways System

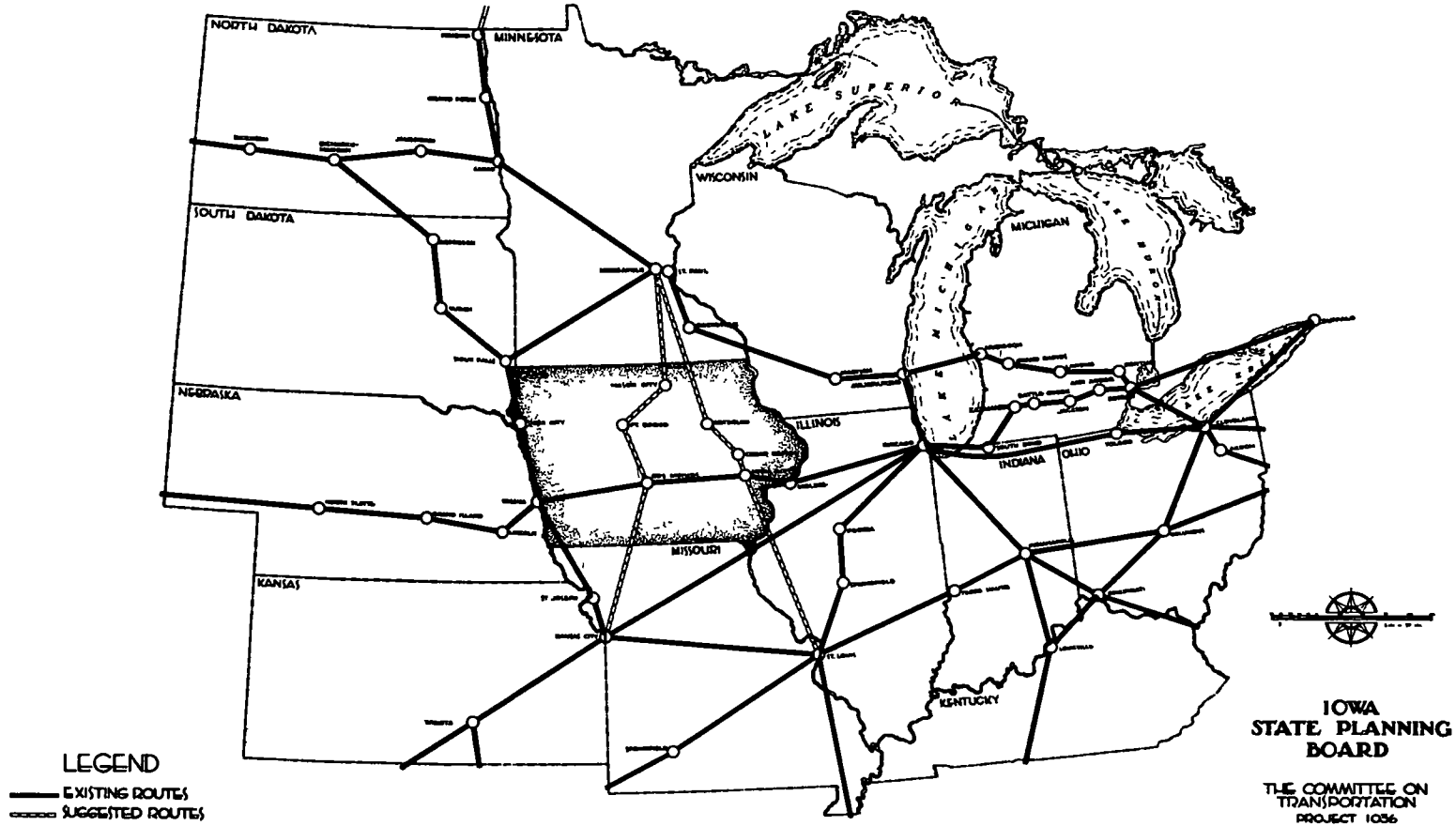

Figure 8 Midwestern Airways

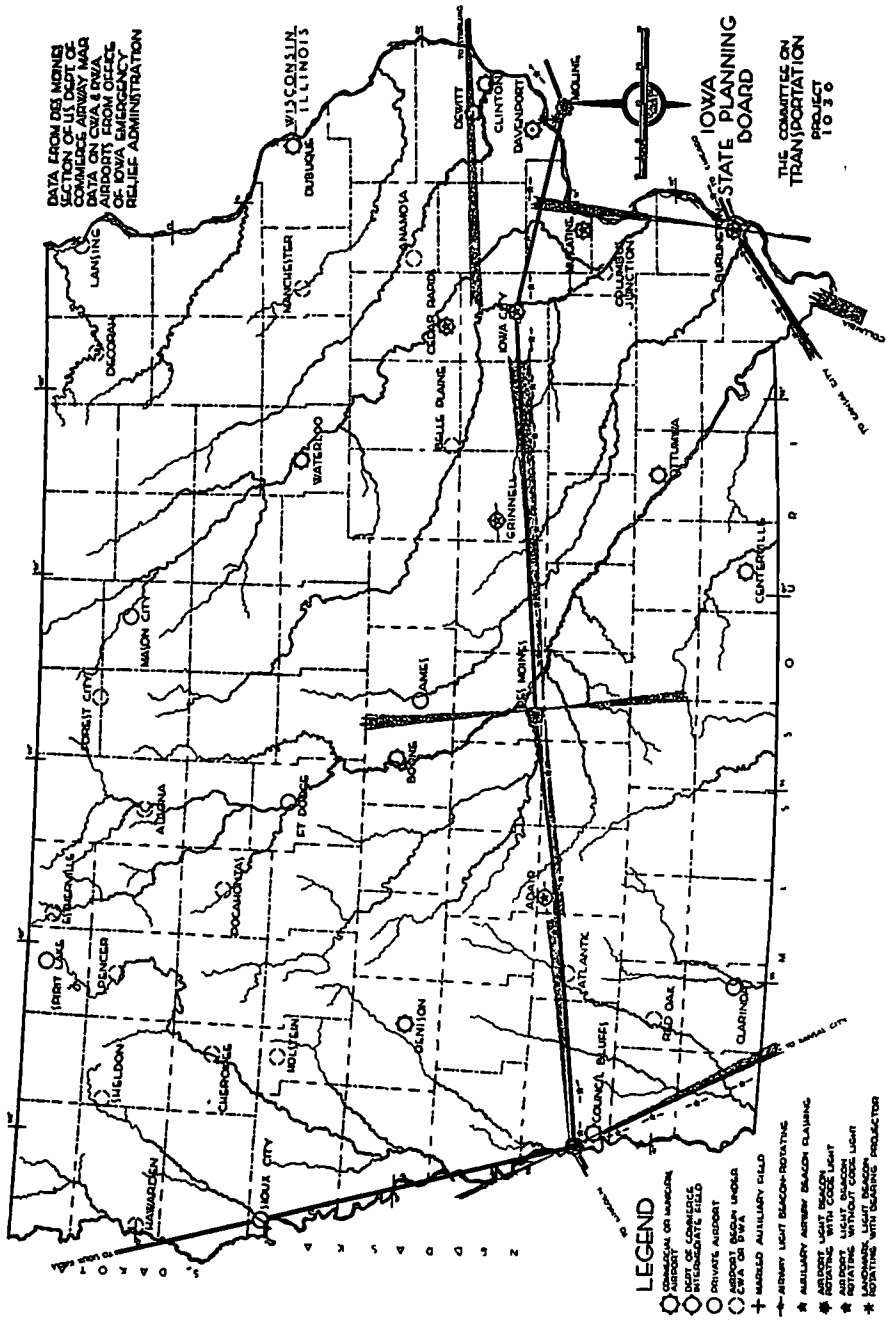

Figure 9 Iowa State Plan—Airways

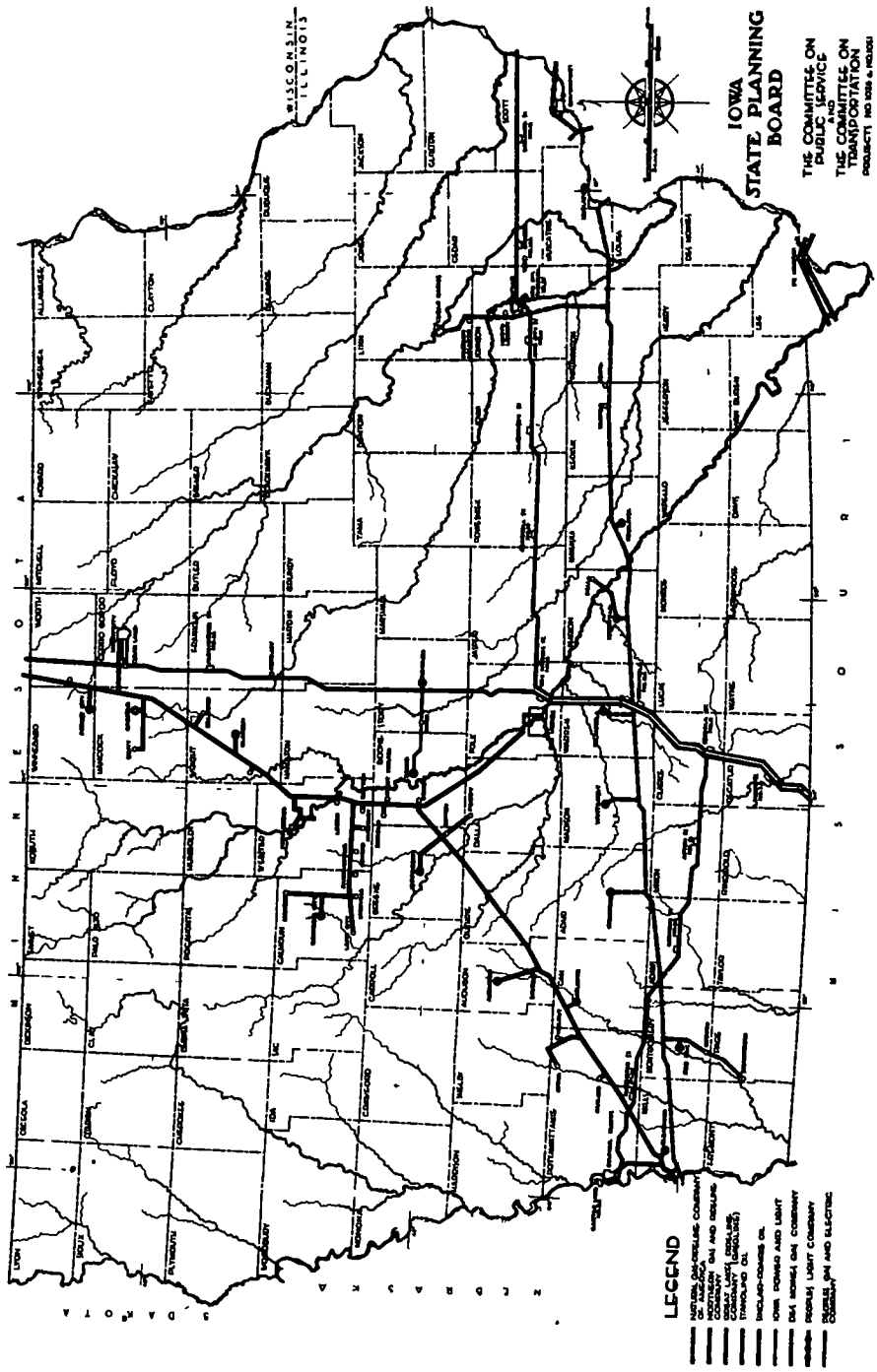

Figure 10 Iowa State Plan—Pipe Lines for Distribution of Gas and Gasoline

The component systems were built by fiercely competing companies, with the governing motive not of rendering the best service but of making the most money for their promoters The main lines were mostly planned as links in competing east and west through railways The branches were mainly built to get business away from competing railways North and south transportation needs were especially neglected They, and in many instances other transportation needs, were left to suffer all sorts of inconveniences and insufficiencies, at the same time, there was much waste of money in building unwise, inefficient duplications of railway lines.

Iowa's present improved and rapidly improving highway systems have been developed, during the last 22 years, to enable her constantly multiplying and improving motor vehicles to supply her transportation needs satisfactorily and efficiently, in all directions and in all localities The competition of their more satisfactory transportation service has caused the railways to lose much of their former business Much of the new service is so superior to anything the railways can offer that they cannot reasonably hope ever to get it away from the highways What is needed now is a general reorganization of the railways, eliminating unwise duplications, abandoning unprofitable lines, and providing quick, low cost, door to door freight and passenger service by an effective union of railway and highway transportation

New capital is needed to reconstruct the main lines for high speed service, and to provide new equipment and new transfer facilities As in former great transportation changes, much existing investment will doubtless have to be written off At present this process is progressing slowly and agonizingly. Wise cooperative national and state legislation and helpful guidance are desperately needed The railway problems are not capable of solution by any one state States, however, can cooperate in collecting the data needed for equitable solutions, and can help to formulate just and wise public policies

Iowa Railway Traffic Studies Figures 1, 2, 3, 4, show the results of railway traffic studies which have been made by Mr Neil Cook, of the Iowa Highway Commission staff, working under the direction of one of the writers The data were obtained through the kindness of the Iowa Railroad Commission and of the railways, the different systems complied promptly with the Railroad Commission's request for data of freight traffic during the years 1924 and 1934, respectively

These data have already been helpful in formulating the immediate railway grade crossing elimination program for Iowa At present, only a small fraction of these crossings can be eliminated with the funds available A detailed railway grade crossing survey is much needed, in order to formulate a comprehensive future elimination program Evidently all grade crossings should be eliminated on main lines operating trains at 60 to 100 miles per hour

COORDINATION RESEARCH STUDIES OF IOWA HIGHWAYS

The 102,533 miles of Iowa state primary roads, county trunk roads, and county local roads constitute a great public utility, comparable both in importance and in magnitude of investment to Iowa's railways The fact that the highways are owned and maintained (not operated) by 100 public corporations does not in any way change their public utility status

TABLE III

IOWA HIGHWAY EXPENDITURES, 1919–1934

County Roads	Construction	Maintenance	Total
All, 1919–1929			$206,441,734
Trunk, 1930–1934	$16,168,539	$15,081,016	31,249,555
Local, 1930–1934	19,721,502	36,463,665	56,185,167
Total, 1919–1934			$293,876,456
State Primary Roads			
1919–1929	$147,445,264	$28,763,178	$176,208,442
1930–1934	105,219,637	15,510,116	120,729,753
Total, 1919–1934	$252,664,901	$44,273,294	$296,938,195
All Iowa roads, 1919–1934			$590,814,651

TABLE IV

SUMMARY OF IOWA PRIMARY ROAD INCOME STATEMENTS, 1930–34

	1933	1932	1931	1930
Income				
Motor Vehicle License Fees	$9,597,521	$10,517,370	$11,369,275	$11,521,269
Gasoline Taxes	2,707,000	4,394,000	5,575,806	5,136,000
Hy Com Support Balance	88,780	73,212	73,631	94,851
Auto Dep Support Balance	40,327	88,499	247,627	208,779
Federal Aid	3,278,194	2,889,509	6,631,533	3,875,822
N R A	549,381			
Miscellaneous	6,174	3,275	9,397	77,659
Total Income	$16,267,377	$17,967,865	$23,907,269	$20,914,380
Expenditures				
Maintenance Expenses	2,668,974	3,021,681	3,361,929	3,311,620
Operation Return	$13,598,403	$14,946,184	$20,545,340	$17,602,760
Disposition of Operation Return				
Invested in Construction	6,894,962	10,930,710	13,745,992	15,726,385
Bond Redemp and Interest	6,496,822	6,149,736	5,345,856	3,788,755
Totals	$13,391,784	$17,080,446	$19,091,848	$19,515,140
Balances, Bonds, Etc	+206,619	−2,134,262	+1,453,492	−1,912,380
	$13,598,403	$14,946,184	$20,545,340	$17,602,760

They are "affected with a public interest" just as much as railways, water works, or power and light plants The ownership of any utility may be either public or private, the owners of any utility may let others operate it for just charges

At present, data are yet lacking by which to determine reliably the total pres-

ent investment in Iowa's existing highway property That such investment is very large is evident from Table III

Although county road expenditures prior to 1930 were not properly divided between construction and maintenance, a study of all the circumstances makes and new construction, there are no data by which its loss by depreciation can be estimated with any degree of reliability, there are no data by which either the total Iowa investment in highways prior to 1919 or its present value can even be guessed

TABLE V

SUMMARY OF IOWA COUNTY ROAD INCOME STATEMENTS, 1930–34

	1933	1932	1931	1930
Income				
Road Taxes	$8,986,996	$11,760,515	$15,705,816	$15,861,820
Special Assessments	92,465	147,890	121,864	193,509
Poll Taxes	141,040	285,821		429,630
Gasoline Taxes	3,607,134	3,663,282	4,505,081	4,059,140
Motor Carrier Tax	232,911	211,335	191,734	208,218
Primary Road Refunds	740,408	774,730	811,269	898,912
Miscellaneous	636,262	657,313	1,147,815	1,618,228
Total Income	$14,437,216	$17,500,886	$22,483,579	$23,269,457
Expenditures				
Maintenance Costs	7,747,577	11,163,793	11,637,049	12,539,354
Operation Return	$6,689,639	$6,337,093	$10,846,530	$10,730,103
Disposition of Operation Return				
Invested in Construction	4,147,540	7,239,496	8,599,675	8,820,380
Bond Redemp and Interest	181,587	169,518	201,107	86,067
Anticipation Certificates Redemption and Interest	176,083	207,076	278,832	244,028
Totals	$4,505,210	$7,616,090	$9,079,614	$9,150,475
Balances, Bonds, Etc	+2,184,429	−1,278,997	+1,766,916	+1,579,628
	$6,689,639	$6,337,093	$10,846,530	$10,730,103

it probable that 50 per cent of the $206,000,000 may have been spent for construction This and the data in Table III indicate that Iowa may have invested as much as $390,000,000 in her highway systems since the World War alone There are no adequate reliable data in existence, however, by which this great sum can be divided with any plausible accuracy between replacements

Tables IV and V show, in preliminary, sketchy form, some much abbreviated income statements of Iowa's great highway utilities

The people of Iowa own her highway utilities, they are just as much entitled to complete balance sheet and income statements every year of their highway values, incomes and expenditures as are private owners of public utilities (or private

properties), of any kind, to corresponding periodic statements

Governing Principles for Determining Equitable Highway Charges

The two governing general principles for determining the just charges which should be collected for the services of highways are the same as those which the courts have established to govern just rate schedules for other utilities

Principle 1 Highway charges should be allocated between individual users of similar and different highway services in proportion to the reasonable worths of the total services rendered each

Principle 2 The total amount of highway charges collected annually should equal, as nearly as may be· (1) The total annual maintenance costs, direct and overhead Plus (2) The total annual true "actual" depreciation costs Plus (3) A fair net return (interest, say 4 to 5 per cent) on the present value of the present actually existing highway property, "used and useful"

In Iowa, as in other states, the present highway charges have not been determined by these principles The present road property taxes, special assessments, poll taxes, motor-vehicle and other license fees, gasoline and other fuel taxes, oil taxes, ton-mile taxes, etc, have been established empirically, over a long period of years in accordance with the nation's ideas (not to say whims) of legislators, their advisors, and the public

Many of the fundamental data necessary for the determination of just highway charges are yet lacking Some of these are being determined for Iowa in the transportation coordination research studies now under way and planned

Researches on Data for Determining the Just Allocations of Highway Charges

Financial Survey The Iowa State Highway Commission is beginning a joint project, with the U S Bureau of Public Roads, for making an analysis of the total highway taxes and other charges paid by different classes of citizens and road users, in comparison with the corresponding services actually rendered This financial survey is along the lines already followed in similar projects in several other states

Highway Traffic Surveys Two Iowa highway traffic surveys have already been made, a third is just about to begin

(1) Master Traffic Survey This has already continued, at one counting station, 24 hours per day, for more than one entire year See the paper in this volume by Mark Morris, "Master Traffic Count on U S Highways 65, 69, Ames, Iowa, November 1, 1934 to October 31, 1935"

(2) State Wide Winter Primary Road Traffic Survey This was made between December 1, 1934, and April 4, 1935, 1500 different counting stations were occupied (See Figure 20, of Mr Morris' paper) Relief labor was used to a large extent The results have been reported briefly in the "Second Iowa State Planning Board Report—April, 1935" Mr Morris has prepared a comprehensive report for the Iowa State Highway Commission The winter primary road traffic flow map is shown herewith, as Figure 5

(3) Joint State Wide, Year Long, Iowa Highway Traffic Survey, (Iowa State Highway Commission—U S Bureau of

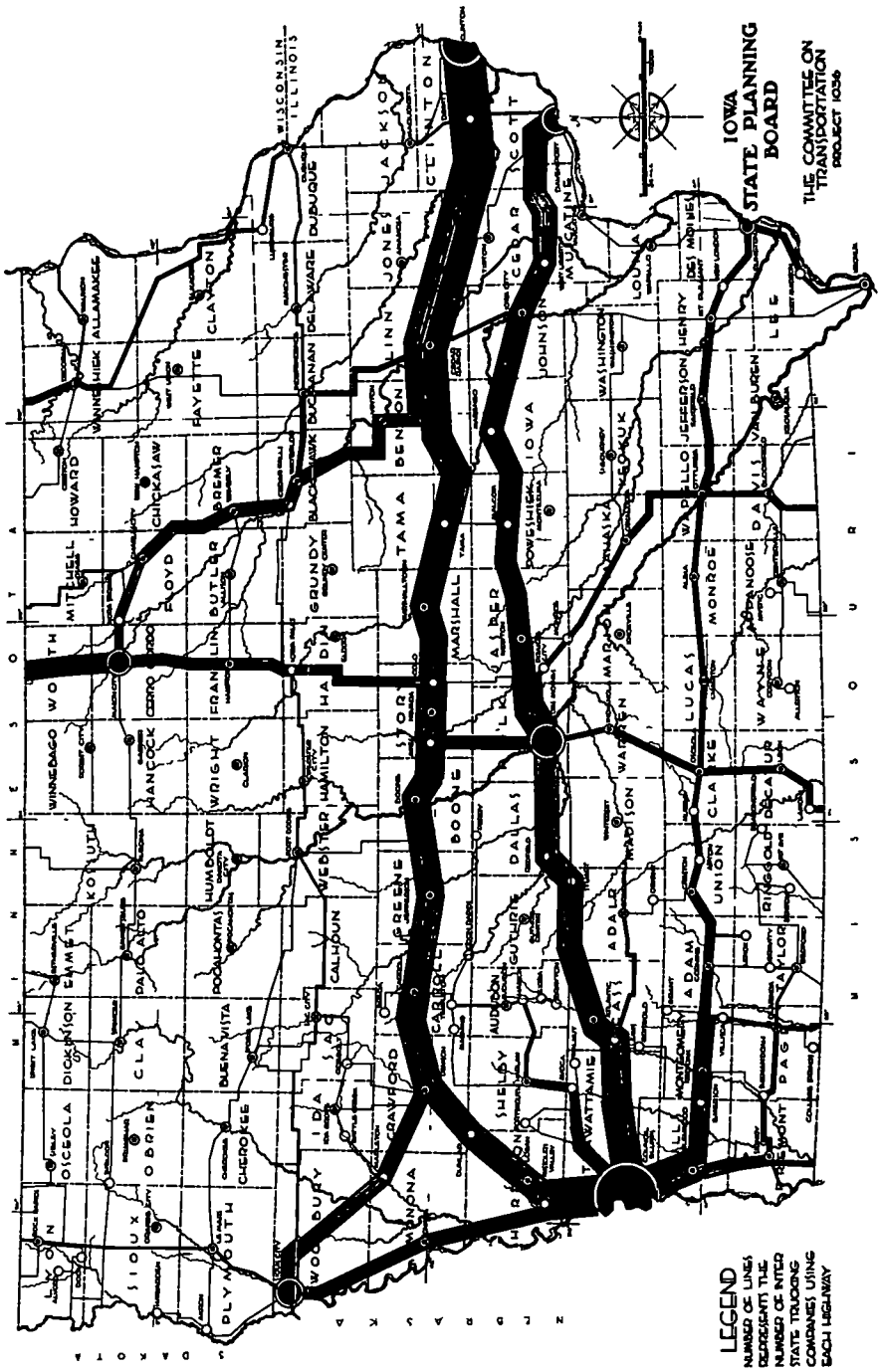

Figure 11 Concentration of Through Truck Traffic on Cross State Highways

Public Roads) This, which is just about to begin, is to occupy several times as many counting stations as the primary road winter traffic survey already made Besides all primary roads, it is to cover all county roads which are found to have more than a certain limited daily traffic It is to be continued for a full year

Research Studies of Iowa Truck and Bus Charges Preliminary studies of this subject were made last fall and winter (1934–1935) The ton-mile as the basis for proportioning motor-vehicle charges between different road users was investigated The primary road winter traffic survey showed that, although Iowa trucks constituted only 11 6 per cent of the total motor-vehicles registered, truck traffic constituted 49 1 per cent of the winter ton-mile traffic, the master traffic survey reported by Mr Morris in his paper December 5, 1935, indicates a reduction of the yearly percentage to about 43 3 per cent, for this 43 3 per cent of the ton-mile traffic, the trucks paid only 24 9 per cent of the total collections from motor-vehicles The average Iowa truck paid only 0 15¢ per ton-mile, although 0 243¢ was paid by the average Iowa passenger automobile Figure 11 gives some idea of the growing magnitude of interstate truck transportation across Iowa

The author is very strongly of the opinion that total charges for motor truck service should be based on the ton-mile unit and that the total charge should be higher per ton-mile for heavy trucks than for light, doubtless the total charges will continue to be divided between license fees, fuel taxes and ton-mile taxes

Professor Ralph Moyer presented December 4, 1935, a paper to the Department of Highway Transportation Economics, of the Highway Research Board, upon the subject, "The Ton-Mileage Basis for Allocating Motor-Vehicle Charges"

RESEARCHES ON DATA FOR DETERMINING THE TOTAL JUST ANNUAL HIGHWAY CHARGES

The data necessary to determine the total annual charges which justly should be collected for the services rendered by any particular highway system have not yet been assembled anywhere Our various states and counties have merely established by dictum such road taxes and fees of various kinds as their legislators upon advice, have believed were needed (and could be collected), (1) to pay annual maintenance and replacement costs, and (2) to pay for desirable additional new construction as rapidly as practicable Our road authorities as yet do not have even correct lists of the items of the highway properties they control, they have no reliable data by which to determine annual depreciation costs, they have no uniform system of accounts, in which the costs of their items of property can readily be found, or in which expenditures are properly divided between maintenance costs, replacement costs, extension and improvement costs

Appraisal Surveys The first thing necessary for determining the total just annual charges for the services rendered by any highway system is a correct, complete inventory of all items of property "used and useful" in rendering road services. It is impossible to prepare such inventories from existing highway book records, survey parties must be put to work in the field, to go over every part of the system, to measure and list all items of highway property As initial

work of this character in Iowa, it is desired to make such appraisal surveys of one or more cross state highways Provision for an appraisal survey of the Lincoln Highway, from Clinton to Council Bluffs, has been included in the highway project submitted by the Iowa State Planning Board to the WPA In making the inventory, the age, physical condition, past and probable future service conditions of each property item should be noted The costs of the various items should then be obtained from the book-records, supplying omissions by fair estimates

Studies of the Actual Service Lives of Highway Surfaces Even with a correct inventory of the highway property items, it is impossible to determine either their present values or their true "actual" annual depreciations without making reliable estimates of their probable service lives Heretofore, only opinion estimates of the average lives of different kinds of highway property have been available, such opinions, even from competent highway engineers, are found often to vary 100 per cent or even more

A study of the actual service lives of highway surfaces in every state (including some cities) is now actively under way in a joint research project of the U S Bureau of Public Roads and the Iowa Engineering Experiment Station [1]

A Study of the Probable Service Lives of Existing Highway Surfaces in Iowa Using the data collected by Mr Winfrey in and out of Iowa, one of the writers and Mr Mark Morris, both of the Iowa Highway Commission staff, are making personal examinations of all present existing Iowa primary road surfaces, we note their ages, present physical conditions, past and probable future service conditions From these data, using the proper type mortality curves in the manner described at the 1934 Highway Research Board annual meeting,[2] the present probable future service lives of the various existing highway surfaces are being estimated, these estimates are to be checked against independent estimates made under the direction of the Highway Commission's division engineers The final estimates are to be used in forecasting the approximate total annual future primary road replacement construction requirements year by year to 1950

Depreciation of Highway Property At present, it is impossible to make correct determinations of either the total accrued "actual" depreciations of highway properties or their true annual "actual" depreciations The fundamental data by which alone correct depreciation estimates can be made are yet lacking Moreover, very few engineers or accountants have studied or understand the correct principles on which depreciation estimates must be based Accountants, of course, have the further disqualification of not understanding the engineering features of the highly technical properties concerned Highway engineers, properly informed, must be given prominent parts in highway accountancy

It is very important that data shall be accumulated and correct methods be adopted whereby the true "actual" depreciations of highway properties can and shall be determined every year Such correct depreciations are essential.

(1) To determine the true annual depreciations of highway properties, these

[1] Preliminary Studies of The Actual Service Lives of Pavements, by Robley Winfrey, page 47 this volume

[2] Proceedings Fourteenth Annual Meeting, Highway Research Board, December 1934, p 49.

must be added to the true maintenance costs to get the true costs of rendering highway services

(2) To determine the true present values of highway properties, it is upon these present values that those to whom highway services are rendered should pay a fair rate of net return (interest)

(3) Without correct annual determinations of highway property depreciations by qualified highway engineers, correct highway accountancy is impossible

A Uniform System of Classification of Highway Accounts The writers have no criticisms to make of the correctness and completeness of present highway accounts in showing that all monies have been received and expended honestly and in strict compliance with law, but this is not enough At present it takes weeks of work with the original vouchers to ascertain the true original cost of a comparatively limited stretch of highway Accounting for highway expenditures by budget appropriations only, instead of by purposes as well, has led to reporting all annual maintenance department expenditures as annual maintenance costs, instead of dividing them properly between new construction, new equipment, replacements, and true annual maintenance Moreover, present highway accounts generally show no, or too often incorrect, allowances for depreciation costs

A uniform system of classification of accounts is needed, corresponding somewhat to that prescribed for railways by the Interstate Commerce Commission Provision for a research survey for the development of a uniform classification of highway accounts has been included in the highway project submitted by the Iowa State Planning Board to the WPA Any uniform system adopted must provide for distributing all items of receipts and expenditures into numbered accounts In a tentative way, the preliminary suggestion is made that these numbered accounts should be of such character that:

(1) All receipts shall be properly classified as to character and source

(2) All expenditures shall be properly classified as to construction, equipment, and maintenance

(3) All construction and equipment expenditures shall be properly classified as to replacements, extensions, and improvements

(4) All construction and equipment expenditure accounts shall be classified to show the costs of particular units (or age-groups of like units)

(5) All construction and equipment accounts shall provide for complete current determinations of, and accountancy for, all true "actual" depreciation losses of value

(6) Construction and equipment accounts should be of such character as readily to permit the ultimate development, and keeping up to date, of property ledger accounts which will constitute complete perpetual inventories

(7) All maintenance cost accounts shall be properly classified as to character and purposes, they shall take complete current account of all true "actual" depreciation costs

(8) Overhead-cost accounts shall be of such character as to permit correct allocation to construction, equipment, and maintenance

The actual work of developing a uniform system of classification of highway accounts will doubtless greatly extend and modify the above tentative suggestions

For some three years, with the cor-

dial and complete cooperation of several Commission officers and employees, the writers have been making a study of the maintenance equipment records of the Iowa State Highway Commission Professor Hempstead's account of the studies of the book-records of some 367 road maintainers is presented

THE ECONOMICS OF RETIREMENTS AND REPLACEMENTS OF PHYSICAL PROPERTY UNITS

During the past few years considerable effort has been expended in developing a "wise retirement principle" to use in helping to decide when to make retirements and replacements of physical property Methods for the solution of the problem include, (a) "Comparison of Unit Costs of Service," in which all unit operation costs including overhead, depreciation, and fair interest charge are determined for the present and the proposed unit, (b) the "Capitalized Savings Method," wherein the annual savings in operation of the proposed unit over the present unit are capitalized for the probable efficient life of the proposed unit, and the resulting estimate compared with the probable necessary investment in the proposed unit, (c) "The Economic Life Method," in which an estimate is made of the probable period necessary for the proposed unit to pay for itself out of the savings in operation cost, and others In all of these methods it is necessary to determine the unit costs of services by the old unit and by the new unit which may replace it

Reactions to each method have been more or less consistent, in that the dearth of actual examples of use has kept all such principles in the realm of mere theories In our work on this problem we are applying the various methods to actual examples of physical property units Through the kindness of the Iowa State Highway Commission we have been enabled to make use of its extensive maintenance equipment for this purpose

A Study for the Accountancy for 367 Actual Highway Road Maintainers

The Iowa Highway Commission possesses a considerable amount of equipment,[3] and in addition, fairly large numbers of the same kind of units, thus providing an admirable proving ground for the problem of demonstrating a "Wise Retirement Principle" The work of applying the "Comparison of Unit Costs of Service" to the Commission's road maintainers will be described herein [4] The Commission's records of these highway maintainers were fairly complete, the units were of a convenient value and were easy to inspect [5]

In order to ascertain the total unit cost of maintainer service each year, it was necessary to determine, first, the true yearly operation costs (exclusive of investment in the maintainers), second, the true "actual" yearly depreciation costs

The True Yearly Road Maintainer Operation Costs

As set up by the Commission, itemized costs of operation are fuel, oil, and grease, anti-freeze, cutting edges for grader

[3] The value of all maintenance equipment owned by the Commission on Jan 1, 1935 was approximately $3,200,000

[4] Mr Robley Winfrey has made many helpful suggestions in this work

[5] The average number of maintainers owned by the Commission during the past seven years has been 267 These are of similar type, having a light blade grader built around a tractor of 10 to 20 or 15 to 30 H P rating While the majority have been equipped with wheels, a few have used caterpillar treads The cost new of a machine ranges from $1400 to $4000, the average being $2685

blades, and repairs—both labor and parts The operators of the machines spend only a fraction of their time using road maintainers and their payrolls are not classified so as to show the amount spent on motor maintenance work However, the costs for their services would be approximately the same for the units retired and their replacements The repair costs charged during the early years of service have been, in many cases, much too high owing to erroneously charging additions and betterments as repairs instead of as additional investment Instances are, enclosed cabs which cost $125 on the average, electric lights averaging $30, larger tires costing $15 to $30 more per wheel, and scarifiers costing

TABLE VI

CALCULATION OF PRESENT VALUE AND THE ANNUAL DEPRECIATION OF STORY COUNTY MAINTAINER NO 32 BY THE COMMISSION'S DEPRECIATION RULE AND BY THE PRESENT WORTH METHOD

Year	Age and probable life	Additions	Value new		Estimates by Commission rule			Estimates by present worth method			
			Actual	I H C rule	Present value	Accrued depr	Annual depr	Condition %	Present value	Accrued depr	Annual depr
	0–10		$2783	$2783	$2783			100 00[3]	$2783		
28							$557[2]				$208
	1				2226	$557		91 67	2575	$208	
29							445				220
	2	380[1]			1781	1002		83 01	2355	428	
30			3163				356				322
	3				1425	1358		74 00	2413	750	
31							285				270
	4				1140	1643		64 63	2143	1020	
32							228				281
	5				912	1871		54 89	1862	1301	
33							182				292
	6				730	2053		44 75	1570	1593	
34							146				304
	7				584	2199		34 21	1266	1897	

[1] Additions to the unit made in 1929 include (a) Enclosed cab—$125, (b) Lighting system—$25, (c) Scarifier—$230

[2] Annual depreciation by Commission's rule = 20% of the value of the unit at the beginning of each year

[3] Condition per cents determined by the present worth method using a 4% interest rate

amount of maintainer service was recorded in miles, and a depreciation estimate was made each year for each maintainer

The most important of the recorded maintainer operation costs are repairs and fuel. Much trouble has been experienced in determining the true repair cost, as this cost has included in the past all ordinary maintenance, replacements, and betterments as well $200 Unfortunately, it is almost impossible to find any evidence in the records which will aid in segregating these additions to the value of the unit

Attention is directed to Tables VI and VII which show the differences between the Commission's estimates of operation costs in comparison with the true operating costs of a unit for which, with the aid of Commission employees, the costs

TABLE VII

COMPARISON OF THE ACTUAL UNIT COSTS OF SERVICE OF STORY COUNTY MAINTAINER NO 32 WITH THE UNIT COSTS AS CALCULATED BY THE COMMISSION'S RULE

Year	Operation Costs					Annual Depreciation		Total Annual Costs		Annual Surface Mileage	Unit Annual Costs	
	Fuel and Associated costs[1]	Repairs		Total								
		Actual	I H C Report	Actual	I H C Report	Actual	I H C Rule	Actual	I H C		Actual	I H C
28	$617	$514	$514	$1131	$1131	$208	$557	$1339	$1688	7542	$17 7	$22 4
29	574	207[2]	587	781	1161	220	445	1001	1606	5529	18 1	29 1
30	396	258	258	654	654	322	356	976	1010	4253	23 0	23 7
31	123	99	99	222	222	270	285	492	507	3142	15 7	16 1
32	215	108	108	323	323	281	228	604	551	3304	18 3	16 7
33	202	215	215	417	417	292	182	709	599	3016	23 5	19 9
34	328	106	106	424	424	304	146	728	570	3661	19 9	15 6

[1] Oil, grease and anti-freeze are included here with fuel costs, though each is separately reported by the Commission

[2] Additions amounting to $380 have been removed from the "Repair" item

Note Wages of operators omitted

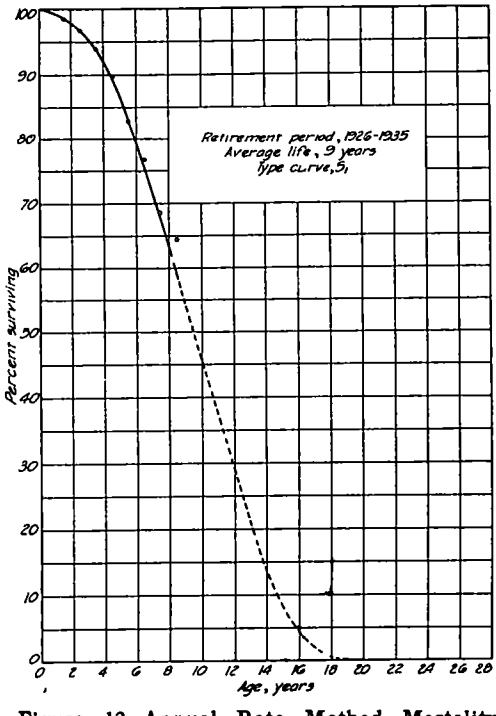

Figure 12 Annual Rate Method Mortality Curve of Road Maintainers

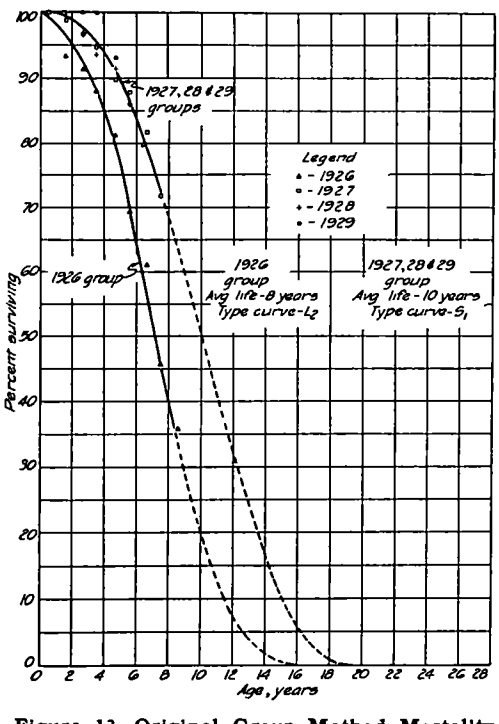

Figure 13. Original Group Method Mortality Curves of Road Maintainers

of additions and betterments have been charged properly to investment

The True "Actual" Annual Road Maintainer Depreciations

The Calculation of the Average Life and Selection of Type Mortality Curves

In order to determine the proper life basis for the estimation of depreciation, the average life of all the various age groups of maintainers was computed This was done by the annual rate method[6] and found to be 9 years Comparison with type curves developed by the Iowa State College Engineering Experiment Station[6] showed it to be of S_1 type, as shown in Figure 12 The retirement data for Figure 12 are of course only partially complete, but there is enough of the curve to definitely indicate the trend

Additional survivor curves[7] for each age group in which any retirements have been noted, are shown in Figure 13 The average life for all age groups is 10 years, except for the 1926 group which is 8 years The type curves are S_1 and L_2, respectively

These estimates of average life were used as the starting point for the forecast of the probable life of each unit, this gives a correct basis for the calculation of the true actual depreciation of each maintainer

[6] For discussion of method see Marston & Agg, "Engineering Valuation," Chapter III Also, "A Mortality Curve Study of the Actual Service Lives of Brick-on-Concrete Pavements, Des Moines, Iowa, 1909–1928," by Anson Marston, Proceedings Highway Research Board, Vol 14, page 49

[7] Reference to this method is made in "Engineering Valuation," Chapter III, and in a report on "Preliminary Studies of the Actual Service Lives of Pavements" presented by Robley Winfrey, page 47, this volume.

Analysis of Correct Road Maintainer Annual Depreciation Costs

Since 1933, the Commission estimates of depreciation have been made by a theoretical method, wherein 20 per cent of the value of the maintainer at the beginning of each year is charged as depreciation This naturally causes the depreciation charge to be a maximum during the first year of service in the unit, and to become nominal after approximately the average life of the unit is reached The average first year depreciation, thus charged by the Commission to the machine investigated, was $648, which is much higher than the true "actual" annual depreciation, on the other hand, the corresponding depreciation to charge in the years just preceding retirement would be merely nominal The true "actual" annual depreciation is much greater when the unit is old than when it is new

Before 1933, the depreciation charges were made by "intuitive dictum," by which an inspection of each unit was used as the basis for the depreciation This method, while not giving correct results because of the personal optimism or pessimism of the hundreds of inspectors throughout the state, was at least based on fact, and not theory The former method, though easy of application, gives results often far from accordance with the actual facts as shown by inspection It is the judgment of the authors that the use of correct depreciation principles, together with an estimate of the true probable life as shown by an inspection of the unit, are absolutely essential for true estimates of depreciation

The computations of depreciation should be properly made by use of the "Present Worth Method"[8] wherein the

[8] For discussion of method see Marston & Agg, "Engineering Valuation," Chapter V

depreciated value of the unit at any date is determined as the present worth of the probable future operation returns[9] yet to be earned by the unit Using an interest rate of 4 per cent approximately the long time average rate for funds loaned the Commission, the true estimates of depreciation can be found.

Comparison of the depreciation estimate, as shown in Figures 14 and 15 indicates the wide variation between the Commission's estimates and the true depreciations The Commission's estimates would make the unit costs of maintainer service appear to be excessively high while the maintainer is comparatively new and efficient, and excessively low when the maintainer is old, decrepit, and inefficient, manifestly, this is exactly contrary to the facts

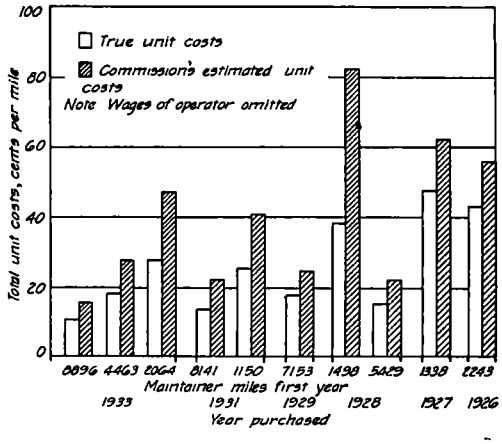

Figure 14. Comparison of True First Year Road Maintainer Unit Costs with Commission's Estimates for 10 Maintainers installed from 1926–1933

Figure 14 shows a comparison of the true maintainer mile unit costs (operator's wages omitted) during the first year of operation of each of 10 selected maintainers put into use 1926–1933, with the Commission's estimate The latter were much too high, toward the end of the service lives of these same units the Commission's estimates would be much lower than the true unit costs The Commission's estimated costs would indicate that it almost never could afford to buy a new maintainer to replace an old, decrepit machine

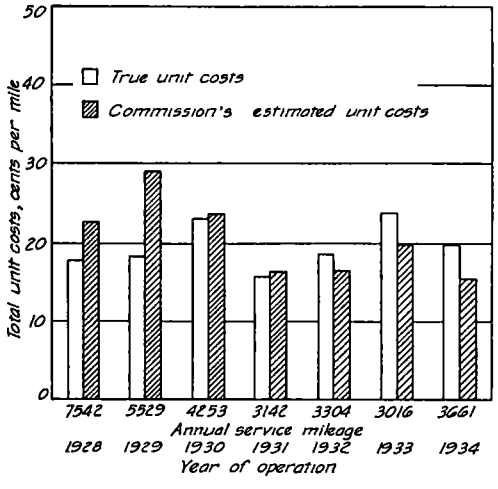

Figure 15 Comparison of the Actual Unit Costs of Service of Story County Maintainer No. 32 with the Unit Costs as Calculated by the Commission's Rule.

Figure 15 and Tables VI and VII show the effects of the Commission's rule This maintainer, purchased in 1928, was placed in severe service on the Lincoln Highway In 1929 new equipment amounting to $380 was added to the unit, but the Commission showed it as a repair cost This accounts for approximately half of the wide discrepancy between the Commission's estimate and the true cost for 1929, the remainder being the difference in depreciation The apparent decrease, as the unit becomes older, in the unit operation costs as cal-

[9] To take care of a probable lack in uniformity a probable future operation return ratio is introduced whenever necessary

culated by the Commission's rule is clearly shown.

It is, therefore, evident that a standard uniform system of classification of maintenance costs is needed, in which investments in maintenance equipment shall be reported as investment instead of annual maintenance operation cost

PRELIMINARY STUDIES OF THE ACTUAL SERVICE LIVES OF PAVEMENTS

By Robley Winfrey

Engineering Experiment Station, Iowa State College and U S Bureau of Public Roads

SYNOPSIS

This paper reports the actual service lives realized from pavements in the cities of Buffalo, New York, and Des Moines in Wayne County, Michigan, and in the State highway systems of Massachusetts and Rhode Island The determinations of average lives were made by statistical methods applied to the records of construction and retirement of pavement for different years The statistical methods are briefly explained and some discussion is given of the forces that cause retirement No conclusions are reached as to general probable average lives for various pavement types as these limited studies do not warrant them, but additional studies now in progress should afford a proper basis for conclusions Mention is made of the need of reliable salvage values and maintenance costs as important factors in the total annual cost of a given pavement type

To remove from the realm of speculation the important item in highway transportation economics of the average life of pavements, the Engineering Experiment Station of Iowa State College and the U S Bureau of Public Roads, last January began a study of the years of service actually being realized from pavements A study of five road systems—city of Buffalo, city of New York, city of Des Moines, Wagne County, Michigan, State highways in Massachusetts, and the State highways in Rhode Island—has been completed Studies are in progress in Connecticut, New Hampshire, Vermont, and Michigan, while plans are being formulated to conduct the study in many additional states during the coming year.

To those interested in the development and maintenance of excellent and economical highway systems, the importance of correct average lives of the several types of roadway surfaces need not be stated It is only with correct average lives that the time of needed future reconstruction can be forecast, that the actual cost of highway transportation can be calculated, and that the true annual cost of various road surfaces can be determined

The average lives of pavements can be determined only by study of the actual lives realized from particular sections, which lives are definitely fixed when the surfaces are reconstructed or abandoned From an analysis of these actual lives and the total pavement exposed to retirement over the same period, it is possible by statistical treatment, to calculate a general average life for the type of pavement under consideration While this average life is determined from past retirements, it will reflect the correct