# MANUAL

FOR

# IOWA HIGHWAY OFFICERS

BY THE

# IOWA HIGHWAY COMMISSION

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# A General Survey of the Public Highways of Iowa

The highways of a country are one of the surest guides to the degree of the advancement and the development of the economic and social life of a people. They have been called the veins of a nation through which surge the rich corpuscles of agricultural and commercial productions into all of its parts, nourishing and quickening them into life and activity. Early in our history the United States built the famous Cumberland Road and planned a great network of such highways that would extend into and through all the states.

Then the railroads became of more importance and attracted the attention which had been centered upon the public roads. Mile after mile the steel tracks were pushed westward, close after the prairie schooners of the tireless emigrants. So rapid was their advance and so quickly did they reach the furthermost parts of the nation that the people were misled into the belief that transportation problems had been solved for all time. Large grants of public lands and many concessions were made to different corporations until the railroads acquired proportions and interests far greater than those of any other industry.

The period of pioneer railroad building is now well advanced. The energy formerly devoted to this cause is being turned to what may be called road perfecting, and large sums of money are being spent yearly in this work. Grades are being reduced, curves eased or taken out altogether, and many miles of excellent double track are being laid. The interurban and suburban lines of electric and steam railways also are forming a vast network connecting the business centers with the surrounding towns. This bewildering activity in the interests of improved transportation has attracted the attention of the people from the importance of the public highways in problems of transportation and their vital influence of such.

The old spirit that characterized the building of the first great national road has only recently been awakened by those

who realize that in the full development of a country the public roads are primary. Railroads at best are unwieldy and costly and the degree to which they are able to serve the best interests of a country through which they run is determined directly by the public highways. At the inception of road building in the United States the leading men of the day championed the movement, and now the foremost men in every state have not only given its revival their approval, but have aided its advancement in every possible manner. President Roosevelt has pronounced road improvement as a mark of those "solid, stable qualities which tell for permanent greatness" in a nation. The movement for improved highways has passed far beyond the stage when it was seized upon by reformers and those whose own interests demanded them and now claims as its friends the best and most conservative business men of every community.

Railroad officials instead of opposing its advance on the theory that it will result in less traffic by rail, realize that improved public roads mean an increased amount of shipping both to and from the farms, so distributed that a continuity of operation hitherto unknown will be possible. In fact much of the increased popularity of the idea with all classes is due to personal faith in the judgment and business discretion of leaders in it. These facts were well illustrated during the past month when one of the leading western railroads sent out a special car carrying men to instruct the farmers and others interested in cheap and effective methods of road maintenance.

## SECTION I.

## GENERAL DATA RELATING TO PUBLIC ROADS.

1. *Mileage and Classification.* In the state there are approximately 100,000 miles of public roads, averaging something over 1000 miles per county. Of this number perhaps twenty-five per cent should be classed as main traveled roads. This would place no man over two miles from a main road running in each direction, and the great majority of the population, would be within a mile or less of a main traveled road. In starting a system of improved roads for a county it is very important that a map should be made, classifying roads into (a) main traveled roads, and (b) second class roads. This classification is, at this stage of development, sufficient. In some other states and in France and such nations as have perfected their systems of highway construction and maintenance, the classifications of the roads is very distinct and much more complete but in this state such detailed classification is not necessary at this time.

The main traveled roads consist of those radiating in at least four directions from the trade centers and also well traveled roads connecting these. In most parts of the state this system is well developed and definite. Along these roads, or within easy access to them, lives by far the larger part of the population in the district. The explanation for this is not difficult. In many cases the roads were laid out first and the incoming settlers built their homes near them. The old state and territorial roads are, for this reason, still the principal highways wherever they have been laid out. Economy of administration does not enter into the question of choosing a site for the house on the farm as does the desirability of placing it near the road which is most traveled. The reasons for this are apparent and need not be considered, but the situation produced is important since by improving a small percentage of the entire mileage of the county a large percentage of the entire population will be located directly along one of these improved roads.

The second class roads will be the cross roads and those in the thinly populated sections which serve only a small

number of people. These should be kept passable but the bulk of the road funds should be concentrated upon the other class until the system is perfected.

2. *Annual Expenditure.* The importance of the proper expenditure of the road funds (including bridge funds) is apparent when the taxes for one year are considered. For 1904 the taxes levied were as follows, (in addition to poll taxes):

| | |
|---|---|
| County bridge tax, | $1,628,719.89 |
| County road tax, | 544,184.45 |
| Township road tax, | 2,283,129.64 |
| Total, | $4,456,033.98 |

The actual amounts for one year are very large and the loss to the state by poor administration of these funds is a heavy drain. Cumulative effects are a serious economic problem. In a county with a taxable valuation of $6,000,000, with maximum levies in each of its road taxes, the total amount would be approximately $50,000. In addition to this sum, some counties spend the mulct tax on the roads and this may amount to some $15,000 in an average county. From a business standpoint no community, township, or county, can slight the proper administration of these taxes and not misuse a considerable sum of money.

3. *The Road Census.* With the possible exception of Illinois, we have the most products to haul over the roads and the worst roads over which to haul them. Not that they are in a bad condition all the time or even most of the time, neither is the most of the hauling done over them when they are in their worst condition, but they are unreliable always.

The justification for the expenditure of public money in the improvement of the highways must be found in the traffic itself. Not only the present amount of travel on the road but also the amount it would be increased, by improved conditions, should be taken into account. The importance of accurate and reliable information in this connection can be readily understood and the almost entire lack of such data is a severe detriment to the cause. The especial need of such data in Iowa and the necessity of placing road improvement here on a broad, firm basis, controlled by business discretion and managed by business methods are readily apparent when the extent of the interests affected are considered.

According to the 1900 census, fifty-six and one-half per

cent of the total population of Iowa was engaged in agricultural pursuits. Her farms were valued at over $1,834,000,000 and in the value of all farm products, she ranked first. Practically all of these products which went to market had to be either hauled or driven there over roads. Then, too, it may be said that very many of the other important industries of the state are dependent upon agriculture in a large measure to supply the means for their maintenance, and, because of this, their activity is considerably governed by the state of the roads.

If, as is stated here, the highways of the state are related to these different interests, in will be shown by the amount and kind of traffic over them. To get the correct amount of this traffic for Iowa, the Highway Commission has succeeded in having inserted in the 1905 census an AGRICULTURAL ROAD SCHEDULE, which will be the first attempt ever made by any state to obtain such accurate detailed information in regard to its public highways. The list of questions is as follows:

County, .....
Town or township, .....
Name, .....
P. O. Address, .....
No. acres in farm, .....
In what section located, .....
Average distance to market, .....miles.
Number bu. hauled to market per year .....corn
.....oats, .....wheat
.....barley, .....other grains,
.....grass and other seeds, .....potatoes and
.....fruit of all kinds, other vegetables,
No. tons hay and other forage, .....
No. loads fuel to market, .....
No. pounds live stock, ....., No. loads other produce.....
No. trips to market per week without considerable load.....
for.....days each year.
Distance to creamery, .....miles
No. loads fuel, building material, etc., hauled from market per year, .....
Average size of full loads hauled, .....pounds.
Average time required for round trip, when hauling full loads, ..... hours.

Average time required per acre hauling ..... .....
Average wages for a man, team and wagon per day..... ....
..... ..... .....

Railroads, streams and deposits of road material are being located on the plat of each township.

4. *Preliminary Results of Road Census.* The work of compiling the results from the census cards has not progressed far enough to give out many results. Table No. (1) has been incorporated to give some idea of the amount of traffic over the country roads. The totals given are those for only one township in each county. Some idea of the

TABLE NO. 1

PRELIMINARY RESULTS AGRICULTURAL ROAD SCHEDULE

| COUNTY | TOWNSHIP | Acres Reported | Total Light Travel—Miles | Total Heavy Hauling—Ton—Miles | Average Size of Loads—Pounds | Average Distance to Market—Miles | Time Required Per Ton—Mile—Minutes | Time Required Per Acre—Minutes |
|---|---|---|---|---|---|---|---|---|
| Adair | Grove | 21,481 | 216,200 | 23,936 | 1,875 | 6.11 | 78.00 | 75.00 |
| Adams | Douglas | 20,813 | 264,212 | 40,116 | 2,0 0 | 7.65 | 57.00 | 81.00 |
| Allamakee | Center | 20,398 | 142,662 | 14,159 | 1,677 | 8.33 | 52.00 | 36.00 |
| Audubon | Hardin | 21,358 | 206,908 | 18,246 | 1,740 | 3.40 | 77.80 | 66.49 |
| Benton | Leroy | 25,578 | 157,664 | 23 431 | 2,018 | 2.50 | 58.00 | 53.00 |
| Black Hawk | Mt. Vernon | 20,536 | 226,565 | 36,474 | 2,116 | 5.03 | 41.17 | 73.11 |
| Boone | Colfax | 19,073 | 127,712 | 13,340 | 2,246 | 2.63 | 85.31 | 59.22 |
| Bremer | Polk | 20,310 | 304,356 | 26,211 | 1,940 | 4.05 | 60.00 | 75.00 |
| Butler | Bennezetta | 21,118 | 168,090 | 26,158 | 2,060 | 4.86 | 53.22 | 65.92 |
| Buena Vista | Fairfield | 16,639 | 123,084 | 10,220 | 1,990 | 3.20 | 66.00 | 40.00 |
| Buchanan | Buffalo | 17,734 | 130,988 | 13,368 | 1,531 | 4.11 | 84.00 | 63.00 |
| Calhoun | Lake Creek | 21,597 | 140,036 | 27,550 | 2,074 | 3.82 | 64.49 | 82.00 |
| Carroll | Wheatland | 21,284 | 165,542 | 21,338 | 2,066 | 3.90 | 52.00 | 52.00 |
| Cass | Brighton | 19,666 | 127,894 | 21,732 | 1,885 | 3.59 | 66.76 | 71.00 |
| Cedar | Springdale | 20,860 | 253,926 | 17,975 | 2,001 | 2.10 | 60.14 | 51.00 |
| Cerro Gordo | Owen | 22,831 | 133,959 | 26,342 | 2,443 | 4.19 | 54.20 | 62.27 |
| Cherokee | Afton | 23,070 | 131,976 | 34,901 | 2,000 | 6.20 | 38.00 | 57.00 |
| Chickasaw | Dresden | 19,660 | 183,140 | 18,342 | 1,820 | 3.69 | 68.58 | 63.98 |
| Clarke | Knox | 20,610 | 145,300 | 11,441 | 2,161 | 3.85 | 72.88 | 40.40 |
| Clay | Clay | 21,757 | 173,446 | 16,425 | 2,400 | 4.30 | 40.00 | 30.00 |
| Clayton | Cass | 18,750 | 118,020 | 13,080 | 1,560 | 3.34 | 89.84 | 72.43 |
| Clinton | Center | 24,571 | 211,208 | 23,709 | 1,957 | 5.70 | 64.00 | 62.00 |
| Crawford | Hanover | 21,070 | 136,874 | 21,791 | 1,842 | 5.10 | 53.00 | 55.00 |
| Dallas | Wafhington | 18,004 | 141,219 | 28,556 | 2,245 | 5.90 | 63.00 | 97.90 |
| Davis | Lick Creek | 19,960 | 163,234 | 17,380 | 1,909 | 4.86 | 69.21 | 60.56 |
| Decatur | Burrell | 17,112 | 129,190 | 8,625 | 1,645 | 3.83 | 89.93 | 45.33 |
| Delaware | Milo | 18,558 | 153,348 | 20,109 | 1,848 | 4.03 | 66.11 | 71.63 |
| Plymouth | Plymouth | 22,668 | 146,604 | 30,524 | 2,333 | 3.10 | 42 40 | 56.44 |
| Sac | Clinton | 19,946 | 152,248 | 29,860 | 1,985 | 5.23 | 61.00 | 91.00 |
| | Averages | 20,600 | 178,331 | 21,904 | 1,977 | 4.40 | 63.00 | 62.40 |

great importance of the public roads can be obtained from these preliminary data. The complete results of the road census will be worked up and published in the report of the Commission.

5. *The Relation of Prices for Agricultural Products to the Condition of the Highways.* In the marketing of a considerable amount of the farm produce, it is almost invariably the rule that full loads are hauled, although the number of pounds which constitute such a load is entirely dependent upon the conditions of the roads. Although this hauling is fairly well distributed throughout the year, the largest proportion is done during the months that the roads are the most unrelia-

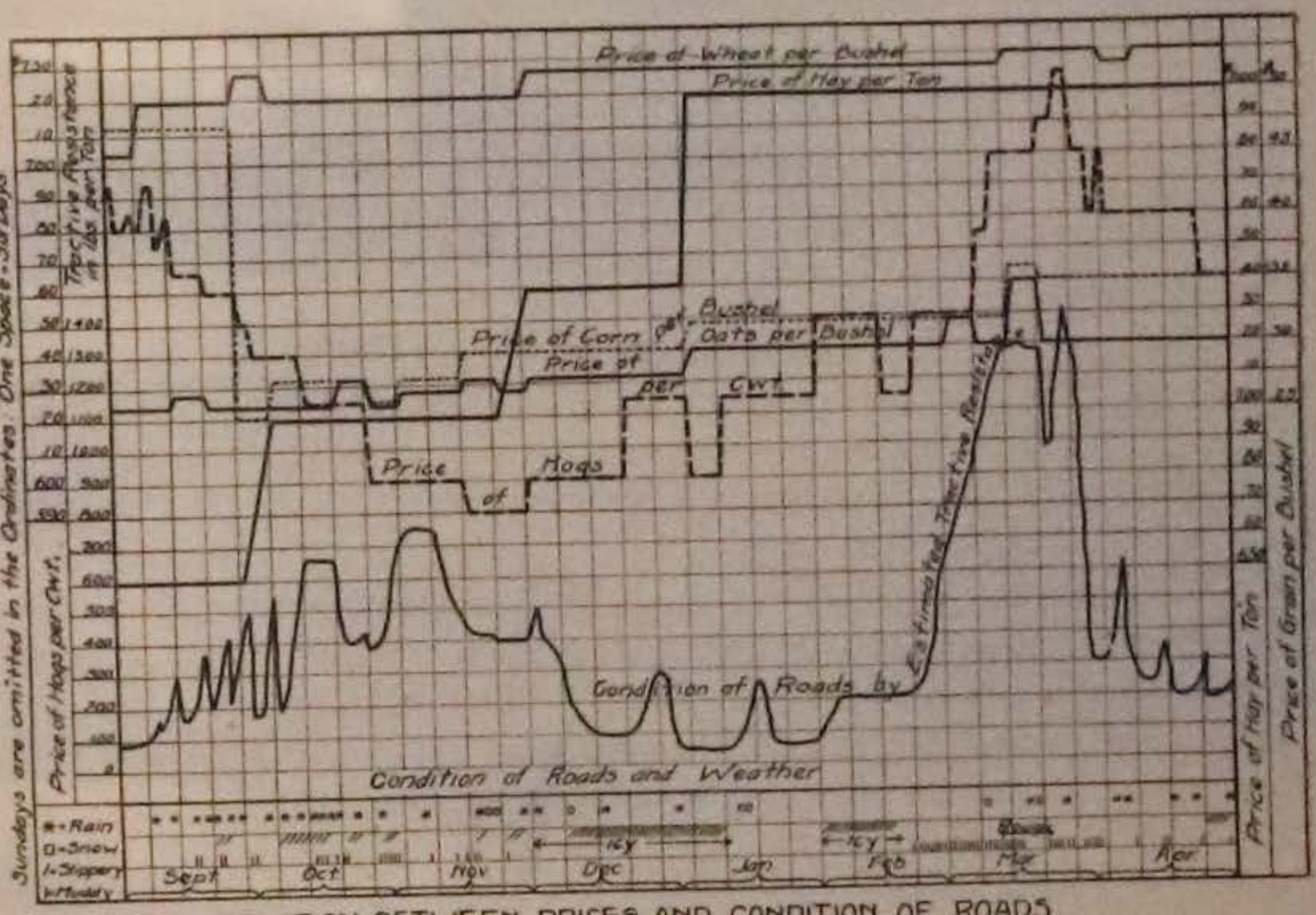



FIG 1. RELATION BETWEEN PRICES AND CONDITION OF ROADS
WOODBURY COUNTY 1902-3

ble. It is also during this time that the maximum prices are usually reached. Market quotations are frequently so favorable when the roads are impassable that it is a positive financial loss to farmers who are not able to deliver their crops to market. If there is any relation between these prices for these products and tne condition of the road it is very desirable that this fact be thoroughly understood. The accompanying diagram (Fig. 1) has been prepared from records

kept for the Civil Engineering Department at a point in Woodbury County during the winter of 1902-3.*

In this diagram the tractive resistance was estimated from the reported condition of the roads and based on traction tests which are being conducted at the same time. The highest price for oats, corn and hogs occurred at the time that the roads were in a practically impassable condition. This brings out very graphically that a certain relation does exist between prices of such products and the condition of the roads. More complete records are now being kept in six representative counties of the State which will give a much better insight into this relation.

*Thesis work of Messrs. A. B. Chattin and E. McClure.

## SECTION II.

## TOPOGRAPHY OF IOWA.

Iowa is one of the great prairie states of the middle west. It has a total area of 55,475 square miles or 35,504,000 acres. This area lies between the Mississippi River on the east and the Missouri River on the west.

1. GENERAL TOPOGRAPHY. The physical features are not pronounced. The total difference of elevation existing in the state between the river at Keokuk and Sibley, which is considered the highest town in the state, is approximately 1,200 feet. The direct fall to the river at Keokuk is 100 feet so there is only about 1,100 feet difference in the level over the remainder of the state. With the exceptions of the bluff-bordered valleys of the two boundary rivers, the appearance of the state is that of a flat plain. The Mississippi flows through a bed whose flood plain varies from 140 feet below the upland at Keokuk to about 700 below the upland at the northwestern corner of the state. The Missouri River bluffs are largely built up of wind-blown soil and the flood plain is very wide.

The drainage systems of the state, belong to these two rivers, and the watershed of the two districts runs in a more or less well defined course from Dickinson County southward to Wayne County so that more than two-thirds of the total area of the state belongs to the Mississippi system.

2. *Drift Sheets.* The surface features of Iowa are essentially drift formations. There have been in the state no less than five distinct invasions of the ice sheets. In point of time these are the pre-Kansan, the Kansan, the Illinoian, the Iowan and the Wisconsin. Of these only three are of considerable importance, viz., the Kansan, the Iowan and the Wisconsin. These glacial sheets took their names from the states in which they were particularly prominent. The only part of the state not covered by one of the drift sheets is a small portion of the northeastern corner, including Allamakee and parts of Fayette, Clayton, Dubuque and Jackson Counties.

These glaciers, or drift sheets, coming one after the other

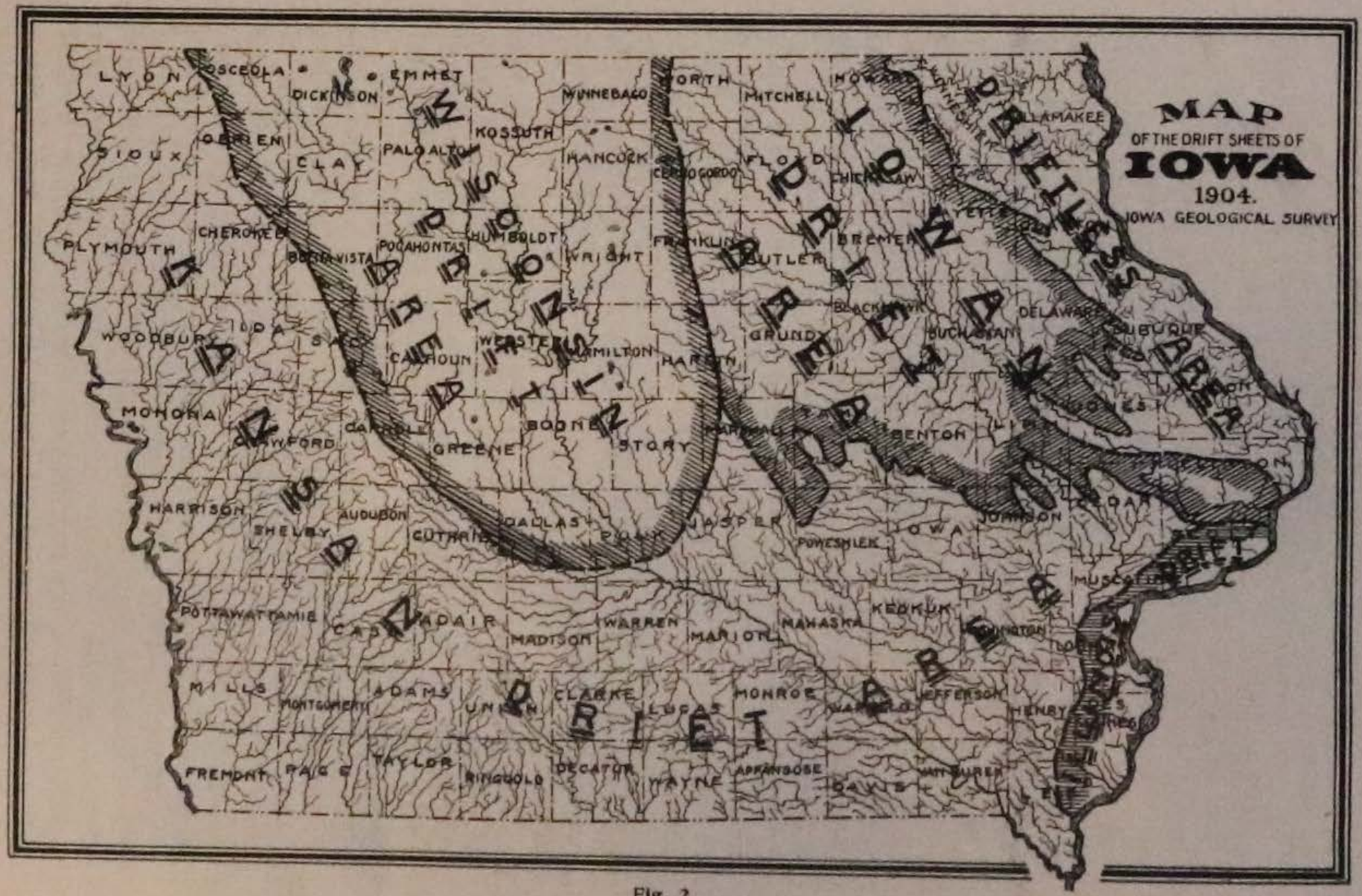

MAP
OF THE DRIFT SHEETS OF
IOWA
1904.
IOWA GEOLOGICAL SURVEY
LYON
OSCEOLA
DICKINSON
EMMET
KOSSUTH
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
O'BRIEN
SIOUX
CLAY
PALO ALTO
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
BLACKHAWK
BUCHANAN
DELAWARE
DUBUQUE
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
BENTON
LINN
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
CEDAR
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
LOUISA
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN

Fig. 2

during each glacial period, reduced the surface of the state to a great plain and deposited over this area a thick covering of the drift or soil carried by them. Figure (2) is a map showing the different drift areas of Iowa,. The differences in the topography of these areas is due almost entirely to the differences in time since they were last covered by one of these ice sheets.

(a) *The Kansan Drift.* The Kansan ice sheet covered practically the whole of Iowa and extended into Nebraska and Kansas, and the drift carried by it covers more than one-half of the state, as seen in the map. This drift sheet is the oldest of those that will be considered in this connection and the drainage system has become so perfected that there is no undrained land in this area except along the flat flood plains of the rivers. The whole surface has been cut into a series of rounded ridges and deep U-shaped valleys. The glacial debris is very thick, averaging nearly 100 feet for the entire state. The upper surface has been completely oxidized or broken up by the action of water and other atmospheric agencies until even the granite boulders that are left crumble easily between the fingers. Many of the hills are covered by a thick layer of loess believed to have been deposited here by the winds. (See Figure No. 3). The soil is the so-called "typical boulder clay" and is a mixture of all kinds of material, including sand, clay, pebbles and boulders, all worked together in a single mass. The weathering of this material has produced the yellowish color merging to shades of red and brown. The wind-blown potion is a lighter colored clay and in many places is only of slight thickness.

There is practically no road material in this area except along the streams and in comparatively few places where the Afton gravels outcrop. The road material carried by the Kansan ice sheet has become thoroughly oxidized and weathered. But the streams have carried a considerable amount of sand and gravel into this region from the Wisconsin drift area. As has been stated, the drainage system has cut the surface of the ground into a series of ridges in many places almost 200 feet above the water level of the streams. The roads which have in practically all cases been laid on the section lines will have to be, in many sections, partially or entirely relocated away from these lines before they can be

Figure 3—Area of the Missouri Loess—Typical Loess Bluffs along the Missouri River

improved without an undue expense both for grading and for maintenance. This latter is due to the serious washing of this soil and the steep grades. The accompanying view (Fig. 4) is typical of the topography of this region.

(b) *The Iowan Drift.* The Iowan drift is much younger in point of time than the Kansan. The drainage system is not yet perfected and the characteristic streams of this area flow in shallow basins and have not yet cut deep trenches. The surface of the counties covered by this drift sheet is strewn with large numbers of the granite boulders and the top soil is quite sandy overlying the blue clay.

In addition to the boulders, many of the streams of this area have rock cut channels, and there are also large deposits of gravel known geologically as the Buchanan gravels since they are particularly prominent in this county.

The bridge problem here is a difficult one since the stream courses are so poorly defined that they change their channels frequently. There are also many dry runs, which during the flood time have a large quantity of water flowing in them, and in some places apparently the attempt has been made to bridge the whole valley. Each year the loss of pile bridging is a considerable drain on the county funds and during the dry seasons cheap, inefficient culverts or small bridges have been constructed, which during the past wet seasons have washed out, causing considerable loss. In some of the counties of this area careful attention has not been paid to the foundations for the larger steel bridges and these, too, have washed out, entailing serious loss.

(c) *Wisconsin Drift.* The youngest of all the drift areas in Iowa is the Wisconsin. As shown on the drift map it is triangular in shape with its base at the north boundary of the state. The terminal moraines of this drift sheet are very pronounced. Its edges are in general marked by irregular hills and knolls.

The Altamont Moraine is the eastern boundary of this drift area. This extends southward through the western townships of Worth, Cerro Gordo, Franklin Counties and east of the middle of Hardin County, Capitol Hill in Des Moines marking its southern terminus.

The drainage system of this district is new and undeveloped. Only the larger streams have defined channels and even these in their upper courses become sluggish and tor-

Figure 4—The Mature Character of the Topography of Southern Iowa

tuous. Their tributaries are as yet merely elongated sloughs. The divides between the streams are broad and flat and on these drainage is almost impossible without first digging large ditches to serve as outlets for the tile drains.

The "basin" or "kettle" topography is typical of this area. Many of these depressions during wet seasons become ponds or sloughs. Boulders are found scattered over the surface in some sections but not in any great quantities. Gravel knobs are frequent along the terminal hills of this drift sheet and the streams have for the most part developed some deposit of sand and gravel.

The soil on the uplands contains considerable clay and sand. The lower districts are covered with the so-called gumbo.

There are large sections of the counties included in this area where even a few inches change of depth in the ponds or small lakes will flood a very large district.

The typical topography of this section is shown in Fig. (5).

(d) As stated before the only unglaciated area is in the northeast corner of the state. This accounts for the rugged features along the Mississippi River since the original rock formations were acted upon by weather and other atmospheric changes which have cut out and carried away the softer limestone and shells and left standing the harder rocks, carved into bo'd and peculiar relief.

Figure 5—Wisconsin Drift Area—"A monotonous stretch of prairie, liberally dotted with undrained ponds, sloughs and lakes."

# SECTION III.

## IOWA'S ROAD LAWS.

### 1. HISTORY AND DEVELOPMENT OF ROAD LEGISLATION IN THE STATE.

The development of the system of laws for any people is indicative. In it may be read the unfolding of the ideals of government as the country grows older and living becomes more complex. In the same way the laws relative to any particular governmental activity will reflect the attitude taken towards it in each succeeding generation. The ideals, however, inherited and acquired, which are the forces persuading and compelling men to seek higher planes of action, must always be tempered and, in a measure, defeated by certain limitations and personal interests. The resulting measures are often a curious compromise shown sometimes in the form but more often in the application of these measures which is strikingly apparent in the history of Iowa's road laws. These deviations are not the true expression of the purposes of the laws and for this reason can only delay the forward movement.

Before attempting to analyze the development of the system of road laws in Iowa, it is desirable that the political history and status of the state should be clearly understood.

In April, 1682, La Salle took possession of the Mississippi and all the country watered by its tributaries in the name of Louis XIV of France. After the fall of Quebec in 1759, by the treaty of Paris all the country between the Mississippi River and the Rocky Mountains was transferred to Spain but by secret treaty in 1800, France again regained control of the country which was purchased by the United States in 1803; one year later this land was divided into the Territory of Orleans and the District of Louisiana. The former of these was organized under a complete territorial government while the District was placed somewhat indefinitely under the control of the Governor and judges of the Territory of Indiana. The people of Louisiana were so dissatisfied with

the form of government that in 1805 they were organized into an independent territory and were reorganized in 1812 as the Territory of Missouri. When Missouri was admitted to the Union in 1812, no provisions seem to have been made for the remainder of Louisiana north and west of that state. The region was left in this indefinite condition until Congress in 1834 made it a part of the Territory of Michigan for the purposes of temporary government. Two years later the Territory of Wisconsin was established and the inhabitants of Iowa came under a regularly organized government. At this time the growth of population in this region was so rapid that in 1838 the Territory of Iowa was created.

The territories were given broad powers of legislation, the only limitation being that they should "extend to all rightful subjects of legislation." The subject of road laws was one of the first to be considered as a proper one for legislation and in the first session of the Legislative Assembly, held at Burlington in 1838-9, were enacted the first road laws of Iowa.

a. *Road Legislation. (1838 to 1857).* The first of these acts is given in full because those following were very similar:

"An Act, to locate and establish a Territorial Road from Keokuk, on the Mississippi River, to Iowa City, on the Des Moines River.

"Sec. I. Be it enacted by the Council and House of Representatives of the Territory of Iowa; that James Lutton, Joseph Robb, and James McMurry be and they are hereby appointed commissioners to locate and mark a Territorial Road, commencing at Keokuk, in Lee County, on the Mississippi River, thence to the horse tail reach, on the Des Moines River, thence up said river as near as practicable to Iowa City, on said river, passing through Farmington, New Lexington, Bentonsport, Columbus and Philadelphia, in the county of Van Buren.

"Sec. II. And be it further enacted that the commissioners aforesaid, or any two of them, shall meet at Keokuk on the first day of June next, for the purpose of proceeding to the discharge of their duties, as commissioners aforesaid, and that they be and hereby are authorized to adjourn from time to time and from place to place, as they may agree and determine; and that in case said commissioners may have adjourned, then let the sheriff of Lee County be authorized and

he is hereby required on the application of any of said commissioners, either written or verbal, to notify in writing said commissioners of some other day, to be by him appointed, and request their attendance on such day at the place aforesaid. Approved, December 14, 1838."

*Territorial Road Laws.* This act evidently pointed out to the legislators the need of a general law covering such grounds and so later in the session the following act was passed:

"An Act to provide for laying and opening Territorial Roads.

"Sec. 1. Be it enacted by the Council and House of Representatives of the Territory of Iowa, that all Territorial Roads to be hereafter located and established within this Territory shall be viewed, surveyed and established and returns made thereof agreeably to the provisions of this act within one year from the passage of the act, by which said road or roads may be granted or authorized to be laid out respectively.

"Sec. II. The commissioners' appointed to locate and establish any Territorial Road shall cause the same to be correctly surveyed and marked from the beginning throughout the whole distance by setting stakes in the prairie at three hundred yards distance and blazing trees in the timber; they shall establish mile posts, which will be marked with a marking iron in regular progression from the beginning to the termination of said road and shall also establish a post at every angle in the said road, marking as aforesaid upon the same and upon a tree in its vicinity, if any there be, the bearing from the true meridian of the course beginning at said angle post set as herein directed and note the bearing and distance of two trees in opposite directions if there be any in the vicinity from each angle and mile post.

Sec. III. The commissioners and surveyor of each road shall make a certified return of the survey and plat of the whole length of said road, specifying in said return the width, the depth and course of all streams, the position of all swamps and marshes and the face of the country generally, noting when timber and when prairie and the distance said road shall have been located in each country.

"Sec. IV. Said return and plat shall be signed by a majority of the commissioners, and the surveyor of said road and

forwarded to the Secretary of the Territory within sixty days after the view and survey of the same, to be by him recorded and preserved; and they shall also within sixty days as aforesaid, deposit in the office of the Clerk of the Board of Commissioners of each county through which said road shall be laid, a return and plat as aforesaid of so much of said road as shall be laid out and established in said county to be recorded as aforesaid.

"Sec V. The said commissioners shall after the completion of the survey of said road as aforesaid, make out a certified account of all services rendered as well by the surveyor and other hands as by themselves, charging to each county, through which said road may have been laid, a proportion of the expense agreeably to the number of days employed thereon and the board of commissioners of said county shall audit and settle the same.

"Sec. VI. All Territorial Roads authorized to be laid out by any law of this Territory and not yet commenced shall be laid out in the manner prescribed in this act and the commissioners shall comp'y with all the regulations herein contained; and furt'er the established width of all Territorial Roads shall be seventy feet.

"Sec. VII When any road shall have been located and established agreeably to the provisions of this act, the same shall be forever a pub'ic highway and shall be opened and worked by the counties through which it shall be laid as county roads are: and no part of the expense of laying out and establishing any Territorial Road or of the damages sustained by any person or persons in consequence of laying out any Territorial Road shall be paid out of the Territorial Treasury"

Approved: December 29. 1838."

b. *County Commissioners.* During this same year an act was passed which provided that three county commissioners should be elected to transact all the county business and levy such taxes as were necessary. These provisions may be regarded as the beginning of road legislation in Iowa under the territorial form of government. Every session of legislature many miles of roads were authorized by acts with very little if any regard in choosing of locations; the importance of a good highway system had not yet made itself manifest.

Almost as soon as Iowa was organized into a Territory, agitation was begun within her borders for a State Constitution. This did not arise from any particular dissatisfaction with the existing form of government but rather from the progressive spirit of those who desired that Iowa should have the full rights and dignity of the other states. Finally in 1846 a Constitution was devised which was approved both by Congress and by the people of the state and Iowa was formally admitted into the Union.

A supplemental act to the one which granted admission to the states of Iowa and Florida provided among other things that five per cent of the net proceeds from the sale of all public lands in the state should be appropriated for making roads and canals. When the General Assembly ratified the proposition of Congress they made an exception of this one section and asked that they be allowed to use the funds so derived for the purpose of the public school. Permission to do this was later given them by a special act of Congress, so this fund was diverted from roads and canals for which it had been originally intended.

There is nothing in the Constitution of 1846 curtailing the powers of the General Assembly to make provisions concerning public roads and the inference from this is that up to this time there had been no considerable abuse of this freedom.

c. *Early State Road Laws.* The form of these early laws does not excite suspicion. They undoubtedly represented more nearly the most progressive ideas of that period than do our present road laws reflect the most advanced thought concerning highway legislation. The manner of application of this law, however, is worthy of particular attention and the situation up to 1857 is well expressed by Mr. Charles Aldrich in "The Annals of Iowa." He says, "Some curious results would be reached in studying the manner in which public roads were projected and located by acts of the Legislature, Territorial and State, up to the adoption of our present Constitution. These inchoate highways would seem legitimately to have had but one purpose—that of facilitating travel and intercourse between different portions of the Territory or State. But in time their estiblishment became an abuse which the makers of our Constitution did well to suppress. Candidates for the legislature were ready and even eager to

promise to secure the establishment of these roads in order to obtain support in securing nominations as well as votes at the elections. The carrying out of pledges was generally easy for as a rule these projects met with very little opposition in the Legislature.

"Then these laws provided not a little patronage in the appointment of commissioners to locate the roads, who were also generally authorized to appoint one or more practical engineers and surveyors, a team, a tent and other camp equipage, and one or more common laborers, the subsistence for the party were also required. The location of some roads required several weeks, and, as the work was undertaken as early in the season as animals could subsist on prairie grass, they were real junketing, picnicing excursions. Nothing could be more pleasant than going out to perform such official duties. The pay was sufficient in those days of small things to make the position of commission a very welcome appointment. The appointments seldom went a-begging The prairies were most beautiful with their carpets of green grass interspersed with myriads of flowers and fairly alive with feathered game. Deer and elk were occasionally killed and as soon as the spring floods subsided fish were plenty and of the choicest quality. Enterprising frontiersmen who had gone out beyond the settlements to make themselves homes always gave them the heartiest welcome. Such settlers were hospitable to all comers but especially so to those parties whose work promised to open up roads and place them in communion with the populous places.

"But it not only became apparent that this work had too often degenerated into schemes of politicians either to acquire influence and votes, or to pay off debts already incurred, but that railroads then rapidly extending westward would largely obviate the necessity for even genuine State roads. So the convention of 1857 in Article III, Section 30, of the present constitution prohibited the General Assembly from 'laying out, opening and working roads and haghways'

"The summer of that year saw the last parties engaged in laying out State roads. The Legislature of 1856, however, had been so industrious in the establishment of State roads that it takes almost three pages in the index merely to name the various laws or sections in which they were decreed. The commissioners in the summer of that year were very ac-

tive and made hay while the sun shone', well knowing that the laws would provide for no more such roads. And so the usage—so pleasant to its beneficiaries—came to an end."

Hardly had the Constitution of 1846 been adopted before it became apparent that it needed strengthening. It had only been accepted by less than five hundred votes out of a total of over eighteen thousand five hundred, and it was not difficult to get a new constitutional convention called to meet in 1857.

d. *Constitutional Limitations* In this a convention modeled upon the old one, but in every way fuller and more perfect, was drawn up. By this time, the Legislatures had so abused the freedom granted them in certain particulars that the makers of the new constitution sought to end this practice and Secion 30, Article 4 was inserted for this purpose:

"The General Assembly shall not pass local or special laws in the following cases:

"For the assessment and collection of taxes for state, county and road purposes;

"For laying out, opening and working roads or highways."

e. *Laws of Seventh General Assembly.* In 1858, the Seventh General Assembly, the first one to meet under the New Constitution, passed a new set of road laws into which were introduced many of the features which are still retained. A board of three men in each township was provided to transact the township business, and were called township trustees. Without attempting to qote these in full, they are as follows: (Chapter 154.)

"Sec. I. The township trustees shall meet and divide their respective townships into as many road districts as they may deem necessary.

"Sec. II. A supervisor shall be elected from each road district to hold office for one year.

"Sec. III. The township clerk shall notify the supervisor of his election and shall administer the oath of office to him.

"Sec. VI The supervisor shall require all able bodied male residents of his district to perform two days labor on the public highways.

"Sec. IX. The supervisor shall perform the same amount of labor as is required of the able bodied man, for which he shall be allowed one dollar and fifty cents per day.

"Sec. XII. The township trustees shall determine the

amount of property tax to be levied for roads, bridges, plows and scrapers which shall not be less than one nor more than three mills on the dollar of the township assessment for that year.

"Sec. XIV. The township clerk shall make an entry of the tax list, showing what it is and for what road district, and require the supervisor to collect the same.

"Sec. XVII. The supervisor shall superintend all road work in his district and (Section XVIII) shall report the same."

in his district and (Section XVIII) shall report the same."

f. *The Board of Supervisors.* The revised Code provided that the duties and powers of the county commissioners under the territorial form of government should be vested in a county court which also had jurisdiction in probate. The Eighth General Assembly, which met in 1860 created the county board of supervisors. The duties of the territorial commissioners were taken from the county court and given to this new board, among which specific duties were the following:

To lay out, establish, alter or discontinue any county roads heretofore or now laid out or hereafter to be laid out, through or within their respective counties as may be provided for by law.

To provide for the erection of all bridges which may be necessary and which the public convenience may require within their respective counties, and to keep the same in repair.

It will be seen by reference to these laws that they gave the supervisors general supervision over the highways, including the bridges, and the trustees the power to levy the taxes necessary for keeping the roads, including smaller culverts, in repair, while the Board of Supervisors was entrusted with levying the taxes for the more important bridges.

g. *New Road Law.* These laws show the introduction into the system of all the officers who are charged with the administration of the road and bridge funds at the present time, except the road superintendent. Few changes were made from this time until the 29th General Assembly passed an Act making each township one road district requiring the property road tax to be paid in money, and creating the office of township road superintendent. This Act is as follows:

"Sec. 1532-a. *Repeal—Consolidation of Township into one road District.* That section one thousand five hundred and thirty-two (1532) of the code be, and the same is, hereby repealed, and the following enacted as a substitute therefor:

"The board of township trustees of each civil township in this state, at its regular meeting in April, 1903, shall consolidate said township into one road district, and all road funds belonging to the road districts of said township shall at once become a general township road fund, out of which all claims for work done or material furnished for road purposes prior to the change, and unsettled, shall be paid.

Sec. 1533. *Duty of Trustees.* Where the one road district plan is adopted, the board of township trustees shall order and direct the expenditure of the road funds and labor belonging or owing to the township; may let, by contract, to the lowest responsible, competent bidder, any part or all of the work on the roads for the current year, or may appoint a township superintendent of roads, to oversee, subject to the direction of the board, all or any part of the work, but it shall not incur an indebtedness for such purposes unless the same has been or shall at the time be provided for by an authorized levy; and shall order the township road tax for the succeeding year paid in money and collected by the county treasurer as other taxes. It shall cause both the property and poll road tax to be equitably and judiciously expended for road purposes in the entire road district; shall cause at least seventy-five per cent of the township road tax locally assessed to be thus expended by the fifteenth day of July in each year; shall cause the noxious weeds growing in the roads to be cut twice a year, when necessary, and at such times as to prevent their seeding, and it may allow any land owner a reasonable compensation for the destruction thereof, when growing in the roads abutting upon his land. If a superintendent of roads is employed, it shall fix the term of office, which shall not exceed one year, and compensation which shall not exceed three dollars a day; and no contract shall be made without reserving the right of the board to dispense with his services at its pleasure."

This act is deemed of sufficient importance to repeat it here in full as there seems to be considerable lack of information concerning a number of its requirements. In some parts of the state the provisions have not been complied with and a

general dissatisfied condition has resulted. In such cases the townships have really been proceeding under the old road district plan.

ORGANIZATION UNDER THE PRESENT ROAD LAWS.

a. *County Supervisors.* This Board is given general jurisdiction over the highways of the county. It has the power to establish, vacate or change them as provided for in the laws. It is their duty to levy the one-mill county road tax and to expend the same. They have to erect and repair all the bridges above a certain span, which varies from 12 to 16 feet, and to pay for the same by taxes, the minimum of which is now limited to four mills, except by a special vote of the people.

b. *County Auditor.* The county auditor acts as the secretary of the Board of Trustees and is required to keep on file in his office the complete records of all their transactions, and reports which come to them. He is also required to make each year, a financial report of the county which in brief should show the entire business transacted during the preceding year, by the county officers, so arranged that it will be a source of information, and readily understood by the taxpayer.

c. *Board of Trustees.* The Board of Trustees is a local board entrusted with the care of the roads in the individual townships. This board has the power to levy road taxes up to a minimum of four mills and to expend the same on the public highways. For the money so raised they are required to account to the Board of Supervisors, the same to be approved by them and published in their proceedings

d. *Township Clerk.* This officer acts in the capacity of Secretary to the Board of Trustees, and the law now requires the county treasurer to pay over to him the road taxes for the township. He is required to make a report of all delinquent road taxes to the county auditor; to certify to the auditor the property road tax levied by the Board of Trustees; to make out and deliver to the Superintendent of roads, a list of all persons required to pay road and poll taxes; to make to the Board of Supervisors, on the first Monday in each year, a "full and itemized account" for the Board of Trustees of all their receipts and expenditures during the preceding year, and to have custody of all the general township fund and of all the road machinery.

e. *The Road Superintendent.* The Road Superintendent is

required to expend the road money of the township under the direction of the Trustees and to report the same in itemized statement to the township clerk on the first Monday of April and of November of each year.

This gives in a general way the means provided by law for the administration of the highway taxes. To better study the conditions produced by this machine it is necessary to take up the different funds or taxes that may properly be used on the highways.

The bridge work in the different counties is let by contract or put in by day labor, under supervision of the Board of Supervisors. Practices are not uniform for the state, but there are a number of points to be observed that quite generally receive little consideration. When the work is let by contract it is very necessary that very careful inspection should be made during the erection of the bridge with especial regard to (a) foundations, (b) material, (c) workmanship, (d) paint, (e) recording. When the work is put in by day labor, these same points are to be followed carefully, but first of all a competent and experienced foreman should be secured to take charge of the work. The records of the bridge fund are extremely important and a full and itemized account should be kept of each year's receipts and expenditures. The following outline is suggested:

1. County Bridge Fund.

Receipts.

1. Amount of bridge funds on hand at beginning of fiscal year.
2. Received from county treasurer.
3. Amount received from sale of old material.

Expenditures.

This should be classed under two heads.

New Bridges.

Repairs.

In order to promote economical and efficient handling of county funds it is highly important to keep records from year to year which will show the cost to the county and its purchases each year, and thus bring into comparison the administration of the different road officers. If there is considerable change from year to year, the records should show the

reasons for this. To conserve the bridge funds as much as possible a system of continuous reports should be instituted in each county including the painting at regular intervals, inspection of foundations and abutments, in tightening of bolts, and such repairs as will materially increase the life of the structures. The records should show for

New Bridges
  Span
  Name of builder
Superstructure
  Material
  Unit cost
  Total cost
Foundations
  Piers
    Material
    Unit cost
    Total cost
  Abutments
    Material
    Unit cost
    Total cost

Other items such as total contract price, kind of material on which foundations stand, date of erection, and other important items should also be added. Where no contracts are let, reports should show the cost, unit and total, of all material, labor, the foreman in charge of the work, and supervisor in whose district erected. A complete record should be kept of all the bridges erected and additions made to this from time to time as repairs are made to the structure. Whenever large contracts are let or the Board of Supervisors is in doubt as to the best methods and materials to use in bridging, some competent engineer should be consulted. The loss each year, due to incompetent handling of this fund, entails a serious loss to the state.

2. County Road Fund. The county road fund although one mill only, has in some counties been used to such good advantage that seemingly more has been done from the one-mill county levy than from the four-mill township levy. In some counties, for instance Greene, Carroll and Chickasaw, this fund is used for improving important roads by grading or

graveling, while in others it has been used much as the township funds have been used in patching small strips here and there in a haphazard manner.

Where contracts are let for road work they should show the cost, unit and total, of the labor, material such as tile, gravel, etc., the amount of road improved, and its location. Other expenditures, such as new machinery, repairs and such items should be carefully reported together with the date, the supervisors making the same. The fund should be distributed as fairly as possible by each supervisor in his district but in conjunction with the other supervisors towaard a system of roads already planned for the county.

3. Township Road Fund. The new road law gives promise of some excellent results, but the practical working of the same has been such as to merit a thorough discussion of some of the principles involved. In the first place the order of new provisions of the law will be taken up as fully as possible as there seems to be a very serious lack of information on this subject.

(a) *The Township, the Unit Road District.* The act makes it mandatory upon the board of trustees to constitute each civil township into one road district. In a number of places this plan has not been followed and thus the first requirement of the law has been violated. The old law gave the power of discretion to the trustees as to whether the township should be made into one road district but the new law takes away this right and makes the township the only legal road district.

(b) *The General Township Road Fund.* The maximum levy on property for this fund is four mills and was formerly optional as to whether it should be paid in cash or labor but the new law takes away this right of choice and requires the taxes to be paid in cash and to be collected as are the other taxes. It now constitutes the general township road fund out of which all claims for labor or material for the township shall be paid. "Under the old law all road taxes in the townships where there was no consolidation of the road taxes were payable with the first installment of the county and state taxes, while the road taxes in townships where there had been this consolidation were payable in two installments, as were the other taxes."

As the law now stands it is the duty of the township clerk

within four weeks after the township trustees have levied the property road tax to certify the same to the county auditor who shall enter it upon the tax lists for collection by the county treasurer along with the other taxes in two installments.*

(c) *Payment to Township Clerk.* The county treasurer is required to pay over to the township clerk on the last Monday in April and October of each year all the road taxes belonging to that township and to receive a duplicate receipt for the same, one of which he shall retain and one of which he shall deliver to the trustees before the first Monday in May or November of that year.

(d) *Expenditure of Township Funds.* The township trustees are required to spend this money by one of two methods: (1) They may let the work by contract to the lowest responsible bidder, or, (2) They may appoint a road superintendent who shall be subject to their directions but who shall oversee the work. This section of the law has been very seriously misconstrued.

(1) When all or any part of the work is let by contract the trustees have supervision of the work to the extent of requiring the contract to be fully and carefully executed. BUT THEY ARE NOT ELIGIBLE TO TAKE THE CONTRACT EITHER COLLECTIVELY OR INDIVIDUALLY. This system for letting all or any part of the work as may be done under the law is a good one when properly executed. In many townships, however, contracts have been let in such a manner that they have defeated their own purpose. Road contracts should never be let through competitive bids in which the units upon which the bids are made are the day labor of a man and of a man and team. The only object for letting a contract is to accomplish a certain piece of work economically and well and at a certain total cost which is known before the work is begun. The day labor contract is diametrically opposed to each of these. When this method is followed the lowest bids will always be lower than the real market value of efficient labor, whether of man or team. This being true a man who bids lower than these values must furn-

*The Thirtieth General Assembly attempted to change the law to make this road tax collectible in one installment but according to an opinion rendered by the Attorney General under date of Feb. 16th, 1905; the changes in the law were not sufficient to control the time of collection of this tax.

ish second rate labor even to pay expenses. Also this method of letting contracts puts a premium upon slow work and there is no way to determine beforehand what the final cost of any piece of work will be. In letting work by contract the trustees should have an estimate prepared by a competent engineer of the number of yards of earth to be moved, culverts to be constructed, tiling to be done, and all the work necessary to make a finished job. An advertisement for bids should be inserted in the papers for a certain period of time. On the date set, all the bids should be opened and the contract let to the lowest responsible bidder. The contractor whose bid is accepted should be required to furnish bond of sufficient amount to guarantee the faithful performance of the work.

(2) If the trustees decide to hire a road superintendent they should select a man for his qualifications along this line. The law contemplates that a man shall be hired to give his full time to the supervision of the work, and there is no reason to think that it contemplates he should do the actual labor himself. Township trustees or other township or county officers are not eligible for this office. Neither should they be hired by the township superintendent to work on the roads as that puts them in the position of employe while they are required by this act to supervise the work of the road superintendent and to see that the money is properly spent on the roads. Some townships have appointed several men to work on the roads and called them road superintendents but this is merely a modification of the old many-district-system. It would be much better and would follow the requirements of the law to have one road superintendent for the township and let him have, if necessary, a number of assistants. The more the work is concentrated under one man and this man held responsible for the proper expenditure of the fund, the more economical will be the administration of the road funds provided the proper man is selected in the first place. As has been said before, a trustee is not eligible to do the work as superintendent of the roads although this has been done in a large number of cases. In one case particularly where the records were examined by the Highway Commission, it was found that the three trustees had divided the money equally among themselves, but the road work showed very poor management of the road funds, and practically no good was accomplished whatever

by the expenditure of about fifteen hundred dollars in the township during the year. This is only one instance in a large number where the trustees have appointed themselves superintendents of roads. An excuse was given in some cases that it was impossible to find men who were qualified to take up the work. It is clearly, however, opposed to the law and contrary to public policy for the township trustees to elect themselves to office, keep their own time, and audit their own bills.

(4) County Financial Report. Chapter 111 of the laws of the 29th General Assembly require the auditor to publish each year, during the month of January, the financial report of the county, which the supervisors shall order printed in pamphlet form, and distributed among the tax payers of the county. The law states definitely a large number of itemized accounts which are to be included in this report but these do not need to be mentioned in detail. The law clearly intends this report to include a report of all the transactions of the county and township officials for the information of the tax payers of the county. Some counties have not begun to issue these reports. In other counties these have been compiled in such a way that they give very little if any information to the tax payer as to the expenditure of the funds raised, and it is questionable if some of them are worthy of distribution as a source of information along this line. Such a report is clearly intended to convey information concerning the kind of work done and the amount accomplished with the different funds, and if it does not do this it fails in its purpose completely. For instance, the financial report of a particular county gives the following report of the expenditure of the road fund by the county for 1903:

Warrants Drawn on County Road Fund.

| | |
|---|---|
| Supervisoral District No. 1. | $1,073.42 |
| Supervisoral District No. 2. | 1,405.22 |
| Supervisoral District No. 3. | 383.35 |
| Supervisoral District No. 4. | 710.67 |
| Supervisoral District No. 5. | 2,194.13 |
| | $5,766.79 |

This schedule tells only the total amount of the county road fund and the amount spent in each district. Further than this there is absolutely no information given. This report

should be so given that anyone looking over it will know for what the money was spent. This applies equally well to the bridge fund or to any of the other county funds. A large proportion of these reports do not contain even a mention of the expenditures of the township road fund and the law clearly contemplates that the report of the township trustees should be embodied in such a pamphlet. Neither are the reports of the township trustees always printed in the newspapers under the proceedings of the Board of Supervisors as the law requires. Often times no report of this fund is made that the public may know in what way the money is being spent. This lack has probably helped to make the trustees more careless in the reports which they hand in, and it is probably true that many of the county auditors do not print some of these reports because they are so poorly made that they are clearly of no value whatever. In a large number of cases the trustees have not even made a report and it has been found by the Commission to be quite the common thing for a county auditor to have perhaps only fifty per cent of the reports from the townships on file in his office. This carelessness is clearly the fault of the auditor as he is responsible for getting these reports in and requiring them to be correct before he submits them to the Board of Supervisors for their approval.

In this connection we may mention that the Commission has not received any of the reports for 1904 as yet, but among the best financial reports for 1903 were those put out by Clayton and Cerro Gordo counties. These as a source of information, altho' lacking details in a few instances, were full and concise. More attention should be paid by County Auditors to this report.

## SECTION IV.

## THE STATE HIGHWAY COMMISSION.

1. *Law Establishing the State Highway Commission.* The law establishing the State Highway Commission is known as House File 371. It was passed by the 30th General Assembly and approved April 13, 1904.

*An Act* to create a highway commission for the State of Iowa, and defining the duties of same (Additional to chapter four (4) of title thirteen (XIII) of the Code, relating to the state college of agriculture and mechanic arts).

Be it enacted by the General Assembly of the State of Iowa:

SECTION I. *Highway Commission—Duties.* That the Iowa state college of agriculture and mechanic arts, at Ames, shall act as a highway commission for Iowa, whose duties shall be:

1. To devise and adopt plans and systems of highway construction and maintenance, suited to the needs of the different counties of the state, and conduct demonstrations in such highway construction of county supervisors, township trustees, superintendents, students of the college and others.

2. To disseminate information and instruction to county supervisors ,and other highway officers who make request, to answer inquiries and advise such supervisors and officers on questions pertaining to highway improvements, construction and maintenance, and when the board of supervisors of a county adjudge that the public necessity requires a public demonstration of improved highways construction or maintenance in said county, and so request and agree to furnish necessary tools, help and motor power for same, the commission shall furnish as soon as practicable thereafter, a trained and competent highway builder for such demonstration free to the county.

3. To formulate reasonable conditions and regulations for public demonstration, and to promulgate advisory rules and regulations for the repair and maintenance of highways.

4. To keep a record of all the important operations of the highway commission, and report same to the governor at the close of each fiscal year.

SECTION II. *In Effect.* This act, being deemed of immed-

iate importance, shall take effect and be in force on and after its publication in the Register and Leader and Des Moines Capital, newspapers published at Des Moines, Iowa.

Approved April 13, A. D. 1904.

Funds for carrying out this bill became available July 1st, 1904, and the provisions of the law followed in the work of the commission. A short outline of the work undertaken up to this time is given for the information of road officers.

The Board of Trustees of the Iowa State College in carrying out the requirements of the act entrusted the work jointly to the Engineering and Agricultural Departments. The personnel of the Commission has been as follows:

A. MARSTON,
Dean of Division of Engineering.
C. F. CURTISS,
Dean of Division of Agriculture.
THOS. H. MACDONALD,
Assistant in Charge of Good Roads Investigations.

In addition to these, Professor Zintheo of the Farm Mechanics Department has had charge of securing road machinery of different kinds.

Without taking up minute details concerning the work of the Commission, it may be said that the requirements of the Act have been used as the basis of the activities of the Commission and that they have been followed in much the same way as in the above paragraph.

## 1. PLANS OF HIGHWAY CONSTRUCTION AND MAINTENANCE.

a. *General.* In order to get a broad view of the general situation and come in contact with the Highway Commissions of other states, and to get hold of the road problems in general throughout the country, Dean Marston made a trip through New Jersey, New York, and Massachusetts. He obtained in this way the system of the organization of Highway Commissions of these states, their method of work and many other standard plans for highway construction and maintenance.

b. *For Iowa.* 1. The geological formation of Iowa is such that while the road problem differs in different localities to a remarkable extent, there are several main divisions of areas which are considerably alike. This is due to their geological formation. These divisions are shown on the

accompanying print as unglaciated area, the Kansan drift area, the Iowan drift area, and the Wisconsin drift area. The road problems in each of these localities as stated before are to an extent the same for each of the counties included within that particular area. The aim has been to study the sections as a whole with regard to the larger problems which affect each district.

2. To study the smaller and more local problems, affecting perhaps only one or more counties, a large number of trips have been made to different parts of the state.

c. *Financial Reports.* This includes the investigation of the different reports that are sent in by the county supervisors and township trustees with regard to the expenditure of road and bridge funds.

d. *Road Material.* An investigation has been made of road material available in a number of counties and the value of the roads upon which it has already been used. Testing laboratories will be fitted up immediately for determining the value of different kinds of material for road purposes.

e. *Local Road Problems.* The methods of work inaugurated in the different counties and townships have been investigated as closely as possible to determine the use the road officers are making of the resources which they have and to find out the things that are giving the most trouble, such as a low standard of road superintendents, lack of road material, topographical difficulties such as poor drainage, steep grades, etc. The individual counties in which most of this work has been carried on are Bremer, Butler, Buchanan, Chickasaw, Floyd, Carroll, Calhoun, Greene, Story, Cerro Gordo, and to some extent in Boone and Linn Counties.

## 2. EXPERIMENTAL WORK OF COMMISSION.

The value of the investigations which have already been made lies in obtaining from them practical methods for improving the highways. For instance, to determine upon a suitable cross section as to width, crown, side ditches and the other important features of a well made road, a large number of roads actually built in the state have been measured and studied both for the good and the bad features. To get at the value of binding material for roads, particularly gravel roads, a short section of gravel road was constructed on the

campus where it is subject to heavy traffic and close watch is kept on the material which was used in the road, and how it is behaving under action of water and traffic. Considerable attention will be paid to the use of concrete for permanent culverts and bridges. The investigations of the commission have shown conclusively that much of the money nominally supposed to be spent on the roads proper is in fact diverted to the bridges and culverts. The need of more permanent structures for these is very apparent particularly on the more important roads. To aid in explaining the proper use of concrete, a number of short sections of concrete culverts have already been built and may be seen at the time of the school. Demonstrations will also be given in the use of concrete and the methods of mixing and placing it as a part of the course. As a result of these experiments a number of standard plans for cross sections of earth and gravel roads have been made and also a number of standard designs for concrete culverts are now ready. Road maps of about twelve counties have been made outlining the main traveled roads, second class roads, and showing such roads as have been improved with gravel or stone.

### 3. PUBLIC DEMONSTRATIONS.

There has been some correspondence with a number of people concerning the demonstrations and it seems quite possible that in a short time some towns will take up the building of a short section of road, not only for demonstration purposes but for practical use. The law requires the counties to pay the cost of such demonstration and they have not yet become sufficiently acquainted with the work of the Commission to go to this expense. At the school particular attention will be paid to demonstration and practical men are being found in different parts of the state who will be available in helping to continue these demonstrations and there is a call for them.

*It should be emphasized in this connection that the Commission is required to furnish free of charge to road officers any and all information possible.*

# SECTION V.

## ROAD CONSTRUCTION IN IOWA.

As has been stated there are approximately 100,000 miles of public roads in the state and of this number not more than 1,000 miles at the outside have received a surfacing of gravel or broken stone. These figures show the necessity of adopting the best and most economical methods of earth road construction and maintenance. Even for counties which are using considerable gravel or other surfacing material the earth road is first in importance for it is money wasted to try to improve a poorly built earth road with any surfacing material.

There are a certain number of general considerations which apply to all roads and which should receive particular attention in this connection.

### 1. ROAD LOCATION.

Practically all of our public roads are laid out on the section lines and the new roads that are opened from time to time are being located in the same way. As the state becomes more thickly settled the call is constantly for new roads but there is very seldom any thought of departing from the section lines. As a result of this custom, the road system of the state has been developed without any regard to the engineering principles of economy and efficiency. In the parts of the state covered by the Iowan and Wisconsin drift sheets this condition is not so important. The drainage lines are not as yet so well defined and the grades for the most part are not heavy.

In the large area, however, covered by the Kansan drift this phase of the question is an important one. The drainage system as shown on the map is well developed. The whole section has been cut by the water and other agencies into such a series of ridges and valleys that an exclusive system of section line location for the roads cause impracticable grades and enormous expense for moving earth. The topography here is such that a road must be curved either in plan or

profile. The section line location prohibits the first and thus necessitates the second, which is much the worse.

The heaviest grade on any road will limit the size of loads that can be hauled over it and for economy of transportation the maximum grade should be kept as low as possiple.

In addition to economy of transportation, the first cost of construction can often be materially lowered and the annual cost of maintenance be decreased by building around a hill rather than over it, or by buying a new right of way around a series of hills. Often times the total cost of entirely relocating a road will be less than trying to make even a faint start at a good road on the section line.

Fig. 7—SECTION LINE LOCATION
This road parallels a valley which is proper location for the road.

The accompanying cut, Figure (7) was taken to illustrate this condition. The section line road which climbs one steep hill after another, parallels a valley which may be seen only a short distance to the left, in which the road could have avoided all the hills shown. In one place on this road a new right of way was purchased around a hill and an almost level road made at a cost of only $70.00. On one alone of the near-by hills the grading done cost about $1,000.00.

A railroad running out from the same town followed the valley almost parallel to the wagon road, showing what a competent engineer could do with the highway.

## 2. DRAINAGE.

The most important of all considerations in the construction of earth roads in this state is efficient drainage. There are two phases of the general subject to consider, which may be classed as (a) district drainage and (b) local drainage.

### (a) DISTRICT DRAINAGE.

*Where Needed.* In the north central part of the state, in the area covered by the Wisconsin drift sheet, the drainage is new and undeveloped. Here the outlets in many places can-

Fig. 8—Typical Pond of Northern Iowa

not be found for the side ditches or tile drains. Figure No. (8) illustrates one of the typical ponds of this section through which several costly but unsuccessful attempts have been made to construct a road. In these localities, district drainage must first be provided. For this work the law requires that a competent engineer be employed to make the estimates and plans for the proposed improvements.

*Proceedings by the Road Officers to Establish District Drainage.* Where the abutting property owners will not institute the necessary proceedings to establish the drainage district to drain a highway, the township trustees shall file a petition

with the county auditor describing the highway to be drained and the lands to be crossed in the construction of such a drain. The payment of the cost of the drain if constructed after the engineer's report is filed, is made out of the township road fund.

If, however, a drainage district has been established by the petition of land owners, the trustees are required to pay the actual cost of constructing the drain across the road out of the township road fund and the board of supervisors is required to pay for any bridges across the same out of the county bridge fund.

The highways lying within a drainage district will always be benefited to an extent by the establishment of such a drain and should be assessed by the commissioners.

*Assessment of Public Highways.* Public highways within a drainage district are benefited by the construction of ditches and hence may be assessed for a portion of their cost and maintenance. The assessment, however, must be made upon a different basis from that of farm lands. The title to land occupied by highways is in the abutting owners, who are assessed for the improvements as "farm land." The public highways do not derive their benefit from added productiveness of the soil as do farm lands, but from their improvements as roads for travel. The public using such roads receives a benefit by reason of their improvement. An assessment for road benefits when made, must be paid by all property owners in township and county upon the basis of assessed valuation of property and is not restricted to property within the drainage district. The Iowa law charges the cost of constructing a ditch across a right of way and of building necessary bridges to the township road fund and the county bridge fund respectively.

The assessment against highways within the district should be a percentage of the entire cost of the ditch improvement on the theory that there is a ratio of value existing between highways and the property they serve. The greater value of the property served by the road, the greater the value of a good road to it. The drainage ditches of a district may in some cases make possible improvements of very great value to the highways; in others they make affect them but little.

The percentage of cost of district drainage which should

be assessed against the highways should not often be less than two per cent nor more than eight per cent. From this amount should be deducted the cost of construction across rights of way in the several cases, since in Iowa the law charges this expense to the road fund."*

*Co-operation of Road Officers and Land Owners.*—Without recourse to the law the road officers, both township and county, can make the best investment of the road funds which are spent for drainage by co-operating with the land owners. In nearly all cases where road drainage is needed, the land on one or both sides would be materially benefited and most property owners should be willing to meet their share of the expense necessary to secure such drainage, and these property owners should have the co-operation of the road officers.

## (b) LOCAL DRAINAGE.

The discussion on district drainage touched upon the general points in securing outlets in an undrained area, but there are no sections of the state where what may be termed local drainage is not necessary in the construction of earth, gravel or macadam roads. Sand roads are the only ones benefited by an excess of moisture.

In local drainage there are first, the ground water, and second, the surface water to remove.

To provide for these two kinds of water a well built road must have FIRST, SUBDRAINAGE; SECOND, A CROWN, AND THIRD, SIDE-DITCHES.

### SUBDRAINAGE.

In all places where the ground water level or point of saturation rises within eighteen inches to two feet of the surface for a considerable part of the year, the foundation will be greatly improved by tile drainage. Wherever bog springs, seeps or springs occur along the right of way, title drainage is *essential* to road improvement.

In places where a grade is to be constructed over a low stretch that becomes marshy at certain times of the year, tile

*Extract from talk by Mr. C. G. Elliott, given before the Iowa State Drainage Convention at Ames, January 13 and 14, 1905.

should first be laid to protect the foundation; also a line of tile along the road will greatly lessen the injury to the road foundation "when the frost is going out." This is a self-evident fact as it removes the ground water rising from capillary action or flowing from the hills to the lower places and provides an outlet for the same. The action of the frost would be without effect if the moisture could be kept away and this is secured by careful subdrainage.

There is some discussion as to the proper position for locating the tile, but it has been well established that the proper place for a line of tile is under one of the side ditches. The minimum depth should not be less than three feet but four feet is much to be preferred if a sufficient outlet can be secured. In some places where the water seeps to the surface or there are springs it may be necessary to lay a line of tile on each side of the road. In general, however, one line will be sufficient.

*Sizes of Tile.* To aid in proportioning the sizes of tile, table No. 2 has been included; also a table of prices based on the local prices at Ames is given, but before using this for any particular places, the local markets should be consulted. Table No. 4 has also been included to aid in estimating size of open ditches necessary where tile drain is not sufficient. To get the full benefit of tile drainage the tile should be carefully proportioned to the amount of water to be removed. The tables are by the Civil Engineering Department of the Iowa State College.

Ordinarily 4 inch tile should be used, with 5 inch or 6 inch only for very long lines.

In laying the tile it is absolutely necessary that certain points be amphasized and carefully observed. The tile should be deep enough to be below the frost line if possible. It should be of ample size and the grade should be continuous to the outlet. The outlet should be carefully protected by a bulkhead of concrete or brick, and covered with a grating to prevent the entrance of small animals.

In drainage ditches, careful attention should be given to the grade. They should be deep enough to afford outlets for the tile drains necessary. The bottoms should be wide enough to avoid stoppage, and the sides should be sloped at least 1 to 1.

Where a considerable amount of drainage is undertaken

TABLE 2. NUMBER OF ACRES DRAINED BY TILES REMOVING ¼-INCH DEPTH OF WATER IN 24 HRS.

| GRADES | | DIAMETERS OF TILE DRAINS | | | | | | | | | | GRADES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Per Cent | Inches Per Rod | 3 Inch | 4 Inch | 6 Inch | 8 Inch | 10 Inch | 12 Inch | 15 Inch | 18 Inch | 20 Inch | 22 Inch | 24 Inch | Inches Per Rod | Per Cent |
| 0.03 | 1–16 | | | | | 37 | 59 | 109 | 159 | 205 | 254 | 319 | 1–16 | 0.03 |
| 0.05 | 3–32 | | 5 | 13 | 28 | 49 | 75 | 131 | 219 | 264 | 332 | 411 | 3–32 | 0.05 |
| 0.10 | 3–16 | 4 | 7 | 19 | 40 | 69 | 109 | 186 | 289 | 373 | 471 | 582 | 3–16 | 0.10 |
| 0.15 | 9–32 | 4 | 9 | 24 | 49 | 85 | 132 | 232 | 355 | 458 | 577 | 713 | 9–32 | 0.15 |
| 0.25 | 3–8 | 5 | 10 | 28 | 56 | 97 | 153 | 264 | 410 | 529 | 667 | 823 | 3–8 | 0.20 |
| 0.30 | 9–16 | 6 | 12 | 33 | 69 | 119 | 188 | 322 | 502 | 648 | 808 | 1008 | 9–16 | 0.30 |
| 0.40 | 13–16 | 7 | 14 | 39 | 79 | 138 | 216 | 371 | 580 | 748 | 942 | 1165 | 13–16 | 0.40 |
| 0.50 | 1 | 8 | 16 | 44 | 89 | 154 | 246 | 416 | 648 | 838 | 1050 | 1300 | 1 | 0.50 |
| 0.60 | 1 3–16 | 9 | 17 | 48 | 97 | 169 | 266 | 457 | 710 | 911 | 1154 | 1422 | 1 3–16 | 0.60 |
| 0.70 | 1 3–8 | 10 | 19 | 50 | 105 | 182 | 287 | 488 | 768 | 988 | 1242 | 1549 | 1 3–8 | 0.70 |
| 0.80 | 1 9–16 | 10 | 20 | 55 | 114 | 195 | 307 | 526 | 822 | 1059 | 1332 | 1645 | 1 9–16 | 0.80 |
| 0.90 | 1 3–4 | 10 | 21 | 59 | 119 | 207 | 326 | 558 | 872 | 1123 | 1414 | 1747 | 1 3–4 | 0.90 |
| 1.00 | 2 | 11 | 22 | 62 | 126 | 218 | 343 | 589 | 917 | 1176 | 1495 | 1838 | 2 | 1.00 |
| 1.50 | 3 | 13 | 28 | 75 | 153 | 267 | 419 | 722 | 1123 | 1450 | 1824 | 2256 | 3 | 1.50 |
| 2.00 | 4 | 15 | 31 | 88 | 178 | 309 | 485 | 832 | 1297 | 1676 | 2110 | 2594 | 4 | 2.00 |
| 3.00 | 5 15–16 | 19 | 39 | 107 | 216 | 377 | 593 | 1020 | 1589 | 1957 | 2592 | | 5 15–16 | 3.00 |
| 4.00 | 7 15–16 | 22 | 45 | 123 | 253 | 437 | 683 | 1176 | | | | | 7 15–16 | 4.00 |
| 5.00 | 9 7–8 | 25 | 50 | 138 | 280 | 486 | 765 | | | | | | 9 7–8 | 5.00 |
| 7.50 | 14 7–8 | 30 | 61 | 169 | 344 | | | | | | | | 14 7–8 | 7.50 |
| 10.00 | 19 13–16 | 35 | 71 | 195 | | | | | | | | | 19 13–16 | 10.00 |

by the township or county, careful plans and specifications should be prepared by a competent drainage engineer. The following specifications and contract for tile drains, have been prepared by the Civil Engineering Department of the Iowa State College and are inserted here. They cover quite carefully the vital points in this subject.

Table No. 2 is computed from the form of Poncelet's formula recommended for the use with tile drains by C. G. Elliott, drainage expert to the U. S. Agricultural Department, Washington, D. C., who recommends the above sizes to drain ground only. If surface water is also to be removed, as in the case of ponds without other outlets, the tiles will drain safely only one-half to one-third the number of acres given in the table

When part of the land in the water shed is rolling, not requiring tiling, count only one-fifth to one-third of such rolling land, in addition to all of the low, flat land, in getting the size of tiles to remove ground water only.

Example 1. What size of tile laid to a 0.1% grade will carry the under drainage of 160 acres of flat land? Answer 15 inches.

Example 2. What size of tile to a 0.2% grade will carry the under drainage of 240 acres, two-thirds rolling? Answer 80 acres flat land plus one-third of 160 acres rolling gives 133 1-3 acres requiring a 12 inches tile.

TABLE 8. COST OF TILE DRAINS

| Size of Tile | Acres to be drained | Weight per foot | Cost per rod | Cost of Digging and Laying per rod | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 2 ft. deep | Add per foot for additional depth over 2 feet | | | |
| | | | | | 3-4 ft. | over 4 ft. | | |
| 3 in. | $ 10.00 | 5 | $ 3.12 | $0.35 | $0.15 | $0.20 | 2c-5c | |
| 4 in. | 22.00 | 8 | 5.00 | 0.35 | 0.15 | 0.20 | 2c-5c | |
| 5 in. | 30.00 | 10 | 6.25 | 0.35 | 0.15 | 0.20 | 2c-5c | |
| 6 in. | 40.00 | 12 | 7.50 | 0.35 | 0.15 | 0.20 | 2c-5c | |
| 7 in. | 50.00 | 15 | 9.37 | 0.35 | 0.20 | 0.25 | 2c-5c | |
| 8 in. | 60.00 | 20 | 12.50 | 0.40 | 0.20 | 0.25 | 2c-5c | 35c |
| 10 in. | 95.00 | 30 | 18.75 | 0.45 | 0.20 | 0.25 | 2c-5c | 35c |
| 12 in. | 120.00 | 40 | 25.00 | 0.50 | 0.25 | 0.25 | 2c-5c | 35c |
| 15 in. | 250.00 | 50 | 31.25 | | | | | 35c |
| 18 in. | 400.00 | 80 | 50.00 | | | | | |
| 20 in. | 600.00 | 100 | 62.50 | | | | | |
| 24 in. | 800.00 | 125 | 78.12 | | | | | |

Example 3. What size of tile land to 0.3% grade will be required to remove both ground and surface water from a pond whose water shed includes 40 acres? Answer 10 inch. (Note.—Double or triple the area for both ground and surface water).

COST OF TILE DRAINS.

The following data show the average cost of tile drains during 1904 in the vicinity of the college. Local markets should be consulted before applying them elsewhere:

The cost of hauling given above is on the basis of $1.25 per ton, or $2.50 per day for a man and team, making two trips.

The prices for digging and laying given above include board furnished by the ditcher. If the farmer furnishes board deduct about 20%. The prices for digging and laying are for average ground, except those in the last column, and should be increased for quicksand or very wet soils.

N. B.—To all estimates it is wise to add 5 per cent to 10 per cent for contingencies and engineering.

Example 4. What will be the cost of 2000 feet of 6 in. tile drain, 2 1-2 miles from the tile yard, of which 1000 feet is 4 feet deep, 500 feet 5 feet deep and 500 feet deep, in average soil?

Answer:

| | |
|---|---|
| 2000 ft. of 6 in. tile @ $40.00 | $ 80 |
| Hauling 2000 ft. 2½ miles @ $3.75 | 7½ |
| Digging and laying 60.6 rods 4. ft. deep @ 50c | 30½ |
| " " " 30.0 rods 5 ft. deep @ 65c | 19½ |
| " " " 30.3 rods 6 ft. deep @ 80c | 24 |
| Refilling 121.2 rods (by steam) @ 2c | 2½ |
| | $164 |
| Add 10% for engineering, etc. | 16 |
| Estimated cost | $180 |

Example 5. What will be the probable cost of 1-2 mile of 15 inch main drain for a county drainage district, wet soil, the haul being 7 1-2 miles, 1-4 mile of the drain being 6 ft. deep and the remainder 4 ft?

Answer:

| | |
|---|---|
| 2640 ft. of 15 in. tile @ $250 | $ 660 |
| Hauling 2640 ft. 7½ miles @ $46.87 | 124 |
| Digging, laying and refilling 80 rods 4 feet deep @ $1.40 | 112 |
| Digging, laying and refilling 80 rods 6 feet deep @ $2.10 | 168 |
| | $1064 |
| Add 10% for contingencies and engineering | 106 |
| Estimated cost | $1170 |

## COST OF OPEN DRAINAGE DITCHES.

The cost of open drainage ditches in estimated by the cubic yard.

To calculate the number of cubic yards per foot of length of ditch multiply the average width by the average depth and divide by 27. Thus a 7 ft. x 12 ft. ditch contains $\frac{7 \times 12}{27} =$ 3 1-9 cubic yds. per foot length.

The cost per cubic yard in Iowa varies from 7c to 18c, depending on the size of the job, the character of the soil, and other local conditions, including the certainty of the contractor getting his money promptly. The larger the work the less is the cost per cubic yard.

The tables for open ditches are calculated by the well known, Kutter's formula, using a "coefficient of roughness" equal to 4.030. The coefficient of roughness is the value recommended by Kutter for channels in moderately good condition having stones and weeds occasionally, and agrees with actual guagings of drainage channels made at the Iowa State College. For ditches in first-class condition, the number of acres may be increased about 25 per cent. The tables have been calculated for ditches having sides with slopes of one foot horizontal to one foot vertical but are approximately correct for other slopes.

The capacity of the ditches has been made as recommended by C. G. Elliott, U. S. Agricultural Department drainage expert, as follows, the ditches to run not more than 8-10 full for the capacities mentioned:

Above the heavy upper line, (tables 2, 3, and 4) 3-4 in. depth of water per 24 hours.

Between the heavy lines 1-2 in. depth of water per 24 hours.

Below the lower heavy line 1-4 in. depth of water per 24 hours.

Local conditions may vary the size needed, and it is necessary to consult a drainage engineer in each case.

Example 6. What width of ditch, having a fall of 5 feet per mile, and a depth of water 3 feet, will be required to drain an area of 5 square miles (3200 acres)?

Answer. About 12 feet.

Example 7. What size ditch having a fall of 3 ft. per mile,

TABLE 4. NUMBER OF ACRES DRAINED BY OPEN DITCHES

Depth of Water 3 feet. Depth of Ditch at least 4 feet.

| Grades | | Average Width of Water | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Per cent | Feet per mile | 4 feet | 6 feet | 8 feet | 10 feet | 15 feet | 20 feet | 30 feet | 50 feet |
| 0.02 | 1.0 | | | 725 | 970 | 1570 | 2240 | 5300 | 18400 |
| 0.04 | 2.1 | 400 | 690 | 1000 | 1360 | 2250 | 4700 | 7470 | 26100 |
| 0.06 | 3.2 | 492 | 850 | 1260 | 1690 | 2770 | 5770 | 18400 | 31900 |
| 0.08 | 4.2 | 572 | 980 | 1460 | 1950 | 4820 | 6670 | 21400 | 37400 |
| 0.10 | 5.3 | 636 | 1100 | 1630 | 2180 | 5360 | 7440 | 23700 | 41400 |
| 0.15 | 7.8 | 791 | 1330 | 2010 | 2670 | 6600 | 19000 | 30200 | 52100 |
| 0.20 | 10.6 | 905 | 1560 | 2210 | 4720 | 7870 | 21800 | 35000 | 60300 |
| 0.25 | 13.2 | 1020 | 1740 | 2660 | 5300 | 17500 | 24600 | 39000 | 67700 |
| 0.30 | 15.8 | 1100 | 1970 | 2900 | 5850 | 19400 | 26800 | 42700 | 74000 |
| 0.40 | 21.1 | 1300 | 2290 | 5050 | 6740 | 22200 | 30800 | 49400 | 85700 |
| 0.50 | 26.4 | 1475 | 2550 | 5620 | 7500 | 24800 | 34800 | 55300 | 95200 |
| 0.60 | 31.7 | 1600 | 2790 | 6230 | 16500 | 27200 | 37700 | 60400 | |
| 0.70 | 37.0 | 1720 | 3010 | 6650 | 17800 | 29400 | 41200 | | |
| 0.80 | 42.2 | 1850 | 4850 | 7170 | 19100 | | | | |
| 0.90 | 47.5 | 1955 | 5140 | 7550 | 20100 | | | | |
| 1.00 | 52.8 | 2050 | 5400 | 7980 | | | | | |

Depth of Water 5 feet. Depth of Ditch at least 6½ feet.

| Grades | | Average Width of Water | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Per cent | Feet per mile | 6 feet | 8 feet | 10 feet | 15 feet | 20 feet | 30 feet | 50 feet |
| 0.02 | 1.0 | 980 | 1470 | 1900 | 5000 | 7150 | 23800 | 43800 |
| 0.04 | 2.1 | 1390 | 2090 | 2800 | 7200 | 20400 | 33500 | 62500 |
| 0.06 | 3.2 | 1710 | 2560 | 5100 | 17600 | 24700 | 40800 | 75500 |
| 0.08 | 4.2 | 1980 | 2980 | 6100 | 20400 | 30000 | 48800 | 88000 |
| 0.10 | 5.3 | 2220 | 5010 | 7600 | 23400 | 33400 | 54500 | 98000 |
| 0.15 | 7.8 | 2720 | 6300 | 17100 | 28700 | 40500 | 66700 | 120000 |
| 0.20 | 10.6 | 4820 | 7300 | 19500 | 33000 | 47000 | 77000 | 139000 |
| 0.25 | 13.2 | 5370 | 16300 | 21900 | 37500 | 53000 | 86000 | 155000 |
| 0.30 | 15.8 | 5900 | 17900 | 23900 | 40700 | 57000 | 94000 | 170000 |
| 0.40 | 21.1 | 6830 | 20600 | 27700 | 47000 | 67000 | | |
| 0.50 | 26.4 | 7600 | 23000 | 31000 | | | | |
| 0.60 | 31.7 | 16700 | 25200 | 33900 | | | | |
| 0.70 | 37.0 | 18100 | 27300 | | | | | |
| 0.80 | 42.2 | 19000 | | | | | | |
| 0.90 | 47.5 | 20500 | | | | | | |

Depth of Water 7 feet. Depth of Ditch at least 9 feet.

| Grades | | Average Width of Water | | | | | |
|---|---|---|---|---|---|---|---|
| Per cent | Feet per mile | 8 feet | 10 feet | 15 feet | 20 feet | 30 feet | 50 feet |
| 0.02 | 1.0 | 2300 | 4700 | 16600 | 28000 | 48000 | 88500 |
| 0.04 | 2.1 | 4850 | 6740 | 23400 | 35400 | 58000 | 106000 |
| 0.06 | 3.2 | 5920 | 17000 | 29600 | 43400 | 72000 | 129000 |
| 0.08 | 4.2 | 6940 | 19100 | 34200 | 50000 | 83000 | 150000 |
| 0.10 | 5.3 | 7720 | 21800 | 38400 | 56000 | 92600 | 167000 |
| 0.15 | 7.8 | 19400 | 27000 | 47200 | 68500 | 112000 | 202000 |
| 0.20 | 10.6 | 22400 | 31300 | 54200 | 78700 | 130000 | 235000 |
| 0.25 | 13.2 | 25000 | 34800 | 60500 | 88000 | 146000 | |
| 0.30 | 15.8 | 27400 | 38200 | 66200 | 96500 | | |
| 0.40 | 21.1 | 31700 | 44100 | | | | |
| 0.50 | 26.4 | 35400 | | | | | |

Depth of Water 9 feet. Depth of Ditch at least 11⅓ feet.

| Grades | | Average Width of Water | | | | |
|---|---|---|---|---|---|---|
| Per cent | Feet per mile | 10 feet | 15 feet | 20 feet | 30 feet | 50 feet |
| 0.02 | 1.0 | 6550 | 27800 | 40800 | 69500 | 127000 |
| 0.04 | 2.1 | 18500 | 34400 | 50000 | 83500 | 157000 |
| 0.06 | 3.2 | 22600 | 41600 | 61000 | 103000 | 193000 |
| 0.08 | 4.2 | 26300 | 48300 | 71000 | 120000 | 221000 |
| 0.10 | 5.3 | 30400 | 54000 | 79100 | 132000 | 244000 |
| 0.15 | 7.8 | 37300 | 66100 | 96200 | 162000 | 298000 |
| 0.20 | 10.6 | 42900 | 76200 | 104000 | | |
| 0.25 | 13.2 | 48000 | 85300 | 125000 | | |
| 0.30 | 15.8 | 52500 | 93200 | | | |
| 0.40 | 21.1 | 60800 | | | | |

and 9 ft. depth of water, will drain an area of three townships (69120 acres)? Ans. About 22 feet.

### CONTRACT AND SPECIFICATIONS FOR TILE DRAINS.

Many disputes between property owners or road officers and tile contractors would be prevented, and better work could be required and secured, if a definite written contract

were made out and signed in the beginning, containing as a part thereof a complete set of printed specifications. On this account it is strongly recommended that in each case the following form of contract and specifications, modified from those recommended by Mr. C. G. Elliott, should be filled out and signed by both parties.

The engineer should be called in during construction, and on completion of the work, to see that the contract and specifications, together with the map and profiles, are strictly complied with.

CONTRACT.

It is hereby agreed between..... employer, and....., contractor, that the contractor shall, except for the furnishing of the tile along the ditch and the refilling of the ditch, entirely construct for the employer the following described drains:

.....

.....

.....

.....

.....

It is further agreed that for the above work the employer shall pay the following prices:

.....

.....

.....

It is further agreed that the employer..... .....furnish board free to the contractor and his helpers during active prosecution of the work.

It is further agreed that the contractor shall begin the work by ..... and complete the same by .....

It is further agreed that all the above work and the payments therefore shall be in strict accordance with the specifications given below and with the engineers' maps, profiles, and plans, all of which are hereby made a part of this contract.

Witness the hands of the respective parties, this..... day of ..... A. D. .....

..... Employer

..... Contractor

SPECIFICATIONS.

1. *Staking out the Work.* The work will be staked out by the engineer, and his stakes must be carefully preserved and followed.

2. *Digging the Ditches.* The digging of each ditch must begin at its outlet, or at its junction with another tile drain, and proceed toward its upper end. The ditch must be dug along one side of the line of survey stakes, and about ten inches distant from it, in a straight and neat manner, and the top soil thrown on one side of the ditch and the clay on the other. When a change in the direction of ditch is made, it must be kept near enough to the stakes so that they can be used in grading the bottom. In taking out the last draft, the bade of the spade must go not deeper than the proposed grade line or bed upon which the tiles rest.

3. *Grading the Bottom.* The ditch must be dug accurately and truly to grade at the depths indicated by the figures given by the engineer, measured from the grade stakes. At each grade stake a firm support shall be erected, and on these supports a fine stout cord shall be tightly stretched over the center line of the ditch and made parallel with the grade by careful measurements at each stake, using a carpenters level. Supports shall be kept erected at at least three grade stakes, and the work checked each time by sighting over them. Intermediate supports shall be set and lined in by careful sighting wherever necessary to support the cord every 50 feet. A suitable measuring stick shall be passed along the entire ditch and the bottom in all parts made true to grade by measuring from the cord. The bottom must be dressed with the tile hoe, or in the case of large tiles with the shovel, so that a groove will be made to receive the tile, in which the tile will remain securely in place when laid.

4. *Laying the Tile.* The laying of the tile must begin at lower end and proceed up-stream. The tile must be laid as closely as practicable, and in lines free from irregular crooks, the pieces being turned about until the upper edge closes, unless there is sand or fine silt which is likely to run into the tile, in which case the lower edge must be laid close, and the upper edge covered with clay or other suitable material. When in making turns, or by reason of irregular-shaped tile, a crack of one-fourth inch or more is necessarily left, it must

be securely covered with broken pieces of tile. Junctions with branch lines must be carefully and securely made.

5. *Binding the Tile.* After the tile have been laid and inspected by the employer or his representative, they must be covered with clay to a depth of six inches, unless, in the judgment of the employer or his representatives, the tile are sufficiently firm, so that complete filling of the ditch may be made directly upon the tile. In no case must the tile be covered with sand without other material being first used.

6. *Risk During Construction.* The ditch contractor must assume all risks from storms and caving in of ditches, and when each drain is completed it must be free from sand and mud before it will be received and paid for in full. In case it is found impracticable, by reason of bad weather or unlooked-for trouble in digging the ditch, or properly laying the tile, to complete the work at the time specified in the contract, the time may be extended as may be mutually agreed upon by the employer or contractor. The contractor shall use all necessary precaution to secure his work from injury while he is constructing the drain.

7. *The Tile to be Used.* Tile will be delivered on the ground convenient for the use of the contractor. No tile must be laid which are broken, or soft, or so badly out of shape that they cannot be well laid and make a good satisfactory drain.

8. *Prosecution of the Work.* The work must be pushed as fast as will be consistent with economy and good workmanship, and must not be left by the contractor for the purpose of working upon other contracts, except by permission and consent of the employer. All survey stakes shell be preserved and every means taken to do the work in a first-class manner.

9. *Subletting Work.* The contractor shall not sub-let any part of the work in such a way that he does not remain personally responsible, nor will any other party be recognized in the payment for work.

10. *Plant and Tools.* The contractor shall furnish all tools which are necessary to be used in digging the ditches, grading the bottom, and laying the tile. In case it is necessary to use curbing for the ditches, or outside material for covering the tile where sand or slush is encountered, the employer shall furnish the same upon the ground convenient for use.

11. *Payments for Work.* Every ..... weeks during the persecution of the work the contractor may claim and the employer shall pay 75 per cent of the value of the work completed satisfactory, the engineer being the arbiter in case of dispute as to the amount of work satisfactorily completed. The remaining 25 per cent will be retained until the entire work is completed satisfactorily, as certified by the engineer, after a final inspection, at which time the whole amount due shall be paid. Prior to any payment the employer may require a correct statement of all claims incurred by the contractor for labor, materials or damages on account of the work, and the employer may withhold payments until proof has been presented by the contractor of release of all liens against the employer on account of such claims.

12. *Dutics of Engineer.* The engineer shall have authority to lay out and direct the work and to inspect and supervise the same during construction and on completion, to see that it is properly done in accordance with the contract. His instructions shall be fully carried out.

13. *Failure to Comply with Specifications.* In case the contractor shall fail to comply with the specifications, or refuse to correct faults in the work as soon as they are pointed out by the engineer or other person in charge, the employer may declare the contract void, and the contractor, upon receiving 75 per cent of the value of the completed drains at the price agreed upon, shall release the work and the employer may let it to other parties.

SIDE DITCHES.

The second system of drainage necessary for a well constructed road is side ditches. In road construction as it is quite generally practiced at this time in the state, the side ditches are carried at the same depth overthe hillsand through the lower places as are the road grades. In many places the dirt is much easier to move on the tops of the hills than in the lower places, with the result that usually the best grades are built on top of the hills. This is all wrong. The side ditches should be cut out and the dirt carried to the lower places, and unless the hill is to be materially lowered, the top surface, which has become compacted by the travel, should be left as it is.

*The first requirement of properly constructed side ditches is a continuous grade to an outlet*, and for this a *road contractor or superintendent should understand the use of a level and be able to lay out and plan the grade.*

The second requirement is that the ditches should be wide and comparatively shallow except where it is absolutely necessary to make a cut through the rise. This is necessary from the point of economy of first cost and of maintenance; also to lessen the danger to travelers, of a deep, narrow ditch. The water should not be carried further than is necessary in the side ditches as it increases the washing and also makes deep cuts necessary near the outlet to furnish the continuous grade. Where the road has considerable grade, careful attention should be given to prevent washing or undermining of the roadway, the gutter should be paved with stone or brick. It is frequently best in constructing side ditches, to provide for freshets by making the banks low on the outside at certain points which will allow an excess of water to escape without damage to the roadbed, as would be the case if a large quantity of water was carried a considerable distance in the side ditches.

### THE CROWN.

For the main traveled portion of the road, a crown of one inch to the foot is recommended with considerably steeper slopes outside of this to the side ditches. (See Fig. 9). The crown should be about three feet above the side ditches, that can be changed to meet the requirements and can be readily adjusted to different road grades. For a steep road grade the crown should be increased to throw the water to the side rather than allow it to run for a considerable distance on the road. On ordinary grades if a crown of one inch to the foot is maintained it will prove sufficient for proper drainage to the side ditches. On a 20-foot traveled way the rise at the center would be ten inches.

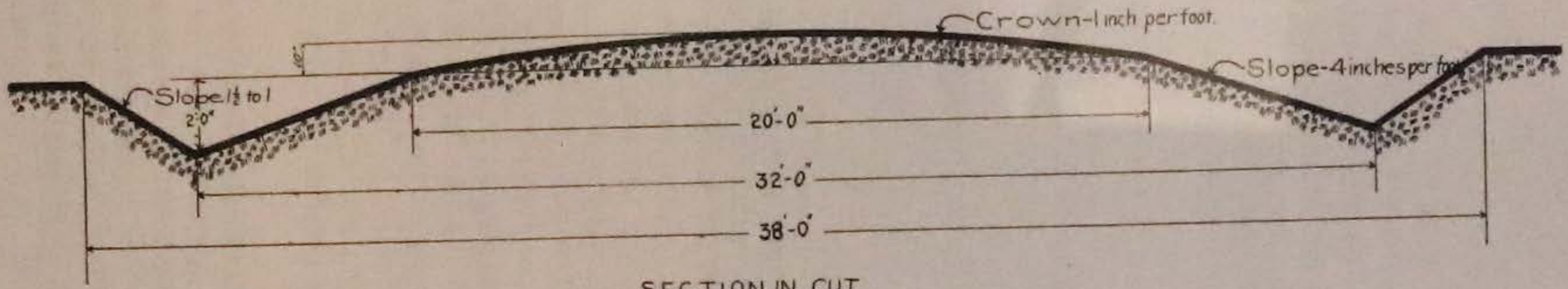
### 3. CONSTRUCTION OF AN EARTH ROAD.

In the construction of an earth road the first important consideration, as has been stated, is securing adequate drainage. This has been considered fully the preceding article.

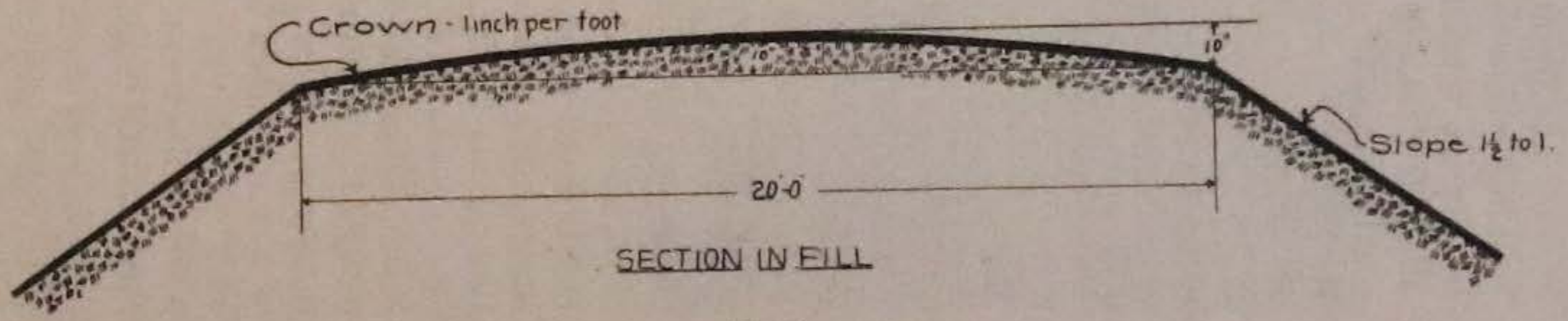
# CROSS SECTIONS of EARTH ROADS

IOWA HIGHWAY COMMISSION

April - 1905




SECTION IN CUT




SECTION IN FILL

Fig. 9

(a) CROSS SECTION.

The accompanying figure, No. (9), is given as the preliminary cross section of an earth road, which is recommended by the Commission for use on the main traveled roads. This has been designed after a careful study of the best types of earth roads that are found in the state at this time. The traveled way is twenty feet wide. This is ample room to accommodate all the ordinary traffic found on even the most traveled country roads, but is also not too wide to be easily maintained in proper condition. The side ditches are wide and sufficiently deep, but the slope to the bottom is so gradual that the entire width of the graded portion could be used if necessary in turning out to pass another team, and a wagon could be driven to the bottom of the ditch with no danger of overturning. The advantages of such construction are very apparent. The outside of the banks are sloped away at a 1 1-2 horizontal to 1 vertical slope. This is the angle of repose or angle at which earth will stand without caving, and the bank is more easily maintained in this shape. A rounding or parabolic contour with the shoulders well rounded is to be strongly recommended. This shape allows the travel to be distributed over a considerable portion of the road, keeping down the wear. Also the tendency of earth roads is to wear quite rapidly, but the parabolic form is less easily hollowed out than if the road is first constructed with two plane surfaces meeting at a point in the center. This last construction is the one most frequently met with in the state. The road superintendent begins at the side ditch and makes a continuous slope from the bottom of each side ditch to the center of the road, leaving there in most cases a pile of sod and clods that is never touched by the travel if possible. This shape very soon wears hollow on each side and the water cannot escape to the side ditches but runs or stands in the traveled way.

The cross section for the embankment has the same width of traveled way as the section in the cut with the side slopes carried down to a slope of 1 1-2 to 1. This slope is recommended for use as it is the angle of repose for ordinary earth work. If, however, it is possible, without too greatly increasing the expense, it would be preferable to use on main traveled roads a slope of 3 to 1.

(b) CLEARING.

In some localities there is there is a consederable growth of timber or brush along the right of way; in other localities "niggerheads" or boulders are scattered quite thickly over the surface. In such places it will be necessary, before com-

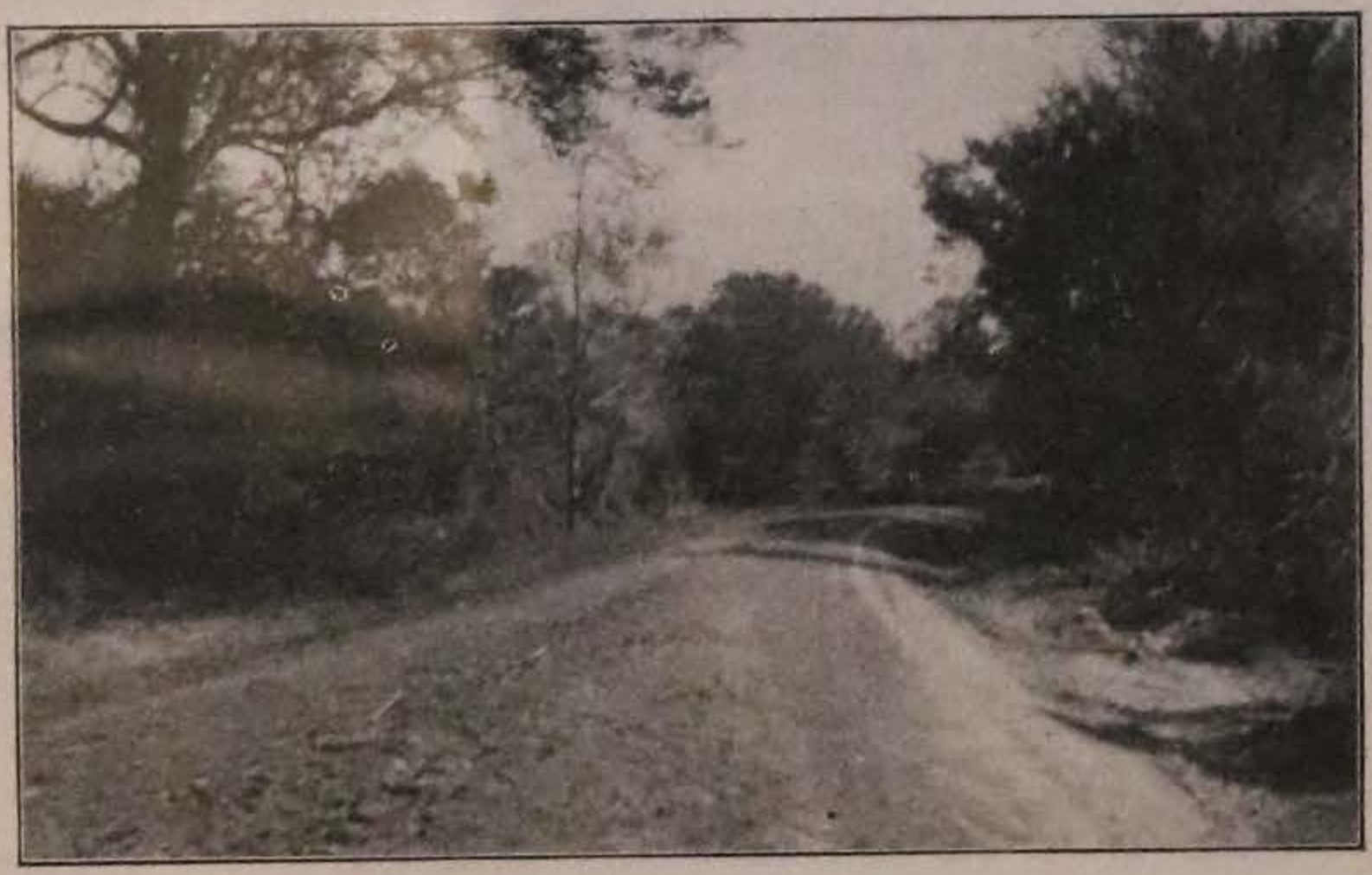


Fig. 10—A WELL BUILT EARTH ROAD IN CARROLL COUNTY

mencing the construction, to clear the location. Figure No. (10) is given showing the construction of an earth road through a wooded district which was cleared of stumps and quite large trees at a minimum cost, by the use of dynamite. While it is necessary to place this explosive in the hands of a competent person and to maintain every precaution to guard against accidents, it can be very highly recommended for this purpose.

(c) SELECTION OF MATERIALS.

Where grades have been put up by using the so-called "gumbo" of the flat portions of the state, they have quite generally proved unsatisfactory. When saturated with water this material seems to "melt" away and a grade soon disappears unless the location is first well drained. In a plastic state, it rolls so badly that the wheels frequently cannot be turned and when dried in this condition it bakes so hard it

cannot be worked. These last conditions can be considerably helped by building the top of the "hill dirt." One serious objection to the use of the side dirt in these low stretches is the lowering of the side ditches below the outlet. Vegetable and loamy soil should also be avoided as much as possible.

In many cuts pockets of quick sand occur and material from these should be carefully avoided. All sod should be plowed or cut by the road machine in as thin layers as possible to facilitate handling and it should always be placed in the bottom of the grades. There is no excuse for leaving a line of heavy chunks of sod in a road. If plowed or cut thin, sod can be considerably broken up by the handling and it will also be compacted by the horses' hoofs and the passage of the wheels over in building the embankment.

### (d) COST OF EARTHWORK.

Without going into details as to the amount that earthwork ought to cost, the following figures are given as the prices at which earthwork has been let by contract in a few counties in Iowa.

*Carroll County.* The work of grading the roads complete has been let in one supervisor's district in this county at 70c per rod. This includes all work that can be done with a road machine but does not include any wheel or slip scraper work.

*Calhoun County.* One contractor in this county gives the following prices at which he has been taking contracts:

> Elevating Grader Work—Delivery direct to embankment—4 1-2c to 6c per cubic yard.
>
> Wheel Scraper Work—7c to 12c for hauls up to 200-300 feet, and 1c per yard of overhaul, that is, 1c for a cubic yard hauled 100 feet over the free haul limit. Where the haul is long the elevating grader is used to load dump wagons and the price depends on the length of the haul.

*Kossuth County.* Slip and wheel scraper work 7c to 15c per cubic yard.

These are only a few examples of contract prices but they serve to show the economy of this system of letting the work by contract, provided the drawing up of the contract and the measurement of the earthwork is handled by a competent man.

Whether the work is let by contract or not ,the number of cubic yards should be measured in every case, and the cost to the public per cubic yard ascertained. It is best to have this done by a surveyor. For the lack of this one thing a large part of our road money is being wasted every year, for neither the public nor road officers would tolerate, for a moment, the inefficient methods in use, if they knew the actual cost and waste of money.

### 4. ROAD MACHINERY.

The road officers of Iowa in their efforts to improve the road situation have been too easily influenced to buy various machines which have proven of little value to them, either because the machines were not designed to meet the requirements or because they were not properly handled. In many places the road situation has become almost desperate and almost new road implements and machines have been discarded to give way to something just enough different to give promise of better results. As a result of this practice the counties and townships now have a considerable investment tied up in various kinds of machinery and by far the largest percentages of this is in the so-called road machine or scraping grader.

Some of the townships, under the old system, were divided into a number of smaller districts, each of which owned one of these graders. The manufacturers have pushed the sale of these machines representing them as the ultimate solution for all the road problems which exist. A short review of the various machines now in use is given to aid in selecting machinery.

DRAG OR SCOOP SCRAPERS. The drag or scoop scrapers also commonly known as "slips" or "slushers." For two horses these are made in two sizes, which hold about 5 and 7 cu. ft. respectively. The larger size will put in the embankment in ordinary use not to exceed 6 cu. ft. This limits the proper use of this scraper entirely to side work and it should never be used when the earth is to be hauled even short distances along the road.

WHEEL SCRAPERS. There are three sizes of wheel scrapers, holding approximately 9, 12 and 17 cu. ft. each. The smallest size the No. 1 is most used in Iowa and unfortunately this is a size that the counties or townships positively should

not buy. It is not uncommon to see a snap team used in loading these. Neither is it uncommon to see long hauls being made with the team arriving at the dump with an almost empty scraper. In practically all places where wheel scrapers should be used there will be a light down hill pull after filling. There is a No. 2 1-2 scraper that can be handled without difficulty by an experienced holder, and which carries twice as much per load as the No. 1. It is true that the No. 1 wheeler costs something less that than the larger sizes, but between the larger drag scraper and the No. 2 wheeler, there is no place for the No. 1 size. One of the greatest causes of waste of our road money is the use of small scrapers to haul long distances. No contractor would tolerate, for a moment, the methods very frequently used in our road work, nor would the public, if they knew, how the road money is being wasted.

The wheel scraper can be used economically in short hauls up to about 300 feet and is of particular value in cutting out the side of ditches where the road drainage is to be carried through a knoll or rise in the ground.



The road machine also commonly called the road grader or reversible grader, is a suitable machine for finishing a road. After the cuts and fills necessary have been made along a stretch of road the grade can be finished effectively, and economically with this machine. It is, however, an exceptional stretch of ground that could be effectively built into a finished road by the use of this machine alone. It often seems, however, that the prevalent idea of road construction is to drive one of these machines over a piece of road cutting the side ditches the same depth over hills and hollows alike, and making the same cross section for the whole length of road. This method of road making is as incorrect as the old slip scraper methods under the old labor tax system.

The common way, during the past few years, of working the roads with one of these machines has been for the township superintendent to hire men and teams near the strip of road on which he is to work. Each man is allowed to drive his own team and there is one man on the grader to operate, which makes three to five men and four teams necessary for

the operation of the machine. This is not economical or efficient. The best driving can be done by one man skilled in the work and the machine should always be operated by a man who is a skilled road builder.

The training of the teams is a considerable task in itself and when once teams are secured which will work well together they should be used continually. If the grader is not to be operated in a country where a considerable amount of mud will have to be encountered mule teams make the best animals for this work. In wet or muddy places, however, they are not so dependable as are horses.

The accompanying cut shows the outfit of one contractor for such work. He has an eight mule team trained so that one man handles them with ease in the most difficult places.

Fig. 11—An Efficient Well Trained Team for Road Building

The field of utility for this machine is a large one where there are grades to be finished or where the country is rolling enough so that high grades are not needed, but it is not an economical machine to use for simple road maintenance nor can it be used economically where dirt has to be moved lengthwise of the road.

### THE ELEVATING GRADER.

The elevating grader is being used with considerable suc-

cess in many parts of the state where dirt must be hauled. There are parts of the state that are so flat it is necessary to build road grades that water will not cover in wet times and and the elevating grader can be used with considerable success if care is taken, to *construct the side ditches to a continuous grade*, and *not to deepen them below an outlet*.

In a more rolling district these machines can be used to good advantage to load dump wagons, but experience so far seems to indicate that it is usually not a good investment for a township to spend the large sum necessary to purchase, or to try to operate one of them, with an unskilled set of men. There is a large sum of money tied up in such a machine, which is used only during a small part of each year. Also it requires a trained crew of men and horses, and a complete outfit for "camping on the job" to prevent loss of time. If the machince is owned by the county, however, it can be operated very successfully in this way provided a competent man is secured as foreman. It would perhaps in most instances be preferable to let the work to a contractor owning such an outfit, after receiving competitive bids per cu. yd., as his profits then depend directly on the results he obtains. It is absolutely necessary in the use of both the ordinary reversible machine and the elevating grader that experienced and competent men be placed in charge of them and that the horses or mules used be trained for the work.

## STONE CRUSHERS.

There are only a very limited number of stone crushers owned by counties in the state. There is no reason why such a plant could not be run successfully by the counties, but so far their operation seems to be unnecessarily costly. A rotary screen should be fitted up in connection with the crusher and when the material is to be used for road construction it should be separated into three sizes. Three sizes commonly are 2 1-2", 1 3-4", 3-4", the last is also known as the screenings.

Stone crushing plants are going to be a necessity in the future, in many cases where local material is available for stone roads.

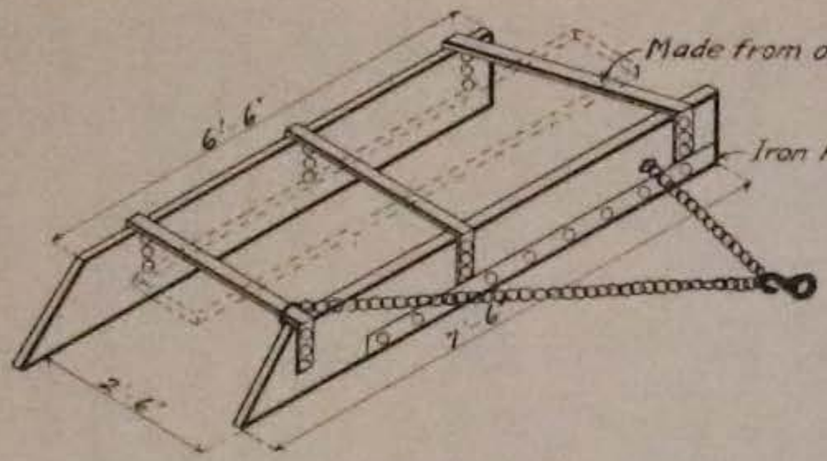
## 5. ROAD MAINTENANCE.

The work of road maintenance for earth roads is largely one of keeping the drainage system free from obstructions and of providing free outlet for the water. This naturally refers back to the three systems of drains which are necessary for a properly constructed earth road, viz., sub-drains, side ditches, and crown.

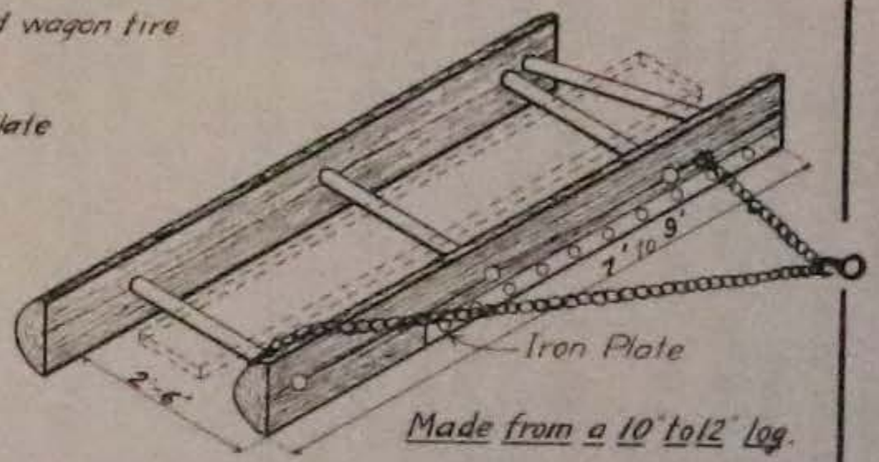
(*a*) *Sub-drains.* Where tile have been laid to take the ground water the outlets should be carefully examined from time to time and any necessary repairs made at once. This will consist in removing brush and drift which frequently collect around the tile outlet and in keeping the screen or grating, which should be placed at the end of the tile, free from obstruction. Where tile outlets are into a stream or slough it may frequently be necessary to dig away a considerable amount of sediment deposited by the spring floods to provide a free egress for the water, and in some cases a few lengths of tile near the opening may have to be taken up and replaced with new ones or cleaned.

(*b*) *Side Ditches.* If side ditches are constructed, as advocated in the article on road construction, with sloping sides, there will be less danger of stoppage by loose material which is drifted by the wind into the road and held by vertical banks. Weeds and grass should be cut at the proper season by the road superintendent and if it is in any considerable amount it should be raked in piles and burned. Where side ditches are beginning to wash badly they should be paved with some kind of stone or brick or the water carried through tile for the necessary distance.

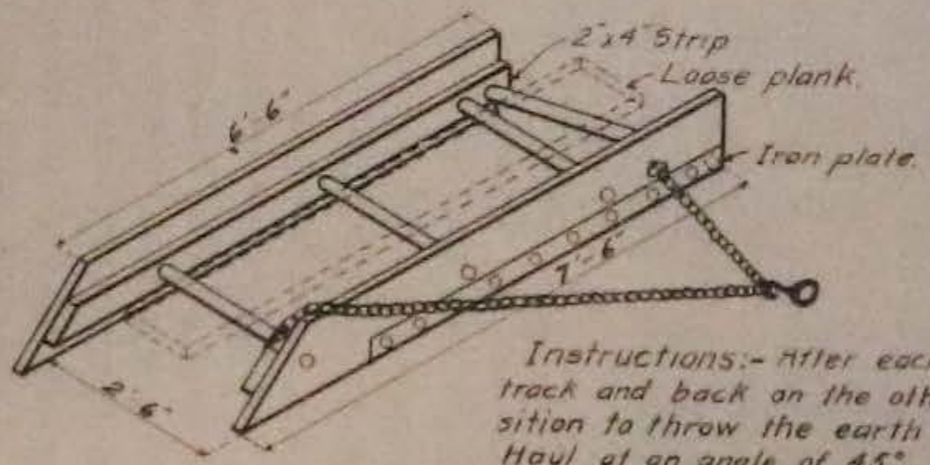
(*c*) *Crown.* To keep a road from being damaged by water it is absolutely necessary to preserve the crown. The whole tendency of the traffic over any road is to wear its surface into a series of hollows or ruts, and the impact of the wheels and the horses' feet grinds the materials into a dust which is picked up and carried by the winds and water so that the crown of the road, particularly of an earth road, is quickly destroyed. As soon as these ruts form the water will stand in them and soften the surface, and each additional team or vehicle deepens them considerably, destroying the surface, and frequently in prolonged seasons of wet weather making the earth road almost, or quite, impassable even to light traffic.




Cut from a 2" x 12" - 14' Plank.




Made from a 10" to 12" log.




# THREE PLANS
FOR
# THE KING ROAD DRAG
IOWA HIGHWAY COMMISSION

May 1905

Instructions:- After each rain drive up one side of the wheel track and back on the other side at least once, with drag in position to throw the earth to the center. Ride on the drag. Haul at an angle of 45°.

Gradually widen the strip dragged as the road improves.

To round up the road better, plow a shallow furrow occasionally each side of the dragged strip, and work the loose dirt to the center.

Fig. 12

THE KING ROAD DRAG.

The accompanying cut, Figure (12), shows the King road drag which has been so widely advocated in the state during the past year. This device is so absolutely simple and inexpensive that the great benefits to be derived from its use are lost sight of by people who demand a complicated arrangement of gears and levers. There is nothing particularly new in the idea which bears the name of Mr. King, as in many parts of this and other states farmers have used quite similar devices to keep earth roads in condition. Mr. King, however, has made more of a success of its use than any other man and has given other people the benefit of his experience in a number of ways, first, through the State Board of Agriculture of Missouri, and next, by a trip which he made through fifteen counties of this state in a special car furnished by one of the leading railroads.

The theory of the use of the King or "split log" drag is very simple. If the surface of an ordinary road is smoothed after each rain the ruts formed are filled and the road is in condition to shed the next water which falls upon it. The drag is hauled at such an angle that a little earth is moved toward the center of the road each time, building up a crown by almost imperceptible degrees. If our ordinary soil is subjected to continual wetting and mixing it is puddled thereby and in this condition can be moulded into shopes that will not hold water. The same thing is met with on the main traveled country roads where the water stands in the ruts and hollows until the surface is thoroughly softened and then the wheels and horses's hoofs mix and pack the earth into a series of cups which will hold water until it evaporates. This is particularly true of gumbo soil and also of clay. Earth containing a considerable percentage of sand or vegetable matter will not puddle. In addition to preparing the road surface to receive the next rain, the action of the drag also distributes this puddled earth over the road in a thin layer which is beaten and packed by the traffic into a very hard surface. The gumbo soils will hold up in this condition under heavy traffic for considerable period of time, even with water standing on each side of the travelled way.

The cost of the implement is very low, varying from $.75 to $2.50 apiece. Road officers should furnish a drag to any

farmer who will promise to use one on a stretch of road. They should also take up the device to use in maintaining earth road.

The economy of using this implement is apparent. For ordinary widths of road one team and one driver will go over a considerably longer stretch of road than will four teams and two men with a road machine when the object is only to smooth the roads. This device is shown in the accompanying cut as constructed of the two pieces of a split log, or of two planks, fastened together with braces about 30 inches apart, and fitted with a chain long enough to hold the double-trees about 2 feet from the drag and arranged so that the angle at which the drag is hauled can be adjusted. For ordinary use this will be about 45°, or quartering to the axis of the road.

The time to use the drag is after each wet period when the road is beginning to dry. If there are many ruts and hollows to fill it would be better to use four horses and go over the road when it is quite wet but after it has been dragged a few times the surface will dry more evenly and the time to use the drag then will be when the material is dry enough to work away from the front of the machine easily. The driver should always ride on the drag and after using it a few times he will

Fig 13—Undragged Road in Sac County, March 28, 1905

learn how to adjust his position so as to move more or less dirt at will. The use of this implement is strongly urged by the Commission as it has proven entirely successful in practical use in many sections of the state. Figures Nos. (13)

Fig 14—Dragged Road in Sac County
View taken March 28, 1905

and (14) were taken in Sac County to show a road on which the drag had been used in comparison with an undragged road.

Figure No. (15) is a view of the C. & N. W. Good Roads Special car taken at Eagle Grove.

## GRAVEL ROADS.

For a certain per cent. of our public highways, which will include the main travelled roads, it is the conclusion of the Commission that some surfacing material such as gravel or broken stone will have to be used and there is no reason why counties should not begin this construction now to the full extent possibly by setting aside for it a material percentage of the present road funds.

a. *Material.* Gravel is quite liberally distributed in many parts of the Iowan drift sheet and along the terminal borders

Fig 15—The C & N. W. R. R. Good Roads Car—Eagle Grove, Iowa

of the Wisconsin drift area. It is also found quite well distributed along the streams of these areas and also along some of the streams that flow through the Kansan drift area.

Bank gravel usually contains a certain amount of clay which makes a good binding material, if it is not present in too large quantities, and is well distributed through the material. The river or wash gravels do not always contain a sufficient quantity of the binder to pack when placed on the roads nd they must either have a certain amount artificially mixed with them, or they will not be thoroughly compacted until a certain amount of soil is carried on to them by the traffic. The material should be as carefully selected as possible and in hauling a man should be kept constantly at the pit to see that a uniform material is secured and that large stones are pitched out and that sand pockets, or other unsuitable material are carefully avoided.

Figure No. (16) shows a gravel pit near Coon Rapids. The gravel here contains a considerable percentage of stones too large to be used on the road. These may be seen in the foreground.

The cost of the material is in the neighborhood of $.30 to

Fig. 16—Gravel Pit near Coon Rapids, Iowa
Note pile of large stones discarded from gravel.

$.35 per cubic yard delivered on the road, if the haul is not too great and at this rate, after roads have been graded to the proper cross section, gravelling can be done for about $300 a mile. In other sections where material is not available it can be shipped by rail for considerable distances and used on the road without making the cost run too high, providing favorable freight rates can be secured.

b. *Placing the Material.* There is some difference of opinion and practice as to the proper way of placing the material on the road. A cross section of a gravel road is given in the accompanying Figure No. (17) which is recommended by the Commission. This cross section can be secured, after the earth is graded as shown, by placing one load of the material to each nine feet, or spreading with a grader to a width of about 10 feet, making the outside edge about 2 inches in thickness. After this layer is packed by the traffic a second layer should be added in the same manner as the first. It has been shown by results that this method will give excellent results, although some counties practice putting on two loads to each nine feet at the same time, dumping one on top of the other, while other localities dump two loads side by side. The gravel that has considerable binding material in it, so that it packs easily, can be spread more than one that contains little

PRELIMINARY

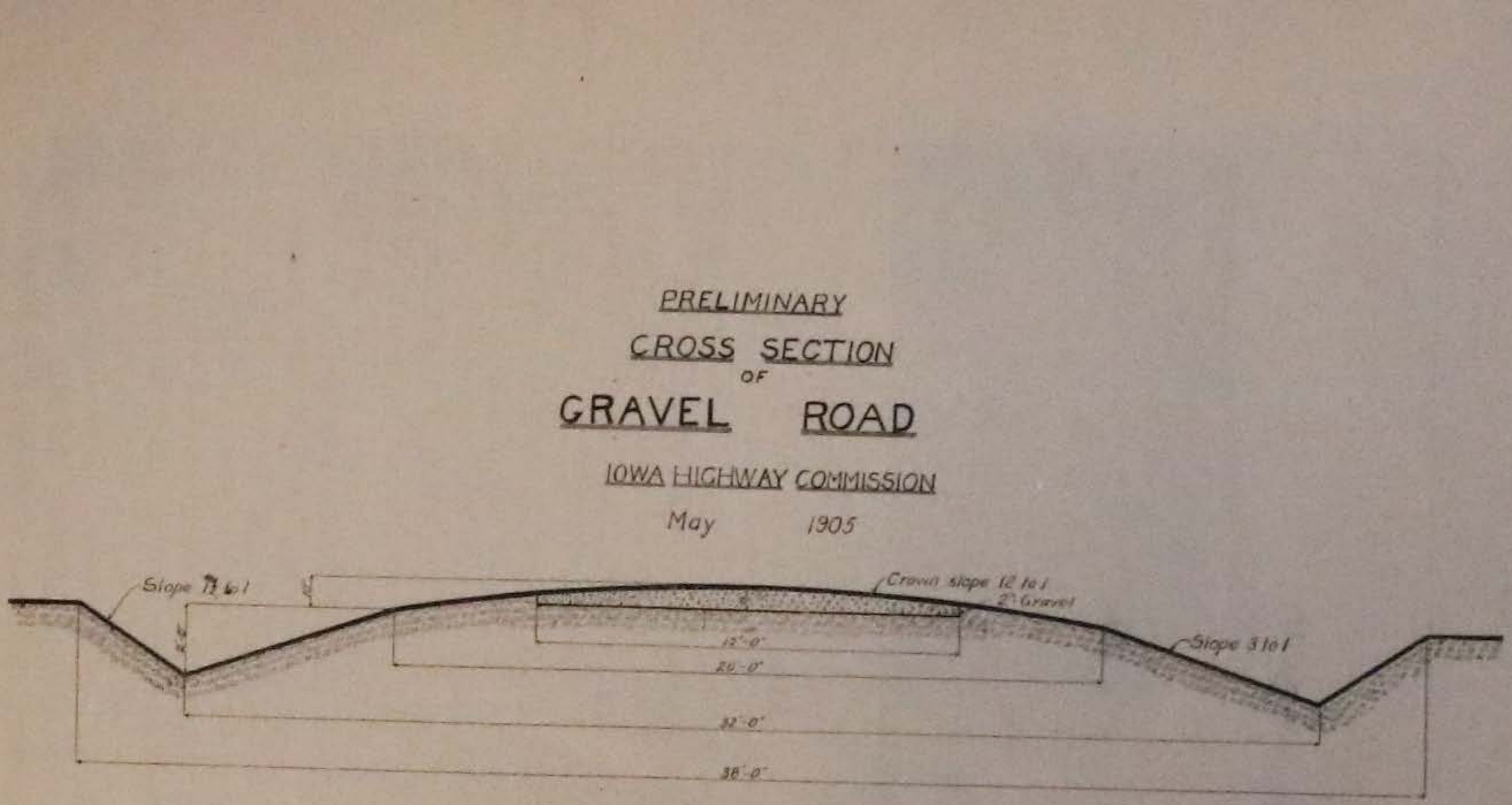
CROSS SECTION

OF

# GRAVEL ROAD

IOWA HIGHWAY COMMISSION

May 1905




SECTION IN CUT

Fig. 17

of this binder. With the first of these the traffic compacts it before there is any considerable waste, while if a gravel with little binding material in it is dumped on the road and spread, it wastes to the sides under the action of the traffic. About 15 per cent. of binding material seems to be the proper amount to use.

Gravels can be sent to the road materials' laboratory of the Iowa Highway Commission, Ames, Iowa, where they will be tested free—the binding materials determined and advice given.

Before attempting the construction of a gravel road careful attention must be given to the proper grade and drainage as these are essential. The more money invested in the surface

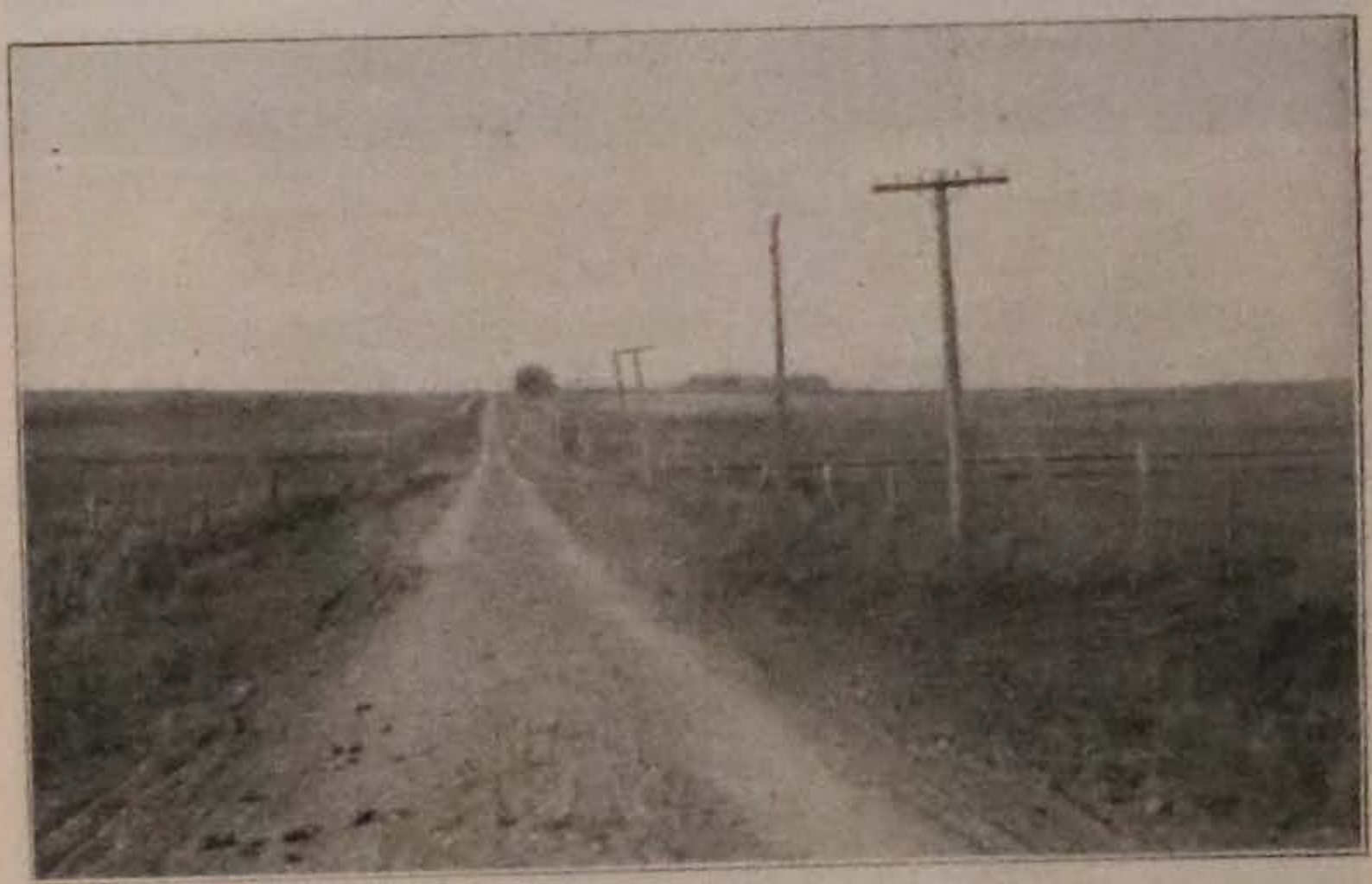


Fig. 18—Road Improperly Drained
This stretch has been gravelled several times bnt gravel has disappeared each time.

material the better should be the sub-grade. View No. (18) shows a country road in Carroll County which has been gravelled several times but each time it has disappeared owing to imperfect drainage. The gravel roads are very efficient during all the year if kept in shape by continuous maintenance such as the smoothing of the roads with the King drag or similar implement and by the addition of new material when the road "wears out" in places.

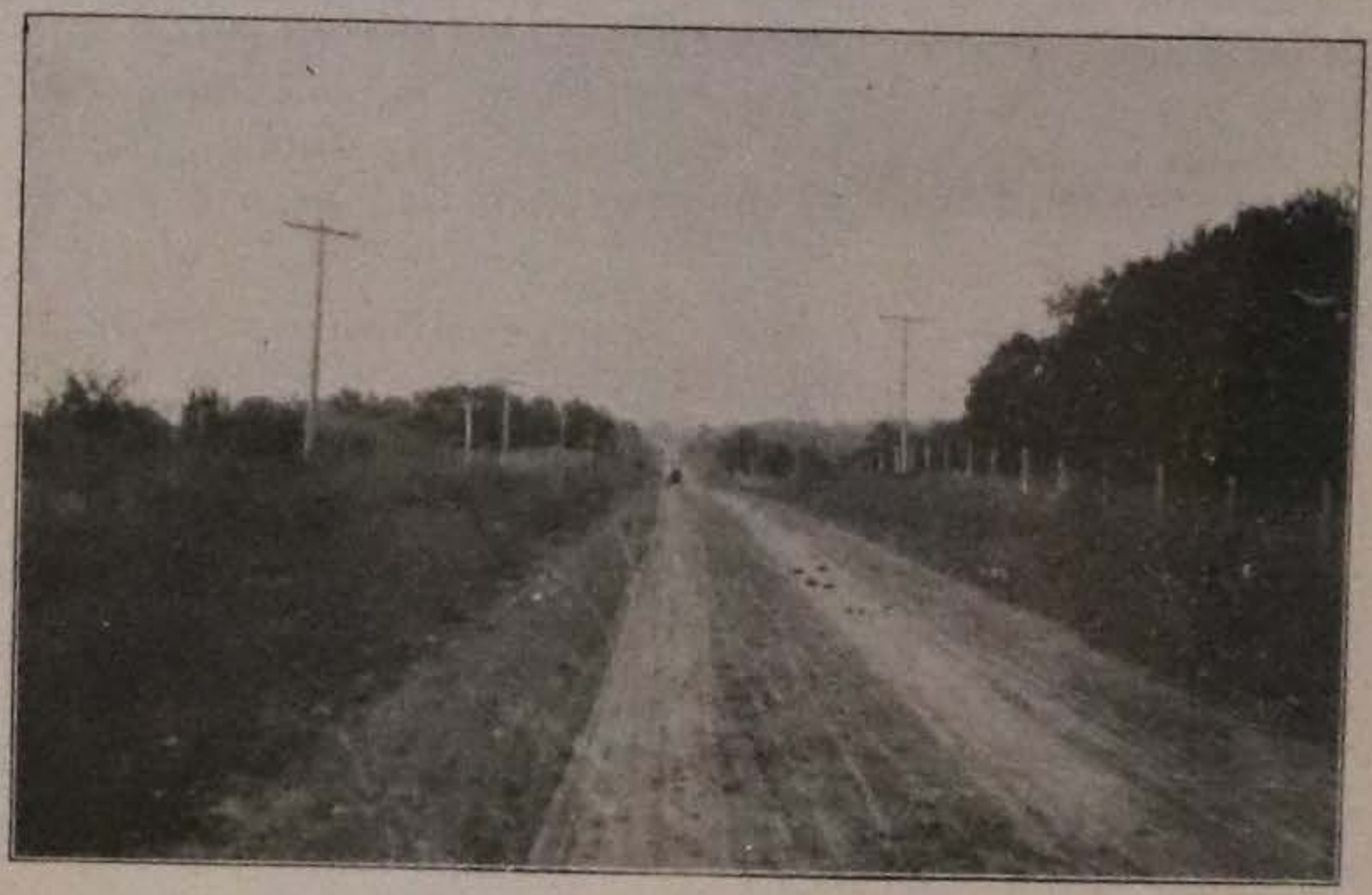


Fig. 19—A Well Built Gravel Road in Greene County

Figure (19) is of a well constructed gravel road in Greene County and Figure (20) shows effect of maintenance with King Drag.

Fig. 20 Gravel Road Showing Maintenance with a King Drag

## MACADAM ROADS.

There is no reason why the construction of macadam or broken stone roads should not begin at once in many counties. This does not mean the indiscriminate or haphazard way of building a stretch here and there that has characterized so much of this work. Rather it means a careful, systematic selection of the roads to be improved, which will be those radiating out from the business centers and which have the most traffic over them. By building short stretches each year only a short time would elapse before a county could have a system of main travelled roads that could be used at all times of the year. Expert advice can be obtained free from the Iowa Highway Commission, in planning and constructing such roads.

a. *The Material.* A considerable part of the eastern part of the state is underlain by limestone which outcrops at the surface in many places. Many of the stone crushing plants already operating, a partial list of which is included in this manual. Much of the limestone is somewhat too soft to be used as road material and most of it, also, should never be used it has been thoroughly dried or hardened. This is true of the stone which comes from the state quarries at Anamosa.

Materials sent to the road material laboratory of the Iowa Highway Commission, Ames, Iowa, will be tested free and advice regarding their use, given.

The cost of this stone from stone crusher plants in considerable quantities should not be over $.50 to $.60 per yard of 2,250 lbs. f. o. b. the quarry. The price of crushed stone is showing a marked decrease in some of the contracts recently let. There is no reason, as has been stated before, why a county should not operate a stone crusher economically and well. When the attempt is made, however, much care should be taken in selecting a competent man as foreman in charge.

Figure No. (21) is of a macadam road and earth road near it.



Fig. 21.—Views taken near Cedar Rapids, Iowa, showing an Earth and a Macadam Road, taken at the same time

## SECTION VI.

## CONCRETE FOR HIGHWAY IMPROVEMENT.

This work deals with a field now just developing in Iowa. In two or three eastern states where the "state aid" plan has been adopted, and where all permanent improvement of the highways is under state supervision, reinforced concrete is fast superseding all other material for culverts and bridges. Here, we have had a long and disastrous experience with various materials, and as yet have no fixed policy. The bridge tax until last year was limited to three mills and could be increased only by a vote of the people. A few counties increased their levy an additional mill in this way. More counties, however, neglecting to do this had become so badly indebted that the last General Assembly (The 30th) to relieve this condition passed an act raising the maximum levy to four mills. A number of counties have already taken advantage of this act and now have the maximum levy.

In addition to the bridge fund proper, as has been brought out before, a considerable part of the one-mill is devoted to bridge and culvert construction and maintenance. The actual sums thus involved are very large, and the loss to the state each year by poor administration of these funds is a heavy drain. It is very important that counties and townships adopt more permanent forms of construction for such structures.

1. Present Status. It is perhaps unnecessary to mention that the conditions which have to be met in introducing this form generally over the state, due to our present political organization, present a more or less difficult problem. In most of the counties townships required to build and maintain all small bridges and culverts up to 16 feet span. For each township there are usually three trustees, and in 99 counties, averaging 16 townships each, there are over 4,000 men whom it is necessary to convince that a type of construction radically different from the one which they are commonly using is better and more economical. Most of these men are practical men, who are making a success of their business, and

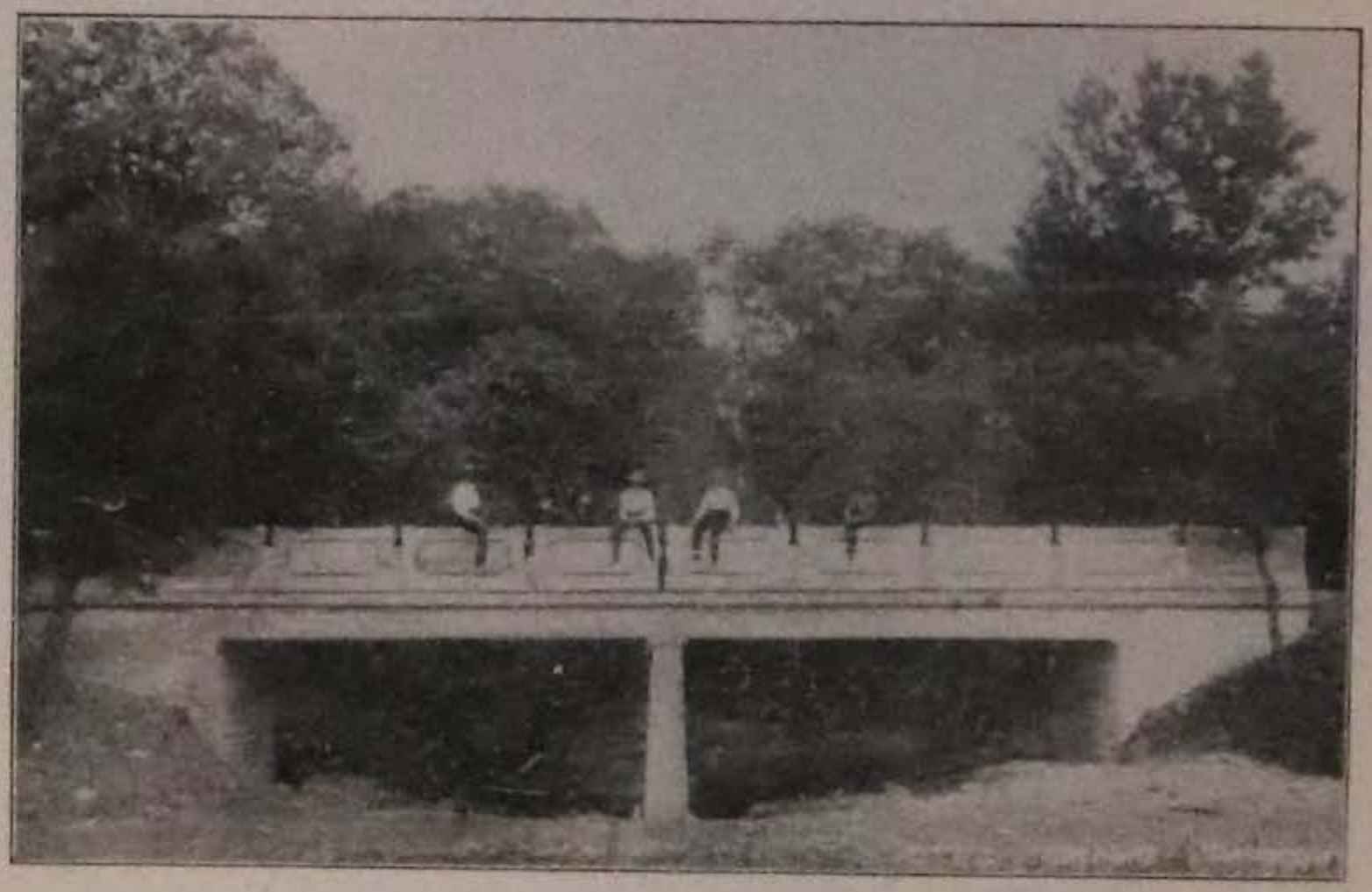


Fig. 25—Slab or Flat Top Culvert near Adel, Iowa

are more or less prominent in their locality. Most of them too, it is only fair to state, are anxious to spend the money entrusted to them in the best way possible. With these conditions in mind it becomes necessary to advance such forms of construction as will appeal to these men from a business standpoint.

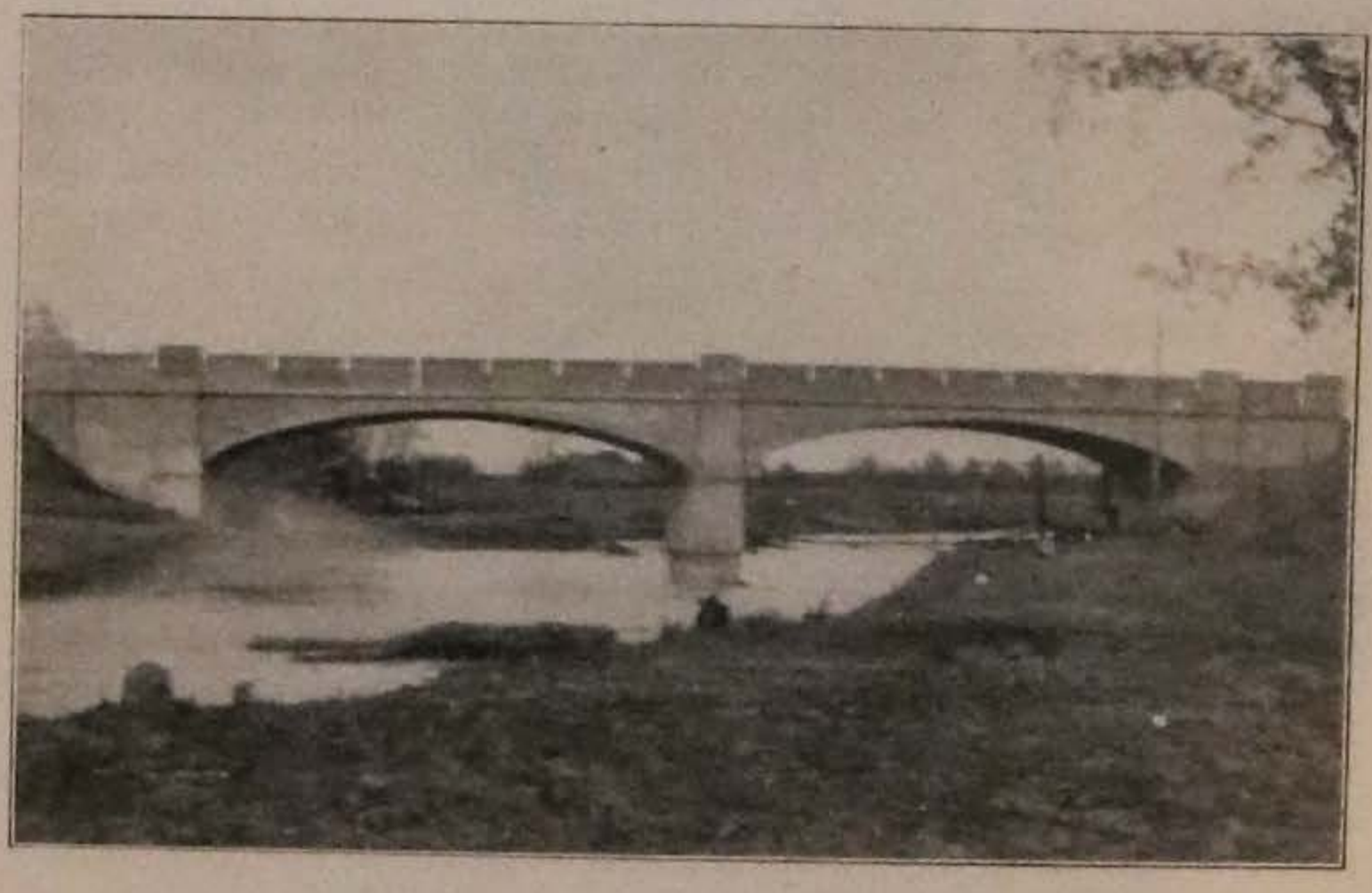


Fig. 26—Reinforced Concrete Arch near Jefferson, Iowa

2. Present Forms of Construction. Experience with the different materials which are now commonly used for culverts has been costly. Tile and sewer culverts as ordinarily used are not satisfactory, which is also true of cast and sheet iron, except where these materials have been used with so much concrete that it might have been more economical for the entire construction. With vitrified pipe considerable difficulty is experienced, due to their freezing full of water and bursting during cold weather, or due to their breaking in muddy weather, when the wheels cut through to them. The cast iron culverts will ordinarily cost more than concrete culverts of the same capacity when each is properly provided with wing walls and aprons. Lumber is becoming higher priced each year and the quality is deteriorating. Three-inch planks of hemlock and pine which have been largely used in culvert construction will cost in the neighborhood of $24.00 to $30.00 per M., while oak is now quoted at almost prohibitive figures. At such prices a two-plank culvert could not be built for less than $15.00. Taking the average life of such construction as five years, it would be much more economical to put $65.00 into a concrete structure. These figures must be considered as only roughly approximate, but illustrate the principle which is involved. Where the lumber culvert tops and bridge floors are exposed to the

Fig. 22—A Timber Culvert in Typical Condition

travel on the main roads, the wear is very fast. In some places oak will last only three or four years. Figure No. (22) shows a typical wooden culvert of Iowa.

3. CONCRETE CULVERTS. a. *Type.* To meet the conditions imposed, a box culvert has been selected by the Highway Commission as the type most simple and economical in design. This form of construction is also commonly known as the flat-top or slab culvert. Each side and also the top and bottom acts as a beam and the stresses imposed may be easily and quite accurately figured. In favor of this form of construction, there is no thrust tending to force the walls outward as is true with arch culverts. In many places the limited head room in which these culverts are to be constructed makes it impossible to put in the arch top. Figure No. (23) is one of the test culverts of the Iowa Highway Commission.

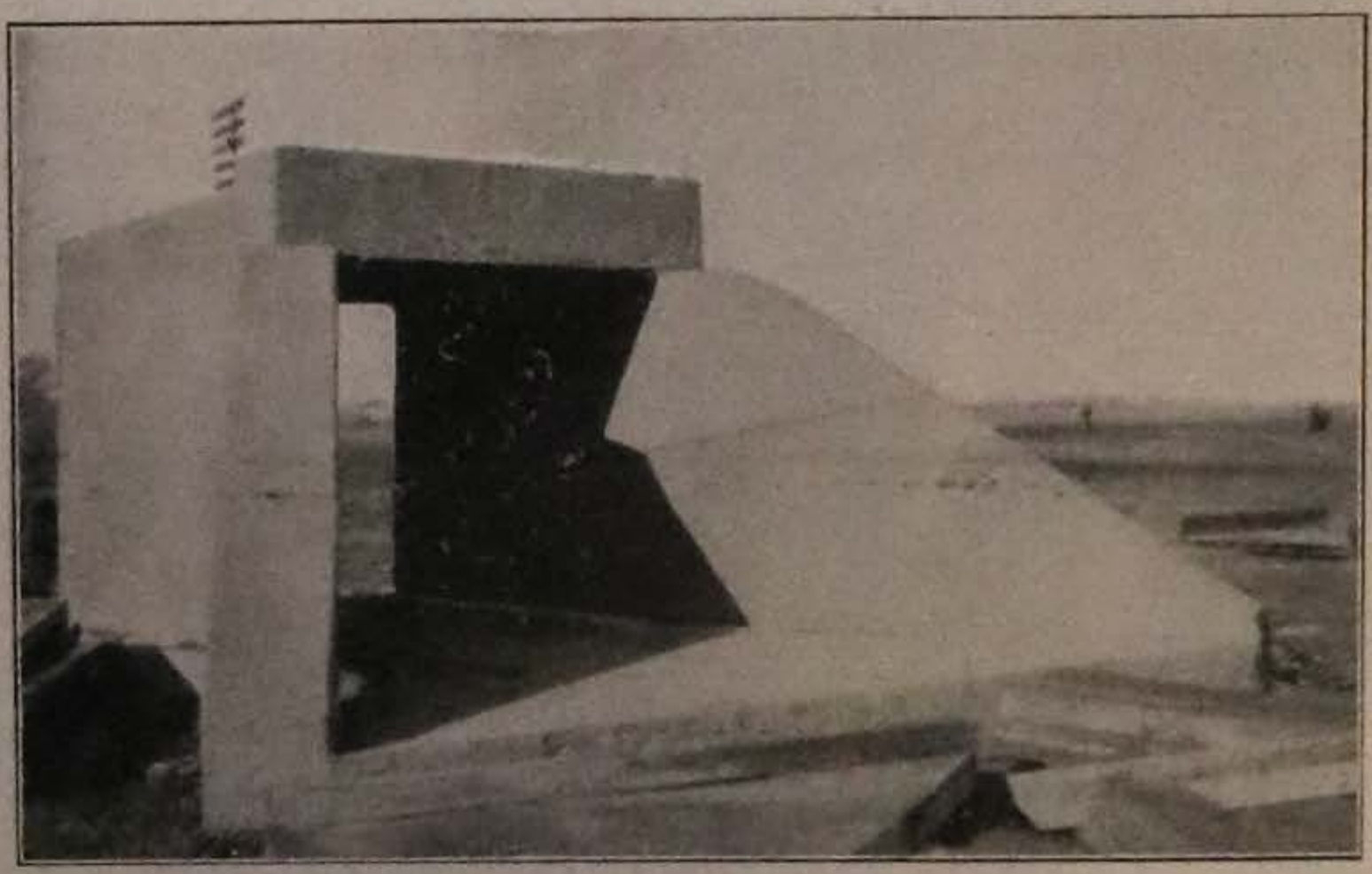


FIG 23—TEST CULVERT OF IOWA HIGHWAY COMMISSION, AMES, IOWA

b. *Design.* The dimensions of the culvert should be proportioned to the loads they are to carry and in order to do this a uniform practice should be followed. A number of formulas for use in reinforced concrete construction have been advocated by different men but a number of these involve certain properties which are common only to the reinforcement for which they are formulated. A simple straight-line formula has been proposed by Mr. Theo. L. Condron of

Chicago based on the tests which have been made with reinforced concrete. This formula has been modified by the Commission and used in designing the standard concrete culverts. A diagram has been plotted from the formula, and furnishes a very simple method of finding the required dimensions. However, rather than insert the theory of the formula or the diagram here, which would be of doubtful value in this connection, a table has been made up, from which may readily be taken the sizes and reinforcement necessary for constructing culverts up to a 12 foot clear span It may also be stated that these culverts are designed to carry a 15 ton road roller and a dead load of 600 pounds per lineal foot, with a safety factor 4. These loads are sufficiently heavy for any cases that will come up in general practice, and it is doubtful if any occasion will arise for which they should be made heavier.

TABLE 5. DIMENSIONS OF REINFORCED CONCRETE CULVERT TOPS

| Clear Span | Depth or Thickness | Reinforcing Area Per Foot | Spacing of ¾-Inch Corr. Bars |
|---|---|---|---|
| 2 feet | 6 inches | .72 sq. inches | 9 inches c to c |
| 4 feet | 8 inches | .96 sq. inches | 6 inches c to c |
| 6 feet | 10 inches | 1.20 sq. inches | 5 inches c to c |
| 8 feet | 12 inches | 1.44 sq. inches | 4 inches c to c |
| 10 feet | 14 inches | 1.68 sq. inches | 4 inches c to c |
| 12 feet | 16 inches | 1.92 sq. inches | 3 inches c to c |

TABLE 6. DIMENSIONS OF REINFORCED CONCRETE CULVERT SIDES

| Height Above Bottom | Thickness | Reinforcing Area Per Foot | Spacing of ½-Inch Corr. Bars |
|---|---|---|---|
| 2 feet | 6 inches | .36 sq. inches | 8 inches c to c |
| 4 feet | 6 inches | .36 sq. inches | 8 inches c to c |
| 6 feet | 10 inches | .60 sq. inches | 5 inches c to c |
| 8 feet | 11 inches | .66 sq. inches | 4 inches c to c |

TABLE 7. DIMEMSIONS OF CONCRETE CULVERT SIDE FOUNDATIONS*

| Clear Span | Thickness of Base for a Uniform Width of 2 Ft. 0 In. | Reinforcing Area Per Foot | Spacing of ¾-Inch Corr. Bars |
|---|---|---|---|
| 2 feet | 6 inches | .36 sq. inches | 18 inches c to c |
| 4 feet | 9 inches | .54 sq. inches | 12 inches c to c |
| 6 feet | 11 inches | .66 sq. inches | 10 inches c to c |
| 8 feet | 14 inches | .84 sq. inches | 8 inches c to c |
| 10 feet | 16 inches | .96 sq. inches | 7 inches c to c |
| 12 feet | 18 inches | 1.08 sq. inches | 6 inches c to c |

*Where needed to prevent washing lay 4 or 5 inch floor between bases.

Table No. (5) gives the thickness and steel reinforcement necessary for the top slab up to a clear span of 12 feet. Table No. (6) gives the thickness and reinforcing necessary for the sides up to a height of 8 feet, and table No. (7) gives the thickness and steel necessary for the bottom as shown in the accompanying figure. The base will be two feet wide and of the given thickness, and where necessary to prevent washing the two side foundations should be connected by a 4 or 5 inch concrete floor. In this floor either bars or wire (plain or barb) may be used as reinforcement. All corners in the concrete culverts should be reinforced with steel to prevent cracking.

4. The Theory of Reinforced Concrete Construction. Slab or beam construction is based on the theory that concrete by the addition of a certain amount of steel, distributed through it, can be made as strong in tension as it is in compression. Whenever a beam is loaded one side is placed in tension and the other side in compression. While concrete is very strong when exposed only to compressive stresses it is weak when placed in tension and the steel is necessary to take this stress. The reinforced concrete construction, as it is called, is more economical, being much stronger than is plain concrete, and many forms of structures are made possible by the peculiar properties which the addition of steel gives to concrete. For these reasons this form of construction has been adopted by the Commission for culverts and bridges. To get the best results particular attention should be given to the selection of the materials which are to be used.

5. Materials. The materials necessary for this kind of construction are as follows:

a. *Portland Cement.* Portland cement is manufactured by mechanically mixing about 20 to 23 per cent. of alumnia with about 75 to 80 per cent. of carbonate of lime. For most of the cement which is manufactured a soft limestone is used to furnish the carbonate of lime and clay or shale is used to supply the alumina. In addition to these constituents there is ordinarily present some silica, magnesia and other impurities which are found in the clay or limestone. It is thoroughly dried, finely ground, and thoroughly mixed in the proper proportions and then burned in a kiln until it is calcined. The clinker thus formed is then ground into a

Fig. 24—A Concrete Culvert in Place
This is practically indestructible.

very fine powder and the product packed in bags or barrels. It is essential in the manufacture of cement to have the materials correctly proportioned, thoroughly mixed and burned to the proper degree. It is also necessary that the cement be finely ground. If any of these points are disregarded the product obtained will be inferior in quality. The cost of the best brands of Portland cement has decreased during the past few years to such a degree that it is now only good economy to buy the best. There are, however, so many factors entering into the present methods of the manufacture and sale of even the best brands that it is a good policy that it should be considered necessary by anyone who is to use a considerable quantity to have each carload tested in some standard laboratory. In this connection it may be said that the Commission has access to the testing laboratory of the Engineering Experiment Station where these tests can be made.

b. *Sand.* A good grade of sand is also necessary for preparing cement mortar. The ordinary specifications for sand say that it should be coarse, sharp and clean. The finer the grains of sand the more cement is necessary too thoroughly coat their surface. The angular or sharp sand offers a better surface than the rounded grains. It is very necessary that the sand shall be clean to the extent of being free

from humus, loam or decayed material. In case sand is to be used which is mixed with these impurities, it should be thoroughly washed. This can be done by constructing a long trough with sufficient slant to give the water a good velocity. A box can be arranged at the foot of the chute with a slide door in the bottom, a stream of water is then turned into the trough and the sand shoveled in as fast as it can be carried away. When the box at the bottom is full the slide door may be opened and the clean sand shoveled from beneath. The operation is thus continuous. The fine sand and impurities are carried away over the side of the box by the water.

c. *Gravel.* If gravel is to be used, it should vary in size from coarse sand to a maximum size of about two inches in diameter. It should be free from vegetable matter or loam, and should not contain a large percentage of fine material. If considerable sand is mixed with the gravel it will be necessary to screen it out before it is used. Screening over a No. 10 screen will ordinarily remove most of the sand. Good gravel is found distributed over the state in sufficient quantities so that it is quite available for use in concrete construction.

d. *Crushed Rock.* About the only deposits in Iowa suitable for crushing are the limestone. There are a few counties in the eastern part of the state where granite boulders are scattered over the ground in sufficient quantities to warrant their being used for this purpose, but at present the only crushed rock available is that from the lime stone quarries. There are a large number of crusher plants in the state and a list is included here for convenience in ordering.

List of Companies Operating Crusher Plants:

Arquitt, B. N. & Sons, Farley, Ia., C. G. W. Ry.
Bealer, E. J. C., Cedar Valley, Ia., C., R. I. & P.
Cedar River Stone Co., Waverly, Ia., C., G. W. Ry.
Chilton, Chas., Ottumwa, Ia., C., R. I. & P. Ry.
Dearborn, H. Bros., Stone City, Ia., C., M. & St. P. Ry.
Des Moines Bld. & Crushed Stone Co., Peru, Ia., C., G. W.
Erickson, F. Co., Stone City, Ia., C., M. & St. P. Ry.
Ellsworth Stone Co., Iowa Falls, Ia., D. M., I. F. & N. Ry.
Kemper, E. G., Burlington, Ia., Burl. Rt.
Linswoods Quarry Co., Linwood, Ia., C., R. I. & P. and C., M. & St. P. Rys.

Le Grand Quarry Co., Marshalltown, Ia., C. & N. W. Ry.
Laines, Andrew, Dudley, Ia., C. B. & Q. Ry.
McManus & Tucker, Keokuk, Ia., C., B. & Q. and C., R. I. & P. Rys.
Shields, T. H. & Sons, Dudley, Ia., C., B. & Q.

Owing to the wide variation in the quality of the limestone which we have in the state, a careful investigation of the product should be made before a supply is ordered. Probably the best rock that is now available is the blue limestone. Much of the stone which is found in the eastern part of the state is entirely too soft to make good concrete. The cost of this crushed stone should not be more than fifty to sixty cents per cubic yard of 2,250 pounds, plus the freight rate. This material, when consigned to a public official, is placed by the Iowa Railroad Commission on the same basis as slack or soft coal, so that where gravel is not available, crushed stone can be purchased at a reasonable figure, even if it has to be shipped some distance. The ordinary "crushed run" product is recommended rather than the screened stone, but if there is a considerable amount of crusher dust, the proportion of sand should be decreased somewhat. Ordinary specifications require that crushed stone shall not be used larger than 2 1-2 inches in its maximum dimension.

e. *Broken Stone vs. Gravel.* There is considerable discussion as to which is the the better for the aggregate in concrete. In reference to this it may be said that the gravel is ordinarily a harder and tougher material than the broken stone. It is rounded so that less bridging occurs to form voids in the concrete. Less ramming is required, and with the well selected gravel there is less danger of an improper proportioning of the materials. On the other hand broken stone, being sharp and angular, gives a better surface for adhesion of mortar and is ordinarily cleaner. For ordinary work the advantage will lie with the material which is available at the lowest cost, as good work can be produced with either provided careful attention is given to the selection and proportioning of the materials.

f. *Steel.* There are many patented forms of steel to be used in this kind of construction. There are also a number of very common kinds of commercial steel which make good reinforcing material, such as barb wire, plain wire, and plain bars or rods. This material can be purchased at almost any

convenient hardware store. When such forms of steel are used, if there are kinks or curves in it, it would seem very desirable to put it under some initial tension when it is placed in the concrete to avoid the tendency there would be for it to straighten out when it is subjected to stresses. Most of this wire, as shown by tests made at the college, has a high elastic limit, due very probably to the work done upon it in drawing it out to a small cross section. Single wire, such as is used in making barb wire, has a cross section of approximately eight thousandths of a square inch and it would take a large number of wires to make a one per cent. reinforcement even on the thin slabs, but the wire can be twisted into cables each containing a number of strands. A table is enclosed showing some of the patented forms which would be the best to use in the culverts, together with the sizes nd weights of the same. The price per pound varies, but it will cost, f. o. b. any station in Iowa, between 2 1-4 and 3 cents per pound. See Table (8).

TABLE 8. SIZES AND WEIGHTS OF STEEL REINFORCEMENT FOR CONCRETE CULVERTS

| Name of Bar | Description | Size | Area Sq. In. | Weig't Per Lin. Ft. | |
|---|---|---|---|---|---|
| Ransome | Sq're. twisted steel | ¼ Inch | .0625 | .213 | High elastic limit |
| | | ½ | .25 | .850 | |
| | | ⅝ | .3906 | 1.328 | |
| | | ¾ | .5625 | 1.913 | |
| | | ⅞ | .7656 | 2.603 | |
| | | 1 | 1.000 | 3.400 | |
| | | 1¼ | 1.5625 | 5 312 | |
| | | 1½ | 2 25 | 7.65 | |
| Johnson | Corrugated | ¼ | .0625 | .24 | High elastic limit |
| | | ½ | .25 | .85 | |
| | | ⅝ | .3906 | 1.33 | |
| | | ¾ | .5625 | 1.91 | |
| | | ⅞ | .7656 | 2.60 | |
| | | 1 | 1.000 | 3.40 | |
| | | 1¼ | 1.5625 | 5.31 | |
| Thatcher | Corrugated | ¼ | .047 | .16 | Low elastic limit |
| | | ⅜ | .10 | .34 | |
| | | ½ | .18 | .61 | |
| | | ⅝ | .28 | .95 | |
| | | ¾ | .41 | 1.39 | |
| | | ⅞ | .55 | 1.87 | |
| | | 1 | .71 | 2.42 | |
| | | 1⅛ | .90 | 3.06 | |
| | | 1¼ | 1.10 | 3.74 | |
| | | 1⅜ | 1.32 | 4.49 | |
| | | 1½ | 1.56 | 5.30 | |
| | | 1⅝ | 1.81 | 6.16 | |
| | | 1¾ | 2 08 | 7.07 | |
| | | 1⅞ | 2.35 | 8.00 | |
| | | 2 | 2.65 | 9.02 | |

6. PROPORTIONS. The theory of the proportioning of the materials for concrete is to select such an amount of each that it will exactly fill the voids in the material of the next larger size—that is, the cement should thoroughly coat the grains of sand, and the mortar should be sufficient to completely fill the voids in the broken stone or gravel. To gain the greatest strength with the least cement, it is necessary that the materials be correctly proportioned, and this should be done before any piece of work is undertaken that will involve the use of a large quantity of a certain kind of material. The following proportions are given as a guide to the general practice at this time.

For arches and flat tops for culverts:

1 part cement, 2 parts sand, 4 parts broken stone, or

1 part cement, 1 1-2 parts sand, 4 parts screened gravel.

For wing walls, or piers, or abutments:

1 part cement, 3 parts sand, 5 parts broken stone, or

1 part cement, 2 parts sand, 5 parts screened gravel.

Where a gravel concrete is used engineers ordinarily require about ten per cent. additional cement to be used over broken stone concrete. See Table (9).

TABLE 9. MATERIAL REQUIRED TO MAKE A CUBIC YARD OF CONCRETE USING DIFFERENT PROPORTIONS

| PROPORTIONS | | | | AMOUNT FOR CU. YD. OF CONCRETE | | | |
|---|---|---|---|---|---|---|---|
| Cement | Sand | Stone | Gravel | Barrels of Cement | Cubic Yards Sand | Cu Yards Stone | Cu. Yards Gravel |
| 1 | 1 | 3 | | 1.90 | .31 | .93 | |
| 1 | 2 | 3 | | 1.59 | .52 | .78 | |
| 1 | 2 | 4 | | 1.39 | .45 | .90 | |
| 1 | 2 | 5 | | 1.20 | .39 | .98 | |
| 1 | 3 | 5 | | 1.04 | .51 | .84 | |
| 1 | 3 | 6 | | .96 | .47 | .93 | |
| 1 | 3 | 7 | | .89 | .43 | 1.01 | |
| 1 | 1 | | 3 | 1.69 | .27 | | .82 |
| 1 | 2 | | 3 | 1.44 | .47 | | .70 |
| 1 | 2 | | 4 | 1.25 | .41 | | .81 |
| 1 | 2 | | 5 | 1.06 | .34 | | .86 |
| 1 | 3 | | 5 | .94 | .46 | | .76 |
| 1 | 3 | | 6 | .83 | .41 | | .81 |
| 1 | 3 | | 7 | .74 | .36 | | .94 |

7. MIXING. There are two methods of mixing concrete on the work, (1) by hand, (2) by machinery.

When hand mixing is employed a tight platform should be built near the work. The material, except the cement, may be measured in wheel barrows or bottomless boxes, but

such an amount should be mixed at one time as will require an even number of sacks or barrels of the cement.

The sand should first be placed on the platform, then the cement spread evenly over it. The shovelers, working in pairs, turn these ingredients until they are thoroughly mixed dry. Water is added and the operation continued as long as necessary. The broken stone or gravel is then added to the mortar and the concrete thoroughly mixed. Three to five turnings are ordinarily necessary to accomplish the best results.

The proportioning and mixing of the concrete should be under strict supervision as these are both essential factors in determining the quality of the products.

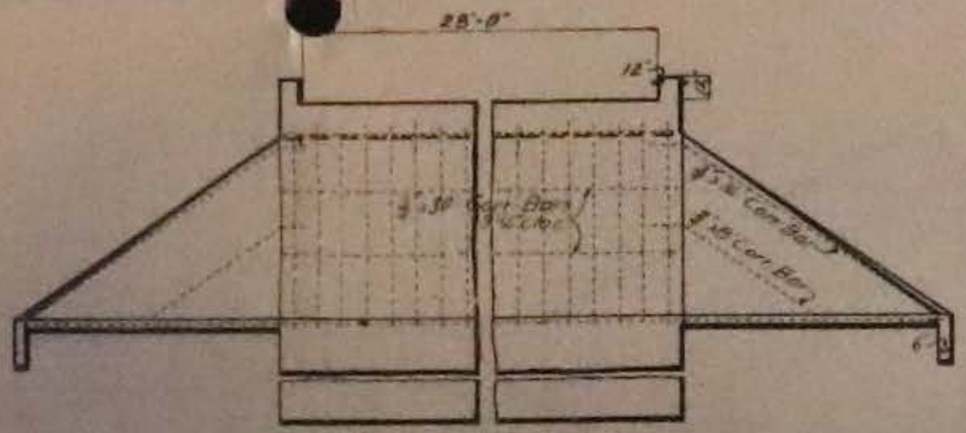
If a machine mixer is used the cost of labor will be less and the product will be more uniform. On jobs taking a considerable amount of concrete, a machine mixer will prove more economical. These can be obtained by townships in hand sizes. A mixer mounted on trucks run by a gasoline engine might be used to good advantage by counties which do a large amount of concrete work.

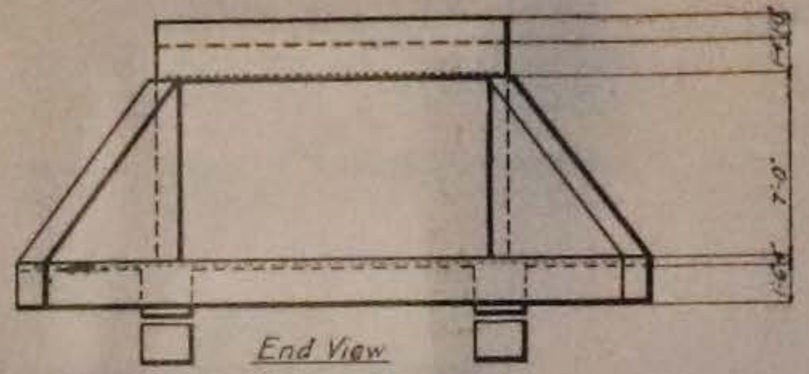
8. Placing the Concrete. The forms for the concrete should be constructed of lumber so stiff that there will be no bulging when the concrete is rammed into place. The simplest manner of holding the forms true is by bracing the outside and also wiring across between the forms. When the concrete is set the wires can be clipped close to the surface.

The concrete should be deposited in layers not over 6" in thickness and thoroughly rammed into place. For the comparatively thin slabs a small rammer should be used and care taken to compact the concrete around the steel reinforcement without displacing it. Considerable care should also be taken not to drop or throw the concrete any distance as this separates the different materials and destroys the homogenity of the product.

When joints have to be made between two days work, the surface of the concrete should be left as rough as possible. Before a fresh layer is added, the old surfaces should be thoroughly cleaned and wet, then to insure a good joint, neat cement should be sprinkled over it.

*Specifications.* A set of specifications is included in this chapter for the use of concrete and steel in culverts and bridges.



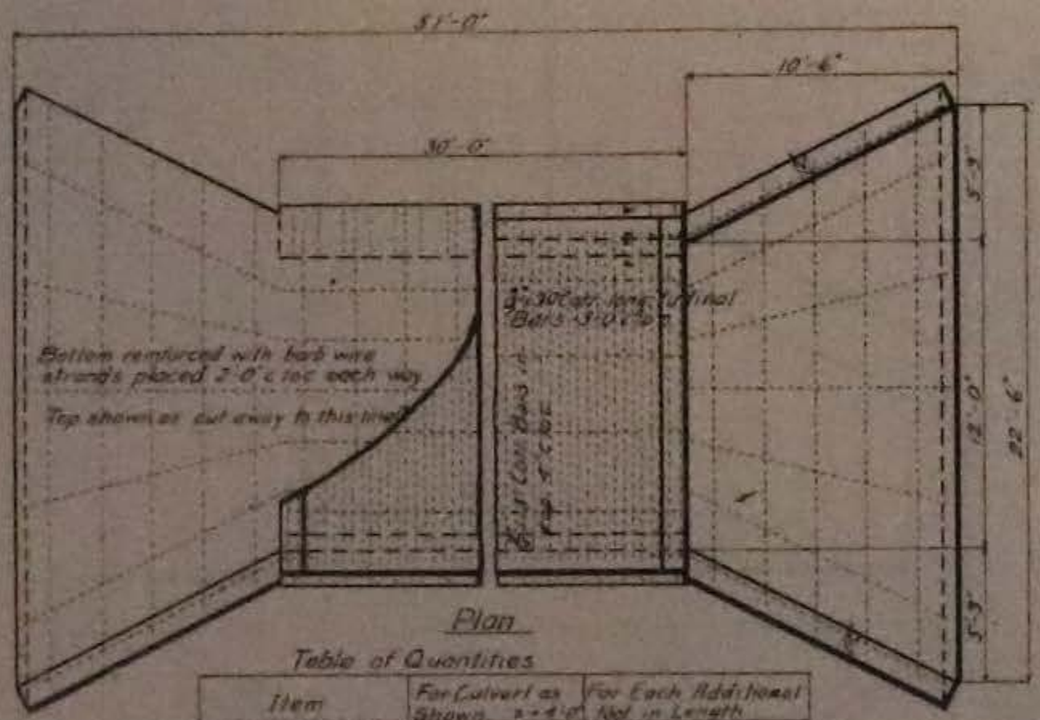
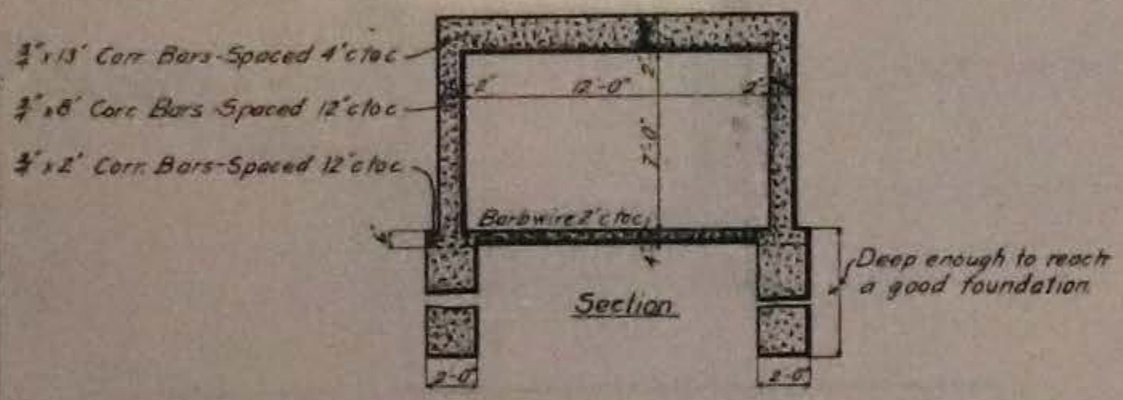




Table of Quantities

| Item | For Culvert as Shown | For Each Additional Ft. in Length |
|---|---|---|
| Concrete 1:2:4 | 57.0 Cu Ft | 10.2 Cu Ft |
| " 1:3:5 | 126.2 " | 31.3 " |
| Cement | 82 Bbls | 2.2 Bbls |
| Sand | 3.3 Cu yds | 0.92 Cu yds |
| Broken Stone or Pebbles | 5.76 " | 1.60 " |
| Corr Bars ¾" x 30' | 8 Bars | Increase length 1'-6" each |
| " " ¾" x 13' | 90 " | 3 Bars |
| " " ¾" x 8' | 64 " | 2 " |
| " " ¾" x 2' | 60 " | 2 " |
| " " ¾" x 14' | 4 " | 0 " |
| Total Corr Bars | 2106 ft = 403.5 lbs | 67 ft = 12.8 lbs |
| Bark wire | 6330 ft = 40 lbs | 10 ft = 0.6 lbs |

Note
Concrete for top 1:2:4
All other concrete 1:3:5
Table of quantities figured for a 4'-1 foundation



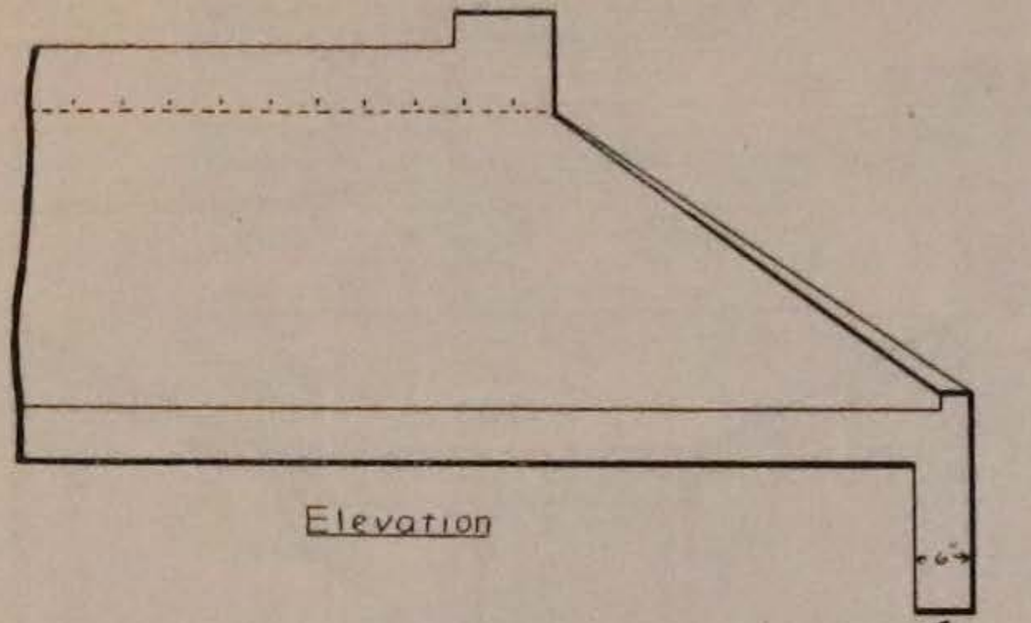

# DESIGN
FOR
# 12 F^I X 7 F^I BOX CULVERT
OF
# REINFORCED CONCRETE

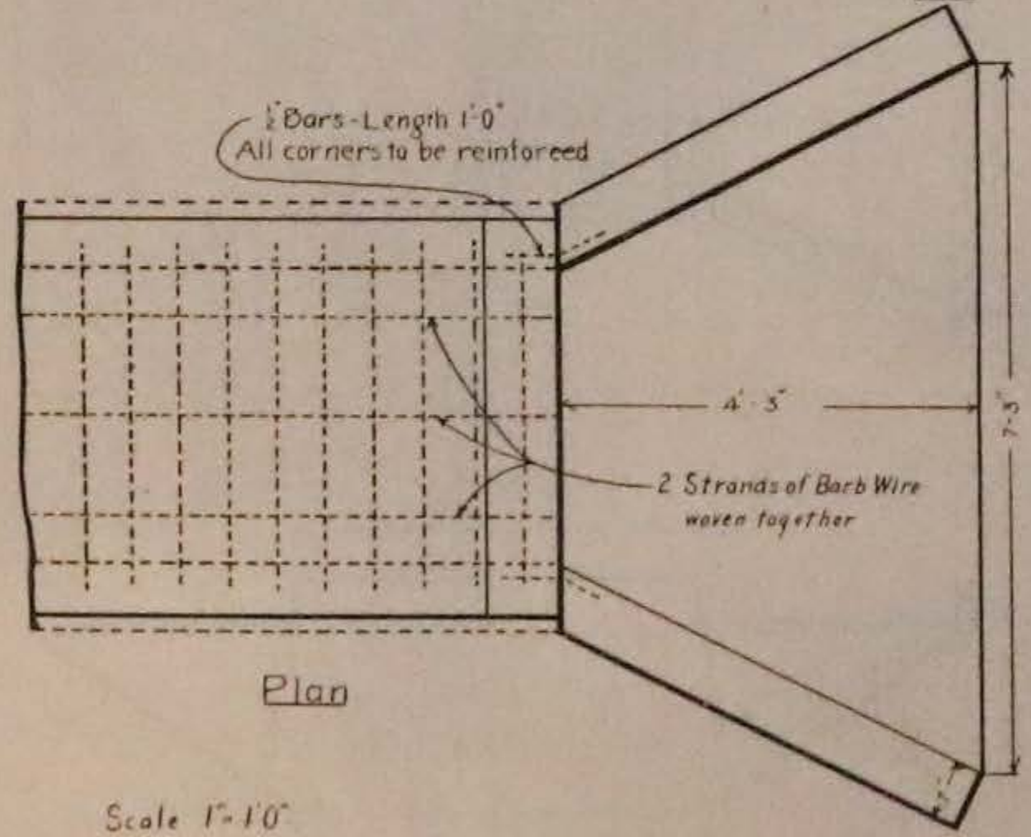
IOWA HIGHWAY COMMISSION

May 1905

Scale 1"=1'-0"

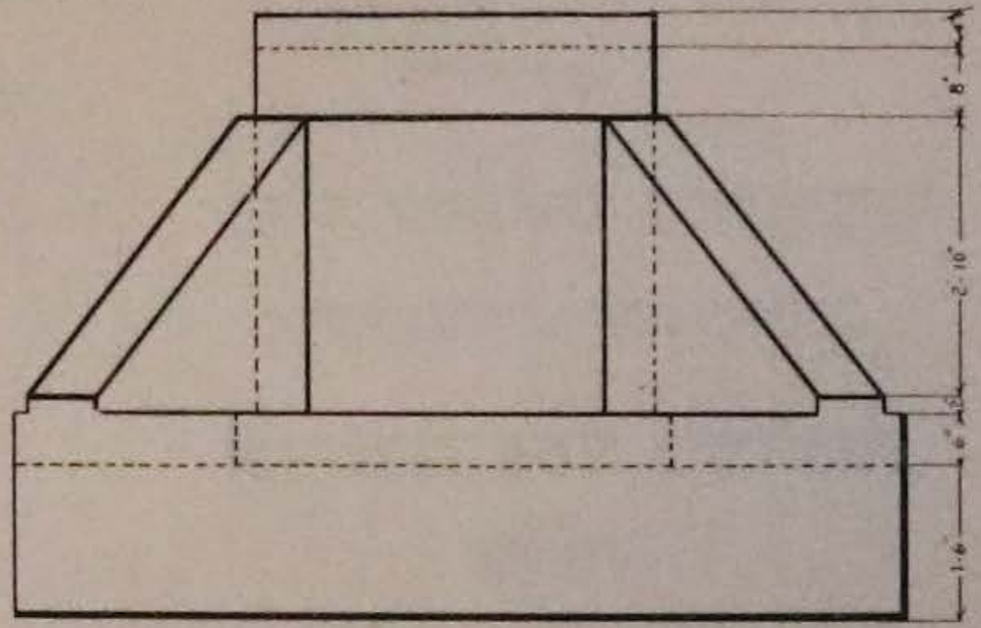
Fig 27



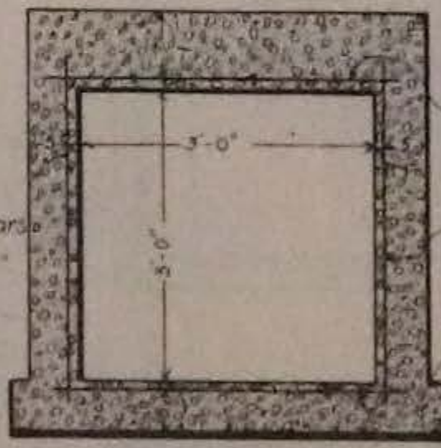




Plan

Scale 1"-1'0"




End View




Steel - 18 lbs per ft ¾" Bars
5 " " ½" "

Concrete 8 cu ft per foot
Top 1 2 4
Sides and Bottom 1 3 5

Section

DESIGN
FOR

# 3 FT. BOX CULVERT
OF
# Reinforced Concrete.

IOWA HIGHWAY COMMISSION

April 1925

Fig. 28

# STANDARD SPECIFICATIONS.

for

# REINFORCED CONCRETE CULVERTS.

## IOWA HIGHWAY COMMISSION.

### (1) Plans.

These general specifications are to accompany and to be regarded as applying to the standard plans put out by the Iowa Highway Commission, Ames, Iowa.

### (2) Forms.

All forms and centering are to be made from 2″ pine or fir, surfaced on one side. These are to be made and fitted together by a competent carpenter. The joints and contact surfaces to be dressed smooth and even. The number and size is to be painted upon all the pieces comprising each standard form.

Clamps and bolts are to be used for all the temporary fastenings.

When not in use the forms are to be stored in a dry place and carefully preserved.

### (3) Material.

a. CEMENT.

*Brand.* The cement used shall be a first quality Portland of an approved brand. (A list of approved brands is appended).

*Tests.* It may be subjected to the standard tests (U. S. Government) before or after delivery. Any cement failing to pass these tests shall be rejected and the manufacturer shall promptly remove it.

*Weight.* A bag of cement shall contain 94 pounds of cement net and a barrel shall contain four bags of the above net weight.

*Storage.* The cement shall be stored in a weather-tight building with the floor properly raised above the ground.

b. SAND.

The sand used must be sharp, coarse and clean.

c. CRUSHED STONE.

*Size.* All stone shall be broken to pass a 2 1-2″ ring and shall be clean, hard, and durable. The crusher-run product shall be used but a reduction of the amount of sand used shall be made approximately equal to the stone dust.

d. GRAVEL.

*Size.* If gravel is substituted for the broken stone, it shall be clean and free from stones larger than 2 1-2″ diameter. It shall be screened.

e. PROPORTIONS.

The following proportions shall be observed: for

*Culvert Tops.*

1 part cement, 2 parts sand, 4 parts crushed stone, or

1 part cement, 1 1-2 parts sand, 4 parts screened gravel.

*Culvert Sides, Bottoms, and Wing Walls.*

1 part cement, 3 parts sand, 5 parts crushed stone, or

1 part cement, 2 parts sand, 5 parts screened gravel.

*Mortar.*

Where mortar is used it shall consist of

1 part cement, 2 parts sand.

f. REINFORCEMENT.

*Percent of Reinforcement.* Unless otherwise specified, a one percent (1%) by area of reinforcement shall be used for all standard plans. In determining the amount of reinforcing the concrete outside the center line of the reinforcing shall not be counted.

*Sizes.* No sizes larger than those shown on the plans shall be used. Smaller sizes may be substituted but the same total area shall be retained.

*Plain Bars.* Plain bars used as reinforcement shall have an elastic limit of at least 30,000 pounds per square inch.

*Corrugated Bars.* Corrugated bars shall have an elastic limit of 45,000 pounds per square inch.

Barb wire or twisted plain wire may be substituted for the bars provided the same total area is used.

*Placing of Steel.* The steel reinforcing material shall be carefully placed as shown on the standard plans.

The reinforcement for the top shall be bedded in a layer of

the mortar one inch thick as shown on the plans, and for the bottom, shall be covered with the same material. The reinforcement in the sides shall be carefully spaced and care shall be exercised during the tamping to leave it undisturbed.

g. MIXING AND LAYING THE CONCRETE.

The materials shall be carefully proportioned by measure and when hand mixing is employed a tight platform shall be used. Upon this the sand and cement shall be thoroughly mixed dry, then the previously wetted stone and water shall be added. This material shall be turned at least three times, and more if necessary, to produce a uniform mixture. A moderately wet concrete shall be used.

The concrete shall be placed in the forms in layers not exceeding six inches, each layer to be thoroughly tamped, and all exposed surfaces are to be "spaded" to produce a smooth outside finish. If the forms cannot be entirely completed before the cement sets, the last layer shall be well cleaned and then wet with a neat cement grout and every precaution taken to secure a perfect bond.

## SECTION VII.

## TRACTIVE RESISTANCE.

The resistance that a vehicle moving uniformly offers to that motion or the traction may be classed under three heads: (1) "Grade Resistance," (2) "Axle Friction," and (3) "Rolling Resistance."

### (1) GRADE RESISTANCE.

The influence that grade has upon the tractive effort required to move any vehicle may be accurately computed and is entirely independent of the condition of the surface. A horse can not pull so much on a grade as on the level surface because he has his own weight to lift and because the inclination of the surface does not allow as good footing, especially when the roads are wet and slippery, but the tractive resistance depends only on the per cent. of inclination.

It is readily shown by a simple mathematical solution that G (the resistance due to the grade) = W P in which W = the load and P the grade in percent.

In words we may say:

The total grade resistance equals 20 times the number of tons times the per cent. of grade.

The total grade resistance for a load of 1 1-2 tons hauled up a 5% grade is

20X1 1-2X5=150 lbs.

### (2) AXLE FRICTION.

Axle friction can be made so very small by proper lubrication that it can be neglected. Few dynamometers will register the axle friction produced with bearings in this condition so that in comparing road surfaces or broad and narrow tires this factor need be considered, only by using similar vehicles.

### (3) ROLLING RESISTANCE.

There are three principal elements which produce rolling

resistance and each one of these is modified by specific factors as may be seen in the following outline:

a. *Impact.*
   1. Speed.
   2. Irregularities on the surface.
   3. Effect of springs.
   4. Kind of tires.

b. *Compression of the Surface.*
   1. Character of the road surface.
   2. Width of tires.

c. *Friction Between Wheels and Surfac.*
   1. Character of road surface.
   2. Width of tires.

a. *Impact.*

If a ball is thrown against a wall, it rebounds to a distance depending upon the speed with which it was thrown and the rigidity of the wall. In the same manner a wheel when it strikes an irregularity in a road tends to rebound. Most of these obstructions are so small that the wheel does not rebound but receives a momentary check. Its own momentum is usually sufficient to carry it on but with diminished speed which must be regained by additional tractive effort.

The diameter of the wheel also affects the tractive resistance. In general the greater the diameter of the wheel the less is the force required on account of the greater leverage.

Springs are of service in lessening the resistance due to an uneven surface. The shock of the impact of the wheels is absorbed by the springs instead of being transferred to the load. Their effect is greater the higher the rate of speed because the force of the impact increases with the speed.

All that is said here in regard to impact assumes that the wheels have metal tires; with rubber tires the shock is greatly lessened and with pneumatic tires it is still less. It will be noticed that reference here is made only to such impact as results from projections on the surface and not to depressions which will be discussed in a succeeding paragraph.

*Compression of the Surface.* The character of the surface as regards elasticity is of prime importance in this connection. If the road material compresses under the wheels, the load has to be drawn continually up an inclined plane, the slope of which depends upon the depth of the depression and the diameter of the wheels. This explains the difference be-

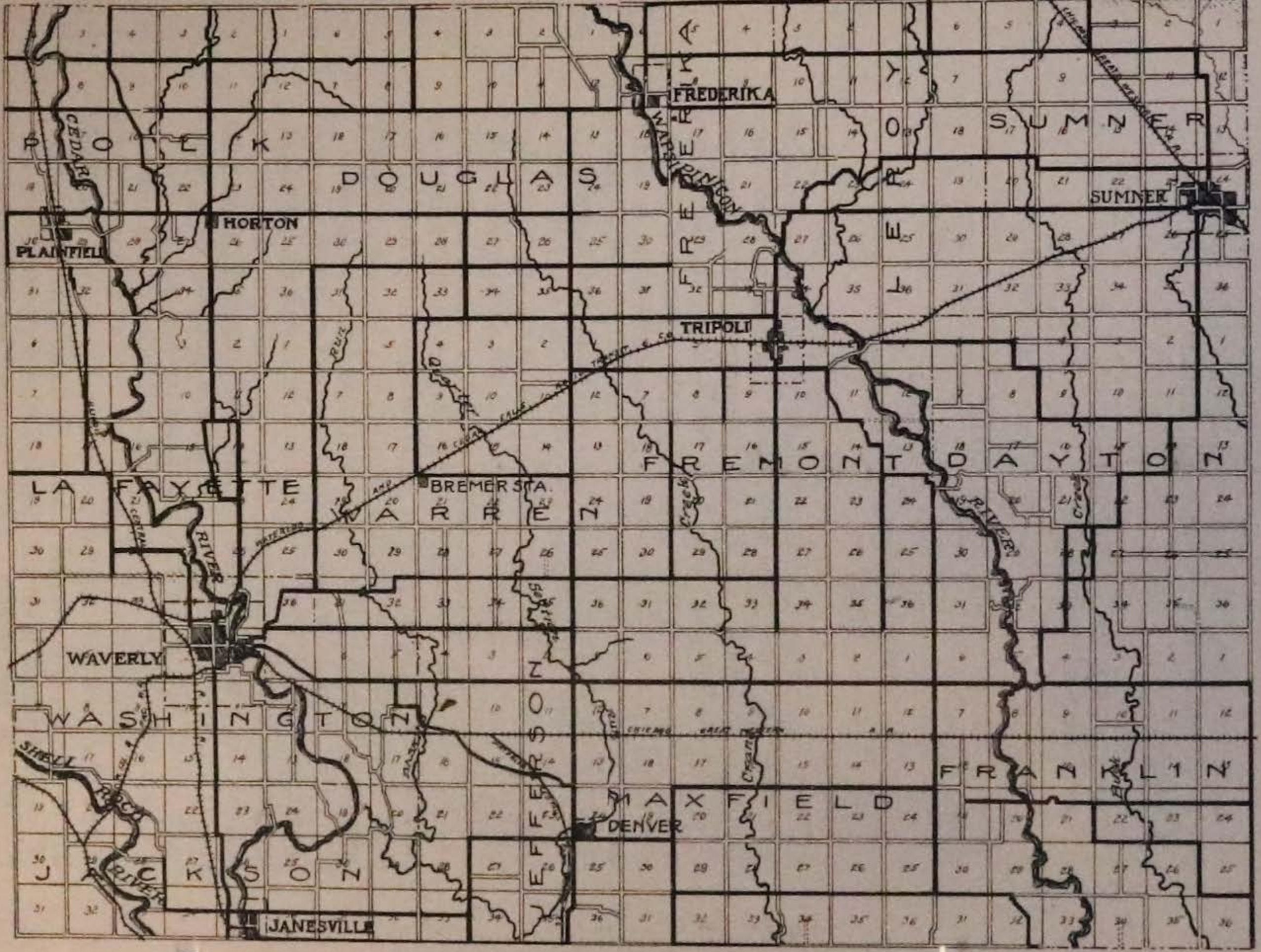



Fig. 6—Road Map of Bremer County, Iowa

tween the asphalt and brick pavements in favor of brick pavements though asphalt is smoother.

If the road material is elastic, the depression under each wheel will vary with the load on it and the traction will be lessened by the use of wide tires.

*Friction Between the Wheels and the Road Surface.* The amount of friction will depend, first of all, upon the relative hardness of the road material. Wtih the road in such a condition that the wheels would have to cut through a layer of loose material or mud to a hard bottom, the narrow tires would be expected to give the lighter draught, but in all other cases the wide tires would be preferable, as is shown by traction tests.

This discussion indicates that traction or tractive resistance is subject to a large and complex number of influences. Its amount is measured with an instrument variously known as a tractometer, dynograph or dynometer. The result obtained will be the total resistance as has been said due to (a) grade, (b) axle friction, and (c) rolling resistance, and for different results to be at all comparable they must be reduced to the same conditions. The effects of grade may be eliminated by taking tests on level stretches or by compensating for the grade when the degree of rise is known. Tests on roads thought to be level should always be made in each direction and the average taken.

The rolling resistance will then be an accurate measure of the value for traction purposes of different kinds of pavement, and of the various conditions which affect them.

*Results of Tests.* For the past three years the Civil Engineering Department of the State College has been carrying on tests of the traction of different kinds of surfaces used on the public roads and streets of Iowa. In addition to these a series of tests was conducted at Pittsburg, Pa., by Mr. A. B. Chattin, a graduate of the College. The State Highway Commission during the past year also has made a large number of traction tests in various places in the state.

*Tractometer.* The tractometer used in these tests was made by the Mechanical Engineering Department of the College. The direct pull of the team is taken by a horse-shoe shaped spring and registered by means of a pencil connected to this spring by a multiplying device. This pencil plays on a strip of profile paper which is moved beneath it by

clock-work. After calibrating the instrument in a testing machine, the number of pounds pull, maximum, minimum or average may be read directly from the record.

*Outfits Used.* The aim in this work being to get as near to the actual conditions as possible, care was taken to get an ordinary wagon and team. The teams were of the average size and weight used for draught purposes, and the wagons were in most cases the kind generally used on farms.

TABLE 10. TRACTION TESTS COMPARATIVE OF EARTH AND GRAVEL ROADS

| NO. | CONDITION OF ROAD SURFACE | AVERAGE (IN POUNDS) PULL PER TON | |
|---|---|---|---|
| | | Mch. 22-23, 1905 | May 19, 1905 |
| | GRAVEL ROADS | Worst Spring Condition | Ordinary Dry Condition |
| 1 | Old resurfaced | 112 lbs. | 68 lbs. |
| 2 | Well graded, drained | 170 | 35 |
| 3 | Old, very dirty, poor | 201 | 114 |
| 4 | Good condition | 195 | 78 |
| 5 | Same as No. 4 | 193 | 102 |
| 6 | New, soft | 327 | 78 |
| 7 | New, well packed | 159 | 58 |
| 8 | Old, well graded | 135 | 45 |
| 9 | Same as No. 8 | 135 | 56 |
| 10 | Graded, good | 154 | 62 |
| 11 | Old, dirty on top | 193 | 70 |
| 12 | New, well crowned | 318 | 74 |
| | EARTH ROADS Average | 191 | 69 |
| 1 | Graded | 288 | 110 |
| 2 | Poorly Graded | 389 | 186 |
| 3 | Clay, very poor drainage | 531 | 215 |
| 4 | Black loam, graded | 286 | 148 |
| 5 | Same as No. 4 | 236 | 99 |
| 6 | Flat, poor drainage | 234 | 87 |
| 7 | Well graded | 258 | 91 |
| 8 | Sandy | 365 | 87 |
| 9 | Gravelly | 262 | 83 |
| 10 | Gumbo, little grade | 408 | 139 |
| 11 | Poor drainage | 346 | 124 |
| | Average | 328 | 124 |

Diameter of wheels, 42 inches and 52 inches.
Width of tires, 1½ inches—farm wagon.

# TABLE 11. TRACTION TESTS

## COMPARATIVE OF TRACTIVE RESISTANCE OF WIDE AND NARROW TIRED WAGONS

| DATE | DESCRIPTION OF ROAD SURFACE | RESISTANCE lbs. per ton | |
|---|---|---|---|
| | | Width of Tires | |
| 1905 | AN EARTH ROAD, GOOD GRADE BUT FLAT. WELL DRAINED BY TILE SIDE DRAINS. | 1⅝ in. | 3⅛ in. |
| Feb. 17 | 4 inches snow well packed | 260 | |
| " 18 | 4 inches snow well packed | | 228 |
| " 21 | ¾ inches slushy snow | 134 | 175 |
| " 28 | Snow gone. Frost out in places | 178 | 198 |
| Mar. 4 | Well dried and fairly smooth on top | 162 | 162 |
| " 21 | 2 inches to 3 inches thick mud | 238 | 238 |
| " 25 | 3 inches to 4 inches thick mud; dryer | 315 | 289 |
| Apr. 1 | Dry, fairly smooth. Some dust | 135 | 120 |
| " 13 | Dry, worn smooth. Some loose dirt | 84 | 72 |
| " 21 | Thin loose mud on top, 1½ inches | 140 | 121 |
| May 12 | Cut up 2 inches deep | | 178 |
| " 22 | Smooth track worn; ¼ inch loose dirt | 85 | 86 |
| | EARTH ROAD, POOR GRADE, POORLY DRAINED, HEAVY TRAVEL. | | |
| Feb. 28 | Thick mud | | 198 |
| Mar. 4 | Dryer track, fairly smooth | 192 | 141 |
| " 25 | 3 inches thick mud | 287 | 289 |
| April 1 | Dry, very rough | 228 | 211 |
| " 13 | Dry, wearing smooth | 116 | 90 |
| " 21 | Ruts 1 inch to 3 inches; thin mud, water in places | 113 | 127 |
| May 12 | 3 inch to 8 inch ruts full of loose mud and water | | 157 |
| " 22 | Deep ruts wearing smooth | 105 | 99 |
| | A WELL BUILT DEEP BED GRAVEL ROAD, WELL DRAINED. | | |
| Feb. 22 | 1 inch loose wet gravel on top | 220 | 144 |
| Mar. 4 | Smooth. A little loose gravel | 121 | 101 |
| " 21 | Slightly damp | | 111 |
| " 25 | Moist. Hard | 110 | 96 |
| April 1 | Dry. Some loose gravel | 94 | 108 |
| " 13 | Dryer. Some loose gravel on top | 59 | 62 |
| " 21 | Smooth, a little loose gravel on top | 73 | 84 |
| May 12 | Smooth and dry on top | | 58 |
| " 22 | Smooth and dry, a little loose gravel | 56 | 56 |
| | A VERY REPRESENTATIVE SAND ROAD. FINE SAND, DEEP SURFACE FLAT WITH GROUND. | | |
| Feb. 28 | Frozen 1½ to 2 inches slush | 170 | 132 |
| Mar. 4 | Wet loose sand, 2 inches | 170 | 164 |
| " 21 | Moist | | 184 |
| " 25 | Slightly moist | 195 | 172 |
| April 13 | Sand loose and dry on top | 93 | 92 |
| " 21 | Damp and solid beneath | | 110 |
| May 12 | Well defined ruts 1 inch to 2 inches. Moist | | 89 |
| " 22 | 1 inch loose dry sand on compact suaface | 91 | 90 |

## TABLE 11. TRACTION TESTS—Continued

### COMPARATIVE OF TRACTIVE RESISTANCE OF WIDE AND NARROW TIRED WAGONS

| DATE | DESCRIPTION OF ROAD SURFACE | RESISTANCE Lbs. per Ton | |
|---|---|---|---|
| | | Width of Tires | |
| 1905 | GRAVEL ROAD, CLAY BINDER, WELL CROWNED, WELL DRAINED | 1⅝ in. | 3⅛ in. |
| Feb. 28 | 1½ inches thin mud | 146 | 136 |
| Mar. 4 | 1½ inches to 2½ inches, ruts, wet surface | 172 | 138 |
| " 25 | 1 inch soft slush | 157 | 141 |
| April 1 | Dry, slightly dusty | 100 | 82 |
| " 13 | Smooth, dry, no loose material | 47 | 47 |
| " 21 | Wet, some slush in places | 116 | 104 |
| May 12 | A little soft, but smooth | ------ | 63 |
| " 22 | Smooth and dry, a little dust | 46 | 58 |
| | CINDER DRIVE, LOW, WELL DRAINED GRADE, HEAVY TRAVEL | | |
| Feb. 28 | Cut up 1 inch deep | 152 | 125 |
| Mar. 4 | Dry, smooth, a little loose dirt | 103 | 65 |
| " 21 | 2 inches to 3 inches thick cinder mud | ------ | 275 |
| April 13 | Dirty, smooth, some worn hollows | 61 | 54 |
| " 21 | Fairly smooth, thin slush in holes | 100 | 121 |
| May 12 | Hard and smooth, some wet places | ------ | 84 |
| " 22 | Hard and smooth | 65 | 68 |