

Highway Finance

Financial conditions are so varied in the different states that it would be difficult indeed to give a rule that would apply generally. It is becoming more apparent that in the future taxes for whatever purpose will generally be decreased rather than increased. It is to be regretted that it is becoming increasingly difficult to provide additional funds to take care of increasing traffic requirements. The limit which property should pay as a direct tax for highway improvement has been reached or exceeded in a great many communities. The general cry has been to let traffic pay its own way. It is too big a problem to be analyzed here.

One basic principle that might be stated is, that from all funds appropriated for highway work an adequate sum should be set aside for the maintenance of existing highways. Another is that construction should follow the requirements of traffic. Each state should have as an economical minimum for highway work a sum capitalized at standard interest rates and based upon its total number of motor vehicles at an average estimated value of perhaps \$500 each. A sum less than this is not adequate for normal development and maintenance, to say nothing of bridge replacements, grade crossing separations (both rail and highway), widening and reconstructing, and other specific betterments.

The big problem of the next 10 years will be that of adequately awakening the public to the fact that funds for highway work are far in arrears of the requirements of traffic.

RESURFACING OLD ROADS

By A. H. Hinkle,
Supt. of Maintenance, Indiana State Highway Commission.

Preliminary to my paper proper on "Resurfacing Old Roads", I should like to comment on a few things which are appropriate subjects for discussion at the Road School and perhaps our best opportunity to discuss them with the county highway superintendents.

Because of the nature of the work of the state highway commission and the county highway superintendents, it is necessary that there be cooperation between these organizations in order to properly and most economically handle their problems.

We expect our local maintenance superintendents to cooperate in every way consistent with the county men and we will appreciate immensely their cooperation in return.

Dragging Gravel onto State Roads at Road Intersections

In traveling over the state roads of the gravel type, you will frequently find at the intersection of a county road a high place, sufficient to produce quite a bump to the high speed traffic which goes over it. We have frequently ordered our men to cut down these elevations, but it seems that this does not keep them down.

An examination into this situation shows that these high places are principally caused by the drags or graders used on the crossroads being turned at the intersection and permitting the loose gravel in front of the blades to be deposited upon the state road. Frequently this gravel contains sod and silt from the roadside which acts as a binder and causes the loose material to "set up" quickly. This is done many times during the year at an intersection and results in building up a high place in the state road which can not always easily be cut down and if cut down to the proper grade soon appears again from succeeding draggings. It would be not only a saving of expense to the state but to the county as well if the latter could retain this gravel on the county road instead of depositing it in a pile on the state road, where in this particular case, it is not wanted. In this instance, the donation of gravel to the state highway commission is not a favor.

Detours

As you all know, the state is now required to maintain detours over county and township roads where the state road is closed. This requirement of the law is not only a great advantage and saving to the general public using the roads, but also in some respects it is a considerable saving to the counties because they are not required longer to bear the expense of maintaining the detours. The highway commission is limited in the amount of funds it has to spend and what is expended on detours can not be expended in extending the pavement on the state system. There has been in some cases an undue demand to expend more on the detour routes than perhaps is justified in view of the condition of the state system as a whole. It is hardly expected that the state should go to great expense to "build up" these detour roads so they can be maintained in as good a condition as the state road has been maintained. The principal purpose of the detour maintenance law was to secure better detours for the traveling public and not to save the county funds. This latter feature is secondary.

The state road is closed for paving because the gravel or stone road was not satisfactory for the heavy traffic and in order to make a detour road, which frequently has very little metal on it, in as good condition for travel as the old state road, we frequently would have to spend \$4,000 to \$6,000 per

mile on the detour. It would not be a good policy for the state to spend any such sum on the average detour road.

I know that the county superintendents are just as interested in securing a paved system on the state roads in their county as are any of the state highway officials. I am hoping that due consideration will be given the proper progress of the pavement on the state system when demands are made on the commission to spend greater sums than the commission feels justified, on the detour roads. In other words, we should not expend too much on the detour roads unless we expect to sacrifice the progress of our work on the main highway. We hope to maintain these detour roads in a reasonable state of repair and leave them in as good or better condition than they were before the detour was established. Frequently these will be in far better condition because of the metal required to satisfactorily carry the traffic.

Advertising Indiana

Much has been said about advertising Indiana to the general public. I do not know of anything that will come nearer doing this than the development of a great highway system. If many of the rights of way on the state highways were wider, much could be done in future years toward roadside development, planting and ornamentation, which would be a very great asset to the state. A park effect along the roadsides would be an advertisement for any local community and of which they could be proud. This would also provide a place for tourists to stop and eat their lunch or perhaps even camp on the roadside. If such roadside development could not be brought about on all the state roads, it could at least be developed at certain places.

This work should have the support of the local communities. It would do more to advertise Indiana to tourists and people outside of the state than all the artificial advertising that could be brought about by other means.

I am mentioning this feature of cooperation here because it has been a custom of the highway commission to require the county or local community to furnish the right of way for state road improvements and it has been reported on several occasions that they have opposed this policy instead of promoting it. I am sure if this is true it has usually been the result of a misguided influence. We should keep in mind that while the state road is primarily intended for through traffic, it also takes care of the local traffic and the local community is almost always the largest beneficiary of its construction.

Resurfacing Old Roads

This is somewhat of an old subject, but it is quite evident that it is going to be an appropriate subject forever, for the

more roads we build, the more old roads we will have each succeeding year and the problem of how to take care of them and with what to resurface them, is an important one from the point of view of highway economics. Hence, this subject should interest all those who are required to pay for this work.

I have discussed this subject in previous years at the Road School and will take up this time only two phases, which with respect to some features of the work we did this past year are more or less new.

(1) Resurfacing Old Roads with Three-fourths Inch Rock Asphalt on Bituminous Macadam

The Old Road As a Base. This past year we resurfaced four different roads with the above type of top. One was an old concrete road built some years ago which, due to defective concrete and insufficient thickness of slab, had broken up badly under traffic so that it was very expensive to maintain. Before resurfacing, the places that were too defective in the old slab were patched with concrete. The old concrete was given a light surface treatment of Liquid Asphalt CB or Asphalt OH₂ and No. 4 covering to roughen the surface and thus avoid a slick, hard condition which would permit the macadam stone to slide about under the roller. On the other three projects this top was placed upon old macadam roads after they had been leveled and trued up with a waterbound macadam course.

Constructing Bituminous Macadam for Rock Asphalt Top. On the old road prepared as described above, a bituminous macadam layer was constructed about 3½ inches thick. This was constructed according to our standard specifications, except that only about 1.25 gallons of tar or asphalt per sq. yd. was used in two applications instead of about 1.8 gallons as used in the standard bituminous macadam. Only about 10 pounds of covering stone was used per sq. yd. This limited quantity of bituminous material and covering stone left the surface of the black base with voids so that the rock asphalt anchored itself well to the penetration macadam.

Three-Fourths Inch Rock Asphalt Top

Upon this black base a rock asphalt top was built with a compacted thickness of about ¾ inch. The amount of rock asphalt used was 75 to 80 pounds per sq. yd.

The rock asphalt was unloaded from cars by hand shovels or with a small half-yard gasoline shovel. As the cold weather approached, making it difficult to handle, the rock asphalt was either pulverized without heating or was heated with steam in the cars before removing. (Fig. 1.)

Cold Pulverized Rock Asphalt. The rock asphalt was passed through a pulverizer stationed either on the road surface just ahead of the spreading or at the side of the car where



Fig. 1. Unloading Rock Asphalt from Cars, Grinding and Loading in Trucks.



Fig. 2. Steam Heating Rock Asphalt in Cars.

the shovel dumped the cold, lumpy material directly into the pulverizer. This pulverizer consisted of a cylinder and concave from an old threshing machine with about two-thirds of the teeth removed. The cold rock asphalt was finely ground

in passing through, making it easy to shovel and spread on the road surface.

Steamed Rock Asphalt. The steaming process was accomplished by forcing half-inch perforated iron pipes about 4 ft. long attached to a $\frac{3}{4}$ -inch steam hose, into the rock asphalt at various places in the car. The pipes were forced through to the car floor and then raised a few inches, which permitted the condensed steam to drain off through the floor and thus reduce to some extent the amount of moisture collecting in the rock asphalt. (Fig. 2.)

The steam passes out through the perforations and bottom of the pipe and rises up through the surrounding rock asphalt and heats it to the desired temperature. As the shovelers approach the pipes, the pipes are reinserted in the rock asphalt ahead. Care should be taken to insert one pipe near enough to each corner of the car so as to heat the rock asphalt clear to the corner. Sufficient pipes to keep a uniform temperature ahead of the shovelers is very desirable. An uneven heating is liable to add to the difficulty of spreading the rock asphalt to a uniform surface on the road, since the hotter material will compact more readily than that with the lower temperature.

It usually takes about two and one-half hours for the steam to sufficiently heat the surrounding rock asphalt. It is desirable that the steaming process, at any one place, be limited to five hours in order to avoid an excess of moisture resulting from condensed steam.

The steaming process made the rock asphalt soft and easy to shovel and spread; however, due to its soggy condition as compared with the dry pulverized material, it is more important to be on guard against a non-uniform density when it is spread on the surface. For instance, if a workman throws a big shovelful of steamed material with some force on the road surface, it is liable to produce a more dense mix at this point which will eventually result in a slight elevation on the finished surface. The cold pulverized rock asphalt, being dry, presented less difficulty from this source. Hence, we conclude that it was a little easier to secure a smooth surface on the road with the cold pulverized rock asphalt than with the steam-heated material; however, there seemed to be no objection to the moisture from the steamed product even when laid at temperatures near or below freezing. Comparing the results secured with the two conditions, it is quite evident that the steam-heated material showed no signs whatever of raveling when laid as late as December 1st during freezing temperatures, while the unheated product does show some symptoms of raveling when laid at this low temperature.

Spreading Rock Asphalt on the Black Base. The pulverized or heated rock asphalt as described above is dumped by

trucks just ahead of the shovelers and shoveled into place. Metal strips $\frac{1}{4}$ inch thick, $1\frac{1}{8}$ inches wide and about 18 ft. long, bent at right angles near one end to prevent them from tipping over, were laid 3 ft. apart on the road surface to be used as a guide in gauging the thickness of loose material. Rock asphalt was then raked to as near the proper elevation of the metal strips as possible and afterwards brought to the exact level of the metal strips with a $3\frac{1}{2}$ -inch triangular lute 4 ft. long having a handle 12 ft. long. On some of the work 7-ft. lutes were used. This longer lute rested on three of the metal strips as it was pulled forward. With these lutes, the loose rock asphalt was brought to a very uniform surface. As the metal strips were slid forward, the loose material behind was leveled by cross-luting with an oak lute 1 inch thick and 6 ft. long having a handle 12 ft. long. By this cross-luting the marks left by the metal strips were removed. (Fig. 3.)



Fig. 3. Raking and Luting Steam Heated Rock Asphalt.

Rolling and Planing. The rock asphalt was first rolled with either a 5-ton tandem or a 10-ton, 3-wheel roller. After one rolling the rock asphalt was planed to a level surface with a long base, metal planer which cut the high places and filled the low places with loose material. On part of the work planing was done on the loose rock asphalt before the first rolling. There were indications that, with the thin layer used, this might even be a more practical process than rolling before planing. The planing of the loose material in this manner leveled the rock asphalt in about the same manner as the planer levels the loose gravel in dragging a gravel road.

Additional rock asphalt was fed in front of the planer blades where necessary to provide material to fill up any small depressions in the surface. (Fig. 4.) After going over sev-

eral times with the planer, the surface was again rolled and where necessary further planing done. In all cases, the final rolling was done with a 10-ton, 3-wheel roller. We were not able to conclude from our experience as to how much merit there may be in using a light roller for the first rolling.



Fig. 4. Feeding Pulverized Rock Asphalt in Front of Planer as Part of Smoothing Process.

Curing Before Planing. It is found that the time required for curing before the first planing ranged all the way from a half day to a week, depending largely upon the atmospheric temperature. The rock asphalt laid in October normally had to cure four or five days before it could be successfully planed. During late November and early December when we were using steam-heated rock asphalt, the material was rolled as soon as possible after laying, and was planed six to twenty-four hours later.

Experience soon teaches that there is one certain stage in the curing process during which the planing can be done successfully. If an attempt is made to plane the surface too early, the planer blades will tear up large areas of the surface, whereas if it is delayed too long, the rock asphalt will become so hard that it is very difficult to plane off the high places.

One stretch of pavement that was laid and permitted to harden too long in a rough condition was smoothed up with difficulty by scraping with a heavy 12-ft. blade grader. If the planing is delayed too long, the loose material scraped off the high places will not readily bond to the surface of the depressed areas.

The above methods and processes of laying the rock asphalt surface result in a much smoother riding surface than ordinarily is secured by the usual methods that have been used.

consisting merely of raking and rolling. Experience demonstrates that with the above processes it is not difficult to secure a surface which shows no depressions greater than $\frac{1}{4}$ inch with a 20-ft. straight edge nor greater than $\frac{1}{8}$ inch with a 4-ft. straight edge when laid parallel with the center line of the pavement.

Judging from our experience during two seasons, the bituminous macadam is a very satisfactory course on which to lay a thin rock asphalt top. Due to the thin coat used perhaps a proper designation for such a top is a "Rock Asphalt-Bituminous Macadam Top Course".

(2) Resurfacing Old Stone and Gravel Roads With a Bituminous Retread Top

This type of surface may be described as between a surface treatment or mulch mixture and a bituminous macadam (penetration) top. I shall describe same by giving a specification for this class of work.

Specifications for Bituminous Retread Top

1. *Description.* This bituminous retread top shall consist of a mixture of bituminous material and crushed stone, slag or gravel, made by applying successive applications of the bituminous material to a layer of aggregate spread on the old road to a smooth surface and a uniform crown and grade. The mixture is kept smooth and uniform, by the use of a grader or planer if necessary, until the bituminous material hardens sufficiently to cause the stone to compact under a roller. The aggregate is rolled after each application of bituminous material when the bituminous material is in the proper stage of curing. The surface voids that can not be closed by rolling, after the second application of bituminous material, are closed by the addition of No. 4 aggregate.

2. *Preparing the Old Road As a Base for the Retread Top.* The old gravel or stone road shall be leveled and trued up by dragging and scraping. A coat of No. 3 or No. 2 aggregate shall be applied if necessary to strengthen the old base. Scarifying before leveling may be resorted to if there is an abundance of coarse aggregate in the old road. (However, since the old road is usually weak it will generally be found more economical to build up the low places rather than cut down the high places.) After the old surface has been brought to proper grade and crown and after a sufficient thickness of base metal has been obtained, and the base is compacted either by traffic or rolling, the road is ready for the retread top. (If metal is added to level and strengthen the old base, it is prefer-

able that it be done several months in advance of putting on the retread top so that a smooth and uniformly compacted base without much loose, fine material thereon will result.)

If there is any material amount of fine aggregate such as sand or crushed stone on the old road after it is prepared for the retread top aggregate, same shall be uniformly distributed over the road surface so that it will not work up into the coarse aggregate non-uniformly. (Any spots in the coarse aggregate that are filled with this fine aggregate will likely develop into "fat" spots after the bitumen is applied. Such spots will be a source of trouble later on.) In some cases this excess loose material on the old surface has been treated with a light tar or asphalt oil, thus solidifying the loose material and producing an impervious layer before the retread stone is placed thereon.

3. *Bituminous Materials.* The grade and amount of bituminous material used in this work shall depend upon the depth and grade of aggregate. (No more shall be used than just sufficient to prevent raveling of the surface.) Table I in paragraph 9 shall be used as a guide in determining the quantities to be used. If the aggregate contains much fine material, the first coat of bituminous material should be Liquid Asphalt ACG, Tar TC or TCM instead of the grade given in the table. The successive coats of bitumen shall follow each other just as soon as time for curing of the preceding coat has been allowed. Distributor and application shall comply with specifications in item 5 for bituminous macadam top.

4. *Covering Material.* Covering material shall consist of grade A crushed stone, slag or gravel, size No. 4 (1" to $\frac{5}{8}$ "). No covering material shall be applied just after the first coat of bituminous material. If the aggregate is No. 2 size or coarser a small amount of covering may be applied just preceding the second application of bitumen.

The amount of No. 4 covering required will depend upon the size and hardness of aggregate that has been used. It may range from one cubic yard to 150 sq. yds. of surface where No. 3 aggregate has been used, up to one cu. yd. per 100 sq. yds. of surface where No. 2 aggregate has been used.

5. *Spreading Coarse Aggregate, for Retread Top.* The road shall be coated with 1" to 3" of No. 2 ($1\frac{1}{2}$ " to $2\frac{1}{2}$ ") or No. 3 ($1\frac{1}{2}$ " to $\frac{7}{8}$ ") grade A crushed stone, slag or gravel. This loose aggregate may be spread directly from the trucks but shall be leveled with a road grader and maintainer so that it conforms to the proper crown

and grade without any dips or irregularities. This loose material, if of size No. 2 and a hard stone, shall be smoothed and compacted with a 10-ton, three-wheel roller just preceding the first application of bituminous material. If the aggregate consists of No. 3 size, this rolling before the first application of bituminous material may be omitted. If a comparatively soft aggregate is used, this rolling shall be omitted on the No. 3 aggregate and may be omitted on the No. 2.

6. *Applying the First Coat of Bituminous Material.* To the aggregate uniformly spread as described above shall be applied the first coat of bituminous material. The aggregate may be rolled once while the bitumen is quite soft so that the maximum smoothing effect of the rolling will be secured. This coated aggregate shall then be permitted to cure until the bituminous material stiffens or becomes just sufficiently hard that it will not be unduly displaced by the rolling. (The curing period before extensive rolling will vary from a few minutes to several days, depending on grade of bitumen used and atmospheric temperature.) Any portion that has been disturbed by traffic or the distributor wheels to such an extent that the roller will not relevel same, shall be leveled either by hand or a road grader or maintainer just before rolling. As soon as the bituminous material is sufficiently hardened that the stone will compact well and remain so under the rolling, it shall be thoroughly rolled with a 10-ton, three-wheel roller. The wheels of the roller shall be sprinkled with water during the rolling, sufficiently to prevent the bituminous material from adhering to same. This provision shall be carried out in all successive rollings. This rolling can not be completed at one time but must be extended over several days in order that the aggregate will assume a proper position and remain bonded in place after the rolling is completed. The bulk of the rolling shall be done when the bitumen is sticky and stiff enough to hold the stone in place but not sufficiently dried as to become hard and brittle.

7. *Applying the Second Coat of Bituminous Material.* After the first coat of bituminous material has sufficiently hardened so as to prevent the aggregate from being greatly disturbed by the roller or distributor wheels, and the surface has been thoroughly rolled, the second application of bituminous material shall be made. After this application, and when the bitumen is in the proper curing stage, the rolling shall be continued in sufficient amount to thoroughly compact the aggregate and eliminate all irregularities and depressions. Any depressions and irregularities which can not be eliminated by rolling shall be removed by the addition of aggregate of the same size as

used in the top course and which has been previously coated with asphalt or tar. This rolling and leveling process shall continue until a true and uniform surface results and the bituminous material has sufficiently hardened so that the surface will resist longer being distorted by the roller or distributor wheels. The time of this curing process and rolling will vary from one day to five days, depending upon the grade of bituminous material used, and the temperature at the time the work is being done.

After the surface has become solid and just preceding the application of the third coat of bituminous material, the voids in the surface shall be uniformly filled with loose No. 4 grade A covering. *No rolling or traffic shall be permitted on this loose covering before the third application of bituminous material.* (These voids can best be filled by uniformly spreading same on the surface and sweeping them by hand brooms or with a broom dragged behind a light truck or car [Fig. 5].) If an extremely



Fig. 5. Sweeping No. 4 Covering Stone into Voids Before Third Coat of Bitumen.

hard stone is used for covering and the coarse aggregate shows very open voids, part of this covering may be applied just after the second application and before the rolling is completed. However, care shall be taken not to close up the voids too early as the bitumen down in the mixture must have time to harden before closing the surface voids; also any excess of covering and bitumen may be the source of waving and rolling later on.

8. *Applying the Third Coat of Bituminous Material.* After the voids have been filled with loose No. 4 aggregate as described above, the third application of bituminous material shall be made. After the third coat of

bituminous material has been applied, it shall be covered with additional No. 4 aggregate, after which the surface shall be thoroughly dragged with a long base metal blade drag or planer (Fig. 6). The surface shall then be again

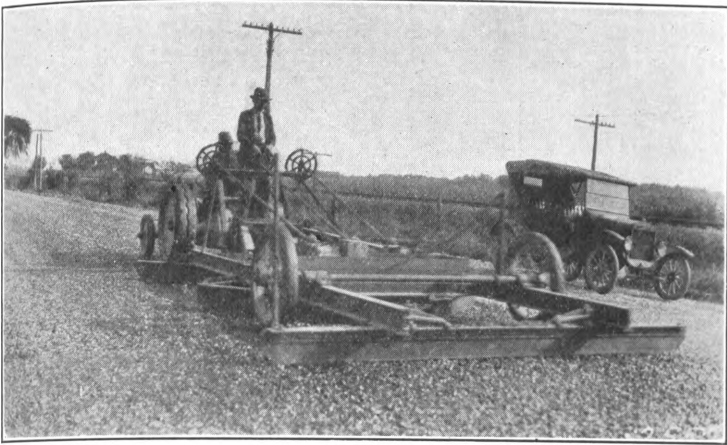


Fig. 6. Dragging Retread Surface After Final Coat of Bitumen Has Been Applied.

thoroughly rolled, after which it can be opened to traffic. If under traffic the surface does not sufficiently close up to eliminate danger of raveling, another coat of bituminous material and No. 4 covering may be added, preferably just before the road goes into the winter season.

(The greatest precaution that must be taken with this type of work is to avoid building up a rich mat of bituminous material and fine covering. For this reason no sand or limestone dust or fine aggregate finer than No. 4 should be used in building up the surface. Any material amount of dirt, dust, sand or other fine aggregate with the bitumen is very likely to produce a soft, mushy mixture which sooner or later will wave and roll under heavy traffic. *For this reason it is always best to be conservative on the amount of bituminous material used, keeping in mind that a little additional material can be added at any time while if too much is applied, it is impossible to remove the excess.* Difficulty from a slight excess of bitumen can be partially corrected by the addition from time to time of hard No. 4 or coarser covering, permitting traffic or the roller to force same into the soft, mushy surface. While this is a partial corrective remedy for the excess bitumen, *it is always best to avoid in the first instance the condition which will cause the waving and rolling of the surface.* On heavily traveled roads there is more danger of using an excess of bitumen than on roads with light traffic.)

TABLE I. Amounts of Bituminous and Covering Materials Required for Different Amounts of Coarse Aggregate.

Estimate Reference	Depth of Loose Aggregate	Size of Coarse Aggregate	Aggregate Required for Different Thicknesses (based on 2,500 Lbs. per Cu. Yd.)				Gallons and Grade of Bituminous Material Required per Sq. Yd. of Surface							
			Coarse		Covering		1st Coat		2nd Coat		3rd Coat		4th Coat	
			Tons per Mile for 20 ft. Width	Lbs. per Sq. Yd.	Tons per Mile for 20 ft. Width	Lbs. per Sq. Yd.	Gal.	Kind	Gal.	Kind	Gal.	Kind	Gal.	Kind
A	3"	No. 2 (2½" to 1½")	1,222	208	200	34	.45	TM or CB	.35	TH or CB	.40	TH or CB	.2	TM or CB
B	2½"	No. 2 (2½" to 1½")	1,019	174	200	34	.40	CB or TM	.35	CB or TH	.35	CB or TM		
C	2"	No. 2 (2½" to 1½")	815	139	200	34	.35	CB or TM	.30	CB or TH	.30	CB or TM		
D	2"	No. 3 (1½" to ¾")	815	139	160	27	.30	TM or CB	.25	TH or CB	.30	TH or CB		
E	1"	No. 3 (1½" to ¾")	407	69	145	25	.25	TC or AC or CB	.25	TM or CB	.20	TM or CB		

9. *Amounts of Bituminous and Covering Materials Required for Different Amounts of Coarse Aggregate.* If the coarse aggregate should have much fine material in it, which is very undesirable, the first coat of bituminous material should consist of asphalt ACG, or tar TC or TCM. Tar TCM may be used at any time instead of TM and it has the advantage of hardening quickly and will permit as early a completion of work in hot weather as CB. There is no value of the TCM over the TM or TH in cool weather. The No. 4 covering should be largely used just before the third coat of bitumen, the object being to fill the voids in the surface with coated No. 4 aggregate by the dragging process. Some additional covering should be spread over the surface from time to time if it shows signs of being too rich with bitumen.

Keeping the surface that shows signs of an excess of bitumen constantly covered with No. 4 covering to be beaten in by traffic will greatly aid in reducing the tendency for the surface to wave and roll. This covering material dilutes the excessively rich mixture.

Methods of Maintaining Retread Top

The standard method of maintenance of this type of surface is with retreatments every year or two.

The ills and ailments of this type of surface might be classified as: (1) Waving and rolling under traffic, largely due to excess bitumen, and which is accelerated by fine material; (2) Breaking and disintegration of the crust, thus forming "pot" holes or a raveled surface; (3) Failure of the base which results in a rough surface under heavy traffic and eventually a breaking of the surface.

The *first* defect, namely, waving and rolling, can best be corrected when it becomes excessive, by scarifying that portion of the surface which is defective, thoroughly breaking up the bituminous crust and adding to it a small amount of uncoated aggregate from the base, or by the addition of new aggregate to the top. This new aggregate should be thoroughly mixed with the old mixture by harrowing. After this broken-up material is thoroughly mixed it is leveled off and again rolled in place and traffic permitted to immediately go over same. If there develops symptoms of disintegration of the reformed surface a very light application of bitumen usually not exceeding 0.1 gallon per sq. yd. may be added to prevent surface disintegration. Some repairs of this nature have been made which seem to carry quite heavy traffic for many months without again waving or rolling. The breaking up of the old bituminous surface and adding of new aggregate either from below or above, not only dilutes the mixture that

is too rich in bitumen but also permits a ventilation of the bituminous material during which the volatile matters pass off, thus hardening the bitumen and reducing the tendency to wave and roll. Isolated wrinkles or rolls may be corrected by hand picking and tamping the mixture back in place after the method described above.

The *second* defect, namely, breaking and disintegration of the crust, can frequently be prevented by applying a light surface treatment of tar or asphalt with the necessary covering material. Holes that have formed in the surface should be patched with one of the many patching mixtures; or, if only a shallow depression, with a "paint patch".

The *third* defect, namely, failure of the base, has but one remedy and that is to build up a thicker crust of metal. This may be done by building an additional retread top over the old one which is failing, after sufficient base metal has been added to secure the proper thickness.

Where Retread Top May Have Merit

We should not expect too much from any road with a weak base. This type of surface should not be built on a road with very little base metal where heavy trucking is part of the traffic. The thickness of base required will depend upon the amount of heavy trucking that will come on the highway.

This type has merit in surfacing old stone and gravel roads which have a heavy course of metal or roads which carry a heavy automobile traffic only during the summer season.

With the proper conditions of base and traffic, the type has its chief merit in that a smooth riding, dustless surface can be built at a very low cost compared with many types of pavement. The type is cheap in first cost because of the nature of the construction work which permits of dumping and spreading of the stone direct from a truck and also which permits the stone to be leveled with a grader or maintainer before the bituminous material is applied. These cheaper mechanical operations reduce the hand labor to a minimum which by taking advantage of the old metal in the base, whether this be gravel, stone or some other material, are the principal things which contribute to the low cost of this type of road.

Someone has criticized the type because it is not as good as one of the more expensive types of road. The same argument might be used against a Ford automobile because it is not as good as a Lincoln. Granting the latter statement to be true, this is no argument why we should stop using Ford automobiles. A lot of people can have a Ford car that can not afford a Lincoln. The same thing is true with the cheaper types of road. Many communities can have such a type that can not afford the more expensive type. In buying a commodity, we must make the purchase fit the pocketbook.

However, we must not fool ourselves by thinking that a very thin crust of metal will carry heavy traffic in this climate where we have deep frost action and a rainy period which may come immediately after it thaws. *This type has its limitations and they must be recognized.* It would be more than wasteful to indiscriminately build it and thus place much of it where it is not appropriate.

RESURFACING OLD ROADS WITH ROCK ASPHALT

By W. C. Dickey,

Construction Engineer, Stone Construction Co., Richmond,
Ind.

My concern here is a discussion of Mr. Hinkle's very able paper, in so far as he has dealt with "Resurfacing Old Roads with $\frac{3}{4}$ -inch Rock Asphalt on Bituminous Macadam". My experience along this line was gained on the Indiana State Maintenance Contract No. 83 at Alexandria during the fall and early winter of last year. This contract was awarded to the Stone Construction Company on August 9th and I drew the assignment of being the man on the "firing line" for our company.

Mr. Hinkle has covered the high points of this work. In other words, he has "planed off the high points", and it therefore falls to my lot to "fill in" the low ones so we may have a smooth riding surface on our theorizing journey.

With the belief that you are more interested in the construction of the rock asphalt top course, I will try to give you an insight into some of the "trials and tribulations" in our attempt to complete the work in 1927, get the best quality possible and obtain a smooth riding surface. In passing will say we completed the job, have the quality and a passably smooth surface.

Mr. Hinkle has told you relative to unloading, grinding, steaming, spreading, etc., but I wish to say we did very little steaming. We unloaded the material for about one-half mile by hand and ground about half of this on the road, the other half being broken up by hand. From then on, all the rock asphalt was unloaded with a crane, ground at the unloading point and hauled to the road. The only steaming we did was as an experiment one day to help in the unloading when the material was digging hard in extremely cold weather.

We were quite successful in getting a good surface by our spreading methods—I believe at least as good as that ever obtained by any other method. Our rolling and planing oper-