large-scale unemployment is going to be with us for years to come. In the second place, there is still a vast amount of public work that needs to be done throughout the country. For those two substantial reasons I am convinced that our co-operation through the Work Projects Administration or some similar agency will continue.

In closing I should like to make it clear that I do not for a moment believe that the WPA program as now operated is the final answer to federal participation in the solution of the problem of unemployment. The WPA is in a continual state of evolution, and many improvements have been made in the four and one-half years of its existence. However, I regard it as one of our main responsibilities to search for further improvements and increased efficiency. In this endeavor I solicit your co-operation and assistance, as governmental officials who have sponsored projects with us are among those persons who are best fitted to make constructive suggestions for the improvement of the program.

SALVAGING HIGHWAY INVESTMENTS

N. F. Schafer,

Engineer of Maintenance, State Highway Commission of Indiana, Indianapolis

Webster says that "salvaging is the act of saving"; "highway is a road or way open to the public"; and "investment is the laying out of money in the purchase of some species of property." Therefore, the title of this paper is interpreted to
mean the "saving of road property for which there has been an outlay of money." This investment of money has already been made in the form of roads that are given to the public official to guard just as if they were money deposited in the bank. The proper supervision of these roads will pay dividends just as if their original cost was on time deposit.

A public official has many difficulties to face while expending road funds. Probably the greatest of these stems from the lack of highway construction and maintenance knowledge of the travelling public, who pay the bill. Because of their lack of knowledge of the various materials and traffic requisites, the public is often critical without reason. This adverse criticism is often influenced by sales promotion and advertising. I bring out the above facts only to show that the public official has a difficult task trying to satisfy everyone in the administration of road funds; but the public will see that their investments are being protected if you, as an official, salvage or save those materials already in place on the road.

To salvage highways economically, the official must constantly be investigating, with an open mind, those processes that will give him the most years of satisfactory service from existing road surfaces. If a road, in place, can be salvaged rather than rebuilt, the difference in cost will permit the construction and reconstruction of many miles of highways that otherwise would not be built or improved. This is made possible because, when building onto the present road surface, you are utilizing the benefits of that money that has already been expended to lessen the cost of the immediate improvement.

In general, the proper method to save some surfaces for a period of time is correct maintenance. In order to get the maximum life from each surface, you must properly maintain it with good materials.

For discussion, I have divided the subject of salvaging into three classes of surfaces: low, intermediate, and high. Naturally, the high-type surface, with a greater first cost, offers the greatest salvage value, but the savings to be secured from the low and intermediate types should not be overlooked.

**LOW-TYPE SURFACES**

We have found that a great portion of the investment in the low- or drag-type surface is lost through the air in the form of dust. This can be proved by measuring the depth of the aggregate in place at the beginning of a year and again at the end of the same year.

To prevent this loss of fine particles, a dust palliative can be applied. It is better to apply the palliative in two smaller applications, the first in the spring and the second in late summer, rather than in a single application equalling the total of
The two. The cost of this dust palliative will not be entirely lost because it is a good first treatment for a skin mat that may be applied the next season.

Many roads have varying depths of surfacing aggregate as well as weak base conditions. Last summer our maintenance department salvaged some roads of this class by stabilization. One road was particularly interesting. It was 3.65 miles long, part of which was traffic-bound aggregate surface on new location and the balance old county road that had been widened. The aggregate varied in depth from 1 to 4 inches, and the subgrade was sandy loam and clay. Several base failures had occurred in this road.

The stabilization method was to scarify the road to a depth of 4 to $4\frac{1}{2}$ inches, and the edges were thickened to a total depth of 6 to 8 inches, according to conditions. After the soil and aggregate had been thoroughly mixed and windrowed and sufficient water had been added to make a workable mixture, the bituminous material was applied. The soil, aggregate, bituminous material, and water were thoroughly mixed and again windrowed. The windrowed material was placed on the surface in three equal lifts and compacted. A tack coat was applied to the compacted surface and, after traffic had used this for several days, a bituminous surface treatment was applied for a wearing course. To date, no base failures have appeared on this road. It is my opinion that base stabilization will be used more and more in the future as a method of salvaging drag-type surfaces that have weak bases or insufficient aggregate to carry the traffic load.

**INTERMEDIATE-TYPE SURFACES**

For this discussion, retread, surface-treated water-bound macadam, bituminous-coated aggregate, or other comparable surfaces will be included in the intermediate-type surface. In general, these surfaces are maintained by patching, surface treating, or applying seal coats. If the surface is slightly rough and requires a small amount of leveling, or is both rough and slick, a surface treatment may be applied. This drag treatment may consist of from .4 to .5 gallons of bituminous material and 30 pounds to 40 pounds of $\frac{1}{2}$ inch to No. 8 aggregate per square yard. The voids of this treatment should be filled with clean fine aggregate.

Certain slick surfaces that require no leveling should be given only a seal coat. This may consist of an application of from .15 to .25 gallons of bituminous material per square yard, covered with 10 pounds to 15 pounds per square yard of clean fine aggregate, and rolled.

Too often a regular surface treatment is applied when just a seal coat is all that is needed to eliminate the infiltration of water and add two to three years of life to the surface in place.
HIGH-TYPE SURFACES

When speaking of salvaging high-type surfaces, one is speaking in terms of "big money," because large expenditures have been made in the original construction. Those surfaces in place represent the same amount of money today that they represented the first day they were opened to traffic several years ago. It is the public officials' duty to make an appraisal and to see if each should be removed and replaced with a new surface or salvaged by resurfacing. One method takes advantage of the investment that has already been made and the other does not. The result of either is a surface satisfactory to the travelling public.

Many high-type surfaces are not salvaged because the resurfacing is delayed until the pavement in place is a complete failure. To prevent this, periodic investigations should be made and the resurfacing done before complete failure takes place, thus utilizing the investment in place. In the salvage or resurfacing work, bases should be used that are adequate for the traffic, or, with the addition of a binder course, will be adequate for the traffic. With the above base requisites and good vertical and horizontal alignment, a rough or failing surface may easily be modernized by adding a binder course and wearing surface. The binder course will level the old base and a non-skid wearing surface will be provided by the wearing course.

On our jobs, the first operation in resurfacing was to patch the old surface. A surface which was exceedingly rough received a drag (road-mixed) treatment of bituminous material and aggregate. The aggregate and bituminous material were mixed and spread with long-base maintainers or retread pavers. The long-base equipment permitted a greater amount of material to be deposited in the low places and a lesser amount on the high places, thus providing the first step in the leveling process.

For surfaces that were not exceedingly rough, the above treatment was eliminated. On these surfaces and those that had been treated, a plant-mix binder was applied. Both hot- and cold-mix binders were used. With either material the procedure was the same. The bituminous plant-mix was hauled to the job in trucks and dumped into mechanical finishing machines. After the finisher had spread the mixture, it was thoroughly rolled. The cold-mix was given a seal coat of approximately .15 gallons of bituminous material and 10 pounds of chips per square yard. These chips were broomed into the voids and rolled. Both types of binder were permitted to cure and then opened to traffic.

Natural sandstone rock asphalt was used as a wearing surface. Before the rock asphalt was applied, the binder was primed with approximately .05 gallons of bituminous material per square yard. This prime was applied the day before the laying of rock asphalt.
The rock asphalt, after it had been steam heated in the cars, was hauled to the job in trucks and dumped into mechanical finishing machines and spread. After the material was lightly rolled and all tears or irregularities were repaired, the surface was then given a final rolling. The material was permitted to cure for seven days after it had been spread and then opened to traffic.

By the above resurfacing method it is possible to correct a pavement that is too rough for present-day traffic, to salvage a pavement that is disintegrating, or to change an intermediate-type surface to a high-type surface, thus reducing the cost of maintenance.

**ECONOMIES POSSIBLE**

Resurfacing involves certain economies other than the saving of the investment already made in the original construction of the road surface. These economies involve the differences in cost of resurfacing and new construction. Our highway commission by law takes bids for more than one type of surface in new construction and constructs that type of surface that has been bid low. Therefore, it is interesting to compare the cost of new construction, regardless of surface, with the cost of resurfacing.

In the calendar year of 1938 our maintenance department supervised the contract resurfacing of 108 different locations, and, in 1939, 84 locations were treated in the same manner. These improvements included city streets and rural highways in practically every part of the state. After diagnosing the 192 locations, it was found that the average cost for resurfacing for this two-year period, including the binder and wearing courses, was $0.7256 per square yard. For the same period of time the average cost for high-type pavement, new construction, was $1.848 per square yard. The removal of pavement in place cost a minimum of $0.20 per square yard. Therefore, the cost of new pavement plus the removal of the old pavement cost a total of $2.048 per square yard, contrasted with $0.7256 per square yard for resurfacing. This is a difference, or saving, of $1.3224 per square yard. Using the figure of $1.3224 per square yard and multiplying it by the number of square yards resurfaced, we find that $7,397,997.53 has been saved in this two-year improvement program. This could only have been done by utilizing the investment in the road surface which was already in place.

You may think that I misread the preceding figure of more than $7,000,000 as a saving that was actually accomplished through the two-year improvement program, because it does not seem possible; however, this is a fact, because if the 192 locations had been torn up and rebuilt with new pavement, the cost would have been $11,460,000. But the actual amount was only $4,060,000. Another interesting fact is that
the amount of money saved was about twice the amount expended to make the improvement.

The resurfacing method of improvement not only salvaged and modernized 414 miles of city streets and rural highways, but also permitted approximately $7,400,000 to be expended for the construction of many miles of low-, intermediate-, and high-type surface and new construction.

I often think of an illustration of two men of moderate means who owned homes adequate for their family needs. These homes had reached the point where some major repairs were needed to put them in good condition. One man made his home satisfactory for his needs by repairing, while the other man tore down his home and built a new one. It is easy to see that the first man was economical, while the second man was extravagant. It was the second man's privilege to be extravagant with his money, although it was unwise; but it is not our privilege, as public officials, to be extravagant with road funds, because they are not our personal property.

The public official should study the economics of each improvement to see if it is possible to salvage any of the original investment. A low-type surface salvaged is a lesser saving, and a high-type surface salvaged is a greater saving; but either will permit the improvement of a greater number of miles—surely service that the public expects: that is, the greatest number of satisfactory improvements possible with the minimum amount of money expended.

SALVAGING HIGHWAY INVESTMENTS

Ralph Witt,
St. Joseph County Road Supervisor,
South Bend, Indiana

Mr. Schafer has covered his subject very thoroughly from a state highway point of view. I have been asked to discuss it as it pertains to county highways. Immediately the money problem appears. The state has limited funds, but ours are more limited. The comparison is somewhat similar to David and Goliath. Under existing conditions we can be interested only in low and intermediate classes of salvage.

In our county, the problem of earth roads is growing rather than decreasing. Subdivisions, outside the corporate limits, are springing up. People are moving to these districts to escape the high tax of a corporate city. These people work in the factories and stores of our cities. They demand high-type roads. The farm-to-market road must be improved because these are the community links between subdivision and city.

To salvage the investments in our present roads, we are using stabilization and surface treatment. We have had very