pacted base of five to six inches, more new material should be added. We use gravel from our maintenance-stock piles. This material is fine and has a sufficient amount of clay for compaction. The old base is scarified to the required depth and thoroughly pulverized and mixed. All large aggregate is thrown out by men with forks during the mixing process. The mixed material is then leveled off and tar (T M 2) is applied at approximately 150° to 165° F. and at the rate of one-third of a gallon per square yard. A heavy maintainer is used, while the tar is being applied, to aid in mixing. A spring-tooth harrow will do this work very well. Then the material is bladed back and forth until it is thoroughly mixed. A power grader and maintainer is used in the mixing operation.

Water may have to be added in hot, dry weather. Just enough water should be added to make the mixture damp; six to eight per cent moisture is sufficient.

After the mixing is completed, the material is windrowed and leveled off in thin layers and thoroughly rolled. This process is continued until the road is properly shaped and compacted. If the surface becomes dry and dusty, a light application of water is made.

When the base has been thoroughly rolled, a tack coat of tar (T M 2) is applied at the rate of .2 per gallon per square yard and covered with five to ten pounds of sand, or No. 12 stone, per square yard. The road is then left open to traffic for a day or so before the seal coat is applied.

The surface should be swept clean of all loose sand or stone and be perfectly clean before sealing. A heavy tar (T H) is applied at approximately 200° F. at the rate of .3 gallon per square yard and covered with fifteen to sixteen pounds of No. 12 limestone or gravel. A long broom drag is used to spread the chips and insure a smooth surface before and during the process of rolling.

We have used 1.2 gallons of T M 2 per square yard in the base mixture and tack coat, and .3 gallon per square yard of heavy T H in the seal. This totals 1.5 gallons per square yard for the complete job. The road was closed to traffic only when the tack and seal coats were being applied. Fourteen miles of this type of road were constructed in Boone County in 1940, and three miles in 1939, all being in excellent condition at this time.

SURFACE STABILIZATION IN DEKALB COUNTY

Wayne T. Van Auken,
Dekalb County Surveyor and Road Supervisor

The most important problem facing county engineers today is the formulation of a balanced program which will include
all the roads in the county. In the past, a large percentage of county highway funds has been spent in constructing and maintaining a relatively few miles of high-type surfaces. Secondary roads were maintained, if and when funds were available, by adding new gravel or stone and floating the material back and forth across the road. Within the last few years, however, county engineers have begun to dig into these surfaces to determine the amount of road material present. Results obtained from these tests were both enlightening and alarming. In our county the material had almost entirely disappeared. The only reasonable answer to the disappearance was that the material had blown away in dust and been kicked into side ditches by passing traffic.

That there is a way to eliminate gravel replacement, to provide gravel roads with dustless, comfortable riding surfaces, and still keep within the budget has been proved by Dekalb County this year. We chose two sections of gravel road on which to conduct surface consolidation tests. The methods used were simple and the results more gratifying than anticipated.

One section consisted of two and one-half miles of what we call the Auburn-Butler road, terminating at State Road No. 8 at the east corporation line of Auburn. This road is one of the oldest highways in the county, cutting across land lines diagonally with a general direction of N.E. and S.W.; and in common with all highways of this type and direction, it carries a heavy load of local and through traffic, being a somewhat shorter route between Auburn and Butler than the state highways.

It has always been a problem to keep this gravel road in shape, because of poor drainage and clay subsoil which heaved badly during winter months leaving soft spots until late in the following summer. Corrugations were always present.

I am trying to give you a true picture of the circumstances surrounding this project in order that you can form an intelligent conclusion of what actually happened to this road from the addition of a small amount of bank-run gravel containing, by weight, about eight per cent of sandy clay and calcium chloride.

The other section chosen for test was a one-mile section terminating on State Road No. 6. This is a direct outlet from the north part of the county into Butler and has nine farm and suburban homes located on it. Its direction is approximately north and south, and during the summer months it became very dusty and corrugated.

**Methods and Costs**

Some years back the county commissioners applied some light road-oil to this mile, and we found slight traces of it yet
in the roadbed. We scarified this road to a depth of about four inches and removed the oversized aggregate, added about forty tons of clay, and bladed and rebled until we had it fairly well mixed before finally shaping and applying the chloride.

Our only trouble with this stretch occurred shortly after we completed the road and was due to excessive rainfall before the road was completely consolidated. Some spots had to be touched up with gravel, which soon worked into the mixture and became a part of the consolidated surface. This section has had only two bladings up to December 24 and has remained in fine condition without corrugation and practically dust free.

Our cost accounting shows this mile cost $220 for reconstruction and maintenance, a sum including the cost of the calcium chloride and labor. This was slightly less than the cost of the other section, which carries more traffic.

The two and one-half mile section was not scarified, but all loose material was bladed off to one side in a windrow, and about 300 cu. yards of bank gravel per mile, one hundred percent passing a $\frac{3}{4}$-inch screen and containing by weight eight per cent of reddish, sandy clay, was added to the roadbed. We then scattered about thirty yards of pure clay to the mile on the loose material, bladed off the road, and waited for a dry period in order to mix thoroughly the two aggregates. Because of almost continuous rainfall during May, we never did get it thoroughly dry.

We mixed the material with two power graders and finally laid it out and applied six and one-fourth tons per mile of calcium chloride late one afternoon. That night we had another torrential downpour, and it was a sorry-looking mess in the morning; but by noon the surface began to consolidate and we bladed it lightly to eliminate wheel tracks and give it a final crown.

One section of this road, about 500 feet in length, remained under water for ten to twelve hours, but now the consolidation seems as good there as anywhere else. Nothing further was done to this two and one-half mile section for nine weeks, until we had a heavy rain, when it was again bladed to fill up some pot-holes that had formed on the crown. Later on in the summer we applied two and one-half tons per mile of calcium chloride and gave it a light application of one and one-fourth tons late last fall.

Our failure to build enough crown is the only noticeable fault in this road. The association engineer called our attention to this defect during construction, but being "flat-crown men" we thought it unnecessary; however, one lives and learns by experience, as we did. Pot-holes appear on this road only in places where the crown is too flat. Late last fall this high-
way was bladed a couple of times, and with the exception of pot-holes along the crown, it has remained in excellent condition.

Ordinary gravel roads require constant working of the surface to maintain smoothness. The more important ones, carrying from 400 to 500 cars per day, are bladed every other day and, at that, we have a hard time keeping any degree of smoothness. Dust is always present and is not only a nuisance but is becoming more dangerous each year. Last year it was the direct cause of two deaths on one of the roads, which is now treated with calcium chloride, and it also caused many other non-fatal accidents on other roads. Figuring necessary gravel replacements and blade maintenance, this type of road cost us around $300 a mile for the year. Of this amount, $100 goes for blading alone.

Our calcium-chloride-consolidated roads have received a total of five bladings on the heaviest traveled section and one blading on the other since they were treated in May. This means that we have saved approximately $85 per mile of our former blading cost. As for the gravel replacements, at no time this year have our roads had any loose material on them. This means that our gravel loss will be nil. Dust has been entirely eliminated and, except for a few pot-holes which were caused by not having enough crown in the road, the roads have been smooth and presented a safe riding surface. Since the improvements were made under regular spring maintenance, the only expense we can rightly charge against the improvement is the application of calcium chloride, and this will be offset by the reduction in blading and conservation of road materials. The calcium chloride cost us $228 a mile on the heavier-traveled section, and $149 a mile on the other. The difference in the amount used was due in part to the fact that the former road is about four feet wider and carries about twice as much traffic.

**Advantages**

There are several important advantages which we have observed in using this type of maintenance. The roads are absolutely free from corrugations. At no time have we ever observed a single one. Much has been said about corrugations and their causes, but I am convinced that they are not caused by traffic alone. The common gravel road can be bladed smooth and closed to traffic—and still it will corrugate. I believe that the reason that the treated surfaces do not corrugate is the action of the calcium chloride in maintaining the optimum moisture content throughout the thickness of the road material.

Another advantage of this type of maintenance is that it is self-healing. No matter how many holes the surface may
develop, they can be cut out after rains and the road will assume its original smoothness. Incidentally, these pot holes will not develop if the original mixing is done thoroughly and the proper amount of crown put into the road and maintained there. But this cutting must be done at the right time, and that is either during, or immediately after, a fairly heavy rain. If it is only a light rain, leave your road alone. Without sufficient moisture to reincorporate the bladed material, it will remain loose on the surface and be lost. Whatever you do, don't blade such roads in dry weather!

Our Board of Commissioners is very favorably impressed and has under consideration a plan to surface-consolidate several miles of gravel road next year. We believe this type of maintenance is going to reduce our former maintenance costs of loose gravel surfaces to such an extent that we can afford to give good safe roads to all our people and still make high-type improvements on those roads that need them.

USE OF ROAD OIL IN ROAD SURFACING

Glen Brown,
Huntington County Road Supervisor

I am surprised that one with so few years' experience should be called upon to address this group. I realize, however, that only by discussions such as these can we as a group profit by the trials and errors of others. Before getting too far into my subject, I would like to take a moment to express my thanks to Professor Petty for the very excellent work he has done in connection with the Road School and extension work. If others have benefited as much as I by attendance at these sessions, then I feel that I may speak for all of us. His yearly visits to our counties to inspect our roads and bridges are a tremendous undertaking for him and a definite advantage to us. During these visits, we receive the benefit of his experience in the form of sound advice and instructions, which are of the greatest value to the highway supervisor and his aides in maintaining our county highway system.

Thousands of miles of existing stone and gravel highways provide an excellent base for bituminous roadmix wearing courses. It is the purpose of this paper to touch briefly on the more important aspects of this economical type of construction for all-weather roads.

Because of experience gained over many years, we are taught that the first point to be considered in road building is the proper construction and maintenance of a subgrade. This embraces such important features as correct gradation of aggregates and proper drainage of the subgrade.