repairs. With regular maintenance and a small amount of stone added each year, these roads have held up much better than we anticipated.

The cost of this type of road, of course, varies considerably with the topography. However, I can safely say that our average cost on these roads, where there are no major structures, is about $1,500 per mile, divided as follows: grading and draining $600, and surfacing material $900. This cost is arrived at by figuring our crushed stone at an average of $1.40 per cubic yard on the road. However, many of the roads cost us much less, because of our WPA stone-crushing project, whereby we get much of our stone delivered on the road at an average cost of 63 cents per cubic yard. The roads which we graded last year, according to the standards set up by the state highway department, cost nearer $1,800 per mile.

With but few exceptions, we have used all the WPA men available at crushing stone in privately-owned quarries. When we advertise for crushed stone at the first of each year, we receive bids on two conditions: first, regular crushing, and second, where we furnish the labor to the contractor. As a rule we let contracts to six or seven quarries scattered throughout the county. Whereas our regular price averages 98 cents per cubic yard, the price under the WPA contract averages 63 cents per cubic yard. In addition, by not requesting materials on our project, we have several trucks each month, paid for by WPA, with which we haul the stone on the road.

Under this program, in the five years from 1933 to 1937 inclusive, we graded 158 miles of earth roads and surfaced 128 miles with crushed stone. In 1938 we graded only 9 miles and surfaced 6 miles. This decrease was due to the loss of $30,000 in revenue caused by the new method of gasoline tax distribution.

In 1933 we received in gasoline tax $97,000. This sum gradually increased until in 1937 it amounted to $128,000. In 1938 under the new distribution law, this dropped to $98,000, and for 1939 we will receive approximately $84,000.

Although there are still some 50 to 75 miles of earth roads in Ripley County which should be improved, with this reduction in revenue and the gradual increase in maintenance, it looks as if our grading program must be completely stopped until some other method of financing it can be devised.

OPERATION OF STONE QUARRIES AND CRUSHING PLANTS

Ray Colglazier,
Washington County Surveyor and Road Supervisor,
Salem, Indiana

In June, 1936, I was appointed surveyor and road supervisor for Washington County. We had a balance of $32,000
in the road fund and 871 miles of highway in our system, most of which was in very bad condition. Some 300 miles had been improved with stone and gravel, and over 500 miles were unimproved earth roads on which a few mudholes had been taken care of by the township trustee by throwing in some ballast and napping off the projecting stone by hand.

Today we have a different picture. We have over 700 miles of road improved with stone or gravel, and only 147 miles which are unimproved. Our county is very fortunate in having limestone and creek or river gravel in the county for construction and maintenance. About 75% of the improved roads are stone and 25% are gravel. The gravel is taken from bars in the river at a time when the water is low, is applied without screening or running through a crusher, and makes a very satisfactory road.

Procuring the limestone is a different story; it costs more to reduce it to sizes suitable for road material. It also costs us many headaches.

In June, 1936, the county owned two No. 3 and one No. 4 bell-type crushers, one single-stage air-compressor, and one 35 H.P. tractor for power, all of which had been purchased many years ago. They were operated one at a time in the three different districts. Up to that time, there were no records in the office whereby we might determine the cost of operation.

The following fall we approved a blanket WPA county highway project, which we have operated up to the present time. All labor, except some skilled labor, has been WPA. We have kept a complete record on every operation. We have operated three plants 110 hours each month for the past 20 months. Our funds now are not sufficient to permit us to operate. I know that you all understand why they are not.

**QUARRYING OPERATIONS**

I will try to describe to you the operation of a stone-crushing plant at one of our quarries. The first step is to sign a contract with the owner of the quarry site for 4 cents per ton. Most of the limestone in the county is suitable for road material, although no two quarries are exactly alike. What I mean by that is, that it does not blast or crush in the same way.

For example, the quarry on state road No. 56, nine miles east of Salem, was already opened when we commenced operating in 1936. We set up a No. 4 bell-type primary crusher. The stone is elevated up to the far end of a 30-inch x 12-foot rotary screen passing over four feet of ¼-inch mesh, where the dust is taken out, then passing over 8 feet of ¾-inch mesh. The over-size (about 30%) that reaches the lower end of the screen is returned to a 16 x 24-inch roll-reduction crusher, then down into the elevator to be returned to the screen again. An
old six-cylinder, 40 h.p. truck motor operates the primary
 crusher, and the roll crusher is operated by a four-cylinder
 25 h.p. motor salvaged from a motor truck.

The production from this plant, varying with the moisture
in the stone, is around 15 tons per hour. This could be stepped
up by increasing the power on both units and also opening up
the primary crusher. The lime dust will run about 10% if the
stone is reasonably dry. This dust is sold to the farmers for
agricultural purposes.

After the plant is set up, the next problem is getting the
stone down from a solid ledge to a size that will go through the
primary crusher. The first step is to remove the overburden
from the top of the ledge, which is about three feet deep at this
particular quarry. This is removed with a "trac-tractor" and
rotary slip, but the final clean-up is with hand labor. This
gives us a 60-foot stone face without dirt seams, and it is an
outstanding ledge in our part of the state. We always drill to
a horizontal seam, which happens to be, in this quarry 6, 8, 10,
12, or 16 feet. We use a 210 two-stage motor-driven air-
compressor which will operate three air hammers. Each
hammer drills, on the average, about 15 feet per hour in the
hands of an experienced operator.

The top holes are drilled five feet back from the face and
4 to 6 feet apart and are shot in a single row. The same opera-
tion is repeated back of this shot. If both shots were made at
once, too much stone would be thrown back and left on top of
the ledge. The first shot will have considerable dirt in it and
should be crushed before it gets wet. Wet clay will cause
trouble and cut the capacity of the plant at least 50 percent.
The second row of holes is drilled back 5 feet from the first row on 4-foot centers and staggered between the front holes. These holes are drilled to a depth of 16 feet, or to the first seam in the second ledge. From 10 to 50 holes are shot at a time.

An experienced man is required to load and shoot stone. The front holes are loaded with 12 pounds of 40% dynamite. The exploders are placed near the bottom. The rear holes are loaded with 15 pounds of 60% dynamite with exploders placed as before. The cost per pound for dynamite is 10 to 15 cents.

After the stone is shot down, 15% will still require drilling and breaking into smaller sizes by what we call "pop blasting." Then four or five men are supplied with the well-known 10-pound rock hammer, and the stone is reduced to crusher size. The stone is then loaded by hand into two dump trucks, requiring the services of 10 or 12 men. This completes the operations to the bin.

As I stated before, the finished product from this plant is 3/4-inch down, minus dust, which I think is the correct size for proper maintenance. The other two plants are operated in the same manner with the exception of the reduction rolls and screens. The screens are 3/4-inch mesh, which gives a finished product 3/4-inch down, with the dust left in. This is used for maintenance, and 1 1/2 minus is used on earth roads that have never been metaled. A light application of finer stone is used on top. Occasionally we use the material crusher-run, without screening, and it is very satisfactory for new construction.

In 1937 we crushed 15,000 tons and contracted for 7,000 additional tons, making a total of 22,000. In 1938 we crushed 32,000 tons and contracted for 6,500, making a total of 38,500.
The final question is, "What does it cost per ton to produce?" The total cost, figuring WPA labor at 44 cents per hour, is $1.47 per ton. The total cost to the county minus WPA labor, paid by Federal government, is $1.01 per ton. Our contracted price on stone is $1.00 to $1.15 per ton in the bin.

You can see from these figures that, had we not been getting WPA labor and with our county operated equipment out of date as it is, we could not compete with the modern plants the contractor uses today. He uses a gas shovel for stripping and also for loading stone. After the stone is shot down and, with a plant large enough to handle around 40 to 50 tons per hour, the shovel can work efficiently. A plant of this size would cost around $20,000.

WPA WORK ON COUNTY ROAD PROJECTS

D. W. Hufferd,
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The Works Progress Administration was initiated to salvage and conserve the most valuable resource that a nation may have—human personality. Much has been said, and much remains to be said, of the effects of the industrial revolution upon a liberty-loving, self-reliant, and self-respecting people—a revolution that has either resulted in, or been the result of, a monopolization of natural resources, whichever way you choose to look at it. In any event, it has brought about the disinheritig of vast numbers of bewildered citizens by de-