in the center of the road just ahead of our work. Excess asphalt was loaded in trucks and carried ahead.

After we spread the asphalt with shovels, all lumps were broken up and the material was shaped with heavy hand rakes. We continued the raking until the surface was free from honey-combed places, true to grade and of the proper thickness.

We used side forms about 3½ inches wide, and intermediate forms 3⁄8 inches in width, 1¼ inches thick spaced about five feet apart and laid parallel with the center line of the road to gauge the proper thickness. The height of these forms determined the depth of the course after it was completed. Before removing the side forms, the edge was tamped vertically with a hand tamp, and after the sides had been carefully taken away the edge was tamped at a 45 degree angle before we backed it up with earth.

After the material was raked, it was permitted to lie in the sun and heat until it took on a black oily appearance, when it was rolled with a 10 ton roller. The surface was rolled once each day for four days in succession. After the first rolling, we used extra material to bring up the low places and removed material from those that were too high, and the road was again rolled until all marks had disappeared. The pavement was not opened for traffic until after the final rolling.

The finished surface at no place varies more than 1⁄4 inch from a cross-section template, nor from a 10 foot straight edge laid parallel to the center line of the pavement.

SALVAGING OLD PAVEMENTS BY USE OF BITUMINOUS MATERIALS

By H. C. Offutt,
District Engineer, Indiana State Highway Commission.

In doing work of this nature, we have found we get good results by confining ourselves to the use of a bituminous concrete made with a stone aggregate and a tar binder, and mixing both at normal temperature. We have used other variations and have obtained good results, but in this discussion we will touch only on this one kind of mix.

The work, while all done at the same time and by the same organization, is actually divided into two processes. All depressions which require filling, and which are not over one-
half inch in depth, are taken care of by a process which we call “paint patching.” In this class of work, the depressions after they are marked out, are painted with a hot tar and covered with stone screenings or pea gravel.

The depressions which are over one-half inch in depth, we fill with the bituminous concrete and cover same with a seal coat. The depressions when they are not over two inches in depth are painted with hot tar, as in the first case, before the bituminous concrete is applied.

**Estimate of Work**

The conclusions we will give you under this subject are only rough approximations. They are stated for the purpose of giving the superintendent a guide in ordering his materials and are not to be used as a specification for doing the work.

From studies made of our work during the past season, we have arrived at the following:

(a) The average patch will range in size from three square yards to five square yards. Judgment in the field will have to decide which figure will best suit your piece of work.

(b) One square yard of patch requires about:

- 0.5 gal. tar for painting the depressions.
- 0.25 gal. tar for mixing the bituminous concrete.
- 0.25 gal. tar for seal coat.
- 0.33 cubic foot of stone aggregate.
- 0.33 cubic foot of screenings.

We believe that a road surface which is considered rough will have about two hundred patches per mile. One which is very bad will average as high as seven hundred per mile. Figuring an estimate for repairing one mile of surface having about two hundred patches per mile, and figuring three square yards as average size of patch, we would have the following:

<table>
<thead>
<tr>
<th>Patches per mile</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square yards of patch</td>
<td>600</td>
</tr>
<tr>
<td>Materials:</td>
<td></td>
</tr>
<tr>
<td>Tar for painting patch</td>
<td>300 gal.</td>
</tr>
<tr>
<td>Tar for bituminous concrete</td>
<td>150 gal.</td>
</tr>
<tr>
<td>Tar for seal coat</td>
<td>150 gal.</td>
</tr>
<tr>
<td>Total tar</td>
<td>600 gal.</td>
</tr>
<tr>
<td>Stone aggregate for bituminous concrete</td>
<td>$7\frac{1}{2}$ cu. yds.</td>
</tr>
<tr>
<td>Stone screenings</td>
<td>$7\frac{1}{2}$ cu. yds.</td>
</tr>
<tr>
<td>Total stone</td>
<td>15 cu. yds.</td>
</tr>
</tbody>
</table>
Cost of materials:

- 600 gal. tar .......................................... $100.00
- 15 cu. yds. aggregate or screenings ........ 45.00
- Miscellaneous hauling, crayons, etc., 10% 15.00

Total ........................................... $160.00

Labor, 90% ........................................ 145.00

Total ........................................... $305.00

These figures cover the average amounts of material used for a ten-mile project in Warrick County, the surface conditions being about the same as stipulated above.

Organization

On a fair sized job it is best to so organize your gang that one man will be kept busy at one or two operations continuously. He can soon be taught to do these few operations quickly and easily without being watched. A gang organized on this basis should consist of the following:

(a) The foreman of the gang has many duties. First of all he exercises a watchful attitude over the whole gang and keeps the work going smoothly. He should watch the work of the marker and finisher very closely, as their work must be done right. He checks over the finished work carefully and corrects any bumps which have been left. He usually applies the screenings in making the paint patches and assists the tar man in applying tar when necessary, and moves the equipment along the road as progress is made. A good way for the foreman to keep a check on results of his work is to look back over the work occasionally and notice whether cars going at a good rate of speed do any bouncing. Usually if a bump has been missed or a patch made too high, it can be detected in this way, or if he has a car available he can try it out himself, checking the uneven spots as he drives over the finished work.

(b) Two men to mix the tar and stone (making the bituminous concrete) and deliver it to the patching gang.

(c) One man to measure and mark out the patches. When he gets ahead with the marking, he should drop back and assist the wheelbarrow man by loading the empty wheelbarrow for him.

(d) One man to sweep the surface where the patch is to be made. This man has some spare time which is taken up by helping the wheelbarrow man, usually by loading his empty wheelbarrow.
(e) One man to tend the tar kettle, handle and pour hot tar on the depressions.
(f) One man to wheel and shovel the bituminous concrete on to the patch.
(g) One man to spread the bituminous concrete and finish off the patch.

**Equipment**

The equipment necessary for a gang of this size should consist of the following:

- One truck, two-ton capacity.
- One truck, one-ton capacity.
- One trailer, two-ton capacity.
- One concrete mixer, seven cubic feet capacity.
- Three wheelbarrows.
- One tar heater, 200-gallon capacity.
- One wire push broom.
- One fibre push broom.
- One stable broom.
- One 14 foot straight-edge.
- One 16 foot straight-edge.
- Two tar pouring cans, two-gallon capacity.
- Four pails, ten-quart capacity.
- 100 feet of common chalk line.
- One box of boilermakers crayon.
- Two finishing shovels.
- Various square point and round point shovels and scoops.

The two-ton truck is used to pull the trailer, and tar kettle and also to hold the screenings.

The one-ton truck is used to haul the bituminous concrete from the mixing plant to the patching gang and also to haul the men to and from work.

The concrete mixer must be a tilting drum type to give satisfactory results.

The straight-edges are 2 inches by 6 inches, one 14 feet long and one 16 feet long. They are best made from cypress, as they should be as light as possible. They are made two inches thick to prevent warping. The 14 foot straight edge is for the finisher and the 16 foot size is for the marker.

The tar pouring cans are made from galvanized sprinkling cans with the spout cut off about 1 1/2 inches from the body of the can, and the remaining part of the spout squeezed almost together, leaving an opening of about 1/4 inch by 5 inches. This kind of an opening tends to spread the tar very uniformly and saves time.
The finishing shovel is a long handled shovel, as light as possible, having a square point 12 inches wide. A wider point is hard to handle and one more narrow slows down the speed of the finishing. This can be made by putting a long shovel handle in an old gravel scoop. Usually an old scoop will be worn thin, which makes a light, serviceable tool. The gravel scoop point can be heated and the point flattened out so that it will be level all along the bottom of the point.

The crayons used will run about thirty-six to the mile.

Materials

The tars used are T. P. 2, T. M. and T. C. M. The T. P. 2 is used to paint the depressions to hold the screenings or bituminous concrete in place and also to make the seal coat. If there are a large number of square yards to coat, then T. M. should be used. The T. C. M. is used to mix with the aggregate to make the bituminous concrete.

The aggregate is usually of stone, although in the gravel country pea gravel can be used instead of screenings. The sizes of aggregate used are as follows:

- No. 6 (screenings) 1/2 inch to 1/4 inch
- No. 45 3/4 inch to 1/4 inch
- No. 3b 1 inch to 1/4 inch
- No. 34 1 1/2 inch to 1/4 inch

We used as large size aggregate as possible in the bituminous concrete which was to be applied in the depression. To do this, we made three different sizes of bituminous concrete. One size was made out of the No. 45 stone, one size out of the No. 3b stone, and one size out of the No. 34 stone. In a depression having a depth of 1/2 inch to 3/4 inch we applied the bituminous concrete or mix made of the No. 45 stone. In one having a depth of 3/4 inch to 1 1/4 inches we applied a mix made of the No. 3b stone. In one having a depth of 1 1/4 inches to 2 inches we applied a mix made of the No. 34 stone.

In almost any depression a slightly larger sized stone should be used than the depth indicates. It is always advisable to use as near the proper sized aggregate to bring the surface up to normal as can be used. This we think would apply to any patch with a depth up to four or five inches, using for a four-inch depression a three or four-inch stone if available.

Operation

The mixing plant should be located near the road and moved when necessary so as to never be more than two and
one-half miles from the patching gang. At this plant should be kept the aggregates, the tars and the equipment for mixing. The equipment will include the light truck, the mixer, two ten-quart pails, shovels and scoops.

Careful attention should be given to the arrangement and layout of the plant so that all lost motion is eliminated. One good way is to place each size of aggregate in a pile, arranging the piles in a row, so that the mixer can be moved along the row and the aggregate loaded direct from the pile into the loading hopper. The correct amount of aggregate is measured and placed in the hopper and leveled. A line is then painted around the inside, at the height of the leveled aggregate, which shows the loader how much stone to put into the hopper for each batch. The barrels of tar T. C. M. should be handy to the mixer, but not in the way. They should be elevated above the ground high enough to place a pail under the bung. A standard molasses gate screwed into the bung saves time in handling the tar and also eliminates considerable waste.

The mixing is done by two men. One man loads the receiving hopper and brings the tar for the next batch. The other man dumps the mix onto a dumping platform, from which he then loads it into the light truck, ready to be hauled to the patching gang.

The batch must be allowed to thoroughly mix until each particle of the aggregate is completely coated with tar. The stone must be thoroughly dry and free from dust and dirt. Tar and damp stone will not mix. Bituminous concrete made with damp stone and put on the surface will disintegrate and ravel under traffic. A two or three days’ supply of stone is kept covered during the night and during rainy weather. In this way enough stone can be kept dry to keep the work going until the wet stone dries out. When a gang is off for a couple of days it disrupts the organization and it will take about half a day to get them lined out again when they do get started.

For one cubic yard of aggregate, we use from fourteen to sixteen gallons of tar T. C. M., this amount being regulated by the size and cleanness of the stone. The temperature also has some bearing upon the amount used.

These two men can mix and deliver to the patching gang about one cubic yard of mix per hour. One batch will make about five cubic feet of mix. The average time of mixing a batch is about four minutes, the balance of the hour being taken up in loading and delivering the mix to the patching gang. The average daily consumption of mix for a gang of this size will run from seven to eight cubic yards, so by the
time the mixers produce this much mix, clean up and get ready for the next day's run, their time is pretty well taken up.

**Patching Operation**

On the way to work in the morning, the patching gang stops at the mixing plant and loads up with materials. The truck is filled with two cubic yards of screenings, on top of which two or three barrels of tar T. P. 2 are placed. The trailer is filled with various amounts of the three sizes of bituminous concrete, depending upon the character of the surface to be patched that day.

Arrangements should be made by the foreman that one of the gang, the first thing in the morning, goes to the tar kettle and starts a fire, so that the tar is ready for pouring when the gang arrives on the job.

**Outlining the Depression.**—This is done with a straight edge or line. It is a rather tedious task and should be done by some one who is a reliable workman. The depression is outlined with crayon, marking where the straight edge and surface begin to separate. The straight edge is laid parallel with the center of the pavement about one foot from one edge. Marks are drawn on the pavement showing the outside limits of the depression, the straight edge is then moved over about 18 inches or 2 feet and the marking continued until the other side is reached or the patch runs out. The marker should also write the depth of the depression just outside the outline so the men applying the bituminous concrete will know what size mix to use.

The marker outlines all depressions of ¼ inch depth that are over three or four feet in length. Depressions of this depth, but over four feet long will not cause a car to bounce. Occasionally the marker will find a depression that the 16-foot straight edge fails to cover. The foreman then assists him with a line, the line being held to the surface on each side of the depression, which is then outlined the same as when using a straight edge. On a place of this kind, the foreman must use his good judgment as the depression might be entirely too long to repair. If the depression is not over 1¼ inches deep, its length over 18 feet, and its approaches to the normal surface are gradual, it would not need filling.

**Cleaning the Surface.**—Following the marker, the sweeper thoroughly cleans the surface, using a wire push broom and a stable broom. The wire push broom is used to scratch loose any foreign matter which may be stuck to the surface and the stable broom is used to sweep the dust off.
Painting the Depression.—As soon as the depression is thoroughly cleaned, the tar pourer applies a coat of hot tar T. P. 2 to its surface, except when the depth of the depression is over two inches. Where the depression is shallow ($\frac{1}{4}$ inch or under) the application is made slightly heavier, as it is to be a part of the paint patch. The tar pourer should use two two-gallon tar pouring cans instead of one four-gallon can, as the two-gallon cans are much easier to handle. After the tar is applied to the depression, he spreads it with a fibre push broom. We first used a squeege but found that the fibre broom made a more uniform spread, the squeege having a tendency to ridge the tar at its ends, which makes a ridge in the paint patch. This trouble, however, is more noticeable in repairing a rigid pavement than it is on a bituminous macadam.

Applying the Screenings, (Paint Patch).—On the outside edge of the depression where the depth is under $\frac{1}{4}$ inch, or over the whole depression if it does not exceed $\frac{1}{2}$ inch, the dry No. 6 screenings are applied. Judgment must be used in applying the tar and screenings in making these paint patches or feather edging the bituminous concrete patches. More tar and screenings, making a thicker mat, are applied at the deeper spots so that when finished, the patch on its surface will be smooth and level with the surrounding surface. The foreman himself should apply these screenings because it is particular work.

Too many times we find the men applying too thick a coat of screenings. While this extra thickness of screenings is not harmful to the patch as the tar will only absorb so much, it is a waste of material. The dry screenings and hot tar are used for this purpose in preference to a bituminous mix, using this size aggregate, because it is more convenient to handle and finishes off much better than the bituminous mix on these thin patches.

Applying the Bituminous Concrete.—After the feather edge paint patch has been made on the outer edges of the depression, the bituminous concrete is applied. The wheelbarrow man brings the bituminous concrete to the depression in a wheelbarrow. Two wheelbarrows should be used, as the marker and sweeper will have time to load the empty wheelbarrow while the other is being emptied.

The wheelbarrow man must place the bituminous concrete where the finisher wants it, namely: close to the feather edging or on the edge of the bituminous concrete previously placed. It is then worked over into place toward the center by the finisher, using the finishing shovel, until a uniform surface is obtained.
The bituminous concrete in any one depression is usually of one size mix, but if the depth of the depression becomes deeper than 1 1/4 inches at any place, a mix of 1 1/2 inch aggregate should be used in these spots. In a case like this, the outer edges of the depression would be taken care of with the feather edge paint patch, the next portion from 1/4 inch to 1 1/4 inches in depth, with the No. 3b mix, and the portion over 1 1/4 inches deep, with the No. 34 mix. It is not best to use the No. 34 mix to take care of the whole depression as it will contain too many large stones to give a satisfactory and even surface.

**Finishing the Patch.**—There are several things about finishing the patch and obtaining a smooth surface which should be mentioned. The foreman and finisher should insist that the bituminous concrete be not dumped into the center of the depression in a pile. See that it is applied by the shovel-full just where the finisher wants it. This allows him to shove it into place with his finishing shovel by pushing it off of the portion already placed, to the surface of the depression. This tends to spread the bituminous concrete more uniformly and eliminates any high or low places after the patch has compacted.

The finisher should always keep his finishing shovel in good shape, so that it will do good work. Often he will find it necessary to remove the gummy substance which collects on the point of his shovel. This can be done very easily by burning it off in the fire-box of the tar kettle. In doing this he should be careful and not ruin his shovel by getting it too hot.

When spreading the bituminous concrete in cool weather, the finisher will find it pays to heat his shovel every few minutes in order to get a good smooth finish to his patch. Usually the sun is hot and glaring when this work is being done. The finisher can relieve his eyes and also judge much better the smoothness of his patch if he will work with the sun to his back as much as possible. Looking down on the patch from this direction does not cause a glare and the uneven places are much more easily detected.

When the weather is very hot and the bituminous concrete has a tendency to be picked up by traffic, a small amount of clean stone (3/4 inch to 1/4 inch) hand scattered thinly over the fresh bituminous concrete will relieve the trouble. When the depth of the patch is under 1 1/2 inches we do not tamp the bituminous concrete but allow the traffic to do the compacting. Until the finisher is thoroughly acquainted with his work and his eye trained to detect the slightest irregularity, he
should always test his patch with a straight edge before leaving it. The foreman should not trust too much to the finisher's eye, but should satisfy himself completely that the patch is satisfactory.

**Seal Coat.**—If the work is smoothing a bituminous macadam surface prior to a surface treatment, the seal coat is not necessary. The surface treatment itself will supply the wearing coat and seal the open places.

When the work has been smoothing a rigid pavement surface, the bituminous concrete portion of the patches must have all the open places closed or sealed. It is best not to do this until the traffic has thoroughly compacted the patch and any unevenness which may have developed has been corrected.

This seal coat is applied by painting the bituminous concrete with a hot tar T. M., about 0.25 gallon to the square yard, and then coating the surface with our No. 6 screenings at the rate of about 0.25 cubic foot per square yard. If the job is small, or tar T. M. is not available, the tar T. P. 2 will do.

**Filling Deep Depressions.**—At times we are called upon to fill a depression 6 inches or deeper. The depression should be filled with a stone aggregate up to within two inches of the normal surface. The size of this aggregate should be our No. 1 (4 inches-2 1/2 inches). After this stone has been carefully and uniformly spread and is smooth and level, hot tar T. P. 6 or T. P. 2 is applied at the rate of one and three-quarter gallons per square yard. Immediately after this tar application, a covering material of No. 34 stone should be evenly spread over the surface at the rate of one cubic yard to 160 square yards of surface.

Upon this bottom course is then applied a two-inch course of bituminous concrete made of No. 34 stone. After this has been thoroughly compacted, it should be given a seal coat.

If the job is small, it will not require as large a gang as we have outlined. Often not more than three men will be required. In case the force is reduced, it is better to have the men first mix the bituminous concrete then take it down to the job and make the patches. The superintendent should study the situation, outline the work and assign the various duties as will best suit the reduced force.