

inch ring and retained on a  $\frac{1}{4}$  inch ring with sufficient amount of fine material to give proper bond should be uniformly spread over the prepared foundations. This surface of  $\frac{3}{4}$  inch chip can be easily maintained by dragging.

It is my opinion that the  $\frac{3}{4}$  inch chip has solved the maintenance problem of macadam construction. In referring to the  $\frac{3}{4}$  inch chip, I would not require this exact size in all instances, as varying conditions might require a slightly larger or smaller chip. I firmly believe that giving the proper attention to building of the macadam base, providing for a broad foundation, not too much crown and good drainage, the chip wearing surface will take care of a big part of our county traffic.

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## NEW DEVELOPMENTS IN ROAD MAINTENANCE.

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I shall confine my paper to a few subjects which will be of most interest to you either because of some new feature about them or because I believe their importance is such as to deserve emphasis in connection with highway maintenance.

### Plugging Breaks in Roads During Spring Thaws.

Every spring finds us with certain bad places in our gravel and stone roads, and other types have been known to develop their "sink holes." These breaks occur sometimes year after year at the same place, due to wet weather springs or poorly drained places in the roadbed. I might cite as a concrete example, a mudhole we "plugged" four years ago this spring which a local citizen who was forty-eight years old, said had appeared every spring for forty years."

It is not uncommon for deposits of quicksand or such a quality of clay to be encountered that the breaks are expensive to repair while the wet season is on. For the plugging of such breaks nothing is better than a layer of cinders to be covered with gravel, stone or other road surfacing materials for a wearing surface. The cinders will "choke" the mud hole and destroy the high capillarity of the soil much quicker than gravel. The mistake must not be made, however, of putting on the cinders and not covering them, for the cinders have a very low wearing value and during the dry summer will wear and blow away rapidly.

### The Cause and Method of Preventing Corrugations in Gravel Roads.

Corrugations are formed in gravel roads when the traffic reaches a certain density. These corrugations are apparently due to the vibration of the car combined with the slipping or "kick back" of the drive wheel as it drops into the trough of the corrugation. The development of the corrugation is greatly accelerated after a rain by the water being splashed out of the depressions and carrying with it some of the gravel and sand. This accounts for the corrugations developing faster on flat grades.

While any grade of gravel will corrugate under certain conditions, it is apparent that some grades of gravel corrugate much quicker than others; or, stating this another way, we might say that practically all grades will corrugate after the traffic has reached a certain density.

These corrugations develop much quicker in gravels which lack cementing materials and that are deficient in the coarser pebbles. Gravels which have an excess of fine silica sand, which has little or no cementing value, corrugate quite readily. It is very noticeable that gravels containing materials which cement them together, corrugate much less. We frequently have reduced the corrugation very extensively by the addition to the ordinary gravel road of a thin coat of crushed gravel passing a one inch opening and containing all the dust incident to crushing. Also, crushed limestone of the same grade can be used in the same way. Roads made of limestone which are maintained by the dragging process as the gravel roads are maintained, corrugate much less than the average gravel road. At least a partial explanation of this is apparently the greater cementing value usually possessed by the crushed stone. Stone roads not properly maintained are more inclined to develop pot holes instead of the rhythmic corrugations developed by the gravel.

I have noticed frequently that gravel in which the pebbles are slightly coated with clay or calcium carbonate resist the corrugation quite well. It is also quite noticeable that the addition of thin coats of new gravel, of whatever kind, will resist the corrugation better than an old surface where the gravel and sand seem to be worn out.

The method of maintaining and dragging has much to do with the preventing of the corrugations. Our experience has fully determined that the corrugation is greatly reduced by the use of a very heavy drag or grader such that the surface is planed off smooth at frequent intervals. The heavy machinery will not vibrate and bounce up and down on the road surface as will the lighter drags, thus producing the incipient corrugations

themselves. Wherever light drags or very light graders are used under heavy traffic, the corrugations seem to be more certain to form. For that reason we have been using a very heavy drag.

Some of the conclusions which we might draw from the above are as follows:

The corrugations are apparently formed by the vibration of the motor vehicle combined with the slipping of the drive wheels as they go down into the trench of the corrugation.

While all gravel will corrugate to some extent when traffic reaches a certain density, gravels are very different in their nature and some corrugate much worse than others.

Gravels containing an excess of fine sand and a deficient amount of the coarser pebbles, from which cementing material is absent, corrugate most readily. This is perhaps explained by the little resistance offered by sand grains of uniform size to being shoved aside by vehicles. In other words, the greater percentage of voids in the gravel or sand which would exist when the grains of sand are of quite uniform size would permit corrugating most readily.

With the above explanation of the causes of corrugations it is quite evident why the following methods of preventing corrugations are effective:

The frequent additions of thin coats of new gravel will aid materially in keeping down the corrugation. This is perhaps nothing more than saying that a new road is better than an old worn out one.

The application of crushed gravel or crushed stone will greatly reduce the tendency of gravel to corrugate. This no doubt is due; first, to the greater density of the mixture; second, to the cementing value of the dust, and third, to the greater resistance the angular pieces offer to being shoved aside.

The dragging and smoothing of the surface with a heavy drag, plane or grader will greatly reduce the tendency of the road to corrugate. This latter means of keeping down the corrugations is extremely important under heavy traffic.

#### **Dragging of Bituminous Surface Treated Roads.**

An innovation was started this past summer in one class of our maintenance work by dragging a road just after it had been given surface treatment of bituminous material and clean stone chips. After experimenting with an especially made drag for this purpose and an ordinary road maintainer our conclusion is that perhaps our standard Type "B" drag is the most satisfactory piece of equipment for this purpose, although the road maintainer gave very satisfactory results.

It frequently happens that a macadam road which is maintained with bituminous surface treatments is quite rough or irregular. The irregularities in the surface may be greatly reduced by applying a treatment of tar or asphalt and putting on a limited amount of stone or gravel covering after which the surface is dragged as an ordinary gravel or stone road. The drag places the stone or gravel pebbles, which have been coated with asphalt or tar, into the little holes or depressions in the road surface thus leveling up the surface. Part of the work which we did along this line this past summer received a second coat of tar and screenings. It is necessary that the tar or asphalt be just sticky enough so that the pebbles will be moved by the drag and yet will stick in the location the drag places them and not be readily displaced by traffic. This means that the dragging would have to be done immediately after the application if the tar or asphalt was quite a heavy grade of material and applied during the cool weather. On the other hand, if the tar or asphalt was a light grade of material and was applied during the hot weather it would be necessary for some little time to elapse between the application and the dragging if the best results are to be secured.

Since this work has been made public some of the other States have already dragged their surface treated gravel roads. I see no reason why this method of smoothing a road surface after it has been given a bituminous treatment cannot be used to great advantage on many roads of the cheaper type.

#### **Sizes of Stone in Bituminous (Penetration) Macadam Work.**

It has been fully demonstrated that many of the penetration macadam roads have been made of too small sized stone. The small sized stone not only are more susceptible to being displaced by the heavy traffic but are also much more apt to produce areas in the stone where the voids are completely closed by the rolling and thus produce spots where the asphalt or tar cannot penetrate. The finer stone prevents sufficient rolling of the course which is necessary before the application of the bituminous material in order to produce a rigid surface when completed. It is well demonstrated that stone through a 4 inch circular opening is none too large for use in this type of road.

It is important to guard against applying too many screenings after the bituminous material is applied and before the surface is rolled. It might be said that in the rolling of all macadam work, whether bituminous macadam or water bound macadam, the greater part of the rolling should be done so that the roller wheels will come in contact with and press upon the coarse stone. Ruts or depressions made in the layer of big stone in the surface should be removed by rolling on the big stone so far as

possible and not by filling the rut with small stone. As soon as a "bridge" or mat of fine stone or screenings separates the surface of the roller wheels from the coarse stone, a surface is being produced that will wear irregularly under traffic, although the surface may be smoother when finished than the proper method of rolling will produce.

### Repair of Concrete Roads.

At present it is quite generally conceded that the use of a bituminous material for filling cracks in concrete roads is the most economical. The best grade of tar for this purpose that we have been able to specify is a tar meeting our T. P.-2 specifications. This material is heated in a kettle and poured into the joints and covered with sand. This tar is softer than our standard penetration tar, the latter being so hard and brittle that it chips out in winter.

The best grade of asphalt we have found is asphalt emulsion meeting our A. E.-1 specifications. This material is poured into the joint cold and covered with sand. Either of the above materials are suitable for making shallow or skin patches. Asphalt similar to that used in penetration macadam and known in our specification as asphalt filler A. O. F.-1 has been advocated and used very extensively for this purpose for a number of years. Our experience has been that this grade of asphalt if used on roads which have a heavy winter traffic is of very little or no value. It is chipped out by traffic in cold weather so that when spring comes there is hardly a trace of material left on the surface.

The larger cracks and bigger depressions in concrete roads should be filled with a mixture of bituminous material and crushed stone. For this purpose either the cut back tar (our T. C. M. specification) or asphalt emulsion, mentioned above, may be used.

Where it is necessary to replace a good sized area of concrete surface, which is in excellent condition otherwise, it may be desirable to make the repairs out of concrete similar to that used in the original construction. The trouble has been that these patches had to be protected against traffic for a number of weeks which was quite a handicap. However, recent developments have shown that it is possible to make concrete by using the proper mixture, amount of water and compression in placing, together with the addition of a small amount of calcium chloride, which will cause the concrete to assume as much strength in four or five days as ordinary concrete assumes in three weeks. If this process proves practical it is possible that many repairs made heretofore with bituminous materials could be better made with concrete.

### **System of County Roads.**

It seems that we have advanced sufficiently in our highway work in the state that every county should have a definite system of county roads which should be selected with some consideration of the county roads in the surrounding counties. These roads, in order to distinguish them from the state roads, might be designated by letters, as is done in Wisconsin. The necessity of knowing where and what such a system of county roads consists of is made more necessary at the present time due to the fact that part (\$500,000 the first year and \$1,000,000 per annum thereafter) of the gasoline tax is to go back to the counties for road maintenance. According to the law, one-half of this is to be divided equally among the counties and the other half is to be divided among the counties "in the proportion which the number of miles of free gravel or macadam and county unit roads in the county bears to the whole number of miles of such roads in the State."

It is the duty of the State Highway Department to determine the mileage of these roads in each county. It is only with the co-operation of the County Highway Superintendents and County Surveyors that this mileage can be readily and accurately secured. It goes without saying that the State Highway Commission expects your full co-operation in this work.

### **Superintendents With Backbone Needed.**

You highway superintendents, whether working for the state or county, are in such a position that you are subjected to various influences both good and bad. The good influences are such as to stimulate you to do more and better work for the money you expend, or in other words to be a credit to yourself as well as your community by maintaining the roads under your supervision in the best possible condition with the limitation of funds and other restrictions placed upon you. The public is expecting this from you. This is what they are paying you for. You will be criticized at times, of course, for doing your duty. There are greedy citizens who unless they can have you serve their selfish interests at the public expense will criticize you. However, here is a test of your backbone. Will you yield to the demands of selfish interests when you know it is at the expense of the general public or will you keep a stiff upper lip, do your duty and take the unjust criticism? If you yield to every selfish interest, who howls and bellows the loudest, by doing that which you know is unjust to the interest of the taxpayers who are paying you, then you are too much of a jelly fish to hold the responsible position entrusted to you. We must have highway superintendents with backbone. You will lose out occasionally by

doing right it is true, but not nearly so often as in doing wrong. It is far better that you lose your position by doing your duty than by failing to do your duty.

### **Co-operation Between County Highway Superintendents and State Highway Superintendents Necessary.**

It frequently comes to my attention that some of our employes are in more or less conflict with local road officials because of either the county or state having a monopoly on certain supplies of road material. While each must have certain rights and responsibilities, it must ever be remembered that the taxpayers of the state are paying the bills and that if either set of officials can accommodate the other in any way without sacrificing to any extent his own work, it is his full duty to do so. A man can be **smaller than his job**, as **big as his job**, or **bigger than his job**, according to his treatment of others associated with him either directly or indirectly. Regardless of whether or not we may have exclusive lease on a pit, we do not expect to bar the counties from securing gravel from the pit where it is not necessary to do so, and where it would be a great convenience to them to secure such gravel. Likewise, I feel that it is the duty of the county to co-operate with the state to the same degree. You should not forget that while you occupy one position this year that you might occupy the other position another year; that we are all working to the same end, and that is to provide for the people of the state a convenient and economical means of transportation.

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### **HIGHWAY MAINTENANCE FROM THE STANDPOINT OF SERVICE, SAFETY AND ECONOMY.**

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There are some general requirements which any maintenance organization must possess, chief among them being fixation of responsibility. Without this being definitely placed and commonly understood and respected by each party affected, positive control over the work would be lost. The employee must be loyal to his superior authority. Fairness combined with discipline not only creates respect but there is inert driving power in it. To permit men in lower ranks "to go over the heads" of an immediate superior, tends to confusion and jeopardizes efficiency.