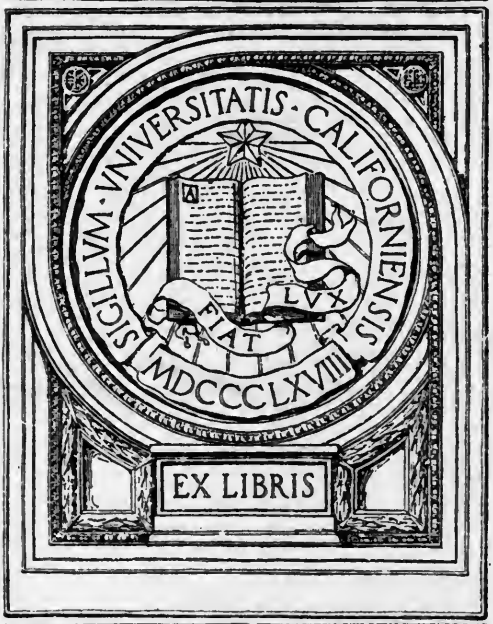

# STREET PAVEMENT

LAID IN THE

# CITY OF CHICAGO

AN INQUIRY INTO

## PAVING MATERIALS METHODS AND RESULTS



REPORT PREPARED BY THE
CHICAGO BUREAU OF PUBLIC EFFICIENCY

JUNE, 1911

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# INTRODUCTION

The Chicago Bureau of Public Efficiency, during the summer and fall of 1910, carried on an inquiry into the subject of street pavement laid in Chicago under the direction of the Board of Local Improvements. The investigation, conducted by A. J. Hammond, chief engineer of the Bureau, was supplemented by collateral inquiry respecting paving methods, materials, and results in other communities, and by conferences with Samuel Whinery of New York, consulting engineer, who co-operated in some of the investigation and reviewed the conclusions expressed in this report. The supplemental investigation included a study of commercial conditions which affect the price and quality of paving materials.

This inquiry is in line with the general purpose of the Chicago Bureau of Public Efficiency to make studies of the expenditures of the local governing bodies and to furnish the public with exact information and constructive suggestions relative thereto. This report is submitted in the hope that it may have suggestive value for officials concerned with paving matters and may prove of benefit to the tax-paying public.

CHICAGO BUREAU OF PUBLIC EFFICIENCY,
HERBERT R. SANDS,
*Director.*

Chicago, June 21, 1911.

# SUMMARY AND CONCLUSIONS

## SECRETIVE METHODS AT CONVENTIONS OF MUNICIPAL PAVING OFFICIALS

The pavement specifications in use by the Chicago Board of Local Improvements at the time of this investigation were based upon the recommendations made by a convention of paving officials of several cities which, on invitation of the mayor of this city, was held in Chicago in February, 1910. The convention was called to effect, if possible, a standardization of pavement specifications. Chicago paving officials were elected to the principal offices and were in charge, not only of that convention, but of the second convention, which was held in New York in January of this year. The work of the latter convention, instead of being done openly, was all carried on by committees sitting in executive session. The specifications recommended were rushed through the convention on the last day without opportunity for general discussion. Inasmuch as the cost of paving is one of the city's direct charges against property owners, and inasmuch as public officials of Chicago had a dominating influence on both conventions and were largely responsible for the personnel and procedure of the committees, and, furthermore, since the specifications recommended by both conventions have been adopted as a guide in Chicago, this Bureau believes that the secretive methods followed should be condemned on behalf of the general public. The desirability of avoiding the charge that special interests may secure undue advantage when meetings are conducted privately would seem sufficient reason for having them public. Moreover, the fact that the expenses of officials attending these conventions are paid out of the public funds would entitle the public to have the matters considered at such conventions discussed in the freest and most open manner. The cost to Chicago of having officials attend the New York convention approximated $1,000, exclusive of the value of time consumed.

## MONOPOLY IN PRESERVATIVE OILS

The Chicago specifications for oil to be used in the preservative treatment of wood block are such as to eliminate genuine creosote oil, which has been used successfully for a half century. On the other hand, the specifications require an oil which is higher priced and of which a larger quantity per cubic foot is recommended and used. To justify the greater cost entailed by the use of this oil, the claim is made that it has special waterproofing qualities. The principal quality that is required in an oil for the treatment of wood block is that it will prevent the decay of the wood so long as the block will last under the traffic it has to bear. Block which is laid on light traffic streets and, for that reason, wears longer than it would if laid on heavy traffic streets, requires more preservative to prevent decay during the longer life. In addition to increasing the cost, however, efforts to effect complete saturation are liable to result in injury to the woody fiber, and therefore only a sufficient quantity of oil should be used, as stated above, to preserve the block until it is worn out by traffic. Without emphasizing the fact that the particular advantages claimed for the new preservative, the special waterproofing properties, have not been clearly proved, there seems to be no reason, therefore, why the material of higher cost should supplant the cheaper product which gave such satisfactory results for so long a period. Some of the dissatisfaction that has attended the use of this more costly product is denoted by the criticism in a recent issue of one of the local dailies, as quoted below, which is typical of the general comment on the subject:

"A widespread annoyance due to the heat was the tar and oil ooze that came up from pavements all over the city. In the loop district there was such a deposit of gum on streets paved with creosote blocks that the street department required the contractors to sprinkle sand not only at crossings, but over entire blocks. This was small relief. Pedestrians continued to find their shoes smudged with the adhesive preparation. * * * Every sidewalk downtown bears blackened marks of shoe imprints. At the La Salle Hotel, in the vicinity of which the melting tar was particularly a nuisance, the doormen and porters were kept busy sweeping the corridors and entrances. Guests paused at curbings to scrape the gummy substance from their shoes. * * * Just what damages from the present heat wave have accrued in spotted rugs and carpets in hotels and residences can only be conjectured."

That there is monopoly control of this high-priced product, which thus far has seemed inferior to the cheaper oil, is recognized by unbiased students of the situation. The Otto-Hoffman coke ovens are substantially the only plants that produce a coal tar from which an oil can be distilled that will comply with the present specifications, and the patents covering these ovens are controlled by the German-American Coke and Gas Company. The plants are erected by this concern for gas companies that use the coking process, and it is this process that produces coal tar as a by-product. Instead of imposing a royalty on the process, however, the gas companies are required to enter into agreements for the sale of the by-product. This is effected through the Barrett Manufacturing Company, a concern that is an associate member of the Association for Standardizing Paving Specifications, and, through its chemist and other representatives who attended the New York convention, appeared to be in close touch with the situation. The German-American Coke and Gas Company was formed a few years ago for the purpose of taking over the by-product coke-oven processes formerly controlled by the United Gas and Coke Company of Philadelphia. The Barrett Manufacturing Company and the German-American Coke and Gas Company are controlled, through stock ownership and their directorates, by the American Coal Products Company.

The directors of the Barrett Manufacturing Company, as furnished in Moody's Manual and Poor's Manual of Industrials, are as follows: Eversley Childs, William H. Childs, I. D. Fletcher, F. M. Rianhard, E. H. Wardwell, New York; H. S. Ehret, Mitchell Ehret, G. W. Elkins, Philadelphia; S. E. Barrett, S. H. Bingham, Chicago; P. S. Marquis, St. Louis; W. H. Rankin, Elizabeth, N. J.; J. C. Runkle, Boston; A. T. Perry, Cleveland; William Orr, Allegheny, Pa. The directors of The American Coal Products Company, according to the same authorities, comprise all of those mentioned above, except William Orr, of Allegheny, with the following in addition: Alexander C. Humphreys, E. H. Kidder, Stephen Peabody, Emerson McMillan, W. N. McIlravy, New York; G. D. Widener, Paul Stackhouse, Philadelphia; R. C. Pruyn, Albany, N. Y.; William Flynn, Pitts-

burgh, Pa. At the New York convention of the Association for Standardizing Paving Specifications, the committee on creosoted wood block permitted Richard Lamb, a member of the American Society of Civil Engineers, to appear before it for the purpose of stating his views on the subject of high gravity oil. Mr. Lamb is consulting engineer for the Wyckoff Pipe & Creosoting Company, of Portsmouth, Va., with a branch in New York. The concern appears to be well regarded commercially, and for that reason should not experience difficulty in purchasing material. Mr. Lamb had published in "Municipal Engineering" for December, 1910, a request for the names of concerns that could furnish from 50,000 to 200,000 gallons of the oil specified within a reasonable length of time. He stated, however, that efforts of his company to purchase this oil had resulted only in securing, from a representative of European manufacturers using the same process, a quotation twice that of the American market price, with no agreement as to time of delivery. He qualified this statement, however, by adding that, *two days before he appeared before the committee,* the Barrett Manufacturing Company finally offered to sell the oil to his concern, but his request that this offer be at the price quoted other customers and that it be reduced to writing, was treated evasively. In response to a communication which this Bureau addressed to Mr. Lamb, he telegraphed, on June 14, 1911, as follows:

"Have sought throughout this country and abroad to buy the 1.10 specific gravity oil. Otto-Hoffman and Semet-Solvay processes are the only makers of the oil that is specified. Their output is controlled by Barrett Manufacturing Company, who sell it only to wood block makers in the combination. The Wyckoff Company refused to go into the combination. Have quotation from Europe at double the American price, with no agreement for time delivery. Companies using same process make the oil there. However, the use of this pitch is unjustifiable in the light of engineering experience. Blocks treated with the 1.10 specific gravity oil often buckle and they rot in a few years. Creosoted blocks do not buckle and will not rot."

The reference in Mr. Lamb's telegram to a combination of wood block preservers is significant from the fact that there is included in the directorate of the United States Wood Preserving Company the names of the following, who are on the directorate

of the American Coal Products Company: William H. Childs, Eversley Childs, Alexander C. Humphreys.

The committee of the Chicago Board of Local Improvements, after its return from the New York convention, reported to the City Council that "ample and positive evidence was found that the material (the higher priced oil) can be purchased in the open market and can be manufactured by anyone desiring to produce it." This statement is at least misleading, in that it does not state that *the oil could not be manufactured on any extensive scale except through arrangements with the people who control the supply of the by-product of coal tar.*

The inference that the Chicago Board of Local Improvements and the Chicago and New York conventions of paving officials, in specifying high gravity oil, played directly into the hands of these oil and wood block interests, is a justifiable conclusion under the circumstances.

## SAVING TO TAXPAYERS FROM MORE EFFECTIVE INSPECTION

The fact that numerous cases of defective work were discovered by the Bureau's investigators indicates that the city inspection is in many ways very ineffective. In order to insure compliance with contract requirements, the inspection service must be made much more vigorous and thoroughgoing than it has been. Great precaution should be taken to guard against laxity in the enforcement of the specifications, whether from ignorance on the part of the inspectors, or from carelessness, or from collusion with contractors. While it is highly important that specifications be properly drawn, it must be recognized that the weakest spot in the city paving system at present is the inspection of the contractor's work. This deserves careful attention on the part of the responsible authorities. More may be done to lengthen the life of the pavement and secure economies in the actual cost by establishing effective inspection than in any other way.

### HOW A DIRECT ANNUAL SAVING OF $200,000 MAY BE EFFECTED

In addition to other economies suggested by this report, a direct annual saving, estimated at not less than $200,000, may be effected by modifying the present specifications for asphalt and wood block pavements to conform to traffic conditions. Pavements on light traffic streets are constructed now of the same thickness as pavements on heavy traffic streets. When asphalt is used on light traffic streets a four-inch concrete base and one and one-half inch asphalt top would suffice instead of a six-inch base and a two-inch top, as now required. There would be a saving effected in this way of two and one-half inches in excavation, in addition to the saving of two inches in base and one-half inch in top. Similarly, when wood block is used on light traffic streets, a depth of three and one-half inches would answer instead of four inches, which is now required. These modifications would mean a saving on light traffic streets of approximately $7,000 a mile when asphalt is used and $6,000 when wood block is used. During 1910 almost 30 miles of asphalt (505,586 square yards) and four miles of wood block (64,000 square yards) were laid in residential districts on light traffic streets. This would have meant a saving during that year of approximately $226,000, and, in view of the fact that half of the streets under control of the city are yet unpaved, it may be expected that a mileage at least equal to that of 1910 will be paved annually for several years, and a corresponding saving, therefore, effected each year.

### PLANS FOR FUTURE PAVEMENTS SHOULD AVOID PAST FAILURES AND SHOULD BENEFIT FROM PAST SUCCESSES

In European cities, scientific studies of traffic conditions and expert analyses of results obtained with the several kinds of pavement have superseded the "hit or miss" method of conducting such work and have furnished statistical information which has been of much value in planning future work. Expert study by the Board of Local Improvements of traffic con-

ditions in the different sections of Chicago and the wear of traffic on the different kinds of pavements, together with scientific analyses of pavement and careful preservation of the records of results obtained by both observation and analysis, would undoubtedly prove of equal value to local taxpayers. The data secured in this way should also be set forth annually in published reports. During the past six years only one printed report was issued, and it contained no information of this nature.

### OTHER RECOMMENDATIONS AS TO SPECIFICATIONS

1. That no plowing be permitted below a surface two inches above the true subgrade, and that the last two inches of soil be loosened with picks to the true grade, or to such depth that when the roller has effected the maximum compression the surface will be true subgrade.

2. That the roller used in rolling the subgrade shall provide a compression of at least 250 pounds per linear inch of roller, and that, where the soil is of such nature that rolling cannot be done, flooding or other means of proper compaction satisfactory to the Board of Local Improvements be used.

3. That the character of dressing for sandstone or other stone curbing be described more definitely.

4. That the apron of the concrete curb and gutter shall have a coat of mortar face one inch in thickness instead of one-half inch, as now specified.

5. That the concrete for pavement foundations be tamped until the mortar flushes to the surface and the concrete has received its maximum compression, and that brushing of the surface be prohibited.

6. That the joints which are made between cold or finished surfaces of asphalt and fresh, hot material be properly cut back and dressed. A rope form, properly constructed, might be used.

7. That, in order to have the material in proper condition for rolling, the minimum temperatures at which surface mixtures may be laid shall be fixed definitely for the various asphalts.

A minimum temperature of 235° F. would meet all requirements.

8. That, as the present tendency with respect to granite pavement in many cities is for close-setting blocks, there should be incorporated in the specifications provision for a Portland cement filler, and that such filler be required on all streets where traffic can be withheld for a sufficient length of time for the cement to set.

9. That the present specification for lugs on the face of brick be eliminated.

10. That the sand which is placed on the surface of brick and wood block pavements after the filler is poured be kept sprinkled and removed within ten days.

11. That, when long-leaf yellow pine timber is specified for wood block pavement, not less than eight annual rings to the inch should be required, measured radially from the center of the heart.

12. That the plan, recently adopted on some streets, of bringing the pavement at crosswalks up to curb grade be extended.

# STREET PAVEMENT

## LAID UNDER THE DIRECTION OF THE BOARD OF LOCAL IMPROVEMENTS OF THE CITY OF CHICAGO

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The subject of street pavement is discussed in this report under the following general heads:

Conventions of Municipal Paving Officials.
The Subgrade.
Stone Curbing.
Combined Concrete Curb and Gutter.
Concrete.
Asphalt Pavement.
Granite Block Pavement.
Creosoted Wood Block Pavement.
Brick Pavement.
Inspection.
Development of Statistical Data.

### CONVENTIONS OF MUNICIPAL PAVING OFFICIALS

The specifications for pavement now used by the Chicago Board of Local Improvements are adaptations of specifications prepared by the various committees at the first meeting of the Association for Standardizing Paving Specifications, held in Chicago during February, 1910. These specifications were amplified by the engineers of the Board to meet local conditions and will be amended further, no doubt, to conform to recommendations made at the second convention of the same organization, which was held in New York City during January, 1911.

The chief engineer of the Chicago Bureau of Public Efficiency attended both conventions. The procedure at these conventions is of importance to the public, in view of the financial interest to property owners which attaches to the recommendations. The work of the first convention, which was held in Chicago, was necessarily done during the meeting, because no opportunity had been afforded for previous deliberation over the specifications which were presented. Although there was considerable discussion in open session, the time allowed for that purpose was relatively short, and the specifications, as recommended, were not the result of as careful judgment and consideration as would appear to have been desirable. With the second convention in view, however, there should have been opportunity for much interim work and conference. Nevertheless, the work of that convention, held in New York, was all done in committees, sitting behind closed doors. The reports, with one or two exceptions, were rushed through on the last day of the convention, when there was very little time for general discussion, and were adopted without consideration. In fact, one report was not even read. It may be admitted that this method expedited matters, but clearly at the sacrifice of the broader judgment which would have been secured had each committee, prior to the meeting, prepared tentative specifications and reports to be submitted to the convention as a whole for general consideration and open discussion.

In view of the fact that pavements laid under the specifications adopted at these conventions must be paid for by taxpayers, and, moreover, that the expenses of municipal employes who attend are borne by the taxpayers, the public is entitled to require that future conventions of the same character be conducted openly. It is suggested, therefore, that delegates from the city of Chicago to future conventions be instructed positively to that effect, in order to guard against the charge that special interests receive unfair advantages in these closed committee meetings. In striking contrast to the procedure adopted at the New York convention may be cited that of the American Railway Engineering Association, wherein a committee files

its report in advance and appears in a body before the convention to meet the discussion of the entire organization.

## THE SUBGRADE

An important consideration in street pavement is the subgrade. While the convention at New York did not devote any time to that part of the subject, it is a fact that the success or failure of pavement depends largely upon the supporting power and the nature of the soil of the subgrade. Specifications for subgrade should be definite and should be detailed sufficiently to insure a uniformly smooth, solid surface for the foundation instead of leaving the matter of compaction as "may be deemed necessary by the Board of Local Improvements." Indefinite clauses afford opportunities for discrimination.

The inspectors of this Bureau noted instances of plowing below subgrade. This should be avoided and should be prohibited in the specifications. The specifications should require that the last two or three inches of subsoil should be loosened with picks, and they should also prescribe the weight of the roller to be used for rolling the subgrade to the desired degree of compactness. The present specifications leave the contractor free to prepare the subgrade as he wishes, with merely the stipulation that "at the expiration of five years it will still be at the original grade." The average contractor, however, prefers to take chances, especially where a concrete foundation is used.

## STONE CURBING

The appearance of a street depends largely on the curb trim. The appearance of the curb trim depends on the character of dressing and the setting of the stone. The present specifications require the curb to be "neatly dressed" on top, "the face likewise dressed to a depth of twelve (12) inches from the top," and the ends "dressed smooth and square to a depth of eighteen (18) inches from the top, so as to make close joints." On North Avenue and also on California Avenue curbing was found with no dressing at all on the face, a few tool marks on top made

with an axe, and the ends jointed very badly. The face of the curbing in some cases had a variation in line on these streets of fully an inch. The finish, in some instances, was little better than a quarry face. It was apparent, therefore, that even the present specifications as to dressing and jointing were not being enforced. Not only should there be better inspection of this work, but the specifications as to dressing should be made definite by requiring either a bush-hammer dressing or a Crandall dressing.

### COMBINED CONCRETE CURB AND GUTTER

Observation of the methods employed in the construction with concrete of a combined curb and gutter also shows laxity in carrying out the detailed requirements of the specifications. For example, the cinder base sometimes was rounded up in the middle and was poorly tamped. This enabled the use of a smaller quantity of concrete, reduced the strength of the apron and thus affected the durability of the gutter. In order to allow for expansion, the contiguous sections of curb and gutter should be separated by cutting entirely through to the foundation. Instances were found where this had not been done. Concrete and the finishing coat of mortar were sometimes allowed to stand during the noon hour after mixing. The initial setting therefore took place before the mortar was used, so that most of the essential qualities of the cement were destroyed and could not be restored by remixing or retempering. The finishing coat of mortar has been laid one-half inch in thickness, as required by the specifications, but this is inadequate, especially on the apron, to withstand heavy traffic. The finish coating on sidewalks is required by the present city specifications to be three-quarters of an inch thick, and it is logical, therefore, that the finish of the gutter apron, subjected as it is to occasional vehicle traffic, should have a thickness of at least one inch.

### CONCRETE

The present requirement of batch machine mixers and the frequent adoption of a one-bag batch, which permits the use of

the original bags of cement as furnished by the cement manufacturers, are to be commended, as they eliminate to a very large degree intentional or other variation in the quality of concrete. It was observed that on two or three streets the concrete contained an excess of water, so that, being sloppy, the mortar did not adhere to the stone. The specifications require that the concrete be thoroughly rammed, and evidently do not contemplate so wet a mixture.

The practice of brushing over the surface of the concrete with a street-sweeping broom should be discontinued. This only can be of advantage to the contractor in plastering over and concealing defective work. The men employed at such sweeping should be put to tamping, because, as a rule, the concrete was not found to be sufficiently tamped. Even where the proper number of tampers were employed, observation showed that they were not doing effective work.

The specification for limestone screenings states that they "shall be of sizes ranging from one-quarter inch down to the finest, and shall be free from dirt, dust and other impurities." A large percentage of the stone observed was too nearly uniform in size, and most of the screenings inspected contained a large percentage of dust. Moreover, the specifications require that when materials are delivered on the street they shall be stored on clean pavements or temporary plank floors. This is rarely done.

The specifications for concrete call for materials and processes which should produce good results, but the city's inspection thereof has been lax and the provisions of the specifications often have not been enforced.

## ASPHALT PAVEMENT

The fact that a great variety of mixtures of asphalts and fluxes are being used in Chicago makes it of the utmost importance that the city maintain a complete laboratory, with a capable chemist in charge, who is especially experienced with asphalts and asphaltic oils. Fortunately, the city had such a man during the three years past. Considerable advance has been made

within the last year or two by the chemist in charge toward more scientific handling of asphaltic paving mixtures, but much is yet to be learned from comparing laboratory results with actual experience on the streets.

A street pavement should be considered as an engineering structure and be designed for the traffic it must bear. The thickness and character of the concrete foundation should afford sufficient strength to bridge ordinary settlement of the subgrade and maintain the wearing surface at a true grade. The wearing surface should be composed of such constituents, properly graded, as will best conform to traffic conditions. On main thoroughfares the surface mixture is so kneaded and compressed by heavy traffic as to afford a greater resistance to the deleterious effect of moisture and the chemical action of the air than on light traffic streets, where such kneading process is lacking. Consequently, less bitumen and oils are required on main thoroughfares and a harder pavement may be laid. In order to withstand atmospheric conditions successfully, a softer pavement is necessary on light traffic streets. It should contain a larger proportion of oils and bitumen, which give a high penetration.

While the present practice recognizes these conditions to some extent, it would be better if the desired penetration were previously determined for each street and separately set forth in the specifications. The surface of any particular street, however, having uniform traffic conditions should have uniform penetration. The specifications provide that the penetration of asphaltic cement shall range from 30 to 100 degrees. The use of the word "penetration" refers to the depth (measured in hundredths of centimeters) which a No. 2 needle, weighted with 100 grams and permitted to act for five seconds, will penetrate when the cement is heated to a temperature of 77 degrees Fahrenheit. In this connection, it is of interest to note that the laboratory records of the city show streets on which the penetration varied from 65 to 129 and from 62 to 123.

The correct theory of the proportions of ingredients which make up a street pavement has been developed within the last few years, and consists largely in the gradation of the elements

so that the voids will be practically filled. For a surface mixture, the sands should be so graded as to obtain a dense mass and should conform closely to the quality and gradation in size of grain that experience has shown to be most suitable for the purpose. Then, when the bitumen is added, it will completely fill the remaining voids.

BINDER

The inspection of numerous pavements being laid in Chicago during October and November, 1910, disclosed the facts that, while the binder mixture was fairly good in most cases, there was generally a lack of the finer sized stone and sand, and the binder was not laid with sufficient care. The raking was more or less careless and the rolling nearly always was deficient. Where rolling is insufficient, the binder is left soft and spongy, and during the hot weather it may yield under the wheels of heavy vehicles and cause settlement in the surface course. On Forty-ninth Street the binder was being laid at a temperature of about 180° F., which is not in accordance with the specifications. At this temperature the binder, when laid on cold concrete, is likely to chill before it can be properly raked and compressed. On Wolfram Avenue the binder had been broken up by teams hauling in the surface mixture. This would not have occurred if the binder had conformed to the specifications and if sufficient care had been taken in laying it. Wherever it becomes necessary to take up defective or injured binder, it should be relaid with hot binder mixture and not with surface mixture, as is sometimes done, for the reason that the use of the latter produces a mass having a different degree of compressibility than the remainder of the street.

Some instances were found where the stone in the binder appeared to have been overheated and to have scorched the thin coating of adhering asphalt, thus reducing its binding qualities. On Sibley Street, from Harrison to Taylor Street, a particularly bad stretch of binder was laid, and the Bureau's inspector called the attention of the city inspector to it. The latter ordered some of it out, but on the refusal of the contractor's foreman to comply with the order it became necessary for the city's inspec-

tor to call on the chief street engineer of the Board of Local Improvements for assistance in compelling the contractor to carry out the specifications. All of the defective binder not having been removed by the following day, it again became necessary for the inspector of the Chicago Bureau of Public Efficiency to call the matter to the attention of the city's inspector. The latter then summoned an officer, who threatened the foreman with arrest in order to compel him to remove the defective material. It is believed that most of the bad binder was removed, but some of the wearing surface was so cold when laid that the Bureau's inspector picked up a sample with his bare hand and demonstrated that it was not even comfortably warm. It is impossible to make a proper binder course with such a cold mixture.

### Surface Mixture

As delivered on the street, surface mixtures usually appeared to be of satisfactory composition and well mixed. The asphalt plants now in operation in the city are capable of turning out good work. Among the asphalts, however, which have been furnished is the Cuban asphalt, which has not heretofore been considered by some asphalt experts as a satisfactory material for street pavements. The chief reason for its limited use has been that it possesses many of the characteristics of the grahamites, such as great hardness and high melting point, small loss by distillation at high temperatures, high content of inorganic matter, low percentage of bitumen soluble in naphtha (often called petroline), and a high fixed carbon. Another objection is the very large percentage of residuum oil that must be used to make a paving cement of the proper consistency. The following analysis of this particular asphalt is of interest in connection with the above mentioned characteristics:

| | |
|---|---|
| Specific gravity—original substance dry at 77° F. | 1.305 |
| Color of powder or streak | Black |
| Luster | Dull |
| Structure | Homogeneous |
| Fracture | Semi-conchoidal |
| Odor | Asphaltic |
| Softens | 232° F. |

| | |
|---|---|
| Flows | 241° F. |
| Penetration at 77° F | Too hard |
| Dry substance, loss 325° F., 7 hours | 0.4% |
| Character of residue | Smooth |
| Dry substance, loss 400° F., 7 hours | 0.5% |
| Character of residue | Wrinkled |
| Bitumen soluble in carbon disulphide | 69.3% |
| Mineral matter | 27.7% |
| Difference | 3.0% |
| Bitumen soluble in 62° naphtha | 47.6% |
| Per cent total bitumen | 68.7% |
| Bitumen insoluble in carbon tetra-chloride | None |
| Residual coke (fixed carbon) | 19.0% |
| Sulphur | 4.55% |

A good pavement may be laid with this material if compounded and used under the direction of a scientific expert, but poor results are likely to follow where only the knowledge and skill of the ordinary paving contractor are available.

An examination of the sands used at the various paving plants indicated that in some cases they were not being properly graded, and further inquiry and investigation corroborates the facts elicited during the inspection. Tests of sand including carbonate of lime, taken from surface mixtures on two streets laid by different contractors, were as follows:

| | Sample A. | Sample B. |
|---|---|---|
| Per cent retained on No. 20 sieve | 18.64 | 2.70 |
| Per cent retained on No. 30 sieve | 9.52 | 2.70 |
| Per cent retained on No. 40 sieve | 8.40 | 3.65 |
| Per cent retained on No. 50 sieve | 9.12 | 8.15 |
| Per cent retained on No. 80 sieve | 11.48 | 20.90 |
| Per cent retained on No. 100 sieve | 15.52 | 35.55 |
| Per cent retained on No. 200 sieve | 17.40 | 15.50 |
| Per cent passing No. 200 sieve | 9.92 | 10.85 |

Sample A has too much and sample B too little of the coarser sizes, Nos. 20, 30 and 40. Sample A has not enough of the Nos. 50 and 80. For a number of years samples from old asphalt pavements, which had been in use for a long term of years and had given excellent service, have been cut out in different cities and analyzed to determine the proportions of the bitumen and sands and the grading of the sands. These tests have furnished a valuable guide in the designing of new pavements. Excluding from the above table the No. 200 material (which is mostly carbonate of lime) and reducing the sieve tests

roughly to new percentages, the following comparison may be made with the ideal sand suggested by Richardson and also by Whinery:

| Sieves. | Sample A. | Sample B. | Richardson. | Whinery. |
|---|---|---|---|---|
| Held on No. 30..... | 31.3 | 6.4 | 13.0 | 10.0 |
| Pass No. 30..... | 9.3 | 4.1 | 10.0 | 24.0 |
| Pass No. 40..... | 10.2 | 9.1 | 13.0 | |
| Pass No. 50..... | 12.7 | 23.4 | 30.0 | 30.0 |
| Pass No. 80..... | 17.2 | 39.8 | 17.0 | 18.0 |
| Pass No. 100..... | 19.3 | 17.4 | 17.0 | 15.0 |
| Pass No. 200..... | ... | ... | ... | 3.0 |

It may be difficult to get a natural sand corresponding to the above standards, but better and more uniform results should be obtained in Chicago than indicated by inspection and tests. If the desired grading cannot be secured in natural sand it would seem necessary that an artificial mixture of different sands be used. The proper grading of sands constitutes one of the most important requisites of an asphalt paving mixture, and the supply, therefore, should be very closely inspected.

### Laying the Asphalt

The methods used in the work of laying and manipulating the mixture on the street, while not violating express provisions of the specifications, nevertheless often were open to criticism in several respects. A large proportion of the work, moreover, has not conformed to the requirements of the specifications. When a load of asphalt surface mixture is dumped upon a street it should receive a uniform raking in order to insure subsequent uniform compression. The impact of the asphalt upon the concrete base when dumped gives an unequal compression to the bottom part, so that to obtain a uniform raking it is necessary that all of the material be turned over or moved. In no case inspected was this requirement being carried out, but when the Bureau brought this requirement to the attention of the engineer of streets, orders were issued by him to turn the mixture. In many cases the joints between cold or finished areas of pavement and fresh, hot material were not properly cut back and dressed. Although the present specifications are silent on this matter, it is nevertheless essential that these joints be properly

made, otherwise depressions in the surface of the pavement are likely to result. This condition was observed in several asphalt streets which had been completed.

There has also been a lack of care in removing from the binder course cold drippings of surface mixture and other refuse before the surface is applied. Where such refuse is allowed to remain and the new material is raked over or around it, the latter is not properly compressed by the rollers and during hot days, under heavy travel, these spots are likely to give way, forming depressions in the pavement, which quickly wear into holes.

The specifications require that the asphalt shall leave the plant at temperatures ranging from 250° to 335° F., but no provision is made for a minimum temperature at which the mixture shall be laid on the street, this being left to the judgment of the contractor and inspector. Under favorable circumstances, the wearing surface should arrive on the street at a sufficiently high temperature; but it was found too cold in several instances when tested. When laid under such conditions, proper compression is impossible, honeycombing develops, and a porous pavement is the result. The surface also is likely to become irregular. The maximum and minimum temperatures at which binder may be laid are now specified, and it would seem desirable that limiting temperatures for laying asphalt should also be definitely stated. The limits might be fixed at temperatures between 235° and 335° F. Each inspector on the street should be furnished with a thermometer to test the material.

As a general thing, the rolling of the wearing surface as well as the binder has been insufficient. All authorities on the subject are agreed that thorough rolling is necessary to produce satisfactory asphalt pavement. If the wearing surface is not thoroughly compressed before it becomes cold, it will thereafter remain more or less soft and spongy, will absorb a larger percentage of water, and will be inferior in wearing qualities. A very slight difference in the final density of a pavement makes a great difference in its ability to endure heavy travel. The light roller should be used on the surface mixture as soon as possible

and the rolling continued with the heavy roller until the material has received its maximum compression.

The city specifications cover many of these points and, if enforced, would insure good results. Directions for the placing of the surface mixture, set forth in the city specifications as follows, should be rigidly enforced:

> "Upon the arrival at the street it shall be dumped at such distance from the work that all of the mixture must be turned and distributed to the place where it is to be raked. It shall be spread while hot upon the asphaltic concrete binder, which must be thoroughly dry, free from dirt, leaves or other foreign matter. The last load of the day shall be spread at least one hour prior to the official time of sunset. After receiving its ultimate compression by rolling, it shall have a thickness of two (2) inches. The initial compression must be effected by means of a small roller, after which a small amount of hydraulic cement shall be swept over the surface. The final compression shall be effected by a ten-ton roller, or the equivalent, of not less than two hundred and fifty (250) pounds per running inch width. Rolling must be steadily kept up and continued until all roller marks disappear and the surface gives indication of no further compressibility."

## Economies Which May Be Effected

It is now generally conceded that, where a binder is used, the binder course should be one and one-half inches in thickness; but the thickness of the wearing surface may be varied with advantage to suit traffic conditions. For the heavier traffic streets, two inches of surface mixture is desirable; but for light traffic streets, or streets entirely residential in character, a surface layer of one and one-half inches would meet all the demands of traffic equally as well and could be constructed at less cost.

A critical study was made of all streets laid with asphalt during 1910, and it was found that of 147 street contracts, covering 923,221 square yards of asphalt pavement, 505,586 square yards were laid on streets, wholly residential, upon which the traffic was very light in character, both in number and weight of vehicles. Some advocates of the present practice of constructing the same thickness of pavement for all classes of streets advance the argument that there are no light traffic streets, because travel seeks the lines of new pavements. This argument is fallacious, however, in view of the fact that there is a large mileage of streets where the only heavy loads are occa-

sional coal wagons or moving vans, and the remainder of the traffic consists of delivery wagons and other vehicles of light character. Since street railways usually follow main arteries of travel, no street having a street railway track was considered as a light traffic street, nor any parallel street which might become a line of through travel.

For light traffic streets a pavement may be designed, less expensive in character than that used on heavy traffic streets. This would have ample strength to carry the occasional coal wagon or moving van and, not being subjected to the continual blows from heavy trucks, would have fully as long life as the heavy pavements now used. The latter construction consists uniformly throughout the city of a six-inch Portland cement concrete base, a close binder of one and one-half inches, and a wearing surface two inches in thickness—a total thickness of nine and one-half inches. For the lighter traffic pavement it is suggested that a four-inch concrete base, a one and one-half inch binder and a one and one-half inch top be used, making a total depth of seven inches.

The average cost for the asphalt pavements laid in 1910 was $1.876 per square yard. The elements which are involved in this total cost of $1.876 may be estimated per square yard as follows:

| | | | |
|---|---|---|---|
| Overhead charges | | | $0.176 |
| Excavation | 9½ | inches | .13 |
| Concrete | 6 | inches | .72 |
| Binder | 1½ | inches | .24 |
| Top | 2 | inches | .61 |
| | | | $1.876 |

Based on the above unit prices, the reductions in cost which would be made possible by the adoption of the lighter traffic pavement would be as follows:

| | |
|---|---|
| Excavation reduced 2½ inches | $0.03 |
| Concrete reduced 2 inches | .22 |
| Asphalt top reduced ½ inch | .15 |
| Total reduction in cost | $0.40 |

Considering, therefore, that in 1910 there were 505,586 square yards of asphalt pavement which could have been laid

as described on residential streets, the net reduction in cost to the property owners of Chicago would have been $202,234.40 in that one year, a saving of 19 per cent.

In this connection, it may be well to note that about the same reduction in cost may be obtained by constructing a pavement with a six-inch Portland cement concrete base, painting the surface thereof with asphaltic cement, and then using a one and one-half inch wearing surface without a binder course. For such a pavement a thin coat of mortar might be spread over the concrete before the course has set, so as to obtain a smooth surface for the paint coat. Careful consideration should be given to this type of construction. The bituminous concrete pavement with its wearing surface laid directly on the concrete has demonstrated the fact that a binder is not really necessary. For streets of very light travel a four-inch concrete base would be sufficient and would effect a further reduction in cost.

Open binder has proved a failure under heavy traffic. The present specifications properly call for a close binder, but in order that the binder and wearing surface shall knit firmly together and thus form an inseparable mass, the directions as to laying should be made more definite. No greater area of binder should be permitted to be laid in one day than can be covered with a surface mixture not later than the following day.

## GRANITE BLOCK PAVEMENT

The granite blocks inspected were well manufactured, of good quality, and capable of being laid with close joints. In general, they were being well laid, but in some instances not as closely as they could be, nor as the specifications required, viz., with a maximum joint space of three-eighths of an inch. Neither were the joints being broken as well as they should be. The specification as to jointing requires a minimum lap of three inches, but in some places the joints were almost continuous, and a lap of only one or two inches was noticed in places on several streets.

The present method of completely filling the joints with

gravel makes it difficult to fill the voids with coal tar, and as a rule only about three-quarters of a gallon per square yard is being used, although one inspector claimed to be requiring one gallon per square yard. The better way, where bituminous joints are used, is to fill the joint only about half full with gravel before the pavement is rammed and then completely fill the voids thereof with coal tar. The upper half of the joint should then be similarly filled with gravel and saturated with coal tar. This method of filling would require about one and three-quarters gallons of coal tar per square yard, but all of the voids would be filled, which is not possible under the present method. The filling of all voids is essential to the success of the pavement, for unless the gravel joints are solidly bound together by the tar the granite blocks are liable to become loosened. Although the Chicago specifications require the use of coal tar exclusively, Portland cement grout is less expensive and many paving experts now concede that the latter also forms a better joint filling for granite pavement. Where the joints are thus properly filled with good Portland cement grout, the paving stones are held in place with great firmness and the whole pavement becomes practically a monolith. The cement filler with closely set granite blocks has been adopted by a number of American cities, and wherever used is giving very satisfactory service.

## CREOSOTED WOOD BLOCK PAVEMENT

The demand for a pavement, particularly in the loop district, which would be practically noiseless and which could be taken up and repaired or replaced easily, led to the adoption of creosoted wood blocks. The wood block pavements laid in other sections of the city are contracted for also under the same specifications as are those laid in the loop district, except as to the thickness of the concrete base. There are no reliable data at hand to estimate the life of this kind of pavement under the loop traffic, but from eight to ten years probably would be the maximum.

Wood block pavement requires, in the first instance, careful

consideration of the kinds and quality of timber best adapted to resistance to traffic and to preservative treatment. These considerations may be understood to include the proper seasoning of the wood.

Of no less importance than the choice of timber is the selection of the preservative and the method to be employed in treating the wood. If the natural tendency to decay can be arrested, the only factor to be considered is the wearing effect of traffic on the wood block. Consequently there is required merely that quantity of any preservative which can be employed most economically to keep the block from decay so long as it will bear up under the traffic.

### Kind and Quality of Timber

The New York convention specifications designate Southern yellow pine, Norway pine, black gum and tamarack as the kinds of timber that may be used for paving blocks. Southern yellow pine is a trade term in the market, which includes the timber of several varieties of the pine family, but chiefly the true long-leafed yellow pine (*Pinus palustris*), the short-leafed yellow pine (*Pinus echinati*), and the loblolly pine (*Pinus taeda*). The woods of the last two named are inferior in strength and subject to rapid decay, and though, when properly creosoted, decay is arrested, blocks made from them lack the strength and durability of the true long-leafed yellow pine. Likewise, what is known as "second growth" timber of all these varieties is very inferior and should be excluded. The provision in the New York convention specifications that the annual rings in yellow pine timber shall be not less than four and shall average not less than eight to the inch will exclude very little timber of any quality found on the market under the name of Southern yellow pine.

The very broad experience which has been had in the city of Indianapolis with the different varieties of pine indicates that, while not all the failures of wood block pavement there have been due to the use of loblolly, practically all of the loblolly blocks have failed.

The Chicago specifications require that the annual rings shall be not less than six to the inch, and the railroads of the country generally require not less than eight. The specifications adopted at the New York convention in 1911, therefore, are decidedly inferior in this respect.

Density of the wood is an important factor in the bearing it has on the quantity of preservative the block will receive. Greater density ordinarily renders the block more durable, though experience has shown that some of the softer pines, such as Norway, hold up quite well under traffic. Tests conducted by the United States Forestry Department since 1906, on Nicollet Avenue, in Minneapolis, indicate the values of the various woods for creosoted pavements in the following order: (1) Long-leaf pine. (2) White birch, Norway pine, tamarack, or hemlock.

It is desirable that the timber for wood block pavement be air-seasoned preliminary to further treatment, for the reason that, in some of the several patented processes of treating green timber, where a heavy tar oil is used, such high temperatures are required in order to secure the desired impregnation of the block that the woody fiber is injured. The "bleeding" of the creosoted pavement, hereinafter referred to, is another fault which has been attributed to the process of steaming the blocks used in Chicago. The explanation of this is that, when the high pressure necessary to introduce the heavy oil is applied to the saturated fiber, moisture is imprisoned, and its subsequent vaporization when the block has been laid forces the oil out of the wood.

The quality of the wood in blocks laid under the 1910 specifications and inspected during this inquiry was found to be satisfactory. The blocks were well shaped and apparently had been carefully inspected and culled. The chief criticism, as detailed hereafter, relates to the methods and materials used in the preservative treatment of the blocks.

### Creosote and Tar Oils as Preservatives

For a half century or more the efficiency of pure coal tar creosote in the preservation of wood has been recognized. The

antiseptic and fungicidal qualities of the three principal constituents of pure coal tar creosote, *i. e.,* carbolic oil, naphthalene and anthracene, have been accepted, though in recent years the latter two, the heavier fractions, have been demanded in greater proportion because of the evaporation of the lighter constituent. The minimum specific gravity has been raised in this way from 1.01 to 1.03 or 1.04, while the maximum has been held at 1.08. This range in values covered European practice in general, as well as the specific practice of the railroads of this country.

Within the last four years, however, it has been advanced that a waterproofing material is most to be desired in treating wood blocks, and that, in order to effectively waterproof the blocks, it is necessary to use heavier oils than the pure coal tar creosote, and a greater quantity (impregnation).

The specifications which were used in Chicago during 1910 required an oil which "shall be a *pure coal tar product,* free from adulteration, * * * the specific gravity (of which) shall be at least 1.10 at 25° C." Though no maximum was specified, this high minimum permitted, or rather required, either a large admixture of coal tar pitch with creosote oil or the use of refined coal tar alone.

With regard to the waterproofing proposition, the utilization of water gas tar, the production of which is about twice that of coal gas tar, is a matter of considerable importance. The by-product creosote (so called) made from water gas tar is strikingly similar in chemical composition and specific gravity to the high-gravity coal tar creosote and is similar to pure coal tar creosote in appearance. The marked difference between ordinary pure coal tar creosote, as generally defined, and water gas tar creosote is in the specific gravity, that of the latter being much heavier. It is not difficult, therefore, to substitute water gas tar oil for the coal tar product of high specific gravity if the specifications are not carefully drawn to prevent it, and though the present Chicago specifications designate coal tar oil, the chemical and physical tests may be fulfilled by either oil.

The summary in the following table affords comparison of the properties of the three oils:

| | Pure coal tar creosote. | Refined water gas tar (called creosote). | High specific gravity coal tar (called creosote). |
|---|---|---|---|
| Original specific gravity at 15° C. | 1.04 | 1.14 | 1.122 |
| Fraction distilling below 315° C. | 84.8% | 16.0% | 34.2% |
| Fraction distilling above 315° C. | 13.8% | 54.3% | 41.8% |
| Total distilling from oil..... | 98.6% | 70.3% | 76.0% |
| Coke remaining in retort..... | 1.4% | 29.7% | 24.0% |

If it be true, as is claimed by some of the advocates of this heavy-gravity oil, that when the pores of the wood are filled with a substance which will effectually and permanently exclude moisture, decay will be prevented without the presence of a fungicide such as pure coal tar creosote oil, then it is only a question of finding a substance that will effectually seal the wood against moisture. There would be no reason, therefore, why a preparation of coal tar should be considered superior to one of water gas tar, nor why it should be specified in preference. With what knowledge of the subject there is now available, however, it seems unwise to assume that a fungicide is not necessary for the proper preservation of the wood. The experience with the new material has extended over so short a time, and such undesirable features have developed, that the good qualities it may possess have been clouded.

In order to render a wood block decay proof, it would seem that the only safe course is to use a sufficient quantity of high-quality creosote oil; but if it is desired also to waterproof the blocks by complete cell treatment with heavy-gravity oil, there may be added to the creosote base a sufficient amount of refined coal tar pitch, or of special residues resulting from the distillation of coal tars, or a heavy portion of water gas tar oil. The tars, however, must be such as will assimilate with the pure coal tar creosote and have such characteristics as will permit complete impregnation of the block. For such a combination of tar and creosote oil the analyses cited herein would indicate that a higher range than 35 or 40 per cent of distillate up to 315° C. should be designated, and that the maximum specific gravity should be limited to 1.10 at 25° C. Chemical investigation could

probably determine the proper limits. The quantity and character of the preservative used for paving blocks in the loop district need only be sufficient to preserve the wood from natural decay for from ten to twelve years at most, while for some of the residence streets and alleys, where the pavement will not wear out, ordinarily, for a much longer period, the amount and quality of the oil used should be adequate to prevent natural decay for the longer life of the pavement.

### Depth of Block.

An appreciable economy could be effected by intelligent variation in the depth of blocks. The present practice is to use block of a uniform depth of four inches. On heavy traffic streets, four-inch block may be required, but three and one-half inch would be a sufficient depth for block on residential streets, and even three inches would suffice on alleys and very light traffic streets. With a twenty-pound treatment of preservative, three and one-half inch block would cost approximately 20 cents per square yard less than four-inch, and three-inch block would cost 40 cents per square yard less than four-inch. On the basis of $2 per square yard for block alone, from 10 to 20 per cent could be eliminated in the cost of block and the character of pavement sufficient for the actual traffic conditions still could be obtained. Having in mind the large amount of wood block pavement which, it appears, the city contemplates laying, serious consideration should be given to the important economy to be secured by using wood block of varying depth to meet the varying traffic demands.

### Chemical Analyses of Creosote Oils

The tests made by the United States Forestry Department of wood block that had been in service a long time (Forest Service Circular No. 98) are entitled to consideration in connection with objections that the advocates of the heavy oils raise to the use of the pure coal tar creosote. The contention that the latter evaporates too rapidly to be an effective preservative is disputed by results of the government's analysis of five samples of block with an average life of 20.6 years. This block, which had been treated with pure coal tar creosote oil, retained an impregnation

of 13.77 pounds of oil to the cubic foot, and the proportion of naphthalene and anthracene, the heavier constituents, was large, as is indicated in the following table by the percentages which distilled at the intermediate temperatures:

| Degrees Cent. | Percentage distilling over | |
|---|---|---|
| 205 to 245 | 20.92 | |
| 245 to 270 | 22.96 | Naphthalene and anthracene |
| 270 to 320 | 23.32 | Naphthalene and anthracene |
| 320 to 420 | 16.56 | |

The residue above 420° was 15.58 per cent.

The proportion of true preservative oils, therefore, as indicated by the distillates below 320° was 67.2 per cent. It will be noted that the Chicago specifications provide that up to 315° C. the distillate shall not exceed 40 per cent. The quantity distilling between 315° C. and 320° C. is unimportant and does not affect the comparison.

Further illustration of the permanent effect of treatment with the lighter oils is had in recent tests which have been made of wood block pavement that was laid in Indianapolis some twelve or fourteen years ago. Block that had received but a twelve-pound treatment of preservative, which had a specific gravity of about 1.04, was found to be still in satisfactory condition.

There were approximately 56,000,000 gallons of (presumably) pure coal tar creosote used in the United States in 1908, of which 39,000,000 gallons were of foreign production. Furthermore, there is an increasing demand in this country for wood preservatives. It is not difficult to understand, therefore, why there would be a desire on the part of those interested in an important source of the supply of domestic oils for wood treatment to have specifications so manipulated that the imported oils, practically, would be excluded and a material would be designated with which the market could be controlled. It is stated that this could be done where the specifications limit the free carbon to two or three per cent and the distillates to 40 per cent below 315° C. Where a pure coal tar product is required also, the specifications obviously furnish a marked advantage by

demanding, in effect, the use of coke-oven tar, even though not particularly specifying it. Coke-oven tar is an important source of the supply of creosote. An analysis, reported by Lunge, of one kind of coal showed the by-products in the following proportions:

| | |
|---|---|
| Light oils | 1.26 per cent |
| Creosote | 21.80 per cent |
| Soft pitch | 74.41 per cent |
| Water and loss | 2.53 per cent |

The average of a number of analyses was stated as follows:

| | |
|---|---|
| Ammoniacal liquor | 4.0 per cent |
| First light oils | 1.5 per cent |
| Second light oils | 1.5 per cent |
| Creosote | 22.0 per cent |
| Anthracene | 4.0 per cent |
| Pitch | 67.0 per cent |

Soft pitch, as indicated above, constitutes a large proportion of the by-product and, when mixed with the creosote, forms an oil having a high specific gravity. It is stated by Richard Lamb (Proceedings American Society of Civil Engineers, January, 1911) that

"the Otto-Hoffman process, which is considered a by-product plant for making coke, illuminating gas, sulphate of ammonia and by-products of coal tar, produces a residuum of pitch having a specific gravity of 1.12, but containing very little naphthalene and anthracene. This pitch is used for roofing and waterproofing, and one company, with its allied interests, as far as can be ascertained, has bought up all the output that can be used for wood block paving. Specifications requiring that the distillate shall not exceed 2 per cent up to 150° C. and shall not exceed 35 per cent up to 315° C. are strictly a call for by-product pitch and a bid for an oil which can be absolutely void of naphthalene and anthracene, the materials engineers have depended on so far to preserve the wood."

Obviously, it is to the interest of those in control of the coke-oven patents to have a demand created for a mixture wherein the soft pitch, which is such a large part of their by-product, can be utilized.

A prominent manufacturer of creosoted paving blocks admitted, in the paving trials at Cincinnati last year, that a requirement limiting the free carbon to three per cent created a monopoly. To favor such a situation would be poor business policy, and it may be asked, therefore, Is it at all justified by scientific

reasons? A high percentage of free carbon in the oil is considered to retard the treatment and prevent the free impregnation of the woody fiber with the preservative. There have been tests, however, which showed that from 20 to 22 pounds of oil per cubic foot, with a specific gravity of 1.10 to 1.12, could be forced into long-leaf yellow pine, where the proportion of matter, principally free carbon, insoluble in benzole and chloroform, was as high as five per cent. Is there any reason, therefore, for limiting the free carbon to three per cent, or three and one-half per cent, as was done in the specifications of the Chicago convention of 1910 and the New York convention of 1911, respectively, unless it was to exclude other preservatives and favor the product of the coke-oven process, which is produced with a low proportion of carbon?

A comparative study of the distillates of pure coal tar creosote with the so-called water gas creosote and with the heavy-gravity coal tar product furnished under the Chicago specifications may be enlightening as to the reasons for raising the specific gravity requirements and the limits of distillation.

### Exudation of Tar from Blocks

There was considerable complaint in Chicago last summer, and there has been a great deal more so far this summer, regarding wood block pavement, because oil in the blocks has exuded so freely that a thick coating of tarry substance has appeared on the surface. This is tracked into houses and stores, to the destruction of floors and floor coverings, and, though an attempt to relieve the annoyance was made in some places by scraping the pavement, the tarry coating reappeared.

One explanation attributes the cause of this to what may be termed the adulteration of creosote oil or dead oil of coal tar, which has a specific gravity ranging from 1.03 to 1.08, with coal tar pitch, in order to raise the specific gravity, as required by the specifications, to 1.10 or higher. It has also been suggested that the trouble is due to pitch filler between the blocks, which, being forced out of the interstices up on the surface by the expansion of the block, unites with some of the lighter oils

of the preservative and forms the tarry coating. In most cases, however, there was no doubt that it was the heavy coal tar oil used in the treatment of the block which was exuding from the wood. Under the influence of heat and its expansive effect on the blocks, augmented possibly by the evaporation of the moisture imprisoned during the steaming process hereinbefore referred to, the tar is forced out of the pores of the wood and forms the coating, whereas, if creosote oil alone is used, the slight exudation is not sticky and objectionable as is the tar.

Reference may be made to the experience of the city of Indianapolis, which has laid a large mileage of creosoted block and was among the pioneers in the laying of such pavement. The earlier pavements there were treated with from 10 to 12 pounds per cubic foot of pure creosote oil, which had a specific gravity of about 1.04, and there was no trouble then from exudation. Almost four years ago, however, the specifications were changed and an oil requiring the admixture of coal tar pitch to bring it up to the higher specific gravity limit was adopted and a heavier treatment was used. From the beginning of its use there was trouble and annoyance caused by the exudation of tar. Last year a new specification was adopted which called for creosote oil derived from the distillation of pure coal tar, which should be free from any adulteration whatever or any mixture of undistilled tar and should have a specific gravity, at 140° F., of not less than 1.04. The oil used had a specific gravity of 1.075 at 77° F., and no trouble has been experienced since it was adopted.

The specifications of the borough of Richmond, New York City, call for an oil having a specific gravity of at least 1.07, and very satisfactory results have been obtained thereby. It has been the practice in Europe to air-season the timber thoroughly before treatment, and pure creosote oil having a specific gravity ranging from 1.03 to 1.055 has been used and no bleeding of the blocks has been noted.

### Monopoly in Tar Oils

There seems to have been a studied effort to throw an air of mystery around the characteristics of creosote oil best adapted

for wood block preservation, and it would seem advisable to have experiments made by absolutely disinterested chemists, expert in the knowledge of tar products, who will prescribe the chemical and physical characteristics of creosote oils and coal tars suitable for wood block preservation. The engineer then may determine the treatment from a germicidal and antiseptic point of view and also as a matter of waterproofing. Impossible conditions should be specified no longer, and the limits of distillation of the Chicago specifications, therefore, should be modified. If the specifications are intended to prescribe the use of coal tar or water gas tar only, either alone or in combination, and for the reason that they are waterproofing materials, those facts should be stated frankly.

The committee from the Chicago Board of Local Improvements which attended the New York convention of the Association for Standardizing Paving Specifications, in its report to the city council of January 23, 1911, stated that "the claim that but one firm can manufacture the 1.10 oil was investigated and found to be without foundation. Its manufacture is not covered by any patent and it can be purchased in the open market. A filtration and distilling plant can be erected at a very reasonable figure by any concern desiring to manufacture this product." In the face of this report, there appeared in a recent number (December, 1910) of the Municipal Engineering Magazine a request by a prominent wood block manufacturer for the address of a firm that could furnish 200,000 gallons of the 1.10 oil as specified, the one firm referred to above having refused to name a price.

This high gravity oil is obtained from coal tar produced by by-product coke ovens, the patents for which are controlled by the German-American Coke and Gas Company. The control of the oil is effected through agreements, made at the time the plants are erected, by which the various gas companies using the coke-oven process are required to sell their by-product tars to the Barrett Manufacturing Company. The same company procures by-products of companies using water gas processes, or the old type coal gas process, largely through the influence on the market afforded by control of the patent coke-oven process. The rela-

tionship of the two mentioned companies is indicated by the fact that the American Coal Products Company controls both, through stock ownership and through their directorates. Admitting that it would be possible as claimed by the committee of the Chicago Board of Local Improvements, to "erect a filtration and distilling plant at a very reasonable figure," the above mentioned conditions indicate that the proprietors would then experience great difficulty in getting any material of the pure coal gas or water gas tar products to distill.

The committee on creosoted blocks at the New York convention, similar to other committees, admitted only such persons to the conferences as were sent for. There was no discussion of the report on the floor of the convention further than the dissenting vote of the engineer for the commissioners of accounts of New York City, who voted against the adoption of the report because, as he stated, he favored free and open competition in street paving. Of all the specifications adopted at that convention, the one on creosoted block was the only one having a dissenting vote on the grounds as stated.

## BRICK PAVEMENTS

The paving brick now being furnished the city seem to be of good quality. The requirement in the specifications, however, for lugs or raised letters on the brick is of no advantage, particularly when a bituminous filler is used. Although the lugs are on one side only, if the brick are carelessly laid so that the lugs face each other, a large joint is made and, with a one-fourth-inch round corner, a space is left of three-fourths of an inch between the tops of the arcs on the corners. Bricks with lugs increase the cost of laying by reason of the greater care thus required, and also on account of the larger amount of filler which is necessary. Bricks without lugs are usually rough enough to provide sufficient space for the filler, and they make a smoother pavement when closely laid. The chief engineer of streets, in his recent report to the city council, stated that, at the New York convention, he had advocated the elimination of lugs.

The specifications require that all brick shall be delivered to the layer on pallets or by means of roller conveyors, *not wheeled with barrows or dumped.* This is a proper restriction, but it has not always been observed, and on one street at least (Paulina) the brick were being badly chipped by rough handling in wheelbarrows. The provision against rough handling should be strictly enforced.

The specifications provide for a minimum lap of three inches, but frequent instances, due to careless laying and inspection, were noted where the lap amounted to but one or two inches.

No squeegeeing of any bituminous filler is permitted by the specifications, but it was noted that practically this method was employed in some cases. There is no reason why all contractors should not be put on the same basis and required to pour the filler through spouts. In order to do this it must be heated to a proper temperature to work satisfactorily, while with the squeegee method fairly cold tar can be spread over the brick. The joints then will seem filled when, as a matter of fact, there is only a thin surface coating.

The edges of the brick are better protected by a cement grout filler than by a bituminous filler such as is now used. Objection is made to the former in that trouble is experienced in keeping teamsters off the brick for a sufficient period to give the cement time to set. It is submitted, however, that if the specifications were enforced requiring that, on streets occupied by street car tracks, the pavement shall be laid on one side at a time, it would not be so difficult a matter. There would also be less inconvenience to residents along the streets and to citizens in general if one side of the street were finished before the other was torn up and made impassable.

After the interstices of the bricks are filled, a layer of fine, dry sand is spread over the surface to fill all crevices remaining. This sand has proved annoying to residents on some streets through being blown into the houses. Arrangements should be made to keep such pavement sprinkled for a period of ten days and then have the sand removed. This applies with equal force to wood block pavement.

## INSPECTION

The report of the Board of Local Improvements for the year ending December 31, 1909, in referring to paving inspection, states that "a much larger number of inspectors were employed than heretofore." During the inquiry made by this Bureau it was noted that, in practically all cases, there were enough local and general (or district) inspectors on the streets to give adequate supervision and inspection to the construction in progress. That the inspection still remained inefficient in 1910, however, was evidenced by the great number of instances of non-compliance with the specifications which were noted during this investigation. The necessity, already referred to herein, for this Bureau to direct the attention of general inspectors to violations of specifications which should have been obvious to even local inspectors, is further proof that the inspection is bad. The most complete and carefully prepared specifications are rendered futile unless the provisions thereof are enforced by those supposed to protect the interests of the city, and it is of little value to increase the inspection staff without materially improving the efficiency of the force.

## DEVELOPMENT OF STATISTICAL DATA

There were 116 miles of pavement laid by the Board of Local Improvements during 1909 and 123 miles during 1910, at a cost of approximately $40,000 per mile. There are 2,900 miles of streets under the jurisdiction of the city, only about half of which are paved. To pave the remaining half a future expenditure of about $60,000,000 will be necessary. Before that can be done, however, a large proportion of the streets now paved will require extensive repairs or reconstruction. With this enormous mileage and expenditure in mind, it is of the utmost importance that reliable statistical data, such as is not now available, be developed as aids to the administration of the work.

A scientific and critical study should be made of local traffic conditions, comprising, for example, a tabulation of the average tonnage per foot width of pavement in different sections of the

city and the general character of such tonnage; also the wear produced on each of the several kinds of pavement in different sections of the city. Pavements which have proved successful as well as those which have failed should be carefully analyzed and the results recorded. Results of laboratory experiments should then be carefully compared with results secured from actual street service. What is learned by observation, analysis and experience should be contained in reports published annually.

The only report published by the Board in six years was issued very recently and contained little more than a list of the streets on which local improvements had been provided for within that period.