widening and improving her network of roads to a very appreciable extent, and they compare favorably with our own. Austria started a very ambitious program of modern road building, but she ran out of money and only a series of scattered fragments is to be found.

Switzerland had a good-roads program in mind for years, and had put it to use long before many of the other countries were aware of what she was doing. As a result there are hundreds of kilometers of good roads in that mountainous country, where road building is most difficult. Spain embarked on a modern road building program as early as 1924, and many miles of heavy-type through roads have been constructed there.

The automobile is popular in England, and so the Britains have started to rebuild their ancient highway system. Their old narrow, crooked roads are wholly unsuited to 1936 traffic, and so straightening and widening of the existent roads is under way on a wholesale plan. A modern road-testing laboratory has been built, and England will soon have a system of highways of which she may be proud.

CEMENT-BOUND MACADAM PAVEMENTS

C. R. Wightman,
Director, Department of Public Works,
Benton Harbor, Michigan

The first known use of cement-bound macadam was in Edinburgh, Scotland, in 1872. Incidentally, that same pavement is still in use and in good condition after sixty-three years. It was first introduced in the United States in 1906 at Lynn, Massachusetts; in Portland, Oregon, in 1908; on the Boston Post Road in 1914; and at Hannibal, Missouri, in 1915 or 1916; and from 1906 until 1922, at various places in the New England states and along the Pacific Coast, some eight hundred miles were built. Portland, Oregon, has nearly 93 miles of this type of paving.

In 1933 a test road was constructed at Elmhurst, Illinois, by the Portland Cement Association, under the able direction of that well-known concrete-paving authority, Frank T. Sheets, consulting engineer. After much scientific research and investigation, there are now available to the engineer data which enable him to design a pavement of major importance and to control its qualities as closely as those of pavement of mixed concrete.

An impasse in street improvement in Benton Harbor having been reached in 1926, any suggestion of resuming operations which entailed special assessments would have meant official suicide to the proposer. Our city manager had requested me to make an investigation of some of the so-called low-cost pavements with the view of being prepared to launch some badly needed paving projects when and if the psychological moment arrived.

For some time previous, I had been making a study of cement-bound macadam and had satisfied myself as to its practicability for use on our residence streets, and determined to build some of it at the first opportunity. This opportunity presented itself in the late summer of 1934. Disgusted with mud and dust, a property owner residing on an unpaved street called at my office and asked what I could suggest to remedy this annoying condition.

Convinced of the merits of cement-bound macadam, I suggested its use to him as the answer to his problem. After I had pointed out to him that the cost of such a pavement would be very moderate, he acted upon my suggestion and interested his neighbor across the street, and they jointly petitioned the city commission to pave the half block. Their petition was favorably acted upon, and before work started, the remainder of the property owners in the block joined on the petition for the same kind of improvement. A similar petition followed for the adjoining block. These two blocks were paved in 1934 and came through the winter in fine condition.

The people on other unimproved streets were so well pleased with the fine appearance and the low front-foot cost that a veritable flood of petitions reached the city commission. So great, in fact, was the flood, that up to August 1, 1935, 21 streets, aggregating 4 miles, had filed petitions for pavement. The commission was obliged to refuse to entertain any more requests for work to be done during 1935. We were unable to complete the 1935 program but will do so in the spring. Petitions are now in circulation for all the work that can be done this coming season, and I venture to predict that by the fall of 1937, Benton Harbor streets will be nearly 100 per cent pavement.

OFFICIAL TEST RESULTS

In our city there were (and I presume they exist in every city) a number of self-appointed critics who were quite industrious in the circulation of the information that there was only ½-inch of mortar on top of a lot of loose stones, and that as soon as the crust broke, the pavement would be gone. To combat this propaganda, I immediately requested Mr. Murray D. Van Wagoner, State Highway Commissioner of Michigan, to have the state core-drill outfit come to Benton Harbor, take cores of the pavement, and report the results.

These cores were taken by the state men at their discretion and proved instantly the falseness of the propaganda, and also that the penetration was perfect in every case. Compression tests of these samples were made at the University of Michigan and indicated a compression strength of from 2,240 to 2,490 pounds per square inch, some of the samples being only seven days old.

In the spring of 1935, estimates were prepared for about 4 miles of paving under the FERA set-up. The cost of materials, the wages of key men, such as foremen, mixer men, and finishers, and the necessary truck hire, were charged to the frontage of the property pro rata. The common or relief labor costs were passed to the benefit of the property owners subject to assessment for the work. Later on, using the WPA set-up, new projects had to be formulated. In these, 15 per cent of the material costs and 50 per cent of the truck hire were included in the federal contribution, and this saving was allocated to the city street fund to pay for street and alley intersections.

The special assessments were spread over a period of ten years, deferred payments bearing 5 per cent interest. Bonds anticipating the special assessment payments were issued and sold at a premium, and these funds were made available for the payment of materials and wages of such key men as it was necessary to use on the work.

We started out using FERA labor to do the excavating; but as the city was then paying the cost of trucks, we found that the excavating costs were running over our estimates, even with free labor, because of the low factor of efficiency of FERA labor. It was costing us from 15 to 30 cents per cubic yard to do this excavating. To reduce this cost, a $\frac{3}{8}$-cubic-yard, gas-powered shovel was purchased, with the result that we are now handling this excavating at a cost of from 6 to 10 cents per cubic yard.

ORGANIZATION

The organization of our work may be of interest to you. For heavy grading, we use a $\frac{3}{8}$-cubic-yard, gas-powered shovel and from 6 to 10 trucks, depending upon the length of the disposal haul. The operator of the shovel is a regular employee of the department of public works. On this division of the work we also have a city foreman who looks after the grades and 2 or 3 WPA employees for handling mats and incidental work around the shovel.

Next come the 6 to 8 form setters, all WPA employees. Six-inch forms are set up on the center line to the crown grade of the street and a six-inch form on one side of the street on the back line of the curb. Then come the fine graders, headed by a regular department foreman, with from 10 to 14 WPA employees and the necessary trucks to prepare the subgrade to receive the aggregate.

Next we have the stone gang, headed by the raker, who is also a regular department employee and is aided by 3 rakers from the WPA ranks and 2 or more laborers to do the dumping. As a truck is dumped, it moves forward, spreading the stone as nearly as possible to the proper depth. The rakers then rake the stone to a template moved along the forms by 2 WPA employees. Following this template comes the tamper, consisting of a 6-inch I-beam, approximately 12 feet long and fitted with plow handles. This tamper is handled by 2 WPA men, weighs approximately 180 pounds, and is worked longitudinally. (Fig. 1.)

Following the longitudinal tamper, a template consisting of 2-inch by 6-inch planks, shod with 2 angle irons, manned by 2 WPA men, is worked transversely. Two WPA men follow closely with forks and rakes to correct discrepancies in the cross-section. After this tamping, the stone is ready for the grout.

The grout crew (Fig. 2) is under the direction of a city foreman and consists of a mixer operator, also a department employee, 4 WPA men as broomers, who spread the grout as it is poured on the work, and 2 WPA men opening the cement and emptying it on the batch trucks. Two WPA men with a template tamper similar to the one used on the stone, tamp the grout as it is broomed into place. (Fig. 3.)

These tampers are followed by the finisher, a regular department employee, who, using a wood float 6 inches by 48 inches (Fig. 4), fitted with a long handle, floats off the surplus water and corrects any high or low spots, after which, aided by WPA men, he completes the finishing process by dragging the surface with a sheet of burlap drawn along the top with a transverse saw motion. (Fig. 5.)

The building of the integral curb follows as closely as possible upon the finishers. A 6-inch form is placed on top of the slab form and a wooden face form provided with iron clamps is placed in position, after which the form is filled with a 1-2-3 concrete mix made in a one-sack mixer. (Fig. 6.) After the concrete has been tamped, the wood form is removed and the top of the curb is then formed with a homemade tool having the form of the cross-section of the curb. Fig. 7.) This tool has a removable sleeve which fits over its edge; and after the curb has been formed and the wood form removed, the sleeve removed from the tool and the mortar facing tooled into place, the finishers then touching up any defective spots with wood floats, the job is completed. The curb crew consists of 1 department finisher, 2 finishers from the WPA, 2 WPA men mixing the curb concrete, 2 WPA men wheeling from the mixer to the forms, and 2 or more laborers in addition to the men already mentioned, handling forms and such work as may be incidental to this curb building.

Fig. 1. Final tamping before grouting, and correction of irregularities in surface by use of template.

Fig. 2. Grouting and brooming. Note attachment with perforated bottom on end of chute to break up impact of grout on surface.

Fig. 3. Tamping after grouting.

Fig. 4. Floating after grouting.

Fig. 5. Final finish with burlap drag.

Fig. 6. Placing coarse aggregate in curb forms.

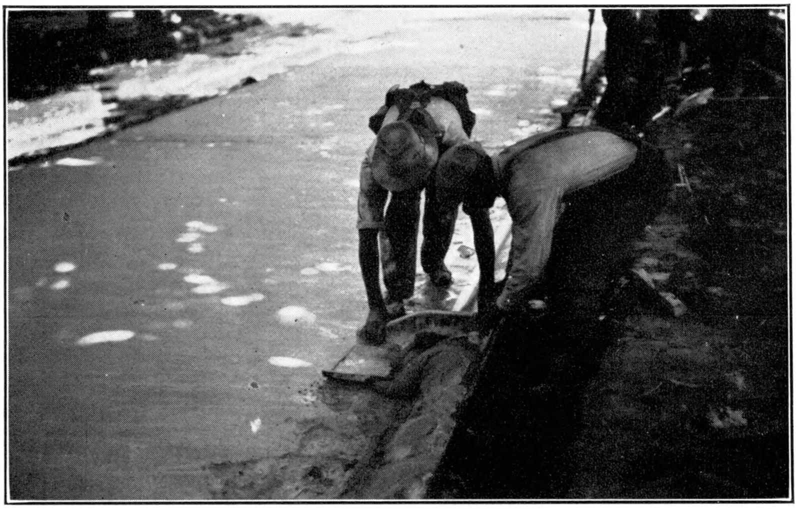

Fig. 7. Shaping and finishing curb after removal of face form.

From 10 to 20 common laborers are employed in taking up and cleaning forms, dressing off tree lawns, and doing such other jobs as arise from time to time. After the final finish, if the weather is hot, we cover the slab with about 2 inches of planer shavings and sawdust, which are sprinkled; and then we allow from 4 to 6 days for curing. In the fall, leaves have been used in lieu of shavings and sawdust—another Scotch idea. When there was possibility of frost, we covered the pavement with marsh hay.

DETAILS OF CONSTRUCTION

As to details of the construction: The subgrade should be prepared with the same care that you would bestow on it if mixed concrete were to be used. In placing the aggregate, we lay only half the width of the slab from one end of the street to the other, and in placing stone, we start midway between two cross streets to obviate the long back-up for trucks.

The center form used has a triangular strip 2 inches by 2 inches bolted to the face side to form a V-shaped key groove. The second half of the slab is thus keyed against heaving or settlement.

Great care should be taken to keep out fine stone, as it will interfere with the free flow of grout and result in poor penetration. We rescreen all our aggregate in loading trucks, and the fines which are screened out are used for the curb concrete.

In building the Elmhurst Test Road, the aggregates were rolled before and after grouting. On our first work we attempted to use the roller but found that the stone shoved ahead of the roller and a wavy surface resulted. Consequently, we abandoned that practice and relied entirely on tamping, with much more satisfactory results.

For grouting, we use a 14-E mixer with a 21-E drum, using 5 bags of cement per batch. We equipped this mixer with a special discharge to prevent slop-over. We also have a drop curtain on the charging side for the same reason. This mixer was formerly equipped with a boom and bucket, and we tried to use it in that form, but found that segregation cccurred in our grout; so we quit using the bucket and adopted a straight gravity chute. We equipped this chute on the end with a perforated box (part of an oil drum) with ¾-inch holes and 2½-inch centers on the bottom and 2 rows of holes around the side. The latter we found undesirable; consequently we plugged them with wood plugs.

A piece of ⅛-inch steel, approximately 24 inches square, with a hinged handle, somewhat like a snow shovel, is used under the grout box, to break the force of the discharge and thus obviate the displacement of the aggregate. We also use a mat of ¾-inch mesh hardware cloth, about 8 by 12 feet, wired to an iron frame of ½-inch round iron. This mat makes it much easier to broom the grout into place properly without displacing the stone.

We also sprinkle the aggregate lightly before grouting. The grout top-finish should be kept as thin as possible without exposure of the aggregate.

Expansion joints consist of two thicknesses of ½-inch celotex, 6 inches deep, previously dipped in cutback asphalt. These are placed every 50 feet, by digging out the stone after it has been placed and then replacing by hand.

The sand used for grouting is No. 14, or plastering sand, used at the rate of 2.2 cubic feet per sack of cement.

One of the most essential considerations is the fluidity of the grout. The proper consistency of the grout is determined by the use of a standard flow cone. This cone is 7 inches in diameter at the top, the vertical walls are 3 inches, and the altitude of the cone is 7½ inches. The orifice is a brass pipe 1½ inches long and ½ inch in internal diameter. This cone is filled level full, and after 5 seconds the orifice is opened and the flow is carefully timed with a stop watch. With aggregate ranging from 1½ inches to 2½ inches, we find that grout of ideal fluidity will empty the cone in from 20 to 23 seconds.

We find that a water ratio of from 6 to 6½ gallons per sack of cement will produce this result, depending upon the moisture content of the sand. These cone tests are taken frequently, but an experienced mixer operator can tell very closely if his mixture is right.

For a $5\frac{1}{2}$-inch slab, such as we have been laying, the materials required per square yard of paving, including the curb, are:

Cement .... .2016 barrels,
Gravel .... .2001 tons,
Sand .... .0569 cubic yards.

Approximately 5 square yards of pavement are grouted per barrel of cement. The cost of the curb on our work is just a little less than 6 cents per lineal foot.

On 16 projects built last year, the front-foot cost to property owners ranged from $1.47 to $2.45, depending upon amount of excavation and storm sewers required. The average of the 16 projects was $1.80 per front foot.

ACTIVITIES OF THE STATE PLANNING BOARD

Lawrence V. Sheridan, Consultant,
State Planning Board of Indiana, Indianapolis

(Editor's note: Mr. Sheridan did not prepare a formal paper. This is a very brief resumé of his extemporaneous address.)

The State Planning Board, in co-operation with the National Resources Committee, has made extensive studies of population, natural resources, land use, housing, gainful occupations, transportation, and the programming of public works. It has assembled the results of these studies in a preliminary report and several special reports.

There is a keen realization by the State Planning Board and its staff that real progress can be made most effectively through local understanding of planning problems and organization by cities and counties for working out solutions of their own planning problems. In order to bring about a better understanding, the State Planning Board is undertaking to make preliminary surveys of planning problems in the several counties and to set up reports which will include a summary of the situation and recommendations as to how these problems may be considered locally. The reports endeavor to set out the principal objectives which will make for greater progress in the counties.

The State Planning Board has two distinct reasons for making these studies. It believes fully that the reports will encourage counties and cities to do more planning themselves and that the studies will give the State Planning Board a better understanding of the local interpretation of general facts and in that way contribute to thoroughly practical recommendations on state planning.