Federal aid to the states has proven a highly effective and satisfactory method of developing a primary road system for the nation. Is it not reasonable to assume that through employment of similar methods by the state and counties an effective and satisfactory secondary road system could be given to Indiana?

SECONDARY ROAD DEVELOPMENT

By A. O. Hastings, District Engineer, Indiana State Highway Commission, Greenfield

Early roads in Indiana were principally established by legislative acts connecting main trading points. These routes followed, in a general way, old Indian trails or higher ground levels between points authorized to connect. The early routes prior to 1853 were opened and maintained by money obtained through an act known as the Three Per Cent Fund Act. This fund came from the federal government and was a part of moneys obtained through the sale of public lands. This was apportioned to the various states something on the order of our present federal aid fund and was administered by a commission appointed by the state legislature.

In 1853, a legislative act conferred upon the several boards of county commissioners the authority of locating and maintaining roads. As the country developed, a network of public roads was laid out and improved. With the economic development of this state, some of these roads became of primary importance while others were only secondary and some of the early locations were eventually abandoned.

Shortly after the Civil War many of the primary roads were improved and maintained by toll-road companies. These toll-roads were pretty generally purchased by the various counties in the 80's and early 90's and formed a basis of the free gravel road system in each county.

Road maintenance and construction was principally carried on by township trustees until about 1909, when the three-mile road law was enacted. The counties are still using this law for county road improvement. About 1913 an act of the legislature authorized the appointment of a county road superintendent, responsible for the expenditure of the free gravel road repair fund in the upkeep of a county system of roads.
Because of the way the three-mile road law was used for improving roads and because of the non-uniformity of construction and maintenance, a checkerboard system developed. By 1917 the automobile had come into such general use that through routes of uniform construction and maintenance were demanded by the public.

In 1919 the state highway commission was created. A state highway system was laid out connecting county seats and the main centers of population. The highway commission went to work to eliminate the checkerboard layout that existed, using the greater part of funds available for the past few years for this purpose.

Increased registration of automobiles and their use in the rural districts is demanding that the secondary road be given consideration, both from the angle to secure an all-year farm-to-market road, and to eliminate the dust nuisance. The allotment of available funds to such roads is quite a problem. The type of improvement should be carefully considered. A comprehensive traffic survey showing the probable load the road carries, an estimate of traffic for the next few years, and the physical condition of the road should be the data upon which the road engineer decides the proper steps used in development.

Many miles of state road have been developed considerably by intensive maintenance and minor betterments, such as small corrections of grade, line, and drainage, and a heavy application of metal. Applications of road oil or calcium chloride have been used fairly successfully as a dust palliative, and in a few cases where the old roadbed was substantially built, a mat has been formed with road oil and maintained as such with good results. A surface treatment of the lighter grades of asphalts or tars produces a very satisfactory mat surface, provided the roadbed has sufficient strength built into it to support such a surface properly. I would like to say here that the success of any of the low cost surfaces, such as skin treatments, light retreads, etc., depends almost wholly on the foundation upon which they are placed.

Retread Surfaces

If a better improvement than just a dust palliative is warranted, the retreads the highway commission has been build-
ing within the last few years should prove satisfactory. Here again the type of retread to be built should depend on condition of road to be resurfaced. A light retread will carry enormously heavy traffic if sufficient bearing strength is in the base, while a very heavy, well built retread will not stand up unless it has base under it. To be sure, the bearing strength of retread should be almost directly proportional to its thickness, with but few variables.

Retread is a mixture of aggregates and bituminous cement mixed in place on the road. The name as used to date covers anything from just a little more than a skin treatment up to a good bituminous macadam varying in cost from $1,500 to $7,000 a mile for a surface 20 feet wide.

One feature adopted this year which adds to the strength of the base very materially at a very nominal cost was treating the loose gravel or stone on the old road with a heavy grade of road oil. This caused such loose material to compact and at the same time formed a more or less impervious layer. This mat of oil and aggregate not only serves as an insulation layer breaking up capillary attraction but also greatly strengthens the base.

I do not know of any type of resurfacing that better lends itself to secondary road surface development than the retreads.

Briefly, the steps in constructing a high type retread are as follows:

(a) Any soft or irregular spots in the old gravel or stone surface are built up or strengthened by adding sufficient gravel or crushed stone under regular maintenance. Intensive dragging for a few weeks, using a long base drag, helps quite materially in producing a smoother and more uniform riding surface.

(b) Any loose material then on the surface is winnowed on the shoulder and the surface given an application of heavy road oil, approximately 5/10 gallon per square yard. The winnowed material is then bladed uniformly over the surface and the road dragged intensively.

(c) After the road oil is dry, crushed stone, size No. 2 (2½ inches to 1½ inches) is spread over the surface to a depth of approximately 4 inches. Sometimes this stone is spread from end-dump trucks and sometimes from spreader boxes. This stone is carefully leveled by use of a long base
blade grader or harrow, and the final leveling is done by hand.

(d) Asphalt cut back or light tar (according to our specifications, asphalt CB or tar TM) is then applied uniformly to the crushed stone at the rate of 4/10 to ½ gallon per square yard. The road is then rolled once, using a 10-ton, 3-wheel, self-propelled roller in all rolling. When the bituminous material is cured sufficiently to become tacky, the surface is thoroughly rolled. Usually from one to three days is required for the bituminous material to cure to the proper stage for best results. The surface is then carefully straight-edged and any depressions are patched with bituminous-coated aggregate, size No. 2 where practical and size No. 4 where depressions are small. Patches are rolled and straight-edged for check. By careful patching much may be accomplished to produce a smooth riding surface.

(e) Asphalt CB, Hot Oil OH2, or tar TM or TH is then applied at the rate of 3/10 to 4/10 gallon per square yard. The heavier asphalt or tar is permitted for this application and if used will speed up the operation, as the heavier bituminous material cures quicker than the lighter; however, ultimate results are about the same whether the heavier or lighter bitumen is used. The lighter grades of coarse bitumen require a little more time to cure. When the bituminous material is in the tacky stage, the surface is again thoroughly rolled. It is important that plenty of rolling be done, as it is practically impossible to roll too much at this time.

(f) Just before applying the third coat of bituminous material, covering material (size 1 inch to 5/8 inch) should be applied in sufficient quantity to fill all the voids in the coarse stone and should be broomed into the voids. Approximately 35 pounds per square yard of surface is used.

(g) Asphalt CB or tar TM is then applied to the surface at the rate of about .25 to 3/10 gallon per square yard. The surface is again thoroughly rolled and the road then can be opened to traffic.

Just before winter weather, this road should be given a surface treatment of asphalt CB or tar TM and sufficient covering material, size 1 inch to 5/8 inch, applied. The approximate quantity of treatment should be 2/10 gallon per square yard. Use 40 to 80 pounds of covering material per gallon.

If this retread is built late in the fall, it may be necessary to put on the surface treatment or fourth coat of bituminous
material shortly after the third coat, and if this is the case, perhaps a little less bituminous material and covering will be necessary.

The surface should be dragged to aid in securing a smooth riding surface. To secure good results with retread:

1. Be sure the old base has sufficient strength to carry the load put upon it.
2. Do not use too much bitumen. I much prefer retread almost to the point of ravel than too rich in bitumen.
3. Roll the surface adequately.
4. Be specific.
5. Protect this initial investment by proper maintenance.

The method just described is costing about $7,000 per mile for pavement only and is one of the higher types of retread. Good results have been secured with lighter courses; however, the thickness of course should be determined by considering the base and the amount of traffic that will go over it. Lighter types of retread can be built at less cost.

ANNUAL REPORT FOR 1929

By Chas. Mann, Highway Superintendent, Marion County, Indiana

Board of County Commissioners:
I wish to submit the following report for the Highway Department for the year 1929.

MILEAGE COUNTY ROADS

<table>
<thead>
<tr>
<th>Type</th>
<th>Mileage</th>
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<tbody>
<tr>
<td>Paved</td>
<td>154.74 mi.</td>
</tr>
<tr>
<td>Gravel and stone</td>
<td>900.92 mi.</td>
</tr>
<tr>
<td>Earth</td>
<td>14.20 mi.</td>
</tr>
<tr>
<td><strong>Total mileage</strong></td>
<td><strong>1,069.86 mi.</strong></td>
</tr>
</tbody>
</table>

NEW EQUIPMENT PURCHASED

(9) McCormick-Deering tractors
(8) Adams No. 6 maintainers
(1) Ford automobile
(1) Ford truck
Total gallons of gasoline used .................. 49,863 gal.
Total gallons of oil used ....................... 1,773 gal.
Total gallons of alcohol used ........................ 100 gal.

MATERIAL USED FOR PATCHING IMPROVED ROADS

<table>
<thead>
<tr>
<th>Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt and tar</td>
<td>19,000 gal.</td>
</tr>
<tr>
<td>Stone</td>
<td>1,200 tons</td>
</tr>
<tr>
<td>Sand</td>
<td>50 cu. yd.</td>
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</tbody>
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