

power; that is, bodies were rather opaque. But as the vacuum became higher the penetrating power of the rays became greater, especially for dense bodies.

The third tube used was one of Queen's adjustable vacuum tubes. To obtain what is here called a low vacuum, the auxiliary spark gap was closed or short-circuited. To obtain a high vacuum the gap was made as long as possible. A photograph of the hand with a low vacuum showed flesh and bones almost equally opaque, while with a high vacuum the flesh was almost transparent. A photograph of a piece of glass, aluminum, steel, carbon, rubber and cork showed that the glass, aluminum and steel were more transparent to the high than to the low vacuum rays. The reverse was true of carbon and cork. No difference was noted with the rubber.

Soon after the X rays were discovered Edison announced that what are known as slow plates are the fastest for X rays. Here again the degree of the vacuum must be taken into consideration. For high-vacuum rays fast plates are most rapid.

The fluoroscopic action of the rays also changes with the vacuum, a rather low vacuum giving the best results.

Whatever be the nature of the X rays it is certain that they possess properties analagous in some respects to pitch and color.

THE TROUBLE WITH INDIANA ROADS BY DANIEL B. LUTEN.

A good road is defined as a road that is hard, smooth and serviceable at all seasons of the year.

The State of Indiana has 60,000 miles of wagon roads, of which about 8,000 miles have been improved by graveling or "piking," and now constitute our free gravel road system, maintained and repaired by the counties. The remaining 52,000 miles are nearly all dirt roads, and are maintained and repaired by the townships.

If we are to judge of Indiana roads by the above definition of good roads, we must admit that less than one per cent. of our 60,000 miles of roads are good roads. I do not mean that the remaining ninety-nine per cent. are always bad; but I do mean that for five or six months of every year they are bad, some of them extremely bad, and that at such

times they are passable for none but lightly-loaded and slow-moving vehicles. From the middle of May until the middle of July the roads are in excellent condition. A dirt road during these months is a splendid road; a gravel road is equally good. From the middle of July until the middle of October they are covered with dust, sometimes two or three inches in depth. Then come the fall rains, and the dusty roads absorb water like a sponge preparatory to December frosts. Then follow three months of good roads with frozen surface over the imprisoned water that is well content to wait, knowing that in March it will have ample opportunity to make trouble. And with the first of March the roads begin to thaw and break up, to be followed by two months of bad roads.

Of the 60,000 miles of roads in Indiana, 52,000 are unrideable for bicycles at nearly all seasons of the year, and the remaining 8,000 are rideable only during about four or five months in the early summer and late in the fall or winter.

There are seven good reasons why our roads are bad:

1. Because of lack of drainage, more especially of the surface water; failure to remove the surface water to the side ditches promptly permits it to saturate and soften even the hardest of road materials. The road surface should at all times be kept shaped like a roof to shed water, and to this end it is necessary always to keep ruts and chuckholes filled, and the surface smoothly and uniformly crowned. The first step in the maintaining of a road in good condition is to eradicate the ruts. And any plan or device that will prevent the forming of ruts will aid in providing good roads. Wide tires help to attain this end; a more clever device is the long doubletree, with the whiffletrees so attached that each horse must travel directly in the wheel track. The horses refuse to travel in the rut, and choosing the smoothest path, the wheels are drawn out of the rut, thus helping to roll it down instead of cutting it deeper.

2. Another reason why our roads are bad is because repairs are too long delayed. On road surfaces, more perhaps than upon any other kind of engineering structures, the repairs should be made promptly; an ounce of prevention is worth many pounds of cure.

3. A third reason for bad roads is because too much of the work on repairs is done at one time, on the principle, doubtless, that if a small dose is good, a large dose will be better.

Our gravel roads suffer most from this method of repairs. Late in the fall they are heaped ten or twelve inches deep with gravel and then al-

lowed to take care of themselves for another year, when they are given another dose, after which they are called "improved" roads!

The gravel is dropped in a heap in the middle of the road, usually with no attempt to spread it uniformly. And that is the fourth reason for our bad roads.

4. Too much material and too little labor. One-fifth as much new material would usually be sufficient, and the labor wasted in hauling the other four-fifths should be used in filling ruts and chuckholes instead.

5. Another reason is that the repairs are made at the wrong season of the year. Gravel roads are frequently repaired in the fall; then the heavy rains turn the new gravel into mush that freezes into a good road for the winter months, but breaks up into soft mud with the first thaw of spring.

The proper season for road repairs is all the time. They should be watched and repaired every day of the year.

6. Reason No. 6 is the use of improper road material. Broken stone applied to road surfaces should never be in sizes greater than one and one-half inches in diameter, and should contain at least twenty-five per cent. of stone screenings less than one-fourth inch in diameter. Gravel should be such that all of it will pass a one-inch sieve and twenty-five per cent. will pass a one-fourth inch sieve. Good road gravel contains no rocks larger than hulled walnuts; nor should there be more than five per cent. of clay present.

7. Another reason for bad roads is poor location; the policy of running roads on section lines is unwise, especially in hilly country. They ought to wind through the valleys and around the hills instead of over them. A proper location for a road is always a compromise between grades and distance. In hilly country the winding road will be an easier road for traffic, will be more picturesque and will frequently be shorter than the section-line road.

Having pointed out the reasons for bad roads, the next question is to find the remedy. I shall not propose better methods of construction; even macadam roads costing say three thousand dollars per mile would give us better service for but one or two years and then would become as bad as the rest if not properly maintained. There is only one kind of road that can be depended upon to remain in as good condition as when first constructed, and that is the corduroy road of olden times. And may Providence deliver us from that.

There is no such thing as a permanent road. They all require constant care and repairs. And the more perfect the road surface the greater will be the care and attention required to keep it smooth. It costs more to properly maintain a stone road than a gravel road. But a good stone road is a better road than a good gravel road.

Some theorists tell us that if we could have all the money that has been expended upon our bad roads we could pave them with gold. Our State has expended \$70,000,000 in road repairs in the past forty years. We are told that if this sum had been expended in building permanent roads we would now have a complete system of good roads. They forget that good roads cost as much for maintenance as poorer roads; they forget that if we had expended \$70,000,000 in building good roads in 1860, we would still have had to expend another \$70,000,000 or more to keep them in good condition to the present time.

Or if, on the other hand, we had saved that \$70,000,000 of repairs to now expend in building good roads we should for that forty years have had to get along with roads that would have been ten times worse than the ones we have had. For there is no denying that the expenditures that have been made upon our roads for repairs, although very wasteful and not a complete success, have been nevertheless of great benefit.

To go back to our search for a remedy, permit me to repeat the reasons for bad roads in Indiana:

1. Bad drainage.
2. Repairs delayed.
3. Too much repairing at one time.
4. Too much material, not sufficient labor.
5. Repairs at wrong season.
6. Improper material.
7. Poor location.

1. To secure proper drainage of surface water requires constant attention. All that is necessary is to keep the road crowned, but it must be watched and cared for at all times and especially in wet weather. There must be some one whose duty it is to keep the ruts and chuckholes filled and the ditches clear.

2. Repairs need not be delayed if some one is employed whose duty it is to attend to them promptly, provided there be a superintendent to see that he does his duty.

3. Repairs would not all be made at one time if a single attendant were employed for a long time instead of the present method of many men for a few days.

4. Too much material is used and too little labor, because material is usually cheap and labor is expensive, and because it is easier to tell a man how to haul a load of gravel than to tell him how to make tools for filling the ruts.

5. Place a man in charge of the road who has to attend to it constantly and he will soon learn that it is easier to keep it in good condition by scraping the ruts than by drawing on four times as much gravel as is essential.

6. Improper material is used because the men employed on repairs have neither the time nor the incentive to learn the qualities of road materials. This requires a certain amount of expert knowledge that can easily be gained by experience.

7. To remedy poor location requires only that a man should be able to see that it is easier to draw a load around a hill than over it. Teach the road attendant to ride a wheel and he will soon appreciate the difficulty of steep grades.

In short the reason our roads are bad is because nobody makes it a business to attend to them. And the remedy is a system of maintenance which shall make it somebody's business to keep them in good repair. Dirt roads should be in good condition for at least nine months of the year, and gravel roads ought to be good at all times.

By our present Indiana laws we have abundant provisions for superintendence, not perhaps of the most expert kind, but engineering skill is not necessary. What is more essential in a road superintendent is that he should have the power to discharge an attendant for lack of attention to duty, and that he should be able to tell when a road is not in good condition. As a matter of fact the average engineer is too apt to go to the other extreme and to attempt to construct permanent roads at great expense when our system of maintenance by no means warrants it, which would be as reckless as to invest in an expensive building and then fail to insure it against fire. Our roads should be divided into sections of not more than twenty miles in length; for each section a man and team should be employed, all of whose attention is to be devoted to the care of that road from the first day of March until the first day of December.

He should be employed by the day so that he may be liable to discharge at any time for neglect of duty. He should be selected by competitive bids for day labor of eight hours per day.

Man and team could be secured for nine months' service at the rate of \$1.50 or less per day. The rate at present paid by our county commissioners for man and team is \$2.50, because they are employed for but a few days at a time. And for this \$2.50 a man is secured who takes no interest in the road and who piles on the material because it is easier to draw gravel than to spread it, and because it makes his job last longer.

To secure the adoption of such a system for our gravel roads requires only that county commissioners should be convinced that it is more desirable as well as more economical than present methods. They have full powers to act.

For our township roads it requires that all road taxes should be paid in money instead of in day labor as at present. The day-labor system produces the same kind of results that would be secured by a school system if the citizens assessed were permitted to work out their school taxes by taking turns in teaching the public school. When road taxes are paid in money, the division of township roads into sections, and the employment of attendants, will solve the road problem.

This method of maintenance by an attendant who devotes all of his time to the road, is in use in isolated cases in the United States, principally in New York State. In European countries it is acknowledged to be the only satisfactory method of maintenance, and it is the basis of the superb system of highways enjoyed by France and Germany.

SOME TESTS ON BALL BEARINGS. BY M. J. GOLDEN.

These tests were made to determine the amount of power absorbed by ball bearings of the form used in supporting shafting and spindles, when the load is light. The bearing, in this set, was loaded with weights that varied from ten pounds (the weight of the parts) to three hundred pounds, by increments of forty pounds, except the last one; that was ten pounds. The apparatus used is shown in the sketch, where (A) is a spindle that is revolved by means of a belt from a counter-shaft. To this spindle is attached (B), the inner part of the ball race; the outer part